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DISSERTATION

USING ISO14001 GAPS ANALYSES TO IMPROVE SUSTAINABILITY OF WATER PROGRAMS AND PROJECTS

Submitted By:

Larry Quinn, P.E.

Civil Engineering Department

In partial fulfillment of the requirements

for the Degree of Doctor of Philosophy

Colorado State University

Fort Collins, Colorado

Spring 2002

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COLORADO STATE UNIVERSITY

April 15, 2002

WE HEREBY RECOMMEND THAT THE DISSERTATION BY LARRY QUINN ENTITLED **USING ISO14001 GAPS ANALYSES TO IMPROVE SUSTAINABILITY OF WATER PROGRAMS AND PROJECTS** BE ACCEPTED AS FULFILLING IN PART REQUIREMENTS FOR THE DEGREE OF DOCTOR OF PHILOSOPHY.

Committee on Graduate Work

Advisor

Department Head

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ABSTRACT OF DISSERTATION

USING ISO14001 GAPS ANALYSES TO IMPROVE

SUSTAINABILITY OF WATER PROGRAMS AND PROJECTS

International water resources management programs and projects (hereafter, projects) historically have sometimes failed to meet increasingly complex societal demands and multiple objectives. The international agencies, banks and national governments have detailed project review criteria, but such reviews often have been narrowly focused. There are few systems in place that assist with formulating, assessing, implementing and monitoring these international projects in an integrated fashion, directed toward the goal water resource sustainability. In addition, water resource needs and potential solutions often are poorly communicated to an increasingly involved general public. Projects are also being assessed for 'environmental due diligence' by the project proponents, but without a comprehensive system or procedure.

The International Organization for Standardization (ISO) has formulated the ISO 14000 series of standards to improve environmental performance of an organization. ISO 14001 is a standard that provides the "core" requirements for developing and implementing Environmental Management Systems (EMSs) that can be "certified" or registered by an external third party.

The hypothesis of this research was that so-called ISO14001 gaps analyses (a gap defines the difference between the existing condition and ideal EMS compliance), using water-related EMSs, could improve the economic/environmental performance and sustainability of projects addressing or affecting regional or national water resources at various stages of project development including formulation, design, review and

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implementation. The development of a set of comprehensive EMSs that can be applied to various types of water-related projects (and projects in other sectors affecting water resources) is a daunting challenge. Such an effort could likely be undertaken by organizations such as the World Bank or United Nations agencies under global environmental project funding.

To foster these international efforts, the objectives of this research were to:

1. Outline the various multi-dimensional criteria that affect the sustainability of international water-related development projects,
2. Determine where and how ISO14001 reviews in the standard project cycle could assist with improving the sustainability of water-related development projects,
3. Develop some representative water-related EMSs for use in standard ISO14001 gaps analyses at various stages of project development and implementation, and
4. Demonstrate the potential application of these EMSs and gaps analyses on a large World Bank water and sanitation project.

The process of defining sustainability will involve many facets and levels of society and could consume decades to matriculate. Local, regional and national viewpoints from many disciplines are required to fully develop sustainable economic planning for a particular country, as well as resolve international water conflicts. It is hoped that this modest start at developing a systematic review process will lead to more comprehensive tools for improving international water project performance relative to sustainability goals.

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VITA

EDUCATION

- PhD Candidate in Civil Engineering, Colorado State University.
- Master of Science Degree in Environmental Engineering, Colorado State University, 1975.
- Bachelor of Science Degree in Industrial and Systems Engineering, University of Pittsburgh, 1970.

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PROFESSIONAL EXPERIENCE

1992-present	Independent Civil / Environmental Engineering Consultant
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1978-1979	Project Engineer; Utility Engineering Co., Fort Collins, CO.
1975-1978	Water Quality Engineer; Colorado Department of Health, Water Quality Control Division, Denver and Pueblo, CO.
1973-1975	Graduate Teaching Assistant; CSU, Fort Collins, CO.
1974	Intern, Western Interstate Commission on Higher Educ.; Dept. of Environmental Quality, State of Wyoming.
1970-1972	United States Army; Engineering Division, US Theater Army Support Command Headquarters, Worms, Germany.
1969-1970	Industrial Engineer, US Steel Corporation, Duquesne, PA.

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EXPERIENCE:

Larry Quinn, P.E. is an independent water resources and environmental engineer based in Lyons, Colorado. Larry serves local and international clients in the areas of water resources planning, multi-media pollution control, and environmental assessment and decision support systems. Larry has over twenty-five years of experience in the private and public sectors and has worked on a wide variety of water-related and environmental projects. He is proficient in the application of many computer-assisted modeling tools in the areas of water resources, water quality, air quality and environmental noise. His project experience has included several water quality assignments, water resources planning, areawide assessments for clean water and wastewater, drainage design and floodplain delineation, stormwater quantity and quality design, environmental assessments including a variety of medias and assessment criteria, and regulatory processes. He has coordinated major studies in wastewater facility inventories and salinity control, consulted on major water quality assignments in both domestic and international locations, developed wastewater treatment plans for small local treatment areas up to and including complete water basins, and has developed particular experience in integrated water quality and environmental planning. His work experience also includes the public sector where he was an NPDES-permit and district engineer for the Colorado Department of Health, Water Quality Control Division. He has a unique background in industrial/systems engineering and water/environmental engineering which allows for blending of the technical and environmental considerations in the analyses of complex projects involving multi-disciplinary concerns. His overseas assignments have included projects in the Palestinian Occupied Territories, Nigeria, Europe, Philippines, China, Taiwan, Pakistan, Bangladesh and Hong Kong. In China, he

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has worked on two large World Bank water and sanitation project, the Sichuan Urban Environment Project in Sichuan Province and the Huai River Water Pollution Control Project in Anhui and Shandong Provinces. In 2002, he is working on a third World Bank water and sanitation project in China, the Zhejiang Environment Project in Hangzhou.

PROFESSIONAL INTERESTS

Water and Environmental Decision Support Systems, Water Resource and Water Quality Planning and Modeling, Multi-Media Pollutant Assessment and Control, Pollution Prevention and Waste Minimization, Sustainable Infrastructure Development Projects, Environmental Analysis and Information Systems, Sustainable Water Resource Systems, Integrated Planning and Emerging / Appropriate Technology

PUBLICATIONS AND AWARDS

Quinn,L., "Wyoming Environment - 1974 and Beyond," WICHE internship and published by the Wyoming Department of Environmental Quality, September 1974.

National Grand Award, Planning, 1982. American Consulting Engineers Council. "Salinity Investigation of the Glenwood-Dotsero Springs Unit"

Balloffet, A.F. and Quinn, L. "A Basin-wide Planning Approach for the Assessment of Water Quality Impacts Associated with Toxic and Hazardous (THS) Discharges," Regional Seminar on "Towards a Productive and Stable Ecosystem," Philippine Natural Science Society, Los Banos, Philippines, December 1989.

Quinn, L., "Sustainable Industrial Development and Environmental Pollution: The Tradeoffs," presented at the North American Regional Conference of the Society for International Development, Fort Collins, Colorado, October 1993.

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Quinn, L., "Environmental Economics and Natural Resource Management in Developing Countries" presented at the American Geophysics Union Conference, Fort Collins, Colorado, February 1995.

Quinn, L., "Development and Use of Environmental Indicators in Water Quality Management", at the American Institute of Hydrology meeting in Denver, Colorado in May of 1995.

Quinn, L., "Appropriate Sanitation Technology Advisor: A Planner's Tool In Less Developed Countries," ASCE North American Water Congress '96, Anaheim CA, June 1996.

Quinn, L., "A System to Improve The Water-Related Sustainability Characteristics of International Development Projects," ASCE North American Water Congress '96, Anaheim CA, June 1996.

Quinn, L., "Planning for the Restoration of Polluted Rivers in Sichuan Province, China," ASCE Wetlands and River Restoration Conference, Denver, Colorado, March 1998.

PROFESSIONAL AFFILIATIONS

American Society of Civil Engineers — Water Environment Federation

Society for International Development — Consulting Engineers Council

SELECTED COMPUTER CAPABILITIES

A variety of technical programs involving Water Resources Management, Water Quality and Toxics, Wastewater Treatment Facility Costs/Statistics, Air Quality and Noise. Other capabilities include CAD, GIS, word processing, spreadsheets, data bases, optimization, and other programs.

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DEDICATION

To my wife Dr. Linda Backup, my son Andrew Quinn and my daughter Meghan Quinn for their loving support through the many years of toiling over this document. They dealt with my six months of absences working in the Sichuan Province of China, and they also made a trip to Sichuan Province to view the project areas first-hand. My family provided me with the love and inspiration necessary to complete this task at an "experienced" age, and I could not have completed this effort without them. I can only hope that they realize that they are much more important to me than any project or university research effort.

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7. **SUEP Case Study**
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9. **Literature Summary**

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LIST OF ACRONYMS

AAES	American Association of Engineering Societies
ADB	Asian Development Bank
CBA	Cost-Benefit Analysis
CERF	Civil Engineering Research Foundation
CIDIE	Committee of International Institutions of the Environment
DO	Dissolved Oxygen
DSS	Decision Support Systems
EA	Environmental Assessment
EIA	Environmental Impact Assessment
EMP	Environmental Management Plan
EMS(s)	Environmental Management System(s)
EPA	Environmental Protection Agency (United States)
ESD	Environmentally Sustainable Development
EU	European Commission
GAP	A 'Gap' defines the difference between the existing condition and ideal ISO 14001 EMS compliance
GATT	General Agreement on Tariffs and Trade
GDP	Gross Domestic (Or National) Product
GIS	Geographic Information Systems
ICR	Implementation Completion Report
ICWE	International Conference on Water and the Environment

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IPDP	Indigenous Peoples Development Plan
IISD	International Institute for Sustainable Development
IMF	International Monetary Fund
IRR	Internal Rate Of Return
ISO	International Organization for Standardization
IUCN	The World Conservation Union
IWG	Interagency Working Group (United States, on Sustainability Indicators)
LEIA	Life-Cycle EIA
MCA	Multi-Criteria Assessment
NAE	National Academy of Engineering
NEAPs	National Environmental Action Plans
NEFs	National Environmental Funds
NRA	Natural Resources Accounting
ODSS	Organizational Decision Support System
OECD	Organization for Economic Cooperation and Development
PAD	Project Appraisal Document
PCD	Project Concept Document
PSR	Project Supervision Report
RAP	Resettlement Action Plan
RBPI	River Basin Pollution Index (SUEP)
REAs	Regional Environmental Assessments
SAGE	Strategic Advisory Group on the Environment (ISO)
SEA	Sectoral EA

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SIA	Social Impact Assessment
SNA	System of National Accounts
SOE	State-Owned Enterprises
SOx	Sulfur Oxides
SUEP	Sichuan Urban Environment Project
TC 207	ISO's Technical Committee 207
UN	United Nations
UNCED	United Nations Conference on Environment and Development
UNDP	United Nations Development Program
UNEP	United Nations Environment Program
UNIDO	United Nations Industrial Development Organization
UPIA	Urban Pollution Impacts Assessment (SUEP)
WB	World Bank
WCED	World Commission on Environment and Development
WEPSD	World Engineering Partnership for Sustainable Development
WwTW	Wastewater Treatment Works

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USING ISO14001 GAPS ANALYSES TO IMPROVE SUSTAINABILITY OF WATER PROGRAMS AND PROJECTS

1.0 INTRODUCTION

1.1 Statement Of The Problem

International water resources management programs and projects (hereafter, projects) historically have sometimes failed to meet increasingly complex societal demands and multiple objectives. The international agencies, banks and national governments have detailed project review criteria, but such reviews often have been narrowly focused. There are few systems in place that assist with formulating, assessing, implementing and monitoring these international projects in an integrated fashion, directed toward the goal of water resource sustainability. In addition, water resource needs and potential solutions often are poorly communicated to an increasingly involved general public. Projects are also being assessed for 'environmental due diligence' by the project proponents, but without a comprehensive system or procedure.

The stated or implicit goal of development programs and projects related to water resource issues is the provision of "sustainable" water resource development for the area under consideration. Sustainability includes a variety of social, economic, environmental and financial considerations, blended according to the demands of the institutions and decision-makers. Categorical evaluations of criteria relative to "sustainability" are addressed by a cadre of specialists (e.g. such as engineers, economists, ecologists, sociologists, etc.) in their particular disciplines, with minimal effort toward integrated or systematic review

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methodologies. Sustainability criteria are in their infancy, are debated widely, and will likely take many years to fully mature (ASCE/UNESCO, 1998, USACOE, 1999). Sustainability indicators are being developed by the international banks and aid agencies, but remain rather cursory and are rarely used at the project level (OECD, 2000). In addition, the life-line of these projects is often many years, and the ability to consistently improve the sustainability characteristics of these programs and projects over time has not greatly advanced.

Water resource projects of various types (e.g. such as water and sanitation, irrigation, reservoirs, flood protection, hydroelectric power, industrial water supply, etc.) have historically evolved through a blend of economic analyses and political factors. In many cases, planning is done simply to justify decisions reached in a purely political process under predetermined courses of action (Balloffet, 1992). Environmental issues have become more important in the review process, but have not readily been integrated into overall project development, except for more or less site-specific environmental assessment (EA) concerns (World Bank, 1994b).

Both inside and outside of the water sector, there is confusion over the relationship between economic development plans, national water plans, regional and basin plans, and projects. The general public and affected stakeholders many times cannot trace the rationale or linkage of these plans with overall national, regional and local goals (for water or economic development). In addition, the project development formulation has struggled with synthesizing water quantity and quality goals.

The "sustainability" of water is couched in the broad context of overall natural resource issues, and sustainability that has been a goal of the international community over the past couple of decades. This international goal of "environmentally sustainable

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development" (ESD) has been evolving since the Brundtland Report of 1987 (WCED, 1987). ESD involves multi-faceted and multi-disciplinary concerns, as well as significant uncertainty in time, locational scale and dimensions. The process is ongoing and ESD will take years to clarify and decades to implement.

Awareness of the significance of water for human well-being, for virtually any development activity and its relation to environmental problems, has come gradually and partially. At the Stockholm Conference on the Environment in 1972, water was given a low profile. In 1977, the first UN Conference on Water in Mar del Plata, Argentina, marked a concern for water issues. In the Brundtland Report, the role of fresh water is largely ignored.

The International Conference on Water and the Environment (ICWE) held in Dublin, Ireland and the United Nations Conference on Environment and Development (UNCED) held in 1992 both put water more firmly on the agenda. However, water continued to be dealt with in a variety of economic sectors, ignoring the linkages between quantity and quality planning, and the need for time-based integrated planning (World Bank, 1993b). There are few direct tools in place for water resource decision-makers to use in addressing the "projects" relative to national and international sustainability goals.

Water has not been a non-issue, especially in terms of investments and public concern. Significant investments were made in irrigation systems by national and international governments and banks since the 1960s, and the 1980s were earmarked as the International Drinking Water and Sanitation Decade, which could be seen as the most tangible outcome of the Mar del Plata meeting. A significant feature of the policies that formed the background to these developments was a lack of a realistic and proper perception of water as a finite, mobile and vulnerable resource. The Water and Sanitation Decade ended

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without meeting most of the defined goals that had been set by the international community (UN, 1992b). In many areas of the world, the per capita supply of fresh water is actually declining due to population increases, and sanitation remains a serious problem.

Water policies have focused on the task of augmenting supply, and formulated from pressing social issues. Irrigation has helped to alleviate mass hunger and famine. Improved water supply to households promised the reduction of human suffering from disease and premature deaths, and lessening the drudgery of water fetching. From these views, activities in the water sector have been commendable, and progress has been made. When one compares the costs and efforts expended, performance is not undisputed. Health improvements are much less than initially expected, and many of the irrigation schemes built during recent decades are beset with well-known problems of low efficiency and environmental consequences in terms of salinization, waterlogging, etc. (Baum and Tolbert, 1987). In addition, the negative water quality and ecosystem impacts have been severe (World Bank, 2001). These failures in the water sector have fueled a growing skepticism in the general public and reiterate the need for better education and training, as well as communicating water resource needs and potential solutions to the general public.

Apart from poor overall performance, there are other circumstances indicating that prevailing strategies for water management need revision. A concern for management of water resources under increasing scarcity and societal stress, including financial constraints and with due consideration to the functioning of ecosystems, is a key challenge. Many countries are currently in the process of formulating comprehensive frameworks for water resources management (World Bank, 2001). These efforts are supported by major international organizations. The World Bank, for instance, issued a comprehensive policy

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paper where its objectives for the water sector were specified (World Bank, 1993b). Corresponding activities are found in many international agencies, multi-lateral banks and bi-lateral aid agencies. However, water resource projects continue to be developed and implemented under a "pipeline" that sometimes seems disconnected from these integrated and comprehensive planning objectives.

The ICWE (1992) Dublin Statement and the UNCED Agenda 21 action plan (UN, 1992b) provided the international community with definitive targets for water resources and water quality and recommendations for integrated water resources and water quality planning. By themselves, the Dublin Statement and Agenda 21 did not provide for "sustainable" water resources, but they have set in motion planning mechanisms and interim targets which directs water planning toward sustainability. Many of these targets were not met for the year 2000, and are currently under review by national governments and international aid organizations relative to a new set of achievable targets (World Bank, 2001). There is a growing need to assess proposed international development programs and projects that impact regional water resources from a broader perspective, beyond merely attempting to link quantity and quality in "regional" or "watershed-based" approaches.

Although ESD is the goal of many international agencies and national governments, it is a concept that is very difficult to quantify in terms agreeable to the various disciplines connected with it. National Environmental Action Plans (NEAPs) are being implemented in many areas in an attempt to define national priorities with an eye toward integration of economic, social and environmental objectives. These NEAPs have been slow to develop, have difficulty in translating national goals into regions or sectors, and rarely are carried forward to the individual project level.

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One of the most overriding issues that emerges in any review of water resources and sustainability is the full involvement of all stakeholders including the general public and full disclosure of information. However, the various stakeholders and disciplines involved in most water resource projects somewhat speak "different languages or perspectives" that is often incomprehensible and/or unclear to the general public (World Resources, 1995). Many of the conflicts that emerge over water projects involve incomplete, unclear, or poorly developed information that foster distrust and conflict. An integrated set of EMSs could serve another key role in "de-mystifying" the project development and review process, while nurturing the open-ness and full disclosure goals of the international community. Conflicts will not necessarily be prevented, but they can hopefully move the conflict into areas of goals and technical issues, rather than disagreeing on the information base and decision-making process.

The modern era of assessing economic progress began in the late 1940s when systems of national accounts and the annual calculation of gross domestic (or national) product (GDP or GNP) were introduced. These measures were designed to allow national governments to track the flow of goods and services in the economy through a calculation of national income. In time, the ease by which the simple numbers could be communicated, their usage in many countries, and the appeal of comparative assessment led to the popularization of GDP/GNP as an indicator of the overall well-being of a given nation.

Over the past half-century, many have spoken out against this practice. In 1987, the Brundtland Commission added its voice to the appeal for new ways of measuring progress that would go beyond economic signals and capture a fuller sense of human and ecological well-being. This lay at the heart of the idea of sustainable development and its recognition

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that a shift in the nature of human activities was required if life for future generations was to be as rich as that found currently. In 1992, The Earth Summit in Rio de Janeiro, Brazil, echoed this same message in Agenda 21. There is a widespread international concern with establishing a means to monitor performance and to assess progress toward sustainable development (World Bank, 2001).

There is a clear link to "results-based management" and associated reporting, whether the scale is a local project, a corporate enterprise, or a large political jurisdiction. Faced with growing demands that expenditures of increasingly limited resources be both well directed and monitored in terms of success, decision-makers are actively pursuing systems for ensuring accountability.

Although many have offered lists of indicators that would supplement the GDP in an overall assessment of progress, consensus has not emerged. Many question whether or not a common list is even possible, given the wide variety of natural conditions and the differences in values apparent from place-to-place.

Development means to expand (or realize the potentialities of) gradually to a fuller, greater, or better state. It has both qualitative and quantitative characteristics and is to be differentiated from growth, which applies to a quantitative increase in physical dimensions. Sustainable development is not a "fixed state of harmony." Rather, it is an ongoing process of evolution in which people take actions leading to development that meets their current needs without compromising the ability of future generations to meet their own needs. Conversely, actions that reduce the ability of future generations to meet their own needs should be avoided. The concept of sustainable development is value-based. The design of a sustainable world, or the choice and degree to which "certain features" are to be sustained,

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will depend on the operating set of values, values which will shift over time and will vary within communities and from place to place. Development projects flow through a definitive "project cycle" defined by international agencies and lending institutions.

The lack of international consensus relative to sustainability criteria and indicators need not distract decision-makers in the water resources fields from pursuing systematic approaches to developing, analyzing, and implementing sustainable water resource development programs and projects. Water resource development organizations are seeking practical tools to enable them to manage the impact of their activities on the environment while maximizing their water resources objectives.

The International Organization for Standardization (ISO) has formulated the ISO 14000 series of standards to improve environmental performance of an organization. ISO 14000 is a series of standards and guidance documents that falls into two broad categories. The first category is ISO 14001 is Environmental Management Systems (EMSs), comprising the following three standards plus an overall guidance document:

- ISO14000, Guidance on How to Set Up and Improve an EMS
- ISO14001, EMS Specification Standard for Registration Purposes
- ISO14010-12, Auditing Principles and Procedures for Internal/External Auditors
- ISO14031, Guidance on Measuring Environmental Performance

The first series of EMS standards provide the "core" requirements for developing and implementing Environmental Management Systems (EMSs) that can be "certified" or registered by an external third party. The second category of standards is more operationally focused in areas of product stewardship. Two standards are under development and initial use, one sets governing methodology for life-cycle assessment (ISO14041-44) and

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a second governing labeling principles (ISO14020-24). An EMS is that aspect of an organization's overall management structure that addresses the immediate and long-term impact that its products, services and operations have on the environment. By implementing an EMS, the entity is able to anticipate and meet growing environmental expectations and to ensure ongoing compliance with national and international requirements.

The use of ISO14001 protocols has been advancing rapidly in the private sector during the past five years, and there appears to be some interest in moving these concepts into the public sector. As will be seen in the literature review, some public sector entities are investigating the use of these protocols, but there does not appear to be any current application of the protocols to project development and assessment.

EMSs are being developed by a variety of public and private sector organizations to assess environmental performance. There is no systematic and integrated set of EMSs related to water resource development programs and projects in place to allow them to be continuously "steered" toward sustainability from formulation to implementation stages of their development. Perhaps this research effort will initiate the development of such protocols and processes.

1.2 Hypothesis and Approach

The hypothesis of this research was that so-called ISO14001 gaps analyses (a gap defines the difference between the existing condition and ideal EMS compliance), using water-related EMSs, could improve the economic/environmental performance and sustainability of projects addressing or affecting regional or national water resources at

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various stages of project development including formulation, design, review and implementation.

A framework of EMSs, using ISO 14001 methodologies and protocols, could assist water resource managers and decision makers with improving the sustainability characteristics of their projects at various stages of the project development cycle. The results of the EMS gaps analyses could provide a significant tool for demonstrating environmental due diligence and for communicating the results of project reviews to the general public.

EMSs could provide a standardized protocol or "umbrella" methodology for the various disciplines involved in project reviews. The use of a set of phased EMSs from project formulation through implementation could allow environmental and sustainability issues to be addressed in a much broader basis that extends throughout the project cycle. EMSs could provide a convenient mechanism to array a variety of environmental and economic factors under one protocol, with ongoing methodologies developed for assessing the results of the EMS audits and trade-off analyses. EMSs could also provide a platform for the development of environmental and sustainability indicators and assist in their maturing process.

1.2.1 Purpose

The development of a set of comprehensive EMSs that can be applied to various types of water-related projects (and projects in other sectors affecting water resources) is a daunting challenge. Such an effort could likely be undertaken by organizations such as the World Bank or United Nations agencies under global environmental project funding. This

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research is intended to provide a set of evaluative criteria for use in an EMS "gaps" analyses for water resources projects, as outlined in the international standards for an ISO 14001 audit of an enterprise (Voorhees and Woellner, 1998).

1.2.2 Objectives

To foster these international efforts, the objectives of this research were to:

1. Outline the various multi-dimensional criteria that affect the sustainability of international water-related development projects,
2. Determine where and how ISO14001 reviews in the standard project cycle could assist with improving the sustainability of water-related development projects,
3. Develop some representative water-related EMSs for use in standard ISO14001 gaps analyses at various stages of project development and implementation, and
4. Demonstrate the potential application of these EMSs and gaps analyses on a large World Bank water and sanitation project.

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2.0 LITERATURE REVIEW

A detailed Literature Summary has been included as Appendix 9 in this dissertation, with the important aspects to this research summarized in this chapter.

2.1 Environmentally Sustainable Development

The United Nations World Commission on Environment and Development defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). The American Association of Engineering Societies (AAES) and the World Engineering Partnership for Sustainable Development (WEPSD) jointly published "The Role of Engineering in Sustainable Development" (AAES/WEPSD, 1994).

The Civil Engineering Research Foundation (CERF, 1996 published "Engineering and Construction for Sustainable Development in the 21st Century: Assessing Global Research Needs." This report indicated that only through continued and accelerated development would the quality of life be improved for the growing world population. CERF (1996) called for translating general philosophical statements into objectives and criteria for design decision-making.

The Stockholm Environment Institute in 1993 (Gleick, 1993) prepared a cogent overview of the status of the world's freshwater resources. Gleick (1993) pointed out that the key to peaceful solutions of disputes over shared water resources is continued communication between the states concerned, preferably on the technical level, over everything from hydrologic and meteorological data to basin-wide development plans.

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To arrive at an integrated concept of land and water conservation and management, an appropriate philosophical underpinning should be developed. The present concept of "environment" is usually used to describe that which surrounds a central object (Lundkvist and Falkenmark, 1997). Talk about environment typically focuses on local scales, and often excludes the role of humans. The concept of the landscape focuses on the mesoscale surroundings of all those living the humans as well as other species. The landscape concept may be better adapted for the inter-professional, inter-sectoral, and interdisciplinary dialogue needed to integrate land and water management."

Whipple (1996) indicated that it is clear that the more important aspects of planning and decision making for water resources and associated land areas should be comprehensive, in that key economic and environmental objectives should all be considered. Water quality criteria are based on considerations of both human health and ecological damage (whichever requirement calls for the stricter criteria). Whipple (1996) indicated that it is important to realize that the environment affected by water resources development is only one of a number of national objectives.

According to Environmental Economics and Natural Resource Management in Developing Countries (World Bank, 1993c), specific elements of environmental concerns need to be considered for integration in the project cycle adopted by development assistance organizations and governmental/non-governmental institutions

The World Bank (1993c) states that the environmental analysis should be designed to achieve the greatest present benefit possible from the use of natural resources without reducing their potential to meet future needs and the carrying capacity of the environment. A more comprehensive approach is needed than project-by-project analysis. A project level

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EIA should be performed and linked to the CBA at the earliest stage of project development and it should be a natural extension of previous sectoral level EIAs. The Asia Technical Department of the World Bank (1994g) indicated that a program of regular monitoring of environmental quality is essential. Miller (Third World, 1995) addresses such environmental solutions in various levels (Global, Regional, National and Local).

Chapter 40 of Agenda 21 (UN, 1992a) dealt with environmental information and decision-making. It was noted that in sustainable development, everyone is a user and/or provider of information (data, information, appropriately packaged experience and knowledge) in the broad sense. Holmberg (1992) indicated that one important consequence of a shift in rights and responsibilities from central government to the local level should be an improvement in the management of resources - human, physical and financial. But for the system to work in this way, a local community must be able to obtain decision-making power over its own affairs. For this infrastructure to be effective, three essential requirements must be borne in mind - Transparency, Accountability, and Freedom of information.

In 1994, the IUCN provided background into the range of principles or approaches to sustainable development are now being expressed more frequently in international agreements and domestic legislation (Carew-Reid et al, 1994). In 1995, the World Bank (1995a) listed "Ten Hallmarks of the New Environmentalism." The Asian Development Bank (1990a) found that structural adjustment policies in a number of countries in its region might have led to environmental degradation. National sustainable development strategies provide an opportunity to expose inequities and imbalances that result from economic policies and past trading relationships among countries.

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There have been a wide variety of efforts to develop sustainability reviews through the use of Decision Support Systems (DSS) with varying success. Thierauf (1988) indicates that an important part of user-oriented DSS is the capability of the user not only to solve problems in a traditional manner, by using the problem-solving process, but also to engage in problem finding. The main thrust of problem finding is looking into the future and identifying problems that should be solved now.

DSS are fundamentally systems designed to support the decisions of managers and some operating personnel. They can be defined as an approach to effective decision-making involving an interface between the individual and the computer, from problem formulation to solution. The capability of combining subjectivity (individual judgment) and objectivity (computer output) permits a more thorough examination of the problem.

Giaoutzi and Nijkamp (1993) presented an overview of the use of DSS and Geographic Information Systems (GIS) in a case study of sustainability in the Greek Sporades Islands. System theory offers a fruitful background and frame of reference for assessing various effects in a compound spatial economic and environmental system. In the Giaoutzi and Nijkamp (1993) study, they used the adjusted system's approach developed by Passet in 1979, as this seemed to provide an appropriate approach to environmental issues. Passet distinguished three subsystems - viz. economic, human and natural.

According to the founder of systems theory (Bertalanffy, 1975), a system can be defined as a group of elements with mutual relations. Subgroups of the elements may form subsystems in the largest system, provided there is a relationship between the elements of these subgroups (the connectivity condition). Dynamic systems analysis seeks to analyze (i.e., describe and predict) the driving forces and their interdependence

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in a relevant system. Shepherd and Ortolano (1996) outlined a concept called a critiquing expert system. Such a system was designed to improve the planning and analysis of water resource management systems, including design and operations. *A critiquing expert system fits the template of ISO14001 gaps analyses.*

Another similar concept and approach was addressed by the National Academy of Engineering in 1994, in a book entitled "The Greening of Industrial Ecosystems" (NAE, 1994). This book addressed a concept entitled industrial ecology, based on a unique systems approach within which environmental issues could be comprehensively addressed. It was based on an analogy of industrial systems to natural ecological systems.

One of the most cogent and relevant references to project appraisal is a book entitled "Ecological Sustainability and Project Appraisal" by Michael van Pelt (1993). He indicated that there is a consensus that the sustainability concept emphasizes:

a) Long-term perspective, particularly a concern for future generations, and
b) Two-way interrelationships between socio-economic and environmental variables, which leads to
c) View that limits should be imposed on the use of natural resources in production and consumption processes.

Like Munasinghe (World Bank, 1993c), van Pelt (1993) was in favor of considering cost-benefit analysis (CBA) and multi-criteria analysis (MCA) as potentially complementary appraisal tools. The approach would apply MCA to two criteria: the outcomes of a partial CBA, and the non-monetary environmental impacts.

According to Trzyna (1995), a review of sustainable development issues by the IUCN resulted in the following conclusions and challenges, with notes by the author:

1. Sustainable development requires cutting across many professions and disciplines, and this cross-cutting is a strength and a weakness; how can we break down the barriers between them?

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EMSs can be used under a variety of criteria from many professions and disciplines.

2. Among other things sustainable development is a social and political process and the ultimate challenge is not a scientific or technical one, but one that requires changing human behavior; what works?

EMSs can deal with social and political issues, as well as help to build a case history of successes and failures.

3. Above all, sustainable development is a moral principle, not so much about what is but what should be; how can we build it into decision-making?

EMSs can provide a convenient and internationally standardized protocol for assessing proposed projects for sustainability concerns.

The World Bank (2001) recently published a summary of their current strategy for environmental protection. The Bank indicated that EA is only one element of a larger environmental management system used by the Bank and its borrowers to both "do no harm" and promote good environmental management. This reference can be considered the most recent international reference on the connection of projects and sustainability, and it is discussed in more detail later.

2.2 Sustainable Water Resources

The protection and sustainable management of freshwater resources require an ecosystem approach and an adequate knowledge and appraisal of linkages with environmental and social economic issues. First, there is a need to understand the nature and bio-geographical implications of freshwater resources at the global, regional and local levels. Second there is a need to recognize the cause-effect relationships between the environmental issues and the development (UN, 1992b).

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The use of systems analysis techniques, with national master water plans, finds solutions that can achieve optimum social and economic benefits while observing a series of conditions (UN, 1992b). To achieve sustainable development and environmentally sound management of water resources in urban areas, greater attention should be paid to the formulation and implementation of a national policy, the general objectives of which are (UN, 1993):

1) To ensure on a sustainable basis adequate water supplies for present and future needs of urban users;
2) To prevent water pollution and to reverse current trends of water resources degradation and depletion.

Most societies have managed water resources as if the biological systems associated were indeed incidental to society. Davis and Simon (1995) described five realities that point to a need to change this view.

Some of the well-recognized problems in international water management have already been addressed. The World Bank Integrated Water Policy seeks to balance two fundamental considerations (World Bank, 1993b):

1) The need for a holistic management approach that gives due weight to longer-term factors and to protecting the ecosystems.
2) The advantages of relying more on markets and pricing to improve the allocation of water among competing users.

The Principles and Standards (P&S) published in the Federal Register in 1973 emphasized the need to balance the pros and cons of water resources development alternatives and stated two objectives for water resources planning (USACOE, 1999). The goals were (1) to enhance national economic development by increasing the value of the nation's output of goods and services and improving national economic efficiency, and (2) to enhance the quality of the environment by management, conservation,

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preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems. A number of changes were made to the P&S in 1980 and in 1983 the P&S were replaced with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). The US Principles and Standards could be updated to include sustainability concerns and be translated into international practice (USACOE, 1999). *The ISO14000 system essentially accomplishes this for multi-media environmental assets.*

To meet the requirements of environmentally sound, sustainable development and management of water resources, the water policy should promote a multi-sectoral and multidisciplinary approach to integrated water resources planning and management that optimizes the interests of environmental protection and sustainable socio-economic development (United Nations, 1997a). In the Asia-Pacific region, four main issues were identified for priority attention (United Nations, 1997b). *These Asian priorities are directly relevant to the enclosed case study on the Sichuan Province of China.*

A Task Committee on Sustainability Criteria of the Water Resources Planning and Management Division of ASCE and the Working Group of UNESCO/IHP Project M-4.3 published "Sustainability Criteria for Water Resource Systems" in 1998 (ASCE/UNESCO 1998). Sustainable water resource systems are those designed and operated in ways that make them more adaptive, robust, and resilient to these uncertain changes. Sustainable water resource systems are "water resource systems designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity."

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In 1999, the US Army Corps of Engineers released "Sustainable Development: Concepts, Goals and Relevance to the Civil Works Program." (USACOE, 1999) This report was produced partially in response to the President's Council on Sustainable Development (PCSD) report, "Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future" in February 1996. The PCSD report highlighted a triad of economic prosperity, environmental health and social well-being and equity.

In the European Commission (EU, 2000), the major issue consists in recreating a culture which involves managing water as an irregular and scarce resource, in which the scarcity is determined not only by physical reasons, but also by socioeconomic and ecological costs. In principle, the decisions related to resources management should be 'economically efficient, politically feasible, territorially equitable and socially acceptable.' In accordance with the criteria of sustainability, the new institutional management mechanisms should encompass a combination of regulatory means and market instruments, designed to introduce 'scarcity indicators' as incentives to water savings (EU, 2000).

The EC (2000) promulgated Framework for Community Action in the Field of Water Policy in October of 2000. The purpose of this Directive was to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater.

2.3 Project Formulation

The International Conference on Water and the Environment, held in Dublin, Ireland, in January 1992, was the most all-embracing conference dealing with global water

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management issues since the United Nations Water Conference held in Mar del Plata, Argentina in 1977. The United Nations Conference on the Environment and Development (UNCED) held in 1992 in Rio de Janeiro attempted to forge new global strategies that both the "north" and the "south" could embrace. The main product that emanated from the conference regarding development and pollution control was Agenda 21, a blueprint for action into the 21st century (UN, 1992b).

The Dublin Conference and Agenda 21 provided a wide array of definable goals and objectives for water resources and water quality. **Appendix 1** contains a detailed summary of these water-related goals and objectives. An Earth Summit Plus 10 conference is now being planned for 2002 in South Africa. Many of the Agenda 21 goals and objectives have not been met and new achievable targets will be a main focus of the new conference. In implementing the 1993 Bank policy for managing water resources (World Bank 1993b), Bank support is continuing to shift toward four imperatives:

1. Support a comprehensive view of water management issues.
2. Emphasize improvement of the efficiency of existing irrigation systems before creating new ones.
3. Encourage decentralization and local management of water resources.
4. Impose charges for using water that reflect its value as a scarce resource.

The World Bank has worked hard to add to understanding of how to manage development projects. "Investing in Development" (Baum and Tolbert, 1987) reviewed the Bank's experience between 1945 and 1985. Their conclusions were generally in agreement with those of Jon Moris in 1981 who comprehensively reviewed the challenges presented by Third World development programs and drew on an extensive literature review to distill some general tactics and principles for effective program development.

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Carter et al (1992) introduced a concept called "organizational decision support system (ODSS)," which is a decision-support system (DSS) that is used by individuals or groups at several locations in more than one organizational unit who make varied (interrelated but autonomous) decisions using a common set of tools. An ODSS is designed to coordinate and disseminate decision-making across functional areas and hierarchical levels such that the decisions are congruent with organizational goals (Carter et al, 1992). The performance of an organization can be enhanced if its decision-makers share common data and models. An ODSS facilitates such sharing, thereby providing a means for communication and coordination among personnel at the same or different levels in the same organizational unit, and at the same or different levels across organizational boundaries. As soon as a decision is made, the database is updated and the latest information can begin to be used immediately by others in the organization. This helps to integrate and unify an organization, and improves control and consistency. It also improves the efficiency and effectiveness of organizational decision-making (in addition to individual decision-making) (Carter et al, 1992).

Choosing a single criterion for an ODSS can be a difficult problem in situations with multiple conflicting objectives, costs that cannot easily be translated into dollars, and benefits that are difficult to quantify. Such inherent conflicts appear in many complicated decision situations. Various ways have been developed to handle multiple objectives in a prescriptive model (Carter et al, 1992):

- Define the objective function to be a weighted sum of each of the individual criteria. It is difficult to determine what the appropriate weights are - especially since they will change with changes in the environment. On the other hand, this can be a useful technique when the user is free to vary the weights. Then the user can try out different weights and see how far they can go in accomplishing each goal or goals.

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- Order the criteria according to organizational preferences, then optimize in sequence. This is known as preemptive goal programming.
- Establish a specific numeric goal for each criterion, formulate an objective function for each criterion, and then seek a solution that minimizes the sum of deviations of these objective functions from their respective goals. This is known as non-preemptive goal programming.
- Obtain agreement about the minimum acceptable level of attainment of all except the most important of the criteria and then use these minimum levels as constraints while optimizing the remaining most important criterion.

The ISO 14001 gaps analysis can be considered an ODSS since there are definitely multiple objectives in play. However, the selection of weighing systems, goal programming, or other techniques for assessing the results of the gaps analysis has been left to the later phase of moving the technique into the mainstream. The various agencies who might be candidates to use this system will all have pre-conceived notions on this subject, as well as differing stakeholders that will have to be satisfied.

The World Bank (2001) recently published a summary of their current strategy for environmental protection. The Bank indicated that the world is experiencing a systemic crisis as a result of unsustainable use and management of water resources. A rapidly increasing population is exacerbating the traditional problems of providing water supply and sanitation services. The Bank indicates that environmental sustainability is a fundamental element of sound water resource management. The integration of environmental objectives remains an important challenge in the water policy reform and management process. The lack of clear environmental sustainability criteria for the water sector, capacity constraints, and lack of commitment to follow through with politically difficult decisions hinder the effective integration of environmental issues in water projects.

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2.4 Technical and Economic Assessment

Baum and Tolbert (1987), in their review of several decades of World Bank experience, define a project as 'a discrete package of investments, policy measures, and institutional and other actions designed to achieve a specific development objective (or set of objectives) within a designated period'. It may be useful to emphasize that projects usually refer to packages of activities that are implemented at the micro level, as opposed to the sector, regional or national level. Project appraisal or feasibility study is an important stage in the evolution of a project. It is important to consider alternatives, identify and assess risks, at a time when data are uncertain or unavailable. The individual project, however significant and potentially beneficial to the promoting organization, will only constitute part of corporate business.

According to Engineering Project Management (N. J. Smith, 1995), the life cycle of the project splits into three major phases: appraisal and implementation of the project followed by operation of the completed facility. In the public sector, appraisal may extend over many years and be subjected to several intermediate decisions to proceed. In the economic literature on developing countries, project appraisal is often regarded as synonymous with cost-benefit analysis. However, project appraisal involves a systematic analysis of the extent to which a project contributes to a set of development objectives, taking account of different priorities that may be assigned to these objectives as well as the scarcity of resources that would be used in the implementation of the project.

Appropriate technology should be able to satisfy the requirements for fitness for purpose in the particular environment in which it is to be used. It should also be maintainable using local resources, and it should be affordable. Many would argue that

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all technology should be appropriate, and perhaps therefore it is intermediate technology that we should be focusing our attention upon (Smith, 1995).

Market failure exists when markets fail to reflect fully environmental values (Barbier et al, 1989). This can also be interpreted as directly related to project assessments affecting these markets. The presence of open-access resource exploitation, public environmental goods, externalities, incomplete information and markets, and imperfect competition all contribute to market failure. Policy failure occurs when the public policies required to correct for market failure over or under-correct for the problem. It also occurs when government decisions or policies, in areas where there are no market failures, are themselves responsible for excessive environmental degradation. Market and policy failures lead to a distortion of economic incentives (Barbier et al, 1989). That is, the private costs of activities that result in environmental degradation (e.g. problem projects) do not reflect the social cost of that damage, in terms of environmental values foregone. The failure to take account of these social costs may result in excessive levels of environmental degradation.

There has been a significant effort in the field of environmental economics to incorporate environmental considerations into standard economic analyses and project evaluations. The efforts range from broadened and strengthened EIA procedures to national environmental accounts similar to national economic accounts. The concept of "environmental capital depletion" has been emerging as a method of tracking the sustainability of policies and projects (Barbier et al, 1989).

As pointed out by the authors of the classic United Nations Industrial Development Organization Guidelines (Dasgupta, et al, 1972), the main rationale for conducting social cost-benefit analysis is 'to subject project choice to a consistent set of general objectives of

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national policy. Introducing environmental considerations further complicates the picture. As Markandya and Pearce (1988) observed, natural resources are more likely to be over-exploited at high discount rates than at low ones, but, at the same time, consistent use of low discount rates can lead to greater levels of investment in projects which degrade the environment. Given the additional problems posed by environmental risk and irreversible impacts, the authors concluded that it is generally preferable to adjust project costs and benefits and adopt additional sustainability criteria, rather than to adjust the discount rate.

Efforts to undertake resource accounting are part of the larger initiative to design economic policies that can balance economic efficiency with the need to correct problems of environmental degradation in developing countries. This agenda has two primary components (World Bank, 1993c):

1. Design of investment programs supporting environmental and natural resource objectives; and
2. Promotion of economic, social and institutional policies and incentives that influence the behavior of government agencies, major resource users and countless small-scale resource-using activities which occur throughout a nation's economy.

In January of 1992, the Committee of International Institutions of the Environment (CIDIE) organized a conference to discuss emerging techniques for incorporating environmental considerations into natural resource management decisions (World Bank, 1993c). CIDIE indicated that there is a growing need to incorporate environmental concerns into projects and that a consensus must be arrived at on the appropriate application of economic instruments for environmental management and protection.

The appraisal of projects in developing countries has received much attention in the 1970s and 1980s, strongly stimulated by the emphasis on projects in aid programs of multilateral and bilateral donor agencies. Economic appraisal of projects has focused on

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allocative efficiency: how to maximize aggregate welfare, given available resources. CBA has been routinely been applied by many aid agencies and governments of developing countries. They tend to use a special CBA version that differs in several respects from traditional CBA, as applied in the developed world.

Social CBA has appeared to be an inappropriate tool to assess efficiency and equity simultaneously due to conceptual and empirical reasons. From a purely theoretical viewpoint it may therefore be of interest to explore possibilities to expand social CBA by incorporating sustainability concerns as well. If poverty is considered an important cause of environmental degradation, project benefits accruing to the poor could be valued even higher than in traditional social CBA. Investments in environmentally sound practices might be valued higher than investments in unsustainable practices (van Pelt, 1993).

The World Bank (2001) recently published a summary of their current strategy for environmental protection. The Bank indicated that addressing environmental priorities that affect the long-term sustainability of development requires a proactive approach to find and implement cost-effective solutions through investment projects and addressing key policy issues through projects and programs. Some of the key strategies mentioned were:

- Improving the design and performance of environmental projects and components.
- Improving the use of project-level indicators.
- Coordinating investments and policy reforms.
- Applying a location-specific focus.
- Supporting capacity development.
- Enhancing the environmental outcome of adjustment lending.

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2.5 Enhanced Environmental Impact Assessment

Initially resisted by many in the project community, the Environmental Impact Assessment (EIA) process allows consultation and dialogue between developers, the community, regulators and others, and ensures that time is spent at the 'front end' in examining options and ensuring that the project appears viable. A positively presented proposal can make all the difference in CBA being positive (World Bank, 1991).

The following examples indicate how EIA elements might be recast into a "second-generation" process to ensure sustainability (Gilpin, 1995):

- Screening of economic and development policies for their conformity with sustainability goals and principles (for example, identifying environmentally perverse subsidies),
- Preliminary assessment of environmental costs of development programs to identify low-impact, resource-efficient energy, transportation and manufacturing strategies,
- Areawide assessment to establish resource and land use zoning systems for regional development,
- Extending project EIA to identify in-kind compensation for loss of natural capital (for example, offsetting fish and wildlife losses in one location by rehabilitating habitats elsewhere.

All policy measures and investments require information. Environmental information is often the most difficult to assemble because it requires that a system of environmental monitoring be in place. In many developing countries such monitoring is often rudimentary, and what monitoring there is often has unknown bounds of uncertainty. Monitoring systems involve two dimensions (UNEP, 1994a):

1) measurement of emissions and waste arisings, for example emissions of sulfur oxides (SOx) and the quantities of solid waste generated; and land use change;
2) measurement of environmental impact from a given level of emissions or waste arisings, for example the reduction in water quality as measured by levels of dissolved oxygen (DO) in the water.

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The participation of the community for whom the project was intended was initially employed to provide assistance with the construction of rural projects, such as the development of water, sanitation, and irrigation schemes. This was primarily to reduce costs and to ensure that the local community would have sufficient expertise to enable them to operate and maintain the schemes once they had been constructed. The idea has since been developed further to encompass identification, planning and even design of projects, the argument being that the community have a much better local knowledge, they know what they want, and of course they are aware of all the social, cultural and religious factors that may affect the design.

Regional environmental assessments (REAs) are desirable when a number of development activities are planned or proposed for a relatively localized geographic area, such as several projects in one watershed. They serve a number of useful purposes, as outlined by the World Bank (1996). Like an REA, a sectoral EA (SEA) can be used to examine the cumulative impacts of multiple projects planned in the same sector. The other purposes of SEAs are somewhat different, as outlined by the World Bank (1993e).

Life-cycle EIA (LEIA) is a procedure for evaluating environmental impacts of a product, process, or activity, throughout its whole life cycle, cradle to grave (Gilpin, 1995). Each phase may be accorded a score on an environmental index, for example, for: natural resources, raw materials, land use; emissions to air, water and soil; noise; manufacturing procedures about economy, energy, work and the public safety; waste handling; recycling, and ultimate disposal. It is distinct from project level EIA which is much concerned with location, focusing on the life cycle of individual projects rather than the life cycle of infrastructure.

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For the planning of water resources development, a philosophy is as valuable as its practical usefulness. The basic question is: how can sustainability and environmental soundness be measured in reality, i.e., what are the practical indicators? For this purpose, a comparison can be made with the way the objective of socioeconomic well-being has been translated into operational objectives (UN, 1992c). Many economists are trying to adjust conventional notions of GNP and define a Green GNP. Negative impacts on the environment are subtracted from conventional measures of GNP. Shadow prices are used to quantity the loss of environmental quality. A Green GNP would be an indicator of both the economy and the environment. Critics argue, however, that adjusting the conventional GNP will never result in the calculation of a real Green GNP. It would be better to work with several indicators taking into account all aspects of a sound economy and a sound environment (UN, 1992c).

Emissions and waste arisings are simply indicators of the proximate pressure on the environment. They reflect underlying pressures arising from sectoral change in the economy that in turn reflects population change, public policy (including any changes in property rights regimes and public opinion - the latter being especially important in developed economies) and macroeconomic changes to prices, international trade and overall GNP. The various sectoral impacts can then be measured in terms of state of the environment (SOE) indicators, e.g., changes in length of river with a particular classification of water quality, or change in DO levels in a given river over time, and so on. In order to make the transition to measures of importance, SOE indicators need to be translated into effects indicators, i.e., usually measures of damage (or improvement) in assets, natural and man-made, that have economic value to individuals. Thus, an SOE indicator might be the ambient level of SOx,

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but an effects indicator might be the rate of corrosion of exposed metal surfaces. In turn, the effects indicator can be measured in biophysical terms and monetary terms (World Resources, 1995).

The Organization for Economic Cooperation and Development (OECD, 1993) identified the following criteria for indicator selection:

- Policy Relevance and Utility for Users
- Analytical Soundness
- Measurability

There are many efforts on a global basis on the development of environmental indicators. According to the book "In Search of Indicators of Sustainable Development" by Kruk and Verbruggen (1991) of the Netherlands Institute for Environmental Studies, a measure of sustainable development should include indicators for the pressure from society on the environment (pollution, resource use), and indicators for the state of the environment (ecological integrity or biodiversity). Both (sets of) indicators should confront actual flows or states with sustainable flows or states. The Netherlands has operated under the "Environmental Policy Performance Indicators," initially proposed in April 1993 by Dr. Albert Adriaanse. Environment Canada has produced a set of indicators, as well as the US EPA (1996). Some international agencies have worked in the area including the OECD. The United Nations Environment Program (UNEP) published a technical report in June of 1994 entitled An Overview of Environmental Indicators: State of the Art and Perspectives (UNEP, 1994). This document provided a complete review of the indicator development process throughout the world. UNEP also held a workshop in July of 1993 in conjunction with Delft Hydraulics to test a procedure for evaluating the sustainability characteristics of proposed projects (Delft, 1993).

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A Rome Conference of the OECD in 1999 (OECD, 2000) reviewed progress in meeting goals for development of sustainability indicators. The discussions showed considerable interest in indicators that better reflect the linkages between the three dimensions of sustainable development and their interactions (positive and negative). There was also interest in reduced and balanced sets of indicators that provide signals on key dimensions of sustainable development to policy-makers and the general public. There was general agreement that sets of indicators reflecting key trends and policy variables are useful to respond to common policy goals, and to demands for simplified indicator lists. The conference highlighted four key areas (OECD, 2000):

1. The importance of a pragmatic approach to developing indicators (i.e. insuring that they are useful to decision-makers and to stakeholders) was stressed.
2. It was emphasized that work on communicative indicators needs to be linked more closely to an understanding of citizens' interests and information needs.
3. It was suggested that there is a need to demonstrate the "value-added" that indicators have for advancing sustainable development, especially in order to secure resources for further work in both capitals and international organizations.
4. Work is required to strengthen links between institutions; links to institutions with expertise on social issues was considered particularly important, in light of the need to better reflect the social dimensions of sustainable development in indicator sets.

In the United States, an Interagency Working Group (IWG) has been convened to develop approaches to sustainable development indicators. This group published an "Experimental Set of Indicators" in September 2001 (US IWG, 2001). The IWG are not trying to define and measure sustainability with sufficient precision to show when it has been achieved. The IWG felt it to be more practical to develop indicators useful in assessing progress in that general direction. The IWG believes that it is more appropriate to regard sustainability as a dynamic condition than as a static end point. Note that this fits the main premise of this research that water projects need to be continually steered

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toward a sustainability objective that is not yet clearly defined (US IWG, 2001). The IWG believes that to integrate the concept of sustainability into an Indicator Framework requires that the concept deal equally with the economic, environmental and social realms. The economic sustainability principle most useful to IWG purposes was "don't spend principal." This concept was developed by Hicks who defined income as the amount that can be spent for consumption without decreasing the productive capacity of the capital from which the income is derived (US IWG, 2001).

Internationally, the issue of "sustainable development" is the major driving force for indicator development and the integration of environmental and economic planning. The ultimate goal of many of these efforts is an "Index of Environmental Indicators" and/or an integrated "Index of Environmental and Economic Indicators" to supplement or replace the common economic planning tools.

The World Bank (2001) reviewed the Bank's history of social and environmental assessments (SIA and EIA) relative to how well sustainability was being promoted. They indicated that SIA/EIA should be moved upstream in the decision-making cycle on projects, particularly with the use of strategic social and environmental assessment. SIA and EIA should be focused on "doing good," not just minimizing harm. The World Bank (2001) indicates that SIA and EIA policies should be revamped so that they are applied to policies, programs, structural adjustment and sectoral operations, and then assist with project selection. They indicated that a "fundamental overhaul probably is necessary to integrate social and environmental precautions as equal partners with the rest of development." *The proposed enhanced EIA EMSs in this research attempted to assist with such an overhaul.*

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2.6 Project Implementation and Tracking

Project appraisal has generally centered on an economic appraisal, with a supplemental environmental review. Implementation of the project was given little emphasis, and has directly been causal to the high failure rate of water resource projects, even without sustainability concerns. Even when the environmental review has been done adequately, there has been a general failure to ensure that recommendations, mitigations and monitoring programs are followed through during project construction and operation. There are a wide variety of institutional issues and problems during construction and with operations and maintenance (O&M). In addition, there has not been a reasonable reporting or tracking mechanism to provide insights into the reasons why projects succeed or fail, to assist with the formulation of new projects in the sector and project area.

The development of competent and sustainable institutions that are capable of managing the proposed infrastructure is a problem in many parts of the world. The problem can be eloquently developed, the solutions optimal from various multi-criteria perspectives, but the project can fail to meet its objectives because of management issues. As such, it is incumbent on the proposed development project (affecting water resources) to ensure that management systems are developed and in place to ensure that project objectives are met. This is one objective of the proposed EMSs in this category.

The physical sustainability of water resource projects has been hampered by poor maintenance. Insufficient funding, poor construction standards, and weak planning at the appraisal stage have been cited as reasons for the inadequacy. There has been a tendency to support project construction and not operation and maintenance (O&M). World Bank

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reviews of water resource projects have highlighted the need for the Bank not to detach itself from post construction activities (Serageldin and Steer, 1993).

The World Bank has placed a great deal of emphasis on developing institutions. Despite these efforts, O&M, financial management, and planning have often been unsatisfactory. Lack of administrative capacity, poor institutional arrangements, and political interference contribute to this poor performance. Furthermore, too many agencies have overlapping responsibilities, and interagency coordination is limited. In a Bank review of 120 Bank water and sanitation projects, management organization was often mentioned as a problem. Governmental interference was linked to inappropriate senior appointments, overstaffing, and rapid turnover of staff.

Finally, there is a definitive need for feedback and "lessons learned" from projects, whether they successfully meet their objectives or not. This feedback will assist with:

- Development and refinement of sustainability indicators,
- Improvements in the project development processes,
- Enhancements in the project assessment and environmental reviews, and
- Provide a source of information to outside reviews and the public.

2.7 ISO 14000 Standards

The International Standards Organization (ISO) is a federation of non-governmental organizations established in 1947 to develop international standards, improve international communication and collaboration, and facilitate the exchange of goods and services. The federation is currently comprised of close to 100 national standards bodies (member bodies) from countries representing approximately 95 percent

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of the world's industrial production. The headquarters of the ISO secretariat is in Geneva, Switzerland (Conway, 1996).

In preparation for UNCED, the ISO established a Strategic Advisory Group on the Environment (SAGE) in 1991 to assess the need for international environmental management standards. SAGE recommended that ISO proceed with an environmental standard by 1992 and that a technical committee be established to carry it through. On June 1, 1993, ISO's Technical Committee 207 (TC 207) held its first plenary meeting. TC 207 was directed to establish environmental standards in five areas of environmental management (Conway, 1996):

1) Environmental management systems;
2) Environmental auditing and related environmental investigation;
3) Environmental labeling;
4) Environmental performance evaluation; and
5) Life-cycle assessment.

The key factor that propelled the ISO 14000 series of standards forward throughout the 1990s was the increase in national environmental standards. With the proliferation of environmental standards, concerns have been expressed that these standards would fragment international markets and unduly favor the companies of the countries or of the regions where these standards were developed, unless they were developed by authoritative and broadly based international bodies. The ISO was to serve this role. Conway (1996) provided principles that outline the goals of an EMS.

It is not intuitively obvious how ISO 14000 helps to meet the global need to move toward sustainable development, especially in non-industrial settings. Implementation of a management system based approach will help companies (or water management developers or operators) focus attention on environmental issues, and bring them into the

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main stream of decision-making. ISO 14000 is designed to provide the public with a reasonable assurance that the performance claims of an entity are accurate (Cascio et al, 1996).

ISO 14000 was developed to meet the demand for an environmental management system that will be consistent for many sorts of organizations. The ISO 14000 set of standards and guidelines defines the core environmental management system itself, and the auditing procedures necessary for verification. It also defines three sets of tools that are important in implementing an EMS: life cycle assessment, environmental performance evaluation, and environmental labeling (IISD, 1996).

In broad terms, ISO 14000 fills two requirements in an organization (IISD, 1996):

1. The internal need for a system that will help the organization address all of the legal, commercial and other challenges related to the environment that it faces.
2. The need to be able to assure those outside of the organization that the organization is meeting its stated environmental policies.

Internal to the organization, a systematic approach to managing environmental issues can help to ensure that environmental incidents and liability are reduced. A systematic approach can help to identify opportunities to conserve material and energy inputs, to reduce wastes and to improve process efficiency. A systematic approach to management leads indirectly to improved environmental performance and improved cost control.

Top management commitment to improved environmental management, clearly defined goals, responsibilities and accountabilities, creates a greater awareness and understanding of environmental issues and an improved organization culture (IISD, 1996). *Although these internal benefits are directed at industrial entities, it is easy to make the correlation with water management and water projects.*

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External to the organization, third party assurance and recognition demonstrates that the organization products and services meet certain conditions. This is exactly what standards do efficiently, especially when combined with third party conformity assessment programs. They reduce or eliminate the need of companies to individually inspect each supplier's products and services with its own auditors. International standards such as the ISO 14000 series provide the widest possible recognition of this assurance. The accountability of water management agencies and development projects is also a problem that could be solved with such international protocols (IISD, 1996).

ISO 14000 does not set environmental performance standards. It leaves these up to the organization, saying only that its policies must include a commitment to comply with all relevant laws and regulations. How then can those interested in improving environmental performance make use of the system? First, ISO 14000 provides a useful tool with which to hold entities accountable. When an entity does establish a positive environmental policy, the ISO 14000 system can be used to check that it is actually accomplishing its goals, and reporting appropriately on them. Furthermore, entities can be encouraged to insist that all of their suppliers meet the environmental policy goals. Finally, just the existence of an EMS in an entity will usually lead to environmental performance improvements (IISD, 1996).

Although developed in the corporate context, the following definition developed by the International Institute for Sustainable Development (IISD, 1996) is equally useful for water projects:

> For the business enterprise, sustainable development means adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future.

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This definition captures the spirit of the concept proposed in the report of the WCED and focuses attention on areas of specific interest and concern to enterprises (read water management or water development). It recognizes that economic development must meet the needs of the enterprise and its stakeholders. The latter include shareholders, lenders, customers, employees, suppliers and communities who are affected (either positively or negatively) by the enterprise's business activities. The definition also highlights the dependence of the enterprise's economic activities on human and natural resources, in addition to physical and financial capital.

ISO 14000 will contribute to sustainable development to the extent that it helps organizations meet the above definition. A key aspect of the ISO 14000 standards is their international acceptability. They will be available for use by enterprises all over the world, as the common international approach to environmental management and verification of environmental performance claims. This can simplify international trade and inter-company procurement (IISD, 1996).

The ISO 14000 series environmental management and environmental auditing standards are not about environmental performance *per se* but about management systems. The difference is fundamental, and can be the source of much confusion if not clearly understood. Rather than dealing with the values and limits of performance, with energy efficiency ratings and emission levels, a management system standard establishes what the organization needs to do in order to manage itself so as to meet its goals. It is a fundamental principle of ISO 14000 that organizations set their own goals, based on whatever considerations they wish to include, including the demands of customers, regulators, communities, lenders or environmental groups. That is, an entity can set its

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own objectives and targets for performance. The ISO 14000 management system provides a framework to develop plans to meet those targets and to produce information about whether or not the targets are met.

The management of the business, with or without outside help, assesses the current state of affairs relative to each item and records the results. This assessment is not intended to be a complete environmental management system audit; rather, it is an overview of each area of practice to determine what is being done and how that activity meets the ISO 14001 requirements (Voorhees and Woellner, 1998).

The use of ISO 14000 and 14001 techniques in the public sector is a relatively new concept. Most think of industrial companies obtaining certification in the same way that many did for the ISO 9000 Total Quality Management standards. The US National Science Foundation has been working on grants from the US EPA related to applying ISO14001 principles to water management entities in the United States. Although there are few examples of the use of ISO14001 in the public sector, the principles remain relevant to water management and the development of international projects affecting water resources.

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2.8 Summary

The literature review (and detailed summary of **Appendix 9**) provides a context to the problem of integrating sustainability concerns into the development, assessment and implementation of international projects affecting water resources. Although there is significant work in the field, it can be seen that integrating these concerns at the project development stage has not fully matured. In the United States, the USACOE (1999) has summarized the options for improving the sustainability of water resource projects and concluded that modifying the former Principles and Standards of 1973 to meet sustainability concerns may be practical, but this has not apparently been implemented.

The World Bank (2001) provides a flowchart illustrating environmental and safeguard input into the Bank's decision-making and project cycle. It includes the use of Country Diagnostic Studies and Sector Strategy Studies early in the pre-lending phase.

The safeguard policies are implemented in the identification and preparation phases and include EA, environmental management plans (EMPs), resettlement action plans (RAPs), and indigenous peoples development plans (IPDPs). The flowchart includes environmental and social covenants in the loan document phase and monitoring of environmental and social outcomes in the implementation and evaluation phases. There is also a feedback mechanism shown from the evaluation phase back to future operations.

There is little guidance on how the sustainability concerns are evaluated as the proposed project moves from the Project Concept Document (PCD) in the preparation phase, to the Project Appraisal Document (PAD) in the appraisal stage, to the Project

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Supervision Report (PSR) in the implementation phase, to the Implementation Completion Report (ICR) in the evaluation phase. In addition, there does not appear to be any visible method to translate these various reviews into a format and language that can be used to improve the transparency of the decision-making with public officials, public and private interest groups, or the general public.

Concurrent with these efforts to track environmental and social performance of development projects, the private sector is implementing ISO14000 protocols as a way to certify compliance with international environmental norms (Voorhees and Woellner, 1998). There has been some movement to expand the use of ISO14000 into the public sector as well, but nothing in the literature suggests a possible use of these protocols in the development and review of development projects.

This research attempts to bridge this gap and suggest a possible use of these ISO14000 techniques in a manner that improves the sustainability of international water projects and also provides a method to report the reviews to other interested stakeholders.

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3.0 DESIGN AND METHODOLOGY

Based on personal experience and the literature, there appears to be a need for a comprehensive and consistent project review process that is cognizant of the shortcomings in the current systems (as outlined in the Literature Review). This research investigated existing ISO14000 protocols for a suitable method to apply the project development scenario. Again, based personal experience and the literature, the author outlined a system of EMSs at various stages of project development that had been found useful in the assessment of projects. These suggested EMSs were based on well-known and widely used manuals and literature sources, but this research was the initial effort to combine them in a comprehensive review system.

The ISO14000 family of EMSs is not a set of prescriptive standards or criteria. The entity wishing to certify compliance with EMSs follows a prescribed path (but not with prescribed results) as follows (Cascio, et al, 1996):

1. Design a procedure to identify the environmental aspects of the operation.
2. Identify environmental aspects and impacts.
3. Design a procedure to identify legal and other requirements of the organization.
4. Identify legal and other requirements.
5. Create environmental objectives and targets for each relevant function and level of the organization.
6. Establish a program for achieving targets and objectives.

Because ISO14001 protocols do not prescribe detailed EMSs, the development of suitable EMSs is left up to the organization for self-certification. The author's EMSs were arrayed according to the standard international project development cycle according to

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author's experience with international water projects, as well as identified shortcomings of the processes that arose in the literature. In some cases there was redundancy between these EMSs, and this was intentional since some of the same concepts could be used to modify the project at various review stages. The use of a gaps analysis procedure to test compliance with an EMS was suggested by Voorhees and Woellner in 1998. This protocol was outlined in basic form, and it was applied in this research. However, the system of EMSs and methodology and system of phased reviews were developed in this research.

3.1 Rationale

As previously outlined, an ISO 14001 "gap" defines the difference between the existing condition and ideal EMS compliance. This research used a simple 0-4 rating system to test compliance with an EMS, with the caveat that various weights and optimization techniques could be added to the process later. It is expected that this gaps analyses process and set of EMS reviews could assist decision-makers in performing:

- Assessments and audits of sustainability characteristics of these projects,
- Appropriate improvements to projects at various stages of project development,
- Feedback of appropriate project review information into national and international systems of environmental indicators,
- Improved communication on the project needs and rationale for the proposed solutions to decision-makers and the general public.

New tools are required to assist decision-makers in evaluating the sustainability characteristics of the programs/projects (hereafter called projects) relative to natural resources such as water, while the dialogue on sustainability matures. This research effort is

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designed to provide some initial public sector EMSs that can assist loan and donor agencies (and receiving institutions) in improving both the development and the implementation of projects to foster sustainability of the water resources in various spatial scales. These "projects" are defined as any development effort that potentially impact water quality or water quantity (through direct or indirect use or residual impacts) and are not limited to water resource development efforts.

This ISO14001 gaps analyses protocol, using water-related EMSs, is intended to provide decision makers with a system which can be used to interrogate project characteristics at various points in the project cycle, critique the project relative to sustainability-related evaluative criteria, and provide suggestions for project improvements and enhancements. It provides a mixture of policy, technical, economic, environmental, public participation, and implementation criteria for review. The EMSs can also recommend monitoring systems for the project to allow for improvement in assessing project economic and environmental performance and impacts as well as providing information relative to "sustainability indicator" efforts.

It is likely that the process of defining sustainability will involve all facets and levels of society and will consume decades to matriculate. Local, regional and national viewpoints from many disciplines are required to fully develop sustainable economic planning for a particular country. An initial step toward a solution would be the integration of natural resource accounts into national economic accounts. Problems with valuation and costs of resources and pollution will probably delay implementation of this approach. A standard protocol of ISO14001 gaps analyses using water-related EMSs could provide a convenient supplement to standard economic valuation approaches.

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3.2 Project Development Context

Despite over thirty years of fervent environmental debate since environmental concerns were moved into the forefront, most economic evaluations of international projects still tend to ignore or downplay procedures for evaluating the ways in which environmental concerns affect economic decision-making. This is not to deny the existence of many manuals that are directly concerned with environmental appraisal, but few attempts have been made to integrate environmental issues into economic appraisal techniques (World Bank, 2001).

Environmental concerns should be analyzed throughout the project development cycle, from formulation to implementation. In using an economic approach to project evaluation, it is essential that decision makers become conscious that individuals, communities and nations have multiple objectives. These objectives are not all reducible to the traditional concern of economists with economic efficiency that usually amounts to trying to make people "better off" on the whole. Efficiency and fairness are often incompatible in the sense that the pursuit of the maximum amount of one of them will impair the achievement of the other. Fairness applies to people now, and as it applies across generations in time, and conventional economic decision rules could be modified to account for fairness objectives.

Environmental and natural resource sustainability issues are likewise somewhat incompatible with standard economic evaluations. Economic evaluations cannot easily pursue these "non-efficiency" objectives very far. Such issues can be added to the standard economic evaluations of projects in a multi-objective fashion through the use of

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gaps analyses with water-related EMSs throughout the project development, appraisal and implementation cycle. The factors that give rise to environmental degradation are many and complex. But without some understanding of them, policy measures aimed at improving the environment will risk failure, and the rate of return on investments may be less than expected if project impacts feed back negatively to the environment.

Past policy appraisal of projects has been severely criticized from an environmental standpoint on two major grounds (OECD, 1994):

1) The failure of appraisal to account for environmental values in the same terms as the conventional development costs and benefits;
2) The discrimination against the interests of future generations due, allegedly, to the practice of discounting future costs and benefits.

The phrase "sustainable development" has done much to encapsulate concerns about the way in which economists have traditionally evaluated projects and policies. The term "development" is a deliberate diversion of attention from "economic growth" to a more embracing social goal. Unfortunately, development can mean whatever one wants it to mean and the end result has been an obfuscation of what is useful in the overall phrase of sustainable development. The reality is that governments everywhere have multiple goals and some mixture of those goals is usually what is meant by development.

Without question, development does embrace the goal of raising real per-capita incomes, whether the context is developing or developed countries. But it also embraces advances in human capital health and education, notably increases in human freedoms, and, increasingly, environmental quality improvements.

This explains the many new international measures of development such as the UNDP "Human Development Index" (UNDP, 1992). Economists accept that development is a multi-attribute concept, but argue that securing economic efficiency has more than one

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attribute. It is an enabling attribute of development, i.e., it is a means of securing the various components of a human development index.

If the goal of development is slightly nebulous, the idea of sustainable development has become quite controversial. It grew out of long-standing ideas of "sustainable yield" in forestry or fisheries management, whereby the stock of the resource itself is not allowed to decline, but the maximum economic rent from that stock is sought. As it happens, sustainable yields are consistent with many levels of stock in renewable resource management, so what is sought is the optimal stock of the resource, i.e., that stock corresponding to the maximum yield of rent.

Translated to the overall sphere of national development, sustainability appears to lose some of its basis. Resources are heterogeneous and include non-renewable resources such as coal and oil. A "sustainable" resource base thus appears to be impossible. But this misses the importance of the valuation issue, because what sustainability means in this context, is that the overall value of the stock of capital should not be declining if there is to be sustainable development.

Determining the optimal national yield of economic rent also appears very problematic, and hence so does the idea of identifying the optimal stock of resources. Economists can only know whether the movement from the existing position is good or bad since that can be determined by the measurement of gains and losses in monetary terms. They may know in which direction to move, but not where the optimum stock is. This kind of consideration has led some writers to be critical of some of the prevailing notions of sustainable development. Others have been openly dismissive. Thus, this quote from Little and Mirrlees in 1990:

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"Sustainability has come to be used in recent years in connection with projects. This is more of a buzzword - probably derived from the environment lobby - than a genuine concept. It has no merit. Whether a project is sustainable (forever? - or just for a long time?) has nothing to do with whether it is desirable. If unsustainability were really regarded as a reason for rejecting a project, there would be no mining, and no industry"

If indeed anyone has suggested a terminology of "sustainable projects" then these complaints would be partly justified - only partly because investors are rightly concerned that projects should survive and prosper beyond the point where investment flows are associated with technical aid and capacity building, especially in developing economies. But the discussion has been about sustainable development, not projects. However, sustainable development does have implications for project and policy appraisal.

The traditional focus in early evaluation manuals (Dasgupta, et al., 1972) was on government projects since most economies were characterized by large public sectors. The modern focus (World Bank, 2001) is on those same public projects - especially infrastructure, energy supply, water and sanitation, etc - but has become much broader with the increasing role of private enterprise in the development process, and in the role that both domestic and international policy can play.

Sustainable development simply means development that lasts (OECD, 1994a). That this is a significant concern is evidenced by the number of economies in which all forms of investment' capital are "mined" so that, ultimately, sustainable income levels above some minimum acceptable level are not secured. Lack of sustainable development in this sense can come about for all kinds of reasons, including war and famine, but also because of mismanagement at the macroeconomic level, poor project formulation and execution, and so on. That there is unsustainable development should not be doubted. The issue is whether project and policy appraisal needs to be changed in any way in order to avoid this un-

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sustainability. Sustainable development is a macroeconomic objective and it is very likely that securing it will mainly involve macroeconomic policy, not revisions to project appraisal. But there are implications for project and policy appraisal from the idea of sustainable development. Self-evidently, development is not sustained if, through time, the chosen index of development goes down. Ensuring that it rises, or is at least constant through time, and in per capita terms, means ensuring that future generations have no less capacity to generate "development" than current generations. That capacity lies in the capital stock and in technology, and in ensuring that rapid population growth does not quickly dissipate the benefits of growing capital stocks (OECD, 1994a).

Environmental assets are as much capital as machines or roads or factories (OECD, 1994a). A tropical forest has a great many ecological functions and all of those functions have economic value. Thus, the forest protects the watershed system and if removed that system may suffer damage, depending on the land use system that replaces it. At the global level, the ozone layer protects humans from amounts of ultra-violet radiation that would otherwise impair human health and ecosystem productivity (OECD, 1994a).

If capital stocks are integral to future capacity to sustain development, then the overall maintenance of those stocks is an integral part of sustainable development policy. In essence, future incomes are not sustainable if the capital stock is run down. A main ingredient for the recipe for sustainable development is therefore not to let capital stocks runs down. How far the stock of natural assets should be run down depends on how far we think other assets substitute for them.

At the risk of oversimplification, the ecologists are saying that there are severe limits to substitution (OECD, 1994a). Economists, by and large, probably believe in

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substitutability, but it has to be said, they do so on the basis of assumption more than empirical evidence. If one is not sure of the degree of substitutability, and that seems a fair if limited statement of the truth, then risk aversion should dictate caution about depleting that natural capital stock. The fact that the existing stock may not be the optimal stock then seems largely academic in the derogatory sense, for if one cannot identify the optimum with reasonable certainty it barely seems worth the risk of reducing the stock in order to probe for an optimum less than the stock one has. In any event, few seriously suggest running down national capital stocks in the aggregate sense.

So, far from not being "a genuine concept", sustainable development does have interesting implications for the way national economies are managed. Moreover, conservation of environmental capital becomes more important still in the context of sustainable development, and this explains in part the emphasis it received at Rio in 1992 and earlier in publications such as the WCED report in 1987. The implications are as follows:

1) Revisions to the measure of National Real Income that traditionally underlies development policy. [This is the national income accounting implication)\];
2) Importance of measuring the economic value of environmental assets and their flows of services in project and policy appraisal;
3) Importance of correctly pricing goods, services and inputs so that environmental costs and benefits are fully reflected.
4) Maintaining the economic value of the overall stock of capital in value terms, and within that objective, paying special attention to the overall stock of natural capital.

The general objective of maintaining capital stocks sets the broad economic framework for policy in general. It affects policy and project appraisal in that all policies and projects must, when aggregated, comply with the overall objective of securing the conditions for sustainable development. Environmental problems range in terms of their impact from being local to global. Although the distinction is not always a firm one, it is also useful to

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distinguish problems as they relate to renewable resources and non-renewable resources. The former have the capacity to regenerate, as with fish or forests; the latter do not, as with oil or copper.

Sustainable development is simply the goal of ensuring that future generations are no worse off than this one (OECD, 1994a). "Development" has various meanings but clearly involves raising individuals' well-being through increases in real income, educational achievement, health status, personal freedoms and environmental quality. Securing sustainable development involves making sure the next generation has the capacity to generate as much well-being as today. This means leaving them a stock of capital assets and technology no less than that possessed today. In practical terms, this "constant capital" means a constant or rising economic value of capital assets of all kinds.

One of the most important characteristics of sustainability-oriented project appraisal, which affects all appraisal stages, is the explicit role of environmental objectives in decision-making. In a basic criteria set, a sustainability criterion, as a reflection of these objectives, would need to be included in addition to the traditional criteria of allocative efficiency and a fair distribution (intratemporal equity) (Van Pelt, 1993). Sustainability is a strongly normative concept. Consequently, in the determination of criteria weights, policy-makers (and other agents in society that may be affected by a project) will often face new types of sensitive trade-offs between the traditional objectives of efficiency and equity and new sustainability concerns.

Operationalizing the concept of sustainable development starts with outlining the objectives of development itself, and the relations between environment and welfare. The concept of ecologically sustainable development integrates objectives regarding welfare and

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intergenerational equity, and knowledge about the role of the environment in creating welfare. Natural resources should be considered both a source of and a constraint on development. Whatever the precise definition of sustainability, a guideline for policy is that limits should be imposed on the use of natural resources (Van Pelt, 1993).

3.3 Research Approach

A systems approach using global ISO 14000 standards coupled with risk reduction techniques can assist in improving water project performance (Voorhees and Woellner, 1998). Sustainability can be achieved if project proponents make continual improvements to their processes and services and eliminate environmentally degrading sources of pollution. The systems approach can foster sustainability and, at the same time, allow project proponents to identify and limit their impacts, prevent pollution, restore natural resources, and minimize environmental risks and liabilities.

Managing and reducing risks are part of a global ideological shift that is creating opportunities for future generations to live free of past encumbrances. Two types of efforts have traditionally characterized project risk management: those performed to control existing risks and those performed to reduce future risks. Managing environmental risks effectively requires a comprehensive systems approach that combines both skills. The ISO 14000 series of standards can serve project proponents as a model for an integrated series of management systems that identify, control, and monitor environmental risks. Additional risk management strategies include the use of information technology, risk-based approaches to internal and external environmental communication, insurance and risk-transfer methodologies.

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Reducing future risks has as its central focus the identification of the causes of potential regulatory, public, and employee conflicts coupled with the elimination of adverse environmental impacts. ISO 14000 environmental management systems need to be augmented with auditing, litigation avoidance, collaborative decision-making, alternative dispute resolution, involvement with proactive environmental programs, and other innovative risk reduction techniques. All of these areas need to be considered when creating or enhancing a comprehensive environmental management system.

The systems approach takes these risk management and reduction strategies and techniques and creates opportunities for further process innovations and solutions to environmental problems that will make the world a healthier, safer, and more prosperous place in which to live. It employs methods to avoid repeating past mistakes while at the same time encourages future revenue growth. It provides strategies for corporate managers to follow when developing environmental risk management systems together with specific examples of techniques to eliminate risk. It contains guidelines for implementing environmental management systems and using daily experience with the system to enhance its effectiveness.

When environmental management systems are effectively implemented, they reduce pollution, minimize regulatory problems such as potential civil and criminal environmental liability, and maximize the public's confidence in public safety and the government efforts to preserve and protect the environment. The systems approach serves as a written guide for project proponents to develop projects in a safe, environmentally responsible manner. It also demonstrates that project proponents are proactively managing their environmental concerns and are committed to safeguarding the environment.

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The project development process is a "system" that somewhat defines the potential effectiveness of the ultimate project, including its ability to meet sustainability objectives. In reviewing the literature and current practice, there appeared to be potential benefit in utilizing the systems approach using global ISO 14000 standards suggested by Voorhees and Woellner (1998) to facilitate a "cradle to grave" tracking mechanism throughout this project development process. To recall from the literature, ISO 14000 fills two requirements in an organization (IISD, 1996):

1. The internal need for a system that will help the organization address all of the legal, commercial and other challenges related to the environment that it faces.
2. The need to be able to assure those outside of the organization that the organization is meeting its stated environmental policies.

Project proponents continue to struggle with both of these aspects relative to insuring due diligence with environmental and sustainability objectives, as well as reporting the results of the internal and external reviews in a transparent fashion to the affected stakeholders and general public. There have been some extensive efforts by project proponents to improve internal auditing of project successes and failures, but these efforts have not yet resulted in an integrated review system, and little has been accomplished in reporting this information to the public.

The World Bank (2001) indicates that the following areas are slated for potential improvement relative to the project development and assessment process and/or are emerging challenges:

1. Early attention to environmental issues.

   Although EAs are now routine, it is difficult to address environmental and social concerns when strategic decisions are made at the sectoral or program level. In addition, national goals and objectives are not routinely translated into project

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goals and objectives, and strategic environmental indicators remain poorly developed. The recognition that better environmental outcomes can be achieved at lower cost by integrating such concerns at the planning and design stages has spread slowly throughout the world.

2. Increased supervision during project implementation.

Implementation of safeguard policies during supervision is generally weaker than compliance during preparation. Problems during project implementation are usually due to inadequate performance in undertaking agreed mitigation, monitoring, and institutional-strengthening actions. Problems also arise when project designs are adjusted in the course of implementation and safeguard policy issues are not adequately reexamined.

3. Consistency in the application of safeguard policies.

The Bank's internal Quality Assurance Group has indicated weaknesses in the systematic application of safeguard policies. In some cases the ambiguities in the scope, intent and requirements of the policies have contributed to these failures. New types of monitoring approaches are being developed for Bank supervision of the application of safeguard policies.

4. Development of an integrated safeguard system.

The Bank indicates that the application of the various environmental, social, and legal safeguard policies into an integrated suite of measures for promoting project quality and ensuring compliance is still evolving. *The proposed ISO 14000 gaps approach could potentially be used for such a role.*

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5. Responding to changing lending profile.

The ongoing shift in the Bank's lending operations to include an increased emphasis on policy and programmatic lending, use of innovative instruments and expansion of Community Driven Development poses new challenges and opportunities for safeguard policies. It requires a stronger focus on assessing and strengthening country capacity to systematically implement proper safeguards.

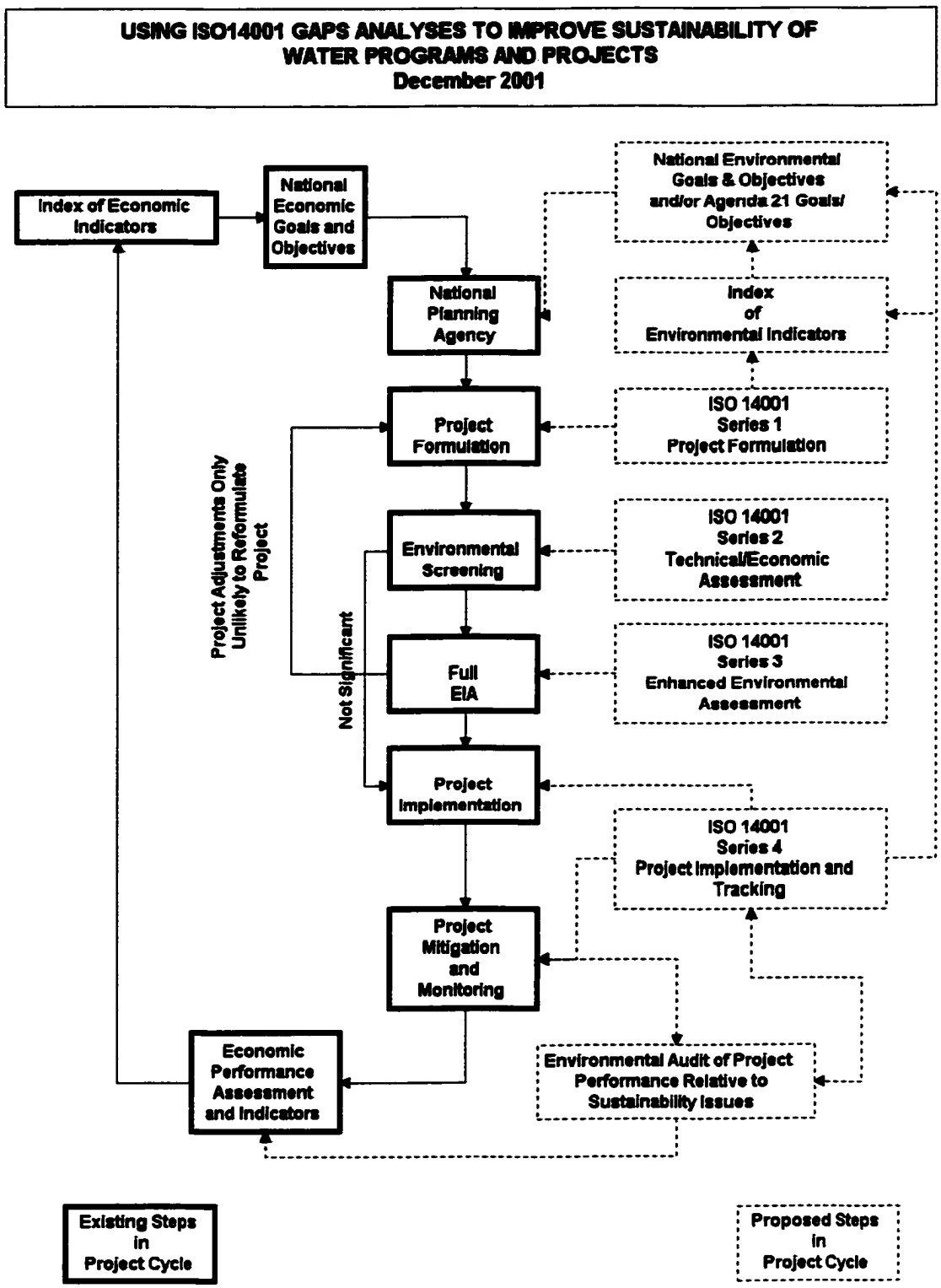
6. Expanding coordination with partners on safeguard policies.

Development of coordinated approaches to safeguard policies at the institutional and/or project level avoids conflicts over the nature and extent of analysis, proposed mitigation measures, procedures for consultation, and disclosure of information.

Based on the author's personal experience in working on large international water resource projects for over 15 years, a proposed project cycle incorporating ISO 14001 reviews was developed. (It is interesting to note that many of the World Bank (2001) identified areas needing improvement and emerging challenges are addressed in this proposed system.) **Figure 1** presents an overview of this systems approach for sustainability reviews at various stages of project development from formulation, assessment, design, environmental review to implementation. This approach recognizes that projects can be steered toward sustainability at various stages. It also provides feedback mechanisms to improve the development of new projects from an environmental perspective and assist with national and international efforts in defining sustainability indicators.

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Figure 1, Proposed Systems Approach Using ISO14001 Gaps Analyses:



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If a decision maker cannot precisely identify the significant parameters of the problem, it is said to be unstructured, since human intuition and judgment are generally needed to reach a decision (Theirauf, 1988). Typically, the rationale for the inability to identify specific parameters in the problem is that the time frame is too long. Maintaining the sustainability of natural resources such as water currently meet the description of an unstructured problem. In effect, the parameters of the problem are too loosely defined to solve it with a high degree of accuracy.

When a problem is unstructured from the perspective of the decision maker, computerized mathematical or statistical models are generally inappropriate. To reach a decision, there is a need for data, information, managerial experience, know-how, intuition, judgment, and past experience. This may mean taking a descriptive approach to decision making. Rules of thumb may be appropriate to resolve unstructured problems. This may require resorting to hypotheses, evaluations, educated guesses, and the like. It is problem solving under uncertainty. The attendant circumstances must be surveyed to determine whether or not mathematical methods are appropriate for solving unstructured problems (Theirauf, 1988).

The decision-making process can be viewed from two major perspectives:

(1) the normative approach and,

(2) the descriptive approach.

In a normative or quantitative framework, the accent is on determining specific values for all parameters of the problem and solving for a specific value or a range of values. In contrast, a descriptive or qualitative framework does not attempt to quantify the factors but rather to state them in general terms and solve the problem on that basis.

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The descriptive framework incorporates adaptive or learning features, and the act of choice spans many dimensions of behavior, rational as well as non-rational.

A descriptive decision model allows the human capacities of the decision maker to be given some measure of recognition. They bring to bear the totality of forces, both external and internal to the decision maker, that influence a decision. Whereas normative decision models are most valuable for recurring decisions, descriptive decision models are most significant for one-time, non-recurring decision (Theirauf, 1988).

The two approaches just described are legitimate in a decision-support environment, the normative focusing on a quantitative approach and the descriptive centering on a qualitative approach. Depending on the type of problem being solved, the normative approach is well suited for well structured and many semi-structured problems, whereas the descriptive approach may be more appropriate for unstructured problems and some semi-structured problems. To make the best use of both approaches, Thierauf (1988) recommends that the decision maker use their best features, namely, the experience of the descriptive approach and the problem-solving steps of the normative approach, together with creativity. This combined approach can be used successfully as an integral part of a decision-support environment (Theirauf, 1988). An ISO 14001 "gaps analysis" methodology can be considered a combination approach.

As outlined in Literature Review, Carter et al (1992) introduced a concept called "organizational decision support system (ODSS)," which is a decision-support system (DSS) that is used by individuals or groups at several locations in more than one organizational unit who make varied (interrelated but autonomous) decisions using a common set of tools. The ISO 14001 gaps analysis can be considered an ODSS since there

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are definitely multiple objectives in play. However, the selection of weighing systems, goal programming, or other techniques for assessing the results of the gaps analysis has been left to the later phase of moving the technique into the mainstream. The various agencies who might be candidates to use this system will all have pre-conceived notions on this subject, as well as differing stakeholders that will have to be satisfied.

As has been outlined in this paper, the sustainability of water resources involves significant uncertainty, multiple dimensions, and long time frames. Ensuring that proposed projects affecting water are sustainable is a problem that fits the definition of unstructured. In addition, multiple players in the project development process require organizational decision support to address and support a standardized descriptive approach to ensuring sustainability.

The use of ISO14000 protocols is being expanded worldwide as a standard template for ensuring that organizations are meeting or exceeding environmental objectives. Moving these protocols into the public-sector project-development process and developing EMSs at various stages of project development can serve the role of a standardized descriptive approach for organizational decision support, while using the problem-solving steps of the normative approach.

This research used such a combined approach by developing a gaps analysis protocol for each stage of project development, from formulation to implementation. The previously described phased EMSs were used to test the proposed project for sustainability characteristics and ratings were developed, using a case study.

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3.4 Evaluative Criteria System Development

3.4.1 Overview

The Literature Review (in Chapter 2) illustrates that there are few systems in place that assist with formulating, assessing, implementing and monitoring these projects in an integrated fashion, directed toward international water resource sustainability goals. Water resource needs and potential solutions are poorly communicated to a skeptical general public. Projects are increasingly being assessed for "environmental due diligence" by the project proponents, but without a comprehensive system or procedure.

An ISO14001 gaps analysis procedure could provide a convenient and internationally consistent protocol for addressing water project sustainability at various stages of the project cycle. Such a procedure can easily complement existing economic and environmental review processes that are typically used by project proponents.

A current and ongoing challenge is the need to evaluate proposed development programs and projects relative to their likely impact on the environment and whether they are fostering sustainability. This research defines a systematic ISO 14001 approach using gaps analyses and water-related EMSs from which a project implementer (funding or operational level) can improve the water-related sustainability characteristics of a proposed developmental effort. Concurrently, the proposed system can provide various recommendations for the monitoring and data collection efforts associated with project implementation that will:

1) Assess project performance from a coordinated economic/environmental perspective,
2) Complement the international effort at defining and measuring national progress toward sustainability goals, and

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3) Assist with making the decision-making process more "transparent."

The proposed ISO14001 gaps analysis sustainability system uses sets of "phased EMSs," set up according to standard project cycle stages. The project implementers then determine whether the project impacts on water quantity and quality can be improved and the monitoring and information systems that are necessary to better gauge the responses to the EMS questions. The gaps analyses also provide a methodology for extracting information from the project to "feed" the growing demand for "national indicators of sustainability." The intended outcome is a methodology to allow decision-makers in both the funding and recipient locations to develop better projects and also improve the water-related sustainability characteristics of ongoing projects prior to implementation. The project components can be modified, financial or operational arrangements revised, management entities upgraded, etc.

Although the EMS review system is integrated into monitoring, data synthesis, information management, and indicators, the system is not designed to provide "national indicators of sustainability." Many others in the international arena are working diligently on this effort, albeit to a degree of detail in the water sector that many would find less than fully operational (refer to section 2.5). The system of EMSs produced in this research is intended to improve project assessment and development, recommend improvements in monitoring and data analysis, and provide the level of water information on a project level to foster and improve these international efforts.

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3.4.2 System Formulation

The system of ISO14001 Environmental Management Systems (EMSs) has been formulated as a set of questions for rating under a suggested '0 – 4' system, with 4 representing ideal compliance with the EMS (Voorhees and Woellner, 1998). There are a wide variety of weighing systems that a particular user group may deem appropriate to utilize with such a system so the system merely provides the framework for user choices of weights. In addition, a particular set of questions may also be weighed to derive a categorical degree of compliance with the idealized "norm."

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4.0 RESULTS

4.1 Project Formulation (Series 1.0)

In the context of this research, "project formulation" is considered the multitude of national planning efforts that culminate in a water management project or program. It is noted that many other development efforts affect, or are affected by, water issues other than traditional water management schemes. As such, the system may also prove useful to evaluate projects in other sectors that have major water-related aspects and/or potential impacts.

Much of the literature and review procedures deal with previously conceived water management schemes with little focus on how these schemes are derived. Water management has moved beyond the historical scenario where political and technical interests somewhat arbitrarily combined to produce proposed structural schemes. There are a wide variety of technical, economic, social and environmental factors that must now be integrated into the project development process. This multi-dimensional process has been organized in the research as shown in **Table 1**:

Table 1. Project Formulation (1.0)

1.1	**Broad International and National Goals - Dublin Statement and UNCED**
1.2	**Integrated Water Resources Management Concepts**
1.3	**National Planning Components for Sustainable Water Resources**
1.4	**Detailed Water Project Development Processes**

The Project Formulation Series first extracts important international goals and objectives that emerged from The International Conference on Water and the Environment, held in Dublin, Ireland, from 26-31 January, 1992, and the Earth Summit

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in Rio de Janeiro, Brazil in June 1992 where many of the recommendations were incorporated into the Agenda 21 document, a blueprint for action into the twenty-first century. Relative to international cooperation and coordination, the EMSs dealt with management systems regional coordination schemes information exchange programs. Other broad goal-setting concerns included in the EMSs were:

- Framework of International Policies
- Strategies and Programs Enabling Environment at the Sectoral Level
- Capacity Building
- Water Resources Protection and Conservation
- Protection of Quality and Supply of Freshwater Resources
- Groundwater Protection
- Ocean Protection
- Health Impacts
- Drinking Water Supply and Sanitation
- Water for Sustainable Food Production and Rural Development
- Environmentally Sound Technology

This series then uses integrated water management concepts outlined in the Literature Review. These concepts illustrate that water resources development and management should be planned in an integrated manner, taking into account long-term planning needs as well as those needs with narrower horizons, that is to say, they should incorporate environmental, economic and social considerations based on the principle of sustainability. They should include the requirements of all users as well as those relating to the prevention and mitigation of water-related hazards. Finally, they should constitute

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an integral part of the socioeconomic development planning process. To be effective, the EMSs were targeted at:

- Legal, institutional, budgetary and other constraints.
- Planning objectives at national, regional and local levels.
- Physical interrelationships among the units of a water resources plan.
- Supporting infrastructure that is needed to secure the products and services of a plan, their distribution to beneficiaries, and the benefits and costs of the plan.
- Identification of all appropriate alternatives for development, preservation and enhancement with different contributions to planning objectives and different amounts of products and services.
- Possible trade-offs among objectives, purposes, and effects of a plan.
- Externalities of the plan.
- All effects of the plan including those of engineering, economic, environmental, social, legal and institutional nature.
- Contributions by engineers, economists, biologists, and other disciplines related to the plan, and contributions by agencies representing, all economic sectors affecting or affected by the plan.
- Involvement of groups or individuals affected by or interested in the plan, particularly women's groups.
- Method of presenting the features and expected results of the plan so that it can be commented upon by interested parties and acted upon by decision-makers.

Finally, the Project Formulation series addresses national planning issues as well as detailed water project development processes. A prerequisite for the sustainable

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management of water as a scarce vulnerable resource is the obligation to acknowledge in all planning and development its full costs. Planning considerations should reflect on the one hand all types of benefit, both direct and indirect, and on the other all investment, environmental protection and operational costs, as well as the opportunity costs reflecting the most valuable alternative use of water. Actual charging need not necessarily burden all beneficiaries with the consequences of those considerations. Charging mechanisms should, however, reflect as far as possible both the true cost of water when used as an economic good and the ability of the communities to pay. This series of national planning EMSs targeted the following issues:

- National policies in integrated fashion for all water-use sectors
- Institutional development including management systems and human resources
- Legal systems
- Public participation
- Health policies and health assessment issues

Relative to the EMSs developed to address detailed project development processes, specific environmental guidelines were cited, as well as donor lessons from past international project experience, issues related to the financial security of projects, appropriate project development steps and sequencing, promotion of international environmental objectives, and detailed water project details and targets.

The Project Formulation series of EMSs is not necessarily targeted at Yes/No decisions on potential projects. The goal of this system, as has been stressed throughout this paper, is to continually steer proposed projects toward water sustainability goals, and should result in an action plan to improve the project characteristics as it moves ahead.

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4.2 Technical/Economic Assessment (Series 2.0)

After a project or program has been formulated, there are several assessment levels that it must pass through during its development cycle. Although cost-benefit analysis (CBA) has been an important characteristic of project review for many decades, CBA has been inadequate to deal with the magnitude and complexity of issues related to water-related sustainability. In addition, the technology assessment component has emerged in recent years as an important measure of the sustainability of both the water resources affected as well as the technologies employed to manage the resources.

As such, the second set of EMSs are a somewhat integrated set of technical and economic queries that together assist in improved project characteristics and performance measures, and are shown in Table 2:

Table 2. Technical/Economic Assessment (2.0)

2.1	**Appropriate Technology**
2.2	**Conservation and Demand Management**
2.3	**Environmental Valuation/Pricing Accounting Framework**
2.4	**Economic Instruments**
2.5	**Financial Planning and Economic Impacts**
2.6	**Risk Management**
2.7	**Cost Benefit Analysis and Multi-Objective Decision-Making**

Many development agencies and banks are already using many of these procedures but this system strives to connect them with a review protocol that is readily apparent to project proponents and the general public. Once again, the system should be considered a supplement to standard CBA and other project assessment processes, rather than attempting to replace these standard techniques. Figure 1 in Section 3.3 illustrates how this series connects with the standard project cycle.

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This series of EMSs first addresses how well appropriate technology has been incorporated into the project components, an important consideration in many developing countries (and developed countries to some extent). The Conservation and Demand Management series of EMSs strives to insure that appropriate water conservation and pollution control strategies are in place, existing sources of water and demand management strategies are fully employed, and that proper financial and institutional development systems are in place to implement the proposed project.

The EMSs targeting environmental valuation and pricing were developed to insure that exploited water resources were assessed under current economic concepts and pricing mechanisms, overall water resources capital stock considerations were taken into account, ensured that the "true" economic value of water resources were accounted for during the investment decisions.

The use of proposed EMSs relative to economic instruments again worked to insure that economic strategies were fully integrated with proposed structural control measures, to optimize potential project benefits. These EMSs included:

- Non-structural components as potential substitutes or complements to proposed structural controls
- Appropriate pollution and waste charging mechanisms
- User, product and administrative charges
- Tax differentiation and subsidies
- Enforcement incentives
- Policy instruments for implementing economic incentives

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The EMSs that addressed financial impacts and economic impacts first addressed key issues related to developing a financially-viable water sector, and tracing economic impacts beyond the project level to the sector, regional and national levels. Risk management EMSs were developed with a recognition that risk management is becoming an integral tool in the assessment of projects. It is now used to develop priorities for action as well as the potential probabilities of negative impacts (financial, technical, environmental, etc.) as a result of project implementation. These EMSs focused on risk management relative to environmental degradation and social impact potential.

In addressing the shortcomings of traditional CBA approaches, the Cost-Benefit and Multi-Objective Decision-Making EMSs attempted to insure that CBA was applied with the use of improved techniques, and that the benefits of multi-objective decision-making were fully assessed in the project reviews.

4.3 Enhanced Environmental Impact Assessment (Series 3.0)

Environmental degradation results in an ultimate loss of productivity. A project-by-project assessment for addressing this overall degradation of natural resources puts a country's future at risk economically and socially - as well as environmentally. A multidisciplinary approach is called for that combines broad environmental policy, institution building, and other aspects of resource management.

Environmental Impact Assessment (EIA) is a particular form of policy analysis, with a characteristic purpose and approach. By definition, this approach is concerned with identifying, evaluating, and mitigating the negative environmental consequences of proposed decisions, and strives to be rational, systematic and integrated. EIA and its

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related components - social impact assessment (SIA), risk analysis, and so forth - initially were developed to augment the deficiencies of economic techniques in accounting for the qualitative and intangible effects of major developments.

EIA is applied as a project planning and mitigation tool - focusing on how (rather than whether or where) development should take place. This circumscribed role in decision-making works well within an integrated policy and planning context in which prior-order issues of justification and alternatives are resolved in a phased manner. Gilpin (1995) provided examples to indicate how EIA elements might be recast into a "second-generation" process to ensure sustainability. The third set of EMSs attempts to move EIA toward such a "second-generation" process for sustainability, starting with an improved understanding of water-related benefits and impacts in traditional assessment procedures. It uses the following subsets of EMSs as shown in Table 3:

Table 3. Enhanced Environmental Impact Assessment (3.0)

3.1	**Project Specific Criteria**
	3.1.1 Dams
	3.1.2 Fisheries
	3.1.3 Flood Protection
	3.1.4 Groundwater
	3.1.5 Hydroelectric
	3.1.6 Irrigation
	3.1.7 Water and Sanitation
3.2	**Bioassessment**
3.3	**Point and Non-Point Source Pollution Control**
3.4	**Minimum Stream Flows**
3.5	**Regional, Sectoral and Cumulative Impacts**
3.6	**Environmental Indicators**

The international effort at developing integrated environmental and sustainability indicators (as described in the last section) is indicative of the growing attempt to use

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environmental assessment information more fully to communicate the nature of the 'pressure – state – response' cycle (Adriaanse, 1993) of environmental information to decision makers and the general public. As such, environmental assessment is growing beyond a snapshot review of localized considerations to a more regional, national and global focus of interconnected information. Water issues are an important part of this advancement.

This series of EMSs first applied widely used project specific EIA references (such as World Bank, 1991b) related to water resource development, applying direct and indirect physical and social concerns. These traditional EIA issues were expanded in the proposed EMSs by addressing biological integrity issues of surface waters, beyond standard surface water classification schemes used in most developing nations. Next, the proposed EMSs addressed the overall framework for point and non-point source pollution control and how the proposed project worked within this framework and/or facilitated the implementation of such approaches.

The lack of adequate surface streamflow and potential dilution capability in many parts of the world was addressed by EMSs dealing with minimum streamflow assessment. The regional, sectoral cumulative impact EMSs were designed to take traditional EIA analyses beyond localized issues and impacts. Although some level of analysis is typical, there is not an established international protocol for incorporating such concerns at the project-level EIA preparation and review stage.

Finally, EMSs were developed to ensure that the proposed project promotes the development of, and/or adheres to national systems of environmental and sustainability indicators. Such a system of indicators, when matured, could serve a valuable role in the

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Project Development stage of the projects. These indicators can also provide a valuable tool for reporting progress to the public in meeting water and environmental goals and objectives, and how the proposed project assists in this process.

4.4 Project Implementation and Tracking (Series 4.0)

A proposed international water project or program that successfully works its way through the development cycle and addresses the first three sets of review queries would then be implemented. However, the need to continue to track the integrated performance measures proposed for the project continues into project implementation and operation.

A gaps analysis summary report could provide significant information relative to lessons learned regarding successes and failures of the project to meet or exceed performance expectations. Such information can provide valuable information to decision-makers for future phases, projects, or programs. As such, the last set of EMSs addresses the implementation and operation phases with the following subset of EMSs shown in Table 4:

Table 4. Project Implementation and Tracking (4.0)

4.1	**Integration of Environmental and Social Impact Assessments**
4.2	**Environmental Mitigation and Monitoring**
4.3	**Performance Auditing and Management Indicators**
4.4	**Operation and Maintenance**
4.5	**Feedback Mechanism - Project Formulation Stage**

This series of EMSs first addresses the integration of environmental and social impact assessments to insure seamless recommendations are employed. In a similar manner to the need to expand environmental concerns beyond the project "footprint" into sectoral and regional concerns, the social assessment needs to address project "winners and

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losers" beyond merely quantifying potential relocation requirements. Both assessments should address construction impacts as well as operational impacts, and community participation to the extent possible in local political and cultural contexts should be employed.

A detailed mitigation and monitoring plan must be developed and funded for the proposed project with specific implementation entities and procedures outlined. Monitoring programs must again be funded, with specific testing and reporting requirements, and potential corrections outlined for identified problems. Since existing water resource and water quality monitoring programs remain weak in many developing countries, these EMSs also target the implementation of improved monitoring programs through technical assistance components or other similar actions.

The auditing of project effectiveness is being implemented by most project proponents and the performance auditing and management indicator EMSs attempt to insure that these audits are proposed, properly performed, and include environmental performance as well as economic performance. Operation and maintenance (O&M) is a large problem in developing countries which is exacerbated in the international project area where sophisticated technologies, high operational cost, lack of spare parts, lack of operator training and other issues contribute to poor O&M. The O&M EMSs attempt to minimize such concerns during project operations.

Finally, a series of EMSs were proposed to ensure that lessons learned (positive and negative) are fed into a project database that assists in the development of new projects in the future. This will allow the development of better projects, assist with public communication of results, and foster environmental indicator development.

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New information that emerges in this phase can be used to "tweak" the project during implementation toward better environmental performance and sustainability. The World Bank (2001) indicates that performance assessment measures are being included in the Implementation Completion Reports (ICRs), and new measures are being developed to integrate reporting of environmental and social outcomes in addition to economic performance. The suggested gaps analysis protocol could potentially serve this identified need as an adjunct to the ICR.

4.5 Format of Gaps Analyses

The proposed method for assessing compliance with sustainability goals in this research is the use of "gaps analyses" at various stages of project development and implementation. ISO 14001 has three distinct phases of implementation. Phase One is a "gaps analysis," in which the entity's existing environmental management programs are compared to the requirements of the ISO 14001 standard. Phase Two is the development of an environmental management system, following the requirements of ISO 14001, and then the implementation of the system. Phase Three involves the third-party assessment, or registration audit of the entity, after the environmental management system is implemented. When put into the context of ISO 14001, a 'gap' is the difference between what the standard requires and what existing environmental management practices actually exist in an organization. The gaps analysis compares the existing environmental management practices, methods, and techniques with the requirements of ISO 14001. The results of the study enable management to determine the degree of conformance with the ISO 14001 requirements (Voorhees and Woellner, 1998).

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A gaps analysis can be performed by using a matrix of individual ISO 14001 requirements as a baseline. The management of the entity assesses the current state of affairs relative to each item and records the results. This assessment is not intended to be a complete environmental management system audit; rather, it is an overview of each area of practice to determine what is being done and how that activity meets the ISO 14001 requirements. For each ISO 14001 requirement, the entity needs to determine:

- What the standard requires
- What procedures currently exist
- How the current procedures compare with the standard

If the entity has performed an initial review of environmental aspects and impacts, legal and other requirements, this information can be used as input to the gaps analysis process. The degree of implementation of each of the requirements can be assessed using a scale from 0 to 4. Each point value corresponds to an increasing level of implemented systems that meets the requirements of ISO 14001 (Voorhees and Woellner, 1998).

Voorhees and Woellner (1998) define the scale as follows (*comments by author*):

0 = Nothing exists at all. *(Project needs significant modifications described in the Action Plan.)*

1 = A program description exists but is not implemented. *(Project moving in the right direction but still requires reformulation or concurrent/followup actions.)*

2 = A system is developed and partially implemented or is fragmented and uncontrolled. *(Project components may need minor reworking.)*

3 = A system is developed and implemented but does not meet the intent of ISO 14001. *(Project may need slight reformulation.)*

4 = The system is developed and implemented and meets the ISO 14001 intent. *(No further action necessary for the project.)*

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The gaps analyses are recorded and used as a basis for determining resource priorities for implementing the environmental management system. Systems having a rating of '0 or 1' obviously will require much more effort than those receiving '3 or 4' ratings. The purpose of the gaps analyses is to obtain results that can be used to estimate the activities and extent of effort required to implement an ISO 14001 EMS, and to provide the basis for allocation of resources. It is not expected that the final outcome will be accurately predicted; rather, the framework provides a judgment of what will be necessary.

Once each requirement has been assessed, and the entity has an overall picture of its activities relative to the ISO 14001 EMSs, it can begin to develop action plans for improving the project's performance on each EMS. The key to successful ISO 14001 implementation is to integrate the planning efforts with the existing planning activities of the entity. As with any planning effort, the gaps analysis is used as an input tool to develop specific action items and priorities. Management also needs to ascertain certain dimensions of the ISO 14001 gaps analyses before it commits to the implementation path. These dimensions include (Voorhees and Woellner, 1998) (with comments on how these dimensions relate to international water projects by the author):

- The size of each gap (does the entity have to develop and implement any major program components?)

For the water projects, this could involve modifying project characteristics, implementation arrangements, or related projects and programs.

- How can each gap be filled (what exactly will the entity be doing?)

This includes the necessary changes, budgeting issues, schedule, etc.

- The amount of current information available (what else does the entity need to know to do this?)

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Additional monitoring and/or data collection might be required before the appropriate path can be formulated.

- The nature and type of approvals required (what choices and options require additional approvals?)

The environmental due diligence often identifies areas of environmental reviews and approvals that may not have initially be considered by project proponents.

- Deadlines and timing (how does the ISO 14001 effort integrate with the rest of the entity's activities?)

The correction of the gaps will hopefully be integrated into the project development process in such a manner that the project schedule is not unduly affected.

As projects are moving through the project development and implementation cycle, the project proponents can decide the appropriate responses to the identified gaps. In some cases, this might involve cooperative arrangements with other entities. The standard interdisciplinary project review teams can perform these assessments and document them in review reports. In general, an evolving appraisal report is being prepared and supplemented at various stages. The gaps analysis could be a standard section of the appraisal reports.

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5.0 CASE STUDY-SICHUAN URBAN ENVIRONMENT PROJECT

5.1 Project Overview

The Sichuan Urban Environment Project (SUEP) is a World Bank Water and Sanitation Project located in Sichuan Province, China. It involves water supply, wastewater treatment, and solid waste management. Phase I of SUEP was awarded a $150M USD loan by the World Bank in 1999. During 1997 and 1998, this author was responsible for conducting the World Bank Environmental Assessment of all project components, in conjunction with the Provincial Environmental Protection Bureau. The SUEP is now being implemented, but project components are not yet in operation. **Appendix 7** contains significant detail on the SUEP Phase I project, based in large measure on the Environmental Assessment for the project.

Sichuan Province, located in the southwest of China, is the third most populous province with over 82 million people over an area of about 385,000 km^2. The province had been the most populated province until the spring of 1997 when Chongqing and the surrounding area were given provincial status. Sichuan Province is land-locked, approximately 1500 km from the sea and shares its borders with 8 other provinces - Qinghai, Gansu and Shaanxi to the north, Hubei and Hunan to the east, Guizhou and Yunnan to the south and Xizang (Tibet) to the west. Refer to maps in **Appendix 7**.

The topography of Sichuan Province consists mainly of mountains and plateaux and can be geographically divided into the eastern basin area, the western plateau and the mountain area. About 95% of the provincial population lives in the basin area. The capital of Sichuan Province is Chengdu, located in the portion of the basin area known as

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the Chengdu plain, often referred to as "the land of plenty". Chengdu plain's level terrain, fertile land, plentiful rainfall and temperate climate combined with established irrigation systems such as the Dujiangyan Irrigation Scheme (operating since 300 A.D.) all contribute to the area's large agricultural output. The western half of the province is dominated by the Himalayan Mountains, with an average altitude of 3,000 m, which peaks at 7,500 m at the Gonga Shan massif located in the southwestern area of the province.

Most of the large cities in Sichuan Province are located on tributaries to the Yangtze River, located along the southern provincial border. The small amount of precipitation in the dry season, coupled with significant wastewater inflows and high year-round agricultural use, contributes to significant water pollution problems in these tributary surface waters. In order to fully solve these pollution problems in Sichuan province, major works will need to be developed for most of the cities in the province. It is not possible to finance all necessary works in one step. It is therefore foreseen that the SUEP will continue over many years with several phases. The present project is seen therefore to be Phase I of a longer-term program.

The SUEP objectives were to enable municipalities to recover from past environmental degradation of water and land resources and to implement policies, practices and institutions to facilitate and sustain the cost of effective provision of essential services. The location of the Sichuan Province and SUEP cities in upstream areas tributary to the Three Gorges Scheme (TGS) on the Yangtze River was also a key determinant of project priority. The overall objective of the SUEP was therefore:

- **To allow environmentally sustainable growth in Sichuan Province.**

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The eastern half of the Sichuan Province has four major rivers, the Tuo, Min, Jialing and Wu, which all flow into the Yangtze at the southern part of the province. Together with the Jinsha and rivers in the mountainous western part of the province, they endow the province with rich water resources. Sichuan Province lies to the northwest of the Yangtze and 98% of the province's surface run-off drains to the Yangtze. The Project Cities lie on the Tuo and the Min Rivers, which drain to the Yangtze.

The significant urbanization and industrialization is putting extreme pressure on the surface waters in the five Phase I SUEP cities. Selection of the projects in these cities is described in **Appendix** 7. It is also very important to realize that there are many small drainage channels and tributaries in these urban areas that consist mainly of domestic and industrial wastewater discharges, hence the environmental needs extend well beyond the larger, classified surface waters.

The Phase I SUEP projects concentrated on urban water resources and water quality issues. The water resources modeling and strategies contain significant information on the overall water resource conditions and wastewater loadings from other pollutant sources in the study area. Important environmental aspects in the long-term plans for the province should cover aspects such as industrial wastewater, agricultural water usage and water quality impacts, non-point pollution control and related issues.

These issues were found to be significantly important to the overall water resource and water quality situation of the Province but were not fully addressed in the Phase I of SUEP. The Provincial authorities agreed that these issues must be re-visited in later phases of SUEP, but the proposed interventions of Phase I are necessary regardless

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of the ongoing efforts to develop an integrated system for water resources and water quality decision-making in the Province. The Industrial Pollution Control Action Plan, which is now being implemented, provides a reasoned development plan to deal with the serious industrial discharges in the area and will form a basis for the introduction of more effective industrial pollution control.

Agriculture is by far the most water-consuming sector in the province. From the present average consumption of 37 million m^3/day, it is expected (despite a decrease in agricultural land) that irrigated agriculture will increase to create a water demand of 40-45 million m^3/day in 2010. The general agricultural practices, with widespread terracing capturing the natural runoff, favors high water losses by evapotranspiration, thereby limiting the water available for the major cities. Because water use for irrigation mostly coincides with dry weather conditions, it is a significant factor affecting water resource availability during periods of low river flow, and hence, is often the key factor determining water resource conditions for urban areas. An overall discussion of the provincial water supply and consumption is given in **Appendix 7.**

The pollution level in Jinsha-Yangtze and Jialing rivers is generally low, but the entire Tuo river and parts of the Min river are polluted by wastewater. Small rivers like the Fu in Chengdu and the Fuxi in Zigong are heavily polluted. Available monitoring data for these rivers is included in **Appendix 7.** According to previous studies, the main pollutants are mostly confined to the following:

- Micro-organisms including bacteria from households and animal husbandry
- Degradable organic matter from households and industry
- Ammonium/ammonia from households and industry
- Nutrients, phosphorus and nitrogen, which contribute to eutrophication problems.

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The Sichuan provincial government has undertaken overall planning of the exploitation and utilization of water, the collection treatment and discharge of wastewater and the collection and disposal of solid waste in a number of the cities in the Yangtze River catchment area as a part of the longer term objectives of SUEP. This planning covers the cities of Chengdu, Deyang, Zigong, Neijiang, Luzhou, Leshan, Yibin, Mianyang, Guangyuan, Panzhihua and Nanchong. The objectives of this planning are to:

- Comprehensively control water body pollution of the main channel of the Yangtze River and its four tributaries in Sichuan Province;
- Meet the increasing water demand of large and medium sized cities in the province and to improve the urban environmental quality of cities along the rivers;

Over the long term, the complete implementation of the above planned components or sub-projects will ultimately resolve the problems related to water supply, wastewater treatment and solid waste or refuse treatment/disposal for 75% of urban residents in the province. According to Provincial authorities, the implementation of those sub-projects will have practical and far-reaching significance for creating a good ecological environment, improving people's living standard and achieving the strategic target of sustainable development in Sichuan. (Phase I of the SUEP includes some but not all of these planned projects.)

The SUEP Phase I has been undergoing preparatory work for several years under a variety of funding sources, in addition to the World Bank project preparation work of Mott MacDonald, under funding by the British Department for International Development (DFID). Some of the most relevant work on the project is listed below:

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- Water Sector Fact Finding Study carried out by Ausino (Australian funding);
- Development Trends Infrastructure Study undertaken by Chreod (Canadian funding);
- Urban Water & Wastewater Resources Strategy including water quantity and quality modelling carried out by COWI/DHI (Danish funding);
- GIS Implementation study carried out by several Canadian firms in joint venture as the Canadian Sichuan Information Management Consortium.

Although a large number of proposals were submitted to SUEP Management Office (SUEPO) from the project cities, SUEPO has proposed that the projects within the Tuo River Basin, Chengdu and Leshan for priority implementation during the Phase I of SUEP. The provincial SUEPO provided the following background information relative to this prioritization:

- The Tuo River Basin has the highest preference because it contains over 22 million population, or about 20% of the provincial total, even though it only contains 5% of the provincial land area. Water shortages are severe in the basin and pollution loads are serious, negatively affecting the ability to abstract more water.
- Chengdu City, the capital of Sichuan, is the center of Southwestern China in terms of economy, trade and culture. The environmental infrastructure is minimal, far short of what is necessary to serve the city causing extreme water quality degradation in the urban area.
- Leshan is one of the most popular tourist cities in China and the location of the Grand Buddha cultural and historic site. Water supplies are outdated and

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insufficient and there is no adequate wastewater collection or treatment system. Solid waste management in the city is also inadequate.

Six cities were originally to be included in the Phase I of SUEP but the Neijiang WwTW scheme was dropped due to funding limitations and lack of project readiness. Five cities are now covered by the SUEP Phase I, with four getting new water treatment works, four getting new wastewater treatment works, and one getting an improved solid waste management system. **Appendix 7** provides details on the size and costs of these SUEP component projects.

The Urban Pollution Impacts Assessment (UPIA) considered impacts on Sichuan's rivers from discharges of municipal wastewater that was of domestic and industrial origin. The objective underlying this water quality modeling work was to identify, from a selection of possible wastewater treatment and collection schemes, those bringing the greatest benefit to the environment and to the people of Sichuan for the least expenditure of limited funds. Normally in a benefit cost analysis a monetary value is calculated to quantify the benefits and this may be compared directly with the construction and operating costs of the project. For an environmental improvement project such as SUEP it is not practical or realistic to attempt to calculate a monetary value for the benefits. For this reason, an alternative using a River Basin Pollution Index (RBPI) was developed, which provided a sound, objective and consistent quantitative measure of environmental improvement. Details on the development and application of the UPIA and RBPI can be found in **Appendix 7.**

The prediction of the UPIA was that unless major steps are taken to reduce and treat discharges, the quality of the water in the rivers Min and Tuo is going to seriously

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deteriorate from its already poor condition. The implementation of the component works, selected from the UPIA prioritization, will do much to improve river water quality but even on completion of these works it will not be possible to meet river water quality objectives, in all seasons, for much of the length of the rivers in the Min and Tuo Basins.

The main problems in the basins are hydrology, in that over 80% of the annual precipitation occurs during the 4-6 month monsoon season, causing little dilution capability in the dry season. The UPIA indicates that the low flows in a number of river reaches would need to be augmented in the dry season for objectives to be attained. Most of the dry season streamflow consists of wastewater effluents from a variety of urban and industrial sources. Agricultural water usage will also need to be clearly assessed. Clearly this is must be addressed in later Phases of the SUEP. The appraisal and environmental assessments for the Phase I of the SUEP came to the following conclusions:

1. The environmental conditions are serious and the environmental infrastructure needs of Sichuan Province are high, and expanding rapidly.
2. The Phase I SUEP projects have emerged from a rigorous prioritization process, are well formulated, and have a detailed and complete preliminary designs and cost estimates.
3. There is good public support for the projects based on 'Willing To Pay' surveys and public opinion surveys. (See **Appendix 7** for details.)
4. The proposed projects can meet financial and economic tests of sustainability and are affordable to the local citizens.
5. Social impacts consist mainly of land acquisition and resettlement and these impacts are not significant and being well managed by a detailed RAP.

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6. The potential environmental benefits of the Phase I SUEP projects are large based on results shown in the UPIA.
7. Potential construction and operational phase impacts of the proposed Phase I projects have been adequately assessed and no major issues or unmitigatable were identified. Detailed mitigation and monitoring procedures have been prepared which should adequately lessen the overall effect of these potential impacts. Monitoring costs have been included for this work and assignments detailed.
8. The overall conclusion was that the potential positive impacts are large, the potential negative construction and operation impacts can be successfully mitigated, and the projects contain no serious problems or "fatal flaws" in its formulation. These project components are essentially environmentally-positive and should be approved by the World Bank (project approved by Bank in 1999).

5.2 SUEP Gaps Analyses

The proposed Environmental Management Systems (EMSs) shown for the various project phases in **Appendices 2-6** were applied to the Phase I of the SUEP. **Appendix 7** provides more detail on the designs, environmental issues, and project reviews for the Phase I of the SUEP. The construction of the Phase I SUEP projects is ongoing, since the World Bank loan was only approved in 1999, hence the proposed implementation schedule is somewhat out of date. As such, the last phase of the project relative to Implementation and Tracking is somewhat premature at this time, but the project was assessed to the extent possible.

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The format for the gaps analyses was described in Chapter 4.5. For now, the author used his personal experience working on the project for over six months in Sichuan Province to score the compliance with the various proposed EMSs. If this procedure were to be implemented by entities such as the World Bank, such reviews would likely occur during appraisal missions and be accomplished at workshops with input from local officials, Bank specialists, consultants and others. The goal of these reviews would be to continually "steer" the project toward a sustainable outcome at various points in the project development process, up to and including implementation.

Appendix 8 contains the detailed results of the SUEP Phase I Gaps Analyses, with the EMSs given shorthand descriptions. More detail on the phased EMSs is found in **Appendices 2-6.** The following sections summarize some of the ratings and project characteristics that can be seen in these charts.

Project Formulation (1.0)

The gaps analyses results in **Appendix 8** indicate that the SUEP is moving the regional cooperation, national and provincial policies and strategies, and water management institutions in the desired direction but there remains a lot to accomplish. The development of water quality goals and prioritization schemes in SUEP are the first such efforts in Sichuan province. The SUEP is requiring the establishment and/or strengthening of water supply and wastewater management companies working under an enterprise concept. Relative to health and water/sanitation goals, the SUEP should provide significant health improvements in these urban areas, where the population is exposed to raw sewage in open sewers. The Urban Pollution Index indicates that significant additional investment is

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required before the surface rivers in Sichuan Province meet the water quality standards. (Much of this problem is hydrological, whereby the monsoon precipitation patterns means that many areas receive most of the annual precipitation over a 4-6 month period, and there is inadequate dilution water in the dry season.) However, SUEP is moving in the desired direction, and the removal of much of the direct access to the raw sewage (i.e. - covering open sewers and raw sewage outfalls) will be an important health benefit immediately.

Based on cost-effectiveness evaluations, the SUEP is employing appropriate technology and addressing industrial wastewater contributions. Demand management is not a SUEP target, but significant areas of water supply losses in the existing distribution systems are to be located and repaired. Public involvement was limited to surveys of public officials, but this is considered a positive step in the right direction to a more open process. Integrated water management addressing the large irrigation water use, potential for conjunctive use, inter-basin transfer of water to assist with low streamflows and other concepts are moving ahead but need significant additional work.

The SUEP complies with national policies but is unable to ensure compliance with these goals in Phase I alone. Although health improvement is a SUEP target, there was not a health assessment component in the project. The SUEP was formulated well in regard to the coordination of donor activities, as the bi-lateral aid projects were all folded into the SUEP Phase I project analysis. The SUEP is designed to improve technology, transfer technology, and design and construction expertise, and improve management institutions. The overall conclusion is that the Phase I of SUEP is formulated well in regard to the EMSs, and the gaps identified can assist in the formulation of later phases of SUEP, with the ultimate outcome targeted at sustainable water management in Sichuan Province.

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Technical/Economic Assessment (2.0)

The use of appropriate technology was given some measure of limited review, but low-cost and non-mechanical wastewater treatment options were not considered viable by the Provincial EPB. This is in spite of the fact that only 1% of the approximately 80M residents of the Province have any form of wastewater treatment, beyond septic tanks. Also, the one existing large mechanical WwTW in Chengdu has suffered from operational problems, lack of meeting effluent standards and a total inability to operate the anaerobic digester. Given mechanical treatment as baseline by local authorities, secondary treatment was found to be more cost effective than primary treatment, except in Leshan where preliminary treatment only is used in Phase I (due to significant dilution provided by Qingyi River at this location).

The project fully used willingness-to-pay surveys and a complete economic analysis of the proposed projects. All were found viable. CBA was not used due to problems in quantifying benefits, but the UPIA demonstrated the appropriateness of investments and potential improvements in surface water quality. Resource pricing was demonstrated by setting the required rate structures for the water supply and wastewater treatment companies, operating under the enterprise concept. The evaluation of non-structural approaches was barely initiated under Phase I of the SUEP and will need to be developed further in the integrated water management studies in future phases. Enforcement issues are problematic and were not fully addressed by SUEP. There are not sufficient enforcement mandates to ensure that municipal WwTWs are operated properly and meet effluent standards. The SUEP does ensure that pretreatment programs are in place for industries discharging to

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municipal WwTW, but enforcement may again be problematic, especially for aging state-owned enterprises (SOEs).

Potential risks relative to project failure were addressed in the SUEP appraisal reports. These generally centered around financial and institutional issues, and not the risk to the natural resources. The Phase I of SUEP made some effort at quantifying multiple objectives, but the Terms of Reference for the project were fairly well focused on meeting water and sanitation goals. Again, future phases of the SUEP addressing integrated water management will need to focus on issues such as irrigation water use, groundwater, non-structural alternatives, dry season flows, etc. Lack of available dilution water in the non-monsoon season is a severe problem, especially with the enormous populations and wastewater volumes.

The overall conclusion is that the Phase I of SUEP was assessed fairly well technical and economic issues, given the identified need for additional testing and monitoring systems, some of which were added as a Technical Assistance Component to SUEP. Phase I will require implementation of additional future components addressing integrated water management issues before sustainable water management becomes a reality in Sichuan Province. In addition, the financial and institutional risks could be severe, since the management of wastewater is a relatively new concept in Sichuan Province. There are also questions of institutional enforcement issues relative to ensuring that WwTW are properly operated, that industries comply with pre-treatment standards, and WwTW sludge is disposed of in an environmentally acceptable manner.

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Enhanced Environmental Impact Assessment (3.0)

The Phase I of the SUEP did a good job of addressing the EIA water and sanitation EMSs as shown in the gaps analyses. Due to wastewater inflows, lack of year-round streamflows, and significant channelization, there is minimal biological integrity in the surface waters of Sichuan Province (except for the Yangtze River) and bioassessment and biological criteria were not addressed in the SUEP. Relative to comprehensive assessment, and has been mentioned previously, the Phase I of SUEP had not fully addressed all parts of the regional or sectoral water quality system in the province, and future phases of the SUEP will be required.

The regional water quality assessment performed by COWI as a precursor to the SUEP provided a good first-cut analysis of water quality issues, but significant additional testing and monitoring is required to verify some of the data and assumptions contained in this work. Some surface water quality monitoring data were provided to the SUEP, but with non-verified testing and laboratory procedures. Phase I of the SUEP has a technical assistance component to improve water quality monitoring in the province.

The SUEP addressed minimal dry season streamflows and quantified the water quality problems associated with these conditions. However, any potential solutions to improve the dry season baseflows were beyond the scope of the Phase I of the SUEP, and will be an important consideration in future phases. Although regional or sectoral environmental assessments or action plans in place, the Phase I of the SUEP did evaluate potential impacts (euthrophication potential) to the downstream Three Gorges Dam under construction on the Yangtze River.

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A provincial-wide prioritization scheme and pollution index was used to verify that the Phase I projects maximized environmental improvement in the province. Cumulative impact assessment relative to other major initiatives in Sichuan province was not conducted by the Provincial EPB, as this requirement is not yet standard practice in China EA work. Likewise, there was minimal effort in the development of environmental indicators for the province in SUEP, but there were performance indicators for the project components.

Construction and operation phase impacts were properly addressed, and appropriate mitigation and monitoring programs were initiated. The costs of mitigation were included in the investment package, and institutional issues were addressed. The overall conclusion is that the Phase I of SUEP handled the Enhanced EIA EMSs reasonably well, given the fact that it is the beginning of a long investment program, and it is only the first step in what will be a long process to provide sustainable water management in Sichuan Province.

Implementation and Tracking (4.0)

The Phase I of SUEP is now being constructed and these EMSs have been evaluated to the extent possible, given that operations have yet to be initiated. The SUEP addressed the likely beneficiaries and noted that the urban poor are most affected by the current access to raw sewage in the cities. A detailed resettlement action plan (RAP) was prepared for the project to ensure that any required relocations or property loss was adequately mitigated. Full community participation is not standard EA practice in China and public participation was limited to a survey of public officials, and a willingness to pay survey. Health impacts were assessed in general terms without a full health assessment. There was not a formal social impact assessment, but a detailed RAP was prepared.

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A detailed mitigation and monitoring plan was prepared (that is currently being implemented), but there was not a provision for independent supervision and management of the plan. The mitigation and monitoring program was definitive and should provide important feedback on compliance during the construction and initial operation phases of the project. There was not a major emphasis on sustainability indicators in Phase I of SUEP. A set of performance and management indicators were developed for the project. Operations and maintenance concerns were addressed to the extent possible, but lack of proper O&M is a large risk factor for the Phase I of SUEP. The performance indicators were developed to ensure that proper O&M is done on all components. Other potential risks include the formation of wastewater treatment companies (no history in the province), and institutional capacity and maintenance of an adequate rate structure.

The feedback mechanism for the results of the SUEP was not a major focus item. The performance indicators, mitigation and monitoring plans, and other implementation reports should provide the requisite information for the development of sustainability indicators and the improvement of future projects. Future phases of the SUEP should address this information feedback and formalize the process. The World Bank (2001) shows such a feedback mechanism to assist in the project formulation stage, but details of how this is to be managed are not included. The overall conclusion is that the Phase I of SUEP was formulated well in regard to Implementation and Tracking EMSs, the project is not yet in operation for full assessment. In addition, some of these feedback loops will need to be more fully developed in future phases of the SUEP, in accordance with the emerging World Bank practice and reporting systems.

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6.0 DISCUSSION OF RESULTS

6.1 System Formulation

The use of ISO14000 protocols is being expanded worldwide as a standard template for ensuring that organizations are meeting or exceeding environmental objectives. This research has demonstrated that moving these protocols into the public sector project development process and developing environmental management standards at various stages of water project development is possible and potentially beneficial. The approach uses a standardized descriptive approach for organizational decision support, while using the problem-solving steps of the normative approach.

The formulation of these proposed phased water-related EMSs for use in an ISO 14001 gaps analysis procedure was developed and tested as a potentially convenient and internationally-consistent protocol for addressing water project sustainability at various stages of the project cycle. The evaluative criteria contained in the initial set of water-related EMSs are recognized in the water resources and environmental arenas. There has not been an effort to systematically combine them in a series of project-related reviews at various stages of project development.

This procedure proposed in this research can easily complement existing economic and environmental review processes that are typically used by project proponents, and should become a standard protocol of appraisal reporting. The phased gaps reviews can be attached to the project documents, and updated continually through an implementation plan to "fill the gaps." Concurrently, the proposed system can provide various recommendations for the monitoring and data collection efforts associated with project implementation that:

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1. Assess project performance from a coordinated economic/environmental perspective,
2. Complement the international effort at defining and measuring national progress toward sustainability goals, and
3. Assist with making the decision-making process more "transparent."

Although the EMS auditing system is integrated into monitoring, data synthesis, information management, and indicators, the system produced in this research was not designed to provide "national indicators of sustainability." Many others in the international arena are working diligently on this effort, albeit to a degree of detail in the water sector that many would find less than fully operational. The EMSs produced in this research were intended to improve project assessment and development (in four sets at various project development stages), recommend improvements in monitoring and data analysis, and provide the level of water information on a project level to foster and improve these international efforts.

The results of the proposed gaps analyses developed in this research can be recorded and used as a basis for determining resource priorities for implementing the environmental management system. Systems having a rating of 0 or 1 obviously will require much more effort than those receiving 3 or 4 ratings. The purpose of this implementation plan will be to obtain results that can be used to estimate the activities and extent of effort required to implement an ISO 14001 environmental management system, and to provide the basis for allocation of resources.

Once each requirement has been assessed, and the entity has an overall picture of its activities relative to the ISO 14001 standard, it can begin to develop action plans for each requirement, at each stage of project development through implementation. The

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gaps analysis should be used as an input tool to develop specific action items and priorities. Management also needs to ascertain certain dimensions of the ISO 14001 project before it commits to the implementation path including the size and nature of the gap, what efforts are necessary to improve the condition, the nature of the unknowns, regulatory processes, resources required, and schedules.

The gaps analysis is done under the presumption that filling the identified gaps can and should steer the proposed project to a more sustainable outcome. The identified gaps filling action plan should be a standard protocol of appraisal missions and documentation reports, as it evolves through the project cycle.

6.2 Case Study

The proposed gaps analysis protocol developed in this research was applied to a case study of a large water and sanitation project being implemented in the Sichuan Province of China. The Sichuan Urban Environment Project (SUEP) is being implemented by the Sichuan Province with assistance from the World Bank. SUEP is providing over $300M of environmental infrastructure to the Province, including water supplies, wastewater treatment facilities, and a solid waste management scheme. The author spent considerable time working on this project over a 2-year period, and was very familiar with the development and reviews used by the World Bank on this project (SUEP, 1998).

The details of the Case Study on the SUEP are shown in **Appendix 7**, while the gaps analyses using the protocols developed in this research are shown in **Appendix 8.** The previous chapter reviewed the results of these gaps analyses in detail. The following sections discuss the results of the gaps analysis and implications for wider use.

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Although regional or sectoral EAs or Environmental Action Plans were not in place, the Urban Pollution Impacts Assessment (UPIA) considered impacts on Sichuan's rivers from discharges of municipal wastewater that was of domestic and industrial origin. The objective underlying this water quality modeling work was to identify, from a selection of possible wastewater treatment and collection schemes, those bringing the greatest benefit to the environment and to the people of Sichuan for the least expenditure of limited funds. The River Basin Pollution Index (RBPI) was developed, which provided a sound, objective and consistent quantitative measure of benefit.

The SUEP Project Formulation (1.0) gaps analysis indicated that the SUEP complies with national policies but is unable to ensure compliance with Provincial goals in Phase I alone. Although health improvement was a SUEP target, there was not a health assessment component in the project. The SUEP was formulated well in regard to the coordination of donor activities, as the bi-lateral aid projects were used and evaluated in the SUEP Phase I project analysis. The SUEP was designed to improve technology, transfer technology, and design and construction expertise, and improve management institutions. The conclusion was that the Phase I of SUEP was formulated well in regard to the Project Formulation EMSs, but it is only the first step in what will be a long process to provide sustainable water management in Sichuan Province.

Relative to the Technical/Economic Assessment (2.0) gaps analyses, potential risks relative to project failure were addressed in the SUEP appraisal reports. These generally centered around financial and institutional issues, and not the risk to the natural resources. The widespread implementation of sophisticated wastewater treatment works could be problematic, in that the only existing mechanical WwTW in Chengdu rarely operates

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efficiently, for a variety of financial and institutional reasons. The Phase I of SUEP made some effort at quantifying multiple objectives, but the project was fairly well focused on meeting water and sanitation goals. Again, future phases of the SUEP addressing integrated water management will need to focus on issues such as irrigation water use, groundwater, non-structural alternatives, dry season flows, etc. Lack of available dilution water in the non-monsoon season is a severe problem, especially with the enormous populations and wastewater volumes. The conclusion is that the Phase I of SUEP was properly assessed relative to technical and economic issues, but Phase I will require addition actions targeting overall integrated water management issues before sustainable water management becomes a reality in Sichuan Province. In addition, the financial and institutional risks could be severe, because the management of wastewater is a relatively new concept in Sichuan Province. There are also questions of institutional enforcement issues relative to ensuring that WwTW are properly operated, that industries comply with pre-treatment standards, and WwTW sludge is disposed of in an environmentally acceptable manner.

The SUEP did a generally good job at addressing the Enhanced Environmental Impact Assessment (3.0) EMSs, mainly by use of the UPIA and RBPI, which dealt with the regional water quality issues. The provincial-wide prioritization scheme and pollution index were used to verify that the Phase I projects maximized environmental improvement in the province. The SUEP addressed minimal dry season streamflows and quantified the water quality problems associated with these conditions. However, any potential solutions to improve the dry season baseflows were beyond the scope of the Phase I of the SUEP. The Phase I of the SUEP did evaluate potential impacts (euthrophication potential) to the downstream Three Gorges Dam under construction on the Yangtze River. Cumulative

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impact assessment relative to other major initiatives in Sichuan province was not conducted, but the UPIA did address overall needs for wastewater treatment in the Province. Likewise, there was minimal effort in the development of environmental indicators for the province in SUEP, but there were performance indicators for the project components.

Construction and operation phase impacts were properly addressed, and appropriate mitigation and monitoring programs were initiated. The costs of mitigation were included in the investment package, and institutional issues were addressed. The conclusion was that the Phase I of SUEP handled the Enhanced EIA EMSs reasonably well, given the fact that it is the beginning of a long investment program, and it is only the first step in what will be a long process to provide sustainable water management in Sichuan Province.

Relative to the Implementation and Tracking (4.0) EMSs, a detailed mitigation and monitoring plan was prepared (that is currently being implemented), but there was not a provision for independent supervision and management of the plan. The mitigation monitoring program was definitive and should provide important feedback on compliance during the construction and initial operation phases of the project. There was not a major emphasis on sustainability indicators in Phase I of SUEP. A set of performance and management indicators were developed for the project. Operations and maintenance concerns were addressed to the extent possible, but lack of proper O&M is a large risk factor for the Phase I of SUEP. The performance indicators were developed to ensure that proper O&M is done on all components. Other potential risks include the formation of wastewater treatment companies (no history in the province), and institutional capacity and maintenance of an adequate rate structure.

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The feedback mechanism for the results of Phase I of SUEP was not a major focus item, and this should be addressed in future phases. The performance indicators, mitigation and monitoring plans, and other implementation reports should provide the requisite information for the development of sustainability indicators and the improvement of future projects. Future phases of the SUEP should address this information feedback and formalize the process.

The conclusion was that the Phase I of SUEP was formulated well in regard to Implementation and Tracking EMSs, the project is not yet in operation for full assessment. In addition, some of these feedback loops will need to be more fully developed in future phases of the SUEP.

6.3 Refinement of Concept in Future

The array of potential EMSs developed in this research are non-exhaustive, and in some cases require expansion and in other cases a more limited focus. These EMSs were extracted from the experiences of the author over the past couple of decades. It is hoped that these EMSs have demonstrated that the sustainability of these projects are multi-dimensional in both technical aspects and time, and the projects can be steered toward sustainability throughout the process. It is likely that refined EMSs would be fewer in number, more targeted and less duplicative, and more focused on the particular type of water management project.

The ISO 14001 gaps analysis can be considered an ODSS since there are definitely multiple objectives in play. However, the selection of weighing systems, goal programming, or other techniques for assessing the results of the gaps analysis has been left to the later

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phase of moving the technique into the mainstream. The various agencies who might be candidates to use this system will all have pre-conceived notions on this subject, as well as differing stakeholders that will have to be satisfied.

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7.0 CONCLUSIONS

ISO14001 gaps analyses, using water-related Environmental Management Systems (EMSs), were demonstrated as a potential tool to improve the economic/environmental performance and sustainability of these projects at various stages of project development including formulation, design, review and implementation. The Case Study on the Sichuan Urban Environment Project illustrated the viability of this concept, albeit with the caveat that the proposed protocol likely needs further refinement by banks and donor agencies.

The development of a set of comprehensive EMSs that can be applied to various types of water-related projects (and projects in other sectors affecting water resources) is a daunting challenge. Such an effort could likely be undertaken by an organization such as the World Bank under global environmental project funding.

This research has demonstrated the viability of the approach and met its objectives by:

- Providing some representative multi-dimensional criteria that affect the sustainability of water-related development projects,

  Refer to Appendices 3-6.

- Determining where potential ISO14001 reviews in the standard project cycle could assist with improving the sustainability of water-related development projects,

  See approach and Figure 1 Flow Diagram.

- Developing some representative water-related EMSs for use in standard ISO14001 gaps analyses at various stages of project development and implementation, and

  Refer to Appendices 3-6.

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- Demonstrating the potential application of these EMSs and gaps analyses on a large World Bank water and sanitation project.

  Refer to Appendices 7-8.

The strength in this proposed approach is that it permits decision-makers to visualize potential ways to improve the sustainability of water management projects in a descriptive fashion while using a strict problem-solving approach. This research has demonstrated that such a gaps analyses process and set of EMS reviews can assist decision-makers in performing:

- Assessments and audits of sustainability characteristics of these projects,
- Appropriate improvements to projects at various stages of project development,
- Feedback of appropriate project review information into national and international systems of environmental indicators,
- Improved communication on the project needs and rationale for the proposed solutions to decision-makers and the general public.

The ISO14001 gaps analyses system using water-related EMSs provides decision makers with a protocol that can be used to interrogate project characteristics at various points in the project cycle, critique the project relative to sustainability-related evaluative criteria, and provide suggestions for project improvements and enhancements. It provides a mixture of policy, technical, economic, environmental, public participation, and implementation criteria for review.

Using the ISO14001 process would standardize the approach in all parts of the world and avoid the problem of varying local and national approaches. The EMSs also

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recommend monitoring systems for the project to allow for improvement in assessing project economic and environmental performance and impacts as well as providing information relative to "sustainability indicator" efforts.

The process of defining sustainability will involve all facets and levels of society and is likely to consume decades to matriculate. Local, regional and national viewpoints from many disciplines are required to fully develop sustainable economic planning for a particular country.

This research has demonstrated the multiple dimensions of the issue of sustainability of water in both time and technical disciplines. These dimensions can be used to improve and steer proposed water projects toward sustainability, at various points in the project development process, from formulation to implementation. It is hoped that this initial start at developing a systematic review protocol will lead to more comprehensive tools for improving water project performance relative to sustainability goals.

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Appendix 1.

United Nations Conference on Environment and Development (UNCED), 1992

Review of Water-Related Goals of Agenda 21 - Extracts

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Chapter 14 - Promoting Sustainable Agriculture and Rural Development
Section on Integrated Pest Management and reviewing national pesticide usage practices.

Chapter 16 - Environmentally Sound Management and Technology
Includes encouraging use of integrated pest, disease and crop management techniques to eliminate overdependence on agro-chemicals, thereby fostering environmentally sustainable agricultural practices.

Major action C) Enhancing Protection of the Environment

Objectives: Prevent, halt and reverse environmental degradation through the appropriate use of biotechnology in conjunction with other technologies through:

a) adoption of production processes making optimal use of natural resources, by recycling biomass, recovering energy and minimizing waste generation
b) promotion of use of biotechnologies with emphasis on bio-remediation of land and water, waste treatment, soil conservation, reforestation, afforestation, and land rehabilitation
c) application of biotechnologies and their products to protect environmental integrity with a view to long-term ecological security.

Activities include:

a) develop environmentally sound alternatives and improvements for environmentally damaging production processes
b) develop applications to minimize the requirement for unsustainable synthetic chemical input and to maximize the use of environmentally appropriate products including natural products
c) develop products to reduce waste generation, treat waste before disposal and make use of biodegradable materials
d) develop processes to recover energy and provide renewable energy sources, animal feed and raw materials from recycling organic waste and biomass
e) develop processes to remove pollutants from the environment, including accidental oil spills, where conventional techniques are expensive, inefficient, or inadequate
f) develop processes to increase the availability of planting materials, particularly indigenous varieties, for use in afforestation and reforestation and to improve sustainable yields.
g) develop applications to increase availability of stress-tolerant planting material
h) promote use of integrated pest management

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i) promote use of bio-fertilizers

j) promote use of biotechnologies relevant to biological diversity and sustainable use of biological resources

k) develop easily applicable technologies for sewage and organic waste

l) develop new technologies for rapid screening of organisms for useful biological properties

m) promote new biotechnologies for tapping mineral resources in an environmentally sustainable manner.

Chapter 17 - Protection of the Oceans, all kinds of seas, including enclosed and semi-enclosed seas, and coastal areas and the protection , rational use and development of their living resources

Programme Area A - Integrated Management and Sustainable Development of Coastal and Marine Areas, Including Exclusive Economic Zones

Objectives: Coastal state commitment to integrated management and sustainable development of coastal areas and marine environment by:

a) provide for integrated policy and decision-making process, including all involved sectors, to promote compatibility and balance of uses

b) identify existing and projected uses of coastal areas and interactions

c) concentrate on well-defined issues concerning coastal management

d) apply preventive and precautionary approaches in project planning and implementation, including prior assessment and systematic observation of the impacts of major projects

e) promote methods such as national resource and environmental accounting, that reflect changes in value resulting from uses of coastal and marine areas including pollution, marine erosion, loss of resources and habitat

f) provide access and information to public and groups for participation

Activities by Categories:

Management Related Activities

Wide variety of institutional, planning assessment activities

Data and Information, Databases, indicators, profiles etc

International and Regional Cooperation and Coordination

Area B - Marine Environmental Protection

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Objectives:

a) apply preventive, precautionary and anticipatory approaches to avoid degradation of the marine environment

b) ensure prior assessment of activities that may have adverse impacts

c) integrate environmental protection into other development policies

d) economic incentives for clean technologies and polluter pays principles

e) improving living standards for coastal inhabitants in developed countries

Chapter 18 - Protection of the Quality and Supply of Freshwater Resources: Application of Integrated Approaches to the Development, Management and Use of Water Resources

Area A - Integrated Water Resources Development and Management

Based on the perception of water as an integral part of the ecosystem, a natural resource and economic good, whose quantity and quality determine the nature of its utilization. Four principles should be pursued as follows:

a) promote a dynamic, interactive, iterative and multisectoral approach to water resources management that integrated technological, socio-economic, environmental and human health considerations

b) plan for the sustainable and rational utilization and management of water resources based on community needs and priorities within the framework of national economic development policy

c) design, implement and evaluate projects and programmes that are both economically efficient and socially appropriate within clearly defined strategies, based on full public participation in decision-making

d) strengthen institutional, legal and financial mechanisms to ensure water policy and its implementation are a catalyst for sustainable social progress and economic growth

Area B - Water Resources Assessment

Objectives:

a) make assessment technology available regardless of level of development

b) have all countries allocate sufficient financial means to conduct water resources assessment including impact assessment of climate change on freshwater

c) ensure assessment information is fully used in water mgmt policies

d) install institutional capability for efficient data handling

e) qualified staff

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Area C - Protection of Water Resources, Water Quality and Aquatic Ecosystems

Complex interactions of freshwater systems demand that freshwater management be holistic (taking a catchment management approach) and based on a balanced consideration of the needs of people and the environment. Three objectives will have to be pursued concurrently to integrate water-quality elements into water resource management:

a) maintenance of ecosystem integrity, according to a management principle of preserving aquatic ecosystems, including living resources, and of effectively protecting them from any form of degradation on a drainage basin basis

b) public health protection, a task requiring not only the provision of safe drinking water but also the control of disease vectors in the aquatic envir.

c) human resources development, a key to capacity-building and a prerequisite for implementing water-quality management

All states should set the following targets:

a) identify surface and groundwater resources that could be developed for use on a sustainable basis and other major developable water-dependent resources and to initiate programmes for the protection, conservation and rational use of these resources on a sustainable basis

b) identify potential sources of water supply and prepare outlines for their protection, conservation and rational use

c) initiate effective water pollution prevention and control programmes, based upon an appropriate mixture of pollution reduction at source strategies, environmental impact assessments and enforceable standards for major point source discharges and high-risk nonpoint sources

d) participate in international water quality monitoring and management programmes

e) reduce the prevalence of water-associated diseases

f) establish biological, health, physical and chemical quality criteria for all water bodies (surface and groundwater) with a view toward ongoing improved WQ.

g) adopt an integrated approach to environmentally sustainable management of water resources, including the protection of aquatic ecosystems and freshwater living resources

h) put in place strategies for the environmentally sound management of freshwater and related coastal ecosystems, including consideration of fisheries, aquaculture, animal grazing, agricultural activities and biodiversity.

Activities:

A - Water Resources Protection and Conservation including various planning efforts, especially drainage area.

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B - Water Pollution Prevention and Control, including:

a) polluter pays principles

b) construction of WWTF for domestic and industrial effluents

c) establishment of standards for effluents and receiving waters

d) pollution prevention and waste minimization

e) mandatory EIA for major water resource development projects, and strengthened control of new industrial installations, solid waste landfills and infrastructure development projects

f) use of risk assessment and risk management in reaching decisions and ensuring compliance with those decisions

g) identification and application of best environmental practices at reasonable cost to avoid diffuse pollution, namely, through a limited, rational and planned use of nitrogenous fertilizers and other agrochemicals (pesticides, herbicides) in agricultural practices

h) encouragement and promotion of the use of adequately treated and purified waste waters in agriculture, aquaculture, industry and other sectors

C - Development and Application of Clean Technology, including:

a) control of industrial waste discharges, including integrated life-cycle analysis with pollution prevention and minimization

b) treatment of municipal waste water for safe reuse in agriculture and aquaculture

c) development of biotechnology, inter alia, for waste treatment, production of biofertilizers, and other activities

d) development of appropriate methods for water pollution control, taking into account sound traditional and indigenous practices

D - Groundwater Protection

a) development of agricultural practices that do not degrade groundwater

b) application of necessary measures to mitigate saline intrusion into aquifers of small islands and coastal plains

c) prevention of aquifer pollution through the regulation of toxic substances that permeate the ground and the establishment of protection zones in groundwater recharge and abstraction areas

d) design and management of landfills based upon sound hydrogeologic information and impact assessment, using the best practicable and best available technology

e) promotion of measures to improve the safety and integrity of wells and well-head areas to reduce intrusion of biological pathogens and hazardous chemicals into aquifers at well sites

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f) water quality monitoring of surface and groundwater potentially affected by sites storing toxic and hazardous materials

E - Protection of Aquatic Ecosystems
F - Protection of Freshwater Living Resources
G - Monitoring and Surveillance of Water Resources and Waters Receiving Wastes
H - Development of National and International Legal Instruments that maybe Required to Protect the Quality of Water Resources, as appropriate.

Area D - Drinking Water Supply and Sanitation

Objectives - four guiding principles from Global Consultation, New Delhi, 1990:

a) integrated management of water resources and liquid and solid wastes
b) institutional reform promoting integrated approach and full part by women
c) community mgmt of services backed by strengthened local institutions
d) sound financial practices, better mgmt, use of appropriate technology

Activities:

A - Environment and Health - treatment of wastes, protected water supplies, treatment and safe reuse of industrial waste water, control of water-related diseases
B - People and Institutions - education, full participation, improved institutions.
C - National and Community Management - link national/local planning, planning integration, appropriate technology, increased urban capacities
D - Awareness Creation and Public Information / Participation - improve information management and cooperation

Area E - Water and Sustainable Urban Development

Objective is support of government efforts (all levels) to sustain national development through environmentally sound management of water resources including following strategies:

a) by 2000, have ensured that urban residents have access to at least 40 liters per capita per day of safe water and that 75 per cent of the urban population are provided with on-site or community sanitation facilities
b) by 2000, have established and applied quantitative and qualitative discharge standards for municipal and industrial effluents
c) by 2000, have ensured that 75 per cent of solid waste generated in urban areas is collected and recycled or disposed of in an environmentally safe way.

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Activities:

A - Protection of Water Resources from Depletion, Pollution, and Degradation- sanitary waste disposal, urban storm water and drainage, recycling and reuse of waste water and solid waste, control of industrial pollution, protection of watersheds, forest research, BMP for agrochemicals

B - Efficient and Equitable Allocation of Water Resources - reconcile city planning with sustainable water resources, basic water needs in urban areas, water tariffs

C - Institutional / Legal / Management Reforms - city-wide mgmt of water resources, expand land use plans with water resources, integrate and utilize all interests

D - Promotion of Public Participation

E - Support to Local Capacity Building (all media, skills)

F - Provision of Enhanced Access to Sanitary Services

Area F - Water for Sustainable Food Production and Rural Development

Objective - Key strategic principles for holistic and integrated environmentally sound management of water resources in a rural context as follows:

a) consider social and economic implications of water

b) full participation in all phases, especially women

c) water resource mgmt integrated with policies on health, food, disasters, environmental protection

d) support the role of rural populations, esp women

Activities:

A - Water Supply and Sanitation for the Unserved Rural Poor - national priorities and budget, appropriate technology, suitable cost recovery, community ownership of W/S facilities, monitoring and evaluation, strengthen institutions, increase hygiene, environ mgmt

B - Water-use Efficiency - more efficient and productive ag water use, better water and soil mgmt, monitor irrigation performance, improve local level mgmt, possible use of brackish irrigation water

C - Waterlogging, Salinity Control, and Drainage - introduce surface drainage into agriculture areas to prevent waterlogging, artif drainage, conjunctive use of surface and groundwater, practice drainage in arid/semi-arid areas

D - Water- Quality Management - cost-effective ag water monitoring systems,

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prevent adverse impacts to wetlands, WQ criteria for ag water and marine and riverine ecosystems, minimize soil runoff, proper sewage disposal, use of integrated pest mgmt, environ. education

E - Water Resources Development Programmes - small-scale irrigation and water supply schemes, large scale and long-term programs, promote local initiatives, technical support, appropriate farming technology, multi-purpose hydro power schemes with full environ concerns

F - Scarce Water Resources Management - inc wastewater reuse

G - Water Supply for Livestock - improve quality, prevent contamination

H - Inland Fisheries - mgmt, data, study, envir sound technology

I - Aquaculture Development - study environ impact

Area G - Impacts of Climate Change on Water Resources

Objectives:

a) understand and quantify threat of climate change on freshwater

b) facilitate implementation of national countermeasures

c) to study potential impacts to areas prone to drought and floods

Activities - series of mainly research based studies

Chapter 21 - Environmentally Sound Management of Solid Wastes and Sewage Related Issues

Area A - Minimizing Wastes

Objectives:

a) quantifiable goals on waste weight, volume and composition for waste reduction

b) strengthen procedures for assessing waste quantity and composition changes for the purpose of formulating operational waste minimization policies

Targets include:

a) by 2000, ensure national, regional, and international capacity to assess, process and monitor waste trend information and implement WM policies

b) by 2000, have in place in all industrialized countries programmes to stabilize or reduce the production of wastes destined for final disposal

c) by 2000, in all countries but particularly developed countries, apply programmes to reduce the production of agrochemical wastes, containers and packaging materials, which do not meet HW characteristics

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Area C - Promoting Environmentally Sound Waste Disposal and Treatment

Objective is to treat and safely dispose of a progressively increasing proportion of the generated wastes. Specific targets include:

a) by 2000, establish waste treatment and disposal quality criteria, objectives and standards based on the nature and assimilative capacity of the receiving environment

b) by 2000, establish sufficient capacity to undertake waste-related pollution impact monitoring and conduct regular surveillance

c) by 1995, in industrialized countries, and by 2005 for developed countries, ensure that at least 50 per cent of all sewage, waste waters and solid wastes are treated or disposed of in conformity with national/international envir and health quality guidelines

d) by the year 2005, dispose of all sewage, waste waters and solid wastes in conformity with national/international envir. quality guidelines

Area D - Extending Waste Service Coverage

Objective is to provide health-protecting, environmentally-safe waste collection and disposal services to all people. The targets include:

a) by 2000, have the technical, financial and human resource capacity to provide waste collection services commensurate with needs

b) by 2025, provide all urban populations with adequate waste services

c) by 2025, ensure full urban waste service coverage is maintained and sanitation coverage achieved in rural areas

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Appendix 2

Proposed Environmental Management Systems (EMSs) - Overview

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EMS Overview

The system of ISO14001 Environmental Management Systems (EMSs) have been formulated as a set of questions for rating under a standard 0-4 system. There are a wide variety of weighing systems that a particular user group may deem appropriate to utilize with such a system so the system merely provides the framework for user choices of weights. In addition, a particular set of questions may also be weighed to derive a categorical degree of compliance with the idealized "norm."

Project Formulation EMSs (1.0)

1.1 Broad International and National Goals - Dublin Statement and UNCED
1.2 Integrated Water Resources Management Concepts
1.3 National Planning Components for Sustainable Water Resources
1.4 Detailed Water Project Development Processes

Technical and Economic EMSs (2.0)

2.1 Appropriate Technology
2.2 Conservation and Demand Management
2.3 Environmental Valuation/Pricing Accounting Framework
2.4 Economic Instruments
2.5 Financial Planning and Economic Impacts
2.6 Risk Management
2.7 Cost Benefit Analysis and Multi-Objective Decision-Making

Enhanced Environmental Impact Assessment EMSs (3.0)

3.1 Project Specific Criteria
- 3.1.1 Dams
- 3.1.2 Fisheries
- 3.1.3 Flood Protection
- 3.1.4 Groundwater
- 3.1.5 Hydroelectric
- 3.1.6 Irrigation
- 3.1.7 Water and Sanitation

3.2 Bioassessment
3.3 Point and Non-Point Source Pollution Control
3.4 Minimum Stream Flows
3.5 Regional, Sectoral and Cumulative Impacts
3.6 Environmental Indicators

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Project Implementation EMSs (4.0)

- 4.1 Integration of Environmental and Social Impact Assessments
- 4.2 Environmental Mitigation and Monitoring
- 4.3 Performance Auditing and Management Indicators
- 4.4 Operation and Maintenance
- 4.5 Feedback Mechanism - Project Formulation Stage

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Appendix 3.

Proposed EMSs

Project Formulation Series (1.0)

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1.1 Broad International and National Goals - Dublin Statement and UNCED

The Goals Module are based upon recommendations of either of the following two major sources:

- The International Conference on Water and the Environment, held in Dublin, Ireland, from 26-31 January, 1992 as incorporated into the Dublin Statement
- United Nations Conference on Environment and Development (UNCED) held in Rio de Janeiro, Brazil in June 1992 as incorporated into the Agenda 21 document

1.1.1 International Cooperation and Coordination

- Have **management systems in transboundary river/lake basins** been implemented through: (a) evaluating the experience gained with existing transboundary basin water authorities, committees and commissions; (b) establishing transboundary river/lake basin organizations to manage the planning, development and conservation of transboundary resources, with well defined objectives agreed to by the riparian countries involved; (c) supporting the further development of legal principles and institutional mechanisms for the coordination of water management within transboundary basins; (d) promoting the cooperation of riparian countries within transboundary basins in the establishment of appropriate legal, institutional and operational mechanisms; (e) providing a forum to encourage dialogue and confidence-building measures regarding transboundary issues among riparian countries, and will this project affect them?

- Have **regional coordination schemes** been developed through: (a) strengthening of existing regional mechanisms of a continental and sub-continental scale in order to harmonize policies, strategies and programs; (b) promotion of cooperation on a regional basis for the exchange of experience in the protection and use of transboundary waters, including legal mechanisms and institutions, and will this project affect these schemes?

- Have **information exchange programs** been implemented for the: (a) exchange of data on the components of the water cycle in terms of the quantity and quality through established international programs; (b) establishment and use of international data centers, supported by regulations under international law specifying mutual obligations and rules of procedure; (c) facilitating discussions and the development of recommendations, based on shared experience in areas related to water management such as legislation, research and development, and technology transfer, and will this project affect these programs?

1.1.2 Framework of International Policies, Strategies and Programs

- Have **functions of existing intergovernmental bodies** dealing with water resources been reviewed with a view to improving the monitoring of events and developing recommendations, guidelines, standards, and conventions and will this project have an affect on these bodies?

- Has a **charter of rights and duties** of national and international organizations been developed in the development, utilization and conservation of water resources through the appropriate intergovernmental body, and will this project affect these organizations?

1.1.3 Enabling Environment at the Sectoral Level

- Are **assessment processes** in-place to address (a): the capabilities and needs of agencies at all levels to design and implement sustainable projects; (b) the technical, institutional and budgetary requirements for planning, design, implementation, operation and maintenance of new projects; (c) the extent of coordination between water related agencies and the need for better cooperation; (d) the

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status of the legislative and policy frameworks at all levels; (e) the efficiency of programs through, inter alia, comparison of costs and options for achieving identified targets;(f) information needs, and will this project affect these processes?

- Has **enabling legislation** been adopted to: (a) incorporate sustainable programs for the water sector in national development plans; (b) enable integrated planning and management; (c) enable management decisions to be made at the lowest appropriate level; (d) make practical provision for the long-term sustainability of WRA and forecasting activities; (e) adopt regulatory and economic instruments to combat pollution from all sources, and ensure that the monitoring and surveillance capability is available to enforce standards; (f) implement national programs to introduce sanitary waste disposal facilities based on low-cost upgradeable technologies, and will this project affect these legal systems?

- Are **cooperative ventures** in place through: (a) the establishment of coordinating mechanisms; (b) the transfer of technology; (c) the rationalization of public and private sector intervention; (d) the establishment of inter-sectoral planning groups involving housing, land management and environment protection agencies at city and regional level, and health, finance and environment ministries at national level, and will this project affect these ventures?

1.1.4 Capacity Building

- Have policies, strategies and legislation been developed to ensure an **equitable allocation of resources** through: (a) establishment of explicit national policies and development plans for the water and sanitation (WSS) sector; (b) formulation of legislation necessary to support viable water and sanitation systems; (c) consideration of health consequences in all water resource programs in order to enhance social and economic development and does this project conform?

- Have **water resource institutions** been enhanced through: (a) strengthening the functioning of governments in water resources management and, at the same time, giving full recognition to the role of local authorities; (b) application of the principle that decisions are to be taken at the lowest appropriate level, with public consultation and involvement of users in the planning and implementation of water projects; (c) integration of community management of water within the context of overall planning; (d) development of linkages between national water plans and community management of local waters; (e) support and assistance to communities in managing their own systems on a sustainable basis; (f) encouragement of water development and management based on a participatory approach, involving planners and policy makers at all levels and the local population, especially women, youth, indigenous people; (g) encouragement of local water associations and water committees to manage community water supply and sanitation systems and provision of technical backup; (h) strengthening of local health services; (i) strengthening the monitoring and reconnaissance capabilities of water authorities in relation to health risks; (j) development and implementation of multisectoral rapid response interventions for dealing with epidemics, especially cholera outbreaks, and does this project conform with these recommendations?

- Has **water-related human resource development** at all levels, including special programs for women, been enhanced through: (a) promotion of primary health and environmental care at the local level, including training for local communities in appropriate water management techniques and primary health care; (b) assistance to service agencies in becoming more cost-effective and responsive to consumer needs; (c) mobilization and facilitation of the active involvement of women in water management teams, and does this project conform with these recommendations?

- Have **water-related health education programs** been undertaken towards: (a) enhancement of hygiene, with a focus on women and children, to stimulate demand for and use of improved sanitation and waste disposal facilities; (b) education of populations at risk, particularly regarding

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their individual responsibilities in the prevention and transmission of cholera and other water-related diseases and regarding the opportunities of using suitable low-cost water supply and sanitation technology; (c) promotion of safe disposal/use of human excreta/waste; (d) activating mechanisms to provide populations with better access to essential technical and environmental information, in order to strengthen their role in decision-making processes; (e) urging the general population as well as public and private institutions to intensify sanitary controls and to improve the cleaning and disinfecting of wells, tanks and drinking water installations, and does this project affect these programs?

- Promote **better and more efficient techniques** through: (a) rehabilitation of defective systems, reduction of wastage and safe reuse of water and wastewater; (b) programs for rational and efficient water use and ensured operation and maintenance; (c) research and development of appropriate technical solutions; (d) substantially increasing urban wastewater treatment capacity commensurate with increasing loads and does this project affect these techniques?

- Are strengthened **monitoring, evaluation and information management systems** in place at national and sub-national levels through: (a) evaluation of water and sanitation facilities, including institutional arrangements for operation, maintenance, planning and financing of these services; (b) identification of a core set of WSS indicators and establishment of national monitoring offices; (c) implementation of annual monitoring of WSS indicators; (d) use of indicators at regional and global levels to promote awareness and raise funds; (e) processing, analyzing and publication of monitoring results at national and local levels as a management and advocacy/awareness creation tool; (f) improvement of coordination, planning and implementation, with the assistance of improved monitoring and information management, particularly in community-based self-help projects; (g) development of national inventories of communities at risk, collection of environmental health and epidemiological data, selection of priority areas, and implementation of appropriate interventions, and will this project affect these systems?

- Are **international support mechanisms** in-place to encourage international cooperation and to encourage national governments and external support agencies to develop common policies through: (a) promotion of the exchange of information between water agencies from different countries; (b) coordination and expansion of international efforts regarding technical and financial cooperation to developing countries, particularly related to sector sustainability; (c) development of guidelines for the sustainability of WSS services to be used by external support agencies and developing countries in the formulation of development plans; (d) channeling WSS assistance in conformity with national policies, and will this project affect these mechanisms?

1.1.5 Water Resources Protection and Conservation

- Are the **regulatory tools** in place for water pollution control including standards for effluents and receiving waters, pollution prevention and waste minimization programs, mandatory EIA for major water resource development projects, and strengthened control of new industrial installations, solid waste landfills and infrastructure development projects?

- Does the project address the prevention or **mitigation of diffuse pollution**, namely, through a limited, rational and planned use of nitrogenous fertilizers and other agrochemicals (pesticides, herbicides) in agricultural practices, and urban runoff best management practices?

- Are there in-place and does the project conform to **national plans for water resources protection** and conservation which include the establishment of inter-sectoral programs and coordination mechanisms to integrate land-use planning with water use and conservation requirements?

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- Are there in-place and does the project meet **water quality and water supply criteria** for ecosystems and health protection?

- Does the project conform with **basin action plans**, especially for priority high-risk basins including their rivers, lakes, and aquifers? (These plans should integrate land-use planning with water management and conservation, and there should be coordination of activities of provincial, national and, where necessary, international agencies. Contingency plans should be developed to control accidental spills and to respond to natural disasters.)

- Has the project been formulated under an established and **permanent, multi-sectoral planning and environmental impact assessment process** for water resources development and management covering hydrological, ecological, social, health, economic, and meteorological aspects? (These processes should be used at the national and international levels in government agencies and external support agencies and they should be simple and readily applicable.)

- Does **appropriate legislation, enforcement and economic mechanisms** exist for water resources protection and conservation at the national level with international cooperation to promote water conservation and recycling, pollution prevention and control, and environmentally sound agricultural and industrial practices?

- Do **tax incentives and other economic benefits exist, where appropriate, to industry for water conservation,** recycling of water and minimization of waste discharges? (Subsidizing environmentally-sound practices and compensating for restrictions needed to reduce water pollution from diffuse agricultural sources.)

- Have the **technical and institutional capacities** been strengthened to identify and protect sources of water supply within all sectors of society?

1.1.6 Protection of Quality and Supply of Freshwater Resources

- Does the use of freshwater proposed assist with the goals and objectives developed under a dynamic, interactive, iterative and **multisectoral approach** to water resources management that integrates technological, socio-economic, environmental and human health considerations?

- Is the proposed use of freshwater in compliance with a **plan for the sustainable and rational utilization and management of water resources** based on community needs and priorities within the framework of national economic development policy?

- Does the proposed use of freshwater meet the criteria of being both **economically efficient and socially appropriate** within clearly defined strategies, based on full public participation in decision-making?

- Does the proposed project assist with **strengthening institutional, legal and financial mechanisms** to ensure water policy and its implementation are a catalyst for sustainable social progress and economic growth?

- Does the project assist with making **water resources assessment technology** available, ensure assessment information is fully used in water management policies, and install institutional capability for efficient data handling including qualified staff?

- Does the project address the maintenance of **ecosystem integrity**, according to a management principle of preserving aquatic ecosystems, including living resources, and of effectively protecting them from any form of degradation on a drainage basin basis?

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- Does the project address **public health protection**, a task requiring not only the provision of safe drinking water but also the control of disease vectors in the aquatic environment?

- Has the project's use of freshwater resources been developed under a program which has identified surface and groundwater resources that could be developed for use on a sustainable basis and other **major developable water-dependent resources?** This program should have also initiated programs for the protection, conservation and rational use of these resources on a sustainable basis.

- Have all potentially effective **water pollution prevention and control programs** been included, based upon an appropriate mixture of pollution reduction at source strategies, environmental impact assessments and enforceable standards for major point source discharges and high-risk nonpoint sources?

- Does the project comply with established **biological/health/physical/chemical quality criteria** for all water bodies (surface/groundwater) with a view toward ongoing improved water quality?

- Has planning and implementation of **environmentally sound management of aquatic and terrestrial ecosystems** including catchment and riparian forests, wetlands, riverine floodplains and associated freshwater and estuarine habitats as integral components of comprehensive water resources development occurred and does this project conform?

- Has planning and implementation of **pollution control programs,** with particular attention to the protection of aquatic habitats and inland fisheries, occurred and does this project conform?

- Has a **rehabilitation program been implemented for polluted and degraded lands, surface water and groundwater bodies** to restore aquatic habitats, maintain biodiversity and improve the quality of the water for various human uses and will this project affect it?

- Have **eco-toxicological studies** been undertaken on the long-term effects of particularly harmful chemicals and noxious aquatic species on aquatic biota and related ecosystems and will this project cause harmful effects?

- Has a program to maintain, restore or enhance the **ecological productivity and diversity** of the wetland ecosystems occurred which are important for their social, economic and environmental values and will this project affect it?

- Are improved **capabilities in place to collect, store and process water-related data,** including data related to climate change, and will this project have an impact? (Monitor the hydrological regime, including soil moisture and groundwater balance, and monitor related climate factors, especially in the regions and countries most likely to suffer from the adverse effects of climate change and where the localities vulnerable to these effects should therefore be defined.)

- Are **research programs** in place at the national level to contribute to regional and international research projects on the question of climate change, its early detection and its impact on the hydrological regime and will this project have an impact? (Develop and apply techniques and methodologies for assessing the potential adverse effects of climate change, through changes in temperature and precipitation on freshwater resources and the risk of floods and droughts.)

1.1.7 Groundwater Protection

- Do proposed **agricultural practices prevent the degradation of groundwater**, including the prevention of saline intrusion by over-pumping of groundwater aquifers?

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- Does the project impact aquifer pollution through use of **toxic substances** that could permeate ground and/or impact protection zones in **groundwater recharge and extraction areas**?

- Are **landfills** that will be used or constructed by the project designed and managed based upon sound hydrogeologic information and impact assessment, using the **best practicable and/or best available technology?**

- Are measures included for **water quality monitoring** of surface and groundwater potentially affected by sites storing toxic and hazardous materials?

- Has the **identification and quantification of major groundwater pollution sources** been completed and incorporated into project formulation? (Includes establishment of national inventories (including mapping programs) of groundwater resources and their character and determination of their responses to development activities. Such aquifer information will permit water managers to identify recharge and abstraction areas and interactions between surface waters and aquifers and establish controls on the types of activities which take place in these zones.)

- Does the project help to ensure that resource management and legislation provides for the **sustainable management of groundwater,** and conform to national legislation for protecting groundwater?

- Does the project promote **conservation and environmentally sound practices,** including: (a) development of agricultural practices that do not degrade groundwaters; (b) design and management of landfills based upon sound hydrogeological information and impact assessment, using the best practicable and best available technology; (c) promotion of measures to improve the safety and integrity of wells and well-head areas to reduce intrusion of biological pathogens and hazardous chemicals into aquifers at well sites?

- Does the project assist with development of technologies for the promotion of **waste minimization, pre-treatment and recycling?**

- Have groundwater abstraction and recharge areas been protected through the establishment of **protective zones** where polluting activities are prohibited and does the project conform?

- Does the project incorporate necessary measures to **mitigate saline intrusion** into aquifers of small islands and coastal plains as a consequence of sea level rise or overexploitation of coastal aquifers?

1.1.8 Ocean Protection

- Does a coastal project operate under a **policy of integrated management** and sustainable development of coastal areas and marine environment including an integrated policy and decision-making process, including all involved sectors, to promote compatibility and balance of uses?

- Are all preventive and **precautionary approaches** in project planning and implementation utilized, including prior assessment and systematic observation of the impacts of major projects?

- Is **national resource and environmental accounting** utilized to reflect changes in value resulting from uses of coastal and marine areas including pollution, marine erosion, loss of resources and habitat, and to provide access and information to public and groups for participation?

- Does coastal zone planning **integrate environmental protection** into other development policies?

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- Are there economic incentives for clean technologies and **'polluter pays'** principles?

- Are the capabilities in-place to **monitor rises in sea-level and related hydrological parameters** and is this project potentially affected?

- Has a model been constructed outlining the likely **socioeconomic and environmental impacts** of a rise in sea-level with potential response strategies and will this project affect this planning?

1.1.9 Health Impacts

- Has **technical and financial support** been provided for the design and implementation of programs in developing countries through: (a) intensification of water quality control and the operation of water treatment plants and other supplies (wells, springs, etc.); (b) assistance to communities to upgrade water storage facilities and identify appropriate technologies for the disinfection of water and wastes, promoting the use of in-house disinfecting techniques where public supplies cannot be adequately safeguarded, and will this project affect these programs?

- Is a **program of environmental health protection** in place through: (a) establishment of protected areas for sources of drinking-water supply; (b) sanitary disposal of excreta and sewage, using appropriate systems to treat waste waters in urban and rural areas; (c) expansion of urban and rural water-supply and development and expansion of rainwater catchment systems, particularly on small islands, in addition to the reticulated water-supply system; (d) treatment and safe reuse of domestic and industrial waste waters in urban and rural areas; (e) development of low-cost sewerage and disinfection systems for low-income settlements and make low-cost water supply and sanitation technology choices available, and will the project affect the program?

- Is the monitoring of relevant **health indicators** occurring and will this project have likely impacts on these health indicators?

- Are **WSS components included in all irrigation projects** with adopted wide-scale environmental management measures to control disease vectors in place and will this project affect them?

1.1.10 Drinking Water Supply and Sanitation

- Does the project foster the **integrated management** of water resources and liquid and solid wastes resulting from the project, directly and indirectly?

- Does the project foster **institutional reform** that promotes an integrated approach and full participation by women?

- Is the community management of services backed by **strengthened local institutions**? This includes sound financial practices, better management and use of appropriate technology?

- Does the project foster the attainment of the following **urban goals** (revised from UNCED goals of 2000):
  a) by 2010, have ensured that urban residents have access to at least 40 liters per capita per day of safe water and that 75 per cent of the urban population are provided with on-site or community sanitation facilities
  b) by 2010, have established and applied quantitative and qualitative discharge standards for municipal and industrial effluents
  c) by 2010, have ensured that 75 per cent of solid waste generated in urban areas is collected and recycled or disposed of in an environmentally safe way?.

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- Do solid waste disposal implications of the project include **quantifiable goals** on waste weight, volume and composition for waste reduction? Are methods included to assess waste quantity and composition for the purpose of formulating operational waste minimization policies?

- Does the project foster the attainment of the following **solid waste management goals** (revised from UNCED goals of 2000):
  a) by 2010, ensure national, regional, and international capacity to assess, process and monitor waste trend information and implement WM policies
  b) by 2010, have in place in all industrialized countries programs to stabilize or reduce the production of wastes destined for final disposal
  c) by 2010, in all countries but particularly developed countries, apply programs to reduce the production of agrochemical wastes, containers and packaging materials, which do not meet HW characteristics?

- Does the project foster the attainment of the following **solid waste and sewage management quantity goals** (revised from UNCED goals of 2000):

  a) by 2010, establish waste treatment and disposal quality criteria, objectives and standards based on the nature and assimilative capacity of the receiving environment
  b) by 2010, establish sufficient capacity to undertake waste-related pollution impact monitoring and conduct regular surveillance
  c) by 2010, ensure that at least 50 per cent of all sewage, waste waters and solid wastes are treated or disposed of in conformity with national/international environmental and health quality guidelines
  d) by the year 2010, dispose of all sewage, waste waters and solid wastes in conformity with national/international environmental quality guidelines?

- Does the project foster the attainment of the following **sanitation goals** (revised from UNCED goals of 2000):
  a) by 2010, have the technical, financial and human resource capacity to provide waste collection services commensurate with needs
  b) by 2025, provide all urban populations with adequate waste services
  c) by 2025, ensure full urban waste service coverage is maintained and sanitation coverage achieved in rural areas?

- Has international technical and financial support been provided to develop **costed proposals** (including operation and maintenance) for providing services to the urban and rural poor, with allocated commensurate budgets, and will this project affect these proposals?

- Are **appropriate procedures for project implementation** and the improvement of water and sanitation (WSS) services in place through: (a) designing of projects on the basis of effective demand and what people want and are willing to pay for; (b) utilizing technologies appropriate to the capabilities of the communities, for example the village level operation and maintenance (VLOM) program of the World Bank; (c) adopting cost recovery policies which are compatible with the users' willingness to pay for WSS services; (d) adjusting land-use practices and improving sanitation and community and industrial waste disposal to ensure the protection of groundwater and surface water including coastal seas, and will this project conform to these procedures?

- Has **community ownership, empowerment and management of WSS systems** been implemented through: (a) accepting of WSS as a comprehensive development activity rather than an engineering project; (b) actively promoting the use of participatory mechanisms for involving communities, with emphasis on the role of women, in the planning and implementation of programs for water use, water conservation, and WSS services, and will this project affect it?

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- Has a program been implemented to ensure the **equitable and efficient use of water** through: (a) using progressive water tariffs that reflect the true cost of providing and maintaining supplies, including cost-recovery, and encouraging conservation and minimization of waste; (b) charging policies that will enable the very poor to receive basic services; (c) basing the choice of technology and service levels on user preferences and willingness to pay; (d) introducing suitable cost-recovery through demand management mechanisms, and will this project affect the program?

- Have **WSS sector plans and national programs** been undertaken with particular emphasis on the optimization and sustainability of existing systems, the adoption of appropriate technology in new schemes, sound finances and extension to marginal areas, and will this project affect these plans and programs?

1.1.11 Water for Sustainable Food Production and Rural Development

- Does the project encouraging the use of **integrated pest, disease and crop management** techniques to eliminate over-dependence on agro-chemicals, thereby fostering environmentally sustainable agricultural practices?

- Does the project foster the key strategic principles for **holistic and integrated environmentally sound management** of water resources in a rural context as follows:
  a) consider social and economic implications of water
  b) full participation in all phases, especially women
  c) water resource management integrated with policies on health, food, disasters, environmental protection
  d) support the role of rural populations, especially women?

- Does the project assist with **water supply and sanitation for the unserved rural poor** through national priorities and budget, appropriate technology, suitable cost recovery, community ownership of W/S facilities, monitoring and evaluation, strengthened institutions, increased hygiene and environmental management?

- Does the project utilize more efficient and **productive agricultural water use**, better water and soil management, monitor irrigation performance, improve local level management, possible use of brackish irrigation water?

- Does the project address potential for **waterlogging, salinity and drainage problems** including the introduction of surface drainage into agriculture areas to prevent waterlogging, artificial drainage, conjunctive use of surface and groundwater, etc?

- Does the project provide for **integrated water quality management** including cost-effective agricultural water monitoring systems, prevention of adverse impacts to wetlands, WQ criteria for agricultural water and marine and riverine ecosystems, minimizing soil runoff, proper sewage disposal, use of integrated pest management, environmental education, etc.?

1.1.12 Environmentally Sound Technology

- Does the project prevent, halt and reverse environmental degradation through the **appropriate use of biotechnology** in conjunction with other technologies? This would include bio-remediation of land and water, waste treatment, soil conservation, reforestation, afforestation, and land rehabilitation.

- Are proposed production processes making optimal use of natural resources, by recycling biomass, recovering energy and **minimizing waste generation**? This would include maximizing the

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development of environmentally sound alternatives and improvements for environmentally damaging production processes.

- Is **pollution prevention** a major design goal for a proposed production process? This would include developing applications to minimize the requirement for unsustainable synthetic chemical input and to maximize the use of environmentally appropriate products including natural products, developing products to reduce waste generation, treat waste before disposal and make use of biodegradable materials, and developing processes to recover energy and provide renewable energy sources, animal feed and raw materials from recycling organic waste and biomass.

- Does the project **anticipate environmental problems** such as unintentional discharges of pollutants and provide for mitigation measures? This includes development of processes to remove pollutants from the environment, such as accidental oil spills, where conventional techniques are expensive, inefficient, or inadequate.

- Do proposed methods to handle sewage and organic waste and organic waste utilize **"appropriate technologies"** for the area in question, taking into account short and long term goals? This includes the development of appropriate methods for water pollution control, taking into account sound traditional and indigenous practices.

- Are proposed industrial waste discharges evaluated with **integrated life-cycle analysis** and the maximum use of pollution prevention and minimization?

1.2 Integrated Water Resources Management Concepts

Integrated water resources planning should have two principal **goals**:

1. to plan **environmentally sound** programmes and projects that are **economically efficient** and **socially desirable**, and
2. to execute projects that will be **sustainable** over a longer period of time, **irrespective of the continued availability of external financial or technical assistance.**

To be effective, integrated water resources planning and management should **pay proper attention** to:

- Legal, institutional, budgetary and other constraints.
- Planning objectives at national, regional and local levels.
- Physical interrelationships among the units of a water resources plan.
- Supporting infrastructure that is needed to secure the products and services of a plan, their distribution to beneficiaries, and the benefits and costs of the plan.
- Identification of all appropriate alternatives for development, preservation and enhancement with different contributions to planning objectives and different amounts of products and services.
- Possible trade-offs among objectives, purposes, and effects of a plan.
- Externalities of the plan.
- All effects of the plan including those of engineering, economic, environmental, social, legal and institutional nature.
- Contributions by engineers, economists, biologists, and other disciplines related to the plan, and contributions by agencies representing, all economic sectors affecting or affected by the plan.
- Involvement of groups or individuals affected by or interested in the plan, particularly women's groups.
- Method of presenting the features and expected results of the plan so that it can be commented upon by interested parties and acted upon by decision-makers.

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1.2.1 Loan and Donor Targets

- Was the project developed under a **comprehensive analytical framework** for water resources management, and does the project meet the country's needs, resources, and capabilities?

- Does the project allow for the **incorporation of cross-sectoral and environmental considerations** in the design of investments and policies by recognizing the interactions between the various elements of the local river basin's ecosystem?

- Does the project place emphasis on **incentives for efficiency and financial accountability** by promoting financially autonomous water entities, privatization, and community ownership?

- Does the project rely on **pricing as a management device** that reflects scarcity and encourages efficient utilization of the resource?

- Was the project developed under a **strengthened legal and regulatory framework** for dealing with the pricing, monopoly organizations, environmental protection, and other aspects of water management that are not adequately handled by unrestrained market forces and does this project positively impact this framework?
- Does the project support regional efforts to **decentralize water service delivery** responsibilities to local governments and to transfer some of these functions to the private sector, to financially autonomous entities, and to community organizations, such as water user associations?

- Does the project enhance the capacity of governments, staff, and related institutions at the central and local levels to manage water resources through **support for training in various aspects** of water management?

- Does the project **encourage the participation of beneficiaries and affected parties** in planning, designing, implementation, and management of water activities?

- Does the project assist with government actions in protecting, enhancing, and restoring water quality and **water dependent ecosystems,** and in abating water pollution, through improved and expanded sanitation and wastewater collection and treatment?

- Does the project assist with local efforts to provide adequate **water and sanitation services for the poor,** thus helping to stop the spread of disease in crowded low-income areas?

- Does the project support **appropriate technology** by supporting research and development of low cost options, and adaptation of technology for irrigation distribution, water supply and sanitation, flood control, pollution monitoring, and waste treatment?

1.2.2 Formulation of sound national water policies

- Does the project **support the major data collection and dessemination elements** necessary for the preservation of the natural water resources system including:

    - establishing and maintaining an effective **national hydrologic data system;**
    - coordinating this system with other specialized public and private data systems;
    - establishing open access to these databank systems;
    - participating in a national geographic information system combining data series on land, water and other resources;
    - and promoting the highest scientific standards in all of these activities?

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- Does the project support **sustained research** on understanding the natural water resources system and its connections with other natural resources and human activities?

- Does the project operate under **appropriate spatial units** for water resources assessment and planning such as the river basins or groundwater aquifer, so as to incorporate major land-water-ecosystem interactions?

- Does the project work under a **conjunctive management system** for quantity and quality of surface water and groundwater to maintain the integrity of the hydrologic system and achieve efficient use of these water resources?

1.2.3 Demand Management

- Has the project adopted demand management as an integral part of water management, including formulating and evaluating demand reduction methods and strategies as complements to and substitutes for supply augmentation projects, in order to bring **projected demands for and supplies of water into balance?**

- Does the project **use prices as a tool for demand management** including volumetric pricing of supply or wastewater on the basis of marginal supply or disposal costs, along with increasing block rates? (Where appropriate, seasonal pricing and temporary drought surcharges would be imposed.)

- Does the project specify efficient technical means to **reduce urban water use and transmission losses in the supply system,** including changes in plumbing codes to require water-saving plumbing fixtures, programmes of leak detection and control, and sustained operation and maintenance?

- Do **industrial components specify recycling** and other technical means to reduce withdrawal rates for water for industry, especially for cooling?

- Do irrigation components specify technical means for **reducing irrigation water use,** including drip irrigation, sprinkler irrigation, land leveling, canal lining, along with institutional means such as modifying water rights systems to encourage efficient use of irrigation water?

- Does the project consider use of **lower-grade water for certain domestic, commercial, industrial and agricultural purposes?** (The use of brackish water and treated wastewater for non-potable purposes often involves installation of dual water supply systems.)

- Does the project adequately address **reducing the generation of pollutants at the source,** through changes in production processes, by-product recovery, and wastewater reuse, making use of technical advice, regulation and enforcement, pricing policy, and tax incentives?

- Does the project implement a **"polluter pays policy"** including:
  - the levy of effluent charges adequate to achieve desired reduction of pollutants, and earmarked to finance the cleanup costs of residual pollution,
  - installing basic sanitation facilities in rural and low-income urban areas, including, community involvement in planning and installing and maintaining low-cost facilities meeting, minimum standards?

- Does the project adequately address **reducing water pollution from agricultural, grazing and forestry activities**, by lowering sedimentation from soil erosion, cutting discharges of pesticides and fertilizers, and reducing the saline content of irrigation return flow? (Tools which may be used are

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subsidies (where appropriate), removal of perverse subsidies, changes in property rights, tighter regulation of forestry activities, and enforceable stipulations on types and methods of application of agricultural chemicals.)

1.2.4 Establishment of appropriate mechanisms and institutions

- Does the project work under a **national water code,** including a water rights system which recognizes the hydrological realities of surface water, groundwater and return flow linkages, and the stochastic nature of precipitation and stream flows?

- Does the project work under a water resources management system that includes **integration of activities of different agencies at the planning and implementation stages,** spatial integration by river basin, water resources demand region, or political jurisdiction. and division of responsibilities for water resources management among national, provincial, local public, and private sectors? (The activities involve water allocation, regulation of use and abuse, development, preservation, and operation of water supply and treatment facilities.)

- Does the project meet **unified national objectives and priorities** for water resources management, including setting guidelines for resolving the conflicts between national economic growth and self-sufficiency, sectoral development, equitable income distribution and social impacts, environment quality, and sustainability of the resource base?

- Have **constructive international agreements** on water management, involving equitable sharing of benefits and costs of development / management of international river basins, and clear definition of rights and responsibilities of affected states, been adopted and does the project conform to these agreements?

- Has a system of **guiding national investments in water resources development** been implemented by means of capital investment budgets and programmes, national-local cost-sharing, international or bilateral grants and/or loans, cost-sharing by provincial, local and private agencies, and private investment and has this project emerged as a high priority from this system?

- Has a system of **project formulation and valuation criteria** been adopted involving benefit-cost analysis, risk assessment analysis, and multiple objective (including environmental impact) analysis, to be used for project and programmes and has this project rated high in this criteria?

- Have approaches for allocation of water and waste assimilation capacity that take account of **interdependency of water uses and the role of pricing policy** been adopted and does this project conform? (Alternative approaches that may be considered include allocation through water markets with clear property rights, allocation through planning, and a combination.)

- Does the project promote **public involvement / local participation** in project planning and implementation, upstream watershed management and rural/urban water supply and sanitation?

- Does the project provide for **adequate funding of project operation and maintenance,** for example, from user charges, especially for projects to be turned over to local water users for operation and maintenance?

- Does the project recognize the **economic value of water** to ensure rational development and allocation among competing uses and promote efficient use within sectors? (Correctly costing both environmental and social attributes will help to ensure that both favorable and adverse impacts of pending decisions are taken into account.)

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- Does the project recognize that water pricing is fundamental to sectoral efficiency, financial strengthening of water companies, and reduction of public subsidies and work under an **efficient pricing system?**

- Does the project assist with **prevention of irreversible damage** to the water resource base, to the extent possible through immediate and low cost actions to prevent further degradation in critical areas? (This includes assistance in estimating the costs of "business as usual' in terms of health, ecology and economics; demonstrating benefits of preventing further degradation and reversing current trends; assistance in low-cost designs of mitigative measures.)

- Does the project analyze and put in place improved policies, by **developing and integrating water policies with land, industrial, agricultural and environmental policy,** and using pricing to signal users, promote efficiency, reduce pollution, and advance cost recovery? (This includes promoting water resource policies that are sensitive to social and environmental issues; ensuring that lending and donor support is consistent with country strategy papers and environmental planning; and ensuring existence of adequate social safety nets.)

- Does the project work under a system of **improved legislative and institutional changes** including shifting from centralized to decentralized administration, financial autonomy of development and operating entities, more enterprise forms of institutions with performance-based accountability, separated planning and operations from regulatory functions, strengthened laws and regulations, including water law, water rights, environmental law and enforcement, and better coordination of efforts of non-governmental organizations?

- Does the project assist with **improved program and project preparation,** by adopting a river basin basis for planning, explicitly addressing multisectoral conflicts and needs, identifying, promoting and implementing non-physical measures, repairing and upgrading existing infrastructure, improving operations and maintenance, incorporating full environmental and social costs in project appraisal, and increasing local consultation?

- Does the project assist with **improving planning methodologies,** including techniques for land management, erosion control, demand management, project appraisal, social impact analysis and resettlement, and condition water resource lending on sound sector policy and project planning? (Demonstrate efficiency gains by simulation and case studies.)

1.2.5 Water Resource Management Strategies

- Does the project affect general recommendations for water resource management strategies designed to foster better and more **environmentally sound water resource management** including taking immediate actions to prevent irreversible ecological harm; defining water sector policy; adjusting legislation and institutions; planning programs and projects; and building capacity?

- Does the project take immediate actions to the extent possible, given financial resources and technical feasibility, to **conserve and protect untainted environmental assets** and to prevent further irreversible damage to ecologic systems?

- Does the project assist policies adopted within the water sector that are **complementary to pollution abatement policies** being adopted in other sectors (especially in industry, municipalities, and agriculture)?

- Does the project assist with implementing policies that require some legislation and/or institutional change, including the **careful definition and empowerment of a balanced cluster of required institutions,** such as (a) a centralized body for setting standards and policy; (b) a river basin planning

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entity for water pricing, allocation, investment planning, and (perhaps) service management; (c) a decentralized agency for water quality enforcement, with the power to impose fines; (d) water service companies; and (e) local user organizations?

- Does the project help to prepare programs and projects which are **consistent with policy objectives**, generally in the following sequence:

  - Because their relative cost-effectiveness is usually superior, identify, promote, and implement **nonphysical measures** for achieving sustainable water resource management. These include demand management through water and waste discharge pricing to promote conservation and efficiency in water use and waste management; land use controls to prevent deforestation and industrialization of ecologically sensitive areas; and farmer education to encourage erosion control and safe agrochemical usage.

  - Because existing facilities are often not used to their full design capacity or efficiency, **repair and upgrade existing infrastructure,** improve maintenance and introduce real-time system management. With regards to system operation, ensure that ecologic needs are fulfilled (for example, that adequate flows are maintained below dams).

  - From a list of alternative and competing prospective development projects, **prioritize and select programs and projects in terms of a complete accounting of economic, social and environmental costs and benefits.** Nonquantifiable attributes, such as the maintenance of water quality for human and ecologic health, and base flow quantities sufficient for ecologic purposes, should be a part of the selection criteria.

  - Plan and design the selected programs and projects and prepare **operating rules, management procedures, and monitoring plans that cover, among other things, environmental concerns.** Phase the plans to capture early benefits during the course of implementation.

  - Build selected projects while ensuring that **environmental safeguards are part of the construction process.** Examples are ensuring that erosion is controlled, fish migration paths are maintained, and downstream or groundwater quality is not affected by construction activities.

  - **Monitor midpoints and outcomes,** including economic, social, and environmental impacts, and adjust activities and operations if necessary. Prepare future plans, designs and operations to reflect lessons learned.

- Does the project assist with **capacity building,** in recognition that comprehensive water resource management requires well-trained and qualified personnel?

1.3 National Planning Components for Sustainable Water Resources

1.3.1 National Policy

- Does the project work and foster a **national policy,** the general objective of which is to **develop and utilize water resources in an environmentally sound, economically efficient and equitable manner** in order to satisfy the present and future demands of society for water and water-related goods and services.? [The water policy should promote a multisectoral and multidisciplinary approach to integrated water resources planning and management that optimizes the interests of environmental protection and sustainable socioeconomic development.]

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- Have **all the water use sectors,** such as water supply for domestic use, agriculture, industry and irrigation, **been considered together** in formulating this project and its underlying development policy?

- Does the project target the **reconciliation of conflicting demands** for water from various users with the ever-growing **environmental concerns** while keeping in sight the **needs of the poor** layers of society?

- Has the project been developed under a **comprehensive water resources assessment system** including the following:

a) Compiled information on the **quantity and quality of water resources** as well water-use statistical data.

b) Improved mechanisms for **cooperation and coordination** among related agencies to collect, supply and disseminate the relevant information on water resources and their uses, and a governmental agency with adequate executive authority for establishing and maintaining a national database on water resources.

c) **Regular (and integrated) national assessments** of water resources and wateruse surveys in various sectors of the national economy, such as agriculture, industry and domestic water supply.

d) **Computerized processing, storage and retrieval** of water resources and water use data on the planning, development and management of water resources.

- Has the project worked under and fostered an **integrated approach** to water resources development and management including:

a) **Holistic management of water as a finite and vulnerable resource** and the integration of sectoral water plans and programs within the framework of national economic and social objectives.

b) **Comprehensive ecosystem assessment,** taking into full consideration the use of water in human activities and giving due consideration to environmental protection for sustainable development as the main principle behind the environmentally sound, sustainable development of water resources.

c) **Feasibility frameworks** for integrated management depicting financial implications and changes in operational elements, monitoring, planning and management structures.

d) **Established central mechanism** for coordinating all water interests at the national level, to ensure an interdisciplinary approach to the integrated and coordinated management of water resources.

e) **Improved economic planning - water resource planning coordination** and feedback to allow water managers to assess and charge for the full costs of water resources management involved in sectoral economic development plans, and economic agencies becoming instrumental in the implementation of integrated water resources management plans.

- Has the project been developed under a **system of basin-wide, regional and national master water plans,** which provide frameworks for the planning of individual water development projects and lead to the optimization of economic and social benefits, while minimizing adverse environmental impacts?

- Has the project promoted **increased participation by women** at all stages of development and at various levels of responsibility, including decision-making?

- Does the project adequately address **water demand assessment and management** as an integral part of water management in order to bring projected demand for and supply of water into balance, with demand reduction methods and strategies as complements to and substitutes for supply augmentation projects?

- Has the project addressed the implementation of an **integrated pollution control policy** that:

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a) encourages **low and non-wasteful water use**, and control of pollution sources through land-use policy, waste-water recycling and recovery, application of clean technologies and substitution of hazardous substances and techniques,

b) reduces the generation of pollutants **at the source** through changes in production processes, by-product recovery and wastewater reuse in industry and agriculture,

c) adopts the **"polluter pays"** policy, including the levy of effluent charges adequate to achieve the desired reduction of pollutants, should be adopted,

d) gives high priority to the installation of **basic sanitation** and solid waste facilities in rural and low-income urban areas (with emphasis on community involvement in planning, installing and maintaining low-cost facilities meeting minimum standards) as a means of minimizing water contamination by human wastes?

- Have **proposed water reservoir components** of the proposed project been developed with a vision toward harmonizing conflicting, and sometimes inconsistent, requirements of different commercial functions (water supply, irrigation, hydropower generation, etc.) as well as environmental and subsistence functions, and included:

a) special consideration for **multipurpose projects** which satisfy the interests of different sectors of national economy, maintaining the environmental conditions in the river basin,

b) adequate consideration to **both the economic and social benefits** of water reservoir projects as well as their possible **adverse social and environmental impacts** such as the resettlement of population, silt entrapment, dam breaks, and the loss of valuable ecosystems,

c) improved **water quality and regulation of sedimentation** through water catchment management and sufficient water is made available to maintain the subsistence and environmental functions of the water resources system downstream of the reservoir,

d) operation rules that guarantee a **controlled flooding** of the floodplains downstream of the dam in order to maintain the subsistence functions of the river basin, including agriculture and fisheries,

e) site selection that recognizes potential **water quality impacts** by minimizing stratification, the pollution load from upstream point and non-point sources, the decomposition of drowned vegetation, and watershed management to reduce sediment inflow?

- Does the project assist with efforts to **improve regional cooperation** for sustainable development and environmentally sound management of water resources, including the exchange of information and experience on the application of the ecosystems approach to the planning and management of water resources, and at legal and institutional aspects of promoting integrated water management?

- Do the project components with potentially significant **impacts on territories of other countries** include exchange of relevant hydrological and meteorological data and information on the environment, notification and consultation on the planned development activities, joint studies on the assessment of water resources shared by the countries, collaborative planning of shared water resources development, and implementation of mutually agreed mitigation measures, including water-related natural disaster reduction?

- Does the project have **quantificable performance criteria and indices** describing its role in the achievement of environmentally sound and sustainable development of water resources?

- Have any project components dealing with **interregional mass water transfer** been considered thoroughly, taking fully into account potential socioeconomic and environmental implications in both source basins and recipient basins, with full cost accounting of impacts in both source basins and recipient basins?

- Has the project been fully analyzed relative to a national prioritization scheme with a **reconciliation of conflicting demands** for water from agriculture, industry and urban users? (Priorities of food security,

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industrial growth, water requirements of population, environmental protection, educational institutions, health services and other economic or social environmental entities should be identified, taking into consideration the availability and long-term sustainability of water resources.)

- Has the project been developed under a **flexible and pragmatic planning system** that includes some of the following in a sequential manner:

a) realistic situation analysis including an **estimation of available resources and of the resource gap;**
b) optimal policy package to breach, of minimize the resource gap;
c) selection of optimal technology/strategy options for maximum acceleration of sustainable coverage;
d) setting of realistic sector goals ; and
e) establishment of a pragmatic planning/ monitoring framework?

- Has the project emerged from a prioritization scheme that identifies **priority problems** where actions and resources are most critical with the following criteria employed:

a) magnitude of health impacts associated with the problem;
b) size of urban productivity losses caused by the problem,
c) relative impact of the problem borne by the urban poor;
d) degree to which the problem is caused by unsustainable water consumption or whether it will lead to an irreversible outcome;
e) extent to which local support or constituencies exist to help resolve the problem; and
f) existence, or likelihood of building needed capacity to manage the problem?

- Does the project follow the principles of comprehensive analysis, opportunity cost pricing, decentralization, stakeholder participation, and environmental protection with improved efficiency of water allocation and assist with **achieving the following objectives:**

a) for industry, extensive water conservation and protection of groundwater sources,
b) for water supply and sanitation, more efficient and accessible delivery of water services and sewage collection, treatment, and disposal by extending existing supplies through water conservation and reuse and by using other sustainable methods and greater involvement of the private sector, nongovernmental organizations, and user groups,
c) for irrigation and hydropower, modernized irrigation practices, greater attention to cost recovery, drainage and salinity control, measures to reduce pollution from agricultural activities, improvements in operation and maintenance of existing systems, and investments in small-scale irrigation and various water-harvesting methods,
d) for the environment and poverty alleviation, more rigorous attention to minimizing resettlement, maintaining biodiversity, and protecting ecosystems in the design and implementation of the projects?

- Does the project include a **realistic forecast of the demand for water,** based on projected population growth and economic development, and a consideration of options for managing demand and supply, taking into account existing investments and those likely to occur in the private sector?

- Does the project work and foster an **integrated system of "land and water management"** with careful consideration of the interactions to address three basic criteria for ecological security:

a) groundwater remains drinkable, land productive, and fish edible,
b) biological diversity is conserved,
c) long-term overdraft of renewable resources is avoided?

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1.3.2 Institutional Development

- Does the project mitigate against the **four principal and related problems** in the way government institutions have managed their water resources which are:

a) water management is fragmented among sectors and institutions, with little regard for conflicts or complementarities among social, economic, and environmental objectives resulting in excessive and unproductive investments, with different agencies developing the same water source for different uses,

b) dependence on centralized administration to develop, operate, and maintain water systems resulting in unreliable projects that produce services that do not meet consumers' needs and for which they are unwilling to pay,

c) water is not treated as an economic good resulting is waste and depletion and less than fully productive investments,

d) neglecting to link the quality of water to health, the environment, and economic development, with environmental degradation of water resources causing human suffering and burdening future generations with the costs of remedial actions?

- Does the project assist with the **development of human resources in the water sector**, since one of the most critical constraints in water resources development and management is the lack of trained personnel?

- Does the project support **self-sustaining and socially relevant programs** including community involvement, with emphasis on women's participation?

- Does the project work under an ***integrated approach to water resources management and water pollution control*** in those areas where the responsibility of water supply is quite separate from that of water pollution control? (Institutional mechanisms dealing with various aspects of water resources development, management and protection should be strengthened and water resources management should be integrated with land use planning in urban areas.)

- Have the **responsibilities** for water resources management been delegated, to the extent possible, to the **lowest appropriate levels,** to ensure the involvement of local citizens in the planning, execution and management of the project? (A close interaction between management institutions at the lowest appropriate level and those at the regional and national levels should be enhanced, thus ensuring that adequate support is given to local institutions.)

- Has the project development process included a **significant role for nongovernmental organizations** (NGOs) in water development and management since NGOs can provide a link between community and local institutions, and NGOs are usually flexible, credible, and are ready and able to experiment with innovative approaches?

1.3.3 Legal Systems

- Does the project facilitate the **public trust doctrine** placing a duty on the state to hold environmental resources in trust for the benefit of the public, including allowing private rights of action by citizens for violations by the state (directly or indirectly) of the public trust?

- Does the project facilitate the **precautionary principle** (as defined in the Rio declaration) holds that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (or when in doubt about the impact of development, manage according to the worst-case scenario of its effect on the environment)?

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- Does the project facilitate the **principle of inter-generational equity** is at the heart of the definition of sustainable development and requires that the needs of the present are met without compromising the ability of future generations to meet their own needs?

- Does the project facilitate the **principle of intra-generational equity** requires that people within the present generation have the right to benefit equally from the exploitation of resources, and that they have an equal right to a clean and healthy environment, (within nations, it is particularly susceptible to cultural and socioeconomic forces)?

- Does the project facilitate the **subsidiarity principle** is resurfacing worldwide after many decades of centralized planning and decision-making, and it is the principle that decisions should be made by the communities affected or, on their behalf, by the authorities closest to them, to encourage local ownership over resources and responsibility for environmental problems and their solutions?

- Does the project facilitate the **polluter pays principle** (PPP) suggests that the polluter should bear the cost of preventing and controlling pollution, with the intent to force polluters to internalize all the environmental costs of their activities so that these are fully reflected in the costs of the goods and services they provide?

- Does the project facilitate the **user pays principle** (UPP) applies the PPP more broadly so that the cost of a resource to a user includes all the environmental costs associated with its extraction, transformation and use (including the costs of alternative or future uses foregone), (the PPP and UPP can be expressed in similar ways through market systems and government regulation)?

1.3.4 Public Participation

- Does the project **encourage full public participation** in its development and management activities (an important instrument to promote a successful implementation of policies for environmentally sound water resources development) in the assessment of social and environmental impacts, planning and implementing of water resources development structural and non-structural components and water management activities?

- Does the project utilize a **participatory approach,** involving users, players and policy makers, service providers and nongovernmental organizations at all levels as an important instrument to promote a successful implementation of policies for sustainable development and environmentally sound management of water resources?

- Does the public involvement program **conform to the following public involvement steps:**

- Define the issue and identify problem
- Provide an open agenda - no secrets
- Fully display data and information, clarify limitations, and define boundaries
- Establish credibility and create a "good faith" environment
- Build trust
- Provide sufficient time for effective citizen participation
- Openly recognize the potential and existing sources of discord
- Establish common goals with which parties can identify
- Reach the public
  - Seek out existing, organized groups
  - Seek out existing community leaders
  - Identify and involve other impacted parties and individuals
  - Organize open meetings for citizen participation
- Give status recognition to any group
- Overcome cultural barriers
- Beware of communication barriers created by cultural differences
- Sell the process

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- Know when to call in a third party neutral
- Include identified stakeholders and the general public in the problem and process definition

- Has the project developed **appropriate guidelines** addressing the tradeoffs between the costs of various possible public participation programs and the potential benefits gained?

1.3.5 Health Policies

- Have all efforts been made to quantify **potential hidden and uncomputed costs** associated with health and safety in addition to project benefits, including the use of health impact assessment during environmental impact assessment?

- Has the project **incorporated all available information** on the health impacts of existing projects as the best indicator of future health impacts?

- Has the project **identified health objectives** in the water resources development, since development policies designed to improve the economic conditions and living standards of communities often have unintended effects on health, as well as identified vulnerable groups and their health risks so that adverse socioeconomic factors can be dealt with?

- Has the project addressed the potential to exacerbate the **major parasitic diseases** affected by water resources development projects including lymphatic filariasis, malaria and schistosomiasis?

- Has the project fully addressed the **construction phase health risks** including:

a) the fact that the construction of dams and formation of reservoirs and irrigation systems in tropical areas can cause rapid environmental degradation, and health risks may arise even before there is any awareness of the danger and before preparations have been made to overcome it,

b) workers involved in the construction of dams and irrigation networks, and their families, sometimes come from distant regions and may affect the epidemiological situation as follows:

- by introducing diseases;
- by introducing new strains of a parasite or new vectors, possibly better adapted than the original ones to the ecological conditions that have been created;
- by lacking immunity to local pathogens;
- by increasing the population density in the foci of transmission?

- Does storage components of the project address changes in both the **upstream and downstream areas**, including forest clearance, which is likely to be followed by a reduction or drying up of watercourses?

- Has the project fully evaluated proposed **alterations to aquatic ecosystems** relative to modifying the habitats, breeding patterns and, ultimately, the distribution and density of intermediate snail hosts and insect vectors? (A water resources project does more than alter the distribution and flow of water. Deforestation, land occupation, soil degradation, and desertification may all contribute to ecosystem changes.)

- Does the project **prioritize** the greatest requirement for control measures in **areas undergoing rapid development** and disease control needs to occur before construction has finished?

- Does the project mitigate the failure to **appreciate that health problems in water developments are ecological in character** and that long-term solutions require broad participation and the integration of many sectoral inputs?

- Does the project assist health officials in **demonstrating the adverse effects of disease on capital projects** in economic terms?

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- Does the project **overcome donor agencies that have a negative or dissociative attitude to health matters** in project developments and external support is very weak if recipient countries wish to fund health and control programs in connection with water resources development?

- Does the project assist government ministries of health in their roles as custodians of health in major development projects and becoming assertive in defining the health risks associated with projects, and **provide technical options or identify intersectoral input for the prevention and control of parasitic diseases?**

- Does the project **overcome the assumption that the price of development has to be paid in terms of disease** and the costs of disease are considered to be less than the potential economic benefits? (The depth of ignorance in the political sector on the feasibility and simplicity of mitigating negative health effects should be addressed by the health sector.)

- Does the project **prevent the completion of only a pro forma document** to fulfill the legal requirements, without requiring the donor or contractor to prevent or mitigate potential risks, even when adequate legislation requires preliminary environmental and health risk assessment for the proposed water resources project?

- Does the project recognize the following **critical health needs** relative to local-level water management policy:

a) ensure that control programs are not oriented to only one disease and are not centrally managed, so that communities and agencies participating independently in the development process have a linkage with the activities undertaken,
b) supply trained personnel to investigate, plan and evaluate control programs,
c) ensure that resources for maintenance and replacement do not diminish in response to economic recession,
d) assist to harmonize community participation through women's groups, local political groups, and nongovernmental organizations with control activities,
e) improve databases on health and disease emanating directly and indirectly from water resources developments and health effects need to be documented at the local level and analyzed, usually at the central level, in order to assess the implications for planning and policy development?

- Has the project addressed **minimum health care systems** for major water resources projects, and added components such as:

a) immunization against common communicable diseases, including yellow fever, Japanese encephalitis, cerebrospinal meningitis and childhood diseases;
b) limitation of population growth through family planning;
c) provision of essential drugs;
d) establishment of effective emergency services with ambulance-supported referral;
e) training of village health workers and microscopist.

- Does the project fully address the **ecology and epidemiology of water-related diseases** to permit a clearer choice of options for project implementation? (Health ministries have the most accurate information on the distribution of waterborne diseases. Areas of similar ecology do not necessarily have the same disease endemicity. It may be useful to propose project implementation in non-endemic rather than in highly endemic areas with attendant risks.)

- Does the project address the close relationship between **good water management practices and both economic and health outcomes**? (Ministries of health need to understand and recognize that professional engineering competence in the design and maintenance of irrigation systems, small reservoirs and large dams will assist in the control of waterborne diseases. In this crucial intersectoral aspect of water resources

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development, health ministries can provide support and justification to ministries of agriculture or energy for adequate design and management, if unacceptable short-cuts are proposed at the higher planning levels.)

- Does the project recognize that **existing technologies** can be harnessed for feasible and effective control strategies ? (The control of parasitic diseases today aims first and foremost to reduce morbidity and mortality, and the tools needed for this purpose are available.)

- Do **irrigation related project components** contain protection for the following potential health hazards:

Irrigation: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Vector-borne disease	Proliferation of vectors
	Water-borne disease	Domestic water supply contamination
	Malnutrition	Loss of subsistence crops
	Injuries	Floods
Planning and Design	Poisoning	Agrochemicals
	Water-borne disease	Sanitary waste disposal
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	STDs	Labor camps
Operation	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	Poisoning	Misuse of agrochemicals
	Vector-borne diseases	Creation of vector habitats, lack of maintenance and lack of protection measures

- Do **industry related project components** contain protection for the following potential health hazards:

Industry : Screening for Health Hazards (including fertilizer and cement manufacture)

Project stage	Health Hazard	Causes
Location	Poisoning	Pollution
	Injury	Explosion
	Vector-borne disease	Endemic disease foci
Planning and Design	Poisoning, Injury	Inadequate occupational safety measures and pollution control, hazardous waste disposal, zoning
Construction	Poisoning, Injury	Inadequate occupational safety measures
Operation	Poisoning, injury, deafness, respiratory disease, miscarriage, fetal deformity, cancer	Inadequate occupational safety measures and pollution control, hazardous waste disposal, catastrophic accidents

- Do **Fisheries and Aquaculture related project components** contain protection for the following potential health hazards:

Fisheries and Aquaculture: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Food Poisoning	Pollution, Algal blooms
	Injury	Storm and flood
	Parasitic disease	Endemic disease foci

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Planning and Design	Communicable diseases associated with excreta	Use of fresh excreta as fertilizer
Construction	Poisoning, injury	Inadequate occupational safety measures
	Communicable disease associated with poor living supply, poor food hygiene conditions	Poor sanitation, poor water
Operation	Injury	Storm and flood
	Food Poisoning	Poor monitoring of water for pathogens and toxins

- Do **watershed development related project components** contain protection for the following potential health hazards:

Watershed Development: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Vector-borne disease	Endemic disease foci, resettlement
	Malnutrition	Loss of common property resources, resettlement
Planning and Design	Vector-borne disease	Creation of vector habitats
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living supply, poor food hygiene conditions	Poor sanitation, poor water
	STDs	Labor camps
	Vector-borne disease	Exposure to endemic foci
Operation	Communicable diseases associated with excreta	Upstream pollution

- Do **Forestry related project components** contain protection for the following potential health hazards:
Forestry: Screening for Health Hazards Including tea, rubber and fruit

Project stage	Health Hazard	Causes
Location	Malnutrition	Loss of common property resources
	Injury	Insurgency
	Vector-borne disease	Endemic disease foci
Planning and Design	Malnutrition, vector-borne diseases	Resettlement
Construction	Poisoning, Injury	Inadequate Occupational safety measures
	Communicable disease associated with poor living supply, poor food hygiene conditions	Poor sanitation, poor water
	STDs	Labor camps
Operation	Injury	Inadequate Occupational safety measures
	Communicable disease	Poor sanitation in logging camps
	Vector-borne disease	Colonization of plantation by vectors

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- Do **Land Clearing and Rehabilitation related project components** contain protection for the following potential health hazards:

Land Clearing and Rehabilitation: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Malnutrition	Loss of common property resources, esp. of women
	Vector-borne disease	Endemic disease foci
Planning	and Malnutrition	Resettlement
Design		
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	STDs	Labor camps
	Vector-borne disease	Exposure to vectors in endemic disease foci
Operation	Vector-borne diseases	Creation of breeding sites
	Respiratory disease	Dust

- Do **Dams and Reservoir related project components** contain protection for the following potential health hazards:

Dams and Reservoirs: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Malnutrition	Loss of common property resources, loss of irrigation water
	Poisoning	Contamination of downstream waters
	Vector-borne disease	Endemic disease foci, access to forested hinterlands
Planning and Design	Malnutrition, vector-borne disease, communicable disease associated with poor living conditions	Resettlement, access roads
	Water-borne disease	Downstream river pollution
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	STDs	Labor camps
	Vector-borne disease	Exposure to vectors in endemic disease foci
Operation	Vector-borne diseases	Creation of breeding sites through draw down operations and stream ponding, access to forested hinterland

- Do **Mining and Mineral Processing related project components** contain protection for the following potential health hazards:

Mining and Mineral Processing: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Malnutrition	Loss of common property resources

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	Vector-borne disease	Endemic disease foci
	Poisoning	Pollution from spoil deposits
Planning and Design	Dust-induced lung disease	Excessive dust
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	STDs	Labor camps
	Vector-borne disease	Exposure to vectors in endemic disease foci
Operation	Dust-induced lung disease, infectious respiratory disease	Poor protection from dust, poor ventilation
	STDs	Labor camps, unaccustomed wealth, poor health education
	Injury, poisoning, deafness, drowning	Poor occupational safety, abandoned mine workings, dam failure

- Do **Electricity, oil and gas distribution lines related project components** contain protection for the following potential health hazards:

Electricity, oil and gas distribution lines: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Vector-borne disease	Endemic disease foci
Planning and Design	Injury	Zoning
	Vector-borne disease	Access roads
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	STDs	Labor camps
	Vector-borne disease	Exposure to vectors in endemic disease foci
Operation	Injury such as electrocution and explosion	Fuel leaks, poor maintenance, illegal connection

- Do **Airport related project components** contain protection for the following potential health hazards:

Airports: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Malnutrition	Resettlement
Planning and Design	Injury	Crashes
Construction	Poisoning, Injury	Inadequate occupational safety measures
Operation	Vector-borne and other communicable diseases	Accidental introduction of vectors and pathogens
	Injury	Poor maintenance

- Do **Highway and Road related project components** contain protection for the following potential health hazards:

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Highways and Roads: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Vector-borne disease	Endemic disease foci Access to forested hinterlands
	Malnutrition	Loss of common property resources, increase in land values, change in livelihood
Planning and Injury		Roads with poor safety features
Design	Communicable disease	Borrow pits, pooling, interrupted surface flows
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	STDs	Labor camps
	Vector-bole disease	Exposure to vectors in endemic disease foci
Operation	Vector-borne diseases	Roadside squatters using surface water supplies
	Communicable disease associated with poor living conditions	
	Respiratory disease	Dust
	Injury	Poor vehicle and road maintenance, poor traffic regulation, poor driver education, increasing traffic density
	STDs	Long distance truck drivers

- Do **Port and Harbor related project components** contain protection for the following potential health hazards:

Ports and Harbors: Screening for Health Hazards

Project stage	Health Hazard	Causes
Location	Malnutrition	Loss of communal fisheries
	Poisoning	Leakage of hazardous materials during transit
	Excreta related diseases	Poor waste disposal facilities
Construction	Poisoning, Injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
	STDs	Labor camps
Operation	Exotic communicable diseases, including bubonic plague	Accidental shipment of infected rodents, vectors or pathogens
	STDs	Transit of single males
	Injury	Poor operation and Maintenance

- Do **Urban Development related project components** contain protection for the following potential health hazards:

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Urban Development: Screening for Health Hazard

Project stage	Health Hazard	Causes
Location	Communicable disease associated with poor living conditions	Displacement through slum clearance, excreta disposal, water supply
	Injury	Steep hillsides, flood-prone valleys, poor access to and for emergency services
	Non-communicable disease	Pollution, hazardous waste hazardous occupation
Planning and Design	Excreta-related disease, vector-borne disease	Water supply and sanitation problems
	Injury	Traffic
Construction	Poisoning, injury	Inadequate occupational safety measures
	Communicable disease associated with poor living conditions	Poor sanitation, poor water supply, poor food hygiene
Operation	Vector-borne diseases	Blocked drainage, domestic water storage, solid waste management
	Excreta-related diseases	
	Injury	Traffic

- Do **canal related aspects of the project** incorporate the following design recommendations:

Design and construction of canals

- Canal beds should be properly elevated to prevent formation of pools of stagnant water.
- Canals should be lined with concrete, or with cement blocks and polyethylene, to prevent silt deposition, the formation of shallow sunlit pools, and overflowing.
- Construction should be properly supervised to ensure good workmanship and the use of materials of high quality.
- Sprinkler and trickle irrigation should replace the older methods.

Operation and maintenance

- Water management practices inherent in optimal agricultural production, if maintained, contribute to vector control.
- Canals, reservoirs and fish ponds should be periodically cleared of weeds, and forestry management applied close to reservoirs and canals.

Environmental modification

- Unnecessary bodies of water should be filled and drained.
- Bridges should be built where fording is common.
- Adequate water supplies, latrines and bathing facilities should be provided.
- Health education on the transmission of waterborne diseases should be given, with emphasis on preventive and control measures.

1.4 Detailed Water Project Development Processes

1.4.1 Guidelines for Policies and Projects

- Does the project ensure **self-renewal of renewable sources** by preventing over exploitation and mismanagement?

- Does the project **prevent unnecessary environmental damage** from the extraction and processing of both renewable and nonrenewable resources?

- Does the project **promote recycling** where it is economically and environmentally beneficial?

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- Does the project **avoid irreversible environmental effects** and undertake environmental protection measures that can be shown to have economic benefits that exceed their economic costs?

- Does the project emphasize **effective protection over rehabilitation** on grounds of greater cost-effectiveness?

- Has the project fully adopted the principle of "users and polluters pay" by **internalizing scarcity and environmental costs?**

- Has the project fully **assessed the environmental effects of sectoral and macroeconomic policies** and internalized them, partly by adjustment of these policies and partly by mitigation of residual impacts?

- Are project components affecting renewable resources designed to ensure that **rates of use not exceed the regenerative capacity** of these resources or environments? (For example, fisheries projects should not lead to overfishing, livestock projects should not lead to overgrazing, irrigation projects should not lead to destruction of watersheds, and agricultural projects should not lead to mining of the soil, excessive soil erosion, and overuse of pesticides.)

- Does the project **prevent irreversible deterioration** of the environment (i.e. - not-causing species extinction, habitat destruction, loss of significant biological diversity, or destruction of natural and cultural merit sites?

- Does the project not **unduly compromise the public's health and safety** by, for example, using chemicals such as asbestos, producing hazardous wastes, or building reservoirs in areas of earthquakes or volcanic activity?

- Have the project features that could **displace people or seriously disadvantage certain vulnerable groups**, including tribal groups, been adequately investigated and include sufficient mitigatory and compensatory measures that leave them better off?

- Does the project conform to all **international environmental agreements** (for example, the Montreal Protocol and the Basel Statement on Hazardous Waste Shipments)?

- Does the project **significantly modify natural areas** designated as national parks, wildlife refuges, biosphere reserves, or World Heritage sites?

- Have the project features been designed to **minimize unavoidable adverse consequences** of projects through site selection, scale adjustment, timing, attenuation, and mitigating measures?

- Has the project been developed in a manner that **balances short-term development gains against long-term environmental degradation** or resource impairment (trade-offs) or internalize environmental damage through consideration of foregone long-term development benefits? (Short-term development often leads to environmental degradation that constrains long-term sustainable development.)

- Does the **project design clearly identify (with supporting rationale)** the following:

- Problems or issues the project intends to address
- Long and short term objectives of the project
- Target groups or main project beneficiaries
- Activities required to achieve the objectives
- Financial and human resources required to achieve the set objectives
- Management responsibility and structure
- Implementation modalities

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1.4.2 Donor Lessons

- Does the project conform to the ten main lessons for donors (for simplicity, both development assistance agencies and lending institutions/banks are here called donors), which have been learned through more than ten years of their involvement in strategies:

1. **Coordinate donor activities:** Recipient governments must be supported in taking a leading role in coordinating external contributions to the strategy process.
2. **Invest in the long-term:** Low-level continuous external backing over a long period is almost always much better than short, high-level, one-off inputs (unless contributing to a strategy trust fund).
3. **Support the process:** Programme funding is needed for the capacity-building process; not just the products of strategic planning. Programme-oriented approaches are often more valuable than projects that are not an integral part of a strategy
4. **Support existing strategies:** If funding is conditional, the conditions should respect alternative approaches to strategies that exist locally. Buy in to existing processes, even if they do not quite fit the bill.
5. **Do not impose external models:** The corollary to supporting 'homemade' or tailor-made strategies is the need to guard against designing for schedules, budgets and skills which do not fit with local norms and capacities.
6. **Form and encourage partnerships:** Close working links with other donors and partnerships, and support for a variety of participants in a strategy, both governmental and non-governmental, add momentum and stability to the process. A good first step is to help governments identify stakeholders and their potential contributions.
7. **Seek coherence in aid programmes:** Each donor needs to ensure that all components of its support interrelate and build upon each other within the strategy process.
8. **Devise new forms of assessment:** Donors need to develop new indicators for sustainability and evaluation to reflect and give greater importance to the qualitative and process elements of strategies.
9. **Refocus existing investment:** Donors need to review all elements of their aid programmes and help governments refocus existing investments towards sustainable development principles and objectives defined through the strategy process. This refocusing will be more important than initiating new 'environment' projects.
10. **Be flexible and creative in financial arrangements:** Support innovative financing mechanisms; for example, National Environment Funds, which lead to consistency and self-reliance in maintaining the strategy process.

1.4.3 *Financial Security of Projects*

- Does the project include **innovative and flexible financial arrangements** that can bring greater local control and security to the strategy process? (Examples include various forms of trusts or endowments which work on a consistent level of return through interest on a principal sum. Also, grant funding can be particularly useful in the early years of a strategy.)

- Does the project allow for sufficient time to invest in the process of discussion and design leading to the **most appropriate form of fund for local conditions**, whether government-run, private, or a mix of the two? (In some cases, it is better to create an NGO-dominated fund, focusing on support to smaller scale activities, so that government commitment to internalizing investment for environment protection is not diminished.)

- Does the project contain sufficient **analysis of the sustainability of existing development investment?** (The current approach to national strategies, encouraged through National Environmental Action Plans or NEAPs, is to define a portfolio of environment-related projects which are then marketed to donors.)

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- To ensure that the impacts of the projects will not be insignificant in terms of the mainstream of development, does the project utilize **specific sustainability analysis** including items such as:

- **comprehensive regional reviews** followed by investment programmes, such as those now being developed for the Ethiopian NCS through an extensive consultative process within the framework;
- various forms of **environmental auditing,** for example, the procedures governing industry performance within the European Community; and
- a **green reporting process** as introduced recently in Norway.

- Have the donor countries effectively matched the project aid with an **analysis of the environmental debts (and importation of carrying capacity)** that may be hidden in their relationship with the project recipient? (Special policies and phased programmes of support to the industries concerned may be needed and should be built in to the national strategies of both the donor and recipient countries.)

- Do the financial and institutional planning features of the project recognize the following **general tactics and principles for effective programme development:**

- **politics**: location is a political matter; the political dimension is often under-appreciated by 'outside experts'; underdeveloped countries often have overdeveloped institutions; events should be synchronized with the political timetable;
- **economics and finance**: cost-benefit analyses may be misleading for a large period of the project's life; loan financing should be avoided in the early stages and adequacy of funding should be ensured for recurrent (as much as for capital) costs;
- **technology**: innovations should be kept to a minimum; the systems consequences of technology transfer should be understood;
- ***organization***: emphasis should be placed on finding the key people; people should be developed from successful projects; creating self-renewing leadership is the hardest step; the greater the number of organizational levels, the greater is the uncertainty of outcome; structures that overlap bureaucratic jurisdictions should be avoided.

1.4.4 Project Development Steps

- Has the project emerged from a system that has **adequately developed its objectives, standards, technical base and general strategic planning** are inadequately considered or poorly developed, or if its design is not firmly managed in line with its strategic plans?

- Has the project considered adequately that its **definition both affects and is affected by its external environment** (such as politics, community views, economic and geophysical conditions, availability of financing, and project phasing and duration)? (Many of these interactions operate through the forecast performance that the project will deliver once completed.)

- Has the adequately incorporated and nurtured a **supportive attitude of the affected parties** to allow for effective management of the project's interaction with external, financial and other matters? (Implementation will be much harder to manage and may be seriously prejudiced if the attitudes of the parties essential to its success are not positive and supportive.)

- Does the project **move at the appropriate pace** through its development life cycle - doing the right thing at the right time (neither too soon nor too late) through careful planning and integrative decision making?

- Has the project been **organized properly**, both internally and with regard to outside parties, by getting the right balance between the owner (or, sponsor and operator) and the project implementation specialists?

- Does the project specify **contracts that adequately reflect the project objectives**, are motivational, and appropriately reflect the risks involved, and the ability of the parties of bear these risks?

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- Does the **project team include experienced, strong people** who can drive the project forward and lead those involved with and working on the project, and also establish checks and balances between their enthusiasm and the proper caution of the project's sponsors?

- Does the project specify the use of **techniques and tools for project planning, monitoring and reporting** which properly identify the real technical, financial, schedule and other issues, are user-friendly, and allow project staff to develop the project effectively and to predict final outcomes reliably?

- Does the **project strategy document** cover the following items:

- clear identification of sponsor and project objectives
- statements on how these are to be achieved
- environmental issues and strategy
- quality policy and programme
- safety policy
- owner's role and the role of third parties, e.g. consultants and contractors
- financial/economic objectives, financial strategy, funding strategy, cost planning
- legal and insurance issues and strategy
- technical strategy, technical policy, design philosophy
- project/work breakdown structure
- milestone/high-level schedule
- risk management strategy
- contracting/procurement strategy
- logistics policy
- employment and industrial relations strategy
- communication policy, particularly external policy
- information technology strategy.

- Has the project considered the **Ten Hallmarks of the New Environmentalism** proposed by the World Bank that rejects the old-fashioned development-versus-the-environment paradigm in favor of a new environmentalism? This paradigm recognizes economic development and environmental sustainability as partners, including the following principles:

- **Set priorities carefully.** Not all problems can be addressed at once. Priorities need to be set using a combination of modern valuation techniques and participatory input from citizens and experts.
- ***Go for win-win options first.*** *Although tradeoffs exist, there is often scope for improving* the environment by adopting policies and investments that are justified for reasons other than the environment. These free lunches, however, need to be exploited carefully.
- **Promote cost-effectiveness.** As demonstrated by recent work in countries like Chile and Mexico and in regions such as Eastern Europe, huge opportunities exist for saving resources by carefully analyzing costs. This has rarely been the practice in industrial-country policymaking.
- **Use market incentives where feasible.** A growing body of evidence, some supported by Bank projects, points to the gains from market-based instruments.
- **Economize on administrative and regulatory capacity.** Administrative and enforcement capacity is often as scarce as money. In these cases, blunter instruments (with fewer points of intervention) and self-enforcing policies (for example, deposit-refund schemes) can help. So can involving local communities and NGOS in enforcement and monitoring.
- **Set realistic standards and enforce them.** The old approach of adopting Western standards, failing to meet them, and thus undermining the credibility of the government's commitment is giving way to a new approach whereby realistic and phased targets are set and enforced.

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- **Work with the private sector.** Much of the investment required to improve the environment will come from private businesses and farmers. A shift in attitude is required (and in many places is occurring), with an emphasis on incentives, consultation, good business citizenship, and public disclosure of good as well as bad corporate performance.
- **Recognize that public involvement is crucial.** Success or failure often depends more on the commitment of stakeholders, including local communities, than that of the central government. Protecting natural habitats, forests, and even river basins requires genuine community involvement in planning and implementation. Many successful examples are emerging.
- **Build constituencies for change.** Sustained improvements in environmental policymaking, which will usually involve losers as well as winners, are more likely with a well-informed public and active support from citizens. The most effective governments are building such constituencies for change-through education and awareness programs and through promotion of an active civil society.
- **Incorporate environmental concerns from the outset.** Prevention is usually much cheaper than cure. Environmental concerns need to be built not only into the beginning of each investment, but also into the fabric of economic policymaking, including tax and regulatory policy, and even into the national accounts.

1.4.5 Water Project Details

- Does the project support a **comprehensive view** of water management issues, using policies that are sustainable from economic, social, and environmental perspectives?

- Does the project **emphasize improvement of the efficiency of existing irrigation systems** before creating new ones, including increased user participation in the design of irrigation and drainage projects, as well as institutional strengthening for water management?

- Does the project **encourage decentralization and local management** of water resources to improve efficiency and accountability of public sector irrigation management agencies?

- Does the project **propose charges for using water that reflect its value** as a scarce resource, supporting the implementation of equitable user charges for water?

- Does the project conform to **recommended priority reforms and activities** to be addressed in analytic work including issues such as the appropriate (a) incentive framework and pricing, (b) service delivery to the poor, (c) public investment priorities, (d) environmental restoration and protection, (e) water resource assessment and data requirements, (f) comprehensive analytical framework, and (g) legislation, institutional structures, and capacities?

- Is the project developed within a **comprehensive framework** before the design and implementation stages?

- Has the project provided **detailed guidelines, training, and information** should be provided to borrowers, especially for coordinating intersectoral water resources management, designing and administering fee structures, and monitoring project performance?

- Are **minimum conditions met for a healthy expansion of capacity**, including autonomy and accountability of management in operations, acceptable levels of unaccounted-for water, and cost-based prices for all except low-income residential consumers?

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- Have the **appropriate water agencies established and followed arrangements for coordinating their activities**? When they must withdraw needed technical services, this should be done gradually and with careful attention to transferring responsibilities to other government agencies, water user associations, or private firms.

- Has the project attempted to use cost-benefit analysis to justify itself when it **failed to consider the environmental damage** caused by borrowers' policies?

- Was **poverty relief** should be a project goal at the design stage?

- Has the project established **adequate databases** when the project was being prepared and appraised to monitor and evaluate the impact of Bank lending on the physical environment and on the populations affected by the project?

- Has the project **analyzed O&M capacities** and not made major new investments until this capacity has been brought to adequate levels?

- Has the project facilitated the **development of WSS organizations** that rely less on government involvement in implementation and more on a clear regulatory framework?

- Have the **water users been given more responsibilities for managing the water** and, where feasible, was emphasis given to private pumping and small-scale systems managed by users?

- Were **drainage networks** included as an integral part of the basic design of all irrigation systems to protect the environment, the **water table continuously monitored** for operating irrigation projects, and **erosion control and reforestation programs** an integral part of the project design for reservoir catchment areas?

- For irrigation projects, were **better construction standards** promoted through the careful review of the final design and bidding documents, a better selection of contractors, and better supervision of construction? A portion of the loans should be allocated to post completion activities such as monitoring.

- Does the project conform with nine suggested concepts which serve as the foundation - the framework-for **sustainable water resources engineering** including:

1. **Education.** As facilitators of sustainable development, engineers must have the skills, knowledge, and information that are the stepping stones to a sustainable future. Engineers need to understand environmental and economic issues and problems, especially the risks and potential impacts of engineering actions.
2. **"Ecosystems" thinking.** Engineers are traditionally taught linear problem-solving techniques: they break each problem into its simplest pieces, study each piece, and then move on to the next challenge. Ecosystems thinking calls for synthesis - the combining of separate elements to form an integrated and coherent whole. Sustainable development requires that imitation of the natural processes around us, and engineering should become a unifying, not a partitioning, discipline.
3. **Emphasize the aggregate consequences.** Practicing "ecosystems" thinking requires that engineers begin to examine more carefully the aggregate long-term consequences of decisions in terms of both time and space.
4. **Acquire environmental-economic tools.** Engineers must integrate the environment and social conditions into market economics. Within the context of market economics, engineers must grapple with the need to develop and practice "environmental economics."
5. **Search for sustainable alternatives.** The engineer as a project team leader or member bears much of the responsibility for recommending the technical alternative solutions.
6. **Develop and apply technology to serve sustainability.** Engineers need to develop new technologies, new materials, and new manufacturing processes that meet and surpass today's dreams.

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Technology focused on sustainable development is the key to solving problems created in the past and preventing new ones in the future.

7. **Listening to those we serve.** Engineers must consider sustainable development as a dynamic process that responds to the continually changing needs and expanded knowledge base of the specific society, culture, and community served.

8. **Cultivate a multidisciplinary team approach.** The approach goes beyond the array of engineering disciplines to include many others, including the knowledge, skills, and insights of the natural, social, and physical sciences and firmly integrate them into the engineering process.

9. **External education.** Engineers should continually educate the public and promote the adoption of a sustainable development ethic among all elements of society. (Perhaps special efforts should be directed toward private and public sector decision makers; investors; and local, regional, national, and even international governing bodies.)

- Do project components which include **inter-basin transfer** evaluate the following zones when analyzing possible side effects: (Ortolano 1978).

a. area of withdrawals;
b. area of flow accumulation and regulation;
c. area along the conveyance route;
d. area of water use?

- Has the project considered the primary negative factors in fixing an **acceptable value of post-project streamflow** including:

- modification of the hydrologic regime due to streamflow control, diversions and sediment transport;
- modification of hydro-physical and hydrochemical processes in water bodies;
- modification of the hydrogeological regime of adjacent areas as a result of land inundation and drainage and reduction of the water level in the lower river reaches;
- changes of structural and functional characteristics of aquatic ecosystems due to transformation of the hydrological regime.
- modification of terrestrial ecosystems due to changes of the natural hydrological and hydrogeological regimes of adjacent areas;
- socioeconomic effects of modification of natural processes and human activities in the whole area?

- Does the project incorporate **standardized ecological criteria** to evaluate marginal situations in natural processes such as:

- conservation and preservation of environmental quality;
- enhancement of social well-being and public health;
- preservation of valuable ecosystems;
- preservation of species of animal and plant populations?

- Do projects targeting improved potable water include and support the following recommendations:

1. **Improve the management of renewable water resources.** Greater emphasis must be given to improving the management of existing renewable water supplies. A national management program should include: (1) prevention of further water supply deterioration and better management of land-use and forestry practices; (2) improvement of the ability to capture a larger proportion of renewable water supplies, including wetland protection and extension; (3) implementation of water recycling and conservation practices to improve efficiencies of water use, including lining of irrigation canals, installation of more efficient-plumbing, and consideration of reallocation of water rights.

2. **Support the consolidation of small distribution systems.** Consolidation of small water

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systems should be encouraged to improve the overall quality of water and provide the necessary revenue to implement treatment technologies now available to the larger systems. The drive toward consolidation should take advantage of the replacement of distribution systems that will be necessary in the near future in many communities.

3. **Support changes in treatment technologies.** The traditional concepts of water treatment and distribution can be expected to change substantially in the future as a result of the changing profiles of contaminants of concern. A number of promising technologies will need to be improved and implemented, including membrane treatment. In addition, methods will need to be developed for stabilizing water in distribution systems that do not depend on maintenance of a residual oxidant in the distribution system.

4. **Accelerate research in risk assessment methodologies for chemical and microbiological contaminants of water.** Modifications of current water disinfection treatments to minimize chemical risks in the drinking water supply must consider the relative risks, i.e., the magnitude of microbial risks that may be introduced as a result of the changes, as well as the creation of other disinfection by-products. Substantial research is needed in risk assessment methodology for both chemical and microbial risks.

5. **Establish a surveillance or alert system for emerging waterborne pathogens.** The almost certain changes in water treatment and distribution systems in the next decades and the increased consolidation into larger systems for efficiency of control and delivery of water, pose the very real danger of the generation and transmission to large populations of heretofore unknown microorganisms that may pose serious health risks. A surveillance or alert system to detect these risks early should be put in place.

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Appendix 4.

Proposed EMSs

Technical and Economic Assessment Series (2.0)

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2.1 Appropriate Technology

2.1.1 Appropriate Technology Concepts and Training

- Have the project proponents and developers received **training in AT concepts and applications** and have they incorporated the training into this project? The following concepts are applicable:

- AT is either synonymous with or an important part of sustainable development and infrastructure and it is a way of thinking about the choices and the applications of technology to solve a problem or to create something, such as a structure, a machine, an instrument or a system.
- AT involves a search for technologies that have beneficial effects on income distribution, human development, environmental quality, and the distribution of political power--as well as productivity--in the context of particular communities and nations.
- AT represents what one might call the social and cultural dimension of innovation and the idea here is that the value of a new technology lies not only in its economic viability and its technical soundness, but in its adaptation to the local and cultural environment.
- Assessing the appropriateness of a technology necessarily implies some sort of value judgment both on the part of those who develop it and those who will be using it, and when ideological considerations come into play, as they often do, appropriateness is at best a fluctuating concept.
- Faulkner and Albertson (1985) define technology as: "knowledge, skills, organization and machinery related to the production of goods and services". Then they define AT as: "The skills, knowledge and procedures for making, using and doing useful things, while making optimum use of human, natural, renewable and person-made resources..." They further break down AT into appropriate hard technology and appropriate soft technology:

  "**Appropriate hard technology** relates to engineering techniques, physical structures, machinery, and scientific and technical information. It is usually related to an economic goal."

  "**Appropriate soft technology** deals with the social structures, human interactive processes, and motivation techniques. It is the structure and process for social participation and action by individuals and groups in analyzing situations, making choices and engaging in choice-implementing behaviors that bring about change."

- Faulkner, 1991, further defines and explains that **Social Infrastructure consists of:**

1) The social institutions, such as schools and hospitals, through which access exists to the goods and services that are the product of development efforts.

2) The system of social structures into which people in the community organize themselves for development decisions. Decisions include identifying common development needs and objectives, ranking their importance, and finding the resources to work for their achievement and their subsequent maintenance. Development decisions also include those that reject or modify proposed development, and those that mediate between competing interests. Ad hoc citizen groups, task forces, cooperatives, credit unions, and permanent planning, monitoring and oversight committees illustrate such structures. Such a system of social structures can also promote optimum use of technology.

- **Sustainable Infrastructure & Appropriate Technology** is the appropriate and sustainable use of: knowledge, skills and information; social infrastructure, including organizations, processes and motivation; and physical materials, machinery, and instruments for the production of infrastructure systems which are desired by those people being served. These infrastructure systems are provided in a way that is compatible with nature and the environment, and uses renewable resources, including renewable energy resources, to the maximum extent possible.

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2.1.2 Appropriate Technology Review Criteria

- Have the project proponents and developers **incorporated AT concepts into the project review criteria** in formulating and developing project components? The following concepts are applicable:

- Rules for determining 'appropriateness' vary with disciplines. Engineers traditionally gage appropriateness by quantifiable criteria: calories, man-hours, tons, dollars. Others may judge appropriateness on the basis of tradition or belief. .... It is on the identification of appropriateness that we must increasingly focus.
- No single technology is 'appropriate' for all developmental purposes, but every technology is 'appropriate' for reaching some objectives, which then leads to the idea that we must first decide our objectives and then select the technology that will in fact accomplish and achieve the objectives.
- Since projects are engineering features which translate science and technology into physical structures, the engineering works link the natural environment and society together in a way that hopefully promotes long term sustainable development.

- Were **sustainable planning processes used in project development and review** including public participation, multidisciplinary teams, baseline sustainable development studies, strategic planning, life-cycle consequences, monitoring and evaluation?

- Have all efforts been made to ensure that the project has been developed in a way that **engineering and social infrastructure work in concert** to make choices about technology proposed in development efforts, mitigating some constraints in this process as follows:

- Serious conflicts can exist where characteristics of the engineering profession or the social infrastructure serve to block collaborative and cooperative efforts.
- Ethnocentric premises often underlie efforts by technical experts to encourage the adoption or approval of technology. Their scientific education legitimizes and promotes a hierarchy in which the expert is assumed to have all the knowledge necessary for decision-making, and the lay person to have little or none.
- Information about the impact of technology is not always shared, and often is not fully explored in relation to factors other than those considered important to the expert.
- Technologies may be appropriate to the purposes of the expert, but inappropriate to the community in which they are sited.

- Has the **project infrastructure been developed with an eye toward "industrial ecology"** where unit processes and industries are viewed as interacting systems, based upon an analogy with natural ecological processes and systems? This analogy illustrates "the points of leverage for, and barriers to, improving the environmental characteristics of industrial ecosystems at the macro-level (global economy), meso-level (the firm), and the micro-level (the industrial process)." (National Academy, 1994) The ultimate goals of an IE approach and an AT approach are extremely similar in scope, with the former focusing on industrial development and the latter on infrastructure development.

2.1.3 Incorporation of AT at Various Process Levels

- Has information and concepts related to the development of **manuals of practice in AT** been followed throughout the project development process in areas such as:

a. Policy. Guidelines to assist decision makers in the reorientation of economic policies so that they complement regulatory programs for controlling environmental degradation. This would include the development of enhanced environmental information and decision support systems.

b. Standards. Guidelines for setting appropriate minimum acceptable standards for urban and rural infrastructure services, for all categories of developments, with equal attention to affluent, poor, and poorest areas. This should be done on the basis of relative environmental health risks and costs, not by simply copying current standards of industrialized countries.

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c. Master planning. Guidelines for national, regional, and local infrastructure master planning, to be done in an integrated fashion with careful attention to environmental, sustainability and people concerns.
d. Economic analysis. Manuals for performance of economic analysis of development projects on an economic cum environment (E-c-E) basis, which includes an accurate assessment of all the social costs.
e. Infrastructure design. Manuals for design of infrastructure systems which are "appropriate" (which meet the need at acceptable levels at affordable cost), with particular attention to ensuring adequate O&M, for all categories of development.
f. Environmental impact assessments. Handbooks for conducting EIAs for all categories of infrastructure projects, in sufficient detail to facilitate wide-scale use and application of the EIA process, expanded to regional and sectoral levels, and integrated with CBA analyses.
g. Monitoring. Guides for planning and conducting appropriate environmental monitoring programs, including all aspects of the community environment. These programs must address people participation, quality-of-life, socio-economic, institutional, and financing aspects. They must provide for periodic evaluation of the monitoring data for use in planning needed improvements, and include establishment of an appropriate national environmental data base adequate for assessing environmental quality in quantified terms suitable for use by administrators, engineers, environmentalists, and economists.
h. Operation and Maintenance. Improving operational performance and resource utilization after completion of an infrastructure system.

2.2 Conservation and Demand Management

2.2.1 Water Conservation and Pollution Control

- Has the project worked under and incorporated a strong **water conservation and pollution control policy** including protection of available water resources, water conservation and prevention of wasteful use of water, to enable demands to be met more economically compared with the costs of developing new water sources?

- Does the conservation policy encourage the following **water usage features**:
  (a) efficient, non-wasteful water use;
  (b) pollution reduction through wastewater reuse and recovery,
  (c) introduction of clean technologies and water-saving appliances in various economic sectors?

- Has the project taken proper account of the high quality, reliability and value of **groundwater resources,** particularly the implications of their pollution and misuse?

- Does the project foster water conservation/reuse by all means including **economic incentives and legal regulations, administrative measures and public awareness**?

- Does the project fully consider **reduction of the generation of pollutants at source,** preferably by on-site treatment of wastewater, such as reducing the polluting load from the low-income urban areas through the introduction of basic sanitary waste disposal facilities based on environmentally sound low-cost and upgradable technologies, for example, oxidation ponds and land irrigation?

- Do municipal and industrial components of the project conform with **discharge quality standards** for municipal and industrial effluents which are enforced by legislation and pricing mechanisms? (This would include use of the "Polluter Pays Principle", including the levy of effluent charges adequate to achieve the desired reduction of pollutants.)

- Has the project fully incorporated water demand management in the domestic, municipal and industrial sectors **within the framework of a policy for sustainable and environmentally sound development** and management of water resources, vigorously promoted using economic incentives and legal instruments, and supplemented by reduction in leakage and unaccounted for water losses?

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- Does the project fully explore strategies for pursuing the broader goal of providing **sustainable expansion of sanitation services** that are adequate in terms of coverage and effectiveness in services quality and environmental pollution abatement?

- Has the project fully investigated the promotion, development and production of a wider range of sanitation technologies and **lower-cost sewerage systems** so that the range of options and costs would enable a wider group to enjoy the benefits of improved sanitation services?

2.2.2 Demand Management

- Has the project fully recognized that the cost of developing new sources of water supply is continuing to increase, and the **effective utilization of existing resources** mainly through demand management may become more beneficial in the long term as the cost of saving water might be significantly lower than the cost of developing additional water resources?

- Does the project adhere to the basic principle of demand management, that water should be considered **an economic good having a value consistent with its most valuable potential use**? (Managing water as an economic good is in important way of achieving efficient and equitable use, and of encouraging conservation and protection of water resources.)

- Have **agricultural and irrigation components** of the project fully incorporated demand management concepts, allowing for reallocation for other urgent water needs, while giving due consideration is to be given to the possible impacts of such transformation on food security and rural development?

- Have **industrial components** of the project fully incorporated demand management concepts into proposed or existing water usage schemes including:

a) concentration of industries in special zones rather than being scattered throughout metropolitan areas to allow them to be served by lower quality water, thereby preserving limited drinking quality water for domestic consumption;

b) separation of industrial wastewaters from municipal wastewaters to allow for improved and separate appropriate treatment;

c) introduction of water-saving technologies, recycling techniques and water reuse, with the additional benefit of reduced wastewater discharge;

d) accurate water pricing to prevent the discharge of wastewater without treatment or with minimum treatment because the additional intake make up supply of fresh water is cheaper than the introduction of water conserving and saving measures?

- Have the **domestic and municipal sector** project components included demand management concepts such as:

a) accurate water pricing as an important instrument for stimulating efficient use of water;

b) public water uses, such as park watering, be paid for from the municipal budget;

c) reduction of water losses in distribution networks (from the present "unaccounted-for" water rate of 45-50 per cent in a number of large cities to a reasonable level);

d) demand-based sanitation approach which is basically a participatory approach for making informed choices from a range of feasible alternatives for (i) supply options, (ii) financial options, and (iii) institutional arrangements?

- Do **sanitation related options** in the project fully incorporate demand-based approaches including:

a) allocation of financial resources driven by merit of locally determined sanitation plans;

b) choice of technical solutions consistent with user willingness to pay, and solutions for different income groups are chosen to minimize financial gap between total system costs and revenues;

c) projected cash flows are sufficient to meet current financial obligations for operation and maintenance and for servicing debts;

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d) financing proposals are based on local demand for service, and
e) reliance is put on user charges to recover costs?
f) guidelines for screening zones for investment include (i) user willingness to pay; (ii) minimizing financial gap between system costs and revenues; (iii) externalities (including environmental pollution abatement); and (iv) equity considerations

2.2.3 Financing and Institutions

- Does the project financing plan recognize that the **starting point for supply choices is demand,** and the goal is to: minimize subsidy, subject to specific administrative constraints such as tariff level, service coverage, equity, or environmental pollution abatement?

- Have the **supply options of the project** fully addressed the type of technology, type of service providers (public, private, NGOs, community-involved, or self-provision), extent of coverage (who, how much, and when); and tariff level?

- Has the project financial plan fully addressed the **following financing options** using criteria for choice between these options of efficiency and demand orientation, expansion of service, sustainability; and reliability:

a) direct user charges and benefit taxes from user areas;
b) charges to cover nonuser beneficiaries in service area (i.e., in situations where externalities are involved with the provision of the service);
c) loans repaid from user charges;
d) subsidized loans;
e) grants; and
f) cross-subsidization (but must be kept to a minimum, because it undermines demand orientation)?

- Has the **project institutional management plan** addressed the following institutional options using criteria for choice between these options of operational efficiency, service quality, accountability, reliability, flexibility, and equity:

a) service ownership: public or private;
b) service providers: public, private, NGO, community involved provision, and self provision;
c) competition/competition surrogates: decentralization, multiplicity of service providers; and
d) policy reform: separation between supply and regulatory functions; creation of enabling environment of legal, regulatory, and incentive environment as well as administrative practices to permit use of market friendly approaches?

- Has the project recognized that there may not be adequate local capacity to implement the bottom up demand-oriented process and provided **technical assistance** to local communities that pre-qualify on other grounds for competing for resource allocation?

- Does the project **assist service providers,** whether they are public, private, NGO or community groups, in their major reorientation of attitudes (and specific training) in order to be able to implement the demand-based approaches?

2.3 Environmental Valuation/Pricing Accounting Framework

Sustainable development means ensuring that future generations have as many opportunities as we have. **Ensuring that this will be possible for the increased populations of the future requires increasing the world's stock of capital.** Four types of capital - which are often strong components but weak substitutes for one another- need to be recognized (Ismail Serageldin and Andrew Steer of the World Bank, 1993)

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Sustainable development is about development progress; it is not a doctrine of "no-growth" environmental protectionism. It is about a particular form of progress. Specifically, sustainable development places the focus on two groups of disenfranchised people: the poor of today and the generations of tomorrow. Its goals are to increase opportunities, improve livelihoods, and reduce the risk of disease or impoverishment for the people who live below the line of acute poverty or not much above it, for the people who lack even basic sanitation services, and who yet cannot enjoy the benefits of modern energy. (World Bank, 1996)

2.3.1 Capital Stock and Environmental Accounting

- Has the project been formulated and reviewed under an **environmental accounting framework** that recognizes the four categories of capital: human-made or "fabricated" capital (machines, factories, buildings, and infrastructure), natural capital (as discussed in many works of environmental economics), human capital (investments in education, health, and nutrition of individuals), and social capital (the institutional and cultural bases for a society to function)?

- Since traditional project benefits focus on **human-made capital** (since it is the most measurable), has this project included the other forms of capital, since it is there that remedial analysis and action are needed?

- Has the project fully addressed the **protection and enhancement of natural capital,** the stock of environmentally provided assets (such as soil, sub-soil minerals, forests, atmosphere, water, wetlands) that provide a flow of useful renewable and non-renewable goods and services, which may be marketed or unmarketed?

- Has the project recognized that **substituting non-natural capital for natural capital** is possible in the short to medium term but eventually is limited since thresholds can be crossed, after which yields will decline, often sharply, regardless of how many other inputs are supplied?

- Has the project recognized the **importance of human capital formation,** since investment in people has a very high return on investment, especially in developing societies, and investment in human resources is an essential, possibly the most essential, ingredient of development strategy?

- Have the full ramifications of **social capital** been recognized by the project, the forms of governance and of cultural expression and social behavior that make a society more than the sum of a collection of individuals, based on inclusion, participation, and the promotion of an enabling environment? (The myriad institutions that we take for granted as essential premises of a functioning society must be grounded in a common sense of belonging by its members, and the institutions must reflect a sense of legitimacy in their mediation of conflicts and competing claims. In short, if that social capital is inadequate, the resulting failures make it impossible to talk of economic growth, environmental sustainability, or human well-being.)

- Has the overall environmental accounting framework that the project has been formulated and reviewed under **recognized the following difficulties in accounting the environmental obligations:**

Feature	Traditional Obligations	Environmental Obligations
Time span Involved	Relatively well defined, short to medium term	Ill-defined,more long term (intergenerational)
Interdependence	"Self-contained" liability	High degree of interdependence
Ease of estimation	Relatively easy to estimate	Inherently difficult to estimate
Stewardship concept	Traditional private property, shareholder stewardship concept	Common property, stakeholder stewardship concept

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Contractual basis	"Explicit" contract between known transacting parties	Implicit social contract with unknown, "invisible" parties
Valuation basis	Fair-market transaction values	Court-arbitrated values
Philosophy	Economic orientation Anthropocentric (centered on human beings)	Recognition of noneconomic impact on other habitats Multi species orientation
Entity	Entity specific	Ecosystem specific

- Does the overall accounting framework **incorporate environmental concerns** by using the following definitions in balance sheets:

- **Assets include both the natural capital upon which a reporting entity is economically dependent** and probable future economic benefits obtained or controlled by a particular entity as a result of past transactions or events.
- **Liabilities are probable future sacrifices or economic benefits** arising from present obligations or a particular entity to transfer assets or provide services to other entities in the future as a result of past transactions or events **and the risk of the consumption of natural capital.**
- **Expenses are outflows** or other using up of assets, **including the consumption of natural capital,** or incurrences of liabilities (or a combination of both) from delivering or producing goods, rendering services, or carrying out other activities that constitute the entity's ongoing major or central operations **(including the preventive maintenance of the natural capital** essential to maintain a going concern)?

2.3.2 Sustainability and the Capital Stock

- Does the project set aside the simplistic view that sustainability requires leaving to the next generation exactly the same amount and composition of natural capital as we found ourselves, and substitute the more promising concept of **giving future generations the same, if not more, opportunities?** (In other words, the stock of capital that we leave them, defined to include all four forms of capital, should be the same if not larger than what we found ourselves.)

- To accomplish and track such transfers of one form of capital for another, does the **project accounting framework** allow for:

- Measuring each kind of capital
- Defining the production function, in terms of the degree of substitutability and complementarity between the different kinds of capital, and how these may change in a dynamic context
- Defining (in the absence of a common numeraire) an "exchange rate" for the different kinds of capital, accepting that it, too, may be dynamic.
- Defining sustainability in terms of a context of thresholds within which the more efficient (highest return) activities could be selected, in such a way that individual investments and entire strategies could be meaningfully evaluated.

- Since such an approach is comprehensive and rigorous, and a long way off to full implementation, does the project at least allow for **incorporating human capital and natural capital** into conventional economic analysis, improving our understanding of the inter-linkages between these three kinds of capital? (Social capital will take longer to elaborate, and in the meantime can be left to the political processes in each country to arbitrate.)

- Has the project review determined a level of sustainability appropriate for the project after careful consideration of the types of sustainability:

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- **Weak sustainability** is maintaining total capital intact without regard to the composition of that capital among the four different kinds of capital. This would imply that the different kinds of capital are substitutes, at least within the boundaries of current levels of economic activity and resource endowment.
- **Sensible sustainability** would require that in addition to maintaining the total level of capital intact, some concern should be given to the composition of that capital (among natural, human-made, human, and social). Thus, oil may be depleted so long as the receipts are invested in other capital, for example, human capital development, elsewhere, but, in addition, efforts should be made to define critical levels of each type of capital, beyond which concerns about substitutability could arise. These levels should be monitored to ensure that patterns of development do not promote a decimation of one kind of capital, regardless of what is being accumulated in other forms of capital.
- **Strong sustainability** requires maintaining different sub-components of capital intact separately. Thus, for natural capital, loss of forest in one area should he replaced by new forest of a similar type elsewhere, and receipts from depleting oil should be invested in sustainable energy production. This assumes that natural and man-made capital are not really substitutes but complements in most production functions and that even within capital types, there is limited substitutability. Thus, a sawmill (human-made capital) is worthless without the complementary natural capital of a forest.
- **Absurdly strong sustainability** would never deplete anything. Non-renewable resources could not be used at all; for renewables, only net annual growth rates could he harvested, in the form of the over-mature portion of the stock.

- Has a **pragmatic approach been used in reviewing the priority of this project** and encouraging the growth of natural capital by reducing the level of current exploitation; investing in projects to relieve pressure on natural capital stocks by expanding cultivated natural capital, such as tree plantations to relieve pressure on natural forests; and by increasing investment in human resources, particularly of the poor who are both the victims and the unwitting agents of economic degradation in many of the poorest societies on earth?

- Since a "perfect" formulation on sustainability is still to be found, does the project assist with the **improvement of our data bases** related to the different kinds of capital, especially the physical stocks and flows of natural capital, and the interaction of these into coherent views of ecosystem integrity and resilience at the regional as well as the global level?

2.3.3 Environmental Resource Pricing

- Has the project ensured that the **"true" economic value** of water resources were accounted for during the investment decision? (There is a fundamental connection between the issue of **economic valuation of environmental resources** and the **pricing of environmental resources.**

- Has the marginal economic value of the water resources been entered into an accounting procedure such as **cost-benefit analysis or national accounting**? (In the former case the market is then left to react to the actual price charged for the resource. In the latter case economic decisions are based on the **accounting price** or **shadow price.)**

- Has the project ensured the **internalization of environmental damage costs** to prevent distortions in the economy that have the effect of **biasing investment and policy decisions** against environmental concerns? (Unless water resources are correctly priced, and those prices internalized in actual decisions - there will be a misallocation of resources in the economy and social well-being will not be maximized.)

- Has the project correctly identified the two contexts for the proper pricing of water resources: (a) when the resource is **consumed directly,** as with water supply - pricing involves **user charges**; (b) when the resource is **consumed indirectly**, as with the receiving capacity of water in terms of its assimilation of wastes - involves

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emissions or **waste charges**? (Quite often, user, emission and waste charges are all called "user charges" because they all make an attempt to price for the use of environmental resources.)

- Has the project followed the basic rule for the optimal pricing of water resources in that the price should be equal to the **cost of extracting or harvesting** the water resources, plus any **external costs that the extraction or harvesting causes**, plus any **"user cost" element**?

- Does the water resources project address a **water shortage due to the under-pricing of water**? (That is, the shortage is "contrived" to the extent that past investments have not been properly priced, encouraging over-consumption relative to the true value of water.)

- Does the project utilize the following **recommended method for pricing water**?

Since water is (generally) a **non-tradeable resource** its economic price is determined by the marginal cost of supply. There are alternative methods over which marginal cost concept to employ. **Short run marginal cost** (SRMC) relates to the marginal cost of expanding the quantity supplied given the existing capital stock for supplying water (dams etc.). **Long run marginal cost** (LRMC) relates to the cost of expanding the existing capacity. LRMC is the relevant concept when planning new infrastructure. Given the "lumpy" nature of investment in water supply, pricing at SRMC will tend to produce the result that prices rise as existing capacity is more and more utilized, but could fall again as new capacity is brought into being. Partly for this reason, LRMC tends to be preferred.

LRMC is most often approximated by the **average incremental cost (AIC)** and this, in turn, is approximated by:

$$\mathbf{AIC} = \Sigma (K_t + C_t)(1 + r)^t / \text{SUM (delta Q)}(1 + r)^t$$

where K is capital cost, C is operating cost, and delta Q is the extra quantity of water that would be made available. Capital costs will include storage and transmission to the "city gate" or "farmgate", and distribution costs within the city or local area to households, farms, etc.

Note: In water scarce countries it is important to note that the use of the AIC formula may well dictate high prices for new water supplies. The fact of scarcity tends to reflect the use already made of accessible water supplies, so that new investment can only come from major new borehole activity or, as in a growing number of countries, the introduction of desalination plant. As with all pricing and project appraisal, of course, AIC should be estimated using shadow prices rather than market prices. Estimates of AICs vary, but for arid areas desalination may cost as much as $1.3 per cubic meter compared to "inter-basin" supply costs of $0.5 per cubic meter.

2.3.4 Environmental Valuation

- Does the project address the most useful valuation methods which look at **how environmental changes affect directly observable behavior valued in conventional markets** on:

- **Effect on production.** Impacts valued by the effect on the quantity, quality, or production costs of marketed outputs;
- **Effect on health.** Impacts valued as output lost due to sickness or death, including foregone earnings and costs of health care or prevention;
- **Defensive or preventive costs.** Ex-post costs of mitigating damage caused by environmental impacts provide a minimum estimate of original damage costs (for example, the extra costs of purifying polluted water)?

- Does the project address a second set of methods which seeks to **value intended actions in markets** on:

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- **Replacement cost.** Future cost of replacing an impaired environmental resource by an equivalent asset, assuming that the original resource was at least as valuable as the replacement expense;
- **Shadow project.** Closely related to replacement cost - involving cost of special project designed to offset environmental damage caused by another project (for example, cost of new reforestation scheme to replace forest area inundated by hydro-dam)?

- If the project cannot utilize direct market valuation, does it address **indirect market data** to determine implicit values such as:

- **Travel cost.** Willingness of tourists to pay a surplus over the normal price to visit a recreational site Demand (for example, frequency of visits per year) is first related to variables such as visitor income and price---including entry fees, travel costs, and opportunity value of time;
- **Wage differences.** Wage premium needed to compensate for working in polluted or hazardous environment, after first accounting for other wage determinants such as age and skill level;
- **Property value.** Willingness of property buyers to pay extra for real estate in cleaner neighborhoods;
- **Proxy goods.** Market value of a substitute for an environmental asset that itself is not marketed?

- If the project cannot utilize market data of any kind, does it use the final group of methods which **simulate market-like behavior, using marketing experiments or surveys** such as:

- **Artificial market.** Willingness to pay for an environmental asset determined on an experimental market (for example, home water purification kit marketed at various price levels to assess demand)
- **Contingent valuation.** Willingness to pay for an environmental asset or willingness to accept compensation for its loss, determined by direct questions. The method is most effective if respondents are familiar with the asset (for example, drinking water quality)?

2.4 Economic Instruments

The **two principal approaches to water pollution control and waste management are the command-and-control and economic strategies.** Since the inception of environmental policy in most industrialized countries, governments have tended to use command-and-control (that is, direct regulation along with monitoring and enforcement systems) as the predominant strategy in pollution control and waste management. This approach generally requires a government to set health or ecology-based ambient environmental objectives and specify the standards or amount of pollutants that can be discharged or the technology by which polluters should meet those objectives. In most cases, the command-and-control approach also specifies schedules for meeting the standards, permitting and enforcement procedures for facilities, liability assignment, and penalties for non-compliance. The institutional responsibility for defining and enforcing the standards and other requirements is shared in legislatively specified ways between the national, state, and local governments.

Although command-and-control strategies have made substantial progress in reducing pollution, this approach has been criticized for not achieving various legislative mandates and deadlines and for being economically inefficient and difficult to enforce. These strategies are inefficient for the regulatory agency, which must have detailed information concerning production processes and the suitability of various pollution control devices. With diverse industries, it is extremely expensive and time-consuming to obtain the necessary information and expertise on each industry. Other problems with this approach are the high costs for pollution control that leave little opportunity to take advantage of economies of scale. Economic instruments have emerged as complements to the command and control programs as an attempt to rectify some of these issues.

2.4.1 Selection Criteria: Command-and-Control Versus Economic Strategies

- Has the project been **developed under and fully incorporated various economic instruments** (that is, pollution charges, marketable permits, subsidies, deposit and return systems, and enforcement incentives) to introduce more flexibility, efficiency, and cost-effectiveness into water resources and water pollution control components of the project?

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- Do the selected economic instruments operate as **incentives to determine the most efficient and cost-effective means for achieving environmental targets**, incorporating the polluter-pays and user-pays principles? (According to the polluter-pays principle, the polluter pays a financial penalty for higher levels of pollution and pays a smaller penalty or receives a financial reward for lower levels of pollution. According to the user-pays principle, the user of a resource pays the full social cost of supplying the resource, such as for water and related services including treatment costs (OECD 1990).)

- Does the system of economic instruments designed to protect the environment **restore the link between resource scarcity and resource price** by 1) reduction and elimination of subsidies, 2) mitigation of market failures, 3) internalization of full environmental costs in public projects?

- Does the system of economic instruments used in conjunction with project development **insure the following goals are met:**

- promote cost-effective means for achieving acceptable levels of pollution;
- stimulate development of pollution control technology and expertise in the private sector;
- provide government with a source of revenue to support pollution control programs;
- provide flexibility in pollution control technologies; and
- eliminate a government's requirement for large amounts of detailed information needed to determine the feasible and appropriate level of control for each plant or product ?

- Does the system of economic instruments recognize that **to be effective in LDCs, economic instruments require:**

- an adequate information base (costs and benefits, quantity/quality of environmental assets and resources, technological and institutional opportunities and constraints, substitution possibilities),
- strong legal structure (defined property rights, legislative authority, specific legal standing),
- competitive markets (prices and competition play meaningful role in economic structure),
- administrative capacity (design, monitor, enforce, modify), and political will.

- Does the **system of instruments consider the potential problems** that the effects of economic instruments on environmental quality are not as predictable as those under the traditional regulatory approach, some polluters may choose to pollute if the charge is not set at an appropriate level and that they require sophisticated institutions to implement and enforce them?

- Does the system of economic instruments pragmatically recognize that although economic instruments have the capability to control pollution according to market mechanisms and thus facilitate deregulation and a reduction in government involvement, in practice they **have not eliminated the need for regulations, enforcement, and other forms of government participation?** (Notwithstanding the potential benefits of economic instruments - raising public revenues, promoting innovation in pollution control technology, and lowering pollution control costs - government authorities, polluters, and environmentalists have not always supported the economic incentive approach.)

- Does the project recognize that in political terms that **industry and other polluters often resist economic instruments** such as effluent and emissions charges because they have greater negotiating power over the design and implementation of regulations than they do over economic instruments? (Economic instruments act as an additional constraint on industry when they supplement existing regulations; some economic instruments (especially charges) impose a financial burden beyond the cost of complying with regulations.) (OECD 1989).

- Does the project consider that **not all types of pollution are appropriate for an incentive-based approach?** (For example, toxic substances, which can cause serious acute and chronic health problems, are better suited to some form of direct regulation.)

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- Does the system of economic instruments meet the **four performance criteria of effectiveness, efficiency, equity, and flexibility?** (Effectiveness refers to the success in achieving stated objectives in pollution reduction and resource conservation. Efficiency is desirable in that it implies that objectives are achieved at the lowest possible cost. Economic instruments have implications for equity, which involves the distribution of economic and environmental costs and benefits among members of society. An economic instrument should be adaptable to changes in markets, technology, knowledge, and social, political and environmental conditions.)

2.4.2 Pollution charges

- Does the project work under a **system of effluent or emission charges,** which are fees levied by a government authority based on the quantity and/or quality of pollutants discharged into the environment? (A discharger is required to pay a certain amount for every unit of pollution discharged into surface water.)

- Does the system of water effluent and emission charges base the charge on an **optimal mix of water quality objectives, the costs for financing a pollution abatement scheme, and effluent standards?**

- Since the most commonly proposed effluent charge schemes encompass whole regions, does the project fully recognize that a **number of institutional, political, and technical conditions must exist or be created** such as:

1. **responsible institution** (often a regional authority) should encompass natural boundaries (such as watersheds) and have the legal authority to impose and enforce charges on polluters.
2. authority would require: **analytical methods and data** to establish the monetary value of damages caused by various pollutants or a method for estimating the level of the fee necessary to meet environmental quality standards, adequate resources to monitor emissions for each source of pollution, self-monitoring with periodic verification and enforcement, and legal power over the disposition of revenues?

- Does the project **take full advantage of the advantages of effluent and emission charges** such as:

- they induce firms to reduce pollution at lower costs than those under a command-and-control approach;
- they provide incentives to firms to invest in new pollution control technology;
- they generate revenue, which can be used to finance and enhance enforcement activities;
- they can compensate, at least partially, for the unpaid costs of industrial activity usually borne by society at large. (These include government expenditures associated with the development and enforcement of environmental regulations as well as the costs arising from discharges that are legal but still cause damage to natural resources)?

- Does the project fully **recognize and mitigate against the principal disadvantages** of effluent charges related to practical and political considerations such as:

- industry prefers control through standards over a system of fees with the same abatement costs because payment of the fee on remaining discharges will cost more in total;
- there is no scientific or politically accepted way to assign monetary values to pollution damage and charge setting is further complicated because the location of individual pollution sources will determine the extent of damage to ambient quality, thus requiring firm-specific rates;
- areas may compete for economic development by reducing charges, thus penalizing areas trying to improve environmental quality;
- developing and administering fees for numerous pollutants from single or multipoint sources is probably not feasible with available resources for monitoring and enforcement in developing countries;
- local authorities may not be strong enough to handle the complex planning, analysis, monitoring, enforcement, litigation, and interjurisdictional negotiation that would be required under an effluent or emission charge system;

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- defining regional boundaries to apply the fee presents major difficulties (watersheds are relatively easy to define, but the extent of an authority's jurisdiction throughout the tributaries is often unclear.)?

2.4.3 User, Product and Administrative Charges

- Does the project work under and consider a **system of user charges** that are direct payments for the costs of collective or public treatment of pollution? (With respect to water pollution control, for example, user charges are fees paid to water authorities to allow discharges of industrial wastes into public sewers.)

- Do the user charges ensure that the **receiving facility has an economic incentive to improve the quality of its effluent discharge** to surface waters? (Note that certain toxic pollutants should never be permitted to enter watercourses.)

- Does the project work under and consider a **system of product charges** that are fees added to the price of products or product inputs that cause pollution in either the manufacturing or consumption phase or for which a special disposal system has been established? (They function like effluent and emission charges in that they allow users to determine their own cost-effective means for reducing pollution. Revenues from product charges can be used to treat pollution from the product directly, to provide for recycling of the used product, or for other budgetary purposes.)

- Does the project work under and consider **a system of administrative charges** that are fees paid to authorities for such services as chemical registration or the implementation and enforcement of environmental regulations? (They usually are a component of direct regulation and are intended primarily to finance the licensing and control activities of pollution authorities.)

2.4.4 Tax Differentiation and Subsidies

- Does the project work and utilize **tax differentiation** to promote consumption of products that are environmentally safe? (This instrument involves a combination of two surcharges added to other product charges: a positive charge levied on a polluting product and a negative charge on a cleaner alternative.)

- Does the project work under a **system of subsidies** including grants, low interest loans, and tax incentives that act as incentives to polluters to change their behavior or reduce the costs of pollution abatement to be borne by polluters, both private and public?

- Does the project work in conjunction with **tax incentives** that involve tax credits or accelerated depreciation for industrial investments in equipment to abate or control pollution?

2.4.5 Enforcement incentives

- Does the project work under and utilize a **system of enforcement incentives** which are economic instruments tied to direct regulation, designed to encourage dischargers to comply with environmental standards and regulations and include noncompliance fees or fines, performance bonds, and liability assignment? (They can also include denial of public subsidies and financing and partial or total suspension of plant operations.)

- Does the project work under and utilize a **system of noncompliance fees** that are charged to polluters when they emit or discharge pollution that exceeds levels imposed by regulations? (When regulatory rather than economic instruments are the prime method of pollution prevention, enforcement generally may be weak

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when fines for violations are so low that it pays polluters substantially to break the law. To avoid time-consuming litigation, it is better to use noncompliance fees rather than criminal prosecution, provided that these fees are set so that firms have a strong incentive to abide by the regulations.)

- Does the project work under a **system of performance bonds** that are payments to regulatory authorities before a potentially polluting activity is undertaken, with the payments returned when the environmental performance of the activity is acceptable?

- Does the project work under a **system of liability assignment** that provides incentives to actual or potential polluters to protect the environment by making them liable for the damage they cause, ensuring that victims of environmental damage are compensated and serving as a preventive measure? (Making polluters clearly liable for any damages they cause, with the burden of proof on the polluter to establish harmlessness unless the emission level falls within established safety standards, has proven effective in obtaining industry's cooperation in standard setting.)

2.4.6 Policy Instruments for Implementing Economic Incentives

- Does the project include an **appropriate mix of policy instruments** for governments to use to implement an economic incentives approach to environmental management based on the following checklist:

- **Natural Resource Management**
  - property rights (e.g. land titles, water rights)
  - tradable resource shares (e.g. water capacity shares)
  - use rights (e.g. communal land rights and territorial use rights in fisheries or TURFs)
  - development rights (transferable development right for heritage assets, rural amenities, greenbelts, and coastal resources)
  - concession bidding (e.g. logging concessions, national park concessions)
  - licensing fees (e.g. fishing licenses)
  - tradable quotas (e.g. individual transferable quotas in fisheries)
  - resource pricing (e.g. water pricing, pricing of tropical timber)
  - product pricing (e.g. energy pricing)
  - resource taxation (e.g. forest and mineral royalties)
  - tax concessions (e.g. for reforestation)
  - subsidies (e.g. for tree planting)
  - land use taxes (e.g. to discourage erodible crops on steep slopes)
  - betterment fees (e.g. for infrastructure)
  - user charges/access fees (e.g. for roads/parks)
  - performance bonds (e.g. for forest management)

- Environmental Management
  - tradeable pollution rights/permits (e.g. for air pollution, greenhouse gasses)
  - effluent and emission charges (e.g. for water, air and noise pollution)
  - presumptive charges (e.g. for hazardous waste)
  - product charges (e.g. batteries, lubricants, fertilizers, pesticides)
  - pollution taxes (e.g. carbon tax)
  - input taxes (e.g. on PCBs, CFCs)
  - resource input pricing (e.g. water pricing, energy pricing)
  - tax concessions (e.g. duty free import of pollution abatement equipment)
  - tax differentiation (e.g. for cars based on size and year of purchase, for leaded/leadfree gasoline)
  - subsidies (e.g. for 'clean' technologies, for waste products to create a market)
  - location Incentives (e.g. for Industrial polluters)
  - access fees (e.g. to city centers)

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- performance bonds (e.g. for oil spills)
- environmental auditing (e.g. for hazardous waste)
- deposit-refund systems (e.g. for car batteries, beverage can etc.)
- enforcement Incentives (e.g. for hazardous waste)
- liability insurance.

- Does the project fully recognize that the shift towards prevention and sustainability requires governments to use a **broad array of complementary instruments** such as:

- finely-tuned, "innovation friendly" regulatory programmes;
- negotiation with "stakeholders" and the incorporation of market mechanisms;
- more stringent and consistent enforcement of pollution reduction agreements;
- new voluntary agreements to stimulate basic production and product changes;
- technical assistance partnerships;
- joint agreements and action plans between sectoral ministries and their constituents;
- improved environmental education and vocational training programmes;
- consumer education; and
- public participation in a variety of forms?

2.5 Financial Planning and Economic Impacts

A radical rethinking has taken place and is still evolving in all aspects of economic development policy and natural resource policy. It is instructive to characterize an "old view" of sector policy (and the related financing challenges) deriving from the central planning model that dominated development thinking between the 1950s and the 1980s and contrast it with a "new view" that is emerging as a result of the **emphasis on market-friendly policies and environmental sustainability.**

The old view assumes that government has the primary responsibility for financing, managing, and operating services. It is government's task to define the services to be provided, to subsidize these services (especially for the poor), and to develop public organizations for service delivery. External support agencies are to assist this effort by providing the resource transfers necessary for service provision.

2.5.1 Keys to Developing a Financially Sustainable Water Sector

- Does the project recognize that **water has an economic value in all its competing uses** and should be recognized as an economic good?

- Does the project recognize that water development and management should be based on a **participatory approach involving users, planners, and policymakers** at all levels, with decisions taken at the lowest appropriate level?

- Does the project recognize the prime importance of one central tenet that should underlie the financing of water resources management and water supply and sanitation services which is that both efficiency and equity require that **private financing be used for financing private goods and that public resources be used only for financing public goods**?

- Does the project recognize that **social units** themselves (ranging from households to river basin agencies) are in the best position to **weigh the costs and benefits** of different amounts of investment of resources for a particular level of social organization?

- Does the project fully recognize that the **total economic costs** of providing water include both the financial costs of abstracting, transporting, storing, treating, and distributing the water, and the economic cost of water as an input? (The latter cost arises because when water is taken, for example, from a stream for use in a city,

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other potential users are denied the possibility of using the water. The value of the most valuable opportunity foregone [known technically as the "scarcity value" or **"opportunity cost"**] constitutes a legitimate element of the total production cost of water.)

- Does the project include the most appropriate form of water resources management charges based on the **opportunity cost levied on users**? (As an empirical matter, the financial costs of water supplies to urban consumers and industries usually greatly exceed the opportunity costs. For low-value, high-volume uses-specifically, in irrigated agriculture-the relationship is frequently just the opposite; opportunity costs are a considerable fraction of total costs, especially in situations of water scarcity.)

- Does the project recognize on the benefit side that the provision of water supply to households carries several benefits, and because these **"private" benefits constitute the bulk of the overall benefits of a household water supply,** the public finance allocation principle dictates that most of the costs of such supplies should be borne by householders themselves? (Households then make appropriate decisions on the type of service they want - a communal tap, a yard tap, or multiple taps in the household).

- Does the project also recognize that because this household water supply is principally a "private good," most of the **financing for the provision of water supply services should be generated from user charges** sufficient to cover the economic costs of inputs (including both the direct financial cost of inputs such as capital and labor and the opportunity cost of water as an input)?

- Does the project recognize that the financing of **sanitation, sewerage, and wastewater management** are more complex with **households** placing high value on sanitation services that provide them with a private, convenient, odor-free facility which removes excreta and wastewater from the property or confines it appropriately within the property, and **also benefits that accrue at a more aggregate level** and are therefore "externalities" from the point of view of the household?

- Does the project consider that at **levels above the household sanitation services have value** in that:
  - in the block level, **households in a particular block** collectively place high value on services that remove excreta from the block as a whole,
  - at the **neighborhood level**, services that remove excreta and wastewater from the neighborhood or that render these wastes innocuous through treatment are valued,
  - at the city level, the treatment of wastes or their removal from the **environs of the city** is valued,
  - the wastes discharged from one city may pollute the water supply of a neighboring city, and groups of cities (and farms and industries and others) in a **river basin** perceive a collective benefit from environmental improvement,
  - because the health and well-being of a nation as a whole may be affected by environmental degradation in a particular river basin, there are sometimes additional **national benefits** from wastewater management in a particular basin?

- Does the project comply with the fundamental axiom of public financing which prescribes that **costs be assigned to different levels in this hierarchy according to the benefits accruing at different levels**, which would suggest that the financing of sanitation, sewerage, and wastewater treatment be approximately as follows:
  - **Households** pay the bulk of the costs incurred in providing on-plot facilities (bathrooms, toilets, on-lot sewerage connections).
  - Residents of a **block** collectively pay the additional cost incurred in collecting the wastes from individual houses and transporting them to the boundary of the block.
  - Residents of a **neighborhood** collectively pay the additional cost of collecting the wastes from blocks and transporting them to the boundary of the neighborhood (or of treating neighborhood wastes).
  - Residents of a **city** collectively pay the additional cost of collecting the wastes from blocks and transporting them to the boundary of the city (or of treating the city wastes).

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- **Stakeholders in a river basin** including cities, farmers, industries, and environmentalists--collectively assess the value of different levels of water quality within a basin, decide on the quality they wish to pay for, and determine the distribution of responsibility for paying for the necessary treatment and water quality management activities.

- Does the project fully incorporate the **emerging consensus on the financing of water supply and sanitation facilities involving three key ideas:**

- The first, the most mundane, is that the reduction of poverty depends in a fundamental way on **sound economic policies,** which means fiscal common sense and the maximum use of the market and market-like instruments.
- The second idea is that the only true development is one in which **economic progress and environmental enhancement go hand in hand** and are mutually reinforcing.
- The third idea is that **people have to be not only the object but the subject of development**? (It is the people themselves who have to decide what services they want; it is the people to whom service institutions have to be responsive and accountable; it is the affected people who have to make the decisions (based on information from technicians) on environmental policies and standards.)

2.5.2 Tracing Economic Impacts

- A policy analysis system is required to trace the impacts of the project-related decisions at various spatial levels. Has the project level assessment moved **beyond classical CBA?:**

- **Project level.** Traditionally, economists have relied on cost-benefit analysis to help determine whether a project is worth undertaking. This type of analysis increasingly is being adapted to better account for environmental and social concerns, despite special problems. First, some inputs and outputs are not correctly priced by the market. Second, with well over 1 billion poor worldwide living on less than $1 per day, national policymakers often seek to reduce the income gap between rich and poor groups. This goal may justify giving greater weight to benefits and costs that accrue to the poor relative to the rich. Such formal weighing schemes seldom are used in project evaluation. More direct methods, such as poverty assessments and targeting disadvantaged groups, have proved more useful.

- A policy analysis system is required to trace the impacts of the project-related decisions at various spatial levels. Was this project developed under such a **regional perspective?:**

- **Sectoral level.** Studies show that sectorwide actions-water and energy pricing policies, investment programs involving a series of projects, or administrative measures such as improving land tenure -- often have stronger environmental and social impacts than individual projects.

- A policy analysis system is required to trace the impacts of the project-related decisions at various spatial levels. Does the project adequately **address economy-wide constraints?:**

- **Macroeconomic level.** Economy-wide policies (both sectoral and macroeconomic) have an effect on the natural resource base, but the complicated interactions are not well understood. No simple generalizations are possible, but many instances of environmental damage stem from market failures and policy distortions, exacerbated by poverty. Broad policy reforms that promote efficiency or reduce poverty also should help the environment, but some reforms may have negative environmental effects, depending on pre-existing (and often localized) constraints (that is, inadequately defined property or resource rights).

- A policy analysis system is required to trace the impacts of the project-related decisions at various spatial levels. Does the project adequately **address international constraints?:**

- **International level.** Regional impacts (such as acid rain) and global issues (such as ozone layer depletion, global warming, biodiversity loss, and pollution of international waters) have raised concerns. These pervasive and long-term problems have led to new ideas on uncertainty, irreversibility, and time discounting. For example, even when impacts are uncertain, sustainability

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suggests that limits should be imposed on resource degradation, particularly if future consequences could be irreversible and catastrophic. This precautionary approach underlies the emerging consensus on limiting greenhouse gas emissions to avoid possible global warming.

2.6 Risk Management

The standard risk assessor's definition of risk is: Risk = Hazard Times (X) Exposure. Another popular definition is "the probability of the occurrence of an event." Webster's Dictionary defines risk as the "possibility of loss or injury."

The differences among these definitions are significant. The first, the risk assessor's definition, means that risk only exists if there is actual exposure and actual hazard. It does not evaluate the possibility of some future harm that has not begun to occur. In the second definition, risk is predictive, but neutral. It implies that neither the nature of the event nor its effects matter. But the very purpose of comparative risk assessment is precisely to determine which risks matter and how much, and which responses are most desirable. Even the dictionary definition, "possibility of loss or injury," excludes the nature of the entity at risk from the definition of risk, although the words "loss" and "injury" imply a specific kind of impact.

The public understanding of the nature and significance of risk is intertwined with the attributes of the entity at risk. As a society, when we compare risks, we mean something more like the possibility of change that negatively affects something we value. The likelihood of the change, the magnitude of the effect, and the seriousness of the consequences are all elements that must be assessed in order to compare risks. **Risk management is becoming an integral tool in the assessment of projects in that it is used to develop priorities for action as well as the potential probabilities of negative impacts (financial, technical, environmental, etc.) as a result of project implementation.** These EMSs focuses on risk management relative to environmental degradation and social impact potential.

2.6.1 Risk-Based Priorities

- Since every water resource issue and potential strategy poses some possibility of harm to human health, the ecology, the economic system, or the quality of human life, risk assessment should be used to review potential environmental and social impacts. As such, does this water management project address the following key objectives in addressing the water issue at hand:

1) target project structural and non-structural controls on the basis of opportunities for the **greatest risk reduction.;**
2) attach equal importance to **ecological risk** as human health risk;
3) improve the data and **analytical methodologies** that support the assessment, comparison, and reduction of different environmental risks;
4) reflect risk-based priorities in its **strategic planning** ;
5) reflect risk-based priorities in its **budget** process;
6) make greater use of all the tools available to **reduce risk;**
7) emphasize **pollution prevention** as the preferred policy option for reducing risk;
8) increase efforts to **integrate environmental considerations** into broader aspects of public policy in as fundamental a manner as are economic concerns;
9) work to **improve public understanding** of environmental risks and train a professional workforce to help reduce them;
10) develop improved analytical methods to **value natural resources and to account for long-term environmental effects** in its economic analyses.

- Does the project **evaluate potential impacts and issues related to project development on the basis of the following six major criteria,** noting that the first five criteria describe and characterize an issue in various ways, assuming that the issue actually develops as foreseen, whereas the last criterion is predictive and

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describes the likelihood that an issue will, in fact, develop and need to be dealt with within the future time frame of interest:

1) **Timing:** This criterion deals with when an issue will become important: sooner (closer to the beginning of the period considered), later (closer to the end of the period) or throughout the period. Greater weight should normally be given to this factor if the timing is sooner rather than later.
2) **Novelty:** This criterion involves consideration of what is new about an issue but it also involves consideration of whether sufficient attention is being given to the issue in the near term -- whether the issue itself is new or not. .
3) **Scope:** This is an extensive criterion of magnitude dealing with the breadth or extent of the issue with respect to the following different kinds of factors: (1) geographic range: local, regional, national or international; (2) population affected: many or few people are affected or a large or small percentage of people are affected; (3) ecosystems affected: many or few ecosystems or ecoregions are affected or a large or small percentage of such systems or regions are affected; (4) environmental coverage: the issue has broad or narrow environmental effects or it affects a large or small percentage of different types of environments; (5) socioeconomic factors: the breadth of impact in this area (how broadly are societal institutions and societal factors affected: education, jobs, etc.); (6) temporal scope: whether the issue is a long term, persistent issue or a shorter term one; (7) impact on regulatory or legislative activity: the degree of pertinence to many or few regulatory or legislative areas or to a large or small percentage of such areas; and (8) agencies affected.
4) **Severity:** This is an intrinsic and/or intensive criterion of magnitude dealing with the depth or intensity of impact, or the seriousness of the consequences of an issue: the physical, health, ecological, socioeconomic (how deeply are societal institutions and societal factors affected: education, jobs, etc.), legislative, regulatory, and welfare consequences and, in particular, the irreversibility of the effects involved, or of the consequences of, the issue. The time needed to reverse an adverse effect and/or the rate of reversibility are further determinants of Severity.
5) **Visibility:** The "visibility" of an issue refers to the degree to which it is or can become visible as a public issue: to influential groups, to the media, to the political establishment, to the public as a whole. To assess the weight this criterion might have, the following characteristics of the issue need to be considered: its scientific, technical and/or economic plausibility; its political appeal; the recognition it is likely to receive by special groups; and its public comprehension and appeal (including the possibility of the fear of imminent personal harm). Visibility is also dependent on components of the first four issues.
6) **Probability,** is the sixth major criterion; it assesses the likelihood that the issue will need to be addressed. It is an integrative and a predictive criterion, highly dependent on the first five criteria. It expresses the likelihood that an issue will rise to prominence by or within the time period in question and have to be dealt with in the period.

- Using this system of impact and issue characterization, did the project address and prioritize impacts and issues according to the following chart:

High Impact, High Probability:	These issues should be given priority by the project
High Impact, Low Probability:	Project should address these surprise issues and prepare for them, despite their low probability
Low Impact, High Probability:	Since these issues may have to be dealt with soon, so project should prepare for them
Low Impact, Low Probability:	These issues should not be on the project's urgent list

2.6.2 Assessing Welfare Risks

- Does the project recognize that the traditional practice of discounting the values of welfare impacts in time makes no sense ecologically and **assess welfare risks according to the following types and definitions:**

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Types of Welfare Impacts	Definition
Ecological Quality	Indirect impacts on humans that result from a reduced quality of an environmental resource and decreased human utility (Reversible)
Resource Sustainability	Irreversible losses of ecosystem structure and functions, such as lose of critical habitat or species extinctions
Direct Effects - Economic	Direct physical changes that cause adverse economic impacts on humans other than health effects
Direct Effects-Non Economic	Primarily Involves social nuisances such as odors, noise, and reduced visibility

- Does the project fully assess **Ecological Quality**, which are indirect impacts on humans that result from a reduced quality of an environmental resource or decreased human utility, but which do not permanently impair the ecological structure and function of the resource?

- Does the project fully assess **Resource Sustainability** that involves irreversible losses of ecosystem structure and functions, including losses of critical habitats or species extinctions resulting from anthropogenic activities?

- Does the project fully assess the **Direct Effects - Economic category** that involves direct physical changes that cause adverse economic impacts on humans (excluding human health effects), such as the loss of surface water contaminated by industrial effluents or agricultural irrigation source? (These are the effects that are usually included in environmental impact analyses.)

- Does the project fully assess the **Direct Effects - Non-Economic category** of welfare effects that primarily involves social nuisances, odors, noise, and reduced visibility result from sensory modalities that affect the perception of quality of the environment but may or may not affect human health? (There are no generally accepted standards that define an acceptable environmental quality, but liability is determined on a case-by-case basis.)

- Do the risk assessment methods assess risks in a technically sound manner and communicate such findings in a rich yet comprehensible fashion, using knowledge from various fields, including physiology, chemistry, statistics, toxicology, engineering, economics, and psychology, and **produce several complementary types of output:**

- **Numerical estimates of the magnitude** of the assessed risk. These estimates are made either in units of probability (for example, a 1 in 100,000 chance that an individual will suffer an adverse effect or of consequence (for example, an estimate of 500 adverse effects occurring across an entire population).
- **Qualitative descriptions of the type of adverse effect** associated with the estimate of magnitude. These descriptions can be as straightforward as the hazard of lung cancer, which is almost invariably fatal, or as complicated as a description of an the ramifications of a five-degree rise in global mean temperature.
- **Discussions of the knowledge base** on which the predictions of hazard are made. These can be as simple as a narrative statement of how sure the analyst is that the assessment is valid, or as complex as a full quantitative treatment of the uncertainty in the probabilities generated.

- Does the risk assessment system consider the pluses and minuses of the **"hard" and "soft" versions of comparative risk assessment** and choose an appropriate version for project analyses:

- **The basic features of the hard version involve the use of expert panels to generate "best estimates" of the most probable magnitude of various risks, focusing on quantifiable dimensions such as the number of fatalities or the size of affected geographical areas.** The

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experts then compare the sizes of the risks to either the current or potential costs of reducing each risk and recommend priorities designed to achieve the "biggest bang for the buck" in reducing risk, given resource constraints.

- **The soft version starts from the premise that risk is multidimensional and represents the confluence of a variety of public values and attitudes.** A soft ranking of risks, therefore, would tend to be more impressionistic than formulaic; it might use the number of fatalities as a rough starting point, but would modify the ranking by folding in various factors, such as the quality of the dread, mistrust and uncertainty associated with each risk, the equity (or lack thereof) in how each risk is borne by various individuals and subpopulations, and the perceived benefits the risky substance or activity confers. According to proponents of the soft version, the only way to incorporate such factors, and enhance the legitimacy of the resulting priorities or risk rankings, is to give the public equal stature with the experts from the early stages of the analysis.

2.7 Cost Benefit Analysis and Multi-Objective Decision-Making

Cost Benefit Analysis (CBA) has been widely utilized for years as the primary economic decision-making tool for project assessment. It is not the purpose of these EMSs to review CBA practices and problems in detail, but rather provide information on how CBA is being modified to better incorporate environmental concerns into both the cost and benefit sides of the equation. It is virtually impossible to place economic values on all the functions provided by environmental and natural resources. Undertaking project appraisals individually may not be able to capture the provision of environmental benefits and costs at a wider level, because the contribution of each project to the overall benefit or cost might be marginal. A program may entail significant environmental cost or benefit to society as a whole, while individual project appraisals may not account entirely for this benefit or cost. Many of the important benefits of environmental management accrue, however, to future generations and become discernible only after the time at which standard CBA discounts future benefits to zero, thus discouraging investments in projects specifically designed to provide substantial environmental or conservation benefits far into the future.

2.7.1 Improving CBA

- Since CBA is the key element in the appraisal stage of the project cycle, and it seeks to assess project costs and benefits using a common yardstick, has the assessment **correctly applied shadow prices** to reflect opportunity cost, including valuation of externalities wherever practical?

- Has the project assessment **adjusted the national accounts system** to reflect the relation of changes in the environment to changes in the economy (environmental and natural resource accounting)?

- Has the project assessment **adjusted or corrected market prices** (for example with the use of taxes) to reflect the full costs and benefits of using the environment?

- Has the project assessment provided for the **economic value of environmental impacts** in project appraisals?

- Does the project assessment recognize that, apart from passing a CBA test, a project should not result in the **net reduction in the value of the stock of environmental capital**? (That means that if a project entails such negative effects on the environment, it would be necessary to include in the investment program measures to compensate for this environmental loss.)

- Does the project assessment correct market prices to reflect the full costs and benefits of using the environment, which involves **internalizing environmental externalities**? (One suggestion is that depletion of natural resources can only be acceptable if it leads to the creation of other forms of capital whether human or

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physical that can substitute for any of the environment's functions. In order to attain this objective, environmental losses, as well as investments for their substitutes, must be properly valued.)

- Has the use of **"Willingness to pay"** studies adequately reflected not only tastes and preferences, but also **"ability to pay?"** (In many developing economies poverty is widespread, so a standard willingness-to-pay approach to valuing environmental damages may yield only modest estimates of these damages. In the face of enormous poverty, willingness-to-pay estimates may be quite small despite what look to be high rates of environmental degradation. Thus, if willingness-to-pay approaches are used, they must be used with frank recognition that the distribution of income is heavily skewed, and value judgments are called for in making decisions on environmental quality programs. This argues also for putting more emphasis on lost productivity, particularly in the long run, in assessing the damages of environmental degradation.)

- Does the use of **"willingness to pay"** for CBA alternatives recognize that it is a **function of resource endowment** (that is, national or individual wealth) and of cultural preferences and tastes, and different countries (or individuals) will make different monetary choices between environmental protection and other benefits? (If the benefits of environmental management (such as watershed protection) are poorly understood, countries (or individuals) will under-invest in environmental protection, to their ultimate detriment.)

- Has the CBA **appropriately dealt with discounting** in developing countries where the focus is more on long-run development, and the role of discounting is less clear than in developed economies where discounting helps make choices among programs with different time profiles of benefits and costs? (Environmental improvement programs, if they deliver the bulk of their benefits only in the long run, may take lower priority than economic development projects that pay off more quickly. High rates of discount can also lead people to overlook negative environmental impacts that occur far off into the future. The present value of even severe long-run environmental damage can be quite low when it is evaluated with a positive discount rate.)

- Does the assessment use a normal discount rate in evaluating programs, but **augment the typical CBA in developing countries with an analysis of the impacts of the program on long-run sustainability**?

- Does the CBA adequately account for the costs and benefits of the project that might **accrue to society as a whole, in particular**, the costs and benefits associated with a project's environmental impacts must be taken into account? (It has proved difficult, however, to isolate the costs and benefits of alternative ways of dealing with environmental impacts, because development banks integrate environmental considerations into overall development strategy and action.)

- Has the project assessment recognized that since many **environmental effects are "public goods,"** they do not have directly measurable market values and it is not possible to measure all of these costs and benefits?

- Does the CBA recognize that in using a short time horizon and the discounting of future benefits to net present value, CBA inherently **undervalues or completely ignores many environmental functions and services**, and many of the most significant benefits of environmental management accrue to future generations? (This so-called intergenerational problem is, in effect, one of long-term inter-temporal inefficiency, since in a timeless world future generations would presumably pay or persuade present users of the natural environment to conserve more of it. It must therefore be acknowledged that the high discount rates currently (and arbitrarily) employed in cost-benefit analyses discourage investments with long-term benefits, while promoting projects with long-term costs.)

- Does the CBA recognize and mitigate against its **inherent inability to evaluate properly the costs of irreversible damage to the environment and of foreclosing future options**? (eg. Many complex natural habitats [such as tropical rain forests and coral reefs] and their ecological services are now thought to be basically nonrenewable, at least within the life span of human civilizations.)

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- If the environmental goals and objectives are deemed appropriate but difficult to truly incorporate into the CBA, does the project use **"least-cost" approach by carefully analyzing alternative proposals** for achieving a particular goal so that relevant tradeoffs can be evaluated?

- Where some, but not all, benefits are quantifiable, has the project least-cost analysis been supplemented by a **"switching value" approach to answer how large the value of residual environmental benefits** (those not quantified) have to be to justify the project? (Assuming the cost stream, discount rate, and value of directly quantifiable benefits are all known, it is possible to calculate what value the residual benefits must have in order to equalize the stream of total costs and total benefits. The benefits involved usually occur over many years, and future residual benefits can be expressed as a function of first-year benefits.)

- If appropriate, has this kind of "switching value" analysis also been used to deal with **intangible gains or losses,** including aesthetic values and recreational activities? (Such analysis is relevant to problems involving losses of unique natural or cultural assets, since the fact of uniqueness will, of itself, make any kind of market pricing difficult, if not impossible.)

- Does the project assessment describe the effects of alternative courses of action in **qualitative or non-economic terms** where the environmental effects are significant and cannot be quantified solely in monetary terms? (In fact, qualitative, logical analysis is basic; quantification should be seen as a useful supplement, rather than vice versa.)

- In addition to the standard CBA (modified to reflect all readily quantifiable environmental benefits and costs), has the project assessment used a **"safe minimum standard" (SMS) analysis,** which is any non-economic criterion that a project must meet to be environmentally or socially acceptable? (The main reason for using an SMS is that economic cost-benefit analysis cannot adequately measure and weigh all of the environmental or social costs or benefits of a proposed project, program, or policy. The costs of modifying a project so that it meets all SMS criteria are accepted as normal project costs.)

2.7.2 Multi-Objective Decision-making

- Does the project assessment integrate natural resource and environmental issues into economic analyses of projects and policies by incorporating **four major aspects of project assessment:**

a) determining the physical impacts and valuing the impacts in monetary terms
b) multi-objective decision-making
c) discounting
d) risk and uncertainty?

- Does the project assessment recognize that projects/policies and their impacts are often embedded in a **system of broader (national) objectives,** some of which cannot be easily quantified in monetary terms, and substitute multi-objective decision-making as an alternative approach?

- Does the multi-objective decision-making assessment fully recognize the **variety of concerns associated with the project,** with measurement beyond monetary terms?

- Does the project's use of multi-objective decision-making fit the decision at hand and **use appropriate methods such as optimization or satisfaction of a design standard** (eg. minimum dissolved oxygen in a surface water)?

- Does the project's use of multi-objective decision-making recognize that the **model may represent only a single decision-maker (or group)** and that various interested groups may assign different priorities to the respective objectives? (There may be value in constructing models from differing perspectives and then comparing the results.)

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Appendix 5.

Proposed Environmental Management Systems (EMSs)

Enhanced Environmental Impact Assessment Series (3.0)

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Environmental degradation results in an ultimate loss of productivity. A project-by-project assessment for addressing this overall degradation of natural resources puts a country's future at risk economically and socially - as well as environmentally. A multidisciplinary approach is called for that combines broad environmental policy, institution building, and other aspects of resource management.

The following examples indicate how EIA elements might be recast into a "second-generation" process to ensure sustainability:

- screening of economic and development policies for their conformity with sustainability goals and principles (for example, identifying environmentally perverse subsidies),
- preliminary assessment of environmental costs of development programs to identify low-impact, resource-efficient energy, transportation and manufacturing strategies,
- area-wide assessment to establish resource and land use zoning systems for regional development,
- extending project EIA to identify in-kind compensation for loss of natural capital (for example, offsetting fish and wildlife losses in one location by rehabilitating habitats elsewhere.

3.1 Project Specific Criteria

The most widely used EIA references are the Environmental Assessment Sourcebooks and Updates published by the World Bank (World Bank, 1991, etc). These sourcebooks provided the majority of project specific criteria in the following sections.

3.1.1 Dams

- Did the project adequately investigate **alternatives to the proposed dams** such as small scale water delivery schemes, use of traditional techniques, improved water efficiency and minimization of losses, as well as energy efficiency and conservation?

- Does the project recognize and mitigate the **main potential impacts due to existence of dams of reservoirs** such as:
  - upstream change from river valley to reservoir
  - change in downstream morphology of riverbed and banks, delta, estuary and coastline due to altered sediment load
  - changes in downstream water quality (river temperature, nutrient load, turbidity, dissolved gases, concentration of heavy metals and minerals
  - reduction of biodiversity due to the blocking of movement of organisms and because of the other three items?

- Does the project recognize and mitigate the **main potential impacts due to operation of dams of reservoirs** such as:
  - changes in downstream hydrology (total flows, seasonal timing, short-term fluctuations, changes in peak highs and lows)
  - change in downstream morphology caused by altered flow pattern
  - changes in downstream water quality caused by altered flow pattern
  - reduction of riverine/riparian/floodplain habitat diversity, especially due to elimination of floods?

- Does the project operate under a scientifically rigorous set of **instream flow standards** for ecological protection and does the project conform?

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- Has the project recognized the following **potential negative environmental effects of construction:**
  - air and water pollution from construction and waste disposal
  - soil erosion
  - destruction of vegetation, sanitary and health problems from construction camps?

- Has the project taken the following **measures to minimize impacts:**
  - air and water pollution control
  - careful location of camps, buildings, borrow pits, quarries, spoil and disposal sites
  - precautions to minimize erosion
  - land reclamation?

- Has the project efficiently and equitably dealt with the **dislocation of people living in inundation zone** by relocating them to a suitable area, providing compensation in kind for resources lost, providing adequate health services, infrastructure, and employment opportunities?

- Has the project effectively analyzed the resulting **loss of land (agricultural, forest, range, wetlands)** by inundation to form reservoir by: siting the dam to decrease losses; decreasing the size of dam and reservoir; protecting equal areas in region to offset losses?

- Has the project analyzed the resulting **loss of historic, cultural or aesthetic features** by inundation by: siting dam or decrease of reservoir size to avoid loss; salvage or protection of cultural properties, etc.?

- Has the project effectively analyzed the resulting **loss of wildlands and wildlife habitat** by: siting of dam or decrease of reservoir size to avoid/minimize loss; establishment of compensatory parks or reserved areas; animal rescue and relocation?

- Has the project effectively analyzed the potential for **proliferation of aquatic weeds in reservoir and downstream** impairing dam discharge, irrigation systems, navigation and fisheries and increasing water loss through transpiration by: clearing woody vegetation from inundation zone prior to flooding(nutrient removal); providing weed control measures; harvesting of weeds for compost, fodder or biogas; regulating water discharge and manipulating water levels to discourage weed growth?

- Has the project provided mitigation measures to **prevent deterioration of water quality** in the reservoir such as:

  - Clearance of woody vegetation from inundation zone prior to flooding.
  - Control of land uses, wastewater discharges, and agricultural chemical use in watershed.
  - Limit retention time of water in reservoir.
  - Provision for multi-level releases to avoid discharge of anoxic water.

- Has the technical analysis fully analyzed the **potential for sedimentation of the reservoir** and loss of storage capacity and taken measures such as:
  - Control of land use in watershed (especially prevention of conversion of forests to agriculture);
  - Reforestation and/or soil conservation activities in watersheds (limited affect);
  - Hydraulic removal of sediments (flushing, sluicing, release of density currents)?

- Has the potential **occurrence or intensification of seismic activity** during reservoir filling or accompanying sharp fluctuations of water level been fully investigated by the project and mitigated as necessary? (Includes potential for induced seismicity)

- Has the project fully investigate **potential groundwater impacts within the zone of influence,** since groundwater levels are modified by variations of reservoir levels, and positive or negative side effects will

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depend upon geological and topographic conditions? . They may be significant many hundred kilometers from the reservoir and can provide a major water resource for irrigation,

- Has the **potential for seepage** been fully investigated since seepage can result in a permanent rise of groundwater levels downstream of dams calling for drainage structures to protect agricultural land from waterlogging?

- Have the potential for **other major side effects** been taken into account and mitigated adequately in project development such as:

- shoreline erosion under wave action in the reservoir;
- modification of the hydrogeological regime both upstream of the dam and downstream where irrigation is developed on a large scale (water logging, salinization, etc.) as well as changes in groundwater quality;
- effect of water temperature upon the fauna and flora in both reservoir and river downstream (especially for thermal power stations using river water for cooling);
- modification of river-bed equilibrium due to the decrease in sediment transport and possible instability of sea beaches which no longer receive the river sediment load;
- effects upon the ecology of inland deltas no longer subjected to annual flooding, involving loss of pasture lands and traditional migration paths of herds and decrease of fishing industries?

- Has the project incorporated measures to **prevent the formation of sediment deposits at reservoir entrance** creating backwater effect and flooding and waterlogging upstream such as sediment flushing and sluicing devices?

- Has the project incorporated design features to **prevent scouring of the riverbed below the dam** such as appropriate design of trap efficiency and sediment release (e.g., sediment flushing, sluicing) to increase salt content of released water?

- Has the project fully evaluated the impacts of the **decrease in floodplain (recession) agriculture** resulting from the project and taken appropriate mitigation measures such as regulation of dam releases to partially replicate natural flooding regime?

- Has the project fully evaluated the potential for **salinization of floodplain lands** and included regulation of flow to minimize effect?

- Has the project fully evaluated the potential for **saltwater intrusion in any downstream estuary areas** and included maintenance of at least minimum flow to prevent intrusion?

- Has the project effectively dealt with any potential **disruption of riverine fisheries** due to changes in flow, blocking of fish migration, and changes in water quality and limnology by: maintenance of at least minimum flow for fisheries; provision of fish ladders and other means of passage; provide protection of spawning grounds; aquaculture and development of reservoir fisheries in compensation?

- Does the project effectively mitigate the potential for **snagging of fishing nets in submerged vegetation** in reservoir by selectively clearing vegetation before flooding?

- Has the project fully integrated a health assessment into the planning and dealt with the potential for an **increase of water-related diseases** by:

- Design and operation of dam to decrease habitat for vector;
- Vector control;
- Disease prophylaxis and treatment?

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- Was an equitable system used in project development for dealing with **conflicting demands for water use** such as: planning and management of dam in context of regional development plans; equitable allocations of water between large and small holders and between geographic regions of valley?

- Did the project effectively deal with the potential for **social disruption and a decrease in the standard of living of resettled people** by providing a standard of living by ensuring access to resources at least equalling those lost and provision of health and social services?

- Has the project effectively dealt with the potential for environmental degradation from **increased pressure on land** by:
  - Choice of resettlement site to avoid surpassing carrying capacity of the land.
  - Increase of productivity or improve management of land (agricultural, range, forestry improvements) to accommodate higher population?

- Were appropriate project design features or mitigations made to minimize the disruption/destruction of **tribal/indigenous groups** such as avoiding dislocation of these people; and where not possible, relocating in an areas allowing them to retain lifestyle and customs?

- Was the potential for secondary impacts such as an increase in humidity and fog locally, creating favorable habitat for **insect disease vectors** (mosquitos, tsetse) taken into account and mitigated by appropriate vector control programs?

- Were potential **indirect and external impacts** adequately addressed and mitigated such as:
  - Uncontrolled migration of people into the area, made possible by access roads and transmission lines mitigated by limitation of access, provision of rural development and health services to try to minimize impact;
  - Environmental problems arising from development made possible by dam (irrigated agriculture, industries, municipal growth) mitigated by basin-wide integrated planning to avoid overuse, misuse, and conflicting uses of water and land resources?
  - Poor land use practices in catchment areas above reservoir resulting in increased siltation and changes in water quality mitigated by land use planning efforts which include watershed areas above dam?

3.1.2 Fisheries

- Has the project fully addressed and mitigated the **potential for overexploitation of fisheries stock** and long-term degradation of the resource base and proposed a fisheries management scheme for optimum sustained yield using:

  - restricted harvests (minimum size limits, catch quotas, seasonal closures),
  - gear restrictions (trawl bans, specified net mesh sizes),
  - closure of areas (permanent reserves, periodic closures),
  - limited entry systems (licensing, exclusive access),
  - prohibited practices (use of explosives, drift nets),
  - consideration of sustainable traditional fishery practice and incorporation to extent possible in modern fisheries management systems?

- Does the project mitigate against the **potential capture of non-target species and habitat damage** through use of certain equipment and fishing practices such as:
  - Limitation or prohibition of use of such equipment and fishing practices,
  - Testing and pilot scale use prior to large scale introduction of new technologies,
  - Expanded use of fish by development of new products and markets?

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- Does the project ensure that effective mitigation **measures are included to prevent pollution** from oil and fuel spills and leakage, and from bilge flushing such as:
  - Public education program on proper fuel and oil handling and bilge waste disposal,
  - Provision of storage and handling facilities, bilge evacuation and disposal services,
  - Inclusion of recommended "Inland Navigation" and "Port and Harbor Facilities?"

- Does the project include measures to **minimize diver and anchor damage** such as:
  - Public education programs for fishermen on effects of damage and ways to avoid it,
  - Installation of mooring buoys,
  - Designation of anchoring locations?

- Are effective **prohibition and enforcement regulations** in place to ensure that explosives and poison and will not be utilized?

- Are any proposed direct culture fisheries prohibited from **clearing/conversion of coastal wetlands** for construction of ponds by:
  - Prohibition of ponds in area of particular ecological significance,
  - Limitation of area converted to ponds,
  - Intensified management in existing and new ponds to discourage 'shifting aquaculture' and low-input, extensive aquaculture that converts large areas?

- Does the construction of direct culture fisheries include **erosion and siltation mitigation** in the construction phase such as:
  - Restriction of clearance to area needed for ponds,
  - Pond construction during dry season,
  - Stabilization of exposed soil with grasses or other ground covering?

- Has the need for direct culture ponds been fully evaluated relative to **alternative water and land resources demands** of other users by:
  - Assessment of existing traditional land and water use and agricultural, industrial and municipal demands,
  - Planning, management and continuing negotiations to reach acceptable distribution of resources,
  - Siting of pond to avoid disruption of traditional uses of water for washing and drinking,
  - Coordination of aquaculture ponds with other activities to double up on water use (e.g., pond water reused for irrigation)?

- Does the project address the potential **loss of productivity or formation of toxic conditions** in direct culture ponds from high temperature, low oxygen and waste accumulation and provide for adequate pond water exchange and frequent pond flushing?

- Does the project mitigate against the potential **acidification of pond water** due to hydrogen sulfide formation by:
  - Siting in areas not susceptible to acidification (avoid waterlogged soils high in pyrite and organic matter),
  - Adequate pond water exchange and flushing?

- Does the project include the **production of larvae and juveniles in a nursery** for pond stocking to prevent local depletion of larval and juvenile organisms?

- Does the project effectively evaluate and mitigate **potential water pollution from the pond effluent** (nutrient-rich and with varying chemical content depending on intensity of pond management) by:
  - Release into water body with adequate dilution and dispersal capability,
  - Dilution prior to release,

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- Timing of release with period of high water,
- Shorter retention time of water in pond by more frequent pond water exchange and flushing,
- Treatment of water prior to release?

- Is a **ban on exotics enforced** to prevent degradation of native stocks?

- Are measures included to **prevent the introduction of exotics** with subsequent damage to native stocks by competition, predation, spread of disease and parasites such as:
  - Avoidance of exotic introductions except where adequate knowledge of biology and life history of species indicates low risk of negative impacts and where adequate safeguards against escape are taken,
  - Regular monitoring for disease and parasites; if present and spreading, elimination of infected populations,
  - Consideration of using sterile hybrids?

- Are measures included to **prevent the spread of disease in aquaculture stocks and into natural stocks** when stocking becomes too dense such as:
  - Monitoring of disease incidence,
  - Limitation of numbers when disease is positively correlated with fish densities,
  - If disease spreads, elimination of diseased individuals?

- Have the regional implications of a **concentration of pens, pilings, and rafts in natural (non-pond) water bodies** been evaluated extensively to ensure that navigation is not hampered, water circulation is not restricted, water quality is not decreased, and capture fisheries are not precluded?

- Have the **External Impacts** of both Capture Fisheries and Culture Fisheries been thoroughly evaluated and mitigated such as:
  - Dams which could alter water quality and stream flows and disrupt riverine and floodplain fisheries mitigated through use of a reservoir fishery and water release management to minimize damage to fisheries,
  - Irrigation Schemes which could alter water quality and quantity mitigated through development of fishery activities in conjunction with irrigation systems (e.g., use of pond water for irrigation, traps and nets in irrigation canals), and management of irrigation schemes to minimize damage to fisheries,
  - Land use and agricultural practices in watersheds affecting sediment content and water quality mitigated through integrated watershed planning and management, close coordination between fisheries and government agencies responsible for resource management in watersheds to alert them to impacts on fisheries,
  - Flood control measures potentially damaging to water quantity and quality and aquatic habitats mitigated by appropriate flood controls,
  - Pollution from industrial effluent, sewage and agrochemicals affecting fish survival and tainting fish mitigated by appropriate pollution controls,
  - Air pollution and acid rain affecting fish survival mitigated by appropriate air quality controls,
  - Coastal development involving dredging, filling, destruction of mangrove swamps, construction and infrastructure development mitigated by appropriate coastal zone management,
  - Pollution from effluent discharged from industrial fish processing plants mitigated through appropriate water pollution controls including adequate dilution and dispersal capabilities, water quality monitoring, reduction of wastes by recycling into usable products, reduction of water use, and suitable treatment of waste prior to release?

3.1.3 Flood Protection

- Is an **appropriate institutional system in place designed to modify susceptibility to flood damage** and disruption such as:

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- Floodplain Regulations (State regulations for flood hazard areas, Local regulations for flood hazard areas, Zoning, Subdivision regulations, Building codes, Housing codes, Sanitary and well codes, Other regulatory tools),
- Development and Redevelopment Policies (Design and location of services and utilities, Land rights, acquisition, and open-space use, Redevelopment, Permanent evacuation, Disaster preparedness, Disaster assistance, Floodproofing, Flood forecasting and warning systems and emergency plans)?

- Is an appropriate institutional system in place designed to modify the impact of flooding on individuals and the community such as:
  - Information and education
  - Flood insurance
  - Tax adjustments
  - Flood emergency measures
  - Post-flood recovery?

- Does the project incorporate the **use of Natural and Cultural Resources** for flood protection such as:
  - Natural Flood and Erosion Control (Reduce flood velocities, Reduce flood peaks, Reduce wind and wave impacts, Stabilize soils)
  - Water Quality Maintenance (Reduce sediment loads, Filter nutrients and impurities, Process organic and chemical wastes, Moderate temperature of water, Reduce sediment loads
  - Maintain Groundwater Supply and Balance (Promote infiltration and aquifer recharge, Reduce frequency and duration of low flows by increasing/enhancing base flow)
  - Support Flora (Maintain high biological productivity of floodplain and wetland vegetation, Maintain productivity of natural forests, Maintain natural crops, Maintain natural genetic diversity)
  - Provide Fish and feeding grounds (Create and enhance waterfowl habitat, Protect habitat and rare and endangered species)
  - Maintain Harvest of Natural and Agricultural Products (Create and enhance agricultural lands, Provide areas for cultivation of fish and shellfish, Protect silvaculture)

- Does the project address the potential for **flooding of lesser magnitude, but greater duration** of floodplain downstream due to reservoir releases and recommend adaptation measures for existing floodplain agricultural practices?

- Does the project address the **potential for structural failure and floodwaters higher than capacity of control structures/measures** (which could lead to increased risk to life and property because local pre-project adaptations are relaxed or abandoned or increased development on the floodplain has occurred post-project) and include implementation of non-structural measures to prevent increased flood risk, and of a flood warning system?

- Does the project include partial mitigation of effect by regulation of discharge to imitate natural flooding in a controlled way because the **cycle of enrichment and groundwater recharge in the floodplain soils may be broken**?

- Does the project mitigate potential **adverse effects on fisheries and other aquatic resources** by disruption of migratory routes, deterioration of habitat and changes in water quality (e.g., sediment load), leading to reduced productivity of riverine, coastal and marine fisheries by:
  - Installation of fish passageways,
  - Protection of reproductive sites for fish,
  - Incorporation of fishery management, including hatchery and restocking programs?

- Does the project identify the potential **negative impacts of channelization measures** such as:
  - disruption of fish habitat by elimination of pools, riffles and channel irregularities,
  - increased water temperature by removal of vegetation on banks and in stream,

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- increased erosion and sedimentation problems,
- bed and bank erosion,
- downstream flooding and sedimentation?

- Does the project recommend **appropriate mitigation measures** such as:
  - Careful selection of engineering options at planning stage,
  - Limitation of degree of channel modification or maintenance,
  - Mitigating measures after construction phase,
  - Minimize reduction of channel length and preserve some meanders,
  - Limit excavation and fill,
  - Limit destruction of bank and streamside vegetation,
  - Replant/reseed banks.
  - Excavate only one and not both banks?

- Does the project adequately address **potential adverse effects of construction** by:
  - Minimization of effects by avoiding impediments to natural drainage, uncontrolled runoff and soil erosion, and air pollution,
  - Provision for adequate filling of borrow areas, control of land clearing, and disposal of spoil material,
  - Limitation of access of vehicles to stream banks?

- Does the project adequately **mitigate the potential reduction of floodplain grazing**, both through ecological changes on the floodplain and intensified development (e.g., irrigated agriculture) through:
  - Production of fodder crops and usage of byproducts of irrigated food crops and development of alternative water sources,
  - Integration of existing rangeland use (e.g., semi-nomadic herding) with planned developments, to ensure substantial grazing and watering possibilities in valley during dry season?

- Does the project address the **reduction of recession agriculture** by maintenance of the natural flooding regime to extent possible in most productive lands (and intensification of production) by maintaining water courses free of flood control structures or installing structures to enable semi-controlled flooding?

- Does the project provide for the construction of **bridges or special crossing places for wildlife** where new obstacles (levees, dikes, etc.) are constructed?

- Does the project address the **loss of wildlands and wildlife habitat** through the identification of critical habitats and planning of flood control measures to minimize effects; where habitats or species are dependent on natural flooding regime, minimize disruption of flow in that area to extent possible?

- Does the project address **indirect impacts** such as:
  - Improved accessibility, development opportunities in floodplain, and sense of security after flood control measures taken, leading to influx of people with associated agricultural development, deforestation, wildlife poaching, infrastructure development, etc.,
  - Increased fertilizer use on agricultural fields to compensate for loss of fertility, leading to water pollution and dependence on imported supplies,

- Does the project **mitigate indirect impacts** with measures such as:
  - Limitation of access, if possible,
  - Planning for anticipated influx and implementation of companion rural development activities,
  - Introduction of non-structural control measures,
  - Optimal timing and rate of fertilizer application,
  - Use of nitrogen fixing cover crops,
  - Use of organic instead of chemical fertilizers?

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3.1.4 Groundwater

- Does the project work under a comprehensive system of **ambient groundwater quality standards** and does the project potentially negatively impact these standards? (Ambient ground-water quality standards limit the permissible concentrations of a substance in groundwater. The standard may be a single concentration limit for all groundwater resources or various concentration limits based on the water use.)

- Does the project potentially impact any **potable water supplies** in the project area using groundwater as the supply source, either for **primary or secondary drinking water standards**? (Primary standards establish the maximum concentration allowed in tap water provided by a water supply systems based on ideal health goals with a margin for safety. Secondary standards protect the public welfare by providing guidelines on taste, odor, color, and other non-aesthetic characteristics.)

- Does the project comply with applicable **effluent standards** for any discharges proposed directly or indirectly to groundwater? (Effluent standards limit the permissible amount or concentration of a substance to be discharged from a particular source of groundwater contamination.)

- Was the project conceived and designed under a rigorous set of **technical standards** that governed the siting, design, construction, installation, operation, and closure of major potential sources of groundwater contamination? (These include underground injection wells, underground storage tanks, landfills, surface impoundments, septic tanks, mining, and waste piles.)

- Does the project incorporate a specific set of recommended **best management practices (BMPs)** which specify how a potential source of groundwater contamination is to be managed, operated, and maintained? (e.g. BMPs for agricultural operations address tillage practices; crop rotation practices; terrace, grassed waterway, and debris basin installations; and fertilizer, water, and pesticide application. BMPs for forest operations relate to location, design, and construction specifications for roads; harvesting methods; methods of slash disposal; revegetation; and fire prevention. BMPs for surface mining operations relate to location, design, and construction of haul roads; type of mining; handling of overburden; proportion of site uncovered at a time; runoff reduction measures; and revegetation and reclamation of mined land.)

- Has the project complied with all applicable **permitting and project review** processes of the local and regional authorities designed to protect groundwater resources including detailed monitoring and reporting requirements?

- Has the project complied with specific **land use controls** designed to protect groundwater resources and recharge areas including the designation of wellhead protection zones, which are surface and subsurface areas surrounding a drinking water well or wellfield supplying a public water system? (Wellhead protection zones are delineated by each area's unique combination of hydrogeological characteristics, potential sources of contamination, and the available institutional capabilities to manage those sources. Other features of the program might include: public information on the importance and methods of protecting drinking water, drinking water treatment programs, groundwater monitoring, extensive permitting and inspection of all non-restricted activities in wellfield areas, and land use controls that prohibit or limit certain uses in proximity to wellfields.)

- Has any project component that proposes **large-scale use of groundwater resources** fully evaluated and provided mitigation against the overall environmental changes that could accompany such large-scale groundwater use:

- Ecological changes due to changes of groundwater level are especially significant and multiform. If the aquifer is unconfined or if it lies just beneath the first unconfined aquifer, with no sizeable impervious layer between them, the drawdown of groundwater results not only in an increase of the non-saturated zone thickness, but also in alteration of salt and water regimes within the whole system, including the soil.

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- This produces changes in the soil formation regime and results in a new environment for the soil organisms and the plants. Further along the chain, changes in productivity and specific structure of the phitocenoses entail alterations of the environment for the animal populations belonging to the same ecosystems.
- Other potential side effects of groundwater level drawdown include: regional subsidence of land surface; activation of suffusion and karst processes; appearance of toxic substances in groundwater due to drainage of previously water-filled layers that contained insoluble compounds which have become soluble.

- Has the project fully addressed **the interaction of groundwater with surface watercourses** in that the use of groundwater hydraulically connected with the surface watercourses affects their hydrological and hydrochemical regimes? (Changes in the levels, discharges and chemical composition of the water in rivers and reservoirs provoke environmental transformations for aquatic organisms, causing changes in their quantity and specific structure.)

- Has the project fully addressed the **potential negative or positive impacts in any irrigation components** (depending on the specific conditions of a region) where drawdown of an initially high water table can have the following results:

1. improved land reclamation by reducing non-productive groundwater evaporation, by diminishing the risk of secondary land salinization, and by establishing the conditions for land desalinization;(+)
2. establishment of conditions essential to horizontal drainage on irrigated areas, significantly reducing expenditure and increasing the land use coefficient since over 7 percent of the total irrigated area returns to agricultural use instead of being occupied by the drainage network; (+)
3. in some cases reduced pollution of surface water resulting from the release of polluted drainage water; (+)
4. deterioration of water supply conditions for the root system of the plants (with shallow fresh or slightly mineralized groundwater, conditions of sub-irrigation may be changed for the automorphic regime). (-)

- Has the project fully addressed the potential for **excessive abstraction of groundwater** by weighing the economic advantages and disadvantages to society and the environment and setting a permissible abstraction rate that will be observed? (Some side effects of excessive groundwater withdrawal are: the impairing of human health resulting in deformity and even death, the deterioration of the quality of industrial products, the salinization of soils; the reduction of crop yields, a decrease in the amount of exploitable groundwater resulting in the loss of whole water supply areas and the increase of the cost of treatment of water.)

- Has the project effectively evaluated and mitigated against the possibility of **introducing or enhancing sea-water intrusion** in the project area, which is the process whereby sea water enters aquifers situated in coastal areas as a result of the disruption of the natural balance between fresh and sea water caused by withdrawal of groundwater? (The width and position of the transition zone from fresh to salt water in the aquifer depend on the local meteorology, hydrology, aquifer characteristics and human activities, and the amount of fresh water flowing to sea.)

- Has the project analyzed the potential for the important negative side effect of excessive extraction leading to **regional land subsidence**? (This includes the potential for **karst collapse** which is a term for the dynamic geological collapse of the rock mass or loose deposits overlying the cavity developed in soluble rocks, caused by natural processes or by human activities, and results in a pit or sinkhole on the ground surface.)

3.1.5 Hydroelectric

- Has the project recognized the following **potential negative environmental effects of hydroelectric facility construction:**
  - air and water pollution from construction and waste disposal

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- soil erosion
- destruction of vegetation
- sanitary and health problems from construction camps?

- Does the project take the following **measures to minimize potential construction impacts:**
  - air and water pollution control
  - careful location of camps, buildings, borrow pits, quarries, spoil and disposal sites
  - precautions to minimize erosion
  - land reclamation?

- Has the project effectively and equitably dealt with the **dislocation of people living in proposed inundation zones** by taking measures such as:
  - Relocation of people to suitable area.
  - Provision of compensation in kind for resources lost.
  - Provision of adequate health services, infrastructure, and employment opportunities.

- Has the project analyzed thoroughly the **potential loss of land (agricultural, forest, range, wetlands)** by inundation to form any reservoirs:
  - Siting of dam to decrease losses.
  - Decrease of dam and reservoir size.
  - Protection of equal areas in region to offset losses.
  - Creation of useable land in previously unsuitable areas to offset losses?

- Has the project included prevention and mitigation measures relative to the **loss of historic, cultural or aesthetic features** by inundation such as:
  - Siting of dam or decrease of reservoir size to avoid loss.
  - Salvage or protection of cultural properties?

- Has the project included prevention and mitigation measures relative to the **loss of wildlands and wildlife habitat** such as:
  - Siting of dam or decrease of reservoir size to avoid/minimize loss.
  - Establishment of compensatory parks or reserved areas.
  - Animal rescue and relocation?

- Has the project taken appropriate measures to minimize the **proliferation of aquatic weeds in reservoir and downstream** impairing dam discharge, irrigation systems, navigation and fisheries and increasing water loss through transpiration such as:
  - Clearance of woody vegetation from inundation zone prior to flooding (nutrient removal).
  - Weed control measures.
  - Harvest of weeds for compost, fodder or biogas.
  - Regulation of water discharge and manipulation of water levels to discourage weed growth?

- Has the potential for **deterioration of the water quality** in any proposed project reservoirs been mitigated through:
  - Clearance of woody vegetation from inundation zone prior to flooding.
  - Control of land uses, wastewater discharges, and agricultural chemical use in watershed.
  - Limit retention time of water in reservoir.
  - Provision for multi-level releases to avoid discharge of anoxic water?

- Has the potential for **sedimentation of any proposed project reservoirs** (and loss of storage capacity) been mitigated through:
  - Control of land use in watershed (especially prevention of conversion of forests to agriculture).
  - Reforestation and/or soil conservation activities in watersheds (limited affect).

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- Hydraulic removal of sediments (flushing, sluicing, release of density currents).
- Operation of reservoir to minimize sedimentation (entails loss of power benefits)?

- Has the potential for **formation of sediment deposits at any proposed reservoir entrances** (creating backwater effect and flooding and waterlogging upstream) been mitigated with sediment flushing and/or sluicing facilities?

- Has the potential for **scouring of the riverbed** below proposed dams been handled through design of trap efficiency and sediment release (e.g., sediment flushing, sluicing) to increase salt content of released water?

- Has any potential **decrease in floodplain (recession) agriculture** been mitigated through regulation of dam releases to partially replicate natural flooding regime?

- Has the potential for **salinization of floodplain lands** been handled by flow regulation to minimize effect?

- Has the potential for **salt water intrusion in estuary and upstream** been mitigated by providing at least minimum required flows to prevent intrusion?

- Has the potential for **disruption of riverine fisheries** due to changes in flow, blocking of fish migration, and changes in water quality and limnology been mitigated through:
- Maintenance of at least minimum flow for fisheries.
- Provision of fish ladders and other means of passage.
- Protection of spawning grounds.
- Aquaculture and development of reservoir fisheries in compensation?

- Have the potential for **other reservoir-related direct and indirect impacts** been identified and mitigated (see section on dams and reservoirs)?

3.1.6 Irrigation

- Does the project effectively mitigate **potential soil erosion (furrow, surface)** by:
- Proper design and layout of furrows or field avoiding too steep a gradient.
- Land leveling.
- Design Of terraces on hillside minimizing surface erosion hazard?

- Does the project effectively mitigate **soil erosion (with sprinkler irrigation on hilly area)** by designing proposed sprinkler systems to minimize erosion hazard (assuring infiltration rate exceeds application rate of the sprinklers)?

- Does the project effectively evaluate and mitigate against the **potential for waterlogging of soils** by including components such as:
- Regulation of water application to avoid overwatering (including controlled turnout to allow cutting off water supply to irrigation ditches).
- Installation and maintenance of adequate drainage system.
- Use of lined canals or pipes to prevent seepage.
- Use of sprinkler or drip irrigation?

- Does the project recognize and mitigate against excess irrigation water (if not drained off) flowing to groundwater bodies carrying **soil entrained fertilizers and pesticides** making these unfit for human or animal consumption? (Surface water resources may also be polluted when drainage systems discharge in rivers and lakes.)

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- Does the project recognize that the excavation of irrigation canals can result in the **interruption or modification of groundwater flow**, which can result can be either a rise or a fall of groundwater levels, both effects being undesirable in many cases?

- Does the project effectively evaluate and mitigate against the **potential for salinization of soils** by including measures to avoid waterlogging such as:

- Suitable drainage system to accompany any form of irrigation network.
- Leaching of salts by flushing soils periodically
- Cultivation of crops with salinity tolerance.
- Prevention of use of irrigation water in excess of the quantity required for evapotranspiration, applied to leach out the soil, which causes a rise of the groundwater table, increasing the rate of the salinization process and calling for yet more irrigation water?

- Does the project effectively evaluate and mitigate against the **potential for scouring of canals** by including components such as designing canal systems to minimize risk and use of lined canals?

- Does the project effectively evaluate and mitigate against the **potential for clogging of canals by sediments** by including components such as:
- Measures to minimize erosion on fields.
- Design and management of canals to minimize sedimentation.
- Provision of access to canals for removal of weeds and sediments?

- Does the project effectively evaluate and mitigate against the **potential for leaching of nutrients from soils** by including components such as:
- Avoidance of overwatering.
- Replacement of nutrients by fertilizers or crop rotations?

- Does the project anticipate the possible **formation of algal blooms and weed proliferation** and mitigate through the reduction of input to and release of nutrients (nitrogen and phosphorous) from fields?

- - Does the project effectively evaluate and mitigate against the **potential for logging of canals by weeds** by including components such as:
- Design and management of canals to minimize weed growth.
- Provision of access to canals for treatment or removal of weeds?

- Does the project include measures to prevent **deterioration of river water quality** below irrigation project and **contamination of local groundwater** (higher salinity, nutrients, agrochemicals) affecting fisheries and downstream users by including:
- Improved water management; improved agricultural practices and control of inputs (particularly biocides and chemical fertilizers), BMPs.
- Imposition of and measures to meet water quality criteria?

- Does the project take appropriate actions to **prevent seawater intrusion** into downstream freshwater systems through reduction of takeoff to maintain adequate downstream flow and/or recharge of coastal aquifers though injection wells?

- Does the project recognize the impacts of any **reduction of downstream flows affecting flood plain use**, flood plain ecology, riverine and estuarine fisheries, users of water, dilution of pollutants and mitigate through the use of measures such as:
- Relocation or redesign of project.
- Regulation of takeoff to mitigate effects.
- Compensatory measures where possible?

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- Does the project minimize the **encroachment on swamps and other ecologically sensitive areas** through the siting of project components to avoid or minimize encroachment on critical areas?

- Does the project minimize the **alteration or destruction of wildlife habitat and/or creation of impediments to movement** of wildlife by:

- Siting of project to minimize loss or avoid encroachment on most sensitive or criticalareas.
- Establishment of compensatory parks or reserved areas.
- Animal rescue and relocation.
- Provisions of corridors for movement?

- Does the project include passageways to mitigate impediments to **movement of livestock and humans**?

- Does the project effectively evaluate any potential project **threat to historic, cultural or aesthetic features** and take measures to site components to prevent loss and/or salvage or protection of cultural sites?

- Does the project minimize any **alteration or loss of flood plain vegetation and disturbance of coastal ecosystems** (e.g., mangroves) by siting components in less vulnerable areas and limitation and regulation of water take-off to minimize problems to extent possible.

- Does the project minimize the **dislocation of populations and communities** by siting project components to minimize effect and providing resettlement schemes that ensure at least equal standard of living?

- Does the project include a health impact assessment that **mitigates the introduction or increase in incidence of water-borne or water-related disease** (schistosomiasis, malaria, onchocerciasis, etc.) by prevention measures such as:

- use of lined canals or pipes to discourage vectors
- avoidance of stagnant or slowly moving water
- use of straight or slightly curving canals
- installation of gates at canal ends to allow complete flushing
- filling or draining of borrow pits along canals and roads
- disease prophylaxis
- disease treatment

- Do any project components that utilize **wastewater for irrigation** full address potential disease and health implications and mitigate through the use of:

- Wastewater treatment (e.g., settling ponds) prior to use.
- Establishment and enforcement standards for wastewater use?

- Does the project fully address **Indirect and External Impacts** that may result from the project such as:

- Increased pollution and health hazards front downstream industrial and municipal pollutants caused by decreased flow (decreased dilution) of river water (mitigated by control of waste sources downstream and a reduction of water takeoff.)
- Water quality deteriorated or made unusable by upstream land use and pollutant discharge (mitigated through control of land use in watershed areas, control of pollution sources, water treatment prior to use.)
- Change of culture which is often very difficult to assume by the populations, whether directly or indirectly involved. Entire populations are expected to change their way of life and this must obviously be accompanied by constant assistance on the part of project and local authorities, if the project is to be accepted.
- Animal husbandry - the lay-out of many irrigation projects (for the sake of reducing construction costs) is such that traditional pastures are rendered inaccessible to animal breeders who are pushed to the periphery of the irrigated area, often into zones which are much less productive.

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- Introduction of micro-climates, frequently attracting bird life detrimental to crop yields.

3.1.7 Water and Sanitation

International goals for water and sanitation (WSS) have not been met historically. Many of the potential impacts related to the development of domestic water supplies are imbedded elsewhere in these EMSs. During project formulation, concerns are found for capacity building, monitoring systems, economic evaluations, community ownership, appropriate technology, comprehensive planning framework, and institutional strengthening. The enhanced EIA sections contain sections on surface and groundwater protection, pollution control, minimum stream flows, etc. As such, the only set of questions related to the potable water end on WSS deals with the proper treatment and disposal of treatment plant sludge and residuals. There are significant issues related to the sanitation side of WSS.

- Has the quantity and composition of **municipal water treatment plant sludges** been thoroughly evaluated and appropriate treatment, dewatering, and disposal systems been put in place?

- Does the project work under and meet the requirements of a **rigorous water pollution control program** including institution-building and national water pollution control policy formulation components?

- Does the project contain realistic evaluations of the severity of the water quality problems and work under **system of phased improvements that emphasizes incremental improvement of waste treatment components** including a appropriate mixture of: conduits for collection and conveyance of wastewater, pumping stations, conventional and innovative treatment works, wastewater reclamation and reuse projects, ocean outfalls, wastewater treatment sludge management facilities, a variety of small-scale sanitation systems for rural and urban areas, and urban stormwater drainage projects?

- Has the **quantity and composition of the municipal wastewater been thoroughly generated** including the typical wastewater pollutants of suspended and dissolved solids consisting of inorganic and organic matter, nutrients, oil and grease, toxic substances, and pathogenic microorganisms? (Present wastewater volume and strength are basic information for the planning process, and realistic projections of volume are important to establish the magnitude and timing of the need for collection and treatment. In making and updating projections, other planned development activities should be taken into account so that extensions or expansions of wastewater infrastructure can be coordinated with them.)

- Has the potential **urban stormwater contribution** to the overall urban pollution generation been thoroughly estimated, using the same types of parameters?

- Have the potential detrimental environmental and health impacts been investigated at receiving locations for situations where **wastewater is collected but not treated properly before disposal or reuse**? (Direct exposure and impacts to habitat for aquatic and marine life impaired by accumulated solids; oxygen is depleted by decomposition of organic material; and aquatic and marine organisms may be further harmed by toxic substances, which may spread to higher organisms through bioaccumulation in food chains).

- In situations where insufficiently treated wastewater is discharged into confined waters such as a lake or bay, has the project investigate the **potential for the nutrient content causing eutrophication,** with nuisance plant growth which can disrupt fisheries and recreation?

- Has the project's residual management program insured that **solid waste generated in wastewater** treatment (grit, screenings and primary and secondary sludge) is handled properly so as to not pollute soil and groundwater?

- Has the **potential for wastewater reuse been thoroughly investigated** taking into account the potential benefits of increased water availability to support development in the region, the opportunity to diminish

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irrigation demands on potential public water supply sources, reduced need for chemical fertilizers, incremental improvements in crop and timber production, and low-cost means to re-vegetate marginal soils or reclaim them for agriculture or silviculture?

- Have the wastewater project **components been thoroughly evaluated relative to "cradle to grave" operation** including planning, siting, proper design, construction, operation and maintenance, and ultimate replacement?

- Have the **following generic characteristics common to many of the potential impacts and mitigating measures** been emphasized as special issues throughout project preparation, assessment and implementation:

- Importance of sound and comprehensive wastewater system planning;
- Fundamental dependence of wastewater projects on proper operation and maintenance (and thus on strong institutional support for both);
- Selection of appropriate technology;
- Necessity for an effective industrial wastewater pretreatment program in any municipal system serving industrial customers;
- Need to consider a number of potential socio-cultural impacts that are sometimes ignored in project preparation?

- Has significant emphasis been placed on the **decision of the required level of wastewater treatment** since the magnitude of pollutant removal the treatment processes must achieve depends on the performance standards that apply to the system? (National standards for effluent discharge or reuse may already exist; if they do not, they can be based on World Health Organization or World Bank guidelines or derived from the standards of other countries.)

- If the proposed wastewater facilities will be constructed in a modular fashion, adding additional capacity as the collector system is extended and new connections are made, have treatment facilities been designed to match this modular progression of collection and has sufficient **space been reserved for acquiring treatment and disposal sites and in designing facilities**?

- Has the project **identified and mitigated against the most common causes of system failure** which are selection of inappropriate technology, lack of spare parts, shortages of trained operators and skilled technicians and craftsmen, and unreliable power or chemical supplies?

- Has the project **identified and designed for common institutional weaknesses** in technical training and utility management, inadequate operating budgets and unattractive salaries (both often related to artificially low customer charges for water which do not produce revenues to cover the full cost of water supply and wastewater disposal services)?

- Has the concept of **appropriate technology in wastewater systems** been thoroughly incorporated including its technical, institutional, social and economic dimensions?

- Since **community participation** may be a key element in the success of a wastewater management system, has the project identified and incorporated social preferences and customary practices are significant, modified as possible by education programs (some may be rooted in cultural values and not subject to change)?

- Although connecting industries to proposed public sewer systems is usually sensible, has the project ensured that an **industrial pretreatment program** be developed including regulations with specific limits on discharges of hazardous and toxic substances and other pollutants to public sewers, monitoring procedures, and enforcement capability? (There is are risks of exposing water system personnel and components to hazardous materials, disrupting the treatment process, transporting toxic pollutants to receiving waters or the land, and contaminating treatment plant sludge so severely it cannot be put to beneficial use or even disposed of without difficulty.)

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- Has the project equitably dealt with any **involuntary resettlement** required for the construction of proposed treatment facilities?

- Has the project **identified and mitigated against nuisances in the immediate vicinity of the facilities**, with care taken to site treatment and disposal facilities where odors or noise will not disturb residents or other users of the area?

- Has the project evaluated all potential **siting and technological alternatives exists for wastewater collection** such as:

- on-lot treatment
- individual holding tanks with truck collection
- small-diameter gravity, pressure or vacuum sewers
- shallow sewers
- flat sewers
- simplified sewerage systems
- conventional gravity sewers and force mains
- regional collection systems
- community or sub-regional systems

- Has the project evaluated all potential **siting and technological alternatives exists for wastewater treatment** such as:

- community on-lot systems
- oxidation ditches
- stabilization ponds (various configurations)
- aerated lagoons
- artificial wetlands (or constructed wetlands)
- land treatment
- conventional biological treatment
- physical-chemical treatment
- preliminary or primary treatment with ocean disposal

- Has the project evaluated all potential **siting and technological alternatives exists for wastewater disposal** such as:

- reuse in agriculture, silviculture, aquaculture, landscaping
- reuse for groundwater recharge
- rapid infiltration
- underground injection
- reuse in industrial applications
- ocean outfall
- surface water discharge
- nightsoil treatment plants

- Has the project evaluated all potential **siting and technological alternatives exists for wastewater sludge management** such as:

- composting
- co-composting with municipal refuse
- reuse in agriculture or silviculture
- reclamation of marginal land for reforestation, cultivation
- energy recovery (methanization)
- incineration
- landfill
- ocean disposal

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- Has the project's **O&M program included sufficient staffing** including a manager with technical and administrative experience; an environmental engineer; supervisors and workers in operations, sewer maintenance and plant maintenance crafts; laboratory directors and technicians; and support staff in accounting, budgeting, and clerical areas?

- Has the project included **sufficient operator training**, starting before system start-up (with the assistance of the design consultant) including basic familiarization with the system, its relationship to the environment, and fundamentals of occupational health and safety, and operations and maintenance training on the actual equipment? (Industrial waste control staff will need specialized training in sampling and enforcement procedures. Employees of connected industry will need training on operation and maintenance of pretreatment equipment. Any personnel who may have to enter confined spaces, work in deep trenches, maintain electrical equipment, or handle chlorine or other dangerous chemicals must be properly equipped and drilled in safety and accident response procedures.)

- Has the project included a **start-up plan** to ensure that the O&M requirements are met, providing for assembling staff, maintenance equipment and spare parts in advance of need, training all personnel, and establishing revenue sources and budget?

- Has the project included **state-of-the-art construction inspection practices** to ensure that the system is built to specifications, with particular attention given to adherence to the mitigation plan provisions to protect stream channels, beaches, and wetlands?

- Has a **detailed operational monitoring program** been developed to observe trends in influent volume and strength; detect hazardous substances entering treatment works; enforce industrial pretreatment regulations; control the treatment process; assess and manage treatment plant performance; monitor environmental quality at disposal locations; and ensure sludge products and reclaimed wastewater meet reuse standards? (The emphasis should be on supporting sound operations of the wastewater system. This entails establishment of system performance standards. Data should be collected to monitor attainment of those standards, interpreted and then delivered efficiently and timely to those who must make operational decisions -- the system's operators and managers. Monitoring data is also useful to designers for improvement of future projects.)

- Has the project **minimized disturbance of stream channels, aquatic plant and animal habitat,** and spawning and nursery areas during construction by avoiding placement of sewer lines in stream channels and by requiring erosion/sedimentation controls during construction?

- Has the project fully addressed the **potential for alterations in watershed hydrologic balance** when wastewater is exported by collection in large upstream areas and discharged downstream by:
  - Considering sub-regional and small community systems in water-short areas.
  - Taking full advantage of opportunities for wastewater reclamation/reuse, especially in water-short areas?

- Has the **potential for degradation of neighborhoods or receiving water quality from sewer overflows, treatment works bypasses, or treatment process failure** been mitigated in the project by items such as:
  - Phase construction of collector systems and treatment works to avoid raw wastewater discharges.
  - Select appropriate technology.
  - Design for reliability, ease of maintenance.
  - Implement management and training recommendations, monitoring program, and industrial waste pretreatment program?

- Has the **potential for degradation of receiving water quality despite normal system operation** been mitigated by items such as:

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- Site and design treatment works and disposal or reuse systems on the basis of adequate data on the characteristics of the wastewater and the assimilative capacity of the receiving water body.
- Use mathematical models for siting surface water discharges and determining required level of treatment, and for siting and designing ocean outfalls.
- Take full advantage of appropriate land application alternatives, especially in water-short areas.
- Implement monitoring program and industrial waste pre-treatment program?

- Have potential **public health hazards in vicinity of discharges or reuse sites during normal operation** of system been mitigated by items such as:
  - Select appropriate technology.
  - Ensure preapplication treatment and operating guidelines for land application and other water reuse systems are adequate to safeguard health of humans and livestock.
  - Restrict access to wastewater or sludge disposal sites where health hazards are unavoidable?

- Has the **potential for contamination at proposed land application sites** been evaluated in two ways: 1) soil and crops by toxic substances and pathogens, and 2) groundwater by toxic substances and nitrogen and mitigated by items such as:
  - Site and design treatment works and disposal or reuse systems on the basis of adequate data on the characteristics of the wastewater and land application site.
  - Implement monitoring program and effective industrial waste pretreatment program.
  - Ensure pre-application treatment and operating guidelines for land application and other wastewater reuse systems are adequate?

- Has the **potential failure to achieve desired beneficial uses of receiving waters** despite normal system operation been prevented by:
  - Establish realistic use objective and select water quality criteria consistent with desired uses.
  - Establish system performance standards by modeling or other means that will result in meeting criteria.

- Has the **potential for odors and noise from treatment processes** or sludge disposal operations been mitigated by items such as:
  - Site treatment works only near compatible land uses.
  - Select appropriate technology.
  - Include odor control and low-noise equipment in design.
  - Implement management and training recommendations?

- Has the potential for **emissions of volatile organic compounds** from treatment processes been mitigated through the establishment of an effective industrial waste pretreatment program?

- Has the potential for **soil, crop or groundwater contamination and disease vector breeding or feeding** at sludge storage, reuse or disposal sites been mitigated through items such as:
  - Incorporate sludge management in system feasibility studies, technology selection, design, staffing training, budgeting and startup plan.
  - Implement effective industrial waste pretreatment program
  - Ensure pre-application, treatment and operating guidelines for land application and other reuse or disposal systems are adequate to safeguard health of humans and livestock.
  - Inspect for compliance with operating guidelines.

- Has the **potential for worker accidents** during construction and operation, especially in deep trenching operations, been mitigated through enforcement of detailed safety procedures?

- Has the **potential for worker accidents caused by gas accumulation in sewers and other confined spaces** or by hazardous materials discharged into sewers been mitigated through items such as:

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- Emphasize safety education and training for system staff.
- Implement effective industrial waste pretreatment program
- Provide appropriate safety equipment and monitoring instruments.
- Enforce adherence to safety procedures?

- Has the potential for **public and worker health hazard from chlorine accidents** been mitigated by incorporating safety provisions in design, operating procedures, and training, and contingency plans?

- Has the potential for **nuisances and public health hazards from sewer overflows and backups** been mitigated through items such as:
- Routinely inspect sewers for illegal connections and obstructions.
- Clean sewers as necessary.
- Provide monitoring system with alarms for pump station failure.
- Provide alternate power supply at critical pump stations.
- Educate public to prevent disposal of solid waste in sewers.

- Has the project included a **sanitation and hygiene education program** to assist in achieving public health improvement in serviced area?

- Has the project adequately prepared for the **possibility of accidental destruction of archaeological sites** during excavation by including notification and protection procedures for cultural properties in construction contract documents?

- Has the project addressed the **possibility of unplanned development** induced or facilitated by infrastructure and included the following design features:
- Coordinate installation of sewerage with land use planning.
- Strengthen land use control regulations and institutions.
- Integrate planning for infrastructure in urban development projects?

- Has the project addressed the potential for **project sludge exacerbating regional solid waste management problems** and included the following components:
- Incorporate sludge, excreta and septage in regional solid waste management planning and in wastewater system feasibility studies and technology selection.
- Implement industrial waste pretreatment program.

- Has the project adequately evaluated the **importance of receiving water in local and regional fisheries** and implemented mitigating measures for direct impacts in order to protect these resources?

3.2 Bioassessment

Biological integrity is defined as "...the ability of an aquatic ecosystem, to support and maintain a balanced, integrated, adaptive community of organisms having a species composition, diversity, and functional organization comparable to that of the natural habitats of a region" (Karr and Dudley 1981). Least-impacted regional reference conditions form the basis for developing regional biological goals, or biological criteria. Biological criteria are "numeric values or narrative expressions that describes the reference [least-impacted] biological integrity of aquatic communities inhabiting waters of a given designated aquatic life use" (USEPA 1990a).

3.2.1 Biological Criteria

- Has the project been assessed under a **system of water resource goals using regional reference conditions** that describe the "best" attainable biological integrity using the following principles:

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- numeric biological criteria based upon a reference condition from a regional framework
- multiple metric characterization of the aquatic community
- resulting in a comprehensive habitat evaluation?

- Were the biological criteria used in impact assessment of the proposed project used to evaluate and **demonstrate the accuracy of current regulatory and management activities** in protecting aquatic ecosystems?

- Were the biological criteria used in impact assessment of the proposed project used to serve as a site-**specific assessment of ecological degradation and ecosystem response** to remediation or mitigation activities?

- Were the biological criteria used in impact assessment of the proposed project used to **assess biological resource trends** in well-characterized watersheds?

- Does the project impact assessment **recognize the potential limitations of establishing point source permit limitations only** based on the findings of the bioassessment such as:

(1) the degree to which subtle impacts can be detected,
(2) the current lack of diagnostic tools to determine the causes of observed impacts, and
(3) the state of the science in defining ecoregions and reference areas?

- Does the project's assessment recognize and **mitigate against the five primary classes of water resource variables altered by cumulative effects** of human actions which are:

- Water quality: temperature, turbidity, dissolved oxygen, acidity, alkalinity, organic and inorganic chemicals, heavy metals, toxic substances
- Habitat structure: substrate type, water depth and current velocity, spatial and temporal complexity of physical habitat
- Flow regime: water volume, temporal distribution of flows
- Energy source: type, amount, and particle size of organic material entering stream, seasonal pattern of energy availability
- Biotic interactions: competition, predation, disease, parasitism, mutualism?

3.2.3 Reassessment of Water Quality Goals

- Has the project assessment moved beyond the typical goals of measuring the effectiveness of wastewater treatment technology to control point sources of pollution and human cancer risk and **focused on the broader concept of biological integrity** or ecological health of the area's water resources?

- Does the project **foster the attainment of long-term biological integrity goals** for the local watershed?

3.3 Point and Non-Point Source Pollution Control

3.3.1 Comprehensive Assessment

- Has the project been fully **assessed under a comprehensive regional water quality system that evaluates potential project impacts against all regional sources of water pollution** including:

- Industrial Point Sources, Major and Minor
- Municipal Point Sources, Major and Minor Cities and Package Plants (Small Flows)
- Combined Sewer Overflows
- Domestic Wastewater Lagoons
- Agriculture

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- Silviculture
- Construction
- Urban Runoff/Storm Sewers
- Resource Extraction
- Land Disposal
- Hydromodification
- Habitat Modification (other than Hydromod)
- Marinas and Water Vessels
- Atmospheric Deposition
- Contaminated Sediments
- Natural Sources

3.3.2 Valid and Comparable Water Quality Assessments

- Do project assessments work under a **system of water quality indicators that are appropriate to the monitoring goal and scientifically valid to allow acceptance by the public and professionals**? (Valid means measurable, sensitive to the impacts being evaluated, able to discriminate change, accurate, and reproducible.)

- Is the suite of indicators similar enough among all water quality monitoring programs to allow **comparison and aggregation of results with confidence** (e.g., at the regional or national level)?
- Is the **scientific basis for the indicators grounded in developed matrices** of biological response and exposure, chemical exposure and response, physical habitat and watershed-level stressors?
- Are the recommended standard base monitoring **indicators established for each designated use**?
- Are **ecological condition/aquatic life indicators** developed as a first step in implementing a national strategy for the assessment of 'biological condition of streams and rivers' ?
- Is **groundwater monitoring and assessment** grounded in a suite of recommended ground water indicators?

- Are the **existing monitoring systems in the project area using valid/comparable field and laboratory methods** which are scientifically valid, meaning measurable, sensitive to the impacts being evaluated, able to discriminate change, accurate, and reproducible?

- Are specified methods able to **yield comparable data of known quality** among monitoring agencies to allow for comparison and aggregation of results (e.g., at the regional or national level)?
- Are **endorsed and documented reference condition approaches** used for aquatic life assessments?

- Does the **monitoring system proposed for the project work under a regional monitoring design which is appropriate to the clear, quantifiable goals of the water quality program**; including data quality objectives to help ensure that all queries will be answered with a specified accuracy?

- Does the regional system include a high degree of **institutional collaboration and agreement** among national, regional and local agencies on a strategy to improve ambient water quality monitoring?
- Does the system contain a **flexible, targeted monitoring strategy** that features: goal-oriented monitoring, categories of waterbodies based on management focus-maintenance / prevention, special protection, remediation/ restoration, and waters of unknown quality, flexible designs within each category, institutional arrangements for cooperation among agencies?
- Is there adequate **documentation of assessment quality** so that other users of assessment information know the quality of assessments to determine compatibility with their data?
- Is there an easy-to-use **standard interface for individual water data systems**; standard export formats and query systems; incorporation of meta data; use of common reference tables; and networked, distributed data systems rather than only centralized databases?

- Have the **waterbodies in the project area been classified according to an array of "cause categories"** that are consistently applied nationally and regionally such as:

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- Cause unknown, Unknown toxicity, Pesticides, Priority organics, Nonpriority organics,Metals, Ammonia, Chlorine, Other inorganics, Nutrients, pH, Siltation, Organic enrichment or low DO, Salinity/TDS/chlorides, Thermal modifications, Flow alterations, Other habitat alterations, Pathogen indicators, Radiation, Oil and grease, Taste and odor, Suspended solids, Noxious aquatic plants, Total toxics, Turbidity, Exotic species, Other

- Has any project that has potential water quality impacts to an existing lake or reservoir impoundment **considered the full array of potential rehabilitation techniques for lakes** including:

- **In-lake Treatments** - Phosphorus Precipitation/Inactivation, Sediment Removal/Dredging, Artificial Circulation to Increase Oxygen, Aquatic Macrophyte Harvesting, Application of Aquatic Plant Herbicides, Drawdown to Desiccate and/or Remove Macrophytes, Hypolimnetic Aeration, Sediment Oxidation, Hypolimnetic Withdrawal of Low DO Water, Dilution/Flushing, Shading/Sediment Covers or Barriers, Destratification, Sand or Other Filters Used to Clarify Water, Food Chain Manipulation, Biological Controls, Other In-lake Treatment
- **Watershed Treatments**- Sediment Traps / Detention Basins, Shoreline Erosion Controls/Bank Stabilization, Diversion of Nutrient Rich In-flow, Conservation Tillage Used, Integrated Pest Management Practices Applied, Animal Waste Management Practices Installed, Porous Pavement Used, Redesign of Streets/Parking Lots to Reduce Runoff, Road or Skid Trail Management, Land Surface Roughening for Erosion Control, Riprapping Installed, Unspecified Type of Best Management Practice Installed, Other Watershed Controls
- **Other Lake Protection / Restoration Controls** - Local Lake Management Program In-place, Public Information/Education Program/Activities, Local Ordinances/Zoning/Regulations to Protect Lake, Point Source Controls

- Has any proposed project utilizing groundwater or having potential water quality impacts to groundwater considered **all regional potential sources of groundwater contamination** including:

- **Agricultural Activities** - Agricultural chemical facilities, Animal feedlots, Drainage wells, Fertilizer applications, Irrigation practices,Pesticide applications
- **Storage and Treatment Activities** - Land application, Material stockpiles, Storage tanks (above ground), Storage tanks (underground), Surface impoundments, Waste piles, Waste tailings
- **Disposal Activities** - Deep injection wells, Landfills, Septic systems, Shallow injection wells
- **Miscellaneous** - Hazardous waste generators, Hazardous waste sites, Industrial facilities, Material transfer operations, Mining and mine drainage, Pipelines and sewer lines, Salt storage and road salting, Salt water intrusion, Spills, Transportation of materials, Urban runoff

- Does the project **comply with existing groundwater protection systems and programs in the project area** including an array of measures that might include:

- Ambient ground water monitoring system, Aquifer vulnerability assessment, Aquifer mapping, Aquifer characterization, Comprehensive data management system, Ground water discharge permits, Ground water Best Management Practices, Ground water legislation, Ground water classification, Ground water quality standards, Hazardous waste disposal and cleanup legislation, Interagency coordination for ground water protection initiatives, Non-point source controls, Pesticide Regional Management Plan, Pollution Prevention Program, Regional Ground Water Protection Program, Regional septic system regulations, Underground storage tank installation and remediation requirements, Underground Injection Control Program, Vulnerability assessment for drinking water/wellhead protection, Well abandonment regulations, Wellhead Protection Program, Well installation regulations

- Have **industrial or municipal wastewater projects** been evaluated **under a system** in the project area that used all available information sources when determining regional water quality characteristics including:

- **Permit Compliance Records** - analysis of monitoring reports by industries, compliance monitoring or special monitoring in permits by regulating agency, local bioassay tests
- **Monitoring/Modeling Studies**- upstream/downstream chemical, biological, and, habitat monitoring,

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intensive surveys combined with regional wasteload allocation modeling, complaint investigations, data from volunteer monitoring

- Have **irrigation-related projects** been evaluated **under a system** that used all available information sources when determining regional water quality characteristics including:

- **Permit compliance records** - Observation of overflows from total retention (non-discharge) facilities, Compliance with provisions for off-site disposal of animal wastes (e.g., land application, composting)
- **Monitoring studies** - upstream/downstream chemical, biological, or physical monitoring (especially for nutrients and pathogens), complaint investigations
- **Information from monitoring and field observations** (e.g., document bad actors) - edge of field monitoring of runoff from animal holding areas, cropped areas, or pastures, monitoring of inputs from irrigation return flows, subsurface drains, or drainage ditches, proper installation of screens or other measures to avoid fish losses in drainage/irrigation ditches, serious rill or gully erosion in agricultural fields, sedimentation problems in agricultural watersheds, indications of unmanaged livestock in streamside management zones, complaint investigations or data from volunteer monitoring or inventories
- **Records on watershed BMP implementation status** - documented low implementation level (e.g., less than a 70% target) of recommended water quality BMPs, documented problems with specific agricultural operators
- **Modeling** - Use of models to estimate pollutant loads and improvement from BMP implementation, intensive surveys combined with regional wasteload allocation modeling

- Have **silviculture-related projects** been evaluated **under a system** that used all available information sources when determining regional water quality characteristics including:

- **Monitoring and field observations documenting instances of high sediment delivery** - BMPs not followed on logging road, skid paths, or stream crossings, BMPs not followed to protect streamside management zones, serious sedimentation problems (cobble embeddedness or interstitial D.O. problems) in watersheds that are largely silvicultural
- **Records on watershed BMP/management measure implementation status** - documented low implementation level of recommended water quality-oriented BMPs
- **Results of modeling or cumulative effects analyses** - use of models to estimate pollutant loads and likely improvement from BMP implementation, use of water temperature models to help quantify impacts on cold water fisheries, use of landscape analysis techniques to document cumulative effects, intensive surveys combined with regional wasteload allocation modeling

- Have **construction projects** been evaluated **under a system** that used all available information sources when determining regional water quality characteristics including:

- **Information from monitoring and field observations** (primarily to document problem areas or bad actors) - sedimentation problems documented in watersheds with major construction activity, complaint investigations and volunteer monitoring data
- **Information from sediment control management agencies** - records of implementation of sediment control measures

- Have **projects contributing to urban runoff non-point source pollution** in the project area been evaluated **under a system** that used all available information sources when determining regional water quality characteristics including:

- **Monitoring/modeling studies** - upstream/downstream chemical, biological, or habitat monitoring comparing wet weather and normal flow conditions near outfalls, special monitoring for BMP effectiveness-wet ponds, artificial wetlands, grass swales, intensive surveys combined with regional wasteload allocation modeling and catchment models, complaint investigations
- **Information from management agencies** - documented low implementation level of recommended

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or required water quality-oriented BMPs, documented problems with BMP operation and maintenance

- Have projects requiring **hydromodification (dams, diversions, flow regulation, etc.)** been evaluated **under a system** that used all available information sources when determining regional water quality characteristics including:

- **Monitoring and field observations** - recurring problems with inadequate instream flows (e.g., dewatering of streams, reduced pollutant assimilation, unnatural water temperatures), documented interference with fish migration and spawning movements (e.g., for such anadromous fish as salmon or rockfish but also for inland fish that seek spawning habitat outside lakes or large rivers)
- **Modeling** - Analysis using instream flow models to document adverse impacts, Analysis related to hydroelectric permits, habitat recovery plans, regional wasteload allocation (e.g., problems with anoxic or nutrient-laden releases from hydrostructures)

- Have projects requiring **channel hydromodification (Channelization, dredging, removal of riparian vegetation, streambank modification, draining/filling of wetlands)** been evaluated **under a system** that used all available information sources when determining regional water quality characteristics including:

- **Monitoring (usually over considerable period of time) documenting adverse changes** - severe channel downcutting or widening, elimination of vegetation in streamside management zones, excessive streambank erosion and sloughing, loss of significant wetland area in watershed, failure of wetland mitigation projects
- **Modeling studies** - decreases in pollutant assimilation from habitat modification, adverse impacts on hydrology, water temperatures, or habitat

3.4 Minimum Stream Flows

3.4.1 In-stream Flow Problems

- Does the project's proposed use of **reservoirs serve address both the protection against flooding and the resulting streamflow regulation**? (The procedure consists of time redistribution of natural flow. When the increased discharge is required for improving river navigation, recreation, pisciculture, transport of waste waters etc., reservoirs have little influence on the volume of water which transits in the stream bed other than the reduction due to evaporation losses.)

- Does any proposed **abstraction of surface water from streams and rivers** for a supply of irrigation networks, drinking water and industrial water supplies adequately address in-stream flow reductions downstream of the diversion during low-flow conditions?

- Are the **economic reasons for maximized abstraction fully evaluated against in-stream ecological and other impacts** arising from such abstraction, including minimum in-stream flows?

- Are any proposed **reservoir uses for hydropower production,** operating only during periods of peak power demand, fully recognizing the impacts on downstream ecological systems?

3.4.2 Minimum acceptable flow

- Has the project assessment used every effort to determine a **reasonable, cost-effective and environmentally sensitive method** to determine minimum acceptable flow? (Recognizing that the determination of minimum acceptable flow is a very difficult question of water management and there is no universally accepted method.)

- Has the assessment reviewed its findings against a method suggested in 1966 by a group of experts who collected and evaluated data and information from ECE member countries (ECE 1966), and who then

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recommended for general consideration that the following approximate values be retained for fixing minimum in-stream flows:

- small mountain rivers: 0.2 of the average minimum discharge; for shorter periods even smaller values and in exceptional cases zero value;
- larger rivers with fairly constant flow: 0.5 of the average minimum discharge;
- other cases: 0.8 to 1.0 of the average minimum discharge.

- Has the assessment reviewed its findings against a method suggested in 1974 by another group of experts who collected and evaluated data and information from ECE member countries (ECE 1974), and who suggested that the **minimum acceptable flow that should be maintained in a watercourse had to satisfy all quantitative and qualitative constraints and requirements**?

- Does the specified minimum acceptable flow ensure that the following conditions will be met:

- **guarantee a flow of water sufficient to prevent stagnation of water**, formation of mire, and centers of infection dangerous to public health;
- ensure **sufficient dilution** of dispersed pollution resulting from unorganized discharges/riparian dwellings or pollution by other media;
- maintain the **biological balance** of the natural aquatic environment;
- ensure the **necessary flows for unorganized water supplies**, including the watering of livestock;
- **prevent sedimentation and other flow phenomena** which could modify the morphology of the stream bed;
- **preserve natural beauty**-spots/waterfalls, tourist sites etc.

- Does the specified flow ensure that the **minimum acceptable flow is sufficient to avoid the formation of clay and mud zones** in the stream bed? (The minimum acceptable flow is of special importance to environmental protection because rivers are an important element of the natural hydro-biological environment.)

3.5 Regional, Sectoral and Cumulative Impacts

3.5.1 Regional and Sectoral EIA

- Has the project been developed and **assessed under a regional and/or sectoral perspective** that recognizes that a project-by-project assessment for addressing environmental degradation of natural resources puts a country's future at risk economically and socially - as well as environmentally?

- Has the project facilitate a regional/sectoral perspective using a **multidisciplinary approach** that combines broad environmental policy, institution building, and other aspects of resource management?

- Does the project assist with a **regional/sectoral perspective rational, systematic and integrated**, because EA and its related components (social impact assessment (SIA), risk analysis, and so forth) developed to **augment the deficiencies of economic techniques in accounting for the qualitative and intangible effects** of major developments?

- Does the project conform to a regional/sectoral perspective dealing with areas that project-level EA has not such as **how, whether or where the project should happen**, rather than as a project planning and mitigation tool? (This role in decision-making works well within an integrated policy and planning context in which prior-order issues of justification and alternatives are resolved in a phased manner.)

- Has the **project emerged from a tiered (or vertically integrated) process of policy, program and plan review in the regional/sectoral system** where tiering means the sequential process of addressing issues and impacts at the appropriate level and with the degree of effort required for decision-making?

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- Does the project review include regional/sectoral perspectives that included the following integration examples indicated how regional/sectoral approaches and EA elements might be **recast into a "second-generation" process to ensure sustainability:**

- screening of economic and development policies for their **conformity with sustainability goals and principles** (for example, identifying environmentally perverse subsidies),
- preliminary assessment of **environmental costs of development programs** to identify low-impact, resource-efficient energy, transportation and manufacturing strategies,
- areawide assessment to establish **resource and land use zoning systems** for regional development,
- extending project EA to identify **in-kind compensation for loss of natural capital** (for example, offsetting fish and wildlife losses in one location by rehabilitating habitats elsewhere.
- serve as planning tools, assisting in the identification of **environmentally sound projects;**
- contribute to implementation strategies which take into account the **combined impacts of a set of projects already being pursued;** and
- **assist in project preparation by supporting plans and designs** which are sensitive to cumulative impacts, synergisms, interactions, and competition for natural and sociocultural resources.

- Has the project **recognized and mitigated** against the following potential **institutional problems:**

- **Human Resources** - limited facilities and resources for education and training of professional and technical personnel, low status accorded to employment in certain positions (e.g., wastewater treatment plant, local government), inadequate salary scales, benefits and incentives, lack of career paths for technical and professional staff, lack of support in terms of equipment, technical information, and continuing education, civil service hiring restrictions included in economic reform programs, inadequate operating budgets, informal processes that allow circumvention of formal requirements in EA mid decision-making, "hands off' public administrators, lacking in local knowledge, lack of commitment to environmental laws and policies, weak leadership in institutions caused by lack of autonomy and accountability
- **Environmental Policy, Laws, and Regulations** - absence of environmental concerns in national policy formulation, lack of clear environmental policies and/or commitment to them, lack of legal authority for EA as part of resource development decision-making, weak or nonexistent environmental laws regarding resource use, resource protection, environmental quality, pollutant discharge, waste disposal, facility siting, occupational safety and health, lack of legal authority for community involvement in development decisions, absence of regulations to implement the laws that exist, unrealistic regulations that are unenforceable, weak enforcement of laws and regulations, lack of incentives for compliance, existence of legal and financial disincentives for sustainable use of natural resources, local regulatory agencies unable to enforce compliance by large, government-owned industrial operations
- **Organizational Structure** - lack of entities to perform one or more key functions, vertical or horizontal fragmentation of environmental responsibility and authority, environmental agency (ies) isolated, not integrated into economic development planning and decision-making, national environmental agency limited in authority to influence resource development decisions by individual line agencies or to resolve conflicts among them, structure not conducive to intersectoral coordination, no agency to perform objective review of EA, implementing agencies without EA capabilities and maintenance and monitoring over life, implementing agencies not well-staffed for operation of project, inadequate provision for collection, analysis and utilization of monitoring data, local governments not prepared or equipped to cope with burdens imposed directly or indirectly by development projects, centralized decision-making and political interference restrict authority of regional and local agency managers
- **Environmental Assessment and Environmental Management Procedures** - lack of procedures for project screening, EA preparation and review, lack of effective monitoring programs to provide baseline data for EA, lack of national and international information exchange, low public confidence in EA process and development planning process, lack of interagency coordination in project planning, EA, and project implementation, no procedure to identify and resolve intersectoral issues or pursue integrated planning across sectors or within regions, weak follow-up or supervision of

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projects, especially mitigating measures. during implementation and subsequent operation, no feedback of results of monitoring and supervision to agencies responsible for taking remedial action or to those who could use the information to improve future projects, failure of environmental projects or project components because of inadequate operation and maintenance, deficient planning processes, inconsistent enforcement procedures, no procedures to take into account in project planning and design the needs of or impacts on affected local governments, no procedures for involvement of affected groups and NGOs, procurement processes insufficient to meet needs for spare parts, equipment, supplies to sustain environmental management components, no comprehensive environmental education programs

- **Financial issues** - lack of funding for the EA process and for follow-up functions (supervision, monitoring, measurement of impacts, feedback), environment not given priority in economic planning and budgets, unreliable or ineffective cost recovery systems for public infrastructure and service projects, inadequate provision for project operating and maintenance costs in planning and budgeting processes

- Does the project recognize that the most **objective and potentially measurable criterion for sustainable development may be the preservation of the productivity and full functioning of the natural resource base**? (This may not ensure inter-generational equity but it would provide future generations with the same natural resource capital for producing goods and services, with the same life support and amenity services provided by the natural environment.)

- Were the required project resources evaluated under a regional/sectoral system that addressed the **three important categories of natural resources for analyzing the environmental and natural resource impacts of projects**:

1. **exhaustible resources** that are inputs into the productive process,
2. **renewable resources**, such as forests, agricultural soil, fish, wildlife, and surface and groundwater,
3. **life-support resources** for the planet: all levels of the atmosphere, rivers, lakes and oceans, wetlands and ecosystems?

- Was the project's evaluation of the social costs of natural resource depletion and degradation within the regional/sectoral system used to determine whether the project is in **conformity with the sustainable development criterion in two ways**:

1. **assigning the full environmental and resource costs to projects** will cause those with the largest adverse environmental impacts to bear relatively higher social costs - and therefore a lower priority in the allocation of capital,
2. the regional/sectoral system would reveal the total **amount of financing required for the project to meet sustainability conditions**?

- Was the project evaluated by policy-initiating agencies under a system to **screen all proposals as early as possible to identify their potential environmental consequences**, and whether the initiative will be subject to preliminary or full sectoral or regional analysis?

- Does the project evaluated relative to **policies that are not divisible into discrete programs, plans and projects** (for example, immigration and fiscal policies), **or that have global or cumulative environmental effects** that may be only or best dealt with at the policy level (for example, emissions and climate warming; urban development and habitat/landscape conversion?.

- Did the project facilitate its review under a regional/sectoral EA process that has been **fully incorporated into the project area decision-making processes, allowing for the following benefits**:

- Provide a **baseline overview of environmental conditions** within the study area (a regional "state-of-the environment"), which is key to making reliable impact assessments and monitoring environmental change's over time;

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- Assist governments in forming a long-term view of regional, planning and **increase the transparency of the planning process** (that is, show the reasoning behind development plans), thereby modifying or eliminating decisions that might be environmentally harmful;
- Analyze the **institutional and legal framework** relevant to the particular region, identify institutional and jurisdictional gaps, and make recommendations regarding, for example, environmental standards and law, enforcement appropriate for the region (thus reducing the need for similar analysis in downstream EA work);
- Suitably collect and organize regional environmental data and, in the process, **identify data gaps** And needs at an early stage, and outline methods, schedules and responsibilities for data collection and management during program or project implementation;
- Allow for comprehensive planning of region-wide environmental management and monitoring and **identify broad institutional, resources and technological needs** at an early stage, including potential funding problems;
- Provide a **basis for collaboration and coordination across administrative boundaries** and between sector-specific authorities and help avoid contradictions in policy and planning while enhancing efficiencies;
- Strengthen preparation and implementation of individual projects within the region; by recommending criteria for environmental screening, analysis and review of such projects and **setting standards and guidelines for project implementation**; and
- Provide a **vehicle for public participation** in shaping the future development of a region, thereby building public support for the process?

3.5.2 Cumulative Impact Assessment

- Has the project been developed under a formalized approach to cumulative impact assessment **that encourages the following benefits** (Since cumulative impact assessment is concerned with incremental, synergistic and cross-media effects of development patterns on ecosystem and landscape functions.):

a) encourage review of potential environmental effects associated with development proposals,
b) permit more systematic consideration of the need and alternatives,
c) facilitate identification and management of cumulative impacts,
d) catalyze the reorientation of the EA as a sustainability instrument?

- Does the **project's cumulative environmental impacts work toward a drawdown of natural capital, which may be offset by an equivalent investment in resource conservation, rehabilitation or replacement** (Since a formal approximation for environmental sustainability is the non-liquidation of natural capital (that is, resource stocks and the ecological processes essential for their continued productivity and regeneration.))?

- Are the system's **proposed in-kind impact compensation measures, as well as conventional mitigation terms and conditions, applied to non-conforming development activities** (that do not meet the no net loss rule.) and how does was this project evaluated in this basis? (The goal is to promote the art of the practical, creatively employing "best guess" science to implement prudent rules of thumb that help guarantee sustainability.)

- Has the system of cumulative impact assessment filtered to the project-level environmental impact assessment (EIA) process such that the project **EIA incorporates considerations of the cumulative impacts of the proposed action**?

- Does the **cumulative impact assessment system address the key pragmatic questions** when the proposed action consists of either a project or permit including the following:

1) Does the term "cumulative impacts" relate to the **integrated impacts (over time)** of the proposed action on each relevant environmental resource?

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2) Do cumulative impacts refer to the **summation of the impacts of the proposed action across all relevant environmental resources at a given point in time**?
3) Do cumulative impacts **include all existing projects or impact-causing factors in the geographical areas (environs) of the proposed action**? If so, what geographical area should be addressed? (This is a pragmatic issue in delineating the boundaries of the study relative to addressing cumulative impacts.)
4) Should issues such **as synergistic or antagonistic reactions related to environmental effects** be incorporated in the cumulative impacts considerations?

3.6 Environmental Indicators

3.6.1 Defining Environmental Conditions

- Are the estimated **emissions and impacts associated with the proposed project** compared in terms of a complete matrix of indicators showing the **proximate pressure** on the environment, reflecting **underlying pressures** arising from sectoral change in the economy which in turn reflects population change, public policy (including any changes in property rights regimes and public opinion?

- Are these pressure indicators then measured in terms of **state of the environment (SOE) indicators,** e.g., changes in length of river with a particular classification of water quality, or change in DO levels in a given river over time, and so on?
- Are such SOE indicators related to measures of importance, meaning the SOE indicators are translated into effects **indicators,** i.e., usually measures of **damage** (or improvement) in assets, natural and man-made, that have economic value to individuals?
- Are the environmental indicators used in an **accounting framework** which includes monetized measures of damage since these are generally required in order to fit into some other schema such as cost-benefit analysis?

- Was the project assessed under a system of indicators meet the challenge of environmental planning in that they assist with **valuing the effects of and ranking urban environmental problems** in terms of health effects, productivity, amenity, ecological values, and other key measures, placing emphasis on the following areas:

- **Health and Safety.** In examining health and safety effects, assessment criteria include health care costs, lost working days, and higher mortality rates.
- **Productivity.** Any assessment should judge the extent of losses in urban productivity, which is the result of poorly run cities and such external factors as spillover pollution from nearby industrial areas.
- **Equity.** Because the negative effects of urban environmental degradation fall disproportionately on the poor, issues of equity are of critical importance. Efforts to improve universal access to basic sanitation and other essential urban services and to include the poorest of the poor in urban improvement programs will go a long way toward mitigating urban environmental degradation.
- **Ecology.** Ecological effects can be judged by the availability and costs of fresh water, the extent of land subsidence from overdrawn ground water, the vulnerability to flooding, landslides and other natural disasters, and the loss of biological diversity.
- **Amenity.** Effects on amenity include air and water quality, noise levels, scenic beauty, and the presence of parks and clean, open spaces.

- Is a Level I system of environmental indicators in place which simply show the "state of the environment" in **terms of ambient qualities of the receiving environment, emissions and waste arisings, and land use**, and how does **this project potentially affect these Level I indicators**?

- Has a system of Level 2 indicators been developed which are **Level 1 indicators related to some other variable, usually an economic one**, and **how does this project affect these indicators**? (Where quick and approximate calculations are required, depletion per unit GDP is quite a useful indicator which can

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then be related to forecasts of GDP, expected structural change in the economy, and other factors. Time series help by showing how depletion use per unit GDP might be expected to change with time given the state of development of the economy. In turn, pollution emissions tend to have fairly stable coefficients per unit of energy source. In this way, then, it is possible to get a rough estimate of the expected emissions of pollutants given the forecast of GDP.)

- Has a system of satellite accounting using environmental indicators (Level 1 and 2 types) emerged and been **integrated into a wider accounting framework** such as the United Nations System of National Accounts (SNA), using sets of physical accounts which usually show opening and closing stocks of natural resources and changes in environmental quality, and **what are the project effects?**

- Does the system of indicators **follow one of the three emerging branches of sustainability measurement** composition and **rate the project** accordingly:

1. **Monetization,** using values such as market prices, willingness to pay and remediation costs to determine the weighing of specific items.
2. **Expert assessments,** using scientists devising technical weighing schemes, such as reducing phosphates and nitrates to eutrophication equivalents of default back to preference for monitoring a single item.
3. **Compliance with official policy goals** with initial work tending to give equal weight to each issue.

- Has the project addressed and been evaluated under all three branches of the OECD indicator model using **Pressure-State-Response (PSR)?**

- Does the project work under and **foster a goals-oriented approach** that requires indicators that are themselves ratios of descriptive indicators to target values - where targets are defined either technically or by policies?

- Do the performance indicators produce **definitive measures of progress for the project or at least set priorities for further monitoring and data collection and analysis?** (Goals for action and for better monitoring are co-evolutionary.)

- Does the project's **set of performance indicators** use the following criteria suggested by Sen (1993) in another performance context:

Focal Variable - in terms of what variable should progress or regress be judged?
Time Stretch - Are we to identify setbacks with a declining long-run trend line or short-run phenomenon of a sharp decline?
Relativity - Is regress to be understood as setback in absolute terms or only as falling behind other communities or groups (relative to their progress)?
Units - Are countries the right units for assessing regress? Are we concerned over average conditions or those of the worst-off?

3.6.2 Water Project Performance

- Has the project been rated under a set of indicators which can be used to **assess the sustainability of water resources projects such as proposed for the World Bank** as follows (6):

- **Continued delivery of services and production of benefits**
  - (a) Comparison of actual and intended benefits and services and their stability over time;
  - (b) Efficiency of service delivery;
  - (c) Quality of services (benefits);
  - (d) Satisfaction of beneficiaries;
  - (e) Distribution of benefits among different economic and social groups.

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- **Maintenance of physical infrastructure**
  (a) Condition of physical infrastructure;
  (b) Condition of plant and equipment;
  (c) Adequacy of maintenance procedures;
  (d) Efficiency of cost-recovery and adequacy of operating budget;
  (e) Beneficiary involvement in maintenance procedures.
- **Long-term institutional capacity**
  (a) Capacity and mandate of the principal operating agencies;
  (b) Stability of staff and budget of operational agency;
  (c) Adequacy of interagency coordination.
  (d) Adequacy of coordination with community organizations and beneficiaries,
  (e) Flexibility and capacity to adapt project design and operation to changing conditions
- **Political support**
  (a) Strength and stability of support from international agencies,
  (b) Strength and stability of .support from the national government;
  (c) Strength and stability of support from provincial and local government agencies;
  (d) Strength and stability of support at the community level ;
  (e) Extent to which the project has been able build broad base of support

3.6.3 Sustainability Indicators

- Does the project address the following policy analysis **socio-economic aspects** of sustainability reviews:

- finance
  - required capital for investments and maintenance
  - available funds
  - cash flow of costs (interests, depreciation) and revenues

- costs/benefits per sector
  - drinking water supply
  - agriculture/forestry
  - fisheries/aquaculture
  - industry
  - energy production
  - navigation and transport
  - recreation and tourism
  - land reclamation/loss
  - households (net income, removals)
  - government
  -long term project efficiency (erosion, siltation up of reservoirs, salinization)
  - effects of climate change and sea level rise
- effects on the balance of trade and payments
  - effects on employment
  - effects on prices
- effects on distribution of income
  - between countries
  - between regions
  - between population groups
- effects on cultural heritage
- effects on landscape
- social basis
  - involvement of interest groups in policy preparation and the decision making process
  - contribution to emancipation (of minority groups, of sexes)

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- management, legal and institutional aspects
  - compliance with existing plans
  - compliance with existing legislation and government structures
  - agreement with existing institutions for management, maintenance and enforcement
  - expected time for implementation
  - uncertainties with respect to effects (nature, extent)

- vulnerabilities and risks
  - likelihood of natural disasters (storms, earthquakes, tidal waves)
  - damage in case of flooding, calamities or accidents (during construction, maintenance and operation of facilities)
  - damage (gains) due to climate change and sea level rise

- Does the project address the following policy analysis **environmental pressure indicators** of sustainability reviews:

- emissions to the air
- emissions to the water
- emissions to the soils
- disturbance (noise)
- exploitation and mining of natural resources

- Does the project address the following **effects on nature and the environment:**

- seasonal fluctuations in water levels and flows
- frequency and extent of flooding of quays, embankments, shores and flood plains
- tidal levels and tidal induced currents
- concentrations of substances in air, water, soil, ground water, biota/food
- physical changes in the water systems in turbidity, temperature
- changes in salinity levels of water bodies at coastal areas, estuaries, inland waters, ground water (saturated, unsaturated zones)
- morphological changes at coast/shore line, topography (bathymetry) of rivers, lakes and coastal areas, patterns of erosion and sedimentation
- physical changes in biotope conditions
- disturbance (noise, vibration, intense light)
- settling of land
- effects on ecosystems (communities) due to algal (phytoplankton, macrophytes) growth and primary productivity, oxygen depletion, bacteriological pollution, toxicological effects (due to toxics or radiation), hindrance of behavioral patterns (foraging, resting, nesting, migration), changes in diversity of species, risks of species' extinction
- changes in nature values (nature conservation areas, natural elements in the human environment)

- Does the project address the following **effects on health, safety and well-being:**

- risks of exposure to hazardous substances from the environment and from food
- risks of transmittable diseases (via insects, parasites)
- risks of infection diseases (via surface water, drinking water)
- likelihood and effects of flooding
- likelihood and effects of accidents
- effects of living and working conditions
- exposure to dust, smell and noise

- Does the project address the following **structural socioeconomic development aspects of sustainable development:**

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- vulnerability of the economy, multi- vs. mono-sectoral structure
- level of self-sustainability in food production, energy production, and natural resources (water, oil, metals, minerals)
- capital gains
- level of knowledge and education
- infrastructure
- production capacity

- Does the project address **the potential use of the environmental utilization space relative to:**
  - raw materials and energy including energy consumption and efficiency during construction, maintenance and operation, materials' consumption and efficiency during construction, maintenance and operation
  - emissions reduction of solid waste production (re-use, optimization, closing of material cycles)
  - natural resources including efficiency of water-use, exploitation of living resources, carrying capacity of natural systems (against pollution and disturbance)

  - vulnerability of nature (ecosystems) including conservation of regenerative capacity, resilience and buffering capacity of ecosystems (communities, habitats), risks of irreversible effects on ecosystems (communities, habitats)?

- Does the project address **potential opportunities for conserving or enlarging the environmental utilization space using:**
  - conservation of water supplies
  - land reclamation/generation
  - conservation of soil fertility
  - nature-development (eco-engineering)
  - environmentally sound materials (shore protection, structures)?

- Does the project include **provisions for flexibility and sustainable quality of structures and management using:**
  - opportunities for a phased development with gradual increase of operational capacity
  - opportunities for reaction to changing conditions by dynamic development
  - opportunities for multi-functional use and management during the construction phase, and operation phase
  - sustainable quality of structures relative to corrosion and wear and tear
  - opportunities for rehabilitation of the original conditions by autonomous regeneration or active reconstruction and restoration?

- Does the project **foster regional sustainable development** defined as a development which ensures that the regional population can attain an acceptable level of welfare, both at present and in the future, and that this regional development is compatible with ecological circumstances in the long run while at the same time it tries to accomplish a globally sustainable development?

- Does the project ensure that the two conditions necessary for regional sustainable development are enhanced or at least not detracted by the project:

  1. Activities at the regional level should remain **within ecological boundaries** to ensure that future generations in the region will have acceptable social welfare opportunities.
  2. These activities should be **commensurate with global sustainable development.**

- Has the project appraisal added to the traditional view of the efficiency evaluation (that welfare benefits equate with the consumption of goods and services produced in the socio-economic system) and **included environmental amenities as a second welfare attribute?**

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- Likewise, on the cost side of efficiency analysis, has the project accounted for **use of scarce natural resources for including inputs** (such as renewable and non-renewable resources) **and the by-products of outputs** (for instance pollution or material waste generation), and any other type of alterations to ecosystems?

- Has the project operationalized a sustainability criterion which considers the following **five sustainability dimensions:**

- it is expressed in one or more parameters,
- for which target (sustainability) levels are defined,
- as well as acceptable corresponding risks,
- and a time path for achieving those levels,
- at specific spatial levels.

- Does the project work under a sustainability criterion which plays a dominant role in project appraisal by applying a) **strict limits are imposed on natural resource use,** b) limits apply to specific environmental groups **without the possibility of substitution,** c) all **ecological risks should be avoided,** d) **sustainability** should be achieved **in the short-run,** and e) all these requirements are to be met at the **lowest spatial level,** i.e. the project level?

- Does the **strict sustainability criterion** used for the project evaluation corresponds with:

- a risk aversive attitude;
- the formulation of a separate objective for environmental amenities as a social welfare attribute;
- a strong concern with future generations;
- a lack of confidence in possibilities for substitution within economic and environmental production functions.

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Appendix 6.

Proposed Environmental Management Systems (EMSs)

Implementation and Tracking Series (4.0)

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4.1 Integration of Environmental and Social Impact Assessments

4.1.1 Beneficiaries

- Has the project EA fully addressed the potential social benefits for the populations of the areas directly involved in the proposed project, as well as the **longer term and 'down-stream' benefits** from a larger geographical perspective? [For a water-related project, these benefits will have an impact on householders and on employees. The precise nature of the benefits is likely to include water quality, improvement of environmental pollution, health and quality of life.]

- Since households in the poorer areas of cities are generally the worst served with connections to services such as safe water, sanitation and storm drains, do the proposed water project benefits recognize that longer run benefits may be more significant in terms of improving the **water and sanitation environment for the poorest of the cities** than the immediate and short term, tangible impacts?

- Does the project EA recognize and distinguish the potential multiple stakeholders who may benefit from the proposed project, since the **beneficiaries will likely arise in all levels of government** from the local, regional (state, provincial) and national levels?

- Does the project EA recognize and distinguish between **time-related benefits** such as the **longer term** (through items such as improved clean water supplies, waste water and sanitation, and solid waste collection and treatment), **or short term** (such as employment opportunities, and other economic or financial benefits such as the provision of services to construction site workers)?

4.1.2 Disbenefits from the Project

- Does the project EA adequately address the **temporary or permanent relocation** of households or enterprises in the region of influence of the project?

- Does the project EA identify any **groups of people who do stand to be negatively affected by the proposed project** where the new facilities may result in their loss of livelihood?

- Does the project EA identify and adequately mitigate **temporary construction impacts** in the building of plants, laying of pipes and transport of construction materials that may affect local populations, and address these issues in the resettlement action plan?

- Has the project EA correctly identified **all potential financial costs associated with needed relocations** to include the necessary compensations that will be paid, including re-housing, crop compensation, land compensation, and employment opportunities?

- Has the project EA included a **survey of people who were previously relocated** near the study area and identified past problems that occurred with relocation and adequately mitigated these concerns?

4.1.3 Intra-household issues

- Have all project components been developed with **full participation of both men and women,** with each activity of the project assessed in gender terms, so that neither gender will be negatively affected as an outcome of the project activity?

- Has the project EA fully addressed **intra-household distributions of resources and domestic roles,** in terms of determining whom the beneficiaries will be, domestic demand for services, and willingness to pay increased charges?

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- Has the EA included a **household questionnaire survey** to determine if women are more responsible for household management and meeting household members basic needs?

- Has the EA included a **"willingness to pay" survey** of domestic users which includes additional sections to provide information concerning demand for services from different socio-economic groups, affordability, perceptions of current services and environmental pollution, and knowledge of hygiene and health related risks? [The survey allows for a clearer picture of beneficiaries, vulnerable groups, and non-monetary benefits from employment so that consideration can be given to all strata of society and income equivalent values can be developed to provide comparisons between population subgroups.]

4.1.4 Community Participation

- Has an **appropriate community participation process** been used in the EA with committee structures such as residents committees and street committees used as the basis for ensuring that a proper consultation process takes place at all appropriate stages of project development?

- Has a **broadly based public participation process** occurred throughout the life of the EA/SIA, and using additional means (e.g., key informants, participant observation, and where possible, surveys) to ensure that the most significant public concerns are addressed?

- Has the community participation process included the important questions related to **cost recovery and willingness to pay is an area** where early involvement of community groups can ensure a more likely co-operation of the users?

- Has the community participation process **explored options for community involvement** in the project implementation to assist the project in meeting proposed goals?

4.1.5 Health

- Has the project's **household survey** included questions on **water-related health issues** in order to determine the perceptions of individuals about their own health and their knowledge of hygiene practices and in order to determine whether health awareness programmes will be needed as part of future public education and training?

- Has the EA assessment of health issues been related to a wide range of **socio-economic and environmental variables**, including incomes, education, overcrowded housing, and poor infrastructure? [Health indicators are often associated with other aspects of life in a city than that of water quality.]

- Has the project EA reviewed the wide range of **potential negative impacts to the regional health** (see EA module) such as increased disease vectors such as mosquito or snails carrying schistosomiasis parasites?

4.1.6 Social Impact Assessment Methodology

- Since Social Impact Assessment (SIA) is largely related to improving local ability to make judgments on environmental matters, has the project EA included a **rigorous SIA process including the following recommended steps:**

- Identify and involve all potentially affected groups and individuals
- Clearly identify who will win and who will lose and emphasize vulnerability of under-represented groups

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- Deal with issues and public concerns that "really count," not those that are "easy to count"
- Define how the SIA was conducted, what assumptions were used and how significance were selected
- Identify problems that could be solved with changes to the proposed action or alternatives
- Use SIA practitioners who are trained social scientists employing social science methods
- Manage uncertainty by monitoring and mitigating adverse impacts
- Identify data sources, using published scientific literature, secondary data and primary data from the affected area
- Plan for gaps in data?

4.2 Environmental Mitigation and Monitoring

4.2.1 Mitigation Plan Development

- Has the project mitigation program evaluated **all potentially relevant environmental laws, regulations and standards** and included appropriate mitigation measures to deal with such statutes including:
  - General Environmental Protection Laws
  - Water Pollution Prevention and Control Laws (surface and subsurface)
  - Air Pollution Prevention and Control Laws
  - Land Management Laws (including land disposal of liquids and residuals)
  - Standards for Noise
  - River Management Regulations
  - Regulations dealing with Construction Land Acquisition
  - Regulations for Environmental Sanitation Management?

- Has the mitigation program dealt with **all potential project construction phase impacts,** including land acquisition, building demolition and removal, and resettlement?

- Has the mitigation program delineated **specific responsibilities for implementing the mitigation program** including the management of construction quality and progress, and that both for civil construction and environment impact mitigation are properly implemented?

- Has the mitigation management agency **procured independent supervision and management specialists** to supervise and manage the implementation of the environmental protection measures, ensuring that the engineering projects progress according to schedule, engineering quality meets the design standards and that the project as a whole produces environmental benefits?

- Have the **responsibilities of the local governments** (e.g. districts, counties, neighborhood committees, townships, etc.) for implementation of mitigation measures been **carefully coordinated with the mitigation management agency** to deal with issues such as spoil disposal, drainage, construction noise, domestic wastes, and final construction completion and reclamation?

- Does the mitigation program contain **specific monitoring measures during both the construction and operation phases** of the program (see monitoring section)?

- Does the ultimate **management of the project components include careful coordination of local, city and regional authorities**, with specific roles, responsibilities and reporting requirements?

- Does the mitigation program **include non-structural measures to improve the effectiveness of the project** and foster optimal environmental benefits including:
  - Conservation of water resources
  - Enhancement of environmental consciousness through direct (eg. fees) or indirect measures

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- Incorporation of a public health and other educational programmes
- Publicizing the principle of "user pays" for pollution control facilities?

4.2.2 Mitigation Program Monitoring

- Has a **rigorous mitigation monitoring program** been included in the Environmental Assessment (EA) to minimize potentially adverse impacts and enhance the overall quality of the project?

- Is the specified environmental performance monitoring directed towards **measuring and evaluating changes brought about by the project,** and also directed toward assessing the effectiveness of proposed mitigation measures?

- Does the monitoring and reporting system help to insure that the project proponents **successfully implement the proposed project mitigation measures**?

- Does the monitoring program contain **Environmental Performance Indicators (EPIs)** to assist with gaging the effectiveness of the program? [EPIs are technical and institutional activities that are implemented by a project proponent to measure and evaluate environmental (including health and socioeconomic) changes induced by a project.]

- Does the monitoring program **meet the overall objective of environmental performance monitoring** which is to identify predicted and unanticipated changes to the physical, biological and social environment brought about by the project? [This requires baseline information on predevelopment environmental and social conditions, against. which development and post development impacts and mitigation measures can be measured and compared.]

- Does the monitoring program contain **appropriate "triggers"** (when deviations from the baseline beyond predetermined limits occurs) that start corrective actions? [As the degree of uncertainty in impact prediction or effectiveness of mitigation measures increases, monitoring becomes more critical.]

- Does the monitoring program contain a **detailed environmental supervision system,** including a series of activities designed to ensure that the proponents implement the project responsibly, regarding agreed environmental safeguards and the need to address unanticipated environmental problems?

- Does the monitoring and mitigation program contain detailed **Environmental Management Plans (EMPS)** to outline the measures to be taken during project implementation and operation to control adverse environmental impacts and the actions needed to implement these measures to include the following items:
  - Identification and summary of all anticipated adverse environmental impacts;
  - Description of each mitigation measure, including the type of impact to which it relates and the conditions under which it is required (for example, continuously or in the event of contingencies), together with designs, equipment descriptions, and operating procedures, as appropriate;
  - Description of the elements of the monitoring program;
  - Institutional arrangements (responsibilities for mitigation and monitoring), which may include recommendations for strengthening existing institutional capacity;
  - Implementation schedule for measures that must be carried out as. part of the project, showing links with overall project implementation plans;
  - Monitoring and reporting procedures that are designed to ensure early detection of conditions that necessitate corrective actions, and provide information on the progress and results of mitigation and institutional strengthening measures; and
  - Cost estimates and sources of funds for both the initial investment and recurring expenses for implementing the EMP, integrated into the total project costs?

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- Does the environmental performance **monitoring program** should **consist of the following key elements** necessary for an effective program::

- monitoring objectives;
- description of performance. indicators which provide linkages to impacts and mitigation measures identified in the EA;
- description of parameters to be measured, methods to be employed, sampling locations, frequency of measurements, detection limits (where appropriate) and definition of thresholds that will signal the need for remedial actions
- institutional responsibilities, timing and timescales for monitoring;
- reporting arrangements (to the regulatory authorities and the funding agency); and
- costs and financing provisions.

- Does the monitoring program provided in the EMP clearly show the **linkages between specific impacts identified in the EA and indicators to be measured,** with these linkages described in a way that can be readily understood by decision-makers?

4.2.3 Monitoring Recommendations to Allow Better Future Assessments

The Western World has had the luxury of dealing with water quality problems sequentially -- fecal pollution, eutrophication, acidification, toxic contaminants -- but the newly developing World faces all these simultaneously. Yet, even the Western World struggles to establish meaningful objectives for their water quality monitoring systems. On top of these burgeoning demands for meaningful information related to the status of water resources, governments now are asked to establish monitoring systems to assess and measure the "sustainability" of these resources and then projects can be measured against their estimated impacts to this sustainability measure. The multi-faceted dimensions of water and sustainability means that our monitoring systems must broaden to encompass the economic and environmental linkages that sustainability measures require. As such, this section addresses some potential improvements in monitoring systems to allow for better future assessment.

- Does the review of project-related water data recognize that **poor quality assurance and the inability to mobilize integrated water quality and quantity data inhibit the collection and synthesis of useful data**?

- Are **appropriate precautions taken with this project-related data to allow the national government to make cost-effective judgments** about water quality management, water resource policy development, and investment decisions?

- Has the project country carried out **inventories of environmental, resource and developmental data, based on national/global priorities** and does this project conform? (The objectives are primarily three: improved management of sustainable development; identification of gaps; and organization of activities to fill those gaps.)

- Are **appropriate steps underway nationally and does this project assist with addressing the known gaps in most of the data collection and assessment programs**, especially relating to the following programme areas of Agenda 21:

1) Local population programmes (5C)
2) Health risks from pollution and hazards; data on environmental accidents (6E)
3) Energy and transport in the context of human settlements (7E)
4) Comparative evaluation of energy sources (9B)

5) Global isotope monitoring of atmospheric trace gases and river run-off as a part of global change research; impact of aircraft engine emissions in the upper atmosphere. (9D)
6) Mountains: strengthening knowledge and integrated watershed development (13 A&B)
7) People's participation in agricultural policy (14B)

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8) Land conservation and rehabilitation; monitoring of land resources (14E)
9) Plant nutrition (14J)
10) Rural energy (14K)
11) Application of biotechnology to food and raw materials (16A)
12) Application of biotechnology to improving human health (16B)
13) Oceans: establishment of global marine databases supported by GIS as well as a network of marine laboratories for emergency situations; better quality fishery data at the national level (17)
14) Classification and labelling of toxic chemicals; preparation of a priority list for chemicals and accelerating risk assessment for priority chemicals (19B)
15) Prevention and management of hazardous wastes (20A&B)
16) Disposal and treatment of wastes (21C&D)
17) Information on the role, activities and participation of Major Groups, and especially of NGOs (27), local authorities (28), entrepreneurs (30) and farmers (32) (23-32)
18) Availability of environmentally-sound technologies (34)
19) Promotion of the local production and use of sustainable development information (including traditional information) and community-based initiatives?

- Are **appropriate monitoring programs being established or expanded to deal with the following critical measures of sustainability** and does this project conform:

1. capacity of land resources and the impacts of processes such as deforestation, soil degradation and desertification;
2. loss of natural areas and biodiversity;
3. protection of the atmosphere;
4. quantity and quality of freshwater resources;
5. state of oceans and coastal areas;
6. human health conditions and quality of life determined by the environment, including the living and working environment of the poor;
7. accumulation of wastes, particularly hazardous wastes, and chemicals; and
8. risks of biotechnology?

- Are the following **broad goals for environmental monitoring systems incorporated into national plans** and does this **project conform and improve on these systems and plans:**

a) facilitate access to information on on-going and planned environmental activities, and to information held by each part of the system;
b) identify possibilities for collaboration and mutual reinforcement among agency observation and assessment programmes and reports, and with outside partners including governments, the scientific community, NGOs and the private sector;
c) promote and monitor capacity-building for data collection, assessment and reporting;
d) improve the harmonization and quality control of data and the standardization of methodologies to ensure reliable and comparable information on the environment at all levels;
e) facilitate the wider use of information and assessments from each level of government beyond its own constituency ;
f) identify priorities for action?

- Is the **project monitoring system based on a set of indicators** that can communicate complex findings on the conditions, trends and impacts in important environmental sectors to policy-makers as well as the public?

- Is the **project monitoring system based on an information system** which includes: identified users, a problem focus based on the user's information needs; the collection of data at a temporal and spatial scale appropriate to the problem; data availability; reporting requirements; and a reporting function to the users, who in turn respond to the reports and fine tune their information needs?

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- Has the **project monitoring system identified the problem** being addressed:
  - Appropriate audience
  - Audience information needs
  - Ability of a monitoring system to meet these needs
  - Reasons behind their information needs
  - Audience ability to react after provided the information?

- Has the **project monitoring system scaled appropriate data collection** with fine enough spatial resolution to capture the problem being investigated:
  - Appropriate spatial scale
  - Appropriate temporal scale
  - Costs of collecting information and the costs of not collecting information
  - Appropriate level of technology?

- Does the **project's method of analysis make sense to decision-makers**:
  - Framework for analysis
  - Framework is transparent in data and method
  - Framework is independent?

- Does the **project monitoring information system include reports and indicators** in a form that policy-makers can make relevant through use:
  - Dissemination of results
  - Making complex relationships accessible to the target audience
  - Ensuring that technical results be made policy relevant?

- Are the **project's indicators comprised of special data sets or transformed data** that become essential information for policy-makers, policy-shapers, and the public:
  - Reliable statistical measures.
  - Measurable in a comparable fashion over time and space.
  - Its changes can be assessed against a scientifically valid norm, standard or a baseline.
  - It bears a clearly defined societal goal (that might be a particular vision of sustainability)?

- Has the process of determining monitoring objectives started with an **in-depth investigation of all factors and activities which exert an influence, directly or indirectly, on water quality** and the project monitoring based on inventories prepared on:
  - geographical features of the area: including topography, relief, lithology, pedology, climate, land-use, hydrogeology, hydrology etc.,
  - water uses: including dams, canals, water withdrawal for cities and industries, agricultural activities, navigation, recreation. fisheries etc., and
  - pollution sources (present and expected): including domestic, industrial and agricultural, as well as their stage of pollution control and waste treatment facilities?

- Is the project monitoring program based on **preliminary water quality surveys** which have been undertaken to:

  - determine the time and space variability of the quality of the aquatic environment in order to select sampling stations and frequencies,
  - determine the key descriptors to be considered and
  - assess the feasibility and cost of a monitoring programme?

- Has the **project monitoring system considered the four main reasons for obtaining inadequate information from assessment programs** (for groundwaters, by Wilkinson and Edworthy 1981 but equally applicable to surface waters):

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- objectives of the assessment were not properly defined,
- monitoring system was installed with insufficient knowledge of the water body,
- inadequate planning of sample collection, handling, storage and analysis,
- data were poorly archived?
  (A fifth reason could be added, data were improperly interpreted and reported.)

- Has the project monitoring program followed the **ten basic rules for successful assessment programmes:**

1. The objectives must be defined first and the programme adapted to them, and not vice versa (as was often the case for multi-purpose monitoring in the past). Adequate financial support must then be obtained.
2. The type and nature of the water body must be fully understood (most frequently through preliminary surveys), particularly the spatial. and temporal variability within the whole water body.
3. The appropriate media (water, particulate matter, biota) must be chosen.
4. The variables, type of samples, sampling frequency and station location must be chosen carefully with respect to the objectives.
5. The field, analytical equipment and laboratory facilities must be selected in relation to the objectives and not vice versa.
6. A complete, and operational, data treatment scheme must be established.
7. The monitoring of the quality of the aquatic environment must be coupled with the appropriate hydrological monitoring.
8. The analytical quality of data must be regularly checked through internal and external control.
9. The data should be given to decision makers, not merely as a list of variables and their concentrations, but interpreted and assessed by experts with relevant recommendations for management action.
10. The programme must be evaluated periodically, especially if the general situation or any particular influence on the environment is changed, either naturally or by measures taken in the catchment area?

- In view of the long-term nature of many water-related development decisions, does the project's **monitoring system foster these long-term information needs** by:

(a) defining information requirements for national water resources, taking particular account of the multiple demands for water;
(b) reviewing institutional arrangements linking the providers and users of data;
(c) identifying and implementing new mechanisms for funding hydrological services, where such mechanisms are required to provide adequate financial resources;
(d) selecting appropriate technologies for collecting data, particularly data on water quality and on groundwater, and for implementing user-friendly data management systems;
(e) establishing national data banks for information on water resources; and
(f) defining the human resources needed for hydrological information systems and provide education and training to meet those needs?

4.3 Performance Auditing and Management Indicators

4.3.1 Performance Auditing

The proposed project's effectiveness at meeting project objectives must be monitored through a prescribed array of measures. Such effectiveness judgments involve value judgments that can change depending on the time, the environment, the ideology, and the temperaments of individuals, to cite only a few factors. Forming effectiveness judgments calls for a reliance on various attributes, generally thought to be important to the understanding of effectiveness.

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- Has the **following list of effectiveness attributes been prescribed** by the project assessments to assure effectiveness:

- **management direction**: the objectives of an organization, its component programs or lines of business, and its employees are clear, well-integrated and understood, and appropriately reflected in the organization's plans, structure, delegations of authority and decision-making processes
- **relevance:** the extent to which a program or line of business continues to make sense in regard to the problems or conditions to which it is intended to respond
- **appropriateness:** the extent to which the design of a program or its major components, and the level of effort being made, are logical in light of the specific objectives to be achieved
- **achievement of intended results**: the extent to which goals and objectives have been realized
- **acceptance:** the extent to which the constituencies or customers for whom a program or line of business is designed judge it to be satisfactory
- **secondary impacts:** the extent to which other significant consequences, either intended or unintended and either positive or negative, have occurred
- **costs and productivity**: the relationships among costs, inputs and outputs
- **responsiveness:** an organization's ability to adapt to changes in such factors as markets,competition, available funding or technology
- ***financial results***: the matching of, and the accounting for, revenues and costs and the accounting for and valuation of assets, liabilities and equity

4.3.2 Management Indicators

- Are the following types of measurable management indicators included in the project's assessment system:

- **Indicators of Service Efforts**
  1. Inputs - **Dollar costs of the service** during the period.
     a. In "current" dollars.
     b. In "constant" dollars, that is, adjusted for price level changes.
     c. Per household or per capita, and in either current or constant dollars.
  2. Inputs - **Amounts of non-monetary resources expended**, especially the amount of work time expended during the period (for the service). These might be expressed in such units as full-time equivalent years or employee-hours.

- **Indicators of Service Accomplishments**
  1. Outputs - **Amount of workload accomplished.**
  2. Outcomes - A numeric **indicator of program results**. This category includes indicators of service quality (such as timeliness), effectiveness, and amount or proportion of "need" that is (or is not) being served.

- **Indicators That Relate Service Efforts to Service Accomplishments**
  1. Efficiency indicators, including **both input/output and input/outcome indicators**?

- Since the **audit assurance** becomes the ultimate and final test on the effectiveness of the public project, has the **project adhered to the following guidelines** that have been offered for making representations:
  1. All applicable attributes of effectiveness should be considered in making management representations, and an explanation should be given where any attribute otherwise expected is not used.
  2. Representations should reflect the full range of information generated in their preparation and contain whatever explanations or qualifications about the information and analysis that may be necessary to allow users to make informed judgments.
  3. Representations should be prepared in such a way as to take into account the interests of governing bodies.

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4. Representations should be made at the highest meaningful level, and to accomplish this, top management must be involved in preparing them.
5. Each organization should establish a comprehensive strategy for reporting management representations on effectiveness over an agreed period of time.

- Has the management representations included the **service efforts and accomplishments (SEA)** of the project including the categories of SEA indicators of input indicators, output indicators, outcome indicators, efficiency (and cost-effectiveness) indicators, and explanatory information defined as follows:

1. **Input indicators.** These are designed to report the amount of the resources, either financial or other (especially personnel), that have been used for a specific service or program. Input indicators are ordinarily presented in budget submissions and sometimes external management reports.
2. **Output indicators.** These report units produced or services provided by a service or program
3. **Outcome indicators.** These are designed to report the results (including quality) of the service.
4. **Efficiency (and cost-effectiveness) indicators.** These are defined as indicators that measure the cost (whether in dollars or employee-hours) per unit of output or outcome. An example is cost per million gallons of drinking water delivered to consumers.
5. **Explanatory information.** This includes a variety of information about the environment and other factors that might affect an organization's performance on SEA indicators?

4.4 Operation and Maintenance (O&M)

4.4.1 Management Issues

- Does the project include **sufficient operational budgets** to ensure the long-term sustainability and efficiency of operations of the project components?

- Do proposed **utility revenues cover the costs of operating the facilities in an enterprise fashion** to ensure that the operation is fully paid for by users?

- Has the project assessment used adequate **sensitivity analysis in planning out facility operations** such that the management of the facilities can easily handle unforeseen circumstances and/or changed design parameters (quantity and quality)?

- Do the operational budgets include sufficient funds for **short-term and long-term equipment replacement,** as well as consideration of **ultimate project life and replacement**?

- Has sufficient funding been included in the project to insure the **proper training of both management and operational staff** to ensure optimal performance of constructed facilities?

- Will the project facilities be operated under a **management performance system that rewards environmental efficiency rather than minimized costs,** to ensure that the facilities are operated in a manner consistent with planned benefits?

- Does the short-term environmental monitoring and reporting program specified in the project mitigation and monitoring plan contain provisions for evolving into a **long-term institutionalized performance assessment system**?

- Does the project include provisions for **public oversight of operations** and provide for triggers and corrective action based on a specified number of public complaints?

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4.4.2 Technology Issues

- Was the **technology chosen appropriate** for the task at hand (see technology assessment) and are provisions made in the design of project features to ensure the ability to **enlarge and upgrade easily**?

- Does the monitoring system include reporting on the **percentage of project components that are operating at design levels**, and corrective measures to be taken if they are not meeting the design expectations?

- Are the **operating costs**, especially energy and utility usage, **consistent with projected**, and if not, have appropriate measures been undertaken to ensure the project sustainability under actual cost conditions?

- Are measures included to ensure that the **project production meets projected levels**?

- Are measures included to ensure the **ability to obtain necessary spare parts**?

4.5 Feedback Mechanism - Project Formulation Stage

- Are the results of all assessments at all stages **well documented and stored in a case-based system** for actual case histories of water-related projects undertaken in the locality, region and country in question, including both successes and failures, as a learning tool for project proponents and developers?

- Are the **successes, failures and complementary needs of the project well communicated** to others in the water sector to ensure that technical, legal and management issues that could or improve the project performance are undertaken, both for the project in question and for future projects?

- Are **identified institutional deficiencies,** either in insufficient actions or roles, or overlapping responsibilities, **well documented and changes undertaken** to improve water management?

- Does the **project assessment system provide for self-improvement** in that review criteria that are either insufficient or redundant are removed while those found necessary are added?

- Does the environmental performance of the project feed into a **national system of environmental indicators** that work in concert with economic indicators to evaluate national sustainability and the meeting of national water-related goals?

- Does the project foster national and international efforts toward environmental reporting, accountability and public involvement and assist with **sustainability tracking** in some form of easily understood report card?

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Appendix 7. Case Study

Sichuan Urban Environment Project (SUEP)

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Appendix 7-Case Study
Sichuan Urban Environment Project (SUEP)
November 2001

1.0 Introduction

1.1 SUEP Project and Components

The Sichuan Urban Environment Project (SUEP) is located in Sichuan Province, China. Initially in 1996, the project area for SUEP consisted of the entire Sichuan Province including the city of Chongqing. In early 1997, Chongqing and the surrounding area was designated as a Provincial City outside of Sichuan Province. Another environment project known as the Chongqing Urban Environment Project (CUEP) was formulated for this new provincial city. Meanwhile, early work was being conducted by a variety of international consultants relative to delineating the environmental conditions of the SUEP and project priorities. Of particular relevance to the SUEP, the Provincial Issues, Options and Strategies study, which commenced in August 1996, was undertaken by the COWI/DHI team under Danish funding. This early work of 1996 and 1997 narrowed the focus of the first phase of SUEP to the Min and Tuo basins of Sichuan Province.

As such, the project preparation work for the Phase I SUEP entirely focused on the Min and Tuo river basins. Projects were initially formulated for six cities within these basins and initial project preparation work commenced on that basis. Through the process, funding limitations and project readiness reduced the project cities under Phase I to five.

The nine Phase I environmental infrastructure projects that are now contained in the Phase I SUEP were the focus of project preparation and EA. These projects included four water supply projects, four wastewater projects and one municipal solid waste project. Other components in the Phase I of SUEP included: a Cultural Heritage Component, Urban Management Information Systems (UMIS) component including GIS, mapping and decision support systems, and technical assistance. These three components were not assessed in the EA, nor are geographical or environmental issues outside the scope of these nine environmental infrastructure components.

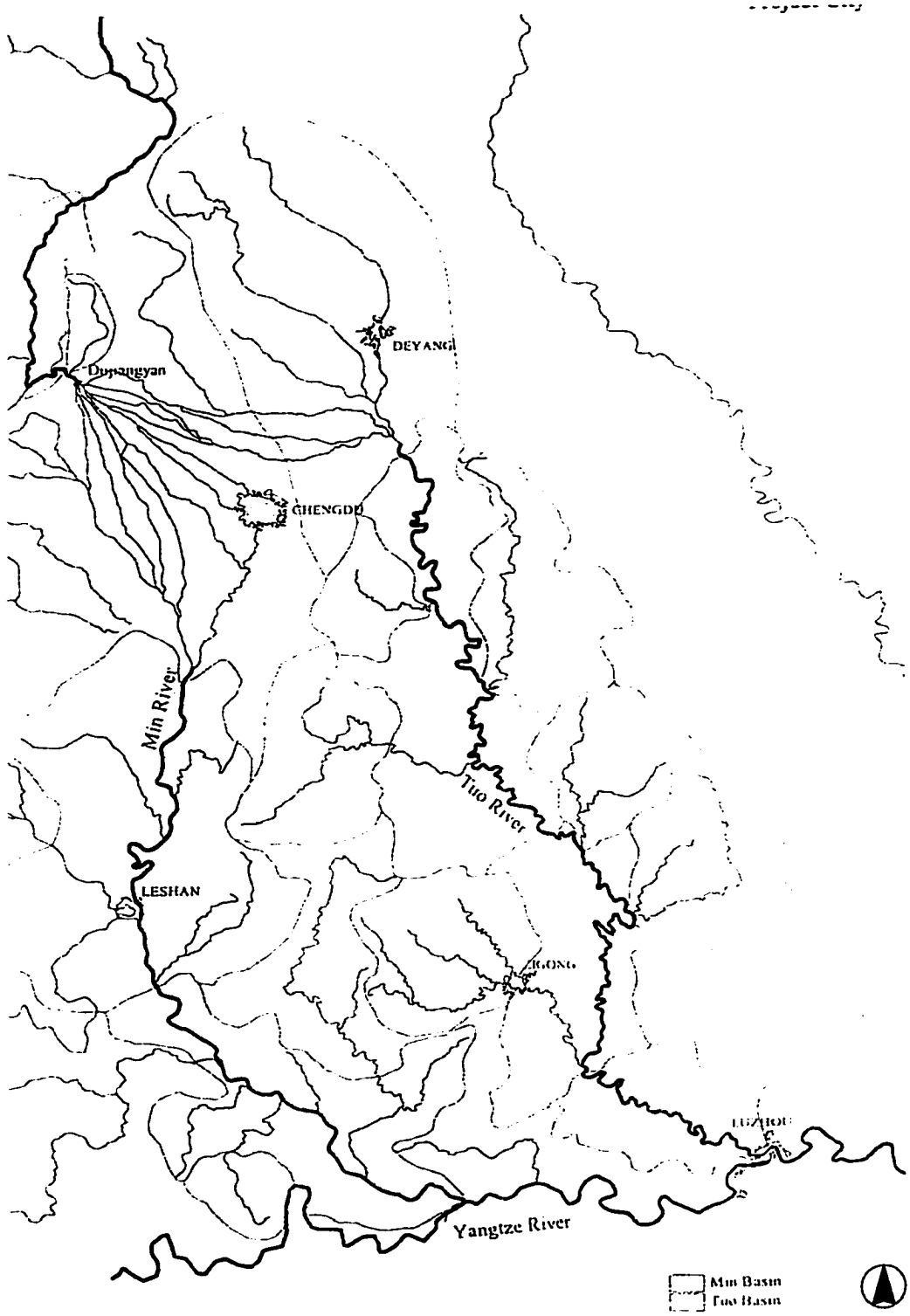
1.1.1 Sichuan Province Overview

The Sichuan Province, located in the southwest of China, is the third most populous province with over 82 million people over an area of about 385,000 km^2. The province had been the most populated province until the spring of 1997 when Chongqing and the surrounding area were given provincial status. Sichuan Province is a land-locked province approximately 1500 km from the sea and shares its borders with 8 provinces - Qinghai, Gansu and Shaanxi to the north, Hubei and Hunan to the east, Guizhou and Yunnan to the south and Xizang (Tibet) to its' west.

The topography of Sichuan Province consists mainly of mountains and plateaux and can be geographically divided into the eastern basin area, the western plateau and the mountain area. About 95% of the population lives in the basin area. The capital of Sichuan Province is Chengdu located in the portion of the basin area known as the Chengdu plain, often referred to as "the land of plenty". Chengdu plain's level terrain, fertile land, plentiful rainfall and temperate climate combined with established irrigation schemes such as the Dujiangyan water conservancy project (over 2,200 years old) all contribute to the area's agricultural abundance. The western half of the province is dominated by the Himalayan mountains, with an average altitude of 3,000 m which peaks at 7,500 m at Gonga Shan massif located in the southwestern area of the province. **Figure 1.1** shows a vicinity map of the Sichuan Province including the Phase I SUEP project cities.

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Figure 1.1 Project Cities



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1.1.2 Provincial Government

Sichuan Province and its municipalities address environmental problems with the same institutional and regulatory framework found elsewhere in China. Regulatory powers are shared by the provincial and municipal Environmental Protection Bureaux (EPBs) and the Urban Construction Commissions (UCCs) and their agencies. The central government's general strategy for urban development has been to develop mechanisms for planning and management at the local level that will reduce waste and enable cities to function effectively using local resources. To arrive at the "best practices", local governments are encouraged to try new approaches. The results are then readily disseminated through the press, professional associations, technical intermediaries, and national ministries. Cities of moderate population size are often good testing grounds for bold experimentation and the largest cities serve best as national demonstration models. The Sichuan Urban Environment Project (SUEP) was formulated by the local officials and the World Bank in a manner consistent with this approach by targeting a combination of large and moderate population sized cities for selected interventions.

1.1.3 SUEP Project and World Bank

The background and overall World Bank policies related to the urban environment in China are reported in the China Urban Environment Service report of December 1994. The following is a brief summary of the key issues and challenges stated in this report as reported in the SUEP Major Issues Report of March 1997:

Table 1.1 - Key Issues, SUEP Major Issues Report of March 1997 (COWI/DHI)

Key Issue	Items of Concern
Water Demand	High per capita water demand and new strategies must accord with reformed market organization of the economy and rely more on price to guide enterprise and consumer choices. Current demand policy sets quotas for industrial water use and recycling but Chinese industries are consuming far above international best practice levels. There is a reported very low unaccounted-for-water (Ufw) of 8.4%, which is questionable compared to reported pipe breakage rates and pipe joint quality. Current water prices are far below the level required to induce water conservation.
Wastewater treatment	Present low treatment coverage and design and management problems. All cities should expand the sewerage coverage for minimum 90% of the build up areas within five years. Medium and large cities should provide a minimum of primary WWT in a phased 10-year programme.
Industrial Wastewater	Only 4.5% of industrial wastewater is treated but EPBs report that 50% of the industrial wastewater meets effluent standards, which is seemingly inconsistent or indicative of inadequate discharge standards and enforcement.
Solid Waste	Landfills are poorly controlled and the provision of adequately engineered and managed landfills would provide the largest single improvement in solid waste handling in China.
Environmental Management	The chief management obstacle is the significant gaps in regulatory control and problems in implementation of existing regulations. A combination of infrequent monitoring and low fines for violations encourages non-compliance. Incentives for saving costs are much stronger than incentives for strong environmental performance.
Tariffs	Tariffs should be designed to allow full cost recovery. China has adopted the "polluter pays" principle but price setting is still politicized. Financial arrangements to cover operations cost shall be established.
Affordability	There does not appear to be a general affordability issue but the urban poor (probably 0.5% of the population) need to be protected from cost of living increases.

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In accordance with these national World Bank (WB) policies and priorities, the Sichuan Provincial Government (SPG) requested WB and bi-lateral donor support for the SUEP. The UK Government agreed to provide a grant, administered by the Department for International Development (DFID), to cover the costs of consultancy services, equipment and training required to assist the SPG in the preparation of the project to meet WB requirements. Support to improved environmental management is one of the main objectives of the World Bank's and DFID's Country Assistance Strategy (CAS) for China. Managing the impact of China's urban environment of rapid urbanisation and economic growth is a focus of the CAS. SUEP is also a key element of China's Agenda 21 programme.

The SUEP objectives are to enable municipalities to recover from past environmental degradation of water and land resources and to put in place policies, practices and institutions to facilitate and sustain the cost of effective provision of essential services. The location of the Sichuan Province and SUEP cities in upstream areas tributary to the Three Gorges Scheme (TGS) on the Yangtze River was also a key determinant of project priority. The overall objective of the SUEP that results is:

- **To allow environmentally sustainable growth in Sichuan Province.**

1.2 Description of the Study Area

The "study area" considered for the Phase I projects and EA is the Min and Tuo river basins, including the city of Luzhou located at the junction of the Tuo and the Yangtze rivers, and the small portion of the Yangtze river upstream and downstream of Luzhou. The study area does not include other tributary river basins in Sichuan province, the Chongqing provincial city, or areas further downstream on the Yangtze including the Three Gorges Dam site.

1.2.1 Economy of Sichuan Province

Traditionally an agricultural province, Sichuan has gradually been shifting the basis of its economy away from agriculture and into industry. Although the large majority of the population is still engaged in farming and other rural activities, Sichuan is becoming an increasingly important industrial center. Many heavy industries such as chemical, fertilizer, paper and steel manufacturing are located within the province, as well as the more traditional textile and food processing industries. This gradual shift towards and industrially based economy has resulted in rapid urbanization. The national government has been promoting economic development through infrastructure investment and other methods to address the income disparity that has arisen between the somewhat more prosperous coastal provinces and those further inland. All Phase I SUEP cities are undergoing significant urbanization and industrialization, and demands for urban services are greatly accelerating. The project identified the existing and projected urbanized areas for the project cities and illustrated this widespread expansion. The following section introduces the economies of the five Phase I project cities, shown within their respective river basin areas.

Min River Basin:

Chengdu
Chengdu is the capital of Sichuan Province and a economic and educational hub in the Province. The City has historically prospered as the center of the rich agriculture area known as the Chengdu Plain, and has recently emerged as a burgeoning economic and industrial center. This rapid industrialisation and urbanisation has been accelerated by the recent completion of a 360 km four-lane expressway between Chengdu and Chongqing. Chengdu also benefits from excellent rail and airline services. The urban environmental infrastructure of Chengdu and other provincial cities has lagged somewhat behind the economic development, especially related to wastewater systems and water pollution.

Leshan
Leshan is located at the junction of three major river systems. The central urban area is located on the west bank of the Min River where it is joined by the Dadu River forming the south end of the urbanized area. In the City, the Dadu River has just been joined by the Qingyi River that forms the western boundary of the

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urbanized area. Leshan is about 167 km south of Chengdu and about 200 km north of the junction with the Yangtze River. The confluence is 360 m asl while the city is on a terrace some 20-30 m above the water. In addition to these major rivers, the Zhugong stream travels through the middle of the urban center, collecting wastewater discharges and dumping into the Min River upstream of the major confluence with the Dadu River. The total area of the Leshan prefecture comprises one county level city and 12 counties with a population of 6.7M in 20,000km^2. In 1995 the industrial output was CNY 19.3 billion from CNY 10.1 billion from heavy industry and CNY 9.2 billion from light industry. The major industries include paper pulp and paper, pharmaceuticals, chemicals, electrical equipment, food and beverages, textiles. Industrial water consumption is on the order of 450,000 m^3/day.

Tuo River Basin:

Deyang

Deyang City was founded in 1983 and has become an important city with industry in the heavy machinery, large-scale power generating equipment, professional mechanical equipment, food, chemical engineering and building material sectors. The city is located on the Chengdu to Mianyang Highway approximately 60 km from each city. There are aggressive economic development plans for the city of Deyang which are indicated by the population projections. The urban environmental infrastructure of Deyang has lagged somewhat behind the economic development, especially related to wastewater systems and water pollution. The total area of the prefecture is 5,950 km^2 and the urbanized area is projected to double in size and in population over the next period to 2010. It is situated in the northwest of the Chengdu Plain, on the banks of the Mianyuan River, which flows from north to south into the Tuo River, a tributary of the Yangtze River.

Zigong

Zigong was established on September 1, 1939 by combining the east salt site from Fushun County and the west salt site in Rongxian County. Salt has been the prime economic commodity for over 50 years but new economic development has occurred such as chemicals and machinery. It has a total territory of 4,373 km^2 with 813 km^2 in the urban center. There are hills in the city with elevations ranging from 280 to 400 m above sea level. Zigong City is widely known as the "City of Salt" because it is rich in well salt production. It has developed into a medium city of salt production, chemicals, machinery building being the major industries as well as food processing, building materials, textiles, metallurgy, electronics etc. A new expressway just completed between Yibin and Neijiang passes through Zigong.

Yangtze River Basin:

Luzhou

Luzhou City is located at the junction of the Tuo and Yangtze Rivers. The city center, Jiangyang, lies at the end of a 5 km long and 1.5 km wide ridge that separates the two rivers, while small suburbs have developed on the north bank of the Tuo River and the south bank of the Yangtze River. The total area of the prefecture is 12,245 km^2. Luzhou is an integrated industrial city with power, chemical, machinery and foodstuff as the main industries. The Changjiang rivers, with the tributaries of Tuojiang, Cishuihe, Yongning rivers flow through its administration area. Many enterprises in the city have their own water supply system, which consists of about 81% of the total water supply consumption in the city. The northern area of the city has recently received rail service and growth and water consumption is both expanding greatly in the area. Water shortage problems have existed for many years in the area, including Xiaosi, Anning and Gaoba. Hongfu town, which became as the Luxian County Town in 1996, will face high speed increase in population and industrial and agricultural output.

1.2.2 Regional Water Resources

The eastern half of the Sichuan Province has four major rivers, the Tuo, Min, Jialing and the Wu which all flow into the Yangtze at the southern part of the province. Together with the Jinsha and rivers in the mountainous western part of the province, they endow the province with rich water resources. **Figure 1.1** shows the river systems of the Upper Yangtze Basin. There is not a significant topographic barrier between the Min and Tuo basins in many areas, and the trans-basin diversions and discharges translate to integration

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of these basins for practical purposes. The Phase I SUEP cities of Chengdu and Leshan are located in the Min River Basin, although the eastern portion of Chengdu drains wastewater to the Tuo Basin. The cities of Deyang, and Zigong are in the Tuo River Basin, although Zigong straddles the Min River basin divide and a small portion of the city drains to the Min. The city of Luzhou is on the Yangtze River at the mouth of the Tuo River. It is necessary to have an understanding of the regional water resource management in the Sichuan Province in order to better appreciate the water quality issues of the study area. The agricultural potential of the Chengdu Plain has been greatly enhanced by the Dujiangyan Irrigation Scheme located northwest of Chengdu on the Minjiang (the Min River). This Scheme consists of major headworks in the Min River and a complex network of natural and artificial channels across the Chengdu plain. The site has documented irrigation systems from over 2000 years ago and the original headworks was built in the year 700. It is reportedly the oldest functioning irrigation scheme in the world and it uses the natural river configuration to minimize sediment in the irrigation systems. The plain drops from about 730 m at Dujiangyan to about 500 m at Chengdu. **(See Figure 1.1)**

There is no current storage capacity associated with the Dujiangyan scheme but there is some planning underway for a new reservoir on the Min River about 15 km west of Dujiangyan. One of the proposed uses for the new storage capacity is to provide additional streamflows in the dry season for water quality enhancement. The Dujiangyan canals also provide trans-basin water and connect to the Tuo river basin in several areas. Since a large proportion of the baseflow in the Tuo is direct trans-basin water from Dujiangyan or indirect water from wastewater discharges according to COWI/DHI, the two sub-basins operate more or less as one sub-basin. The total annual run-off to the Yangtze, from the catchment upstream of Wanxian, is estimated to be some 426 billion m^3 of which some 26 billion m^3 is from the basins within Sichuan. The rainfall/run-off characteristics of the two main rivers affected by pollution discharges from the project cities are shown in **Table 1.2** together with data for the Jinsha/Yangtze river system.

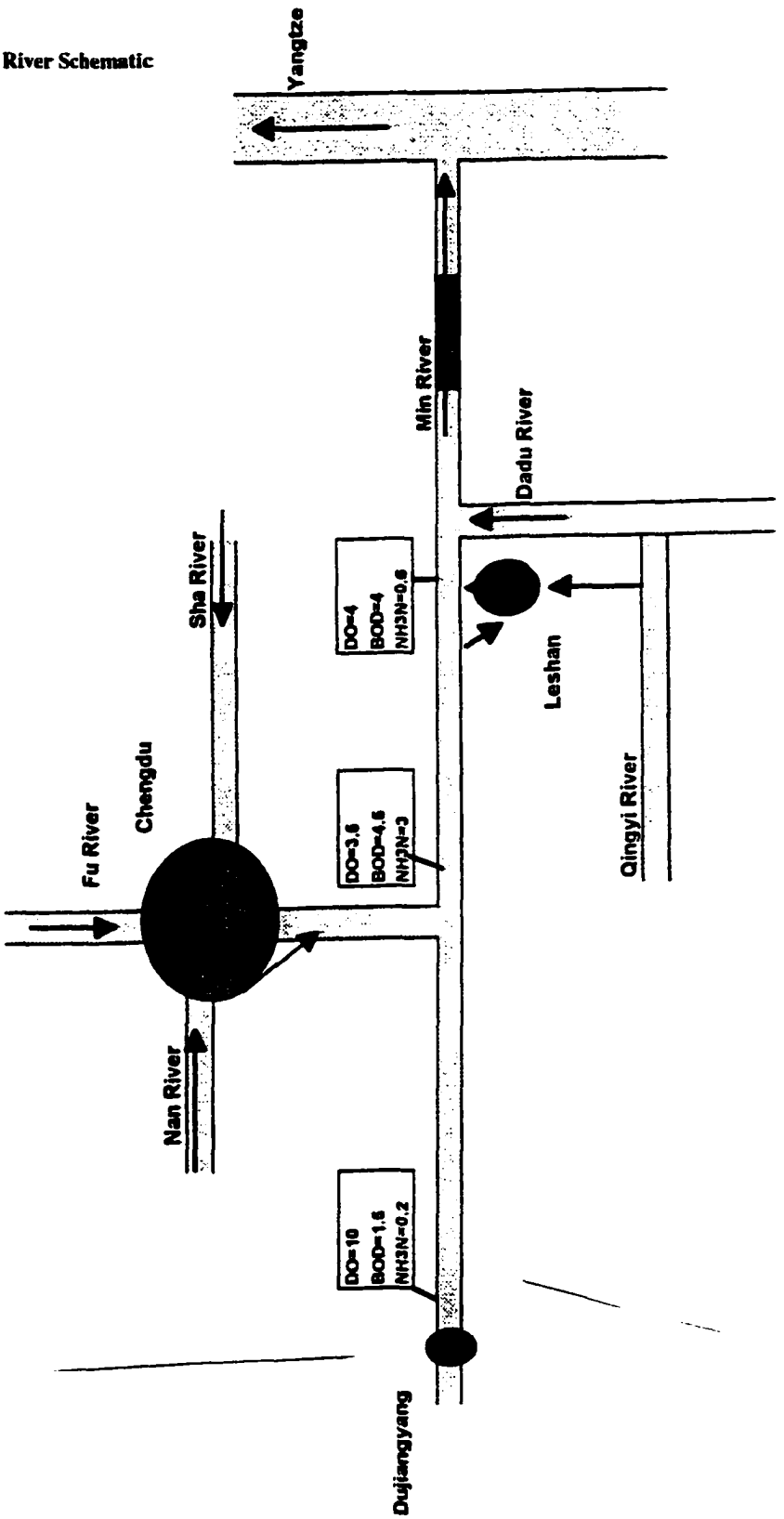
Table 1.2 - Hydrological Characteristics of Selected River Basins

River	Basin-Area km^2	Length Km	Rainfall Mm	Run-off Mm	Run-off Ratio
Tuo	23283	580	900	555	0.617
Min	22664	730	1000	585	0.585
Yangtze	974881	2908	1000	436	0.436

Sichuan Province lies to the N.W. of the Yangtze and 98% of the run-off drains to the Yangtze. The Project Cities lie on the Tuo and the Min which drain to the Yangtze. **Figure 1.2** is a schematic of the Min River and the locations of the project cities in the Min River basin are shown together with the average quality of the river at various locations, based on COWI/DHI reports. It can be seen that upstream at Dujiangyan, the quality of the river is good but following the discharge from the Fu River, which receives the wastewater from Chengdu, the quality deteriorates. The conditions in the Sha, Nan and Fu Rivers in Chengdu are generally much more serious. There is clearly a problem in terms of oxygen demand in the Min and its tributaries and this requires attention. **Figure 1.3** is a schematic of the Tuo River and it can be seen that conditions in the Tuo are even more serious. For the average spring flows the levels of BOD are about 7 to 8 mg/l for the entire river length from Deyang to the Yangtze while Ammonia (N) rises to 5 mg/l and is consistently above 1 mg/l. These are extremely high levels and it can be seen that they result in the DO being reduced to 3 mg/l in places. Cities on the river, such as Deyang and Zigong can no longer rely upon the river as a source for urban water supplies. **Figure 1.4** shows a schematic of the general quality in various reaches of the Yangtze, based upon data for the spring periods of 1993 and 1994. In general these are low flow periods prior to the summer rains. The quality of Yangtze water is good over the entire length despite inflows from the polluted Tuo and Min rivers. Since massive dilution is provided by the Yangtze, there are no problems in terms of BOD and ammonia. More relevant are the concentrations of nutrients, nitrogen and phosphorus, since these could cause problems in the Three Gorges Reservoir if concentrations are high and other requirements for algae growth are met; temperature, light penetration and retention time.

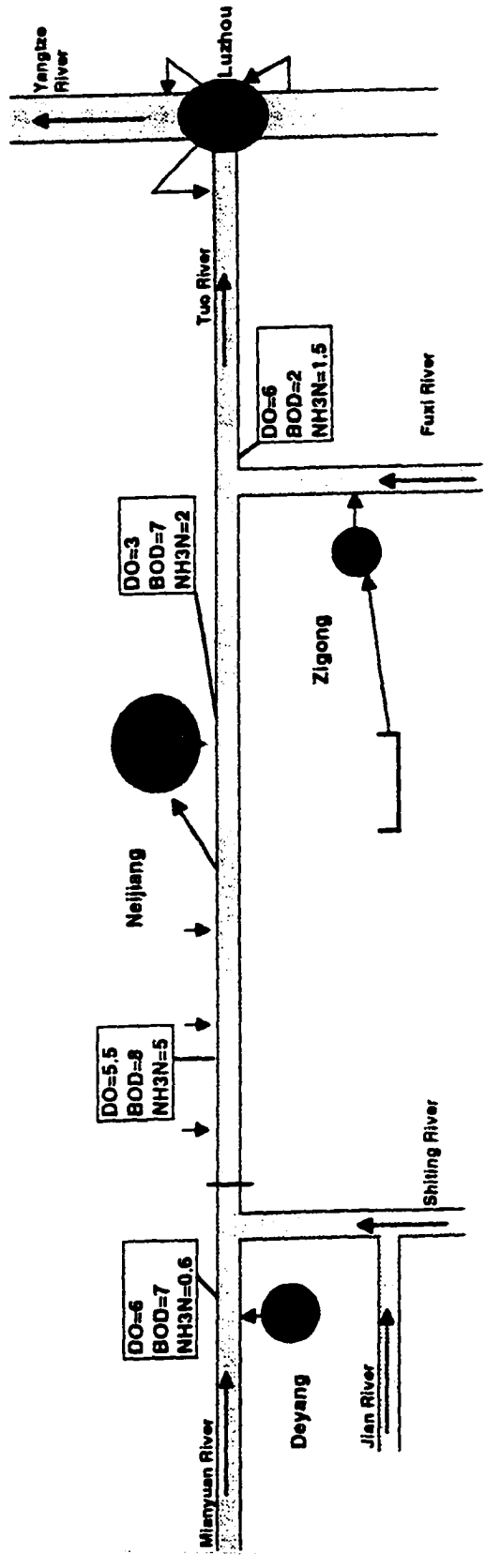
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Figure 1.2, Min River Schematic



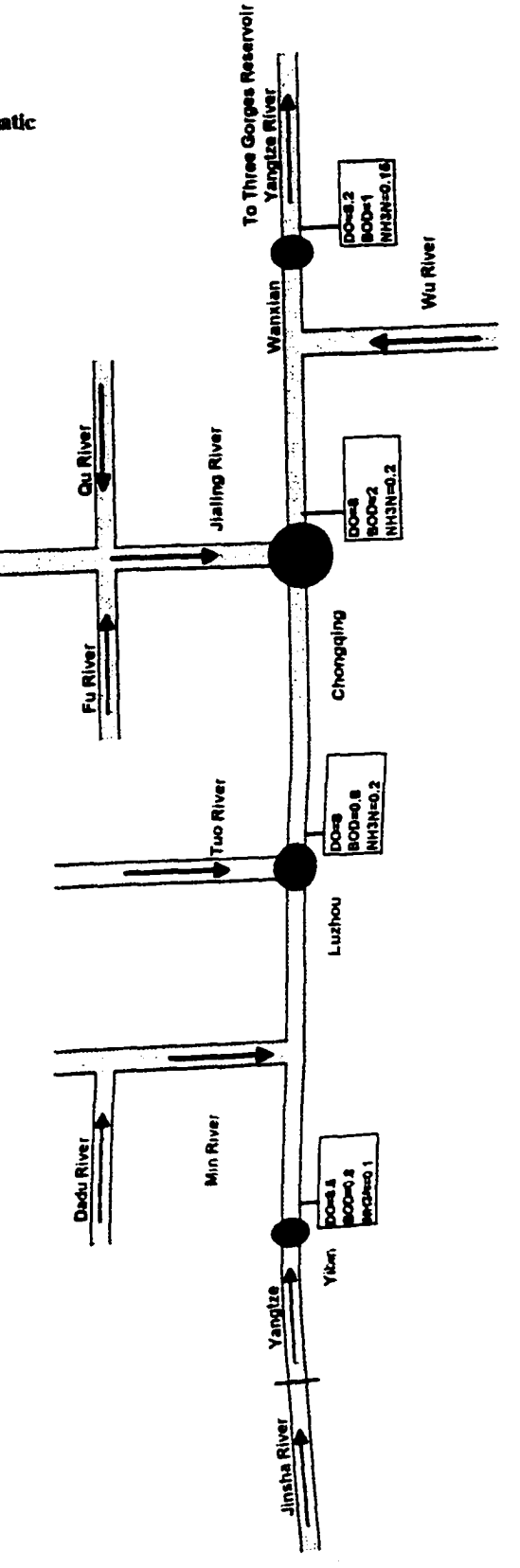
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Figure 1.3, Tuo River Schematic



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Figure 1.4, Yangtze River Schematic



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As a part of the river quality modeling work, COWI/DHI have prepared estimates of the pollution loads entering the Jinsha/Yangtze river system upstream of the Three Gorges Reservoir. By dividing these loads by the flow in the Yangtze an estimate can be prepared of the "potential pollution " of the river. These data are shown in **Figure 1.5** for river flows ranging from 5,000 to 25,000 m^3/s which spans the range of ultra low flows to average flows.

The Threshold Values of Total N is about 2.5 mg/l and Ortho-P is about 0.1 mg/l at which algae can start growing if other conditions such as temperature, uv light penetration and residence time are adequate. The problem levels are about 0.24mg/l for Total N and about 0.02mg/l for Total at which algae usually causes significant problems. It can be seen from the graph that sufficient Total N is present to allow algae growth at sufficient rates to cause problems at the lower flows. Care is required when examining the phosphorus results because the Load Data is only available for Total P and Ortho-P is the key factor in algae growth and the threshold and problem limits shown relate to Ortho-P.

It is clear that problems could exist and the key factor is the concentration of Ortho-P. It has been therefore recommended that analyses of the Yangtze should be undertaken to confirm Ortho-P concentrations. This assessment points to the possibility of there being algae growth in the Three Gorges Reservoir but additional work is required to estimate the significance of the problem. Again based upon the work of COWI/DHI the sources of Total N and Total P in the Yangtze were examined. **In Figure 1.6**, the sources of the nutrients are presented upon the basis of two sets of data:

- Results of a study by Mott MacDonald as part of the World Bank financed Hangzhou Bay Study at the mouth of the Yangtze river
- Results from the COWI/DHI study

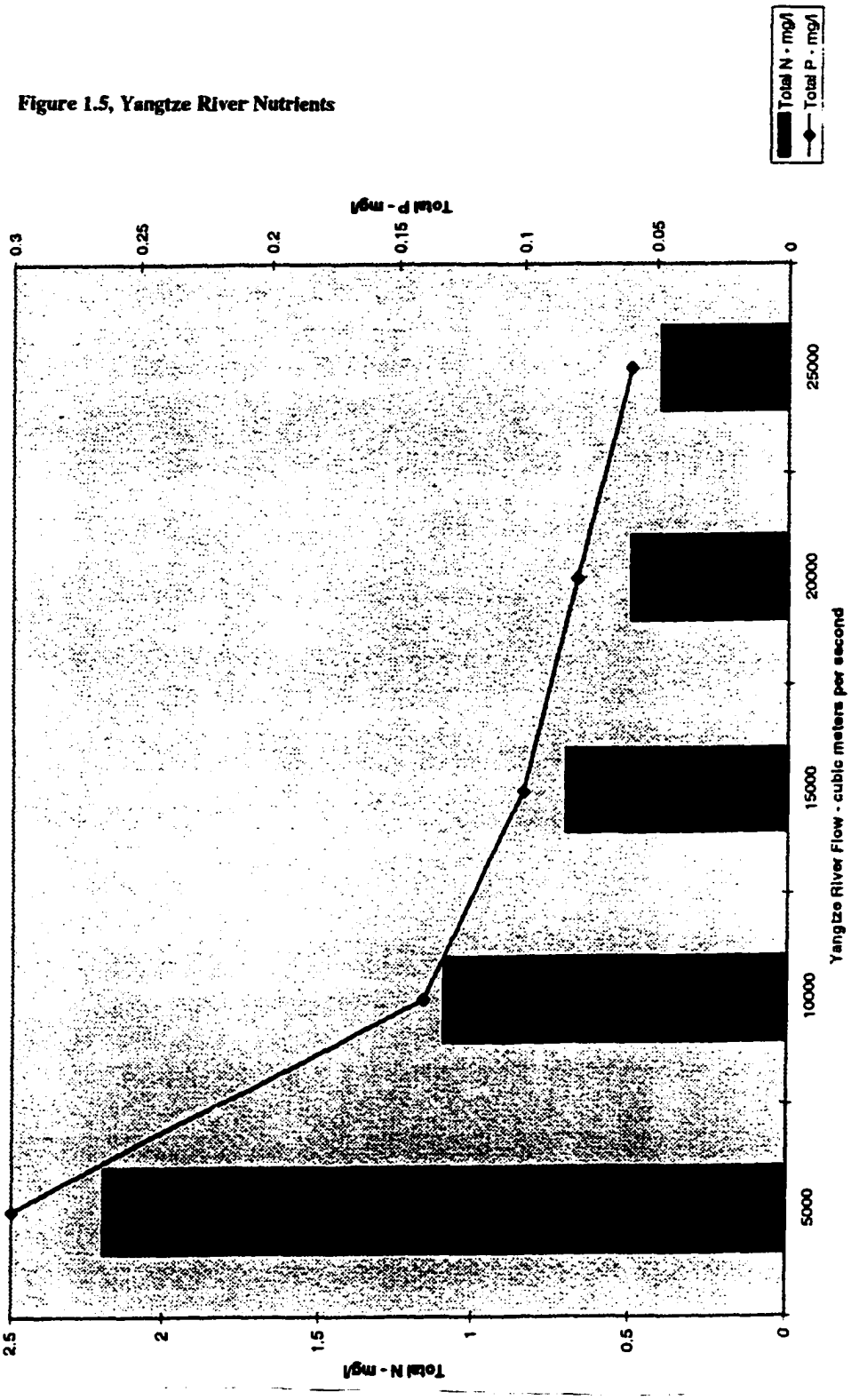
Such estimates cannot be precise. Taking into account the different categorisation of sources used in the two studies and that the Hangzhou study covers the whole Yangtze basin while the COWI/DHI study only covers the basin upstream of the Three Gorges, the results from the two evaluations are fairly consistent. What is evident from both studies is that the bulk of the nutrients are derived from rural agricultural sources. Even if nitrogen and phosphorus removal was introduced for all urban discharges, the reduction of the Yangtze loads would only be about 10% using conventional treatment methods. Treatment for the reduction of N and P in the works proposed for the six project cities would result in no observable change in concentrations in the Yangtze.

These matters were fully discussed at the WB Workshop in May 1997 and the decision was made by the WB that the removal of nutrients should not be considered in the design of project wastewater treatment works. The removal of oxygen demand, in the form of BOD and ammonia, should be the objective in the Phase I SUEP projects. This decision was confirmed by an SPC study team investigating the Phase I of SUEP.

The significant urbanization and industrialization is putting extreme pressure on the surface waters in the five Phase I SUEP cities. The following section introduces the local water resource issues of the five Phase I project cities, shown within their respective river basin areas. It is also very important to realize that there a many small drainages and tributaries in these urban areas that consist mainly of domestic and industrial wastewater discharges, so the environmental needs extend well beyond the larger and classified surface waters.

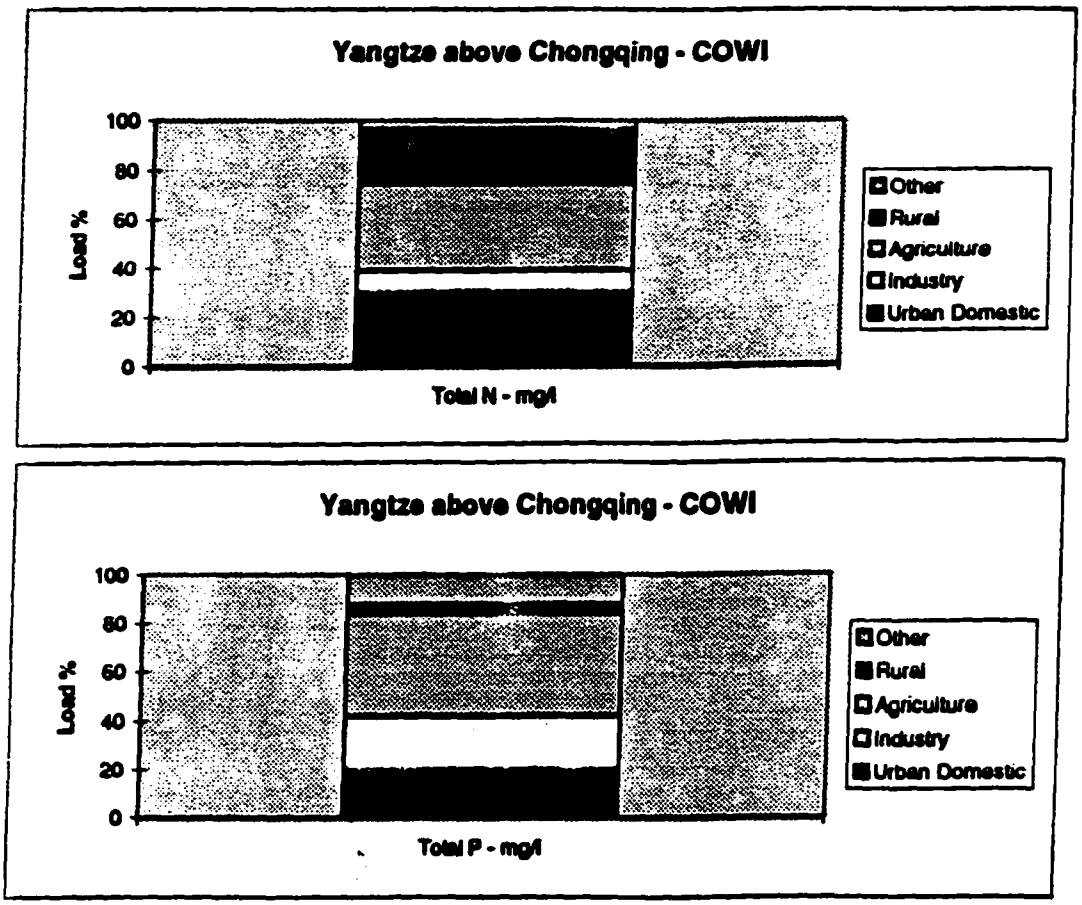
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Figure 1.5, Yangtze River Nutrients



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Figure 1.6, Yangtze River Pollutant Loads



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No.	Year	Construction Schedule
4	2001	1. Winding up installation, water supply projects. 2. Winding up installation of sewage treatment equipment and complete pipe construction works. 3. Installation works, MSW treatment equipment.
5	2002	1. Complete auxiliary works of all projects. 2. Test running and commissioning.

2.2.2 World Bank Review, May 1997

The SPG has committed to incorporating well-known World Bank policies for water resources management into the provincial strategy for the SUEP including five major principles for water resources management:

1. Development shall be based on a sustainable use of resources.
2. Water shall be considered a social and economic good with a value that reflects its most valuable potential use.
3. Water management shall take place at the lowest appropriate levels.
4. Governments shall play an enabling role.
5. Water management shall be based on a holistic approach both in terms of the managing institutions and in terms of the natural resources.

These principles and the main issues related to them with potential tools for implementation identified by COWI/DHI are shown in the **Table 2.6:**

Table 2.6 World Bank Water Resources Management Principles and Issues (COWI/DHI)

Principles	Issues	Potential Tools
Development shall be based on a sustainable use of resources.	Water conservation Recycling and reuse	Modern technology Quantity objectives Quality objectives
Water as a social and economic good with value consistent with its most valuable potential use.	Value of water Pricing of water	Tariffs Incentives Subsidies
Water management at the lowest appropriate levels.	Decentralisation Private sector involvement	Institutional strengthening
Governments shall play an enabling role.	Supply driven development Demand driven development Resource protection	Autonomy to institutions Investment capital/planning Public awareness Environmental standards Monitoring and enforcement
Water management shall be based on a holistic approach	Conflict resolution	River basin authorities Catchment committees Management data and information systems

A Workshop was held by COWI/DHI/SUEPO from the 6th to 9th May 1997 covering all aspects of work undertaken to date. The most significant points to arise in terms of effect upon the SUEP Phase I project and EA are listed in **Table 2.7:**

Table 2.7 – World Bank Decisions of May 1997 Important to EA

SUEP EA Issue	World Bank May 1997 Decisions
Water and Wastewater Strategies	The COWI/DHI work had not yet reached the stage where fully operating river quality models are available to assess the merits of alternative pollution control strategies. The World Bank agreed to proceeding with the preparation of 14 engineering projects for appraisal but required fuller justification for the selection of the particular schemes.

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SUEP EA Issue	World Bank May 1997 Decisions
	It was established that the contribution of the six cities to the nutrients entering the Three Gorges Reservoir would be negligible and that the removal of nutrients, nitrogen and phosphorus, from the cities' wastewater was not justified. The projects should determine water quality improvement from proposed schemes which will necessitate the setting of reasonable "low-flow" conditions for comparing the achievement of Chinese Class III - Class V standards. The project team should evaluate the ability of existing irrigation diversion schemes, especially the Dujiangyan irrigation system diversions to the Tuo Basin. The Bank is very interested in obtaining more information on the operation of the existing septic tanks in the cities and the disposal of sludge, including timetables for removal of these tanks once treatment plants are installed.
Project Selection	The World Bank reviewed and agreed in principle to most of the proposed SUEP projects with some modifications. Sewage treatment plants in SUEP will not have nutrient removal because it was determined that the domestic sewage contribution to potential algae formation in Three Gorges was insignificant compared to total basin loads.
Solid Waste Projects	The World Bank experts were not supportive of proposed incineration and composting plants for a variety of economic and technical reasons. The proposed solid waste projects should be considered landfills at this stage, until additional work can be accomplished to justify the other options. The World Bank would send a solid waste technical assistance team to Sichuan in the summer to further evaluate the solid waste management systems.
EA Processing	The Bank concluded that a category "A" EA should be prepared. The bank officers preferred that a single EA be prepared which first covered the overall SUEP conditions and the entire province, and then individual chapters on each project, and finally an overall mitigation and monitoring plan for the SUEP which combines the recommendations of each selected project. Public participation can be limited to locally elected representatives so that all communications with such officials should be documented and presented as indicative of public participation used in the project. Land acquisition and resettlement planning is very important.

2.2.3 World Bank Final Project Selection, October 1997/March 1998

The WB sent small study teams in July of 1997 to further evaluate the solid waste projects and the overall study progress on all projects. Some of the proposed projects were modified or dropped from the first phase of the SUEP at that time. The WB then moved the next scheduled formal review of the Bank from September to October of 1997. In October of 1997, the WB mission visited the project and confirmed some of the work done by COWI/DHI on the water resources strategy, including water quantity and quality modeling in the study area. At that time, some of the project preparation work had not sufficiently progressed and the appraisal schedule was again delayed to final appraisal in July 1998. In addition, the SPC had not yet formally approved the Phase I of the SUEP but had given tentative approval to a WB loan amount for the project of $150M USD. This reduction in funding and a review of project readiness led to the selection of the nine component projects currently included in the Phase I of SUEP. The WB gave initial concurrence to these nine projects and scheduled formal pre-appraisal in March of 1998. Pre-appraisal was held on the technical aspects of the nine component projects as scheduled in March of 1998. Except for some minor questions and adjustments, the nine component projects were cleared for appraisal relative to technical issues. Some major issues remained on the financial and institutional side, however, and the WB delayed appraisal to the fall of 1998 with a July 1998 mission scheduled to try to wrap up these

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issues. This EA is based on the approved technical designs of March 1998 with minor modifications and adjustments as dictated by WB concerns and comments. The Phase I SUEP was granted loan approval by the World Bank in June of 1999 and is currently being implemented by SUEPO.

2.2.4 Ongoing Activities

COWI/DHI prepared an Urban Water and Wastewater Resources Strategy in March 1998 that outlined and reviewed many of the water resources and water quality problems and potential remedial strategies. This integrated planning work was carried out simultaneously with the project preparation work for the Phase I SUEP projects. Future phases of the SUEP can now address these integrated water resources and water quality studies and strategies based on this effort.

The Phase I SUEP projects that are currently being implemented are necessary features of these longer-term proposals. Similarly, the management and control of all point source domestic and industrial wastewater sources are necessary environmental and provincial goals. The following potential measures were identified in the COWI/DHI work for integrating water quantity planning and water quality within the area:

Option 1 – Changing Diversions at Dujiangyan; The water availability analysis shows, although dilution is not the solution to pollution, proper river flow augmentation management of relatively small quantities can reduce water quality problems during the critical months. In this respect, river augmentation may be obtained through a combination of surface water control and the pumping of groundwater.

Option 2 – Increasing The Inter-Basin Transfer Within The Min And Tuo Basins; Diversion from the Min River via the Qingbai and Pihe canals already contributes about 1/3 of the flow in the upper part of the Tuo basin. Runoff, mainly as groundwater return flow from the Chengdu plain, contributes about half the annual flow. River augmentation on the Tuo can be achieved only in combination with drastic water resource management initiatives in the Chengdu plain.

Option 3 – Increasing Conjunctive Use Of Surface And Groundwater On The Chengdu Plain; Theoretically, the available groundwater resources on the Chengdu Plain correspond to an average river flow of 80 m^3/s, or about ¼ of the flow at Dujiangyan of 320 m^3/s, if it was abstracted only during the 3-month critical dry period. For cities like Chengdu and Deyang located on the Chengdu Plain, it appears that a rational water resources management involving both surface water and groundwater will be necessary.

Option 4 – Introducing And Encouraging Water Savings; A 10% increase in agricultural efficiency could result in a 100% increase in domestic water availability or for in-stream water quality improvement. Important options to achieve water savings in agriculture which may be evaluated include:

- developing small scale storage ponds
- improving water use efficiency
- introducing greater diversification of cropping systems
- introducing water resources tariffs

The World Bank expressed interest in pursuing further study of integrated water resource and water quality options in the Min River basin during the March 1998 mission. Terms of reference have been developed for an additional technical assistance program to undertake such a study of the optimization of water resources and water quality linkages in the Min River basin. This study will provide valuable information for future phases of the SUEP. In addition, the World Bank has also requested that Sichuan Province undertake an Industrial Pollution Control Action Plan. The concept is to enhance the environmental improvements that are expected under SUEP by preparing an action plan for pollution reduction in the largest polluting industries in the SUEP project cities. Such a plan would address both direct dischargers and industrial pre-treatment prior to discharging to city sewer systems. A specific technical assistance component was also added to the Phase I SUEP project designed to improve the environmental monitoring systems of the study area, both at the Provincial and city levels. Such improvements will allow for

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improved assessments of environmental conditions as well as enhanced capability to track environmental improvements resulting from SUEP interventions.

2.2.5 Future Phases of SUEP

Phase I of the SUEP is intended to be only the beginning of a long-term investment program in environmental infrastructure in the Province. Future phases of the SUEP will benefit from the strategy and modeling work performed by COWI, the project preparation work and river pollution index work prepared by Mott MacDonald, and the variety of other action plans and studies just discussed. In addition, the technical assistance program for Phase I of SUEP will prepare a cadre of management and technical leaders for this ongoing work. Some of the initial priorities that should be considered are those projects that were initially selected but then dropped as well as other high scoring projects in the COWI/DHI screening. New projects are likely to emerge from the integrated water resources and water quality work as well as the Industrial Pollution Control Action Plan work.

2.3 Details of SUEP Phase I Component Projects

Outline details of the main components of the water supply schemes are shown in **Table 2.8**. The two schemes for Luzhou each have a capacity of 50,000 m^3/d. The capacity of the Leshan scheme is 100,000 m^3/d, whilst that for Zigong is 200,000 m^3/d. The Luzhou Beijiao scheme involves the supply of 25,000 m^3/d to Fuji, a county town some 35 km north of Luzhou. The Zigong scheme involves the supply of 210,000 m^3/d of raw water but treatment works for only 120,000 m^3/d with 80,000 m^3/d of raw water to supply an existing treatment works.

Table 2.8 Summary of Proposed Phase I Water Supply Schemes

	Leshan	Luzhou Beijiao	Luzhou Daxikou	Zigong
Capacity m^3/d	100 000	50 000	50 000	200 000
Intake Source	Qingyi	Yangtze	Yangtze	Min
Raw Pipeline	3.1km x DN1100	0.55km x DN1000	1.2 km x DN800	66km x DN1400 0.3km x DN1000 0.4km x DN900
Raw Pumps	3 x 2300 m^3/h	2 x 1150 m^3/h	3 x 1150 m^3/h	3 x 4400 m^3/h 3 x 4400 m^3/h
Treatment Works:	100 000 m^3/d	50 000 m^3/d	50 000 m^3/d	120 000 m^3/d
Pre-sedimentation	14.4 m/h	15 m/h	13.8 m/h	13 m/h
Sedimentation	6.9 m/h	6.3 m/h	7.0 m/h	6.8 m/h
RG Filters	12 x 48 m^2	16 x 25m^2	8 x 45 m^2	16 x 48 m^2
Backwash	Air +Water	Water	Air + Water	Air + Water
Disinfection	Chlorine	Chlorine	Chlorine	$Cl_2 + NH_3$
Clear Water Tank	2 x 5000 m^3	2 x 4500 m^3	2 x 3000 m^3	1 x 14400 m^3
TW Pumps	4 x 1800 m^3/h	6 x 972 m^3/h 3 x 972 m^3/h	4 x 972 m^3/h	5 x 2020 m^3/h
TW MAINS	8.13 km x DN 800	30.45 km x DN 700	2 km x DN 1000	7.5km x DN1200
	1.73 km x DN 600	2 km x DN 600	0.2 km x DN 500	
		30 km x DN 100-800		
Reservoirs		2000 m^3+9000 m^3	2000 m^3	4000 m^2 + 2000 m^3

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Details of proposed Phase I wastewater projects are shown in **Table 2.9.**

Table 2.9 Summary Details Wastewater Works

	Chengdu	Deyang	Leshan	Zigong
Capacity (m^3/d)	300 000	100 000	254 000	120 000
Main Interceptor	4.9 km x DN 2400/1800	6.7 km x 1.5 m^2	14.7 km x DN 500-1500	7.3 km x DN 500 – 1600
Raw Pumps	6 x 3240 m^3/h	3 x 3000 m^3/h	3 x 2708 m^3/h 5 x 2604 m^3/h	3 x 400 m^3/h 4 x 2000 m^3/h
Treatment Works:				
Preliminary Treatment	CS,FS,G	CS,FS,G	CS,FS,G	CS,FS,G
Primary Tanks	8 x 36 m dia.	None	None	None
Aeration Type Tank Retention	Activated Sludge 10 h	Oxidation Ditch 15 h	None	Extended AS 15
Final Sedimentaion Tanks	8 x 47 m dia.	4 x 42 m dia.		4 x 44 m dia.
Digesters	6 x 18 m dia. 2 x 18 m dia.	None		None
Gravity Thickeners	4 x 14 m	2 x 17 m dia.		2 x 17.5 m dia.
Sludge Belt Presses	4 x 3 m	3 x 3 m		3 x 2 m

There is only Phase I MSW project, located in Leshan, consisting of improved MSW collection and an upgraded and expanded landfill. A summary of the project details of all Phase I SUEP projects is contained in the following sections.

2.3.1 Leshan Number 4 WTW

The city of Leshan currently operates three water treatment works. The Number 1 Banzhuwan WTW has a capacity of 20,000m^3/d and extracts water from the Dadu River. The Number 2 Renjiaba WTW has a capacity of 15,000m^3/d and extracts water from the Min River. This plant is scheduled for decommissioning due to water quality problems of the Min River. The Number 3 Baiyangba WTW has a capacity of 50,000m^3/d and extracts water from the Qingyi River. The Number 3 Plant is located near the Min River and originally used the Min as its water source, but a new supply system was constructed to the Qingyi due to the increasing problems with the Min River quality. Both the Dadu and Min sources are subject to pollution effects from sources upstream and within the city of Leshan. The following problems of the Leshan water supply system were noted in the engineering reports prepared for this project:

- Current and projected supplies are insufficient to meet increasing demands. Because of insufficient water supplies, private enterprises provide independent water supplies. These self-prepared water sources are scattered, uneconomical, and usually of poor water quality.
- The existing distribution system receives insufficient water and experiences low water pressures in many locations, especially during the peak summer demand periods. Due to limited number of pipelines, small pipe diameters, great leakage losses and low pressure, water supply is extremely limited in some areas.
- Pollution of the water sources is increasing and becoming more serious. WTW 1 and 2 were constructed in poor locations at the lower end of the city and the intake water quality has been deteriorating. The city development has resulted in extreme pollution of the Min River. The phenol content in the source water for WTW 1 and 2 is beyond the standards and this badly affects the treated water quality for these plants.
- Projected water needs for the year 2010 indicate a water shortage of 200,000 m^3/d will occur. The Phase I SUEP project is designed to meet half of that projected need with a design capacity of 100,000 m^3/d. The Qingyi was chosen as the most reliable water source for the system relative to water quality. The proposed supply system includes a new intake structure on the Qingyi River just upstream of the city at Jian Shan Zi, raw water transmission main along the Qingyi to the water works site, and the construction of the 100,000 m^3/d water works at Gu Li Ba.

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The proposed Number 4 WTW has an intake structure located fairly well upstream of the urban area where the Qingyi river is deep and narrow, even during dry season flows. In summary the scheme includes the following components:

- Inlet and pumping works located on the Qingyi River at Jian Shan Zi
- Raw water transmission main from the intake of DN 1100, approximately 3.1 km
- Transmission main swab injection and withdrawal chamber for pipeline maintenance
- Gu Li Ba water works with a capacity of 100,000 m^3/d, located in western portion of Leshan in an industrial area (future phase to 200,000 m^3/d)
- Treated water pumping works at the water works site.
- Treated water transmission mains.

Figure 2.1 shows the existing and proposed WTW in Leshan and **Figure 2.2** is the project schematic for the Leshan Number 4 WTW.

2.3.2 Zigong Min River Diversion and WTW

Present water supplies to the city are limited by lack of resources. Whilst the treatment works and distribution system have a capacity of 230,000 m^3/d the limited resources frequently fall below this supply capacity. A total supply of 247,000 m^3/d could be maintained in a normal year but for 10% of years the average supply cannot exceed 192,000 m^3/d and in recent years supplies have had to be restricted to lower levels, down to 130,000 m^3/d. These restrictions are causing hardship in that in some areas of the city pressures cannot be maintained and supplies are unreliable.

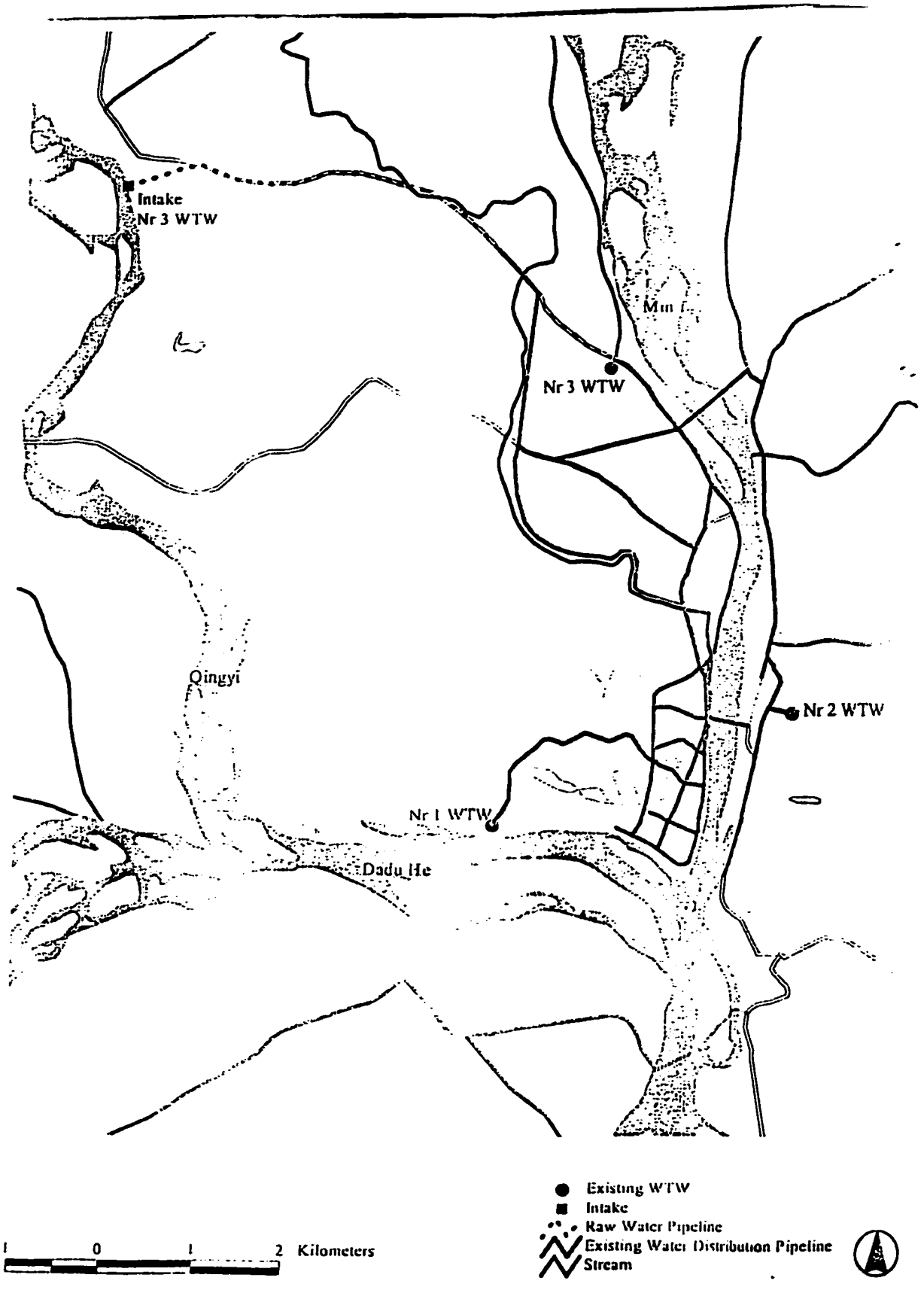
Surveys report that 25% of residents are dissatisfied with the reliability of present supplies and that 93% of those surveyed are willing to pay for an improved service. Industry is also suffering from the severe shortage of water in the area. Factories have attempted to develop their own "self-supplies" but they have now reached the stage that the entire industrial and commercial development of the city is dependent upon the introduction of a large new water source. Existing ground water sources are inadequate for future development and therefore it will be necessary to develop a new source from one of the larger surface waters. The local Fuxi River is entirely inadequate since at times the natural flow falls to zero and the only water carried is largely untreated wastewater. The large rivers of the area that potentially could be used for abstraction are the Tuo, the Min, the Dadu and the Yangtze.

Several alternative water resource schemes were evaluated by the project team. The proposed scheme involves an intake structure located south-west of the city on the Min River and pumping water through a DN 1400 main approximately 66 km to a new treatment works located at Yuan Ba Chang. The supply system involves the intake works and pump station, intermediate pump station and related engineering features, supply of raw water to the existing Changtu water treatment works (to replace the deteriorating water quality supplied by the adjacent Xushui River), and the new water treatment works at Yuan Ba Chang. In summary, the scheme includes the following components:

- Inlet and pumping works on the Min River in Nixi Town, Yibin municipality
- Intermediate pumping station and control structures
- Pipeline of DN 1400 approximately 65.8 km long, including four large river crossings (length of 30m to 90m), four minor road crossings
- Distribution tank and pump station distributing raw water to existing Changtu water works and new Yuan Ba Chang water works.
- Supply Main of DN 900 conveying supply water from the distribution tank about 1 km to the Changtu water works. (local funds)
- New Yuan Ba Chang water works with capacity of 120,000 m^3/day, with future phases to increase capacity to 200,000 m^3/day.
- New distribution mains (local funds)

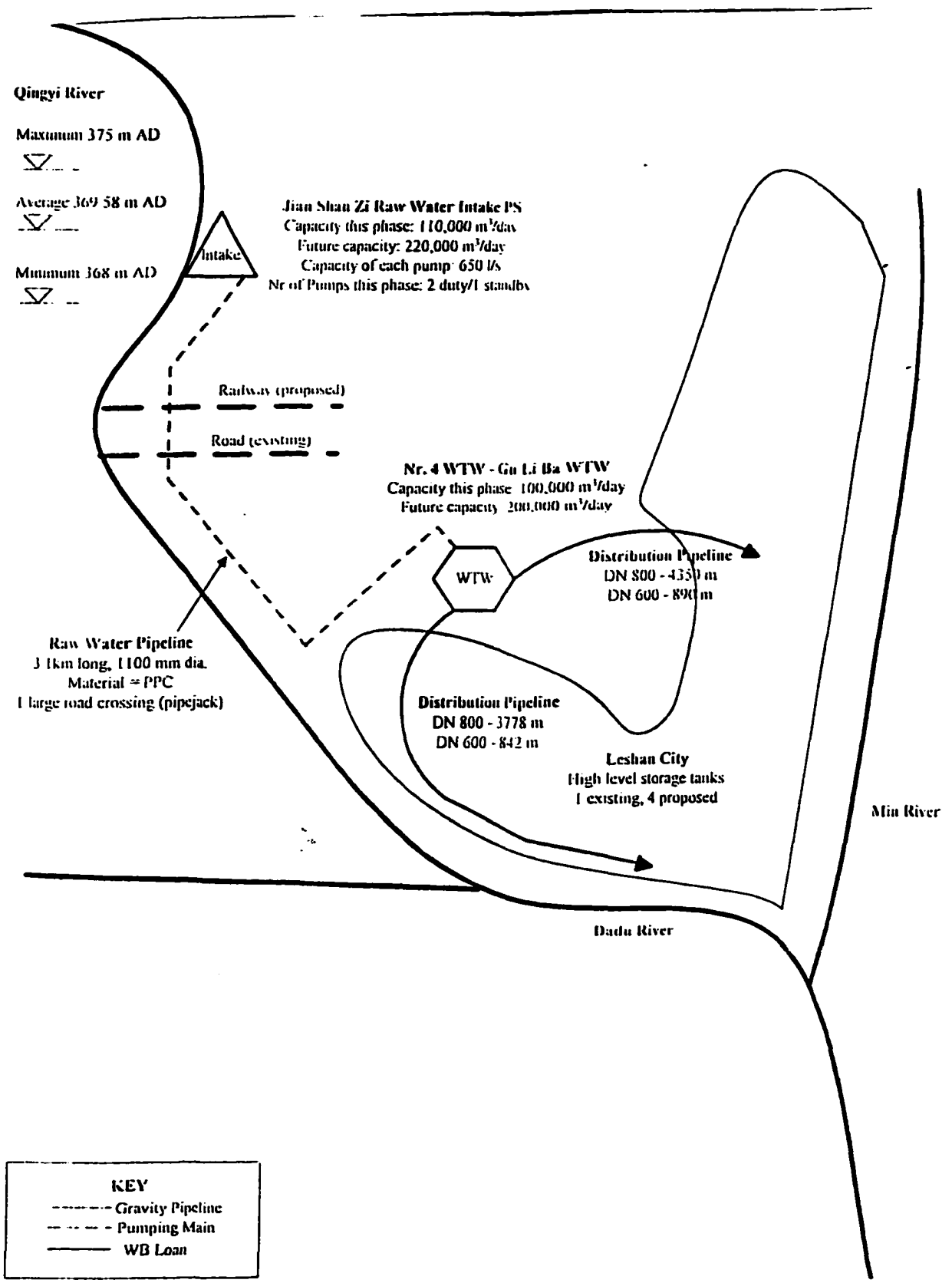
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Figure 2.1 Existing and Proposed WTW in Leshan



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Figure 2.2 Project Schematic for the Leshan Number 4 WTW.



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The proposed intake and pumping system at the Min River will be a 27-m diameter concrete structure located on a solid rock foundation at the riverbank. An analysis of the Min River indicated that both the water quality and quantity are adequate for the proposed use as a potable water supply. It is located in Nixi Town, under the jurisdiction of Yibin municipality. An intergovernmental agreement is contemplated to address the protection of the watershed above the proposed intake from development approved by Yibin.

The transmission main will cover very rocky and hilly terrain following an existing narrow and steep roadway in most locations. Since the roadway is single track and constructed in very rough terrain, the pipeline construction will cause temporary traffic problems. A preliminary construction effort to widen this road to allow passage during pipe construction has been recommended. There is an alternative access to Nixi Town to Yibin along the Min River. The pipeline route bypasses several small communities so the land losses and impacts occur in rural agricultural areas. Of special concern will be the crossing of four streams along the route. **Figure 2.3** shows the existing and proposed WTW in Zigong and **Figure 2.4** is the project schematic for the Zigong Min River Diversion and WTW.

2.3.3 Luzhou Beijiao WTW

Luzhou City is located in the Yangtze valley at the junction with the Tuo River. Historically it is a very old city having been founded in the first century BC. It is an important communication center with river and road access to Yunnan Province and Guizhou Province as well as Chongqing and Chengdu. The original city is located in the fork of the Yangtze and the Tuo Rivers but development has now spread to the northern bank of the Yangtze (Xiaoshi district) and the south bank (Nantian). The principal industries in the area are chemical, food production, and electrical and mechanical machinery.

The city is presently being connected by a spur expressway to the existing Chongqing-Chengdu Highway and has been identified by Chreod as an area of rapid growth. In particular the area to the north and within the corridor along the expressway is likely to develop rapidly and especially the districts of Xiaosi, Anning, Gaoba, and Fuji.

It is planned that Xioasi will be developed as a financial, commercial, and entertainment center. Anning is designated to be an important freight and passenger center with accompanying warehousing facilities and light industry. The district Gaoba to the east and downstream of the city adjoins the harbour of Longxi and is expected to become a container port with railway and road access. It is anticipated that some heavy industry will also be developed there.

In 1996 the Sichuan Government decreed that the town of Fuji 35 km to the north of the city should become the new Administrative center for the adjacent Luxian County. It will therefore become an important political and economic center. Construction within the city is going on apace and considerable new infrastructure has already been completed. The existing industrial area to the south of the town already has ten state owned industries, mainly chemical and construction materials, and further enterprises, including a distillery, are planned. The Luzhou Water Company has been given the responsibility for the supply of water to Fuxi and small towns en route between Luzhou and Fuji. Three separate water companies currently serve the urban areas of Luzhou:

- The Luzhou water Company which serves the central area and the area north of the Yangtze including Xiaoshi and Beijiao
- The Jiang Yang Water Company which serves the area of Lantian on the south bank of the city.
- The Anfu Water Company which supplies the satellite towns of Anfu and Naxi. (12km south-west of the center city)

The existing Beijiao Works is located in the northern part of the City has a current capacity of 50,000 m^3/d and extracts water from the Yangtze River, immediately downstream of the Tuo junction. The southern works also has a current capacity of 50,000 m^3/d and extracts water from the Yangtze River. The standby Zhongshan works has a capacity of 20,000 m^3/d, extracts water from the polluted Tuo River, supplies the area north of the Yangtze and can also feed into the central area via mains crossing the Tuo River. The small Lantian WTW has only a capacity of 6,000 m^3/d and suffers from severe water shortages.

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Min River Basin:

Chengdu

The agricultural potential of the plains surrounding Chengdu have been greatly enhanced by the Dujiangyan Irrigation Scheme located northwest of the city on the Minjiang (Min River). Chengdu is located 30 km east of the Min River on the Fu, Nan, Sha and Pihe branches of the Dujiangyan scheme. The Pihe, which itself is formed by the Su Yian, and Bai Tiao branches drains the eastern part of the city to the Tuo River basin. The Fu, Nan and Sha Rivers join in Chengdu and continue as the Fu He to the confluence with the Min River at the Penshan Bridge about 50 km southwest of Chengdu. Although these streams are a mixture of natural and artificial channels, they are all classified as Class III waterbodies by the city EPB, but the Provincial EPB has recommended changing them to Class IV. However, the Provincial goal is to allow all streams to reach Class III levels downstream of SUEP cities. The Min River itself is classified Class III from Waizou (west of Dujiangyan) to the confluence with the Jinsha River, but it has difficulty meeting the standards in some reaches because of minimum flows, polluted inflow from Chengdu via the Fu He River, and an array of other pollutant sources.

There is currently no storage capacity associated with the Dujiangyan scheme but some early planning is underway for a new reservoir on the Min River about 15 km west of Dujiangyan. One of the proposed uses for the new storage capacity is to provide additional streamflows in the dry season for water quality enhancement. Some of the proposed water resource management schemes currently under review also include revised operational schemes for Dujiangyan, conjunctive use of groundwater during the low-flow months, and water conservation.

Leshan

In Leshan, the main pollutants in the Min River are ammonia, mineral oil and coliform bacteria. The Min River at the Penshan Bridge (upstream of Leshan) exceeds almost all standards because it is located just downstream of the confluence of the Fu River (that drains most of Chengdu). The river does some self-purifying by the time it reaches the Leshan Bridge and then is greatly assisted by the 4 times dilution (dry-season conditions) it receives from the inflow of the Dadu and Qingyi Rivers. Leshan EPB reports that downstream of the confluence of the rivers the water quality is acceptable at Standard II. At the monitoring station Leshan st. 4 downstream the water quality is excellent except for E-coli. Proposed SUEP wastewater treatment interventions in Chengdu will improve the water quality of the Min River downstream as far as Leshan, but not to a significant extent.

Tuo River Basin:

Deyang

Deyang City is located on an alluvial plain formed by the Mianyuan River (flowing north to south through the city) and the Shitingjiang River (flowing south-easterly and joining the Mianyuan to form the Tuo south of Deyang). The average surface elevation in the city is 490-495 m. The two rivers constitute the upper part of the Tuo River system. The average annual flow of the Mianyuan River is about 1,419 million cubic meters. The Mianyuan and upper Tuo basins receive significant trans-basin diversion water from the Dujiangyan irrigation scheme on the Min River. According to COWI, this input reportedly accounts for almost 1/3 of the base streamflow of these upper river systems. The Mianyuan River flows north to south through the urbanized area of Deyang and receives the majority of the wastewater in the City. The Shiting River collects wastewater from the south-western part of the City and joins the Mianyuan a few kilometers downstream. Both of these rivers have extreme flow variations from the wet to dry seasons, with the flow in the Mianyuan less than 0.5 m^3/s at some times, mainly consisting of wastewater effluent.

Zigong

Zigong City is located on the Fuxi river in the southern part of the Tuo river basin some 200 km south of Chengdu and 44 km southwest of Neijiang. The city has developed around the confluence of the Xushui and Weiyuan rivers that join north-west of town to form the Fuxi river. The length of the Fuxi river from Zigong to the confluence with the Tuo river southeast of Zigong is 37 km. The Weiyuan river is polluted severely by the industrial wastewater flowing from the iron and steel industry, coal plant, natural gas desulfurization plant, fertilizer industry, pulp and paper industry of Weiyuan and domestic sewage water of

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this area. In addition, the baseflow in the Fuxi in the dry season drops to near zero, with almost all flow consisting of domestic and industrial wastewater. There are periodically large amounts of sludge and polluted sediments in the riverbed along the metropolitan areas of Zigong, but large flood flows also scour this material downstream. Algae growth is widespread in the Fuxi river and few fish can live in the water. One of the most famous sites along the Fuxi River, Huanshui Pool, has deep water, but no aquatic life has been found there for many years. Even during the wet season, the water quality does not improve because of ground pollutants washed into the river and the scouring of the in-stream sludges. The extreme water quality conditions of the Fuxi River caused wastewater treatment in Zigong to be ranked as the number 1 domestic wastewater project priority by COWI/DHI.

Yangtze River Basin:

Luzhou

The Yangtze River is the longest river in Asia and the third-longest river in the world. Rising in western Qinghai (Tsinghai) province, the river flows 5,990 km to the East China Sea. The drainage basin of the river covers more than 1,827,000 square kilometers. Ancient texts call the Yangtze the "Great River," and it is commonly referred to as Chang Jiang (Ch'ang Chiang, or "Long River"). The Yangtze and its tributaries are navigable for a total length of 30,000 km (18,640 mi). The volume of transportation on the Yangtze River system is greater than the total traffic on all the other rivers and waterways of China combined. The total annual run-off to the Yangtze, from the catchment upstream of Wanxian, is estimated to be some 426 billion m^3 of which some 26 billion m^3 is from the basins within Sichuan.

The quality of Yangtze water is good over the entire length in Sichuan Province despite inflows from the polluted Tuo and Min rivers, although the total solids loading of the river is very high, especially in the wet season. The massive dilution provided by the Yangtze translates to good quality ambient surface water in terms of BOD and ammonia. Therefore, there is not a strong case for controlling the discharges of BOD and ammonia in the Tuo and Min basins as a means for improving the quality of water in the Yangtze. Perhaps more relevant are the concentrations of nutrients, nitrogen and phosphorus, since these could cause problems in the downstream Three Gorges Reservoir under construction if concentrations are high and other requirements for algae growth are met; temperature, light penetration and retention time. Additional monitoring and modeling studies are required to better quantify this potential.

1.2.3 Domestic Water Supplies and Utilization

Min River Basin:

Chengdu

The public water supply system of Chengdu is based upon river water abstraction since early groundwater abstraction at three plants has been abandoned due to groundwater contamination. The Chengdu Water Company manages four water treatment plants with a total design capacity of 1.05 million m^3/day, with a daily average abstraction of 845,000 m^3/day. The City is also expanding the largest treatment plant, Number 5, with a current BOT project. In addition to the municipal supply several major industries supply domestic water to the residential quarters for their employees at an estimated rate of 79,000 m^3/d. Rapid increase in water demand is attributed to three factors:

- Acquisition of water using appliances by urban residents;
- Relocation of families from old urban areas to new apartment districts with water supply and sewerage;
- Planned increases in supply area within Chengdu City.

Leshan

The Leshan Water Company serves about 90% of both the population and area of the city center of Leshan from surface water works. They have currently three WTW with WTW 1 located on the Dadu River supplying 20,000 t/d. WTW 2 is located on the Min River supplying 15,000 t/d, and WTW 3 takes water from the Qingyi River (but is located on the Min River) and supplying 50,000 t/d. The Min River supply is considered unsuitable so they hope to abandon the number 2 plant after completion the proposed SUEP WTW project.

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Average daily production is considerably lower than the total design capacity due to an inadequate distribution system that limits the peak distribution capacity to 80,000 m^3/d. This causes temporary shortages of water in the marginal parts of the supply area and in the new industrial zone. It is estimated that 10% of the Leshan's urban area are not served by the water supply system. Leshan's Construction Commission stated that currently water demand is 200,000 m^3/d, far in excess of the total design capacity of the existing plants. This chronic shortage is eased by the fact that the urban water supply is supplemented by a substantial self-supply by industries and others.

Tuo River Basin:

Deyang

Deyang is located between the Mianyuan and Shiting rivers, approximately 60 km from Chengdu. The Mianyuan and Shiting form the upper part of the Tuo River system but the Mianyuan has insufficient year-round reliable flow to be used as a water source for Deyang. Current water supply is abstracted from groundwater sources. There are three existing groundwater municipal water supply plants in Deyang with a design capacity of about 30-40 thousand m^3/d. In addition, a new 4th groundwater plant is under construction with a capacity of 40 thousand m^3/d, bringing the 1998 treatment capacity in-place to about 70 thousand m^3/d. In 1990, there were also 178 industrial and domestic wells in the city with a maximum annual water use of more than 50 million cubic meters, with several large industries using over 60% of this total. This amount of groundwater pumping is reportedly causing cones of depression in many areas.

The distribution system is undersized for city water supply and that leakage losses are serious. Due to these problems and the over-utilization of groundwater, the City has explored using trans-basin surface water brought from the Min River in the People's Canal. A proposed SUEP project to add a 5th plant of 100,000 m^3/d was delayed until Phase II due to Phase I funding limitations. This project was proposed to extract water about 24km northwest of the city from the People's Canal and supply a new WTW adjacent to the newly constructed Number 4 waterworks. There is also a proposed Qing Ping reservoir to be located about in the northern mountains that could supply some surface water in the future.

Zigong

The Number 1 (Chang Tu) potable WTW source water is from the Xushui river, and although it has a design capacity of 80,000 m^3/d, its average production is only 40,000 m^3/d due to the lack of raw water in the dry season and capacity problems in the distribution network. WTW Number 2 (Li Shi Yuan) and Number 3 (Ma Lie Wan) obtain source water from the Changfu Reservoir located in Neijiang Prefecture. The two WTWs have a total design capacity of 145,000 m^3/d, but the allocation of water from the reservoir is only 100,000 m^3/d. As such, the full design capacity of these two WTWs is not being fully utilized.

The main WTW (No. 2) is in the northern part of town. It was built in 1979 with a design capacity of 100,000 m^3/day. It is supplied through a 1200-1000 mm transmission main from the Changfu reservoir 31 north of Zigong. The transmission main also supplies water to WTW No. 3 which has a design capacity of 45,000 m^3/day. The reservoir allocation to Zigong is 100,000 m^3/day, which means that the WTW 2 and 3 cannot operate at full capacity. The total design capacity of all WTW in 1996 is 225,000 m^3/day, with daily average production of 116,700 m^3/day. Water treatment processes typically include intake, mixing-coagulation-sedimentation, filtration, disinfection and storage. Alum is used for coagulation. The pipe distribution system includes 223 km of pipe with a diameter equal or greater than 100mm, and there are 8 booster pump stations. The cost of making running water is 0.75 Y/t and the average sale price is 0.8 Y/t (0.85 industrial, 1.0 Y/t for commercial, and 0.75 Y/t for domestic use. There is also significant direct industrial supply in the city amounting to 200,000 cubic meters per day.

Yangtze River Basin:

Luzhou

The Luzhou urban water company has three existing WTW. The Zhongshan WTW was built in the 50's and later expanded to 20,000 m^3/d designed capacity. The Southern WTW was built in 1987 and has a designed capacity of 50,000 m^3/d. The third WTW is the northern WTW (Beijiao) with Phase I built in

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1994 with a designed capacity of 50,000 m^3/d. (However, water distribution constraints limit the actual production to 30,000 m^3/d.) The southern WTW and the northern WTW extract water from the Changjiang while the Zhongshan Works extracts from the Tuojiang. The Zhongshan only operates during the rainy season and as a standby WTW because of the poor water quality in the Tuojiang.

There is a fourth WTW, the Nantian WTW, located on the south bank of the Changjiang with a designed capacity of 6,000 m^3/d, but it actually supplies about 10,000 m^3/d. In addition to these main WTW, the urban water company also owns very small water WTW such as Taian, Shuizhongba, Guanshan, and Sawan. There are also a variety of small village WTW. Industries also operate about 27 water sources and most belong to large-middle scale factories and enterprises. The total supply capacity of these sources is 482,000 m^3/d, which contain about 4,000 m^3/d of groundwater. Fuji town is located 35km away from the Beijiao WTW. This area and other small towns will be served by a new pipeline located adjacent to National roadway No. 321. The Naxi/Anfu area southwest of the urban center and south of the Yangtze will also be served by the Luzhou Water Company in a new WTW scheme.

1.2.4 Sewerage Systems

Min River Basin:

Chengdu

Chengdu is divided into five sewerage catchment areas. Approximately 70% of the Chengdu City urban area is covered by the municipal sewer system, and another 20% discharge directly into the Fu or Nan Rivers. The majority of the urban area is drained by gravity to the four main streams crossing the city. There are approximately 650 outfalls into the Fu and Nan Rivers, although a current programme of interceptor sewer construction is being carried out. The existing outfalls into the Fu and Nan Rivers will remain open and act as combined sewer overflows (CSOs) until the sewer network is converted from a partially combined into a fully separate system.

The older areas of the city are served by a combined system, consisting of covered brick or concrete collector channels located in the footpaths on both sides of the street. Larger concrete pipes or rectangular channels are typically located under or along major roads. All domestic sewage reportedly passes through a septic tank before discharge into the public sewerage network, and these tanks will eventually be phased out as WwTWs are constructed. The Shizishan WwTW was the first city sewage treatment plant and consisted of primary settlement only. The facility is worn out and it currently bypasses the raw sewage without treatment. This plant is located in the service area of the proposed Long Quan treatment plant and it will be removed after completion of this project and the sewerage will be directed to the Long Quan plant. In 1992, the Sanwayao WwTW became operational with the sewerage area covering the western and northern parts of the city. It currently receives about 600,000 m^3/d of dry-weather inflow while treating about 100,000 m^3/d. The incoming flow is split and about 400,000-500,000 m^3/d of raw sewage is bypassed to the Fu River after mixing with the treated wastewater effluent. The Phase II construction of the Sanwayao WwTW recently began construction under a loan from the Government of the Netherlands. This phase will increase the capacity of the WwTW from 100,000 to 400,000 m^3/d. Phases I and II of Sanwayao WwTW are located just north-east of the proposed Long Quan WwTW, a short distance upstream on the Fu River.

The industrial wastewater from most enterprises is discharged directly into the adjacent receiving waters, many without any form of treatment. All major industries are supposed to treat their effluent to the provincial standards before discharging them either into receiving waters or into the public sewer network. Chengdu City EPB records that only 68% receives some degree of treatment, from primary to full secondary treatment. There are also ten major industries in the urban area that reportedly contribute 80% of the organic wastewater load in the city.

Leshan

Wastewater from the domestic sewerage system is discharged through 32 outlets to the various rivers with 7 large outlets to the Min River and 6 large outlets to the Qingyi and Dadu Rivers. The Zhugong River

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receives wastewater from 7 minor outlets. The major industries include paper pulp and paper, pharmaceuticals, chemicals, electrical equipment, food and beverages, textiles.

Five major industries reportedly constitute 80% of the industrial wastewater flow, although some of these have reportedly closed operations recently. These industries discharge "pre-treated" wastewater (level of pre-treatment is unverified) into an industrial interceptor running north-south along the west bank of the Min River. The industrial interceptor discharges into the Dadu He at the confluence of the Dadu and Min Rivers. This industrial interceptor is not proposed to change with the SUEP project and it will continue to discharge upstream of the Grand Buddha, although in an area of higher turbulence and mixing provided by the Dadu.

Reportedly, 100% of the urban population of Leshan are connected to the sewerage network. However, only 20% of the remaining municipal population are connected to the sewerage system. There is no existing sewage treatment plant, although domestic sewage is passed through septic tanks before discharge into the sewer network. The pollution on water quality of the Min River has resulted in serious impact to landscapes of Grand Buddha scenic spot and Leshan city and people's daily life. To some extent it has restrained local economic development.

Although all major factories in Leshan are required to pre-treat their waste discharge to the approved Sichuan Provincial Standard for Industrial Discharge, it appears that this treatment is not being achieved. It is understood that the major industries do not fully treat their effluent before discharging into the industrial sewer, but it has not been possible to establish the degree of treatment, if any, that is achieved before effluent is discharged.

All houses in the urban center are connected to the sewerage system but in many cases this is a covered storm sewer system. The covered population is about 230,000 plus small-scale industries, commercial areas and institutions. All new buildings are required to have a septic tank before entering the sewerage system.

Tuo River Basin:

Deyang

For planning purposes Deyang is split into four drainage areas, and the 1st Drainage Area covers the urban area to the west of the railway line and discharges into the Shiting River. The 2nd Drainage Area is the largest of the four and covers the urban center of the city. The Mianyuan River forms the eastern boundary of this subcatchment and is the receiving water for all the wastewater from this region. The main sewers in the drainage area flow from west to east and discharge directly into the river. However, 11 km of interceptor sewer has been constructed along the west bank of the river and collects the flows from the sewers in the top half of the subcatchment. The interceptor is incomplete and at present discharges through a single outfall halfway down the drainage area into the Mianyuan River. South of the interceptor, a number of outfalls exist, discharging sewage from the rest of the catchment into the river.

The 3rd Drainage Area is located on the east bank of the Mianyuan River, and as with the 2nd Drainage Area, all wastewater flows are deposited directly into the Mianyuan River. At present these flows are discharged through numerous outfalls into the river, however the Urban Master Plan for Deyang contains plans for an interceptor sewer to be constructed to convey all dry weather flows to the proposed WwTW. The Urban Master Plan also includes plans for splitting the older combined areas of the sewerage network to make the network exclusively separate.

The 4th Drainage Area is situated to the south of Deyang City and covers a small suburb of the city. The majority of wastewater from this subcatchment is discharged into the Mianyuan River; however, there is a single outfall into the Shiting River in the west of the drainage area.

There is currently no wastewater treatment in the city although some industries do some level of pretreatment and the hospital disinfects prior to release to the sewers. The city of Deyang has been constructing sewer interceptors along the Mianyuan and placing parks and footpaths along the river over

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the new sewers. The planned wastewater treatment plant for the city is to be located 8.5 km south of the city adjacent to the Mianyuan River at Tan Yuo Fang in Ba Jiao Development Zone. It is planned to be 100,000 m^3/day. It is estimated that the current load of sewage is 50% domestic and 50% industrial.

Zigong
The sewerage system covers an area of approximately 37 km^2 including a population of 441,000, small scale industries and commercial areas and institutions. Combined sewers are present throughout the older areas. Flooding is a problem during the wet season as some sewers are undersized. There are numerous overflow points to the various streams in the city.

The Fuxi River passing through Zigong is the main receiving water for all industrial and domestic wastewater. It is highly polluted and falls below the standard for a Class III river, failing even Class IV during the dry season. Eutrophication is a serious problem during the dry season and residents frequently complain about the polluted state of the river. The Fuxi river in the downtown area shows obvious signs of the pollution and is a health and aesthetic problem. During the 6-month dry season, the sewage and industries constitute at least 50% of the Fuxi river flow, which frequently has no natural flow at all.

The entire catchment is served by a combined sewerage network, although all future development is to be served by separate sewers. The existing network is reported to be insufficient to transport storm flows to the downstream end of the network, thus flooding occurs. There is no existing WwTW in Zigong. All domestic effluent passes through a septic tank before discharging into the public sewer system. All major industries are required to treat their effluent to the provincial standards before discharging into the domestic sewer network or directly into receiving waters.

Many heavy industries are located in Zigong, including chemical, salt, natural gas, sugar and metal production. Of these the chemical industry is the most dominant. The Zigong EPB lists 13 major industrial pollution sources within Zigong. The majority of these heavy industries are located around Zigong City and in Fushun, a town situated at the Tuo River. The discharge of industrial wastewater from the 12 largest manufacturers in Zigong City was 85,000 m^3/d in 1995 (78% of the total industrial wastewater discharges).

Yangtze River Basin:

Luzhou
There are no major wastewater treatment works in Luzhou and there are several direct discharges to the Yangtze just upstream of the confluence with the Tuo. Most of the urban area uses septic tanks and the sewers are a variety of combined street drains. There is a small pilot wastewater treatment works (Yaerdang) of 6,000 m^3/day capacity which was completed in 1995 which accounts for about 10% of the domestic sewage from the Jiangyang district. During a site inspection in 1997, it did not appear to be operating properly.

An earlier Phase I SUEP component proposed to extend the Yaerdang pilot works to 60,000 m^3/day on a nearby plot of land of 6 ha. In order to make efficient use of the proposed works, the existing combined sewer system of 120 km would need upgrading to a separate system, and an intercepting sewer must be built along the banks of the Tuo and Yangtze Rivers. This project was dropped from the first phase of the SUEP because of the massive dilution capacity of the adjacent Yangtze River dictated a low environmental benefit compared to competing environmental needs.

Jiangyang district, is the old part of the city and is served by a combined sewerage system. It is estimated that 90% of the urban population is connected to the public sewerage system, with the remaining 10% using latrines. All domestic sewage passes through a septic tank before discharging to the public system, while the hospital doses its effluent with chlorine before discharging it into the sewer system.

Industries located within the city of Luzhou discharge approximately 175,000 m^3 of wastewater each day, with a further 650,000 m^3 being discharged by the remaining industries in the municipality. The main industries within Luzhou are chemical, paper and fertilizer production factories. All major industries are required to treat their effluent to the provincial discharge standard before discharging to local receiving

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waters or into the public sewerage system. However, in reality treatment varies from non-existent to full secondary treatment and there is little knowledge about the overall compliance with this standard.

1.2.5 Solid Waste and Sludge Disposal Systems in Place

Min River Basin:

Chengdu
In Chengdu, domestic solid waste is collected by the Utility and Sanitary Administration Bureau and deposited at a sanitary landfill located 33 km to the east of the city. The landfill is reported to receive approximately 2,000 tonnes of waste each day, which is dumped in one 2-m thick layer and covered regularly with earth. Three drainage channels exist around the site to collect and divert surface water and a dam at the base of the landfill creates a storage area for leachate from the waste. The leachate is conveyed to a small on-site treatment plant, which is designed to treat the leachate before discharging it into a small stream. The plant has not been working recently.

Leshan
In Leshan, domestic solid waste is collected by the Environmental Sanitation Division and deposited at a landfill site approximately four kilometers south east of the city. The landfill site is reported to receive 180 tonnes of waste material each day, of which 30 – 40 tonnes had been incinerated in the past. During recent site visits, the incinerator was not operating, and appeared not to have been in use for sometime. The landfill is not lined but it has a leachate collection and treatment system consisting of settling, anaerobic treatment and disinfection before discharge to a small stream. Solid waste is dumped in one foot thick layers and covered regularly with dirt. Operational procedures, including provision of regular cover, are not adequate. The area is ventilated with stone filled areas to avoid gas accumulations. The Environmental Sanitation Division empties all septic tanks at about 6/month and the sludge (estimated at 140 tons/day) which is hauled to the solid waste landfill supposedly rather than applied to farmland. However, this dumping has not been verified at the landfill and it appears most of this sludge is used on farmland or dumped directly.

Tuo River Basin:

Deyang
The amount of solid waste for the city is estimated at 60 tons per day including waste from minor factories, commercial areas and institutions. It is collected by the Urban Administration Commission. The solid waste is processed at an existing composting plant at a site in Maanshan Mountain east of town and about 2 km from the river, or an existing landfill several kilometers from downtown. It is estimated that about half is composted and half is land filled. The waste plant has an incinerator, composting plant and small landfill with leachate aeration pond. The City initially applied for a SUEP MSW project to increase the capacity of the composting plant but the project was rejected on a variety of technical, cost and environmental grounds. In Phase II of the SUEP, the City will likely upgrade and expand the existing landfill operation, as well as improve their collection systems.

Zigong
The quantity of solid waste from Zigong is estimated at 190 tons/day including waste from minor factories, commercial areas and institutions. The solid waste is collected by the Sanitary Bureau and either brought to a composting plant located 30 km south-east of town or to a dump site 10 km from downtown. The plan is to abandon the dumpsite and expand the treatment site in a future phase of the SUEP. The composting plant was not in operation during a 1997 site visit.

Yangtze River Basin:

Luzhou
Approximately 390 tonnes/day of domestic solid waste is transport to a local landfill site. A new incinerator has been built to the west of the town center between the two rivers. It has a capacity of 200 tonnes/day, but has not been commissioned yet due to the lack of spare parts. This site also contains a

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landfill site that is reported to have experienced several gas explosions over the past. The city will undoubtedly require a new MSW project under a future phase of SUEP.

1.2.6 Population, Water Supply, Wastewater and MSW Projections

Population and project loading projections follow for the nine Phase I SUEP projects. There are three projects in Leshan, two in Luzhou and Zigong, and one each in Chengdu and Deyang.

Leshan Number 4 WTW

Table 1.3 summaries the forecasts of maximum water requirements in order to meet the total water demand for the service area of Leshan City.

Table 1.3 Total Water Requirements, Leshan

Year	Maximum Water Requirements (m^3/d)				
	COWI	SWMEDRIC	Low	Medium	High
1996	42 138		69 100	69 100	69 100
2000	87 726	199 500	97 100	97 500	99 800
2005	129 390	275 350	132 500	138 000	144 800
2010	171 054	351 200	180 400	200 600	223 200
2015		459 900	233 500	266 800	308 700

Zigong Min River Diversion and WTW

Table 1.4 summaries the forecasts of total water requirements for the service area of Zigong Water Company.

Table 1.4 Total Water Requirements, Zigong

Year	Total Water Requirements (m^3/d)		
	Low	Medium	High
1995	149 000	149 000	149 000
2000	192 400	197 700	203 200
2005	267 900	284 400	302 700
2010	386 300	414 200	472 800
2015	527 800	590 100	726 300

Luzhou Beijiao WTW

This project will expand an existing WTW in Luzhou and serve small towns to the north and a new development zone. A median growth scenario was adopted for the purposes of checking preliminary engineering designs. This approach results in the maximum water requirements for each of the five satellite towns shown in **Table 1.5.**

Table 1.5 Median Maximum Water Requirements, Luzhou Beijiao

Year	Water Requirements (m^3/d)						Total (inc. 15% losses)
	Anning	Shidong	Shuang Jia	Desheng	Renhe	Fuji	
1996	700	1 900	160	500	120	6 800	**11 650**
2000	5 000	3 600	500	1 200	500	15 200	**25 800**
2010	10 200	8 200	1 500	3 100	1 500	41 500	**75 900**

The proposed supply of 30,000 m^3/d to Fuji and the satellite towns will be utilized immediately if the high or median growth scenarios are realized, or only be sufficient until the year 2004 if the low growth scenario

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is realized. The remaining 20,000 m^3/d supplied by this project will be used in the existing Luzhou service area, including the new Nan Gao development zone.

Luzhou Daxikou WTW
This facility will serve the Anfu and Naxi service area southwest of Luzhou and replace a small and poor technology facility. Domestic water demand forecasts were prepared on the basis of projected population and a per capita demand, and are presented in **Table 1.6**. The per capita demands used by the UPDI were 200, 250 and 300 l/c/d in the years 2000, 2010 and 2050 respectively. These figures were considered to represent the 'high' scenario and for the purposes of sensitivity analysis, a 'medium' growth prediction was prepared using the lower per capita demands for Luzhou City. **In Table 1.6,** 4,500 m^3/d of water has been added to that produced by the Anfu Water Company as an estimate of the supply from the Gas Company.

Table 1.6 Domestic Water Demand Forecasts, Luzhou Daxikou

Year	'Medium' Scenario		'High' Scenario	
	Per Capita (l/c/d)	Demand (m^3/d)	Per Capita (l/c/d)	Demand (m^3/d)
1996	145	4 200 (+ 4500)	145	4 200 (+ 4500)
1997	148	5,000 (+ 4500)	155	5000 (+ 4920)
2000	159	10 100	200	12 700
2005	170	11 700	213	15 900
2010	180	13 300	225	19 600
2015	200	16 500	250	25 500

Chengdu Long Quan WwTW
The projected wastewater flows for the 3rd Drainage area, to be served by the SUEP Long Quan project, are shown in **Table 1.7.**

Table 1.7. Projection of Wastewater in 3rd Drainage Area, Chengdu

Year	Total Wastewater in 3rd Drainage Area (m^3/d)		
	Low	Medium	High
1995	162 300	162 300	162 300
2000	189 900	197 200	201 700
2005	224 600	244 200	261 600
2010	314 100	356 200	40 300
2015	399 800	480 400	562,000

Leshan Wastewater Collection and Preliminary Treatment System
The new interceptor to be constructed under SUEP will serve the urban area of Leshan, yet will only convey 72% of the total wastewater discharged into the municipal sewer system. The other 28% equates to the amount of wastewater discharged directly by small industries or wastewater that is generated by the sub-urban population that are not being served by this phase of the interceptor sewer. **Table 1.8** presents the average wastewater flows predicted to enter the proposed SUEP interceptor. (Note that the proposed SUEP interceptor sewers provide the main trunk sewers for future extension in Leshan and have a capacity of 254,000 m^3/d.)

Table 1.8 Total Wastewater to Interceptor, Leshan

Year	Total Wastewater (m^3/d)			
	Low	Medium	High	SWMEDRIC
1996	36 200	36 200	36 200	
2000	45 800	46 000	47 000	
2005	62 000	64 600	67 400	
2010	83 800	92 600	102 000	100 000
2015	107 900	122 600	140 100	150 000

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Deyang WwTW

The catchment area of the west bank interceptor comprises approximately half the total area of the city. SWMEDRIC estimate that 40 – 50 % of Deyang's sewage originates from industrial premises, many of whom undertake preliminary treatment of the effluent. **Table 1.9** presents forecasts for wastewater produced in the western drainage area of Deyang. These flows have been calculated by simply proportioning future wastewater flows in accordance with the size of the catchment.

Table 1.9 Projection of Wastewater from Western Drainage Area, Deyang

Year	Total Wastewater (m^3/d)			
	Low	Medium	High	SWMEDRIC
1995	53 200	53 200	53 200	40 000
2000	71 000	74 500	78 000	67 000
2005	98 000	114 500	124 900	100 500
2010	132 900	167 800	196 900	134 000
2015	170 900	233 300	285 700	

Zigong WwTW

The proposed interceptor sewer that will convey wastewater flows to a new WwTW in Zigong will serve approximately 53 % of the urban population. These flows are displayed in **Table 1.10.**

Table 1.10 Total Wastewater Entering Interceptor, Zigong

Year	Total Wastewater entering Interceptor (m3/d)		
	Low	Medium	High
1995	97 600	97 600	97 600
2000	126 000	129 500	133 100
2005	175 500	186 300	198 300
2010	253 100	271 400	309 800
2015	345 800	386 600	475 800

The WwTW at Zigong will have a nominal treatment capacity of 80,000 m^3/d and will be able to treat 120,000 m^3/d of combined flows. Therefore it can be seen that the works, which is scheduled for completion in 2002, will operate at full capacity from the day of completion.

Leshan Municipal Solid Waste Project

Table 1.11 provides the MSW forecast for Leshan:

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Table 1.11 MSW Forecast, Leshan

Year	Population Growth Rate % per annum	City Center Population including migrants (x1000)	kg/ person/ day Growth Rate % per annum	M.S.W. generated T/ day	M.S.W. collected by municipality T/ day	M.S.W delivered by others T/ day	Total MSW to landfill T/ day	M.S.W. recycled or disposed of elsewhere T/day	% collected by munic. gov't %
1995	3	215	0.82	176					
1996	5	222	0.83	184					
1997	6.5	233	0.84	196	80	20	100	96	41
1998	6.5	248	0.85	211	114	25	139	72	54
1999	6.5	264	0.86	227	152	27	179	48	67
2000	4	280	0.87	244	195	25	220	24	80
2001	4	291	0.87	253	205	23	228	25	81
2002	4	303	0.88	266	218	21	239	27	82
2003	4	315	0.89	280	232	20	252	28	83
2004	4	327	0.90	294	247	18	265	29	84
2005	4	340	0.91	309	263	15	278	31	85
2006	4	354	0.92	326	280	13	293	33	86
2007	4	368	0.93	342	297	11	308	34	87
2008	4	383	0.94	360	317	7	324	36	88
2009	4	398	0.95	378	336	4	340	38	89
2010	4	410	0.96	394	355	0	355	39	90

The forecast population figures in the City Center including the migrant population in the year 2010 vary from a maximum of 450,000 to minimum of 200,000. The figures used in **Table 1.11** are closer to the City Master Plan figures because the city PMO believe the high growth rate per annum will be achieved by enlarging the city center, changing the boundaries and bringing rural populations into the urban area.

1.3 Need for the Project

The Sichuan provincial government has done overall planning on the exploitation and utilization of water, wastewater and solid waste in part of the cities in the Yangtze River catchment area. The components of the SUEP in Chengdu, Deyang, Zigong, Neijiang, Luzhou, Leshan, Yibin, Mianyang, Guangyuan, Panzhihua and Nanchong have been placed on the agenda. The objectives of this planning are to:

- Conduct a comprehensive control on water body pollution of the main channel of the Yangtze River and its four tributaries in Sichuan Province.
- Meet the increasing water demand of big and median cities in the province and to improve the urban environmental quality of cities along the rivers.

The complete implementation of above-mentioned components or sub-projects will solve the problems related to water supply, wastewater treatment and solid waste or refuse treatment/disposal for 75% of urban residents in the province. The implementation of those sub-projects will have practical and far-reaching significance of creating a good ecological environment, improving people's living standard and achieving the strategic target of sustainable development in Sichuan.

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2.0 Description of the Proposed Project

2.1 Overview of SUEP Phase I Project Components

The objectives of Phase I of the SUEP were delineated in detail by SUEPO and DFID but can be summarized as follows:

- **To advise and assist the Sichuan Provincial Government in developing environmentally, socially and economically effective schemes to improve water supply, water pollution control and solid waste services for six cities in the province.**

Table 2.1 shows the projects that are now contemplated in the first phase of the SUEP:

Table 2.1 SUEP Phase I Project Components

Water Supply			
1.	Leshan	Water Supply Pipe and Treatment Plant Nr. 4	150,000 m^3/d
2.	Zigong	Water Supply Pipe and Treatment Plant	200,000 m^3/d
3.	Luzhou	Beijiao Water Supply Expansion	50,000 m^3/d
4.	Luzhou	Daxikou Water Supply and Treatment Plant	50,000 m^3/d
Domestic Waste Water			
5.	Chengdu	Long Quan Treatment Plant and sewer	300,000 m^3/d
6.	Leshan	Wastewater Collection and Preliminary Treatment	254,000 m^3/d
7.	Deyang	Treatment Plant and sewer	100,000 m^3/d
8.	Zigong	Treatment Plant, Pumping Stations and sewer	120,000 m^3/d
Municipal Solid Waste			
9.	Leshan	Improved Collection Equipment and Landfill	400 T/d

Note: Six cities were originally included in the Phase I of SUEP but Neijiang WwTW dropped out due to funding limitations and project readiness. Five cities now remain in Phase I.

2.2 Project Formulation and Development

2.2.1 COWI/DHI Project Inventories and Ranking

The SUEP Project has been undergoing preparatory work for several years under a variety of funding sources, in addition to the DFID project preparation work of Mott MacDonald. Some of the most relevant work to the project covered in this EA is listed below:

- Ausino performed a Water Sector Fact Finding Study (Australian funding)
- Chreod performed a Development Trends and Infrastructure Study (Canadian funding)
- COWI/DHI performed an Urban Water & Wastewater Resources Strategy as well as water quantity and quality modeling (Danish funding)
- Several Canadian firms teamed as the Canadian Sichuan Information Management Consortium are doing a GIS Demand study

The consulting teams of Ausino, Chreod, and COWI/DHI all prepared some level of project prioritization work during their input to the SUEP Phase I preparation. The Ausino Priority Guidelines included the following organizational structure:

Water Supply

- projects which contribute to an optimization of utilization of existing facilities
- projects which have the lowest incremental costs

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- municipalities who express a willingness and commitment to introduce cost recovery and demand management
- areas where there is a high incidence of waterborne diseases
- poorer areas

Wastewater Projects

- projects which alleviate the problem of wastewater discharges to receiving waters upstream of water supply intakes
- projects which solve industrial wastewater discharge problems, including industrial discharge problems outside of the large urban areas
- projects catering to the dense old core areas of the cities as a high per capita benefit should be expected in these locations
- projects which have the highest cost-effectiveness
- pollution absorption capacity of the receiving waters.

Chreod used a ranking model based on four themes:

1. urban growth prospects
2. economic growth prospects
3. demand for environmental infrastructure
4. ability to pay for infrastructure

The Ausino and Chreod analyses were integrated into the primary project prioritization work which was undertaken by the COWI/DHI team and finished in the spring of 1997. They ranked 147 schemes they had considered in outline. These comprised 23 water supply schemes, 52 municipal wastewater schemes, 22 industrial wastewater schemes, 18 municipal solid waste schemes, 24 flood control/water resources schemes and 8 other schemes.

The following pre-screening criteria were adopted by COWI/DHI in conjunction with SUEPO in the early elimination of potential projects from the Phase I of SUEP:

- Projects which were outside of the scope of the Urban Water and Wastewater Resources Strategy
- Projects for which funds from other sources have already been allocated
- Projects which are not urgently needed, which have been proposed for implementation beyond the year 2010
- Project which are not adequately described (i.e., lack of cost estimates)
- Municipal projects which address areas outside of the main urban areas
- Projects which are proposed as a direct result of the implementation of the Three Gorges Dam project

After a screening procedure the long list was reduced to a shorter list of 78 projects. The ranking of these projects involved the use of four main criteria, as follows, supported by 8 sub-criteria.

Water, Wastewater and Resource Management Schemes	60
Infrastructure and Management Support	15
Financially viable service providers	10
City/Province and Basin Priorities	15

The COWI/DHI project screening for W/WW projects were evaluated against the following with the corresponding weights in brackets:

1. reduces the bacteriological pollution of surface water (10)
2. reduces pollution with ammonia and organic material in surface water (10)
3. reduces eutrophication in surface water (10)
4. reduces other surface water pollutants (10)
5. reduces groundwater pollution (10)
6. improves the water resource availability (15)
7. reduces the incidence of communicable diseases (25)
8. improves the recreational environment (10)

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The sub-criteria used by COWI/DHI to evaluate the projects' effects within infrastructure provision and management were the following:

1. service level improvements (10)
2. supply capacity (deficit of persons served) (30)
3. unit cost of the proposed project (10)
4. equitable access to services (20)
5. status of project preparation (30)

Although a large number of proposals were submitted to SUEPO from the project cities, SUEPO has proposed the projects within and from the Tuo River Basin, Chengdu and Leshan for priority implementation during the Phase I of SUEP. The provincial SUEPO provided the following background information relative to this prioritization:

- The Tuo River has the highest preference because it contains over 22 million in population, or about 20% of the provincial total, even though it only contains 5% of the provincial land area. Water shortages are severe in the basin and at the same time pollution loads are serious, negatively affecting the ability to withdraw more water.
- Chengdu city, the capital of Sichuan, is the center of Southwestern China in terms of economy, trade and culture. The environmental infrastructure is far short of what is necessary to serve the city causing extreme water quality degradation in the urban area.
- Leshan is one of the most popular tourist cities in China having the Grand Buddha cultural and historic site. Water supplies are outdated and insufficient and there is no adequate wastewater collection or treatment system. Solid waste management is inadequate.

The ranking positions established by COWI/DHI together with the SUEP preferences are shown in **Tables 2.2 to 2.4** (Note SWMEDRIC is the Southwest Municipal Engineering Design and Research Institute of Chengdu, the SUEP local design consultant.)

Table 2.2 Ranking of Municipal Wastewater Schemes (COWI/DHI)

City	Scheme	COWI/DHI Ranking	Preliminary Phase I SUEP Selection	Cost Estimates 1997 (prelim)	
				Million Y	Source
Zigong	No.1	1	Yes	320	SWMEDRIC
Chengdu	No.2	2	Yes	568	SWMEDRIC
Deyang	No.1	4	Yes	210	SWMEDRIC
Neijiang	Baimuchong	11	Yes (*)	346	SWMEDRIC
Leshan	Dujiachang	13	Yes	269	SWMEDRIC
Neijiang	Xinshi	18		60	COWI/DHI
Chengdu	Wuguibei	27		720	COWI/DHI
Chengdu	Jiang'anhe	28		110	COWI/DHI
Chengdu	Fuhe	29		330	COWI/DHI
Chengdu	Sanwayao	30		220	COWI/DHI
Chengdu	Qingbaijian	31		220	COWI/DHI
Leshan	Shawan	36		19	COWI/DHI
Leshan	Zugongshi	37		360	COWI/DHI
Leshan	Wutongquiao	38		26	COWI/DHI
Luzhou	Ya'erdang	41	Yes	136	SWMEDRIC

* Dropped out of Phase I after initial selection due to funding and project readiness.

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Table 2.3 Ranking of Municipal Water Supply Schemes (COWI/DHI)

City	Scheme	COWI/DHI Ranking	Preliminary Phase I SUEP Selection	Cost Estimates 1997 (prelim.)	
				Million Y	Source
Deyang	Municipal	3	Yes (*)	370	SWMEDRIC
Zigong	Min River	10	Yes	450	SWMEDRIC
Chengdu	Qinbaijiang	14		50	COWI/DHI
Luzhou	Beijiao	17	Yes	166	SWMEDRIC
Chengdu	Tw5/6	32	Yes	1120	SWMEDRIC
Luzhou	Daxikou	33		60	COWI/DHI
Leshan	No.4	44		130	COWI/DHI
Luzhou	Lantian	46		80	COWI/DHI
Luzhou	Lingyo	51		50	COWI/DHI
Leshan	Municipal	56	Yes	147	SWMEDRIC
Neijiang	Neijiang Source	73		161	COWI/DHI

* Dropped out of Phase I after initial selection due to funding and project readiness

Table 2.4 Ranking of Municipal Solid Waste Schemes (COWI/DHI)

City	Scheme	COWI/DHI Ranking	Preliminary Phase I SUEP Selection	Cost Estimates 1997 (prelim.)	
				Million Y	Source
Neijiang	Dongguanyuan	15	Yes (*)	12	SWMEDRIC
Deyang	Ma'anshan	20	Yes (*)	20	SWMEDRIC
Leshan	Municipal	34	Yes	62	SWMEDRIC
Deyang	Guanghan	36		10	COWI/DHI
Luzhou	Ganyutang	39		18	COWI/DHI

* Dropped out of Phase I after initial selection due to funding and project readiness

The COWI/DHI rankings shown relate to the whole 78 projects, which cover all types of scheme. Within each table the preferred schemes of the particular type are ranked from the top downwards. The SPG, SUEPO office and the design institute worked closely with proposed project cities to further develop a listing of proposed projects. These projects are shown as "SUEP Selection" in these tables and there was generally good agreement on the selection with the prioritisation scheme.

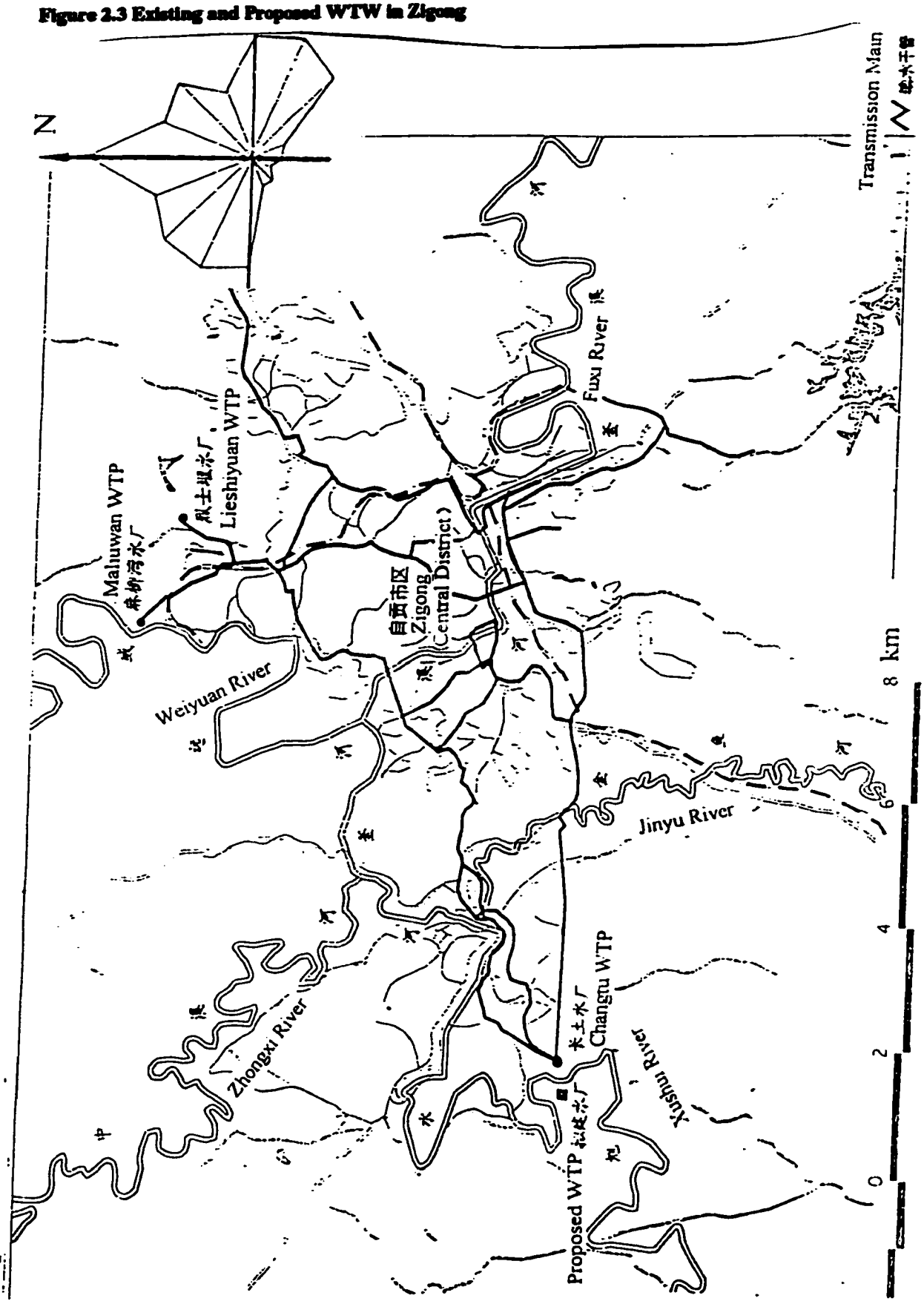
Table 2.5 shows the overall proposed SUEP Phase I construction schedule (may be delayed up to a year due to delays in project appraisal):

Table 2.5 SUEP Phase I Construction Schedule (typical)

No.	Year	Construction Schedule
1	1998	1. Complete preparation of construction. 2. Land Acquisition, resettlement and site preparation. 3. Order foreign equipment.
2	1999	1. Civil works for water supply projects. 2. Civil works for sewage treatment projects. 3. Site preparation for MSW treatment projects.
3.	2000	1. Winding up civil works of WS projects and equipment installation. 2. Winding up civil works of sewage treatment projects, equipment installation, and sewer pipe construction. 3. Construction of civil works of MSW treatment projects.

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Figure 2.3 Existing and Proposed WTW in Zigong



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Figure 2.4 Project schematic for the Zigong Min River Diversion and WTW.

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The present maximum water requirements for the present service area of Luzhou Water Company is estimated to be 80,000 m^3/d. Although Nan Gao Development is a new development it is assumed that the inhabitants will be relocated from Luzhou and that the domestic water supply requirements for this area are already included in the overall water requirements for the city. The Nan Gao Development Zone is a 460-hectare development of residential, commercial and industrial premises already under construction. It is situated on the north bank of the river and is almost as large as the existing central area of Luzhou. The planned population is 50,000. Proposed pipelines will serve this area from the expanded Beijiao water works. In the nearby community of Fuji in Luxian County, there is a rudimentary treatment works supplying a maximum of 10,000 m^3/d. Raw water for the WTW comes local surface water and underground sources which are polluted and unreliable during the dry season. The present population is approximately 20,000, with a considerable number of temporary migrants. Along the Highway 321 there are also a number of villages which could also benefit from the construction of a pipeline from Luzhou to Fuji. These small towns and villages have only rudimentary water supplies at present. The following problems were cited with the existing water supplies:

1. Due to pollution in the Tuo River, the Zhongshan Works has essentially stopped all operations except during very high wet-season flows in the river.
2. The municipal area and surrounding communities are very scattered and there is poor raw water and low water delivery reliability.
3. Water sources owned by factories and enterprises are extremely high, possibly as much as 81% of the total urban water consumption. Much of the water supplied to residents from these systems is of poor quality.
4. There are too many administrative entities managing water in addition to the factory and enterprise systems.

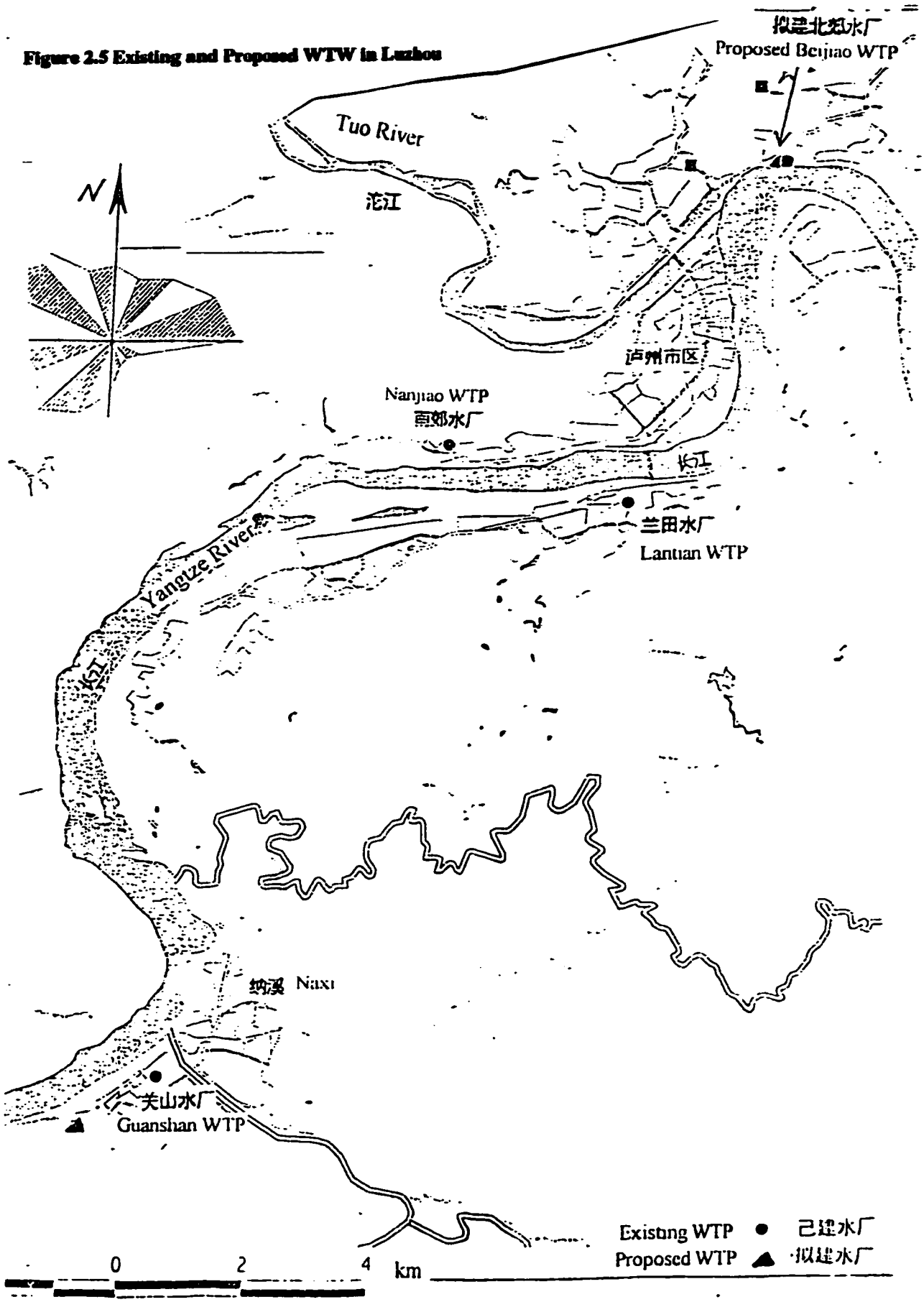
This proposed SUEP project will double the capacity of the existing Beijiao water treatment works to 100,000 m^3/d and supply water to Fuji town and other small communities. The existing intake on the Yangtze is an 18-m diameter concrete structure about 25-m deep, and will require additional pumping capacity only. The upper floor level of the pump station is 1.8-m above the maximum one hundred-year flood level. The intake station incorporates a backwash pipe to enable the cleaning of the intake screens. Studies indicate that backwater effects from the Three Gorges Dam Scheme will be negligible at Luzhou and therefore the statistical water levels upon which the original design was based are still satisfactory. The existing pump house has been designed to accommodate the additional pumps required. The existing pipework arrangement within the pump station permits flow to be passed by gravity to Xiao Shi and also to be boosted to Wan Shan Ping Reservoir. The proposed transmission main to be funded under SUEP will connect into the spine main of the distribution system under construction. The DN 600 main from the treatment works follows the route of the existing main to Wan Shan Ping Reservoir and then follows the route of the existing outlet to the junction with the main to Guankou. The route of the pipeline follows along the eastern edge of the main Highway 321 through Anning, Shidong, Shuang Gia, Ren He, De Sheng to Fuji. The proposed route is along open road and there are no obstructions. The pipeline will be laid in trenches 4-m from the center-line of the road with a minimum cover of 850 mm. At Fuji there is a connection to the new Er Dao Gou storage tank, which is located to control the town.

Figure 2.5 shows the existing and proposed WTW in Luzhou and **Figure 2.6** is the project schematic for the Luzhou Beijiao WTW. The Luzhou Beijiao water works project components proposed for funding under the SUEP can be summarized as follows:

1) Additional 3 pumpsets in the existing raw water intake.
2) Raw water pumping main, DN 1000 mm Steel, 550-m long.
3) Treatment Works
4) Nan Gao Development Zone, including pumping mains, reservoir

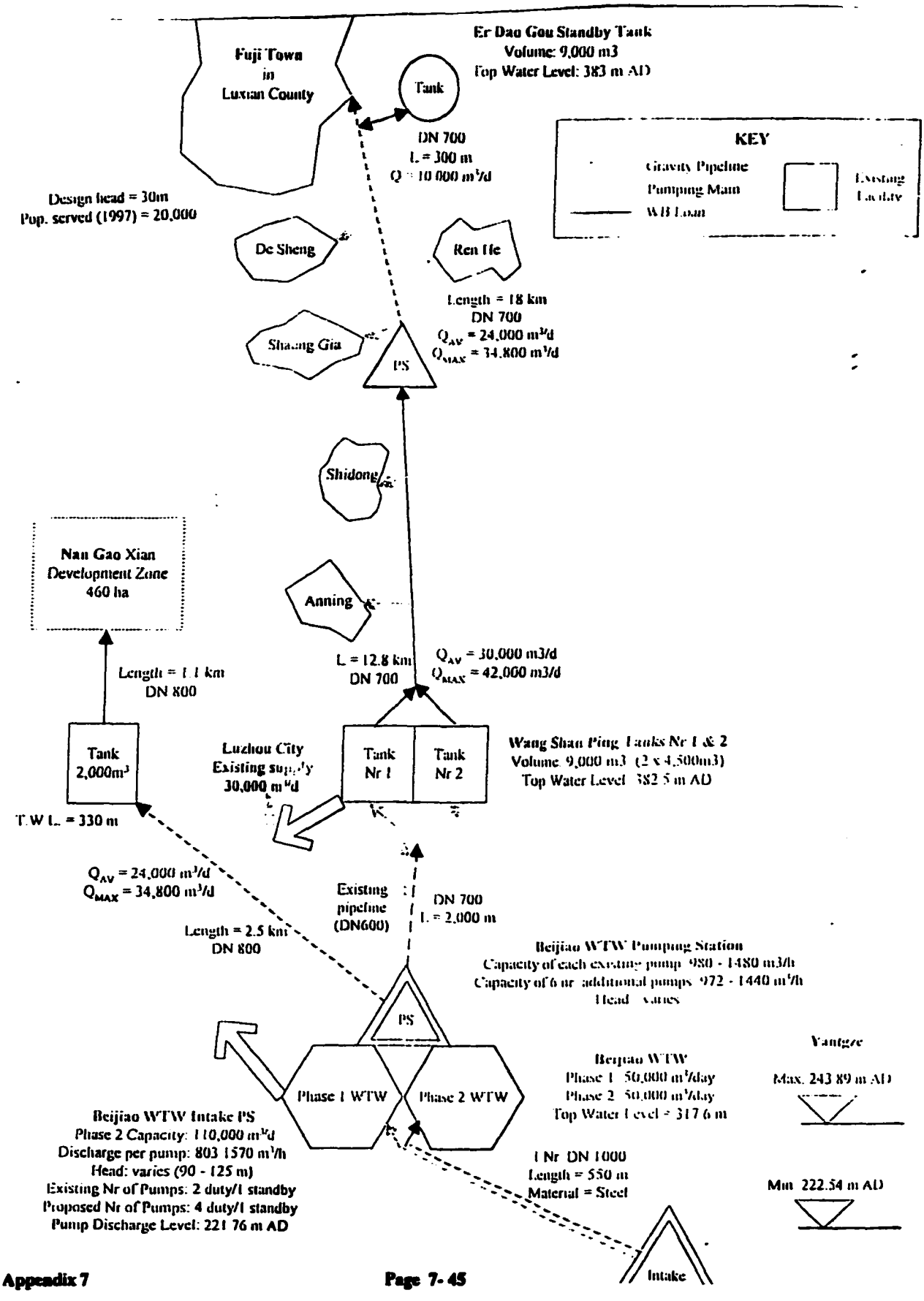
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Figure 2.5 Existing and Proposed WTW in Luzhou



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Figure 2.6 Project Schematic for the Luzhou Beijiao WTW



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2.3.4 Luzhou Daxikou WTW

Three separate water companies serve the urban areas of Luzhou:

- The Luzhou water Company which serves the central area and the area north of the Yangtze including Xiaoshi and Beijiao
- The Jiang Yang Water Company which serves the area of Lantian on the south bank of the city.
- The Naxi/Anfu Water Company which supplies the satellite towns of Anfu and Naxi. (12km south- west of the center city)

This proposed Phase I SUEP Project will provide a new treatment and distribution system to serve the Naxi/Anfu area on the south side of the Yangtze River. This area is about 12km southwest of the Luzhou city center. The Naxi area is located at the Yongning river's confluence with the Yangtze and originated with construction of the Luzhou Natural Gas Chemical Plant which produces fertilizer and raw chemicals. The Luzhou Municipal Government has decreed that the Naxi/Anfu Water Company will be responsible for all domestic, industrial and commercial customers in the Naxi/Anfu supply area. This will exclude industrial water users and the domestic customers located inside industrial complexes that are already self-supplied.

Water consumed in this area has been supplied by the Guanshan water Works, which is administered by the Anfu Hydro-power Company, a subordinate of the Luzhou Construction Committee. This Works was put into operation in 1979 and it extracts water from the Yangtze River. The Works has operated well above its design capacity and also violates drinking water standards during the high turbidity wet seasons. The lack of an adequate water supply is limiting economic development of the area.

The proposed Daxikou WTW will be designed to a capacity of 50,000 m^3/d and new transmission mains, pumping systems and storage tanks will be constructed. The WTW to be covered under the World Bank loan at Daxikou includes:

- Yangtze River Intake Structure
- Raw water pipeline, DN 800, from the Intake Structure to the WTW, 1.2 km.
- Water treatment works, capacity of 50,000 m^3/d.
- Treated water transmission mains, DN 1000 for 1.2 km, and DN 500 for 200 m.
- R.C. Reservoir with capacity of 2,000 m^3.
- Refurbishment of an existing 1,000 m^3 tank at the Guanshan WTW.
- Conversion of existing Guanshan WTW to standby operation only for emergency conditions.

The proposed Yangtze intake structure was originally located about 0.3 km from the WTW site but concerns about clearance for navigation, as well as potential upstream contamination from a new port under construction, caused it to be moved. It is now located about 1.2 km upstream of the WTW site to mitigate these concerns. The intake consists of an 18-m diameter circular caisson sunk to a depth of 27m. Ground floor elevation of the pump station is located about 3.18m above the 100-year flood elevation.

The proposed Daxikou WTW is located just south-west of the Naxi/Anfu town area, less than 0.5 km from the south bank of the Yangtze River. It is mixed forest and agricultural land on a moderate slope, and some ground levelling and a few relocations are required. The Luzhou Daxikou water works project components proposed for funding under the SUEP can be summarized as follows:

- Inlet works including facilities for pre-chlorination
- Pre-sedimentation/sedimentation tanks, associated mixing and flocculation facilities.
- Filter block, containing rapid gravity filters with air/water backwash facilities.
- Water tower in blower house for backwash water. Building also contains air scour blowers, instrument air compressors, and backwash pumps.
- Chemical house containing storage facilities for chlorine drums, chlorine dosing room, coagulant storage, and preparation and dosing room.
- Chlorination with vacuum chlorinators and ejectors, using 1-ton drum chlorine drums.

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- Clear water reservoir, reinforced concrete with capacity of 3,000 m^3.
- Ancillary buildings including workshop, 4-story administration building, canteen, garage and guard house.
- Four treated water forwarding pumps

The treated water mains deliver water to a new 2,000 m^3 reservoir and into the existing Guanshan WTW which will be decommissioned, converted for standby operation, and a new 1,000 m^3 storage facility will be constructed. These transmission mains will be laid on a granular bed across open countryside and track with a minimum cover of 2 m. No potential problems were noted with this construction. A future development zone called He Xi is located south of Naxi and will be supplied by the new 2,000 m^3 reservoir provided in this project. However, the distribution system design has not yet been completed in detail for He Xi.

Figure 2.7 shows the existing and proposed WTW in Luzhou and **Figure 2.8** is the project schematic for the Luzhou Daxikou WTW.

2.3.5 Chengdu Long Quan WwTW

The proposed scheme for the Chengdu Long Quan wastewater collection and treatment system covers the 3rd Drainage Area of Chengdu. The main sewer systems have been constructed and stormwater separated in the 3rd Drainage Area. They feed into a main interceptor which currently terminates near the junction of the New Cheng Ren Road and the Second Ring Road. The SUEP project will extend this interceptor approximately 4.8 km to the new treatment plant site at Long Quan, located in the Liuli Village portion of Chengdu.

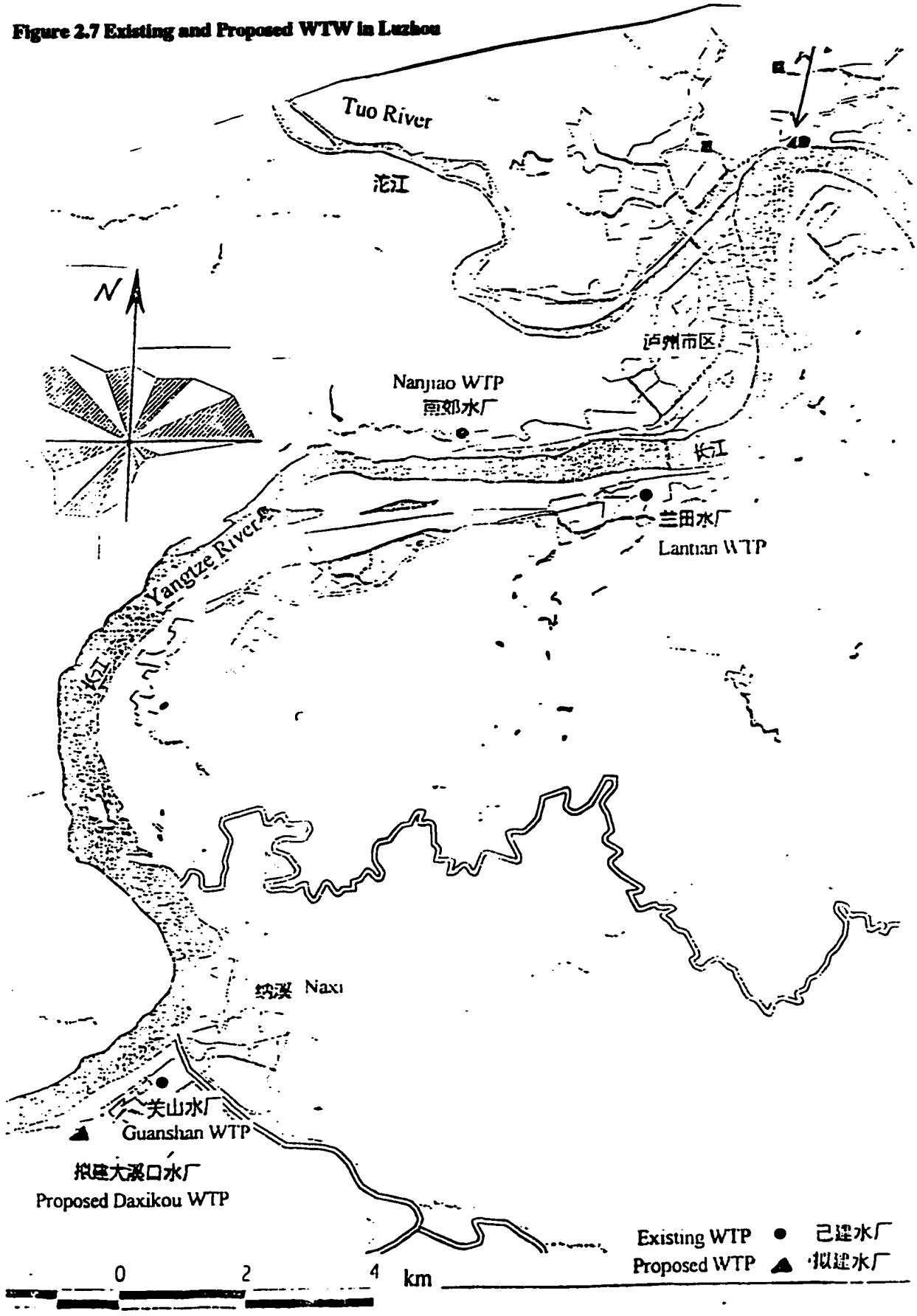
In summary, the scheme includes the following components:

- A 4.825 km interceptor, of DN1800 and 2400 size, delivering wastewater from the termination of the existing sewerage system to the Long Quan WwTW site.
- The first phase of the Long Quan WwTW with a capacity of 300,000 m^3/d. (A future second phase will increase the wastewater treatment capacity at the site to 450,000 m^3/d.)
- A DN2600 outfall, 825m long, from the WwTW to the Fu River, at a point just downstream of the outfall from the existing Sanwayao WwTW.
- A sludge management programme consisting of trucking the sludge (following anaerobic digestion and dewatering) to the sanitary landfill for disposal. The SUEP project includes vehicles necessary for sludge transfer but not any modifications to the existing landfill.

Figure 2.9 shows the existing and proposed WwTW in Chengdu and **Figure 2.10** is the project schematic for the Chengdu Long Quan WwTW.

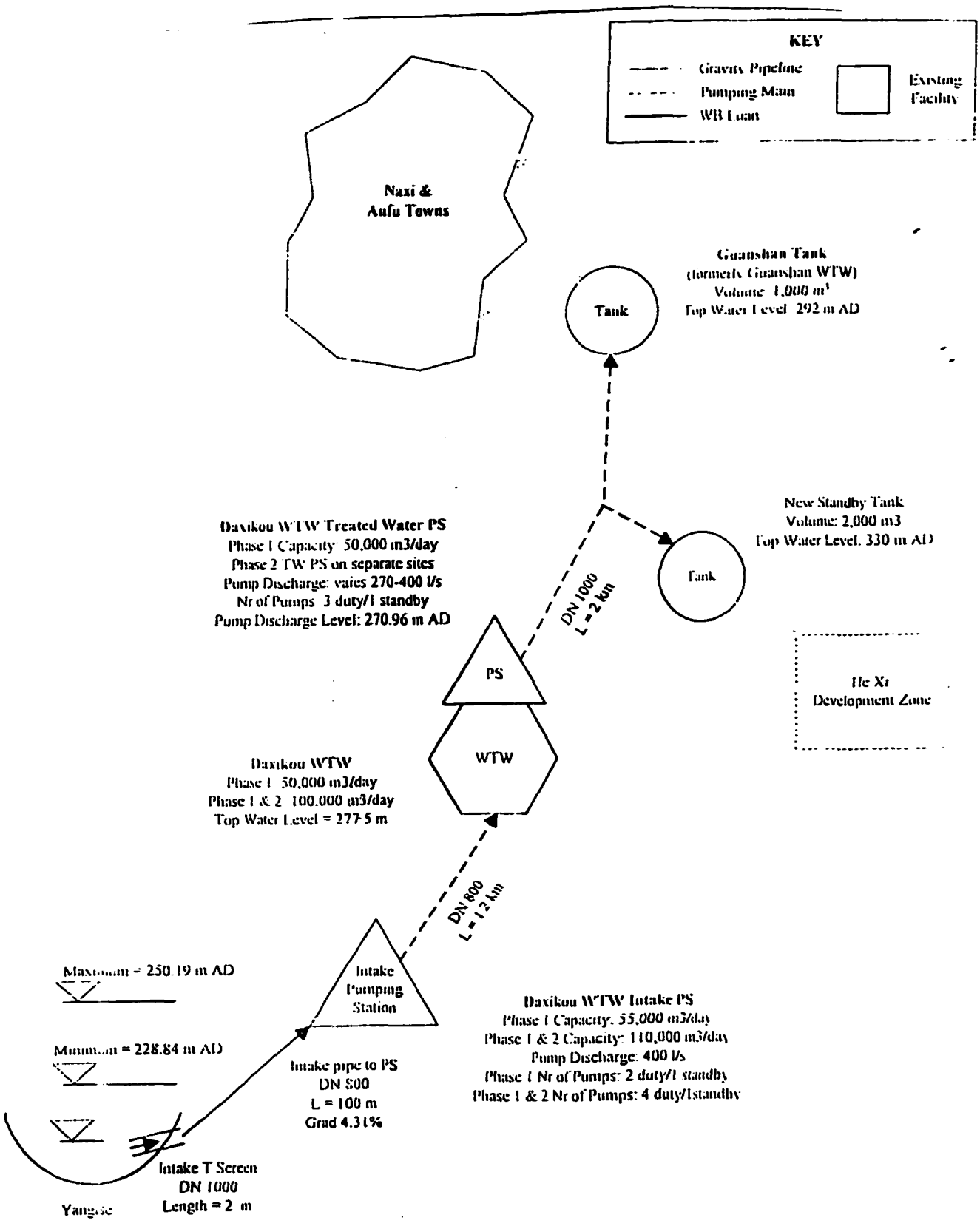
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Figure 2.7 Existing and Proposed WTW in Luzhou



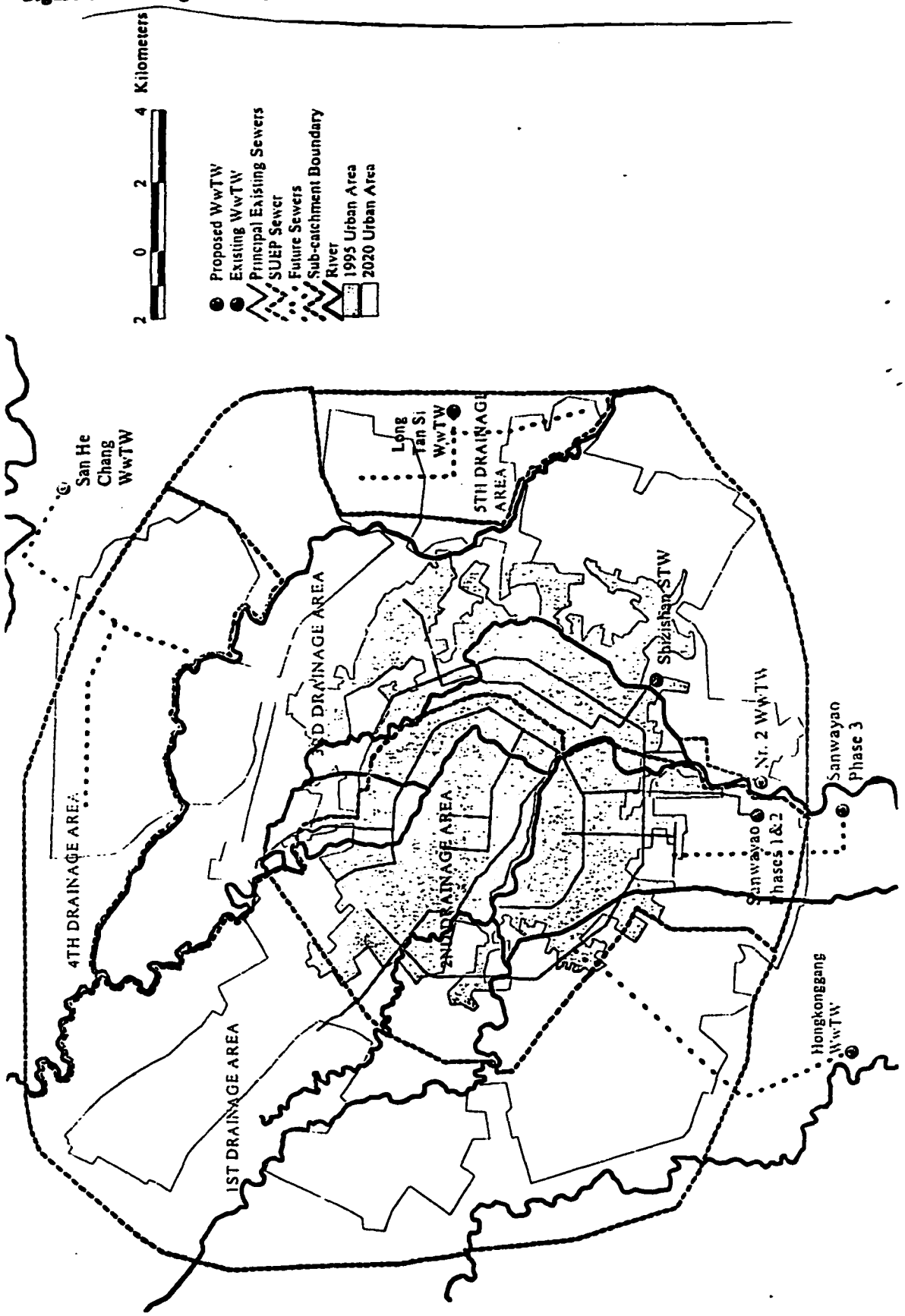
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Figure 2.8 Project Schematic for the Luzhou Daxikou WTW.



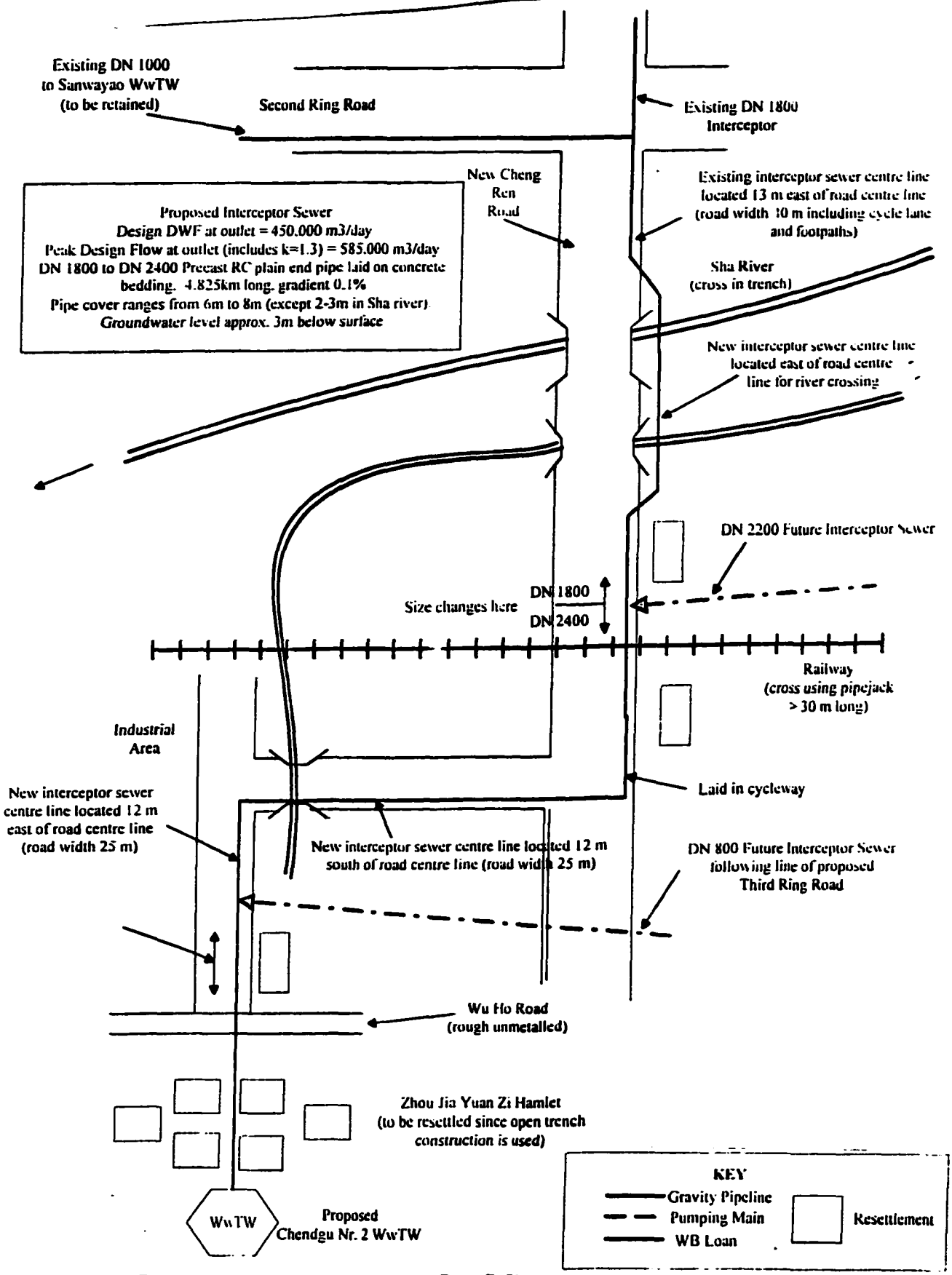
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Figure 2.9 Existing and Proposed WwTW in Chengdu



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Figure 2.10 Project Schematic for the Chengdu Long Quan WwTW.



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2.3.6 Leshan Wastewater Collection and Preliminary Treatment System

The SUEP wastewater project for Leshan was initially conceived as a new domestic sewerage interceptor system with complete WwTW. The wastewater was to be pumped across the Dadu to a proposed WwTW site downstream on the Min River a couple of kilometers. However, an initial analysis of the proposed project determined that:

1. significant sewerage system construction was required to move the wastewater south out of the urban center and,
2. the potential water quality improvement of the Min River downstream due of the proposed WwTW was small due to the large dry-seasons dilution flows provided by the Dadu He.

These analyses caused the project to be reconfigured to a sewerage system and preliminary treatment scheme only during Phase I. Leshan, like all SUEP cities, is under a Provincial mandate to install a secondary WwTW in the near future (all medium cities by 2000). This project will foster the long-term goal of providing a full secondary WwTW for the city of Leshan. In Phase I, the greater health and water quality benefits are achieved by removal of the wastewater from the urban center and cultural sites, and providing preliminary treatment through screening. In subsequent phases of the SUEP, additional treatment can be added at the end of the new interceptor sewer prior to discharge to the Min River. Leshan, like many provincial cities, is not in a position to meet the year-2000 goal but this project will foster long-term achievement of this objective.

For the proposed Phase I SUEP project, the screened wastewater will be discharged to a full section of the Min River, prior to its division into two segments around a small island to allow greater mixing capability. A WwTW site has been located 1.7 km further south of this location and this temporary outfall pipe can easily be extended to a future WwTW under subsequent phases of the SUEP.

The information resources on the existing sewer system in the City of Leshan are quite limited. In the older central area of town, the sewers are covered collecting channels often built of stone arched construction. The larger sewers are either piped or rectangular concrete channels. The system is generally a combined system except in the newer suburbs. In summary, the scheme includes the following components:

- Reinforced Concrete Interceptor system
- Steel pumping mains
- Three pump stations, Number 1 at 130,000 m^3/d, and Number 2 at 32,000 m^3/d, and Number 3 at 254,000 m^3/d.
- Preliminary Treatment with Screening at Pump Station Number 3, before conveying wastewater across the Dadu He.
- A residuals management programme consisting of trucking the screenings from the preliminary treatment plant downtown (following dewatering) to the sanitary landfill for disposal.

The proposed interceptors will be constructed along the banks of the various surface streams flowing through Leshan in order to convey wastewater to a central pumping station at the Dadu. Some of the sewers will be constructed in very restricted and densely populated areas and traffic disruption is inevitable. Sewer interceptors will be constructed both south and north of the Zhugong Xi to intercept existing outfalls. Pump station number 1 will be located at the north bank of the stream at the Zhugong Xi Bridge. Pump station Number 2 will be installed adjacent to the Min River and will be used to intercept and pump an existing major outfall into the new interceptor sewers. The pump station will be built out into the river to minimize demolition and relocation. Pump station Number 3 receives flow from the major interceptor coming south along the Min River and the secondary interceptor constructed along the Dadu. It is located near a park at the junction of the Dadu and the Min River and will be built out adjacent to the Dadu retaining wall. The location is highly visible and near a major tourist area and boat loading dock for tourists sightseeing to the Grand Buddha. According to SRIEP, it is also located in the protection zone of the Grand Buddha cultural park and extra precautions may be necessary relative to noise, odor and screenings disposal in this location. The pumps will feed dual DN 1000 steel mains across the Dadu He, pumped in rotation to decrease the possibility of solids settling in the lines. In order to prevent gases in the high spots and solids deposition in the low spots of the crossing, the pipeline will be periodically flushed with a high velocity. The choice of method of laying the pipe across the river has not been finalized. The

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two choices under consideration are "float and sink" or pulling the pipeline through a pre-dredged channel. The pipeline will be designed to withstand buckling under hydrostatic pressure and installation forces. In either case the pipe will be laid in pre-formed trench in the riverbed.

A preliminary treatment scheme of dual screening will occur at the pump station prior to transferring the wastewater across the Dadu. Each screen chamber contains a 50mm coarse screen and a 5mm fine screen. The City had proposed removing screenings from this preliminary treatment plant by barge to an unknown disposal location. However, in consultation with the EPB and design engineers, this scheme has been revised to a system using minimal dewatering and disposal by trucking to landfill. It was felt that an open barge of wastewater screenings was both unsightly and unhealthy, and there was not an acceptable location for transporting them by barge for ultimate disposal.

Figure 2.11 shows the existing sewer systems in Leshan and **Figure 2.12** is the project schematic for the Leshan Wastewater Collection and Preliminary Treatment System.

2.3.7 Deyang WwTW

This project will serve the 2nd Drainage District of the city that covers the main urban center of the city. The WwTW has been located in such a manner to allow future enlargement and servicing of Drainage District Number 1 (discharging to the Shiting River), and the 3rd Drainage District, located east of and discharging to the Mianyuan River.

An existing interceptor sewer (1.5m square concrete culvert) has been constructed for 11 km along the west bank of the Mianyuan River. This culvert conveys wastewater generated in the 2nd Drainage District (central area of the city) to a point south of the central area. The interceptor sewer currently discharges untreated wastewater to the Mianyuan River at this location.

A proposed SUEP interceptor using 1.5 m square concrete culvert will convey the wastewater southerly from this location approximately 6,700 m to the proposed WwTW location. In the future, another interceptor will be constructed along the eastern bank of the Mianyuan River to serve the eastern portion of the city in the 1st Drainage District. This sewer construction will require future enlargement of the WwTW. This site also allows for future gravity interceptor construction in a proposed development area located north-west of the site.

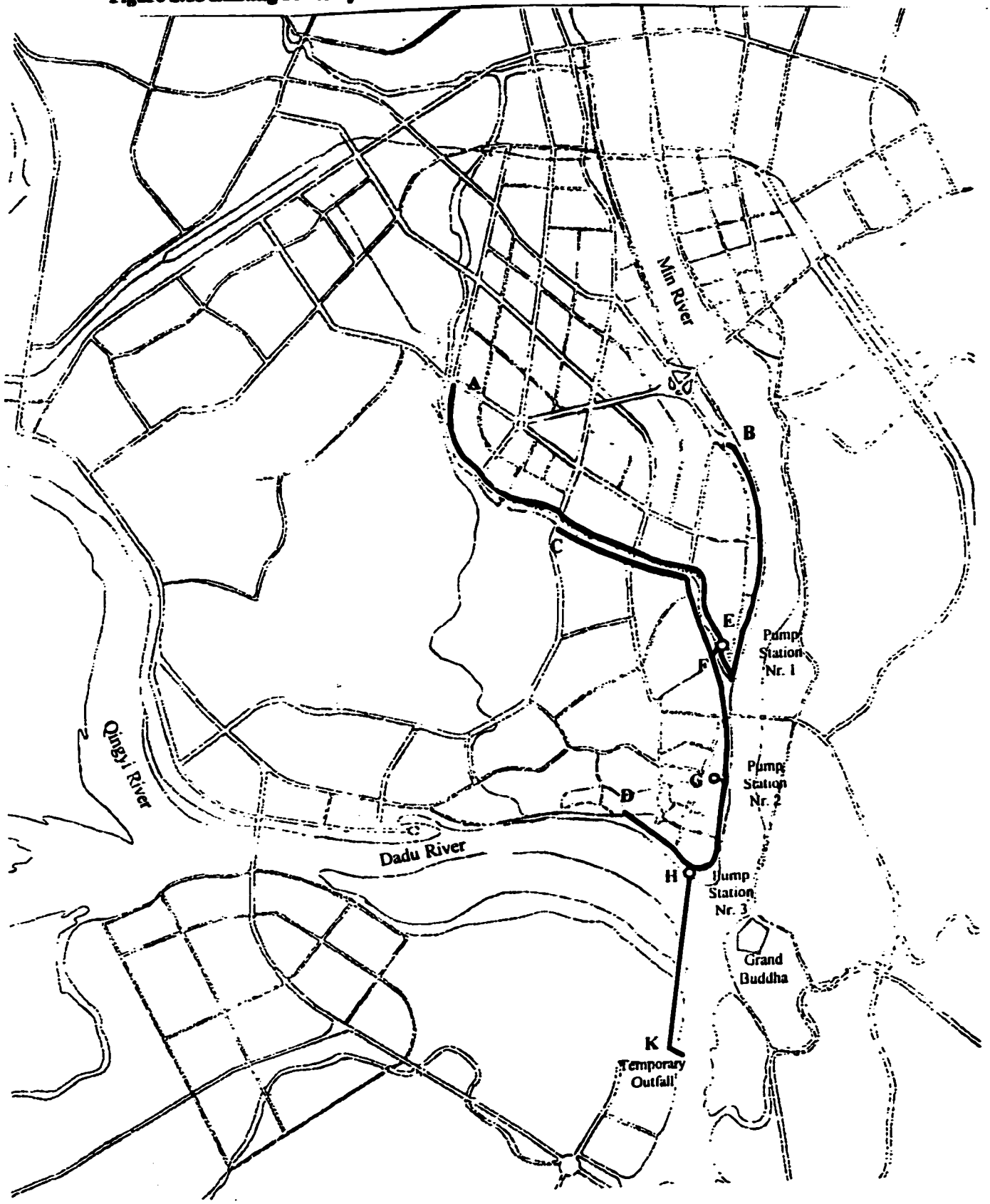
In summary, the scheme includes the following components:

- A 6.7 km interceptor, of 1.5 m square size, delivering wastewater from the termination of the existing sewerage system to the Deyang WwTW site.
- Inlet pump station with screening of raw sewage bypassed directly to the Mianyuan when peak flows exceed 130,000 m^3/d.
- The first phase of the Deyang WwTW with an average flow capacity of 100,000 m^3/d. (Future second phase will increase the wastewater treatment capacity at the site to serve the eastern and south-western districts of the city.)
- An outfall from the WwTW to the adjacent Mianyuan River (assumed 1.5m square culvert).
- A sludge management programme consisting of trucking the sludge (following dewatering) to the sanitary landfill for disposal. The SUEP project includes vehicles necessary for sludge transfer but not any modifications to the existing landfill.

Figure 2.13 shows the existing sewer systems in Deyang and **Figure 2.14** is the project schematic for the Deyang WwTW.

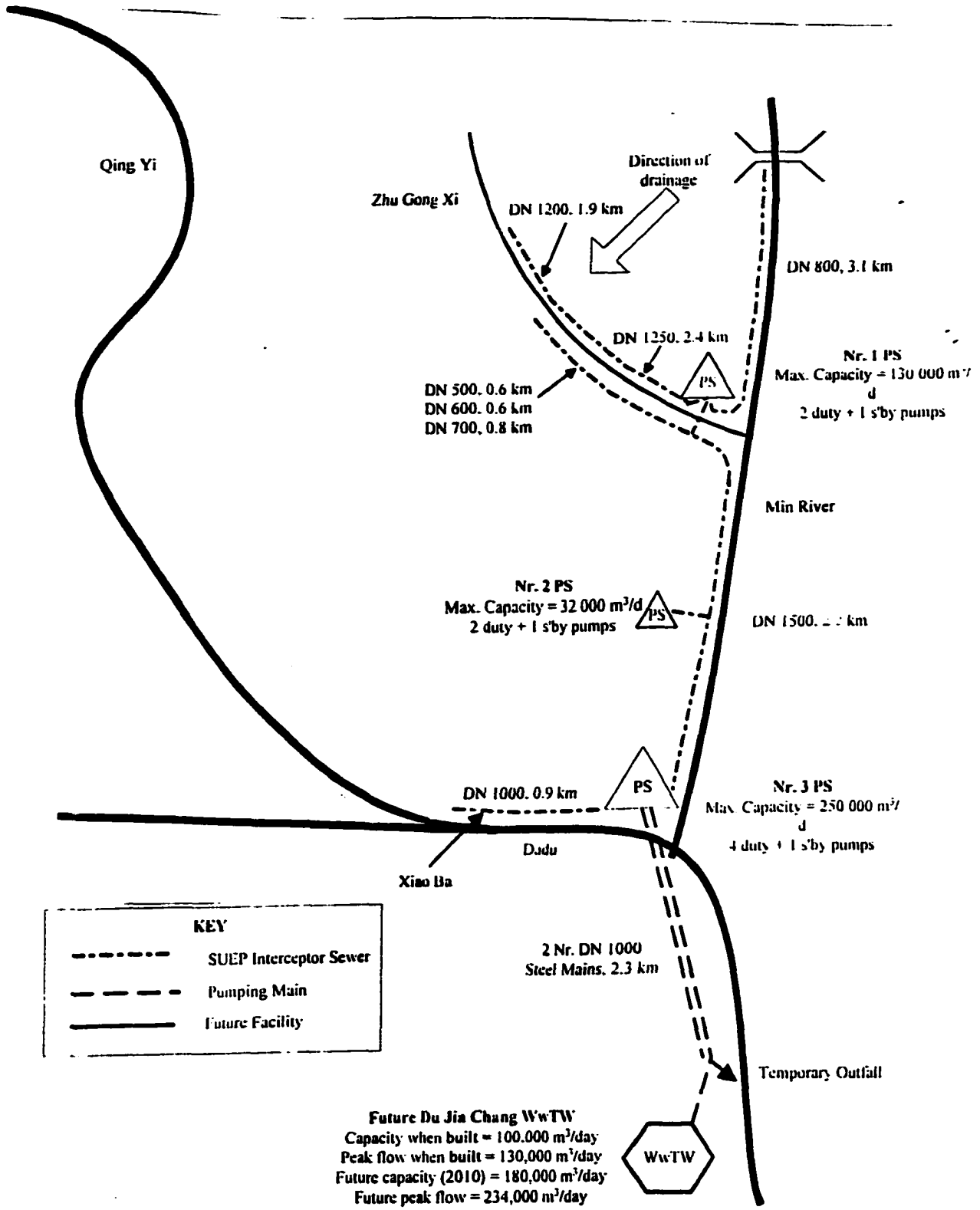
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Figure 2.11 Existing Sewer Systems in Leshan



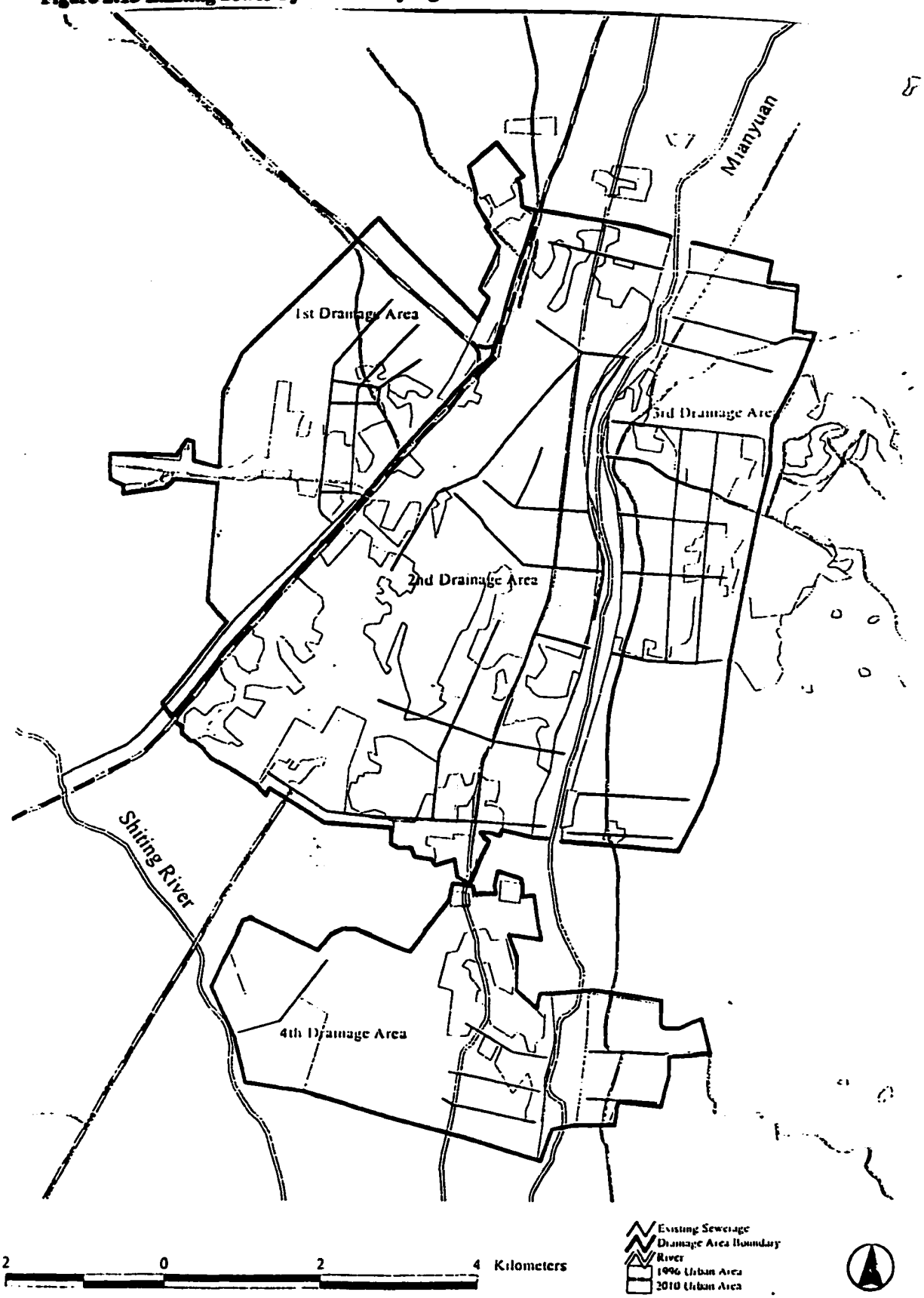
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Figure 2.12 Project Schematic for Leshan Wastewater Collection and Preliminary Treatment System.



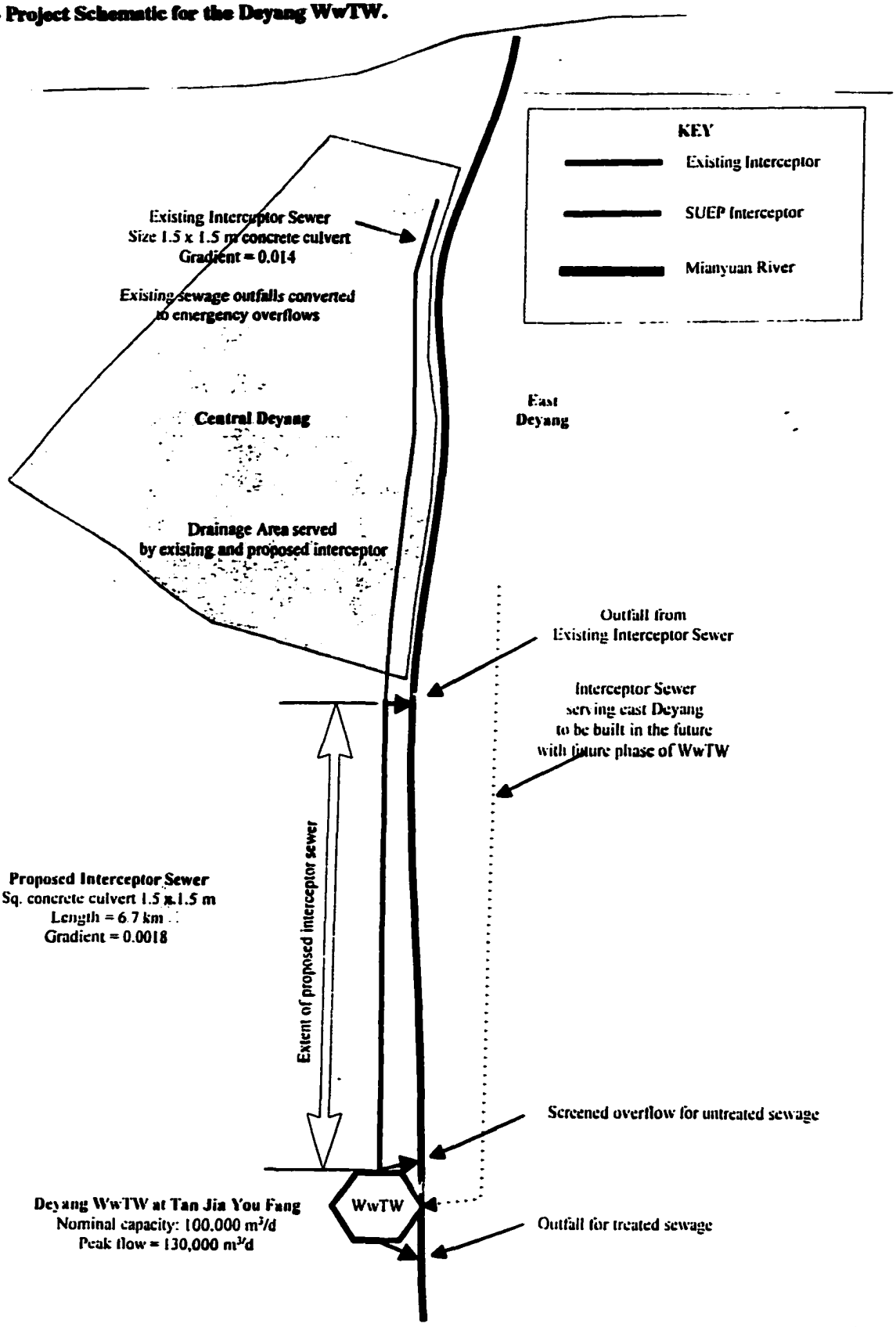
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Figure 2.13 Existing Sewer Systems in Deyang



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Figure 2.14 Project Schematic for the Deyang WwTW.



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2.3.8 Zigong WwTW

There are currently 88 raw sewage discharge locations in Zigong along the Fuxi River. The proposed interceptor sewers will be constructed on piers adjacent in the streambed of the Fuxi River, adjacent to vertical retaining walls in many locations, in order to intercept these outfalls. There are twelve sewer sub-catchment areas in the city and the proposed interceptor will collect the wastewater from seven of them, including the densely populated central areas. Further interceptors, pump stations and treatment capacity will be required for the southern suburbs and the outlying areas of Gongjin and Shuping. Many of the existing sewers are large culverts that also convey storm water from the combined sewer portions of the districts. Zigong intends to separate sewers where possible but the congested and steep portions of the center area are problematic for separation.

The proposed interceptor route essentially follows the Fuxi River from downtown, in many locations on piers located in the River adjacent to the walls forming the River's edge. In some cases it is tunnelled and in some cases it is in a buried section. In some locations it may be below the normal wet season flow level so special precautions will be incorporated to prevent floatation of the pipe and to prevent excessive infiltration into the pipeline. The pipe will be provided 1m of minimum cover when laid on ground sections.

The proposed interceptors be constructed of flexible-jointed concrete pipes and will range from DN 600 to DN 1600. Two pump stations are also required. The Shawan pump station will be located downtown and the Daijiaba pump station will lift all of the city sewerage to the WwTW location above the floodplain of the Fuxi River. Although the Fuxi River can have very low flows during the dry season, it is subject to extreme flooding situations as occurred during the wet season a couple of years ago.

The Shawan pumping station is located at the existing outfall from sewer catchment area 5. It will be 8.6m by 4.6m in plan and located in the river. The pump station will be 2m from the retaining wall and be accessed by a bridge. Provision has been made for emergency overflows to the river, and a second high flow overflow may also be added. It contains three submersible pumps, 2 duty and 1 standby and forced ventilation will be provided to the pump sump. Due to limited space, the distribution and control room may be located in an adjacent house. The Daijiaba pumping station is situated on a 60m by 54m site located on agricultural land adjacent to the Fuxi River. Incoming wastewater will be screened and solid wastes conveyed to the landfill. There are three duty and one standby pumps in the pump station. This pump station transfers the wastewater across the Fuxi River, and up the adjacent hillside to the WwTW site.

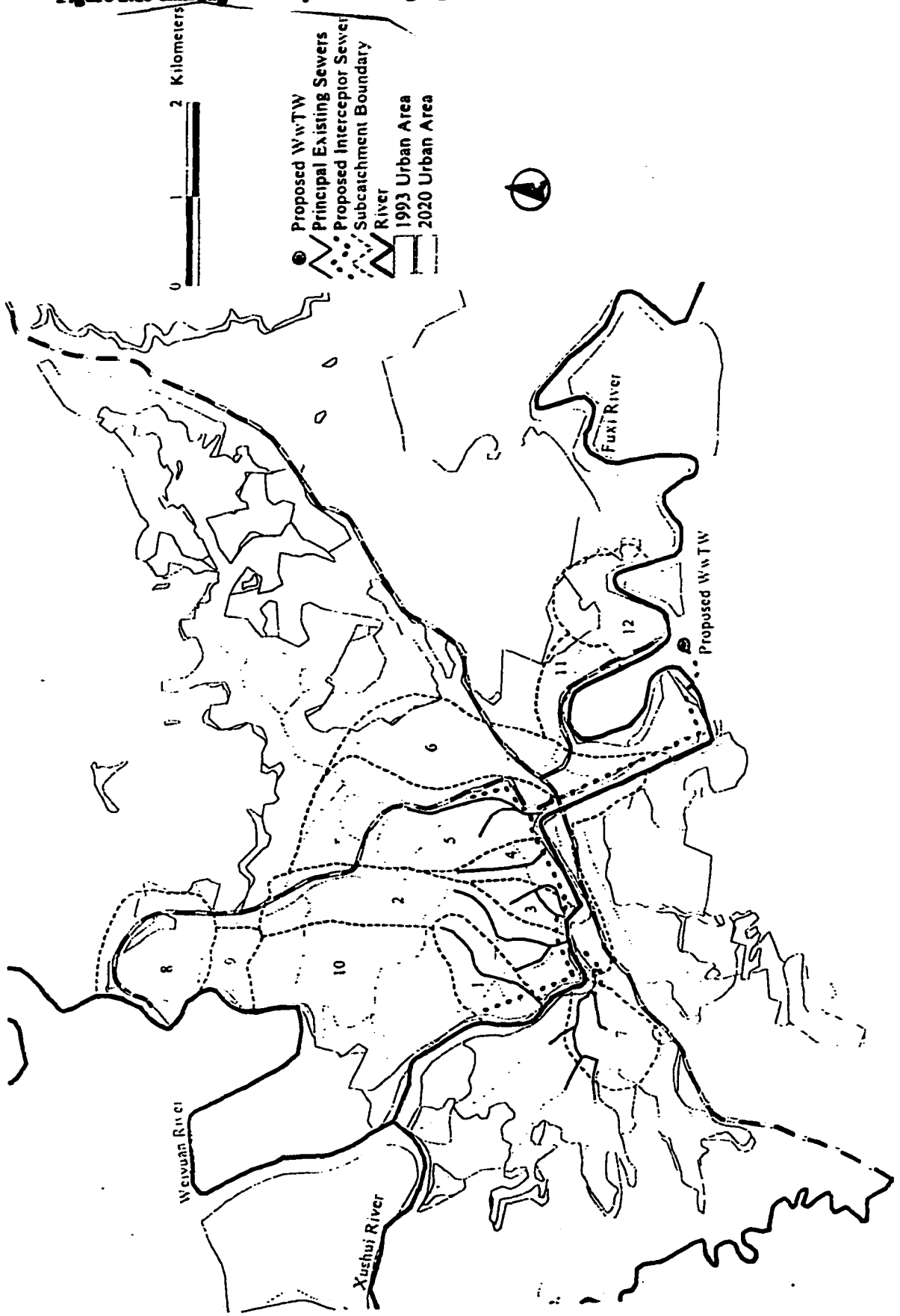
The WwTW site is located about 4km southwest of the city center but 7km downstream along the Fuxi River due to the meander of the stream. It is located on the south side of the Neiyi Highway and access is by underpass under the roadway. The design levels of the site are above the 100-year flood levels of the Fuxi River. In summary, the scheme includes the following components:

- Reinforced concrete pipe interceptor system of 5.2 km total length, in sizes of DN 600 to DN 1600, will collect the wastewater from seven existing major outfalls in the City.
- Pumping station at Shawan to lift the wastewater from an existing outfall into the new interceptor sewer.
- Pumping station at Daijiaba to forward the flows from the entire city to the WwTW site.
- Reinforced concrete pumping main of DN 1200 for 0.9 km.
- First phase of the Zigong WwTW with an average flow capacity of 120,000 m^3/d. (A future second phase will increase the wastewater treatment capacity at the site to serve other sewer districts of the city and outlying areas.)
- Reinforced concrete outfall pipe of DN 1400 from the WwTW to the Fuxi River.
- A sludge management programme consisting of trucking the sludge (following dewatering) to the sanitary landfill for disposal. The SUEP project includes vehicles necessary for sludge transfer but not any modifications to the existing landfill.

Figure 2.15 shows the existing sewer systems in Zigong and **Figure 2.16** is the project schematic for the Zigong WwTW.

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Figure 2.15 Existing Sewer Systems in Zigong



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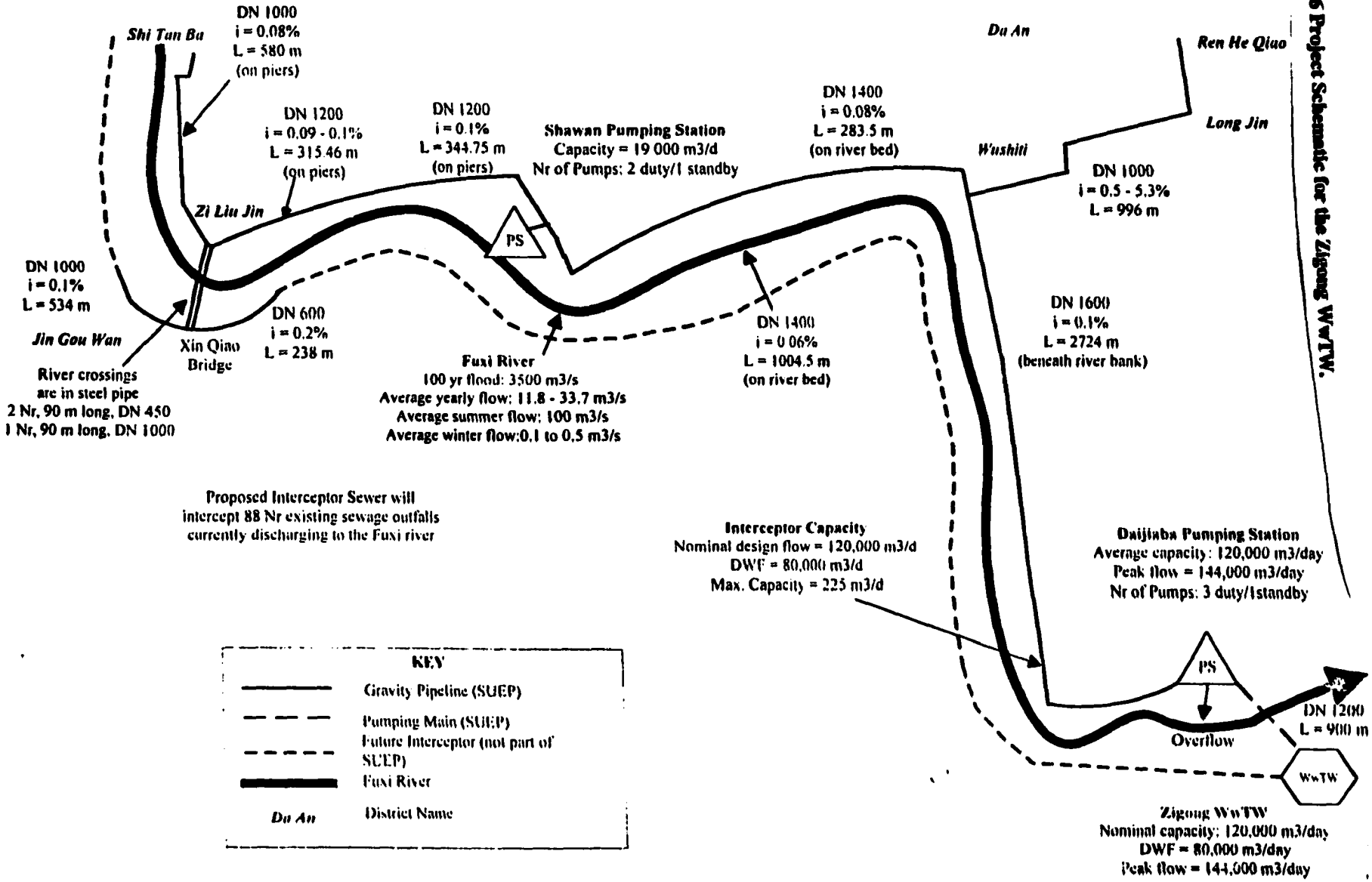


Figure 2.16 Project Schematic for the Zigong WwTW.

2.3.9 Leshan Municipal Solid Waste Project

The total population of Leshan city center is currently 223,000 including migrants according to the Leshan Master Plan. Low and high estimates of the population to be served in the year 2010 are 327,000 and 410,000 respectively. Leshan is a city with long-term growth plans based on tourism and expansion of the urban center. The present per capita MSW generation is estimated at 0.84 kg/d and is expected to grow with economic development to 0.96 kg/d in 2010. The City also has a design target to increase the proportion of MSW collected in the urban center from the 41% rate estimated in 1997 to 80% collected in the year 2000.

This project involves major improvements to the existing municipal solid waste (MSW) collection, transfer and disposal systems in the City of Leshan. Currently, there are four main methods of waste collection/transfer of MSW in Leshan:

1. The first method is the collection point, where bins are stored on or near the side of the road and are emptied daily by a truck. The bin is lifted by mechanical means and emptied into the storage area at the back of the truck (there is no compaction in the truck to increase the MSW density prior to transport).
2. The second method of transfer is to tip cart-loads or basket-loads on to a flat floor for hand loading by shovel into an open top truck for transport to the disposal site.
3. The third method of transfer is for basket-loads of waste to be carried up steps and loaded into a hopper with bottom opening doors about 2½ meters above ground level. The hopper doors are high enough from the ground for an open top truck to park underneath. When the truck is in place, the hopper doors are opened mechanically and the waste falls into the truck. The truck manoeuvres so as to distribute the waste throughout its length and then takes the uncompacted waste to the landfill.
4. The fourth method of transfer is by the use of containers set below floor level in a concrete floor in a warehouse. An overhead crane lifts the empty and full containers on and off transport trucks.

The proposed collection/transfer system will use rear-loader trucks to automate the loading of wastes into compactor trucks, or container and open trucks. Two new transfer stations are proposed in the project. The SUEP project will also provide six 10-ton open trucks, three 5-ton container trucks, twelve 5-ton rear-loading compactor trucks, ten 2-ton rear-loading compactor trucks and one repair truck. This will greatly automate the collection process, minimize human contact of wastes during handling, and make the transportation system much more cost-effective.

All municipal collection trucks travel from the collection and transfer areas about 7-km by road to an existing landfill site located to the south-east of the city near Ling Yun, well away from densely populated areas. A new road was constructed in 1997 that provides good access. A screening, composting and incineration plant is located at the entrance to the landfill but it is currently out of operation. This facility is not up to modern design standards, was closed due to air pollution concerns, and will be removed during implementation of the SUEP MSW project.

The landfill currently operates more as an open waste dump filling valleys between rock outcrops. Little preparation was made to the site prior to filling and the approach for waste filling has been end tipping on to a flat area of waste. A power shovel is used to push the waste over the very steep slope. Leachate pools are located on both tipping faces, and the older working area had approximately 0.30m of cover as well as gas vents consisting of rock filled cane baskets some of which were covered with grass.

A small anaerobic leachate treatment plant, described as experimental and not working, is located in the valley and untreated leachate leaves the site to downstream rice paddies and agricultural areas. During the 1997 wet season, it was measured at a rate of 100 m^3/day. It is a considerable distance to any surface waters from the site but the localized impacts due to exposure to workers and agriculture should be considered serious concerns. During high wet-season runoff periods, it may be conveyed downstream to the Dashi River, ultimately to the Min River.

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After a thorough review of alternative technologies and sites (see Chapter 8.5), the selected MSW disposal alternative involves expanding and upgrading the existing landfill site to meet international technical, safety, health and environmental standards. To accomplish this, the following issues will have to be addressed very carefully:

- Intermediate cover
- Control of leachate (short-term and long-term)
- Better control of landfill gas
- Better tipping method
- Better compaction
- A deeper layer of final cover
- A carefully phased tipping plan to blend the new site with the old.

The improvements to the existing site are designed to allow for collection, recirculation and treatment of the leachate before it is discharged, and the collection and flaring of landfill gas. The proposed design also uses a pattern of waste tipping into cells such that the levels rise from the low point of the site to the high point. The City must abandon the current practice of end tipping down a very steep, unstable slope. Improvement to the existing site is called Phase 1 and will last the city for at least four years.

Enlargement of the site, called Phase 2 and made possible by the purchase of additional land at the site, will enable improved the landfill system to continue for another eight years. Site investigations indicate that there is up to four metres of clay under the base of the site although this thickness tapers to near zero at the top of the rocky outcrops. This clay will be excavated leaving at least one meter of clay in the base and will be redistributed so as to provide the site with a clay seal up the sloping sides.

Figure 2.17 shows the existing MSW systems in the city of Leshan and **Figure 2.18** shows the project schematic for the improved MSW collection and landfill systems.

2.3.10 Urban Management Information Systems (UMIS)

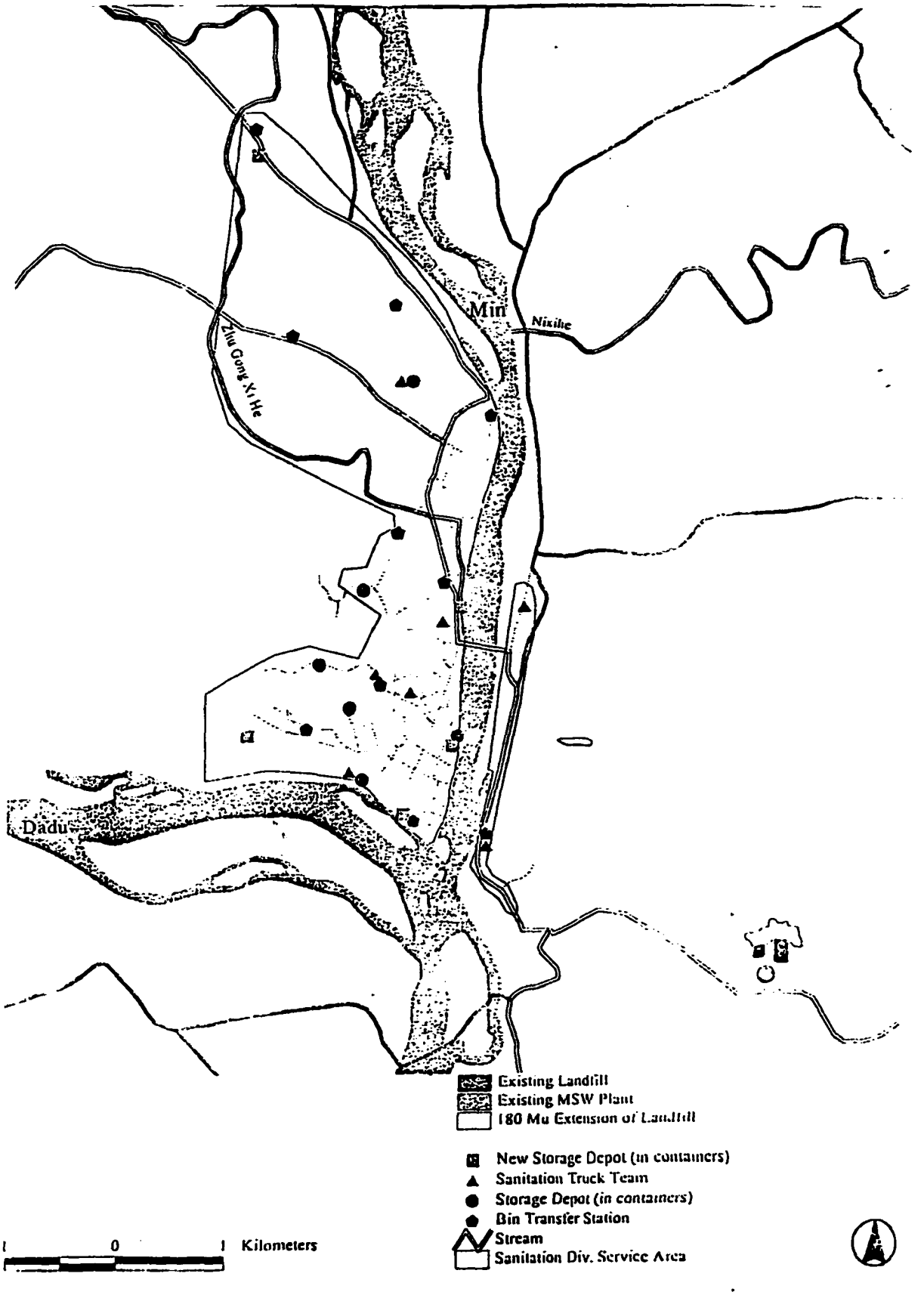
The Urban Management Information Systems (UMIS) component is being prepared for the Phase I of SUEP under support of the Canadian government. It would support the improvement of urban management practices in five project cities through the upgrading of computerised information systems and extensions and updating of urban mapping information. The immediate imperative for SUEP would to be improving decision-making by leaders and urban managers in project cities and within the Provincial Construction Commission by making appropriate information available on a timely basis. Urban management practices that will be addressed are:

1. strategic development and infrastructure planning, or the identification and prioritization of infrastructure investment requirements based on market demand,
2. capital investment

UMIS has minimal physical impacts and is not addressed in the EA.

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Figure 2.17 Existing MSW systems in Leshan



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2.3.11 Cultural Heritage

The Sichuan Province Cultural Heritage Strategic Master Plan (SPCHSMP) is now underway with funding support from the Italian government. The SPCHSMP is designed to assist the SPG in preparing a timely Strategic Master Plan (SMP), an Immediate Measure Action Plan (IMAP) and related investment programme. The SMP will enable the various ongoing and future conservation and rehabilitation activities to be undertaken in an integrated manner, including approaches which would balance improved management of Sichuan's cultural heritage assets with increased educational and tourism benefits. IMAP is designed to place steps in a coordinated and comprehensive policy and a set of best practices for Sichuan Province, which would be a model for use elsewhere in China.

The SPCHSMP is mainly a management component and was not addressed in the EA.

2.3.12 Technical Assistance

The WB considers it critical that institutions responsible for implementing and managing the SUEP projects equipped with the management and technical knowledge, skills and equipment necessary to carry out their mandates. A technical assistance (TA) needs assessment was underway at the time of the EA that will provide training and equipment to the provincial and city PMOs, Provincial and City EPBs, and the water, wastewater and solid waste operating companies or departments.

Of particular relevance to the EA, the WB has insisted on an overall environmental strengthening component in the area of environmental monitoring. This strengthening is aimed at improving the city and provincial ability to monitor and report on environmental conditions under stress, as well as providing the means to better assess the environmental performance of the Phase I investment package. The provincial and city EPB monitoring package will provide the means and mechanisms for complying with the mitigation monitoring outlined in the EA.

2.4 Cost Estimates for Proposed Projects

2.4.1 General

Project cost estimates were prepared for all Phase I SUEP projects in accordance with World Bank requirements. The cost estimates have been based on the preliminary design documents prepared by the local design institutes with subsequent clarifications and minor amendments as necessary. This costing exercise serves to verify the cost estimates prepared by the local design institutes and provides the basis of the subsequent financial and economic analysis of the viability of the scheme and the size of the World Bank loan which will be needed.

Cost estimates for the proposed scheme have been determined using the following data:

- unit rates for common elements of civil works derived specifically for this project;
- empirical cost functions for treatment works, previously used on other World Bank projects in China and calibrated for use on this project; and
- Chinese assessments of the costs of land acquisition, resettlement and compensation checked by the design consultants.

2.4.2 Capital Costs

A summary of the capital costs for the proposed schemes are shown in **Tables 2.10 to 2.12** below together with costs derived by both SWMEDRIC and CMDI for comparison. Power connection and land and resettlement costs are based on rates provided by the design institutes (DI) and extent of the works identified in the preliminary design documents.

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The capital costs include estimates of any customs duties and taxes on items expected to be imported directly for the project. The Chinese Government made significant changes to the levels of such duties and taxes at the end of 1997 and the revised rates have been used in this estimate.

Table 2.10 Cost Estimates for Water Supply Schemes

(M¥)	Leshan	Luzhou Beijiao	Luzhou Daxikou	Zigong
Prime Cost	109.5	126.7	65.9	323.4
Engineering Costs	12.9	15.3	7.8	38.9
Contingencies	27.5	32.2	16.1	82.7
Total Capital Cost	**149.9**	**174.2**	**89.8**	**445**
Annual Cost-M¥ pa	**10.13**	**10.17**	**6.95**	**38.64**

Table 2.11 Cost Estimates for Wastewater Schemes

(M¥)	Chengdu	Deyang	Leshan	Zigong
Prime Cost	550	208.2	82.4	173.4
Engineering Costs	62.7	24.1	10.1	20.3
Contingencies	131.3	50.0	20.7	43.1
Total Capital Cost	**744**	**282.3**	**113.2**	**236.8**
Annual Cost (M¥ pa)	**27.3**	**11.2**	**4.8**	**9.3**

Table 2.12 MSW Facilities and their Costs

Components of the Scheme	Estimated Costs (M¥)
1. Landfill	
Plant Items	11.77
Civil Works	18.81
2. Plant in the City	
Washers & Sweepers	4.08
Collection trucks	6.25
Other	0.43
3. Civil Works in the City	7.03
4. Land Acquisition	9.40
Total Prime Costs	**57.77**
Engineering Costs	6.66
Physical and Price Contingencies	20.6
Total Capital Cost	**85.04**
Annual Operating Cost (M¥ pa)	**1.63**

2.4.3 Operating Costs

Projected operating costs for Phase I projects have been prepared and can be found in the component feasibility reports. Civil and M&E maintenance costs were based on percentages of the base costs for constructing the works. Power, chemical and sludge transport costs were based on the predicted performance of the works as determined for the preliminary design. Staffing costs were based on those produced by SWMEDRIC.

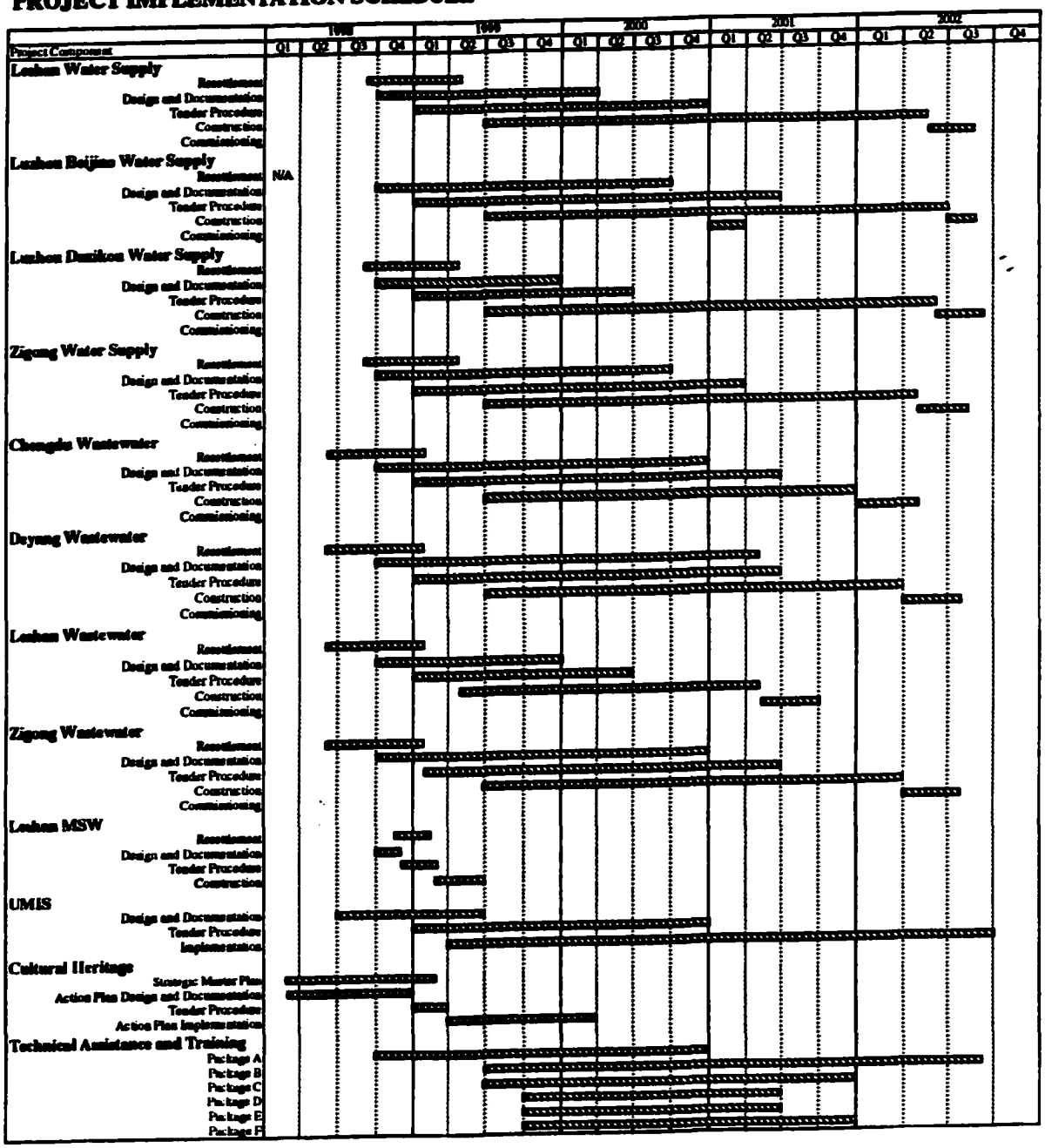
2.5 Implementation Schedule

An overall Phase I SUEP implementation program is shown in **Table 2.13**, based on the timetable for appraisal of fall of 1998. Individual component implementation programmes can be found in the component feasibility reports.

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Table 2.13 Implementation Program

PROJECT IMPLEMENTATION SCHEDULE



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3.0 Description of the Environment

3.1 Physical Environment

3.1.1 Geology

Sichuan lies at the eastern end of the collision zone between the Indian and the Euro-Asian continents. The Sichuan basin in the eastern part of Sichuan is a stable platform that have resisted the intense deformation of the collision zone, with the low mountains surrounding the basin formed in response to minor movements along the margin of the platform. The only area with significant recent sedimentation is the Chengdu plain, where the dissected basin topography has been buried under thick layers of gravel and sand washed out of the mountains by the Min river. The marine sediments deposited on the Yangtze platform are mainly dolomitic limestone and dolomitic shale, i.e., original mud with high content of calcium-magnesium-carbonate. Dry conditions are shown by Triassic salt deposits, which at Zigong have been extracted through 800 to 1,000 m deep boreholes for more than 150 years. Minerals vary in the study area and minerals of importance for each project city were identified. The largest recorded earthquake in the area was magnitude 5.6 on the Richter Scale with an intensity of 6. The earthquake intensity for structural design is 7. There is little concern relative to earthquakes for the type of projects being constructed under Phase I SUEP.

3.1.2 Topography

Although the Sichuan Province is surrounded by various mountain systems, the project cities tend to be located along waterways in rolling terrain. The Chengdu plain watercourses are fed by the Dujiangyan Diversion Scheme on the Min River at about elevation 700m. The main agricultural areas in the upper plain are from 400-600m elevation. The following sections relate the proposed projects and the surrounding landscapes:

Leshan Number 4 WTW
Elevation in Leshan along the rivers is approximately elevation 300-350m. The WTW was moved to a site away from the Qingyi River, in part to provide flood protection. It is a very flat site with little relief or surface preparation necessary.

Zigong Min River Diversion and WTW
The City of Zigong is located in the low hilly area in the south Sichuan, belonging to low hill and river valley landform. The height of the area ranges from 240m to 901m above sea level. The maximum difference of elevation is 661m. The height of the Fuxi River, the Yuexi River and their major tributaries are in the range of 265-500m. Generally there are two terraces in river valleys. The height from water surface of river to its high-rise bank is about 30m. Above the streambanks are various hilly landform on which spread dense and short streams and valleys.

For the proposed SUEP project, the proposed pumping station is sited on a solid rock foundation on the Min riverbank with a floor level of 289.1m AD. The river levels vary between a low level 292.82 m AD (95 percentile) to a high level of 306.329 m AD (99 percentile). The upper floor of the pump station is situated 1.6 m above the highest flood level at 307.82 m AD. The pipeline route is located in a narrow valley and there is little choice of location. The scheme involves pumping water over very hilly terrain through a total static head of 34 m to the water treatment works. The pipeline will then be located on the south verge of the road cutting off the corners of major road bends and with deviations to bypass the various villages.The route is extremely undulating with many deep valleys and peaks. There are four stream crossings along the pipeline route. The WTW site is relatively flat (<3% slopes) and above the flood levels of the adjacent Xushui river.

Luzhou Beijiao WTW
Luzhou is located along the Yangtze River in the transition belt of the Sichuan Basin Plain to Yunan-Guozhou Plateau. It is the connecting point with Yunan Province, Guizhou Province and Chongqing City. Topographically, Luzhou City declines from the south to the north. Southeast part is mountainous area and

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northwest broad area is low hill. The height of the area ranges from 250 m to 300 m above sea level. The WTW is located on a ridge above the Yangtze well above the flood elevations.

Luzhou Daxikou WTW
The height of the area ranges from 250 m to 300 m above sea level. The proposed Daxikou WTW site is located on gently rolling terrain, a combination of light forest and agriculture. Some grading will be required to prepare the site but it is above the Yangtze flood protection level.

Chengdu Long Quan WwTW
The proposed WwTW is to be built on the east side of the Fu River and 800m from the Yong An Bridge. The site is typical low-lying agriculture with a height is 487.2 - 484.8, while the adjacent Fu River has an average level of 484.0 and a flood elevation of 487.4. The topography of the site is very flat with a natural slope of about 2% from south-east to north-west. Filling and a small flood protection berm may be necessary to protect the site.

Leshan Wastewater Collection and Preliminary Treatment System
Elevation in Leshan along the rivers is approximately elevation 300-350m. There is only minor elevation relief in the SUEP project area including the sewerage systems, pump stations, outfall and future WwTW site.

Deyang WwTW
The area of Deyang is on the fan-shaped alluvial plain between Mianyuan River and Shiting River. The terrain of the city slopes gently with the northwest higher than the southeast and the gradient is 2~3%. The city is 500 m or so above sea level. The area is narrow and long with 163 km between the northwest end and the southeast end and 67 km between the northeast end and the southwest end.

The WwTW site is on sand and river gravels at a general level of 474m AD but there are some small depressions at 471m AD. The design level is 474.5m AD and about 16,000 m^3 of fill will be required. The site is relatively flat (<2%) slopes along the western bank of the Mianyuan River. The 1 in 50 year flood is at level 474.35 m AD and the 1 in 100 year flood is 474.7 m AD. A flood bank will be constructed to protect the site. The final effluent discharges through an outfall from a level of 476.1m AD and can therefore be discharged by gravity even at times of high flood.

Zigong WwTW
The height of the Fuxi River, the Yuexi River and their major tributaries are in the range of 265-500m. Generally there are two terraces in river valleys. The height from water surface of river to its high-rise bank is about 30m. Above the streambanks are various hilly landform on which spread dense and short streams and valleys.

The WwTW site is located in a reasonably flat area between hills at levels varying from 280m to 285m AD, but levels reach 307m AD in nearby hills. Considerable ground preparation will be required since the design levels are typically 288 – 289 m AD for the majority of the plant and 287m AD for the administration buildings. The site is 181m from the Fuxi River; the 50 year flood level in the river is 286.3m AD. Flood protection is therefore not a concern at the WwTW.

Leshan Municipal Solid Waste Project
Elevation in Leshan along the rivers is approximately elevation 300-350m. The area of the MSW landfill is in a small agricultural valley with significant relief. This topography was utilized in the MSW disposal plans.

3.1.3 Soils

Detailed soils reports were not available for the project sites but the preliminary information provided on general soil types was provided by the environmental institutes. There are no major issues relative to soils that should affect the Phase I project construction.

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3.1.4 Climate and meteorology

All project cities are located in the semi-tropical monsoon climate zone, and its climate is mild and wet. There is only a minor variation in climate from the southern city of Luzhou to the northern SUEP cities of Chengdu and Deyang. The following summary is shown for Chengdu as an example of the climatic features of the project area:

- Unique monsoon climate, warm in winter and cool in summer, four seasons, majority of precipitation between May and September, little frost and snow, low winds and many overcast days with frequent inversions, high humidity.
- Mean annual temperature is 15.5 °C to 16.5 °C and the absolute maximum temperature is 37.3 °C and the absolute minimum temperature is -5.9 °C.
- The annual frost-free period is 280 days.
- The mean annual wind speed is 1.2 m/s and the main wind direction is north to north-east. Winds are calm on average 46% of the time.
- Mean annual relative humidity is 82% with mean annual atmospheric pressure is 956 millibar.
- Mean annual sunshine time is 1238.6 hours and sunshine rate is 28%.
- The mean annual rainfall is 976 mm while the rainfall between May and September average is 816 mm, or about 86% of the entire year in wet season.

3.1.5 Air Quality

Like many urban areas in China, the ambient air quality is generally poor in SUEP cities with some variation due to topography and pollutant source mix. The topography in Chengdu, in particular, is susceptible to frequent and persistent temperature inversions. Relative to class II standard of GB3095-1996, TSP is the main pollutant and it exceeds the standards in the whole year. NO_x and SO_2 exceed the standards from 5-15% of the time.

There is some concern that these conditions will cause problems related to odor from the proposed Phase I WwTWs, especially since the existing Sanwayao WwTW has had serious odor problems. The temperature inversion near the ground will cause the worst conditions for this odor material. Conditions for inversions in Chengdu occur throughout the year. The frequency in the morning is 5%, in the afternoon is 22%. Intensity average at 7am is 0.81 C/100m, 7pm is 0.79 C/100m. The thickness at 7am is 278.1m and 7pm is 153.5m.

This odor potential is more fully discussed in the impacts and mitigation section. It is hoped that proper design and operation of the WwTWs will greatly reduce odor problems. There are few residences or sensitive receptors in the project areas and appropriate mitigation measures are proposed.

3.1.6 Noise

All major urban areas in the province have locations in the urban area that exceed ambient noise standards. Details of monitoring of these urban areas were identified in the Chinese EAs. Monitoring of ambient noise levels was also conducted at proposed project sites and used in detailed noise modeling by SRIEP. Details of this modeling and recommended mitigation measures can be found in chapters 5 and 7.

3.1.7 Surface and Groundwater Hydrology

The overview of regional water resources was provided in section 1.2.2, since improved water quality is a major target of the SUEP projects. Water quality issues are dealt with in great detail in chapter 4.3 on river systems. The Phase I SUEP projects have concentrated on urban water resources and water quality issues. The COWI/DHI water resources modeling and strategies contain significant information on the overall water resource conditions and wastewater loadings from other pollutant sources in the study area. Areas such as industrial wastewater, agricultural water usage and water quality impacts, nonpoint pollution control and related issues were not significantly addressed in the Phase I of SUEP. These issues will be re-visited in later phases of SUEP, but the proposed interventions of Phase I are necessary regardless of the

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ongoing efforts to development an integrated system for water resources and water quality decision-making in the Province.

Agriculture is by far the most water-consuming sector in the province. From the present average consumption of 37 million m^3/day, it is expected that (despite a decrease in agricultural land) the irrigated agriculture may increase to 40-45 million m^3/day in 2010. The general agricultural practices with widespread terraces provides barriers capturing the natural runoff and favors high water losses by evapotranspiration, thereby limiting the water available for the major cities. Since irrigation mostly coincides with dry weather conditions, the irrigation is a determining factor for the water resources availability in low flow conditions, many times the key factor determining conditions for urban areas.

The pollution level in Jinsha-Yangtze and Jialing rivers is generally low, but the entire Tuo river and parts of the Min river are polluted by wastewater. Small rivers like the Fu in Chengdu and the Fuxi in Zigong are heavily polluted. According to COWI/DHI, the main pollutants are mostly confined to the following:

- micro-organisms including bacteria from households and husbandry
- degradable organic matter from households and industry
- ammonium/ammonia from households and industry
- eutrophication caused by discharges of phosphorus and nitrogen

The environmental impacts caused by discharges of total ammonium are:

- toxicity to aquatic life of free ammonia (NH_3)
- consumption of river water oxygen by nitrification
- deterioration of drinking water quality (even after waste treatment)
- contribution to eutrophication

The groundwater potential within Sichuan is generally low except for the Chengdu plain. The shaly sediments and metamorphic schists that dominate the Sichuan basin have very low porosity and permeability, so groundwater is limited to fractures in the basement rocks and to alluvial deposits in valleys and other low lying area. Along the major rivers, alluvial terraces of sand and gravel may serve for significant abstraction by river bank infiltration and provide substantially better water quality that can be obtained from the surface water due to natural filtering through the sand and gravel. The Chengdu plain sand and gravel has a high potential.

3.2 Biological Environment

The individual SUEP project components include general information about the flora and fauna of the Sichuan Province and SUEP cities. The project areas are a combination of urbanized areas and intensive agriculture with no undeveloped land affected. As such, native species of flora and fauna are few. The polluted levels of the watercourses limits aquatic life to a great degree.

3.2.1 Flora

The rural Phase I sites and project areas contain only common plants such as eucalyptus and pine, and the areas are either urbanized or used for agriculture. There are no undeveloped areas impacted.

3.2.2 Fauna

There is only domestic poultry located in the study areas, no wild animals are located in the vicinity of any Phase I projects.

3.2.3 Special Issues

There were no special issues noted in the project areas such as sensitive plant or aquatic species, wetlands or wildlife habitat, cultural or historic sites (except as noted in section 3.4), or sensitive receptor groups.

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3.3 Socio-cultural Environment

3.3.1 Project Area Overview

The total population of Sichuan was estimated to be 82 million after the separation of Chongqing in 1997 (6.6% of the population of China), with a 'Natural Growth Rate' of 9.87% (1995). This growth is approximately midway between the highest figure of 15.12% for Qinghai and the lowest of 3.35% in Shandong. The total fertility rate is reportedly now very low in China as a whole; a figure of 1.99 live births for women between 15 – 64 is recorded as of October 1st 1995. With such a low birth rate and a high life expectancy the number of the population of pensionable age is increasing. This has implications for cost recovery as the increasing percentage of the population on low incomes (pensions) reduces the ability to pay introduced charges. Males outnumber females in the total population of China: a ratio of 51.03: 48.97. Although this population statistic indicates a significant feature of Chinese society, it does not present issues of significance for the project.

There is considerable rural-urban migration in Sichuan. The migrant population has a higher proportion of males than females. They represent an important source of low-cost labor and it is suggested that the construction sector draws 60% of its workforce from temporary migrants. It is not clear what impact this significant number (8 million rural migrants seeking work in the cities of the Western Yangtze Region (WYR)) will have on demand for services in the six cities and if this will have any implications for cost recovery. In terms of demand, it is likely that new migrants to cities while increasing demand for services will not do so in proportion to numbers. Their obligation to pay for services because of the lack of urban resident status mean that their demand is lower than those of the resident population. However, migration regulations have been considerably relaxed over recent years. As policies continue to evolve and migrants are granted official residence status, their access to free or subsidized water will be the same as those of the existing urban population. This could change the potential income levels from utility user fee charges. The lower status employment that the migrants are engaged in result in lower incomes; the higher level of expenditures on items such as schooling, health, housing and water mean that their capacity to make choices on further expenditures (user fees) are considerably compromised. Their access to services may be lower than that of other urban groups.

Although ethnic minorities only comprise 4.1% of WYR's population, in some prefecture minorities form the largest group of the population. They tend to be concentrated in the most rural and remote of the districts with relatively low GDP outputs. One of the pull factors of rural urban migration is the higher incomes available in urban areas. It seems likely therefore that within the cities with high numbers of immigrants, representation of ethnic minorities will be significant. The relationship between migration and minorities status needs to be established because of the lower 'human capital' generated within the ethnic minority groups. This may have an impact on reducing their demand for services due to lower levels of exposure to health information and lower education levels.

Women share equal rights with men in China. However, responsibilities with daily activities appear to result in women being employed in jobs which enjoy less responsibility, status and salary. While the projects are likely to have social benefits for all groups, women's interests in the impact of the project are likely to be greater than those of men within the domestic arena. They have the main household responsibilities which require access to and use of water, and for cleanliness of the household and surrounding environment.

The incidence rate for infectious and parasitic diseases in Sichuan is up to double the national average, reported to be about 180 per 100,000 in 1995. These diseases are largely water related and therefore indicate the relevance of a programme which aims to improve water and sanitation. The national incidence of Hepatitis A, also a water related disease, has risen to such an extent that the Government has launched a campaign for its control. The main health issues of concern for the project are the need to reduce infectious

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and parasitic disease, and to monitor and control toxic waste emissions and prevent them entering the food chain. Improvement to the monitoring, diagnosing and reporting procedures is recommended.

The number of households in Sichuan in 1995 (1 October) was 34.53 million. Average household size was 3.3 persons, with just over 34 % of households having 3 persons. The labor force was 63.4 million, with 63 % working in the primary sector, 16 % in the secondary sector and 21 % in the tertiary sector.

The average wage in Sichuan in 1995 was ¥ 4645 per annum, compared to the national average of ¥ 5500. Wages in the agriculture, forestry and fishery sectors were ¥ 3 868, in manufacturing they were ¥ 4622, in the utilities they were ¥ 5950, in the construction industry they were ¥ 4 851 and in government agencies ¥ 5087.

Annual per capita disposable income in 1995 was ¥ 4003, compared to the national average of ¥ 4283. Annual per capita living expenses were ¥ 3429, compared to the national average of ¥ 3538 (living expenses refers to the total expenditure of households for daily life, excluding fines and taxes - China Statistical Year Book 1996). Expenditure on food accounted for 51.3 % of living expenses and the cost of household facilities, articles and services amounted to 8.6 % of living expenses.

3.3.2 Social and Public Health Issues

The social impact of the project has been considered upon the basis of data collected from willingness-to-pay surveys, resettlement action plans and information from the city. In all of the cities it was found that people had a high degree of awareness of the importance of public health issues and a good understanding of the links between environmental conditions and health. A high proportion of those interviewed expressed a willingness to pay for services but quantitative results, in the most part, were not obtained. Quantitative data on willingness to pay in Chengdu has had to be used as a basis for assessments elsewhere.

Social behavior, gender issues, household income patterns, health and needs for social awareness have been covered for each of the five cities. Details of these findings can be found in the feasibility reports for each Phase I component project.

Resettlement and compensation planned have been covered in a separate "Resettlement Action Plan". At this stage this report is in draft form and will be submitted to the World Bank in final form, on schedule, one month before Appraisal of the SUEP. In **Table 3.1** the main findings of the draft RAP are summarized.

Table 3.1 Summary of Draft Resettlement Action Plan

	Chengdu	Deyang	Leshan			Luzhou		Zigong		Project Total
	WW	WW	WS	WW	MSW	Daxikou WS	Beijiao WS	WS	WW	
Nr. of people to be resettled	1190	20	5	30	165	30	10	132	180	1762
Land Area to be used (mu)	280	200	66	16	240	28	40	122	224	1216
Total Cost (M¥)	**131**	**23.6**	**0.4**	**7.7**	**13**	**2.2**	**1.3**	**34**	**14.6**	**1544.8**

3.3.3 Finance and Economics

Details of the finance and economic evaluations conducted can be found in the full SUEP Phase I appraisal reports, and summaries of this information is contained in the EA project feasibility reports for each Phase I component project. The main economic and financial indicators for the schemes and the water utilities are summarized in **Table 3.2.** The AICs for Zigong are unusually high because 40 % of raw water is fed to an

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existing WTW and therefore costs have been set against only 60% of the flow, while those for Luzhou - Beijiao are high due to costs of the pipeline to Fuji.

Table 3.2 Economic and Financial Indicators for Water Supply Schemes

	Leshan	Luzhou Beijiao	Luzhou Daxikou	Zigong
AIC - financial, at 10% pa (¥/m^3)	0.81	1.78	0.94	1.94
AIC - economic, at 10% pa (¥/m^3)	0.73	1.56	0.83	1.65
At tariff (¥/m^3)	1.25	1.0	1.0	2.8
FIRR after tax (% pa)	10.5	9.5	10.0	9.2
EIRR (% pa)	15.1	14.2	15.1	15

All schemes have been found to be affordable when personal costs incurred, based upon the tariffs generated by utility level analysis, are compared with the lower 10 percentile incomes. Willingness to pay surveys indicate that a high percentage are prepared to pay for improved services and the tariffs proposed appear to be acceptable. The main economic and financial indicators for the wastewater components are presented in **Table 3.3.**

Table 3.3 Economic and Financial Indicators for Wastewater Schemes

	Chengdu	Deyang	Leshan	Zigong
AIC - financial, at 10 % pa (¥/m^3)	0.88	1.16	0.26	0.69
AIC - economic at 10% pa (¥/m^3)	0.73	0.87	0.20	0.59
At tariff (¥/m^3)	1.2	1.5	0.35	1.0
FIRR after tax (% pa)	8.5	9.3	10.2	9.1
EIRR (% pa)	15.3	16.1	14.8	16.2

Comparison of projected tariffs with lower 10 percentile incomes shows all proposed tariffs to be affordable.

For the MSW component, economic and financial indicators for the scheme are summarized in **Table 3.4** for both the medium and the low growth cases.

Table 3.4 Economic and Financial Indicators, MSW

	Medium Growth	Low Growth
AIC – financial, at 10% pa (¥/t)	118.8	133.2
AIC – economic, at 10% pa (¥/t)	99.7	113
MSW levy (¥/t)	115	136
FIRR (%)	11.5	9.7

3.3.4 Institutional Issues

Institutional analyses have been conducted to establish the needs to be able to achieve sustainable operation and management of the utilities to be responsible for the works to be funded under the World Bank loan for the Phase I SUEP. Proposed water supply projects will be owned and operated by existing enterprise water companies. There are no wastewater companies in Sichuan Province and progress with the formation of the new utilities to cover wastewater works has been slow. Proposals have been prepared by the cities on the structure, responsibilities, working methods, staffing, assets, financial management and institutional strengthening needs. Preliminary assessments of institutional strengthening needs have been identified.

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3.4 Areas of Special Designation

3.4.1 Endangered Flora and Fauna

China has published a listing called the "Chinese Rare and In Severe Danger Protection Plant List" in 1986 by the Environmental Protection Committee of the State Council. It was subsequently revised in 1987 by NEPA. In addition, China published a "State Key Protection Wildlife List" which was approved by the State Council in 1988.

SRIEP used these listings, consulted local EPBs and scientific research institutes, and provided copies of the publications to the project office. There were no listed species in the project area that could be impacted by the SUEP project construction according to SRIEP.

3.4.2 Historic and Cultural Sites

The national law covering protection is called the "Law of the People's Republic of China on the Protection of Cultural Relics" which was adopted by the 25th Meeting of the Standing Committee of the Fifth National People's Congress and promulgated by Order No. II of the Standing Committee of the National People's Congress on November 19, 1982. The province has also passed cultural protection regulations in the Provincial People's Congress on December 23, 1982 and revised on November 30, 1985. They are called the "Regulations for Cultural Heritage Preservation of Sichuan Province."

The SRIEP consulted with the cultural heritage offices of the province in the preparation of the EAs and found that no protected sites were affected by SUEP components. The temporary sewage outfall location in Leshan is not in the protection area of the Grand Buddha but pump station 3 at the Dadu and Min confluence is located in the protection zone. There have been limited efforts to locate and protect cultural and historic "assets" in the province and another SUEP component (funded by the Italian government) is looking into additional measures to locate and protect assets.

3.4.3 Parklands or Other Special Sites

There were no sensitive areas or receptors noted in any of the nine component project areas such as parklands, schools, hospitals or other that needed special protection from the proposed SUEP construction or operational impacts. There are 3 natural preserves near Leshan but not affected by this project: Dafengding Natural Preserve (in Mabian County, at national level), Wawu Mountain Natural Preserve (in the joining place of 3 counties of Hongya, Rongjin and Hanyuan, at provincial level) and Heizhugou Natural Preserve (in Ebian County, at county level).

3.4.4 Watershed Protection Zones

The national and provincial authorities have made significant institutional strides toward protecting watersheds, especially those related to municipal water supplies. Industries are directed away from these watershed protection zones and existing polluting industries are given incentives to close and/or relocate. However, there is enormous competition for the water resources of the province, even though they are abundant. The Chengdu Plain is one of the most productive agricultural areas in China, a country that reportedly feeds its population on only 15% of its land area. This historic agricultural use is increasingly being stripped due to the synergistic industrialization and urbanization of the Province. The increase in competition for water leads one to question whether there should be an expansion of the watershed protection concept into legal and institutional methods to allocate water on a watershed basis, using a variety of economic, legal, social and environmental criteria.

SRIEP has analyzed the impacts of proposed wastewater and MSW projects on existing watershed protection zones and also recommended detailed watershed protection measures for the proposed WTW under the Phase I SUEP projects.

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4.0 Environmental Management and Problems

4.1 Water and Environmental Institutional Arrangements

The Constitution of the People's Republic of China (1982) provides the framework for environmental protection law in China. Article 26 of the Constitution stipulates that the "the State protects and improves the living environment and the ecological environment, prevents and remedies pollution and other public hazards." National legislation is comprehensive and appears to cover most areas of environmental concern. However, the level of enforcement in Sichuan (as the rest of China) is clearly often less than satisfactory. The Chinese economy continues to grow rapidly and there is often a trade-off between the strict enforcement of environmental legislation and promoting economic growth and employment.

4.1.1 National Level

Table 4.1 shows the national water and environmental laws were provided in the COWI/DHI draft Phase I Inventory Report dated March 1997 that impact or are potentially impacted by the SUEP Phase I projects:

Table 4.1 National Water and Environmental Laws Important to SUEP (COWI/DHI)

SECTOR	LAW
Water and Wastewater	Water Law of the PRC Water Pollution Prevention Law of the PRC Implementing Regulations for Water Pollution Prevention Law of the PRC Water Pollution Control Technical Strategy issued by the People's State Council, PRC Temporary Managing Method for Water Pollution (license for discharging water pollution) Environmental Protection Supervision Management Method for Sewage Treatment Facilities Pollution Control Management Regulation for Water Sources, Protection Zones for Drinking Water Temporary Method for Collecting Discharge Fees Financial Management and Accounting of Collection of Discharge Fees
Environmental Protection	Environmental Protection Law of PRC Environmental Protection Law and regulation of the atmosphere Regulation for Noise controls National Environmental Monitoring Management Regulation Environmental Protection Law and Regulation for Enterprises Owned by Street Commission
Natural Resources	Protection Law and Regulation for the Natural Environment Land Management Law of the PRC Forest Law of the PRC

The national laws and regulations are supported by standards which stipulate the quality to be achieved in water, wastewater and solid waste management. Some of the more important standards relative to the SUEP projects and the EAs include:

- GB 3838-88 Environmental Quality of Surface Water

All surface waters in China have been classified according to these ambient stream standards. The following is a general translation of the surface water classes:

Description of Surface Water Classifications:

I - Beginning of rivers and national protected areas
II- Drinking water area, endangered fish, water needing animal area, national/provincial famous visitor area
III - Drinking water source, common fish area, famous city visitor area
IV - Common industrial use, recreation
V - Agriculture area (separate standards also apply to agricultural irrigation water but rarely enforced)

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Table 4.2 provides the numerical standards associated with these classifications:

Table 4.2 Environmental Standards for Surface Water, National Standard GB 3838-88, issued 1 June 1988

Parameter	Unit	Stream Classifications				
		I	II	III	IV	V
Tmp.	°C	average inc in summer < 1; avg inc. in winter < 2				
pH		6.5 – 8.5				6-9
Sulphate	mg/l	250				
Chloride	mg/l	250				
Fe	mg/l	0.3	0.3	0.5	0.5	1.0
Mn	mg/l	0.1	0.1	0.1	0.5	1.0
Cu	mg/l	0.01	1.0(fish 0.01)	1.0(fish 0.01)	2.0	2.0
Zn	mg/l	0.05	1.0(fish 0.1)	1.0(fish 0.1)	2.0	2.0
Nitrate	mgN/l	10	10	20	20	25
Nitrite	mgN/l	0.06	0.1	0.15	1.0	1.0
Ammonia	mgN/l	0.02	0.02	0.02	0.2	0.2
Kjeld. N	mgN/l	0.5	0.5	1	2	2
Total P	mgP/l	0.02	0.1(lake .025)	0.1(lake 0.05)	0.2	0.2
COD(Mn)	mg/l	2	4	6	8	10
Oxygen	mg/l	> 90% sat.	6	5	3	2
COD(Cr)	mg/l	15	15	15	20	25
BOD5	mg/l	3	3	4	6	10
Fluoride	mg/l	1	1	1	1.5	1.5
Se	mg/l	0.01	0.01	0.01	0.02	0.02
As	mg/l	0.05	0.05	0.05	0.1	0.1
Hg	mg/l	0.00005	0.00005	0.0001	0.001	0.001
Cd	mg/l	0.001	0.005	0.005	0.005	0.01
Cr+6	mg/l	0.01	0.05	0.05	0.05	0.1
Pb	mg/l	0.01	0.05	0.05	0.05	0.1
Cyanide	mg/l	0.005	.05(fish .005)	0.2(fish .005)	0.2	0.2
Phenols	mg/l	0.002	0.002	0.005	0.01	0.1
Oils	mg/l	0.05	0.05	0.05	0.5	1.0
Detergents	mg/l	0.2	0.2	0.2	0.3	0.3
E. coli	no/l	-	-	10,000	-	-
PAH	mg/l	2.5×10^{-6}	2.5×10^{-6}	2.5×10^{-6}	-	-

The provincial recommendations for classifications of rivers are as follows:

Jinsha/Yangtze; The water quality at Panzhihua and upstream shall fulfill the requirements of Class II standard; downstream of Panzhihua the water quality shall be Class III. (The Jinsha becomes the Yangtse at Yibin with the inflow of the Min River)

Min River; The water quality shall reach to a Class II in the upper sections and Class III in the remaining part of the river, necessitating construction of new wastewater treatment plants. (Class III is also targeted for small tributaries but this may be unrealistic due to dry season flow conditions in places such as Chengdu.)

Tuo River; The water quality at Deyang and upstream shall be Class II and Class III downstream of Deyang. All small paper mills (capacities less than 10,000 tons) shall be closed down and a number of

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wastewater treatment plants shall be constructed. (Low dry-season flows at Deyang may preclude the ability to meet Class III standards cost-effectively.)

Jialing River; The water quality in Nanchong and upstream shall be class II and the remaining part shall be class III.

- CJ 3020-93 Water Quality Standard for Drinking Water Sources
- CJ 3025-93 Water and Sludge Disposal Standards for Domestic WWTP
- GB 8979-96 Comprehensive Discharge Standard for Wastewater (All)

The Provincial EPB indicates that this national discharge standard is the most widely used and the Provincial discharge standards shown in the next section are usually not applied. This revised standard went into effect on 1/1/98.

- GB 5084-92 Agriculture Irrigation Water Quality
- GB 11607-89 Fishery Water Quality Standard
- GB 12941-91 Landscape and Recreation Water Quality Standard of the PRC

These standards have been obtained but monitoring for compliance and enforcement is essentially non-existent at this time and therefore they are not considered relevant to the SUEP Phase I projects.

- GB 4284-84 Agricultural Use of Sludge
- GB 3096-93 Standard for Environmental Noise of Urban Area
- GB 3095-1996 Ambient Air Quality Standard

These standards are relevant to the SUEP projects and have been incorporated into the assessment of construction and operation impacts. The most important standards related to SUEP Phase I projects were identified.

4.1.2 Provincial Level

Environmental management at the provincial level is performed in accordance with an integrated system of environmental control from the national to local levels. **Figure 4.1** shows the general relationships of the provincial level EPB in relation to the other levels.

The provincial level can produce certain powers through the Legal Systems Bureau to assist in the drafting of legislation and regulations that are produced at the provincial and municipal levels. The main provincial laws that are concerned with water and wastewater management are:

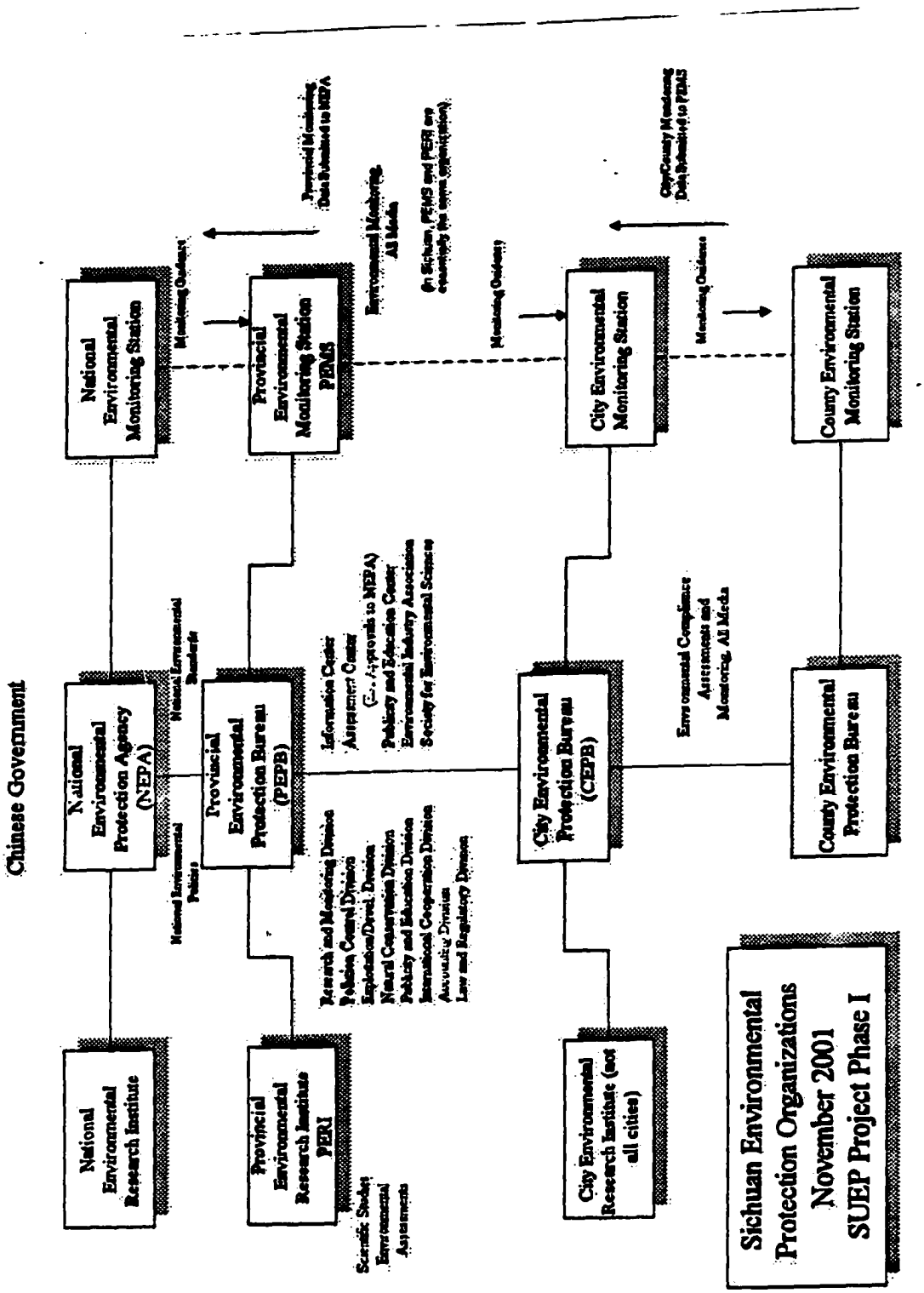
- The Regulations on Water Resources Conservation and Protection of the Changjiang River in Sichuan (1988)
- Regulations on Environmental Protection in Sichuan
- Sichuan Provincial Discharge Standards, DB51/190-93

Provincial Discharge Classes

A = Tuo, Mianyuan, Fuxi, all Chengdu Rivers
B = Minjiang above Leshan
C = Upper Yangtze, Dadu, Qingyi, Min below Leshan, Yangtze

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Figure 4.1 Environmental Regulatory Structure



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4.1.3 City and County Level

The City and County level EPBs are mainly involved in monitoring and enforcing standards and regulations set by the national level (NEPA) or the Provincial EPB. There is, however, some local level planning for environmental management such as the environmental improvement study being conducted by JICA for the city of Chengdu.

4.2 Attainment of Goals, Standards, Regulations

China has put the issue of environmental protection as one of its fundamental policies for the country's sustainable development. It is the national goal that the present pollution situation shall be alleviated so that all the major cities shall be improved in terms of environment quality by the year 2000. One of the main policy statements is the so called "three at the same time" which means that planning, implementing and progressing shall be achieved simultaneously with economic development, urban/rural development and environmental improvements. Other main policy statements include:

- prevention combines with mitigation and prevention is the preference
- pollution shall be mitigated by the one who has generated the pollution(polluter pays)

Concerning water quality, the following issues are focused on:

- control of industrial discharge of heavy metals, organic and chemical pollutants
- introduction of clean technology, updating of production procedures to conserve water and to increase production efficiency
- construction of domestic wastewater treatment plants to improve the environmental quality in urban areas and to reduce the pollution of rivers
- improvement of surface water quality by means of river pollution mitigation, water resource conservation, and enhanced management of the water sector

The Sichuan Province, in line with the national policies, has set the following year 2000 targets:

- the domestic unit water supplies should increase from 160 lcd to 210 lcd
- centralized systems for treatment of domestic wastewater shall be constructed in all large and middle size cities
- in regard to industrial wastewater, the national target rate of treated wastewater shall be 60% compared to 48% at present
- the total amount of heavy metals in industrial wastewater shall not exceed and preferably be less than 1995 levels
- the seriously increasing pollution situation in the Tuo River and the Min River shall be alleviated significantly
- the quality of surface water in all major cities shall be improved and shall correspond to relevant national standards

4.2.1 Surface Water Quality

The streams of the **Min River Basin** are classified as follows according to the Environmental Standards for Surface Water, National Standard GB 3838-88, issued 1 June 1988:

- Above Muong Xian, Class 1 (about 150 km upstream of Dujiangyan)
- Muong Xian to Waizou, Class 2 (about 90 km upstream of Dujiangyan)
  [There are factories located upstream of Dujiangyan]
- Waizou to Yibin, Class 3 **(Leshan WwTW, Leshan MSW landfill, Zigong WTW Supply Diversion)**
- Dadu and Qingyi Rivers, Class 3 **(Leshan WTW)**
- All small streams in study cities are Class 3 (Fu, Sha, Nan) but Provincial EPB has recommended changing them to Class 4 **(Chengdu WWTP)**
- Small headwater streams are Class 2

The streams of the **Tuo River Basin** have the following classifications:

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(Note - Tuo River officially begins at Mianyuan - Shiting River junction)

- Qing Ping and above, Mianyuan, Class 1
- Qing Ping to Hai Wan, Class 2
- Hai Wan to Luzhou, Class 3 **(Deyang WwTW)**
- Fuxi River, Zigong to the Tuo, Class 4 **(Zigong WwTW)**

The streams of the **Jinsha/Jangtze Basin** have the following classifications:

- Upper sections, Class 1
- To Deyong, Class 2
- Deyong to Yibin, Class 3
- Yibin on downstream, Class 3 **(Luzhou WTWs, Beijiao and Daxikou)**

The water quality modeling under the COWI/DHI provincial water resources and water quality strategy analysis has shown that the main rivers in the Upper Yangtze Basin have a large assimilative capacity due to a large, rapid and turbulent flow. This situation provides a natural decay or organic matter and ammonia in the rivers to the extent that there is no significant impact either between sub-basins or between cities. The results of water quality modeling show that without additional wastewater treatment by year 2010 the Class III water quality objective for organic matter, ammonia and dissolved oxygen will only be satisfied for:

- 100% of the Jinsha and Yangtze rivers;
- 47% of the Min river (including the Fuhe branch through Chengdu); and
- 1% of the Tuo river (including the Puyang branch downstream of Chengdu).

COWI/DHI have prepared a wide-ranging water strategy that will form the basis of the SUEP in upcoming phases. Phase I will foster the achievement of the goals of the strategy but significant other interventions are required for significant water quality improvements. At the end of proposed strategy implementation by year 2020, the situation in the Min and the Tuo rivers are estimated to improve and the Class III water quality objective will be satisfied for:

- 60% of the Min river (including the Fuhe branch through Chengdu); and
- 60 % of the Tuo river (including the Puyang branch downstream of Chengdu).

Many of these stream segments may not realistically reach Class III objectives due to the small amount of streamflow in dry season. Additional flow augmentation, transfer of agricultural water, and/or downgrading of objectives will all have to be considered in detail. The limiting parameter is total ammonia and the river sections where the Class III water quality cannot be achieved are the upper reaches immediately downstream of Chengdu.

Table 4.3 Length of river sections satisfying the Class III water quality objective by 2020 after Strategy implementation

Sub-basin	Length of model sections	Compliance with Class III		
		BOD	Total ammonia	Dissolved oxygen
Jinsha and Yangtze rivers	2968	2968	2968	2968
Min and Fuhe rivers	474	378	285	474
Tuo and Puyang rivers	484	443	291	477

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The additional improvement that may be achieved through increased river flow in the upper part of the Min and Tuo rivers will increase the sections that satisfy the Class III objective to:

- 74% of the Min river including Fuhe; and
- 84% of the Tuo river.

Quantification of the amount of BOD and ammonia that exceeds the Class III water quality objective in Basin Pollution Index shows that with traditional wastewater treatment at all sources 93% of the potential improvement can be achieved. **Figure 4.2** shows the proposed improvements in pollution index through various interventions proposed in the strategy. Wastewater treatment in accordance with the Strategy will achieve 80% of this improvement while increasing the flow in Min and Tuo may contribute additionally 5%. The remaining 8% will require more advanced wastewater treatment while the final 7% is the background provided by run-off from agricultural land. In sections 4.3.1 to 4.3.3, water quality monitoring data provided by SRIEP is presented for the Min, Tuo and Yangtze river basins respectively. In section 4.3.4, the relative contribution of the Phase I SUEP wastewater schemes in meeting the surface water quality objectives is analysed using an urban pollution impacts assessment and a river pollution index. In section 4.3.5, SRIEP mono indices are presented for the project areas.

4.2.2 Groundwater Quality

There is an enormous potential for additional groundwater exploitation and conjunctive use in the Chengdu Plain according to the COWI/DHI water quality strategy documents (11/97, 3/98). Further work has been recommended to study this potential and the ability of conjunctive use to assist with water quality improvements in the SUEP area, especially during the critical dry-season flow periods.

Meanwhile, groundwater has not been widely used in the study area, except for early municipal use in the cities such as Chengdu and Deyang. The wide variety of surface waters available coupled with minimum availability has meant little usage of groundwater in Leshan. In the Chengdu Plain, the general conclusions are that groundwater is abundant in some places, some levels of contamination have occurred in the cities, contamination in rural areas from over-application of pesticides and herbicides or inputs from TVEs is not well documented, and that further study is required of the potential to exploit groundwater resources in the future. However, surface water exploitation will continue to be used in Leshan for the foreseeable future.

4.2.3 Water Supplies, Treatment and Distribution

In accordance with the National and Provincial development plan, the per capita demand (current population) for the year 2000 shall be 210 litres/day compared to the current average of 160 litres/day. The average domestic demand for the 14 cities included in the study vary from 97 to 284 lcd with and overall average of 150 lcd, which is slightly below the overall average. The average future demand for the year 2000 and 2010 is recommended at 150 lcd and 170 lcd respectively. Even with increased water using devices, they are hopeful that water conservation will become prevalent.

The limited review of existing WTWs in SUEP cities proposed for water supplies (and sometimes wastewater treatment) has shown that many of the national standards for potable raw water supply are violated in SUEP cities. The cities are making arrangements to replace WTWs that have polluted water sources (eg. Chengdu replacing polluted well supplies with new BOT surface water WTW west of the city, Leshan is replacing polluted Min River WTW). The efforts to provide cleaner sources of raw water is coupled by renewed interest in improving the pollutant source situation in Sichuan province through construction of domestic WwTWs and ensuring industrial treatment compliance. Raw water for potable water will be one of the main beneficiaries of such approaches.

Another factor that greatly affects some WTW performance is the extremely high solids contents of the source waters during high-water flow season. Solids are relatively simple to remove but these levels coupled with somewhat antiquated technologies cause turbidity problems in finished supplies.

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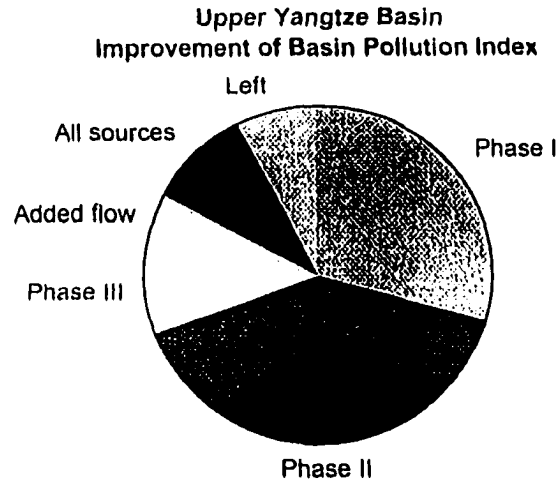


Figure 4.2 **Contribution of different Strategy component to improvement in Basin Pollution Index for the Upper Yangtze Basin (Source: COWI/DHI Urban Water Resources and Wastewater Strategy)**

The natural and man-made source of problems in the raw water to WTWs in the study area translate to treated water that fails to meet Chinese standards much of the time in many cases. These standards are somewhat less stringent than western standards also. Water supplied at the tap is considered non-potable in all SUEP cities and bottled and boiled water is used for domestic purposes. A limited review of treated water records would indicate that serious contaminants have been removed and the water suffers more from high turbidities and bacterial contamination from old treatment and distribution systems. Sampling of raw water sources by SRIEP for the Phase I SUEP projects indicated that the proposed intake sources are not contaminated by pesticides, herbicides or nitrates. However, this may not be the case in many of the smaller and more rural water supplies.

Water losses are reportedly high in all SUEP cities according to SMEDRIC design reports and COWI information. In some cases, the losses may be even higher than reported. In addition much of the distribution systems are undersized. As such, the SUEP projects are requiring complete computer and field checks of the water distribution systems to ensure that water produced by the WTW can be delivered to the customers and predicted revenues generated.

Sedimentation sludges and backwash water is routinely returned to the adjacent surface waters in existing Sichuan WTWs. This practice has been found to cause a variety of problems in western countries relative to solids and alum discharges. However, the problem is somewhat low on the list of water pollution source priorities in Sichuan, where major domestic and industrial (as well as agricultural in many areas) problems remain to be solved. The naturally occurring solids contents of the watercourses also means that such discharges cause minimal impacts to ambient water quality in most cases. SRIEP verified that the proposed WTW sludge discharges in this project cause no measurable impact on surface water quality. (Section 5.3.3) Control of WTW sludges will have to be considered in future phases of SUEP.

4.2.4 Wastewater Collection and Septic Tanks

Relative to sewerage, the most common used system is the combined system in the older areas and the separate system in the new development areas. The trend in China is for a widespread use of the separate system and in several of the cities there are plans for rehabilitation of existing sewerage systems, changing to separate systems in the process. The Fu and the Nan Project in Chengdu, scheduled for completion in 1997, is an example of such a project. Another feature of this project, ie- the construction of intercepting sewers along the rivers and construction of parks, appears to have been adopted by several of the other cities. Treatment of wastewater starts at the housing blocks where the wastewater passes through a septic tank before discharge to the public sewer system. This treatment reduces the suspended solids and also, to a minor degree, the level of BOD and nutrients. If these septic tanks are abandoned after construction of treatment works, the load estimates to the WWTP will increase 10-30%, for the different pollutants.

Wastewater collection has been steadily improving in the area, considering that open stormwater drains were widely used in most areas a few years ago. Urban areas have required the use of septic tanks in homes and other buildings for many years with the overflow to the storm or separate sewer systems. The early sewerage was usually a combined system, that conveyed stormwater plus sanitary wastewater. The new areas of the cities, such as the 3rd Drainage district of Chengdu, are being built with separated sewer systems to keep stormwater away from the sanitary wastewater. However, the use of septic tanks is still usually required since there are few central WwTWs yet constructed.

There is no widely held goal or timetable for the construction of separate sewers, WwTWs and the elimination of septic tanks. There is a provincial goal that all medium cities and larger should have WwTWs constructed by the year 2000, but this is a rather meaningless target, given the immensity of the task and limited funding. It would appear that septic tanks will continue to be used in the SUEP study area for at least another decade.

4.2.5 Wastewater Discharges – Domestic

There is only one central municipal WwTW operating in the Sichuan province. It is the Sanwayao WwTW in Chengdu that began operations in 1994 with a capacity of 100,000 m3/d. A phase II expansion of

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300,000 m3/d is under construction to bring the total capacity to 400,000 m3/d. There is, therefore, little operating experience with WwTW and WwTW performance.

Sanwayao has suffered from operational problems that has seriously affected the performance of the wastewater treatment and effluent quality, and also the sludge digestion and handling. There is limited effluent monitoring available but the treatment efficiencies are not good and in some cases the ammonia levels leaving the WwTW are higher than those entering the plant. There has been little incentive to operate the facility efficiently since the treated effluent is mixed with 4-5 times the quantity of raw sewage before being discharged to the Fu He.

The facility has not been evaluated in detail but limited site investigations would indicate that insufficient aeration is currently used at the WwTW, undoubtedly to save the energy costs. This lack of sufficient aeration coupled with the problems with the sludge digestion and handling facilities has contributed to the odor problems in the area of the WwTW.

The problems at the Sanwayao provide an added level of "need" for the SUEP wastewater facilities in order to adequately design and operate facilities and also train a cadre of professionals on the proper operation and maintenance of central WwTWs for the province.

4.2.6 Wastewater Discharges – Industrial and Other

Wastewater reports and loadings prepared by COWI/DHI coupled with the limited industrial reporting that was gathered during EA production indicates that modern and clean technology industries are not the rule in Sichuan province. Many of the older (especially SOEs) are being closed down for both economic and environmental reasons.

An industrial pollution control action plan has been requested by the World Bank and the Sichuan Province has agreed to produce and implement such an action plan in conjunction with the Phase I SUEP project. The integrated water quality benefits of municipal control and industrial control can greatly accelerate the restoration of better water quality in the SUEP surface waters.

4.2.7 Industrial Pre-Treatment, to Domestic Treatment Plant

Because of concerns that industrial wastewater dischargers that are located on city sewerage systems might dump wastewater difficult to handle in proposed SUEP WwTWs, SRIEP conducted limited sewer sampling in all areas proposed to be tributary to WwTWs. There were no problem wastes found in the sewer systems tributary to proposed WwTWs.

There are significant industrial waste contributions to the proposed Phase I WwTWs and the staff of these WwTWs will require training in the testing of raw sewage quality and the location of wastes that could cause problems in the operations of the WwTWs. It will be especially important to eliminate any potential sources of hazardous or toxic wastes that are both difficult to handle in the WwTWs, but also could present a safety hazard to workers and sewer systems.

4.2.8 Sludge Disposal – Septic Tanks, Treatment Plants

As mentioned above, the only central WwTW in Sichuan province is the Sanwayao WwTW in Chengdu. Sludge processing has been a problem at this facility and the sludge digestion plant has not been operating during the SUEP formulation period. It apparently requires new equipment and remodeling to properly operate.

Sludge from this WwTW has traditionally been used for landscape fertilizer at the WwTW and surrounding area. This practice is not considered environmentally safe both because of the lack of digestion and the potential for heavy metal contamination. Sludge will be recommended for land filling at all proposed WwTWs until there is evidence that sufficient digestion has occurred and the sludge quality can be evaluated for conformance with land application guide-lines.

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Septic tank sludge is reported by some cities as being land filled, but the common practice would indicate that it is used for agricultural fertilizer in a similar fashion as nightsoil. In some cases, it may be directly pumped into watercourses. The long term elimination of night soil and septic tank sludges will be greatly beneficial to the overall health of the population.

4.2.9 Solid Waste Collection and Disposal

General details of solid waste collection in the five project cities was provided in section 1.2.5. There is only limited data available on most SUEP cities because only one MSW facility is included in Phase I of SUEP. In general, the urban core areas appear to have fairly good MSW collection systems, while the disposal systems are totally inadequate. Areas of lesser density surrounding the urban core areas suffer from random dumping and inadequate collection and disposal. The following statistics are given for Leshan, since it is the only Phase I MSW city and the data has been collected there.

Although Leshan estimates the MSW collection rate at over 40%, this figure may be high and is certainly not the case outside of the urban core area. There is widespread dumping of MSW in the surrounding suburban areas, especially along small streams and drainages. These small dump sites are then washed into surface waters during heavy rain periods in the wet season. As such, they are a local health and aesthetic problem that carries over into a basin wide water quality problem. For cities like Leshan that have strong growth and expansion plans, it will be important to begin managing the MSW from the surrounding lower-density areas as well as the urban core.

4.2.10 Landfill and Solid Waste Treatment Designs

Solid waste management facility design and operations are totally inadequate based on the facilities inspected during the Phase I SUEP project preparation work. The vast majority of mechanical MSW plants (using incineration or composting) were shut down due to a variety of design, spare parts, operational cost, or other reasons. All of the "landfills" operate more or less as open dumps without intermediate or final cover, control of MSW into cells, drainage controls, etc. Some facilities had gas and leachate collection systems. However, there was not one successfully operating leachate treatment plant found operating in the entire Sichuan province.

This Phase I SUEP project has significant benefits to Leshan but if it is successful, it could be a model facility for the entire province to emulate. Some World Bank publications have indicated that well-designed and operated landfills are the biggest need for MSW in China and this could not be more evident than in Sichuan province.

4.2.11 Industrial Solid Wastes

The management of solid wastes (anything other than air emissions or liquid discharges) has not been investigated in detail during the Phase I SUEP project. No identified sites have been provided relative to the disposal of conventional industrial solid wastes or more dangerous hazardous and toxic wastes. The latter are banned from municipal landfills but it is unknown how well this is enforced.

In some cases, there is some evidence that some industries use adjacent watercourses to dispose of solid wastes but this has not been verified. Future phases of the SUEP should investigate these issues further. The World Bank has requested that Sichuan Province provide a time-bound action plan for industrial water pollution control and solid waste issues might be a component of such a plan.

4.2.12 Health and Safety

The health statistics for some urban areas in the SUEP indicate that the incidence rate for infectious and parasitic diseases in Sichuan is up to double the national average of about 180 per 100,000. This indicates that infectious diseases, which are dominated by water related diseases, is a key issue for the province both in the present and the future. According to COWI/DHI, high E. coli concentrations at the raw water intakes

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are experienced at Chengdu and Chongqing and are taken as a clear indication of the faucal (human and animal) contamination.

Health statistics that were available (such as Infant Mortality Rates) are described in the project feasibility reports for all Phase I projects. It was essentially impossible to gather information on safety and accident rates, etc. Cursory observation leads one to the conclusion that management of projects and construction is quite dangerous and the accident rates must be quite high. This fact is reinforced by the large amount of work undertaken by human power that is normally performed by machinery in western countries.

4.3 River Systems

Water quality data for the study area is not readily available. The basis of all the water quality modeling performed by COWI/DHI used input data to represent the catchments for a range of different years – 1987, 1995, 2000, and 2010. The model was calibrated to 1986-7 data then verified against 1993-4 data. The calibration and verification are effected by running 1 year's rainfall data through the model then comparing the predicted flows and water chemistry to records of field measurements. Changes are made to the coefficients in the model that describe the physical and chemical processes in nature, and modeling assumptions and simplifications are reviewed until a good match is made between simulated and measured river data.

For the purposes of comparing wastewater improvement schemes it was decided only to considered the situations in which the detrimental impact of the schemes is greatest. This is the situation of low river flows when there is the least available flow in the river to dilute and disperse the pollutants. Low river flows occur in Sichuan during the dry season which lasts from January to early April, which is exacerbated by agricultural practices demanding significant water for paddy fields during the spring. As well as selecting the lowest flow month of the year, flows have been selected for a year representing particularly low flows. Full river flow data are available only for 1986-7 and 1993-4. To put these 2 years in context, a brief analysis of the average annual flow data from the rivers since 1957 shows that, for the Min and the Tuo, 1987 is in the lower region of average flows. While annual average flows do not reliably reflect low flow situations this data is all that has been made available to the project. It was not considered worthwhile to pursue a more detailed analysis of flow data since it would be unlikely to significantly alter any of the relative rankings of the schemes. It was therefore been decided that flow data for March 1987 would be used in basin index calculations.

SRIEP provided some detailed water quality monitoring data for the streams in the Phase I project cities. In many cases, the water quality appears to be better than predicted on the COWI/DHI modeling work, mainly due to flow conditions at the time of monitoring. This information is presented in the following sections, followed by the prioritization work of the urban pollution control index.

4.3.1 Min River Basin Monitoring Data

Chengdu (Min Tributary Streams)
The Three Rivers of Chengdu can be seen to consist of engineered conveyance structures more than natural river courses, and the base flows of all the rivers are highly controlled. **Table 4.4** presents monitoring data provided by the Chengdu City EPB for some of these reaches.

Table 4.4 Chengdu Main Water Quality Monitoring Values (average in mg/l)

No	Reach	River	pH	TSS	DO	BOD_5	COD_{Mn}	Free Ammonia
1	Dujiangyan, Min High	Min	7.5	86	9.8	1.5	2.3	0.002
2	Chengdu WTP #6	Tai Nan Miao	7.9	47	9.3	2.4	2.8	0.002
3	An Gin Zhen	Baio Tao	7.6	87	8.9	1.6	2.5	0.001
4	Gaoqiao	Fu	7.6	87	8.9	1.6	2.6	0.002

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No	Reach	River	pH	TSS	DO	BOD_5	COD_{Mn}	Free Ammonia
5	Daangie Dukou	Fu	7.5	128	5.2	15	7	0.01
6	Yongan Daqiao	Fu	7.6	274	4.7	9.7	9.2	0.015
7	Huayang Zhen	Fu	7.4	133	2.1	7.1	10.2	0.02
8	Shun Hechang	Fu	7.5	119	4	7.7	7.5	0.008
9	Chengdu WTP #5	Sha	7.6	89	8.7	1.7	2.7	0.002
10	Gantamiao	Sha	7.4	532	7.3	4.4	4.6	0.008
11	Chengren Qiao	Sha	7.6	367	5.6	10.1	9.2	0.017
12	Hezuozhen	Zouma	7.9	45	9.1	2.3	3.2	0.002
13	Baihouqiao	Nan	7.5	114	6.4	5.9	4.8	0.005
14	Anshunqiao	Nan	7.5	120	4.4	16.8	9.6	0.012
15	Wenxingzhen	Giangan	7.4	67	8.1	1.4	4.1	0.005
16	Qinglongzhen	Ginma	8.0	86	7.7	1.7	3.9	0.001

Table Notes:
- Min upstream station 1, corresponds to feed water for People's Canal.
- Station 4 corresponds to the beginning of the Fu upstream of the city.
- Station 11 is the Sha near the Long Quan WwTW site, upstream of Fu confluence.
- Station 6 is on the Fu downstream of the Sanwayao WwTW.
- Station 8 is the Fu just upstream of the Min confluence.

The SRIEP conducted a water quality monitoring program to evaluate the potential impacts of the construction of the Long Quan WwTW. For monitoring the existing water quality of two rivers, the Sha River and the Fu River, 5 cross-sections were used. Their locations are shown in **Table 4.5:**

Table 4.5 Monitoring Cross-sections of Rivers, Chengdu

River Section	Cross-section No.	Location
Sha River	I	Water Plant No. 5 upstream of the urban area
Sha River	II	Chengren Bridge upstream of the confluence with the Fu River
Fu River	III	Yong'an Bridge
Fu River	IV	500m downstream of the proposed WwTW
Fu River	V	20km downstream of the proposed WwTW

Sixteen parameters were monitored including water temperature, pH, COD, BOD_5, NH_3-N, NO_2-N, NO_3-N, volatile phenol, Cu, Zn, Pb, Cd, Hg, Cr^{6+}, As and flow rate measured asynchronously. The monitoring was conducted in 3 days from December 4 through 6, 1997, totally 3 days. Sampling was done at 10 o'clock in the morning and 16 o'clock in the afternoon, two times a day. The procedures of sampling, analysis, quality control and data processing are conducted according to the relevant national standards. The monitoring results are given in **Table 4.6 (end of chapter).** The monitoring work was done in the period of dry or low water season of the rivers. At that time, the flow rate of the Sha River was 13.4 ~ 15.3 m^3/s, while 35.1 ~ 50.9 m^3/s in the Fu River. Under the condition of low water season water quality in the two rivers, these monitoring results were compared to the Class 3 water quality standards contained in GB 3838-88 and the results are summarized in **Table 4.7:**

Table 4.7 Water Quality Monitoring Summary, Chengdu

River Sect.	Cross-section No.	Exceedences of GB 3838-88 Standards:					
		DO Rate / Max Value X Standard	COD (Cr) Rate / Max Value X Standard	BOD_5 Rate / Max Value X Standard	Vol. Phenol Rate / Max Value X Standard	NH_3-N Rate/ Max Value X Standard	NO_2 - N Rate/ Max Value X Standard
Sha River	I	16.7 % / 1.17	83.3 % / 1.4	100% / 4.34	n/a	n/a	n/a
Sha River	II	50 % / 1.19	83.3 % / 2.82	100 % / 7.18	66.7 % / 7.6	n/a	n/a
Fu River	III	100 % / 1.39	100 % / 4.56	100 % / 7.1	66.7 % / 5.8	n/a	n/a

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River Sect.	Cross-section No.	Exceedences of GB 3838-88 Standards:					
		DO Rate / Max Value X Standard	COD (Cr) Rate / Max Value X Standard	BOD_5 Rate / Max Value X Standard	Vol. Phenol Rate / Max Value X Standard	NH_3–N Rate/ Max Value X Standard	NO_2 – N Rate/ Max Value X Standard
Fu River	IV	100 % / 1.69	100 % / 6.88	100 % / 10.08	100 % / 9.0	100 % / 3.01	n/a
Fu River	V	100 % / 1.71	100 % / 4.83	100 % / 7.2	100 % / 4.6	66.7 % / 1.48	16.7 % / 1.03

Min, Upstream/Downstream of Leshan

Six cross-sections were selected by SRIEP for conducting monitoring of existing surface water in the proposed project site based on the characteristics of river system and sewage disposal of the future WwTW as follows:

Cross-section I:	Leshan Bridge on the Min River, located on the upstream of the urban area of Leshan
Cross-section II:	Min River Bridge located on the upstream of the urban area of Leshan
Cross-section III:	Ma'an Mountain on the Min River
Cross-section IV:	Limatou on the Dadu River
Cross-section V:	20 km away downstream of the sewage outfall on the Min River

Monitoring and analysis were done according to the analytical methods suggested by the Quality Standard for Surface Water (GB3838-88). Results of water monitoring are shown in **Table 4.8.**

Table 4.8 Monitoring Results of Surface Water, Leshan

Items	Mean values monitored in all cross-sections				
	I	II	III	IV	V
DO	6.1	6.1	8.0	8.0	10.0
COD_{Mn}	5.5	5.7	3.4	2.5	3.75
BOD_5	2.2	2.7	1.0	0.9	1.80
Non-ionic ammonia	0.007	0.011	0.009	0.009	0.008
As	ND	ND	ND	ND	ND
Hg	ND	ND	ND	ND	ND
Cr^{6+}	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
pH	7.66	7.75	8.31	8.24	801
SS	25.7	23.6	61.2	5.1	31.5
Water temperature	9.1	9.2	11.3	11.0	6.0
Pb	ND	ND	ND	ND	ND

All values met the standard of Class C of Surface Water Standard (GB3838-88), which explain that the quality of surface water was good in the assessment area, during this sampling program. However, the quality of the Min River upstream of and through the urban area of Leshan does have problems meeting Class C standards during extreme dry-season as seen by the long-term monitoring reported by COWI.

Qingyi/Dadu/Min Rivers (at Leshan intakes)

In **Table 4.9**, the quality of the water in the three rivers is summarized based upon analyses conducted by the Public Health Department on samples collected from the intakes of the existing works.

Table 4.9 The Quality of Water Sources in Leshan

(mg/l)	Qingyi		Dadu		Min River				Class III
Site	Ganyan	CZ Pharmacy	Banzuwan	Limatou	Tongjiang	Gaodunzi	Renjiaba	Yin Chunmen	
Samples	5	13	76	22	50	14	34	22	
Phenols	0.004	<0.01	0.03	0.0028	0.005	0.004	<0.002	0.042	**0.005**

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(mg/l)	Qingyi		Dadu		Min River				Class III
Site	Ganyan	CZ Pharmacy	Banzuwan	Limatou	Tongjiang	Gaodunzi	Renjiaba	Yin Chunmen	
Cyanide	<0.002	<0.02	0	0	0.008	<0.002	-	0.001	**0.2**
Arsenic	<0.002	<0.02	<0.02	0	0.014	<0.02	<0.02	0	**0.05**
Mercury	<0.001	<0.001	0	0.001	0.00029	<0.001	-	0.001	**0.0001**
Cadmium	<0.01	<0.01	0	-	0.0019	<0.01	-	-	**0.005**
Chromium	<0.004	0.004	0	0	0.018	<0.004	<0.006	0.012	**0.05**
Copper	<0.01	<0.01	0.09	-	0.01	<0.01	<0.01	-	**1.0**
Lead	<0.01	<0.01	<0.09	-	0.018	<0.01	<0.01	-	**0.05**

Table 4.10 provides raw water monitoring results for the Leshan Number 3 WTW, whose intake is located on the Qingyi, just upstream of the proposed intake.

Table 4.10 **Raw Water Monitoring Results at Ganyan Cross-section of Qingyi River (for Leshan No.3 Water Treatment Works) (1991 ~1996)**

Parameter	Class B, raw water Standard	1991 ~ 1995			1996			
		Avg.	Max.	Min.	Jan.	May	July	Oct.
Colour	No obvious abnormal color	20.9	50	<5	20	23	50	13
Turbidity(NTU)					11	20	1500	10
PH	6.5 ~ 8.5	7.63	8.19	7.08	6.5	7.84	7.54	7.42
Smell & taste	No abnormal odor and smell				no	no	no	No
Total hardness (mg/L)	450	118.9	143.5	84.0	178.2	108.1	85.1	123.1
Dissolved iron (mg/L)	0.5				0.046	0.064	0.115	0.058
Mn (mg/L)	0.1				ND	ND	<0.2	ND
Cu (mg/L)	1.0				ND	ND	0.021	ND
Zn (mg/L)	1.0				0.007	0.003	0.028	0.01
Phenols (mg/L)	0.004	0.0021	0.003	ND	<0.002	<0.001	<0.001	<0.001
Anionic detergent(mg/L)	0.3				<0.05	<0.05	<0.05	<0.05
Sulfate (mg/L)	<250				65	40	56	24.4
Chloride (mg/L)	<250				6.0	3.0	2.5	4.0
Dissolved solids (mg/L)	<1000				394	210	220	204
Fluoride (mg/L)	1.0	0.11	0.17	ND	<0.2	<0.2	<0.2	<0.1
Cyanide (mg/L)	0.05	<0.01	<0.01	ND	<0.002	<0.002	<0.002	ND
As (mg/L)	0.05	<0.02	<0.02	ND	ND	<0.001	ND	ND
Se (mg/L)	0.01				ND	<0.005	ND	<0.005
Hg (mg/L)	0.001	<0.001	<0.001	ND	ND	<0.001	ND	<0.001
Cd (mg/L)	0.01	<0.01	<0.01	ND	ND	ND	ND	ND
Cr^{6+} (mg/L)	0.05	<0.005	<0.005	ND	<0.005	ND	ND	ND
Pb (mg/L)	0.07	<0.01	<0.01	ND	ND	ND	ND	ND
As (mg/L)	0.05	<			ND	ND	ND	ND
Nitrate (mg/L)	20	0.82	2.0	0.24	0.27	1.07	1.79	0.69
Total coliform (Nr/L)	10000	2387	>16000	2400	1300	$5.4x10^3$	$>1.6x10^4$	$3.5x10^3$

Min, Proposed Zigong Intake, Upstream of Yibin

All the indexes or parameters of water quality can meet the Class C of Environmental Quality Standard for Surface Water (GB3838-88). The raw water at the intake can meet the requirements specified by the Class A of Water Source Quality Standard for Drinking Water except color, turbidity and total coliform bacteria population **(see Tables 4.11 and 4.12)**.

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Table 4.11 Average Water Quality of the Min River, 1990-91

Parameter	Leshan		Pianchuangzi		Chinese River Class	
mg/l	1990	1991	1990	1991	Class III	Class II
SS	71	48	348	218	-	-
DO	6.4	5.7	7.9	7.7	>5	>6
COD	4.2	3.9	7.0	4.7	15	15
BOD	2.2	2.0	1.2	0.9	4	3
NH3-N	0.61	0.24	0.02	0.03	0.02	0.02
NO2-N	0.037	0.043	0.016	0.016	0.15	0.10
NO3-N	1.23	1.3	0.53	0.31	20	10
Phenols	0.001	0.001	0.001	0.001	0.005	0.002
Arsenic	0.003	0.002	Nd	Nd	0.05	0.05
Cyanide	0.001	0.001	Nd	Nd	0.2	0.0005
Cr(6)	0.001	0.002	Nd	Nd	0.05	0.05
Mercury	Nd	Nd	Nd	Nd	0.0001	0.00005
Lead	0.013	0.01	-	-	0.05	0.05

Table 4.12 Monitoring Results at the Intake of the Min River, (May 1996) (mg/L)

Parameter	Class B CJ(3020-93)*	Result		Parameter	Class B CJ(3020-93))	Result	
		I*	II*			I*	II*
Temperature (°C)		17	17	Chlorate	<250	7.41	5.1
Colour (degree)	<15, no abnormal color	22	17	Fluorite	1.0	0.143	0.3
Turbidity(degree)	3	42	22	Sulfate	<250	11.93	21.5
Visible matters	no	-	no	Cyanide	0.05	ND	ND
Odor & smell	No abnormal odor and smell	-	0	Cr^{6+}	0.05	ND	-
Transparency (m)		113	-	Volatile phenol (in naphthol)	0.004	ND	-
Conductivity		230	-	Hg	0.001	ND	-
pH	6.5 ~ 8.5	8.17	7.9	Dissolved iron	0.5	-	0.28
T-hardness (in $CaCO_3$)	450	128	114	Mn	0.1	-	ND
DO		8.28	-	As	0.05	ND	-
COD_{Mn}	6	2.21	0.74	Zn	1.0	-	ND
NH_3-N (in ammonia)	1.0	0.368	0.38	Cu	1.0	ND	ND
Non-ionic ammonia		0.020	-	Pb	0.07	ND	ND
NO_2-N		0.034	0.02	Cd	0.001	ND	ND
NO_3-N	20	1.01	0.89	Total coliform	1000	238800	16000
SS		46	-				

Note: * — Water Source Quality Standard for Drinking Water (CJ3929-93)
I — Courtesy of Zigong Research Institute of Environmental Protection.
II — Courtesy of Central Lab of Zigong water supply Company.
"-" — No monitoring. ND — Lower than detection limits.

4.3.2 Tuo River Basin Monitoring Data

Mianyuan (at Deyang)

For the purpose of judging the improvement function of the proposed project on the water quality, the river section from Huangxu cross-section, where the river enters the city area, to Lianshan Township cross-section downstream of the project outlet was selected by the SRIEP for additional study.

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For the determination of the impact (both positive and negative) of the drainage from the proposed project on the water quality of Mianyuan River, the river section from the project outlet to Lianshan Township was taken as the monitoring river section. 4 cross-sections are selected from Huangxu cross-section to Lianshan Township cross-section. The total monitoring section was 29km long. Their locations are shown in **Table 4.13.**

Table 4.13 Monitoring Cross-sections of the Mianyuan River

Cross-section	Length (km)	Function
I Huangxu	First cross-section	For background value
II East Bridge	13.0km downstream of I	For pollution monitoring
III Bajiao Township	8.5km downstream of II	For tracking water clusters
IV Lianshan Township	7.5km downstream of III	For water pollutants reduction
Total length of river section	29.0km	

The sampling was continuously conducted in 3 days in November, 1997. It was done once a day. The monitoring results are given in **Table 4.14 (End of chapter)**

The monitoring work was done in the period of dry season. In the monitoring section, the contents of many water pollutants surpass the standard. In the thirteen items under monitoring, except for SS (no standard), CN^- and Cr^{+6}, all of the rest pollutants surpass the standard contents at each one of the cross-sections, i.e. standard-exceeding pollutants in the river water are numerous.

The flow rate of the river in the monitoring period (at the cross-section of Bajiao Township) was 6.88 m^3/s, which is near the flow rate in the dry season. The monitoring results basically reflect the water quality of the river in dry season. In the monitoring section, the water quality demonstrates a conspicuous change from light pollution to severe pollution to relieved pollution, which indicates that the city sewage discharge is imposing an influence on the water quality.

Fuxi (in Zigong, tributary to Tuo)
Based on the environmental characteristics of the Fuxi River Basin and the main protective objectives of the project, 5 cross-section were selected by the SRIEP in the Weiyuan River, Xushui River and the Fuxi River. Their locations are described in **Table 4.15.**

Table 4.15 Zigong- Fuxi River Monitoring Stations

Cross-Section Number	Location	Description
I	Changtu Water Treatment Plant	Xushui River upstream of the central district of Zigong
II	Maliuwan Intake Station	Zigong urban area section of the Weiyuan River
III	Shuanghekou	Zigong central district section of the Fuxi River.
IV	Carbon Black Research Institute	It is upstream of the proposed treatment plant.
V	Bakouchu	Section of the Fuxi River just upstream of the Tuo River.

The monitoring time and frequency was one entire year, 8 ~ 12 times of sampling. Monitoring results are shown in **Table 4.16:**

Table 4.16 Water Quality Monitoring Results of the Fuxi River in 1996, (Unit: mg/L)

Parameter	Cross-section				
	I	II	III	IV	V
pH	7.76	7.76	7.91	7.07	7.53
SS	19.3	23.2	37.5	43.5	23.2
DO	6.1	5.0	6.0	5.0	4.8
COD_{Mn}	4.3	5.7	6.0	7.0	6.1
BOD_5	3.6	4.7	5.3	5.4	3.1
Non-ionic ammonia	0035	0.159	0.449	0.470	0.058
NO_2-N	0.133	0.133	0.313	0.374	0.254

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Parameter	Cross-section				
	I	II	III	IV	V
NO_3-N	1.95	1.72	1.34	1.79	4.04
Volatile phenol	ND	ND	ND	ND	ND
CN	ND	ND	ND	ND	ND
As	ND	0.008	0.007	ND	0.011
Hg	ND	ND	ND	ND	ND
Cr^{6+}	ND	ND	ND	ND	ND
Pb	ND	ND	ND	ND	ND
Cd	ND	ND	ND	ND	ND
Petroleum& derivatives	0.60	0.76	0.57	3.54	0.56

4.3.3 Yangtze River Basin Monitoring Data

Yangtze River in Luzhou

According to the water quality data of the existing Phase 1 Beijiao WTW (**see Tables 4.17 to 4.19, end of chapter**), the water quality is good in the Luzhou Section of the Yangtze River. All the monitoring parameters meet the Class B of Raw water Quality standard for Drinking Water CJ3020-93. That means after treatment by flocculation, sedimentation, filtration and disinfection the treated water can meet the requirements of domestic water supply.

4.3.4 Urban Pollution Impacts Assessment

The Urban Pollution Impacts Assessment (UPIA) considered impacts on Sichuan's rivers from discharges of municipal wastewater which is of domestic and industrial origin. The two most important parameters expressing the detrimental impact of such discharges are: 1. Biochemical Oxygen Demand (BOD), and 2. Ammonia as the ammonium ion (NH_4^+) which, when dissociated to free un-ionized ammonia (NH_3) is highly toxic to fish, ammonia also exerts an oxygen demand as it is biochemically degraded to nitrate (NO_3^-) and water; this oxygen demand is not included in the oxygen demand expressed by BOD. These two factors have been combined to create a parameter of Oxygen Demand (OD). This parameter was calculated according to the formula:

$$OD = BOD + 4.3 * Ammonia$$

Although chemically ammonia requires 4.57 units of oxygen to decay, the multiple of 4.3 times ammonia was selected because the decay process is facilitated by the action of micro organisms and some of the ammonia ends up being incorporated into the bacterial protoplasm in an unoxidized state such that on average 4.3 units of oxygen are used for each unit of ammonia.

The procedure for calculating a pollution index was to compare the OD, estimated at selected points in the river, to the OD that the river water should show if it were in a state considered as unpolluted. The unpolluted state was determined from the river water quality standards (according to Class) assigned to each reach of the rivers by the Environmental Protection Bureau (EPB).

From the river classifications the OD objective was calculated based upon the objective for BOD and the derived objective for ammonia. The reach pollution index is calculated by selecting a representative point in the river reach, calculating the OD predicted by the computer model (OD_p) at this point and dividing the OD_p by the objective OD (OD_o). If the reach pollution index OD_p / OD_o is less than 1.0 then the reach may be considered to meet its objective, in such cases the index is normalized to 1.0. If the reach pollution index OD_p / OD_o is greater than 1.0 then this is an indication of the degree of pollution.

It was desirable to combine the indices calculated for each reach of a river to create an overall river pollution index. Because the river systems under consideration consist not only of the main river channel but also of a number of important tributaries the river pollution index is calculated for all these reaches and

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then called a river basin pollution index. The river basin pollution index is derived by subtracting 1 from the reach pollution index to eliminate any reaches that meet their objective, multiplying the reach pollution index by the length of the reach, then dividing the total of this for all reaches by the total length of the river.

This index would be zero for an unpolluted river. Because the basin pollution index is normalized by length it is reasonable to compare the index calculated for one river basin with that calculated for another to give an overall indication of the degree of pollution. Because the class standard concentration for ammonia is expressed as free unionized ammonia it was necessary to translate this to a concentration of ionized ammonium. This can be done using a standard relationship which is dependent on temperature and pH. The temperature is modeled by COWI/DHI and a global pH of 7.9 has been selected following a review of monitored pH values. For a given concentration of ammonium the proportion unionized will increase with both temperature and pH..

Models were run for March 1987 flows in all cases and for 1987 and 2010 discharge loads. These two years were chosen because 1987 is the year for which a complete data set exists for the calibration of the model and 2010 is the design horizon for the project. Note that a WwTW in Neijiang was still part of the Phase I of SUEP at the time of this modeling, which was subsequently dropped from the Phase I of SUEP.

Table 4.20 below summarizes the findings.

Table 4.20 Expected changes in water quality in Sichuan rivers and impact of proposed wastewater schemes based on an analysis of MIKE11 runs.

Source of Data	Description of Scenario	Basin Index	% Change
Min River 1987 Loads	Baseline	1.45	-
	Phase 1 Chengdu and Leshan	1.04	28%
Min River 2010 Loads	Baseline	2.85	-
	Phase 1 Chengdu	2.39	16%
	Phase 1 Leshan	2.85	0%
	Phase 1 Chengdu and Leshan	2.39	16%
Tuo River 1987 Loads	Baseline	2.11	
	Phase 1 Deyang and Neijiang	1.89	10%
Tuo River 2010 Loads	Baseline	4.40	
	Phase 1 Deyang	4.14	6%
	Phase 1 Neijiang	4.33	2%
	Phase 1 Deyang and Neijiang	4.07	7%

From this it may be seen that the Chengdu wastewater scheme is likely to provide the greatest benefit for the rivers in comparison to any other scheme. The Leshan wastewater scheme is not expected to yield any significant improvements in the overall quality of the River Min as a result of the very large dilutions provided by the inflow of the River Dadu in Leshan. Deyang wastewater scheme will improve the quality of the Mianyuan and Shiting rivers into which its discharges flow but will not significantly improve the quality of water in the Tuo river. Neijiang wastewater scheme will result in a marginal improvement in water quality in the Tuo. (Note that the Zigong wastewater scheme provides significant local improvement to the Fuxi in Zigong, but little improvement in the Tuo river downstream.)

The combinations of treatment strategies show that for the river Min it is possible to effect considerable improvements in water quality and get quite close to meeting water quality objectives in the future. Unfortunately in the Tuo catchment even combining all the treatment schemes together will not prevent further deterioration of the river. However, there will be benefits for the locality of the cities and there will be an increase in the length of river reaches between the cities which do meet their river water quality objectives.

By contrast, for the Min river, although complete treatment of municipal and industrial wastewater in 2010 results in a considerable improvement in the quality of the water and a large reduction in the pollution index, the length of river that actually meets its river water quality objective during the low flow situation

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does not increase from the baseline 405 km out of a total River basin length of 685 km. It is only for the most extreme combined treatment and flow augmentation scenario resulting in a basin index of 0.37 that there is a increase to 449 km length of reaches meeting their objectives under the March 1987 low flows hydraulic situation.

The objective underlying this water quality modeling work was to identify, from a selection of possible wastewater treatment and collection schemes, those bringing the greatest benefit to the environment and to the people of Sichuan for the least expenditure of limited funds. Normally in a benefit cost analysis a monetary value is calculated to quantify the benefits and this may be compared directly with the construction and operating costs of the project. For an environmental improvement project such as SUEP it is not practical or realistic to attempt to calculate a monetary value for the benefits. For this reason, an alternative using the River Basin Pollution Index (RBPI) was developed, which provides a sound, objective and consistent quantitative measure of benefit.

A benefit cost index was calculated as:

$$\frac{BaselineRBPI - SchemeRBPI}{PV\,cost} * 10{,}000$$

The schemes can then be ranked by this index to clearly identify those with the greatest benefit to the quality of the river whole basin for the least cost. **Table 4.21** shows a list of all the schemes involving the treatment of wastewater discharges which have been considered ranked with those with the highest benefit cost index at the top. It may immediately be seen that the treatment of discharges in Zigong receives a very high priority, this is because the river Fuxi is so heavily polluted by domestic wastewater from Zigong and has so little baseflow in which to dilute these pollutants.

Table 4.21 Ranked Benefit Cost for all schemes and combinations involving wastewater treatment

River Basin	Scenario	Detail	Number	Basin Index	% Benefit	PV Cost M¥	Benefit Cost
Tuo	80% Municipal	Zigong	T7	5.55	20%	859.61	16.29
Tuo	Phase 1	Zigong	T3	6.57	5%	254.04	14.96
Tuo	Major industries	Zigong	T11	6.63	5%	259.67	12.32
Tuo	80% Municipal	Deyang	T5	6.34	9%	520.58	11.72
Tuo	80% Municipal	Deyang, Neijiang and Zigong	T8	4.75	32%	1905.55	11.55
Tuo	Phase 1	Deyang	T1	6.60	5%	311.37	11.24
Tuo	Minor industries	Zigong	T16	6.85	1%	96.05	10.41
Tuo	Major industries	Deyang	T9	6.85	1%	96.39	10.37
Tuo	Phase 1	Deyang, Neijiang and Zigong	T4	6.13	12%	850.28	9.64
Tuo	Combinations	80% + Major Industry	T25	3.74	46%	3575.64	8.98
Min	80% Municipal	Chengdu	M4	1.53	52%	2125.48	7.90
Min	Combinations	Chengdu 80% + Major	M12	1.21	62%	2554.86	7.83
Min	Major industries	Chengdu (Min)	M7	2.88	10%	429.38	7.69
Tuo	Combinations	Phase 1 + Major Industry	T23	5.09	27%	2520.37	7.38
Tuo	Combinations	80% + Major + Minor	T26	3.34	52%	4896.67	7.37
Tuo	Minor industries	Deyang	T14	6.82	2%	186.16	6.98
Min	Phase 1	Chengdu	M1	2.72	15%	769.52	6.37
Tuo	Major industries	All Major Industries	T13	5.94	15%	1670.09	6.05
Tuo	Combinations	Phase 1 + Major + Minor	T24	4.63	33%	3841.35	6.04
Min	Combinations	As M12 + 80% Leshan	M13	1.20	63%	3572.55	5.63
Min	80% Municipal	Chengdu and Leshan	M6	1.52	53%	3143.17	5.38
Min	Phase 1	Chengdu and Leshan	M3	2.72	15%	1085.14	4.52
Min	Minor industries	Chengdu	M7	2.85	11%	841.84	4.28
Tuo	Major industries	Neijiang	T10	6.72	3%	595.27	3.86
Tuo	Minor industries	Deyang, Neijiang and Zigong	T17	6.47	7%	1321.06	3.63
Tuo	80% Municipal	Neijiang	T6	6.77	3%	525.37	3.43
Tuo	Major industries	Chengdu (Tuo)	T12	6.72	3%	718.76	3.20

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River Basin	Scenario	Detail	Number	Basin Index	% Benefit	PV Cost M¥	Benefit Cost
Tuo	Phase 1	Neijiang	T2	6.86	1%	284.87	3.16
Tuo	Minor industries	Neijiang	T15	6.70	4%	1038.85	2.41
Min	Phase 1	Leshan	M2	3.21	0%	315.62	0.16
Min	80% Municipal	Leshan	M5	3.20	0%	1017.69	0.10

To clarify the relative benefits of municipal wastewater treatment schemes **Table 4.22** shows the benefits and costs of full municipal wastewater treatment – as represented by 80% BOD and ammonia removal – and the benefits and costs of the Phase 1 schemes.

The order of the schemes remains the same showing that this first programme of works is a step in the right direction. The total benefit cost has been calculated for all the cities and indicates that despite higher costs the overall benefit of providing a high level of treatment in the future is greater than only providing partial treatment. This is largely due to the fact that the scenario of removing 80% of BOD and ammonia removes a greater proportion of the ammonia than the Phase 1 scenarios and, because of the greater OD per ton and lower decay rate of ammonia, shows a greater overall benefit.

Table 4.22 Ranked Benefit Cost for Municipal Wastewater Collection and Treatment Schemes

River Basin	Scenario	Detail	Number	Basin Index	% Benefit	NPV Cost M¥	Benefit Cost
Tuo	80% Municipal	Zigong	T7	5.55	20%	859.61	16.29
Tuo	80% Municipal	Deyang	T5	6.34	9%	520.58	11.72
Min	80% Municipal	Chengdu	M4	1.53	52%	2,125.48	7.90
Tuo	80% Municipal	Neijiang	T6	6.77	3%	525.37	3.43
Min	80% Municipal	Leshan	M5	3.20	0%	1,017.69	0.10
Total		All Cities			14%	5,048.72	7.69
Tuo	Phase 1	Zigong	T3	6.57	5%	254.04	14.96
Tuo	Phase 1	Deyang	T1	6.60	5%	311.37	11.24
Min	Phase 1	Chengdu	M1	2.72	15%	769.52	6.37
Tuo	Phase 1	Neijiang	T2	6.86	1%	284.87	3.16
Min	Phase 1	Leshan	M2	3.21	0%	315.62	0.16
Total		All Cities			5%	1,935.42	6.79

4.3.6 Summary

The prediction of the UPIA is that unless major steps are taken to reduce and treat discharges the quality of the water in the rivers Min and Tuo is going to seriously deteriorate from its presently bad condition. For the river Min the provision of full secondary treatment of sewage from Chengdu combined with the treatment or elimination of the major industrial discharges will reverse this trend and may even result in improvements in water quality. If additional water can be released during the dry season from upstream sources then it will be possible to get very close to meeting the water quality objectives for the river all year round. Such consistent improvements could greatly enhance the ecosystem of the river and provide thepeople living along the river with a healthier environment.

The modeling indicates that secondary treatment of sewage discharges from Leshan would yield no significant benefit for the river Min. The greatest benefits in Leshan will be effected by the provision of sewerage to transfer wastewater from the city center downstream to where it will be diluted to an acceptable concentration. Preliminary treatment and a well designed outfall will be sufficient to ensure that this locality does not suffer from serious localized pollution and will prevent the discharge of gross and floating solids.

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The river Tuo is at present more seriously polluted than the Min and this problem may be expected to worsen in the future. Secondary treatment of all municipal sewage and the treatment of both major and minor industries will not be sufficient to raise the water quality to an acceptable standard throughout the basin at all times of the year. This must be in part due to the expected increase in discharges from the many smaller towns in the catchment, but the main problem is the low flow in the river during the dry season which is insufficient to adequately dilute even secondary treated wastewater discharges.

Unless ways can be found to increase the dry season base flows there is little hope of meeting river water quality objective for very much of the length of the rivers in the Tuo Basin. The Scenarios involving the release of additional flows from head waters show that this is a very effective way of improving water quality during the dry season. If the construction of reservoirs is planned in the headwaters of these rivers then the ability to maintain minimum flows in the rivers could be a major benefit of such projects. Alternatively water could be diverted from irrigation schemes in order to maintain minimum flows and the costs of this offset against the costs of providing further wastewater treatment. The highest priority locations for such schemes would be in the upper Mianyuan and upper Fuxi rivers, even though such schemes will not provide significant improvements during high flow periods.

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Table 4.6 Statistic Data of Water Quality Monitoring, Chengdu

Cross Section	Monitoring Time	Index (mg/l, temperature, pH)																Volatile Phenol	Flow Rate (m^3/s)
		Water Temperature (°C)	pH	DO	CODcr	BOD_5	NH_3-N	NO_3-N	NO_2-N	Cu	Pb	Zn	Cd	Cr^{6+}	As	Hg	CN^-		
1	Range	8 - 10	7.58 - 8.06	3.85 - 9.68	13.2 - 21.8	4.9 - 17.4	0.051 - 0.138	0.438 - 0.726	0.011 - 0.026	ND	ND	ND - 0.01	ND	0.01 - 0.02	ND	ND	ND	ND	13.4 - 15.3
	Ne's average value			5.96	19.86	14.02	0.112	0.684	0.023					0.015					
	rate of standard-exceeding			16.7	83.3	100	0	0	0	0	0	0	0	0	0	0	0	0	
	times of standard-exceeding max. value			0.17	0.45	3.35	0	0	0	0	0	0	0	0	0	0	0	0	
2	Range	10.5 - 13	7.81 - 8.24	3.89 - 7.18	14.8 - 42.3	9.8 - 28.7	0.036 - 0.438	0.215 - 0.863	0.051 - 0.073	0.02 - 0.05	ND	0.02 - 0.05	ND	0.01 - 0.03	ND	ND	ND	0.044	14.4 - 15.3
	Ne's average value			4.51	36.6	24.5	0.36	0.699	0.07	0.03		0.03		0.025				0.033	
	rate of standard-exceeding			50	83.3	100	0	0	0	0	0	0	0	0	0	0	0	0	
	times of standard-exceeding max. value			0.19	9.82	0.18	0	0	0	0	0	0	0	0	0	0	0	0	
3	Range	11 - 13	7.4 - 7.99	2.77 - 4.74	28.9 - 68.5	11.4 - 28.4	0.276 - 0.653	0.369 - 0.728	0.063 - 0.093	ND - 0.01	ND	ND - 0.01	ND	0.02 - 0.03	ND - 0.04	ND	ND	0.029	
	Ne's average value			3.33	58.64	24.8	0.561	0.668	0.086					0.026					
	rate of standard-exceeding			100	100	100	66.7	0	0	0	0	0	0	0	0	0	0	66.7	
	times of standard-exceeding max. value			0.39	3.56	6.1	0.31	0	0	0	0	0	0	0	0	0	0	4.8	
4	Range	11.5 - 13	7.39 - 7.88	0.96 - 1.79	42.7 - 57.8	19.2 - 29.6	0.421 - 0.813	0.248 - 0.673	0.049 - 0.126	0.01 - 0.05	ND	0.01 - 0.05	ND	0.01 - 0.03	0.04	ND	ND	-0.02	
	Ne's average value			1.21	54	27.6	0.727	0.572	0.116	0.02		0.02		0.02					
	rate of standard-exceeding			100	100	100	66.7	0	0	0	0	0	0	0	0	0	0	83.3	
	times of standard-exceeding max. value			0.7	2.85	6.45	0.63	0	0	0	0	0	0	0	0	0	0	3	
5	Range	11.5 - 12.5	7.15 - 7.91	0.91 - 1.86	45.6 - 72.4	19.2 - 28.8	0.438 - 0.739	0.113 - 0.531	0.079 - 0.154	0.01	ND	0.01	ND	0.01 - 0.02	ND - 0.05	ND	ND	0.012 - 0.023	35.5 - 50.9
	Ne's average value			1.18	64.3	26.6	0.673	0.442	0.124	0.01		0.01		0.02				0.02	
	rate of standard-exceeding			100	100	100	66.7	0	0	0	0	0	0	0	0	0	0	100	
	times of standard-exceeding max. value			0.71	3.83	6.2	0.48	0	0	0	0	0	0	0	0	0	0	3.6	
Standard value, Category C, GB3838-88		6.5 - 6	5	15	4		20	0.15	1	0.05	1	0.005	0.05	0.05	0.019	0.2		0.005	

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Table 4.14 Monitoring Results of Assessment Section of Mianyuan River

Unit: mg/L

Cross Section	Index	Flow rate (m^3/s)	pH	SS	DO	CODcr	BOD_5	NH_3-N	NO_3-N	CH^-	Phenols	Cr^{+6}	Pb	Hg	Water Temperature (°C)
Huang Xu	Ne's value		7.89	21.7	7.5	35.97	12.47	0.65	0.02	0	0.024	0	0.09	0.0005	
	max value		7.89	33.2	7.94	37.8	12.92	0.72	0.022	0	0.03	0.001	0.09	0.0008	11
	min value		7.82	11.6	6.73	26.65	11.59	0.48	0.015	0	0.004	0	0.07	0.0002	9
Dong Da Bridge	Ne's value		7.75	11.37	4.66	31.43	10.14	1.13	0.04	0	0.004	0.005	0.08	0.0001	
	max value		7.78	13.6	4.7	33.68	10.71	1.16	0.04	0	0.005	0.007	0.1	0.0002	12
	min value		7.73	4.8	4.45	25.41	8.07	1.01	0.04	0	0.002	0	0.03	0	9
Ba Jiao	Ne's value	6.882	8.77	33.02	4.39	51.33	25.72	2.28	0.27	0	0.033	0.006	0.06	0.0005	
	max value	7.864	12.55	38.6	5.86	57.57	34.56	2.67	0.28	0	0.044	0.009	0.12	0.0019	11
	min value	6.066	7.15	9.3	3.85	30.92	10.27	1.38	0.21	0	0.004	0.005	0.04	0	9
Lian Shan Count	Ne's value		7.72	48.29	5.34	22.45	8.69	1.21	0.19	0	0.02	0.002	0.11	0	
	max value		7.86	54.4	5.77	24.08	9.32	1.31	0.19	0	0.002	0.005	0.13	0.0001	11
	min value		7.54	27	5.19	16.35	7.06	0.94	0.17	0	0.001	0	0.07	0	9
Standard value 8-88 Class C, GB 3838-88			6.5 - 8.5		>5	<15	<4	1	<0.15	<0.2	<0.005	<0.05	<0.05	<0.0001	

Table 4.17

Water Quality Assessment Statistics in 1996 in Luzhou Water Co.

Item	Month	January		February		March		April		May		June		July		August		September		October		November		December	
	Result	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water	Raw Water	Treated Water
1 Colour		5°	1°	5°	1°	5°	1°	5°	1°	5°	1°	5°	1°	5°	1°	5°	1°	5°	1°	5°	1°	5°	1°	5°	2°
2 Turbidity		75°	1°	65°	1°	55°	1°	20°	1°	10°	1°	400°	1°	2800°	2°	1600°	2°	398°	1°	260°	1°	185°	1°	105°	1°
3 Odor and Taste		Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal	Normal
4 Sizable things		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
5 PH		7.8	7.9	7.8	7.6	7.9	7.7	7.5	7.7	7.8	7.7	7.9	7.6	7.9	7.6	7.9	7.7	7.8	7.6	7.8	7.6	8.0	7.8	7.9	7.8
6 Total Hardness (mg/l)		75.56	75.56	82.33	82.53	120.42	121.23	152.1	152.8	152.1	152.8	134.4	137.2	120.42	120.2	128.02	134.00	134.5	138.2	132.44	132.40	150.50	151.00	175	178
7 Fe		0.3	0.2	0.50	0.1	0.3	0.25	0.32	0.3	0.32	0.30	0.34	0.20	0.31	0.25	0.34	0.25	0.35	0.25	0.4	0.25	0.5	0.28	0.4	0.2
8 Mn		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
9 Cu		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
10 Zn		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
11 Volatile Phenol		.	.	.	.	.	.	.	.	.	.	<0.001	None	None	None	.	.	None	None	.	.	.	.	.	.
12 Anion Synthetic Detergent (mg/l)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
13 Sulphate		109.42	108.48	98.54	98.54	129.03	129.03	136.24	136.19	136.24	136.19	124.94	124.32	139.03	139.00	142.39	142.4	139.8	139.5	127.00	127.4	136.4	136.8	154	156
14 C. .		10.23	10.32	9.78	9.78	13.23	13.28	14.28	14.32	14.28	14.32	15	15	10.84	10.54	12.15	12.12	11.50	11.80	12.00	12.3	13.00	12.80	12.00	12.3
15 Total Dissolved Solid		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
16 Fluoride		0.9	0.9	1.0	1.0	1.10	1.0	1.1	1.0	1.1	1.0	0.9	0.9	0.9	0.8	0.8	0.8	1.0	0.9	1.0	0.9	0.9	1.0	0.8	0.7
17 Cyanide		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
18 As (mg/l)		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
19 Se		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
20 Hg		.	.	None	None	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
21 Cd		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
22 Cr^{6+}		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
23 Pb		None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None	None
24 Nitrate		.	.	0.1	None	0.3	None	0.2	None	0.2	None	<0.2	<0.1	<0.05	<0.05	0.22	0.2	0.31	0.1	0.3	0.2	1.5	1	2.0	<20
25 Total Bacterial		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
26 Colon Bacillus		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
27 F - Cl (mg/l)		0.5	0.5	2.4	2.4	0.3	0.3	0.6	0.6	0.4	0.4	0.5	0.5	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.6	0.5	0.5	0.6	0.6

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Table 4.18
Raw Water Quality Survey Statistics Report - Yangtze, Luzhou Anfu

Data / Result / Item	Unit	1991	1992		1993		1994		1995		1996
		March	March	August	February	September	March	October	April	October	March
1. Colour		8	10	2	<1	20	15	30	15	5	15
2. Turbidity	FTU	8	6	200	10	>100	18	>100	20	>100	3
3. Odor and Taste		None	None	None	None	None	None	None	None	None	None
4. Seeable things		None	None	None	None	None	None	None	None	None	None
5. PH		8.34	7.88	8.24	7.82	8.26	8.22	8.23	8.14	8.24	8.2
6. Total Hardness ($CaCO_3$)	mg/l	147.01	152.14	122.19	152.74	100.09	154.54	146.1	142 8	154.9	202.2
7. Fe	mg/l	0.07	0.24	1.88	0.11	0.16	0.29	0.4	<0.025	0.12	0.16
8. Mn	mg/l	0.08	0.07	<0.025	<0.025	<0.025	0.06	<0.025	<0.03	<0.05	0.06
9. Cu			<0.025	<0.01	<0.025	<0.025	<0.025	<0.025	<0.025	<0.02	<0.025
10. Zn			<0.025		<0.025	<0.025	<0.025	<0.025	<0.025	<0.05	0.03
11. Valatile Phenol	mg/l	<0.002	<0.002	<0.002	<0.002		<0.002	<0.002	<0.002	<0.002	<0.002
12. Anion Synthetic Detergent	mg/l		<0.1		<0 1	<0.1	<0.1	<0.1	<0 1	<0 1	<0.1
13. Sulphate	mg/l	37 3	8.16	10	16.4	12	50	20	24	10	24
14. Chloride	mg/l	5 12	19.92	7.97	11.1	8.33	7 22	46	10	13	10.7
15. Total Dissolved Solid	mg/l	218	198	186	240	130	156	114	132	170	218
16 Fluoride	mg/l	0 22	<0.2	<0.2	<0.2	<0.2	<0.2	<0.2	<0 1	<0.1	<0.1
17. Cyanide	mg/l		<0.01	<0.01	<0.01		<0.01	<0.01	<0.01	<0.01	<0.01
18 As			<0.01	<0.02	<0 02	<0.02	<0.02	<0.02	<0 02	<0.01	<0.01
19. Se			-	-	-	-	-	-	-	-	-
20 Hg			<0.001	<0.001	<0.001	<0.001	<0 001	<0 001	<0.001	<0.001	<0.001
21. Cd			<0.01	<0 01	<0 01	<0.01	<0 01	<0 01	<0 01	<0.01	<0.01
22. Cr^{+6}			<0 004	<0 004	<0 004	<0 004	<0 004	<0 004	<0 004	<0 004	<0 01
23 Pb			<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0 01	<0.01
24. Ag			-	-	-	-	-	-	-	-	-
25 Nitrate (N)			1 12	1	<1 0	<1 0	<1 0	<1 0	1 2	1	<1
26 Total Bacterial		3 5	800	140	25	610	23	235	400	6400	1250
27 Total Colon Bacillus		>16000	16000	>16000	50	>16000	<20	16000	9200	>16000	54000
28. Free Cl											

Source Luzhou Anfu Water and Power Supply Co

Table 4.19

Selected water quality parameters in Yangtze river and the frequency the National Standard is exceeded

City: Luzhou							Year: 1995
Station	Yangtze River						
Name	Luojiuxi		Dadukou		Shoubaya		Standard GB 3838-88
Location	Upstream		Downstream		Downstream		
Parameter	Average	Above NS	Average	Above NS	Average	Above NS	Category 3
	mg/l	%	mg/l	%	mg/l	%	mg/l
DO	8.16	-	8.50	-	8.30	-	5.00
COD (Mn)	2.52	-	5.29	33	5.50	33	6.00
BOD_5	0.95	-	1.42	-	1.30	-	4.00
NH_3-N	0.014	-	0.006	-	0.009	-	0.020
Phenol	-	-	-	-	0.001	-	0.005
Oils	-	-	-	-	-	-	0.050
As	-	-	0.0008	-	0.0016	-	0.0500
Hg	-	-	-	-	-	-	0.0001
Cr^{6}	0.020	-	-	-	-	-	0.050
Cd	-	-	-	-	-	-	0.005

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5.0 Determination of the Potential Impacts of the Proposed Project

5.1 Positive Impacts (Local, Basin)

5.1.1 Leshan Number 4 WTW

Water Supply Quality and Availability
Although Leshan is located at the junction of three major river systems, the treated and potable water supply systems are inadequate for current or projected needs of the City. The per capita consumption is currently 148 l/day (although the quantity available to consumers may be much lower), and the urban service area is expanding. The urban supply is supplemented by industries that also supply some domestic water. This project will supply critically needed potable water which will allow the per capita availability to rise, the service area to expand, and the exploitation of economic development opportunities.

Sanitation and Public Health
The supply of raw water from the Qingyi River will allow discontinuation of the use of the Min River as a domestic water source. This eliminates a polluted source of water supply and the attendant problems associated with treating this source water. It will allow higher base flows to be maintained in the Min River through Leshan, and this will provide higher flows for dilution of domestic and industrial discharges.

Economic Development
The supply of adequate municipal water is a minimum need for allowing the city to grow and develop economically into the future.

5.1.2 Zigong Min River Diversion and WTW

Water Supply Quality and Availability
Zigong is situated on the Fuxi River in the southern part of the Tuo River basin, some 200-km south of Chengdu. The city has developed around the confluence of Xushui and Weiyuan rivers that converge to the north west of the town to form the Fuxi River.

Zigong suffers from a general lack of water resources, from both the Xushui River and Changfu Reservoir. The per capita consumption is currently only 75 l/day. The urban supply is supplemented by industries that also supply some domestic water. This project will supply critically needed potable water which will allow the per capita availability to rise, the service area to expand, and economic development opportunities to the residents.

Sanitation and Public Health
The importation of raw water from the Min River will allow the discontinuation of use of the Xushui River as a domestic water source. This eliminates a polluted source of water supply and the attendant problems associated with treating this source water. It also allows additional background water to remain in the Xushui and Fuxi Rivers through Zigong, which is desperately needed for the conveyance and dilution of other domestic and industrial wastewaters.

Economic Development
The supply of adequate municipal water is a minimum need for allowing the city to grow and develop economically into the future.

5.1.3 Luzhou Beijiao WTW

Water Supply Quality and Availability
Luzhou is an integrated industrial city with power, chemical, machinery and foodstuff as the main industries. The Changjiang rivers, with the tributaries of Tuojiang, Cishuihe, Yongning rivers flow through its administration area. Many enterprises in the city have their own water supply system, which is about 81% of the total water supply consumption in the city.

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The northern area of the city has recently received rail service and growth and water consumption are expanding greatly in the area. Water shortage problems had already existed for many years in the area, including Xiaosi, Anning and Gaoba. The area is slated for very quick industrial and municipal development under current city planning.

Although Luzhou is located at the junction of two major rivers and the Yangtze provides enormous freshwater resources, the treated and potable water supply systems are inadequate for current or projected needs of the City. The per capita consumption in the Beijiao service area is currently estimated at 148 l/day (although the quantity available to consumers may be much lower), and the urban service area is expanding. This project will supply critically needed potable water which will allow the per capita availability to rise, the service area to expand, and the exploitation of economic development opportunities.

Sanitation and Public Health
The expanded use of raw water from the Yangtze River will allow the discontinuation of use of the polluted Tuo River as a domestic water source in Luzhou as well as unsatisfactory and non-compliant WTWs in the small towns being served. This eliminates polluted sources of water supply and the attendant problems associated with treating this source water. It also allows additional background water to remain in the Tuo Rivers through Luzhou, which is needed for the conveyance and dilution of other domestic and industrial wastewaters.

Economic Development
The supply of adequate municipal water is a minimum need for allowing the city (and surrounding towns) to grow and develop economically into the future. This facility will service both a large development zone in the city as well as fast growing towns to the north.

5.1.4 Luzhou Daxikou WTW

Water Supply Quality and Availability
Luzhou is an integrated industrial city with power, chemical, machinery and foodstuff as the main industries. The Changjiang rivers, with the tributaries of Tuojiang, Cishuihe, Yongning rivers flow through its administration area. Many enterprises in the city have their own water supply systems, which cater for about 81% of the total water supply in the city.

Although Luzhou is located at the junction of several major rivers and the Yangtze provides enormous freshwater resources, the treated and potable water supply systems are inadequate for current or projected needs of the City. The per capita consumption in the Daxikou service area is currently estimated at 100 l/day (although the quantity available to consumers from the water company is much lower), and the urban service area is expanding. This project will supply critically needed potable water which will allow the per capita availability to rise, the service area to expand, and the exploitation of economic development opportunities.

Sanitation and Public Health
The expanded use of raw water from the Yangtze River will allow the discontinuation of use of the inadequate Guanshan WTW as a domestic water source. This facility is inadequate in both quantity and quality produced for this area, especially with proposed urban expansions. The project eliminates this existing source of water supply that currently violates national standards for potable water quality.

Economic Development
The supply of adequate municipal water is a minimum need for allowing the city to grow and develop economically into the future.

5.1.5 Chengdu Long Quan WwTW

Water Quality Improvements
The collection and treatment of 300,000 m^3/d of domestic and industrial wastewater within Chengdu will have major water quality improvement benefits to the Shahe and Fuhe rivers within Chengdu and smaller

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benefits for the downstream Min River. The proposed project will be a major step on the road to recovery of these surface waters but they will not allow these surface waters to recover and meet the targeted Class 3 surface water standards without other major interventions. The current pollution conditions result from a combination of factors including rural loads (natural and agricultural sources), urban loads (domestic, industrial and nonpoint sources) and insufficient streamflows at certain times of the year.

The urban pollution impacts assessment of the proposed SUEP Schemes assessed the potential water quality impacts of proposed SUEP projects through the use of a water quality index. The greatest benefit from the proposed Long Quan scheme will be along the Shahe through the city of Chengdu where there could be as much as a 50% improvement in the water quality reach index. In the Fuhe downstream of the city of Chengdu, there would be a 20% improvement in the reach index. According to the modeling results, the Min River would be improved about 10% as far downstream as the city of Leshan by this scheme also.

The first phase SUEP projects, including the Chengdu Long Quan WwTW, are designed to move the surface water conditions (as well as the adjacent groundwater system) along the road to improvement. Future phases of the SUEP will address control of the other rural and urban pollution sources, as well as potential streamflow and stream channel enhancements.

Sanitation and Public Health

One of the most tangible and direct benefits of this wastewater collection and treatment scheme will be the removal of the raw domestic and industrial overflows to the local drainage and surface water systems in the city (except for emergency bypass conditions). The pollutants in municipal wastewater are suspended and dissolved solids consisting of inorganic and organic matter, nutrients, oil and grease, toxic substances, and pathogenic micro-organisms. Urban stormwater can contain the same pollutants, occasionally in surprisingly high concentrations. Human wastes that are not properly treated and are disposed of at the point of origin or are collected and carried away pose risks of parasitic infections (through direct contact with faecal material) and hepatitis and various gastrointestinal diseases including cholera and typhoid (through contamination of water supplies and food).

When wastewater is collected but not treated properly before disposal or reuse, the same public health hazards exist at the point of discharge. Relative to the receiving waters, additional harmful effects will occur such as: habitat for aquatic and marine life is impaired by accumulated solids; oxygen is depleted by decomposition of organic material; and aquatic and marine organisms may be further harmed by toxic substances, which may spread to higher organisms through bioaccumulation.

Wastewater projects such as the Long Quan scheme are executed in order to prevent or reduce the effects of the pollutants described above on the human and natural environments. When properly carried out, their overall environmental impact is positive. Direct benefits include abatement of nuisances and public health hazards in the serviced area, improvement in receiving water quality, and increases in the beneficial uses of receiving waters.

Downstream Water Use

Water is used intensively in the Sichuan Province and the discharge of wastewater in one location quickly becomes the raw water supply source for a downstream irrigation, domestic or industrial user. The improvement of the quality of this supply will have obvious positive effects on the productivity of agricultural land and the reduction of treatment system costs for domestic and industrial users. These benefits accrue to entities that are not directly paying for the improvements, pointing out the need for a comprehensive SUEP viewpoint relative to costs and benefits of improvement schemes.

Aesthetics and Water Amenity

The surface waters in Chengdu form a major backdrop and focus in the city and the improvement of water quality and sanitary conditions along these drainageways will greatly improve the city aesthetics. Urban renewal efforts are already underway in the city to replace dilapidated buildings with streamside parks and water amenities. In May of 1998, dragon boat races were held on the renewed Nan River for the first time

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in 37 years. Waterways historically form focal points for economic and tourist activities and the city should reap these benefits with the implementation of this scheme.

Power Production Potential
There is a potential to install gas engines and produce electricity from gas produced by the anaerobic digestion facilities. The proper operation of the digestion facilities will have to be confirmed before this potential can be realized. However, the environmental benefits can be greatly enhanced by a water pollution control facility that also produces energy.

5.1.6 Leshan Wastewater Collection and Preliminary Treatment System

Water Quality Improvements
The serious water quality problems experienced in the reaches of the Min River through Leshan have been outlined. The seriousness of this problem is highlighted by the decision of Leshan to abandon extraction of raw water from the Min River except for emergencies. Although the Min River water quality improves dramatically downstream of the city of Leshan due to inflow from the Dadu, the reaches within the city remain highly polluted in dry-season. The SUEP WwTW proposed in Phase I for Chengdu will only improve the water quality within Leshan to a minimal degree.

The proposed wastewater collection and preliminary treatment project for Leshan will have the capacity to remove over 250,000 m^3/d of raw sewage from the surface waters in Leshan, and the majority of this sewage is discharged directly to the Min or indirectly through the Zhugong Xi stream. As such, the localized water quality within the Zhugong Xi and the Min River will improve dramatically through implementation of the project. There is insufficient water quality monitoring data in these reaches to provide quantitative estimates of the degree of water quality improvement that can be expected but the results should be significant.

Sanitation and Public Health
One of the most tangible and direct benefits of this wastewater collection and treatment scheme will be the removal of the continuous raw domestic and industrial overflows to the local drainage and surface water systems in the city (except for emergency bypass conditions). The pollutants in municipal wastewater are suspended and dissolved solids consisting of inorganic and organic matter, nutrients, oil and grease, toxic substances, and pathogenic micro-organisms. Urban stormwater can contain the same pollutants, occasionally in surprisingly high concentrations. Human wastes that are not properly treated and are disposed of at the point of origin or are collected and carried away pose risks of parasitic infections (through direct contact with faecal material) and hepatitis and various gastrointestinal diseases including cholera and typhoid (through contamination of water supplies and food).

When wastewater is collected but not treated properly before disposal or reuse, the same public health hazards exist at the point of discharge. Relative to the receiving waters, additional harmful effects will occur such as: habitat for aquatic and marine life is impaired by accumulated solids; oxygen is depleted by decomposition of organic material; and aquatic and marine organisms may be further harmed by toxic substances, which may spread to higher organisms through bioaccumulation.

Wastewater projects such as the Leshan scheme are executed in order to prevent or reduce the effects of the pollutants described above on the human and natural environments. When properly carried out, their overall environmental impact is positive. Direct benefits include abatement of nuisances and public health hazards in the serviced area, improvement in receiving water quality, and increases in the beneficial uses of receiving waters.

Downstream Water Use
Water is used intensively in the Sichuan Province and the discharge of wastewater in one location quickly becomes the raw water supply source for a downstream irrigation, domestic or industrial user. The improvement of the quality of this supply will have obvious positive effects on the productivity of agricultural land and the reduction of treatment system costs for domestic and industrial users. These

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benefits accrue to entities that are not directly paying for the improvements, pointing out the need for a comprehensive SUEP viewpoint relative to costs and benefits of improvement schemes.

Although this project only provides preliminary treatment, it forms the basis for long-term wastewater treatment facilities for Leshan. The proposed Zigong Water Supply Project will have its new intake structure located downstream of Leshan on the Min River. There are also many other domestic water intakes located along this reach of the Min River.

Aesthetics and Water Amenity
The surface waters in Leshan form a major backdrop and focus in the city and the improvement of water quality and sanitary conditions along these drainageways will greatly improve the city aesthetics. Urban renewal efforts are already underway in the city to replace dilapidated buildings with streamside parks and water amenities.

Tourism is a major industry in Leshan and economic development plans include a significant increase in tourism into the future. The waterways in Leshan have historically formed focal points for economic and tourist activities and the city should reap these benefits with the implementation of this scheme.

5.1.7 Deyang WwTW

Water Quality Improvements
The urban area of the Mianyuan river conveys an average flow of 45 m^3/s but this can drop to essentially zero flow during the dry season. As such, the dry-season streamflow of the Mianyuan will consist mainly of the wastewater effluent from the proposed treatment works.

The collection and treatment of 100,000 m^3/d of domestic and industrial wastewater within Deyang will have major water quality improvement benefits to the Mianyuan river within Deyang and significant but smaller benefits to the downstream Tuo River. The proposed project will be a major step on the road to recovery of these surface waters but they will not allow these surface waters to fully recover and meet the targeted Class 3 surface water standards without other major interventions. The current pollution conditions result from a combination of factors including rural loads (natural and agricultural sources), urban loads (domestic, industrial and nonpoint sources) and insufficient streamflows at certain times of the year. In addition, no improvement of the water quality of the Shiting River will be achieved in the urban area because the city sewerage plan will not divert direct wastewater discharges to the WwTW until later Phases of the SUEP.

The urban pollution impacts assessment of the proposed SUEP Schemes assessed the potential water quality impacts of proposed SUEP projects through the use of a water quality index. The proposed WwTW will bring about a significant improvement in water quality in the Mianyuan river and will slightly improve the quality of the upper Tuo. The quality of the upper parts of the Mianyuan could also be improved by reducing BOD discharges from the paper mills.

The first phase SUEP projects, including the Deyang WwTW, are designed to move the surface water conditions (as well as the adjacent groundwater system) along the road to improvement. Future phases of the SUEP will address control of the other rural and urban pollution sources, as well as potential streamflow (flow augmentation) and stream channel enhancements.

Sanitation and Public Health
Many stagnant water pits and bends have been formed along the Mianyuan river. The urban wastewater flowing into the river and the pollution of the surface water, especially the worsening of the water quality in the accumulated water area aggravate the pollution of the water environment. After the WwTW removes the raw wastewater from the river, it is estimated that the condition of many sewage pits in the river-bed will be improved gradually. The outward appearance of the water will greatly improve.

One of the most tangible and direct benefits of this wastewater collection and treatment scheme will be the removal of the raw domestic and industrial overflows to the local drainage and surface water systems in the

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city (except for emergency bypass conditions). The pollutants in municipal wastewater are suspended and dissolved solids consisting of inorganic and organic matter, nutrients, oil and grease, toxic substances, and pathogenic microorganisms. Urban stormwater can contain the same pollutants, occasionally in surprisingly high concentrations. Human wastes that are not properly treated and are disposed of at the point of origin or are collected and carried away pose risks of parasitic infections (through direct contact with faecal material) and hepatitis and various gastrointestinal diseases including cholera and typhoid (through contamination of water supplies and food).

When wastewater is collected but not treated properly before disposal or reuse, the same public health hazards exist at the point of discharge. Relative to the receiving waters, additional harmful effects will occur such as: habitat for aquatic and marine life is impaired by accumulated solids; oxygen is depleted by decomposition of organic material; and aquatic and marine organisms may be further harmed by toxic substances, which may spread to higher organisms through bioaccumulation.

Wastewater projects such as the Deyang scheme are executed in order to prevent or reduce the effects of the pollutants described above on the human and natural environments. When properly carried out, their overall environmental impact is positive. Direct benefits include abatement of nuisances and public health hazards in the serviced area, improvement in receiving water quality, and increases in the beneficial uses of receiving waters.

Downstream Water Use
The main surface water source in Deyang is Mianyuan River, which has an average runoff of 466 million m^3. Since much of the water is removed upstream by the Gongnong Canal to irrigate farmland, the flow rate in the city section in dry season is very low and is sometimes zero. The water is so severely polluted that it cannot be used as a water source for city supply, which results in the use of groundwater. Downstream of Deyang, Lianshan Township uses the Mianyuan river for a potable water supply, indicating the seriousness of this water quality problem, as do other domestic users further downstream in the Tuo basin.

Water is used intensively in the Sichuan Province and the discharge of wastewater in one location quickly becomes the raw water supply source for a downstream irrigation, domestic or industrial user. Downstream cities that utilize the Mianyuan River will benefit by having a higher quality raw water for treatment. The improvement of the quality of this supply will have obvious positive effects on the productivity of agricultural land and the reduction of treatment system costs for domestic and industrial users. These benefits accrue to entities that are not directly paying for the improvements, pointing out the need for a comprehensive SUEP viewpoint relative to costs and benefits of improvement schemes.

Aesthetics and Water Amenity
The surface waters in Deyang form a major backdrop and focus in the city and the improvement of water quality and sanitary conditions along these drainageways will greatly improve the city aesthetics. Urban renewal efforts are already underway in the city to replace dilapidated buildings with streamside parks and water amenities. Waterways historically form focal points for economic and tourist activities and the city should reap these benefits with the implementation of this scheme.

5.1.8 Zigong WwTW

Water Quality Improvements
The collection and treatment of 120,000 m^3/d of domestic and industrial wastewater within Zigong will have obvious water quality improvement benefits to the Fuxi River within Zigong and the downstream Tuo River. The proposed project will be a major step on the road to recovery of these surface waters but they will not allow these surface waters to recover and meet the targeted Class 3 surface water standards without other major interventions. It is noted that this Fuxi segment is currently classed for Class 4, but the overall provincial goal is to achieve Class 3 below all SUEP cities. The current pollution conditions result from a combination of factors including rural loads (natural and agricultural sources), urban loads (domestic, industrial and nonpoint sources) and insufficient streamflows at certain times of the year.

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The urban pollution impacts assessment of the proposed SUEP Schemes assessed the potential water quality impacts of proposed SUEP projects through the use of a water quality index. Zigong is built beside the Fuxi River that has very little baseflow. In the dry season the upstream flows are typically less than 1 m^3/s and sometimes go to zero. Downstream of Zigong, the bulk of the river's flow is raw sewage and industrial discharge and the concentration of pollutants is very high. Because the quality of the river water is so much worse than the target quality, the river pollution index indicates the Zigong WwTW will provide the greatest benefits for all proposed wastewater treatment facilities. This verified its number one ranking in the earlier SUEP scoring.

According to the data available industrial discharges are a much smaller source of pollution in Zigong than domestic wastewater - 80% of pollution load is of domestic origin. The major polluting industries in Zigong region are chemical works and sugar refineries and are located on the lower sections of the Fuxi or on the Tuo where their impact is less. There is insufficient baseflow in the river to dilute even treated effluent to a great enough degree. The only way to achieve an acceptable water quality in the Fuxi is to construct storage upstream or divert flows from another river and release this water during the dry season in order to maintain a minimum dilution flow.

The first phase SUEP projects, including the Zigong WwTW, are designed to move the surface water conditions (as well as the adjacent groundwater system) along the road to improvement. Future phases of the SUEP will address control of the other rural and urban pollution sources, as well as potential streamflow and stream channel enhancements.

Sanitation and Public Health

One of the most tangible and direct benefits of this wastewater collection and treatment scheme will be the removal of the raw domestic and industrial overflows to the local drainage and surface water systems in the city (except for emergency bypass conditions). The pollutants in municipal wastewater are suspended and dissolved solids consisting of inorganic and organic matter, nutrients, oil and grease, toxic substances, and pathogenic microorganisms. Urban stormwater can contain the same pollutants, occasionally in surprisingly high concentrations. Human wastes that are not properly treated and are disposed of at the point of origin or are collected and carried away pose risks of parasitic infections (through direct contact with fecal material) and hepatitis and various gastrointestinal diseases including cholera and typhoid (through contamination of water supplies and food).

When wastewater is collected but not treated properly before disposal or reuse, the same public health hazards exist at the point of discharge. Relative to the receiving waters, additional harmful effects will occur such as: habitat for aquatic and marine life is impaired by accumulated solids; oxygen is depleted by decomposition of organic material; and aquatic and marine organisms may be further harmed by toxic substances, which may spread to higher organisms through bioaccumulation.

Wastewater projects such as the Zigong scheme are executed in order to prevent or reduce the effects of the pollutants described above on the human and natural environments. When properly carried out, their overall environmental impact is positive. Direct benefits include abatement of nuisances and public health hazards in the serviced area, improvement in receiving water quality, and increases in the beneficial uses of receiving waters.

Downstream Water Use

Water is used intensively in the Sichuan Province and the discharge of wastewater in one location quickly becomes the raw water supply source for a downstream irrigation, domestic or industrial user. The improvement of the quality of this supply will have obvious positive effects on the productivity of agricultural land and the reduction of treatment system costs for domestic and industrial users. These benefits accrue to entities that are not directly paying for the improvements, pointing out the need for a comprehensive SUEP viewpoint relative to costs and benefits of improvement schemes.

Aesthetics and Water Amenity

The surface waters in Zigong form a major backdrop and focus in the city and the improvement of water quality and sanitary conditions along these drainageways will greatly improve the city aesthetics. Urban

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renewal efforts are already underway in the city to replace dilapidated buildings with streamside parks and water amenities. Waterways historically form focal points for economic and tourist activities and the city should reap these benefits with the implementation of this scheme.

5.1.9 Leshan Municipal Solid Waste Project

Solid Waste Collection and Treatment
The 1997 MSW collection rate was estimated by the City of Leshan to be 41%. This project will foster the city's efforts at improving this rate nearer 80% by the year 2000. The collection systems will be more automated, require less human contact, and allow for economic growth activities.

The current MSW disposal systems are 100% inadequate since the existing landfill operates more or less as a waste dumping ground more than a sanitary landfill. The closed incinerator has also been an environmental problem in the past. Implementation of this project as outlined, will improve the adequate disposal of MSW in the city from 0% in 1997 to 80% by the year 2000.

This project will supply critically needed MSW collection and disposal systems which will allow the collection and removal rates to rise, the service area to expand, and the exploitation of economic development opportunities.

Sanitation and Public Health
The lack of adequate MSW collection systems can contribute to a wide variety of potential public health concerns and the promotion of disease, vectors, and rodents. These potential problems also occur when MSW collection involves a high degree of human contact. The proposed SUEP project will alleviate these concerns and also provide a more attractive city appearance.

Leshan is located at the junction of three major river systems and solid waste that is not collected and disposed of properly will likely end up in the surface waters. It is difficult to quantify the water quality impacts associated with floating debris, but the rivers in this area are highly degraded by floating materials. This impact should be improved by this project.

Economic Development
The supply of adequate MSW collection and disposal systems is a minimum need for allowing the city to grow and develop economically into the future. In addition, tourism is a major existing and proposed economic activity in Leshan and the maintenance of a clean city will foster its image as a tourist destination.

Aesthetic and Enjoyment
The surface waters in Leshan form a major backdrop and focus in the city and the improvement of water quality and sanitary conditions along these drainageways will greatly improve the city aesthetics. Urban renewal efforts are already underway in the city to replace dilapidated buildings with streamside parks and water amenities.

Tourism is a major industry in Leshan and economic development plans include a significant increase in tourism into the future. The waterways in Leshan have historically formed focal points for economic and tourist activities and the city should reap these benefits with the implementation of this scheme and an improvement in solid waste collection and reduced dumping.

5.1.10 Summary of Phase I Positive Impacts

The Phase I SUEP positive benefits listed in the previous sections will be great assets to the cities affected and the Sichuan Province in general. In the following sections, potential construction phase and operational phase impacts are identified. There are no significant environmental problems identified in either phase. Compared with the positive benefits, these potential negative impacts are minor and easily mitigated. Detailed mitigation and monitoring should alleviate these concerns.

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5.2 Potential Short Term Construction Impacts

5.2.1 General Categories

The Phase I projects could cause a variety of short-term construction impacts that must be monitored and mitigated during the construction period. These construction impacts have been sorted according to their geographic location within the overall project scheme. In chapter 7, for each identified potential impact, a corresponding mitigation method is proposed along with the method of monitoring and the responsible monitoring agency. The SUEP PMO will have an ongoing responsibility to track and report the monitoring work of all the identified agencies, in addition to their direct monitoring activities. Although all potential impacts must be accounted for, the following sections list the more major potential impact categories:

Water Supply Projects - *Relocation and Compensation, Demolition/Spoils, Noise and Dust, Transportation, Safety Issues, Public Facilities, Domestic Wastewater*

Wastewater Projects - *Relocation and Compensation, Demolition/Spoils, Noise and Dust, Transportation, Safety Issues, Public Facilities*

Municipal Solid Waste Project - *Relocation and Compensation, Demolition/Spoils, Noise and Dust, Transportation, Safety Issues, Public Facilities, Domestic Wastewater*

5.2.2 Summary of Potential Construction Phase Impacts

These potential construction phase impacts are relatively minor and easily mitigated. Details of mitigation measures, monitoring program and responsibilities are in chapter 7.

5.3 Potential Operational Phase Impacts

5.3.1 General Categories

The Phase I projects could cause a variety of operational impacts that must be monitored and mitigated. These operational impacts have been sorted according to their geographic location within the overall project scheme. In chapter 7, for each identified potential impact, a corresponding mitigation method is proposed along with the method of monitoring and the responsible monitoring agency. The SUEP PMO will have an ongoing responsibility to track and report the monitoring work of all the identified agencies, in addition to their direct monitoring activities. Although all potential impacts must be accounted for, the following sections list the more major potential impact categories:

Water Supply Projects - *Noise, Odors, Sludge Treatment and Disposal, O&M Problems, Chlorination – Safety, Domestic Wastewater*

Wastewater Projects - *Sewage Overflows (collection, pump stations, plant), Industrial Waste Upsets, Noise, Odors, Effluent water quality impact, Sludge treatment and disposal, O&M Problems, Organic Loading and Standards*

Municipal Solid Waste Project - *Inadequate Collection and Transfer Systems, Industrial Waste – Potential for Toxic/Hazardous Contamination, Noise, Air Pollution and Odors, Leachate Disposal and Mixing, Gas Production, Sludge/Screenings Loading and Problems, O&M Problems and Expense, Vectors and Disease*

5.3.2 Summary of Potential Operational Phase Impacts

These potential operation phase impacts are relatively minor and easily mitigated. Many of the concerns have been addressed by detailed design considerations for water treatment and wastewater treatment. Details of mitigation measures, monitoring program and responsibilities are in chapter 7.

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5.4 Cumulative SUEP Phase I Impacts

5.4.1 Related SUEP Components

The economic analysis for cities with multiple SUEP Phase I component projects in Sichuan Province indicates that they are needed and affordable to the population of the cities. This project is meeting a large "backlog" need for environmental infrastructure (including water supplies, wastewater collection and treatment, and solid waste management) and should not induce growth or secondary impacts. The environmental problems are serious and the provision of this environmental infrastructure is necessary for current needs and to mitigate current problems. Future problems without the project become even more critical.

5.4.2 Other Environmental Improvement Programs

The province and the cities are engaged in other environmental and city improvement projects that both affect and benefit from the SUEP Phase I projects. Relative to the province, there is significant effort underway to increase tourism in Sichuan and the environmental conditions are detrimental to these efforts. In addition, Sichuan wants to industrialize and close the income gap with coastal provinces and these efforts are frustrated by a lack of environmental infrastructure.

Within the cities, there are widespread efforts to improve the city centers and the stream corridors as focal points for new city images. This includes the interception of raw sewage outfalls in many locations and transfer of the wastewater in interceptors along streamside walkways. The river restoration and cleanup projects in Chengdu involve a variety of parks, walkways, and recently a test facility for microbial cleanup of a watercourse. A pilot "living water garden" park is now being completed as an environmental education area for the city along the Fu He. Chengdu has spent over 280 million yuan on this work. In the end of May 1998, Chengdu celebrated these efforts by holding the first dragon boat races in the city in over 37 years.

Chengdu is proceeding with enlargement of its largest WTW through the first BOT project implemented in the province. As mentioned, the second phase of the Sanwayao WwTW is under construction through a grant from the government of Netherlands. JICA has been working on environmental improvement projects for the city of Chengdu. Finally, there is a proposal being discussed for a proposed water storage facility on the Min River above Dujiangyan. Such a facility could provide storage to assist with the dry-season water quality problems in the study area.

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6.0 Analysis of Alternatives to the Proposed Project

6.1 Alternatives Reviewed in Project Development

The Phase I SUEP projects were analyzed for a variety of technical alternative features and designs during project preparation. The specific details of each of these evaluations is not relevant to this case study, but the various categories of these alternatives will be presented.

6.1.1 Water Treatment Works

The Phase I SUEP Projects involving water treatment were evaluated for:

Alternative Water Sources
Treatment Plant Design and Technology Selection
Construction Techniques and Materials
Pipeline Design and Technology Selection

6.1.2 Wastewater Treatment Works

The Phase I SUEP Projects involving wastewater treatment were evaluated for:

Alternative Sewer Interceptor Systems
Wastewater Treatment Works (types, design standards, etc)
Screenings and Solid Waste Disposal Systems
Sludge Disposal System(treatment, handling, disposal)

6.1.3 Leshan Municipal Solid Waste Project

The only municipal solid waste project in the Phase I of SUEP was located in Leshan and this project was evaluated for:

Landfill Design and Technology Selection
Siting and Sizing
Leachate Collection and Treatment Systems

6.2 No Project Alternatives

The "No Project" alternatives merely continues the status quo of inadequate water supply facilities in four Sichuan communities, significant wastewater pollution in four Sichuan communities, and inadequate MSW collection and disposal in Leshan. The per capita consumptions, poor existing treatment plant capacities and performance (for WTWs slated for removal), and quickly expanding urban areas provide ample evidence of the need for the water supply projects. The Urban Pollution Impacts Assessment provided ample evidence of the serious nature of the river pollution and the small urban corridors and streams conveying raw sewage may be an even greater concern. Leshan has obvious needs for improved collection and landfill facilities and the entire Sichuan province could greatly benefit from the demonstration effects of a properly designed and operated landfill.

6.3 Phase I SUEP Projects Connection to Ongoing Activities and Future SUEP Projects

The development of the Phase I SUEP projects occurred somewhat simultaneously with the production of the COWI/DHI water resources and water quality strategies. These projects form an important part of the overall Sichuan strategies and the completion of additional work in Sichuan on integrated planning of water resources and water quality or industrial pollution control will not change or lessen the positive impacts of these proposed projects. The COWI/DHI strategies include an extremely aggressive package of environmental infrastructure investment in Sichuan province. At this time, the Phase I SUEP projects are a proper first step along the path of the overall provincial strategies.

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7.0 Mitigation and Monitoring Management Plans

7.1 Mitigation and Monitoring Program

The projects will potentially cause a variety of short-term construction impacts that must be monitored and mitigated during the construction period. These construction impacts have been sorted according to their geographic location within the overall project scheme. For each identified potential impact, a corresponding mitigation method is proposed along with the method of monitoring and the responsible monitoring agency.

The SUEP PMO will have an ongoing responsibility to track and report the monitoring work of all the identified agencies, in addition to their direct monitoring activities. The following coding was used to identify these monitoring agencies:

MSW Monitoring Agencies:

a. Provincial Construction Commission (Implemented by P.M.O.)
b. Provincial EPB
c. City Construction Commission
d. City EPB
e. City Wastewater Company
f. City Urban Drainage Corporation

7.1.1 Construction Phase – WTW

There are four proposed water supply projects in the first phase of SUEP. All four of these projects include a similar package of intake, transmission, treatment, and treated water facilities. There are obviously differences of scope and impact but there are generic similarities in the types of impacts and mitigations that will be undertaken. **Tables 7.1 to 7.6** provide summaries of the expected construction-phase impacts, proposed mitigation measures, type of monitoring and responsible agencies, sorted by area of project:

Table 7.1 Raw water supply sources, intake structures

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Dam and diversion construction, protect downstream water supply intakes	Construction best management practices (BMPs), notification of downstream users	Visual, daily logs	c,d
Disruption of Aquatic Species, Terrestrial Species, Sensitive Areas and Wetlands	Identify – Avoidance – Replacement if necessary	Visual, weekly inspections	c,d

Table 7.2 Raw Water Pumping and Transmission

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	Detailed and sufficient RAPs and replacement	Surveys, visual	c
Sensitive Areas and Wetlands	Realignment or protection	Surveys, complaints, visual	d
Stream and drainage crossings	BMPs and protection	Weekly inspections, complaints	d
Debris Disposal	Contract provisions	Visual and truck logs	c

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Table 7.3 Water Treatment Works Site

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	Detailed and sufficient RAPs and replacement	Surveys, visual	c
Aesthetics, site conversion	Architectural design, landscaping provisions	Complaints	d
Noise	Limited work hours, equipment specifications	Ambient level monit, complaints	d
Erosion and Site work	BMPs	Visual, daily logs	e
Safety	Training and Contract Provisions	Accident, training records	c
Dust and Air Quality	Contract, operational manual	Records	d

Table 7.4 Treated Water Pumping and Water Storage

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	Detailed and sufficient RAPs and replacement	Surveys, visual	c
Sensitive Areas and Wetlands	Realignment or protection	Surveys, complaints, visual	d
Flushing locations	Protection	Complaints	d
Noise and misc. (backup power)	As appropriate, generator	As Appropriate	As approp.

Table 7.5 Distribution System and Water Consumers

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Quantity reliability during construction and start-up of new system	Plant records, recorders, water meters	Review of reports and weekly summaries	c,e
Quality reliability during construction and start-up of new system	Daily treated water quality testing and reporting	Review of reports and weekly summaries	e,d

Table 7.6 Construction Debris

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Uncontrolled dumps	Monitor disposal	Visual, truck logs	c,d
Hazardous material use and disposal	Monitor use and disposal	Visual, truck logs	c,d
Direct or indirect dumping in streams	Monitor disposal, contract provisions	Visual, inspections	c,d

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7.1.2 Construction Phase – WwTW

There are four proposed wastewater collection and treatment projects in the first phase of SUEP. All four of these projects include a similar package of interceptor sewers, treatment plant, sludge disposal and effluent impacts. There are obviously differences of scope and impact but there are generic similarities in the types of impacts and mitigations that will be undertaken. **Tables 7.7 to 7.10** provide summaries of the expected construction-phase impacts, proposed mitigation measures, type of monitoring and responsible agencies, sorted by area of project:

Table 7.7 Wastewater Transmission and Pumping

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	RAPs and adequate compensation	Sampling and complaints	c,d
Dust and Air quality	Contract provisions, supervision	Records	e
Sensitive Areas And Wetlands	Realignment or protection	Records	e
Noise	Limited hours, equipment design	Monthly logs	e,d
Aesthetics	Architectural design and landscaping	Visual, complaints	e
Stream crossings	Best Management Practices (BMPs)	Weekly logs	e
Safety	Training and contract provisions	Accident/training records	e, c
Streambank stability and environment	Best Management Practices (BMPs)	Weekly logs	e
Material hauling	Operating hours, routing provisions	Truck logs, complaints	e,d,c

Table 7.8 Wastewater Treatment Plant

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	RAPs and adequate compensation	Sampling and complaints	c
Aesthetics	Architectural design and landscaping	Visual, complaints	d
Noise	Limited hours, equipment design	Monthly logs	d
Erosion/ site work	Best Management Practices (BMPs)	Weekly logs	e
Safety	Training and contract provisions	Accident/training records	e
Sensitive areas and wetlands	Realignment or protection	Records	d
Dust, hauling - air quality impacts	Contract provisions, supervision	Records	e,c,d
Dewatering	Best Management Practices (BMPs)	Weekly logs	e

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Table 7.9 Sludge Management System

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	RAPs and adequate compensation	Sampling and complaints	c
Aesthetics	Architectural design and landscaping	Visual, complaints	d
Noise	Limited hours, equipment design	Monthly logs	d
Erosion and site work	BMPs	Weekly logs	e
Safety	Training and contract provisions	Accident and training records	e
Sensitive areas and wetlands	Realignment or protection	Records	d
Dust, hauling - air quality impacts	Contract provisions, supervision	Records	e,c,d

Table 7.10 Construction Debris Disposal

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Uncontrolled dumps	Monitor disposal	Visual, truck logs	c,d
Hazardous material use and disposal	Monitor use and disposal	Visual, truck logs	c,d
Direct or indirect dumping in streams	Monitor disposal, contract provisions	Visual, inspections	c,d

7.1.3 Construction Phase - MSW

There is only one MSW project in the first phase of SUEP, located in Leshan. **Tables 7.11 to 7.14** provide summaries of the expected construction-phase impacts, proposed mitigation measures, type of monitoring and responsible agencies, sorted by area of project:

Table 7.11 Collection and Transfer Systems

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	RAPs and adequate compensation	Sampling and complaints	c,d
Dust and Air quality	Contract provisions, supervision	Records	f
Sensitive Areas And Wetlands	Realignment or protection	Records	f
Noise	Limited hours, equipment design	Monthly logs	f,d
Material Hauling	Operating hours, routing provisions	Truck logs, complaints	f,d,c
Safety	Training and contract provisions	Accident,training records	f

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Table 7.12 Sanitary Landfill

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	RAPs and adequate compensation	Sampling and complaints	c
Aesthetics	Architectural design and landscaping	Visual, complaints	d
Noise	Limited hours, equipment design	Monthly logs	d
Erosion, site work	Best Management Practices (BMPs)	Weekly logs	f
Safety	Training and contract provisions	Accident,training records	f
Sensitive areas and wetlands	Realignment or protection	Records	d
Dust, hauling - air quality impacts	Contract provisions, supervision	Records	f,c,d
Dewatering	Best Management Practices (BMPs)	Weekly logs	f
Leachate Control	Best Management Practices (BMPs)	Weekly logs	f
Removal of existing incinerators	Inspections and records	Visual, completion log	f

Table 7.13 Leachate Handling, Existing Facility

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Relocations and land conversion	RAPs and adequate compensation	Sampling and complaints	c
Aesthetics	Architectural design and landscaping	Visual, complaints	d
Noise	Limited hours, equipment design	Monthly logs	d
Erosion and site work	BMPs	Weekly logs	e
Safety	Training and contract provisions	Accident and training records	e
Sensitive areas and wetlands	Realignment or protection	Records	d
Dust, hauling - air quality impacts	Contract provisions, supervision	Records	e,c,d

Table 7.14 Construction Debris Disposal

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Uncontrolled dumps	Monitor disposal	Visual, truck logs	c,d
Hazardous material use and disposal	Monitor use and disposal	Visual, truck logs	c,d
Direct or indirect dumping in streams	Monitor disposal, contract provisions	Visual, inspections	c,d

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7.1.4 Operation Phase – WTW

Tables 7.15 to 7.19 provide summaries of the expected operation-phase impacts, proposed mitigation measures, type of monitoring and responsible agencies, sorted by area of project:

Table 7.15 Raw Water Supply Source, Intake Structure

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Minimum dry season quantity, for users plus in-stream values, is insufficient	Modeling and ordinances	Hydrology records and monitoring	b,c
Raw water not meeting quality standards	Control of upstream discharges, ability to monitor upstream conditions, spills, etc.	Raw water daily samples	e,d
Contamination of upstream source area	Ordinances and watershed protection	Provincial, county, city approvals of potential pollutant sources	c
Pesticides/herbicides, irrigation first flush	Monitor first flush for such contaminants and take corrective action if necessary	Annual sampling	b
Disruption of aquatic species	Fish protection design and operational procedures	Contract and Biomonitoring	b
Noise	Low noise equipment	Ambient levels, complaints	d
Aesthetics	Architectural design, landscaping provisions	Complaints	d

Table 7.16 Raw Water Pumping and Transmission

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Pipeline failure, damage and flooding	Design parameters, construction supervision, O&M plans	Surveys, testing	e
Control or valve failure	Same	Same	e
Flushing location impacts	Protection of private property and environ.	Complaints	c,d

Table 7.17 Water Treatment Works Site, Including Pumping Station

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Plant shut-downs (whole or part)	Contract specifications, O&M procedures	Operating records	c
Raw water problems	Source protection, monitoring	Plant and EPB records	d
Noise	Low noise equipment	Ambient levels, complaints	d
Chemical handling	Design and safety equipment and	Records	e

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Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
	measures		
Safety	Design, safety equipment and training	Training records	e
Distribution system overload	Design review	Models and plans reviews	c,e
Power failure	Backup power or double feed	Records	c
Air pollution affecting treatment units	Cover all treatment units	Plans Review	e
Treated water quality problems	Real time control	Daily records	d,e

Table 7.18 Residuals Disposal

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Quantity of residuals too high	Settlement, ponds, wetlands, etc.	Daily records	e
Quality of residuals is a problem	Same as above	Quarterly sampling	e
Upstream flow reductions causing more impact	Change or modify discharge location	Visual	d,e
Ambient impacts to local environ.	Slow release rather than large slug flows (thickening, storage)	Quarterly sampling	d

Table 7.19 Distribution System and Water Consumers

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Reliability of supply problems	Distribution check, modeling	Surveys, complaints	e,d
Failure to achieve water quality standards	Daily Sampling	Records	d
Fire flow insufficient	Hydrant tests	Records	d

7.1.5 Operation Phase – WwTW

Tables 7.20 to 7.27 provide summaries of the expected operation-phase impacts, proposed mitigation measures, type of monitoring and responsible agencies, sorted by area of project:

Table 7.20 Solid Waste, Septage, and Direct Discharge Sources

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Uncontrolled direct or indirect dumping of solid waste, to surface water	Enforce ordinances, provide better SW collection sites, cleanup campaigns	Inspections and fines	d, f
Septage dumped directly to streams or indirectly through sewer systems	Enact and enforce local ordinances, provide for septage treatment in SW or WwTW projects	List of ordinances and enforcement statistics	d, c, e

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Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Industrial solid waste direct dumping	Enforce ordinances, monitor adjacent waterways	Ordinances and enforcement statistics	b, d
Industrial hazardous and toxic waste direct dumping or indirect impact to groundwater	Enact and enforce a "cradle to grave" tracking and treatment system for haz/toxic waste	Installation of program and tracking and treatment records	b,d

Table 7.21 Raw Sewage, Domestic and Industrial Sources to Sewer Systems

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Low strength domestic sewage, (use of septic tanks, infiltration or inflow)	Eliminate septic tanks when not needed, ensure that local connections are made and are watertight	Sample sewer systems, WwTW influent and connection record	c
Septage dumping causing treatment upsets or bypasses	Enact and enforce local ordinances, provide for septage treatment in SW or WwTW projects	List of ordinances and enforcement statistics, inspect.	c,d b,d,e
Industrial pretreatment problems	Enact and enforce adequate pretreatment programs and make responsible to wastewater company	Pretreatment monitor & inspect., WwTW influent record	d
Industrial accidents and spills, problems- sewers or treatment	Enact regulations requiring notification of the WwTW as well as specified protection measures	List of ordinances and records of incidents and compliance	e
Excessive infiltration or inflow in collection systems	Perform visual/TV/or other inspections of the system and take corrective action	Records of sewer system evaluations	e
Increased domestic consumption causing design load variation	Monitor changes in water use rates and wastewater generation rates by neighborhoods	Meter and plant records	d,e
Decreased industrial con. causing design load variation	Monitor changes in industrial quantity and quality through enforced pretreatment program	Flow and quality records	

Table 7.22 Raw Sewage Overflows, Various Locations

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Overflow impacts in general to health and environment	Sewer separation, I/I correction, protect overflows	Number, quantity est. of overflows	d,c
Excess overflows from design calculations	Evaluate and improve collection systems	Number of overflows plotted against storm events	d,c
Human direct contact	Protect outlets and downstream users	Visual and health records	d,c,health
Impacts to surface waters	Develop mixing zones to dissipate impacts	Visual and surface water monitoring	d
Sensitive area impacts	Relocate or adjust overflow if possible	Visual and compliance records	c,d

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Table 7.23 Wastewater Transmission and Pumping

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Foul odors and gases	Proper design and industrial waste controls	Sampling and compliance records	c,d
Accidents working in sewers	Safety training	Training and accident records	e
Accidental overflows while working in system	Detailed O&M procedures and prevention of direct dumping into system	Records	e
Sewer system blockages	Detailed O&M procedures and prevention of direct dumping into system, cleaning equipment available	Records, visual obs of cleaning equip	c,d
Noise from pump stations	Design and protective measures	Ambient monitoring and complaints	c,d
Power failure at pump stations	Backup power system or dual feed	Electric meters and visual check of the backup system or secondary feed	d,e
Mechanical failure at pump stations	Design, O&M procedures, spare parts available	Weekly logs	d,c
Leaks contaminating local groundwater	Design and protective measures	Ambient monitoring and complaints	c,d

Table 7.24 Wastewater Treatment Plant

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Lower or higher influent quantity or quality than expected	Septic tank usage rates, I/I monitoring, enforcement records of pretreatment program	Connection and operating records	e
Bypasses more frequent than planned	Sewer system monitoring, O&M procedures	WwTW and City EPB records	e,d
Noise	Design and protective measures	Ambient, complaints	c,d
Accidents, including gas, explosions, etc.	Training programs	Training and accident records	c,e
Chemical handling accidents	Design, safety training, warning systems	Training and accident records, visual	c,e
Power failure	Backup system and/or dual electric feed	Electric meters, visual	c,e
Equipment failure	Design, O&M program, spare part availability	Daily logs, meters	e
Operational problems	Design, operator training, lab testing	Daily logs, training records	e
Poor effluent quality	Monitor and enforce discharge records	Daily records and enf. monitor	e,d

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Table 7.25 Sludge Management System

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Lack of adequate stabilization	Monitor stabilization system use and performance, monitor sludge quality	Inspection and daily logs	f,d,health
High heavy metal concentrations for land application	Monitor raw sewage and sludge quality	Quarterly sampling of metals in influent, semi-annual of sludge	e,d,b
Safety	Design and training	Training,accident records	c,e
Inadequate liquid control during dewatering	Design, O&M, operator training	Inspection and daily logs	e,d
Odors	Design, O&M, operator training	Ambient levels, complaints	e,d
Equipment failure	Design, O&M program, spare part availability	Safety training and visual checks of warning systems	c,e
Landfill problems in handling sludge	Design standards, leachate treatment systems	Visual,inspections, leachate monitor	e,f,d

Table 7.26 Receiving Water Issues

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Unplanned overflow impacts on water users and ambient quality	Warning devices for downstream users	Visual and/or sound observations	c,d
Poor effluent impacts on water users and ambient quality	Telephone notification for downstream users of problems occurring	Daily logs, monitor compliance	e,d,c
Sludge dumping, industrial impact impacts on water users and ambient quality	Monitor and enforce disposal ordinances	Logs, monitor, enforcement records	e,d,b
Health impacts due to all of above	Protect from public contact	Posting, fencing, health records	e,d

Table 7.27 Wastewater Reuse and Downstream Users

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Adopt, monitor and enforce reuse ordinances	Ordinances, records and inspections	Records, inspection reports	b, e,c,d
Negative impacts to downstream water supply intakes during bypasses or problems	Notification procedures adopted and used	Visual observation of warning system	e,d,c
Aquatic impacts during bypasses or problems	Regular quarterly ambient sampling, periodic biomonitoring	Sampling records	d,b

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7.1.6 Operation Phase – MSW

Tables 7.28 to 7.33 provide summaries of the expected operation-phase impacts, proposed mitigation measures, type of monitoring and responsible agencies, sorted by area of project:

Table 7.28 Solid Waste Sources

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Industrial haz/tox sources in waste	Enforce industrial regulations, monitor industrial use and disposal	Inspections, industrial logs, approved sites	d,c,b
Hospital/infectious sources in waste	Enforce hospital regulations, monitor hospital use and disposal	Inspections, hospital logs, approved sites	d,c,b
Household haz waste increases	Provide household collection and disposal system	Inspections, verify collection/disp system	d,c,b
Source quantity/mix varies from design	Regular weighing and analysis of wastes	Records and logs	f,c
Household removal inadequate	Review neighborhood facilities and equipment	Plans review, financial analysis	f,c,a

Table 7.29 Collection and Transfer Systems

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Noise	Operating hours, routing provisions	Ambient levels,complaints	c,d,
Worker Safety	Training and contract provisions	Accident,training records	c,f
Public Safety	Protective measures	Accident records	c,f
Sanitary conditions	Establish/enforce health safeguards	Visual, complaints	f,d,health
Dust and Air quality	Contract provisions, supervision	Visual, complaints	f,d
Equipment failure	Design, O&M methods	Daily logs	f,c
Lack of spare parts	Design insures spare parts readily available locally	Plans review, inventory inspection	f,c

Table 7.30 Street Washing and Sweeping Equipment

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Noise	Operating hours, routing provisions	Ambient levels and complaints	c,d,
Worker Safety	Training and contract provisions	Accident,training records	c,f
Public Safety	Protective measures	Accident records	c,f
Sanitary conditions	Establish/enforce health safeguards	Visual, complaints	f,d,health
Dust and Air quality	Contract provisions, supervision		f,d

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Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Equipment failure	Design, O&M methods	Visual, complaints Daily logs	f,c
Lack of spare parts	Design insures spare parts are readily available locally	Plans review, inventory insp.	f,c

Table 7.31 Sanitary Landfills

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Removal of existing incinerators	Inspections and records	Visual, completion log	f
Aesthetics	Architectural design and landscaping	Visual, complaints	d
Noise	Limited hours, equipment design	Ambient levels and complaints	c,d
Erosion and runoff control	O&M Procedures	Weekly logs, inspections	f
Safety	Training, protective measures and contract provisions	Accident,training records	c,f
Gas Explosions	Design, O&M procedures	Inspections, operating records	f,c,d
Dust, hauling - air quality impacts	Contract provisions, supervision	Records	f, c,d
Sanitation of site	Establish and enforce standards	Visual, contract	f,d,health
Leachate Control	Design, O&M procedures	Inspections, operating records	f,c,d
Subsidence	Design, O&M procedures	Inspections, operating records	f,c,d
Lack of adequate cover, daily/final	Design, O&M procedures	Inspections, operating records	f,c,d

Table 7.32 Leachate Treatment Plants

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Higher quantity or quality than design	Design, O&M, inspections	Operating records, monitoring reports	f,d
Treatment plant bypasses	Design, O&M, inspections	Operating records, monitoring reports	f,c,d
Safety	Training, protective measures and contract provisions	Accident and training records	c,f
Chemical handling problems, accidents	Training, protective measures and contract provisions	Accident and training records	c,f
Equipment failure	Design, O&M, spare parts availability	Daily logs	c,f
Poor treatment performance	Design, O&M, inspections	Operating records, monitoring reports	f,c,d

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Table 7.33 Local and Downstream Water Users

Potential Impacts	Mitigation Measures	Monitoring Type	Responsible Agencies
Irrigated agricultural water users	Alternative water supplies, change cropping patterns	Inspect crops and water sources	f,c,d, agric.
Impacts to groundwater	Monitor wells of groundwater users	Monthly sampling	f,d
Impacts to surface waters	Surface water sampling program	Visual and surface water monitoring	f,d,b
Human direct contact	Protection measures, consider subsurface or wetland discharge	Inspections	d,c,health

7.2.1 Institutional Responsibilities

Sections 7.1.1 to 7.1.6 provide the detailed responsibilities for the construction and operation phases of the project, including monitoring procedures, type and time period, and agencies responsible.

On the basis of the Environmental Protection Law of P. R. China, the project unit owner of the project must bring the environmental protection work into the plans, establish a responsible system, and take effective measures to prevent and control the pollution, which may damage the ecological environment, caused by construction, operation or other activities.

According to the characteristics of the project and the practical conditions of Sichuan Province, a large number of institutions of the three systems: project management offices (PMOs), environmental protection bureaus (EPBs) and sector or trade authorities (bureaus) at levels of province, prefecture (or city), county and town are involved in the environmental protection work of the project. The institutions can be divided into the following three categories:

1. Management Institutions: Project Management Office System

a. Sichuan Provincial PMO(SPMO)

SPMO is responsible for:

- organizing the feasibility study, environmental impact assessment and the implementation of the plan of the project construction;
- coordinating the environmental management and monitoring between the sector authority and the project unit;
- guiding the project unit to carry out the environmental management measures;
- regularly reporting the environmental protection work situation to the World Bank and the Sichuan Provincial EPB (SEPB); and,
- guaranteeing the sufficient ratio of the EP investment in the total investment of the project.

b. Local PMOs (LPMOs)

Local PMOs (LPMOs) are responsible for:

LPMOs (prefecture or municipal PMOs) or P/C PMOs are responsible for:

- coordinating the overall management of the construction of the project;
- supervising each authority or department to carry out the EP plan and management measures under the guidance of SPMO;
- guaranteeing the investment of EP facilities; and report the environmental management work of the project construction to SPMO and the local EPB.

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2. Supervision Institutions

a. National Environmental Protection Agency of P. R. China (NEPA)

National Environmental Protection Agency of P. R. China (NEPA) is responsible for:

- coordinating the overall environmental administration or management work,
- examining and approving the EIA report of the project, and,
- guiding the Sichuan Environmental Protection Bureau (SEPB) to enforce the environmental laws and regulations.

b. Sichuan Provincial Environmental Protection Bureau (SEPB)

SEPB is responsible for:

- coordinating the environmental protection management work of the project,
- organizing the relevant institutions or departments to service for the EP work.

c. Local Environmental Protection Bureaus (LEPBs)

LEPBs (prefecture or municipal EPBs) work under the guidance of SEPB and are responsible for:

- supervising the implementation of the environmental laws and regulations;
- coordinating the EP work among the institutions or departments;
- managing the construction check and final examination / acceptance of projects;
- supervising the implementation of EP working plan of "Three Wastes" control programs of project units; and,
- report EP work of projects to SEPB.

3. Executive Institutions

a. Authorities Or Bureaus In Charge Of Project Management

Authorities or Bureaus in charge of project management at provincial, prefectural and municipal levels are responsible for:

- supplying the financial guarantee;
- providing the design and construction of EP facilities;
- ensuring related technologies of EP measures for project units; and,
- installing macro-management on operation and basic management on EP work of projects.

b. Project Units

Project units, or owners of the project (water and wastewater companies), conduct their work under the guidance and management by PMOs at different levels and are responsible for:

- accepting the supervision or monitoring of EP institutions at different levels;
- implementing environmental laws and regulations, and carry out all the EP measures specified by EIA, design and EP working plan;
- guaranteeing the normal operation of EP facilities, and conduct self-monitoring through setting up environmental management department and monitoring department, establish pollution files and reporting to top EPBs;
- providing funds for pollution source re-examination or selective examination.

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7.2.2 Equipment and Training Requirements

The capital budgets prepared for all SUEP component projects includes an allowance for necessary laboratory construction and equipment. SRIEP has a concern that the utility companies would require significant equipment and training but the equipment is a part of the capital budget. Using this equipment to perform the necessary and required testing by the utility is also included in the operations budget for the project.

Environmental strengthening is considered a critical component of the Phase I SUEP project and a detailed Technical Assistance (TA) program is under development. It includes training in management and operations for the PMOs and the utility companies, in a wide variety of disciplines. There is a significant environmental monitoring component to the TA program to provide both equipment and training for city EPBs and the provincial EPBs.

Accomplishing the specified monitoring and reporting outlined in this mitigation plan will be greatly enhanced by this TA program. This TA program will also allow for improved overall performance assessment of the SUEP Phase I program relative to meeting the project objectives. Future Phases of the SUEP will benefit from such assessments.

7.2.3 Impacts and Costs of Plan

Table 7.34 SRIEP Environmental Monitoring Costs

SUEP Phase I Component Project	SRIEP Environmental Monitoring Costs (Yuan/Year)	
	Short-Term (5 years)	Long-Term
Leshan Number 4 WTW	90,000-100,000	30,000-40,000
Zigong Min River Diversion and WTW	110,000-130,000	30,000-40,000
Luzhou Beijiao WTW	100,000-120,000	30,000-40,000
Luzhou Daxikou WTW	90,000-110,000	30,000-40,000
Chengdu Long Quan WwTW	140,000-160,000	40,000-50,000
Leshan Wastewater Collection and Preliminary Treatment System	130,000-150,000	40,000-50,000
Deyang WwTW	120,000-140,000	40,000-50,000
Zigong WwTW	120,000-140,000	40,000-50,000
Leshan Municipal Solid Waste Project	110,000-140,000	50,000-60,000
Phase I Total Annual Cost, SRIEP	1,100,000-1,300,000	330,000-420,000

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8.0 Public Process and EA Public Participation

8.1 Meetings with Public Officials in Developing Project and EA

During the 14-month project development time leading up to pre-appraisal and this EA, there have been many meetings with the city PMOs, utility companies, city EPBs and other affected city departments to discuss the proposed projects and environmental assessments. These meetings have occurred monthly at a minimum and have resulted in full collaboration with local officials and full support of the project and EA process.

8.2 Survey of Public Officials and Citizens in Project Area

The SRIEP used a survey form to gauge the public determination of the positive and negative impacts of each of the proposed projects in the five Phase I cities. An attempt was made to keep the survey random and representative in order to obtain an unbiased response from the community. **Table 8.1** shows the format of the survey form and the type of information solicited in these surveys. For each Phase I project, SRIEP distributed a total of 200 survey forms. **Table 8.2** provides an overview of the responses to these surveys by Phase I project:

Table 8.1 SRIEP Public Opinion Survey Form

Project:				
Name:	Occupation:		Educational Level:	
Your attitude toward the proposed project:		Support:	Objection:	No opinion:
Project for your	Positive Effect	Negative Effect	Bearable Negative Effect	No Effect
Life				
Study				
Work				
Recreation				
	Positive Effect	Negative Effect	Bearable Negative Effect	No Effect
Effect of Project on the surrounding residents				
Effect of Project on developing local economy and improving the environment				
Other Opinions and suggestions:				

Table 8.2 Summary of Public Responses, SRIEP Survey

Phase I Project	**Summary of Public Responses**
Leshan Number 4 WTW	The result of the survey shows that the project is in the keeping with the aspirations of the public for the people who support the project are 136, accounting for 94.4%, and there is no any objection. The people who think that the project construction is favorable for developing local economy and improving the environment are 128, making up 88.9 %, and only 11.1% of people who think it is no effect. The people who think that it has no effect make up 19% ~ 31% only. The people who think that it has bearable negative effect only make up 3% ~ 6%.

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Phase I Project	Summary of Public Responses
Zigong Min River Diversion and WTW	The result of the survey shows that the project is in the keeping with the aspirations of the public for the people who support the project are 162, accounting for 97.6%, and there is no any objection. The people who think that the project construction is favorable for developing local economy and improving the environment are 148, making up 89.2 %, and there is only 32, accounting for 18.1%, persons who think it is no effect. The people who think that it has bearable negative effect only make up 4% ~ 7%.
Luzhou Beijiao WTW	The result of the survey shows that the project is in the keeping with the aspirations of the public for the people who support the project are 194, accounting for 99.5%, and there is no any objection. The people who think that the project construction is favorable for developing local economy and improving the environment are 187, making up 95.9 %, and there is only 4% of persons who think it is no effect. The people who think that it has bearable negative effect only make up 1%. According to the above survey results and the analysis, the local people support the project construction.
Luzhou Daxikou WTW	The result of the survey shows that the project is in the keeping with the aspirations of the public for the people who support the project are 194, accounting for 99.5%, and there is no any objection. The people who think that the project construction is favorable for developing local economy and improving the environment are 187, making up 95.9%, and there is only 4% of persons who think it is no effect. The people who think that it has bearable negative effect only make up 1%. According to the above survey results and the analysis, the local people support the project construction.
Chengdu Long Quan WwTW	191 forms were returned for a recovery rate of 95%. Of these, 31 were workers, 110 were government officials and workers, 35 were scientific and technical personnel, and 15 were miscellaneous. The vast majority were educated with 171 attending either college or a polytechnic school. Of the returned forms, 172 (90.1% of responses) favored the project.
Leshan Wastewater Collection and Preliminary Treatment System	The result of the investigation shows that the project meets the aspirations of the public for the people who support the project was 124, accounting for 86.1% and only 1 shows objection and 19 show without care, accounting for 13.3%. The people who think that it has no any effect making up 18-32%. The people who think that it has bearable negative effect only making up 6-8%.
Deyang WwTW	187 forms were returned. The rate of recovery was 93.5%. The result of the investigation shows that the project is in the keeping with the aspirations of the public for the people who support the project are 185, accounting for 98.9%. The people who think that it has no any effect making up 6%~19%. The people who think that it have bearable negative effect only make up under 2%.
Zigong WwTW	162 forms were returned. The rate of recovery was 81%. The result of the investigation shows that the project is in the keeping with the aspirations of the public for the people who support the project are 158, accounting for 97.5% and there is no any objection. The people who think that it has no any effect making up 8.6~25%. The people who think that it has bearable negative effect only making up 3.7~5.6 %.
Leshan Municipal Solid Waste Project	The result of the investigation shows that the project is in the keeping with the aspirations of the public for the people who support the project are 172, accounting for 90.1% and there is no any objection. The people who think that the project construction is favorable for developing local economy and improving the environment are 180, making up 94.2%, and there is only 11 persons who think it is no effect. The people who think that it has no any effect making up 8.4%. The people who think that it has bearable negative effect only making up 7.8%.

8.3 Summary of Public Input

The many meetings with public officials in the city coupled with the SRIEP surveys of public support show that these projects are extremely positive and well received by the public. The WTP surveys also shows some level of support. It is not possible in China to hold full public meetings on the projects, as is the standard practice in western countries. However, there is no indication that there is anyone that is not is support of these projects or would try to stop their completion.

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9.0 Summary and Conclusions

1. The environmental conditions are serious and the environmental infrastructure needs of Sichuan Province are high, and expanding rapidly.

2. The Phase I SUEP projects have emerged from a rigorous prioritization process, are well formulated, and have a detailed and complete preliminary designs and cost estimates.

3. There was good public support for the projects based on WTP surveys and public opinion surveys.

4. The proposed projects can meet financial and economic tests of sustainability and are affordable to the local citizens.

5. Social impacts consist mainly of land acquisition and resettlement and these impacts were not significant and being well managed by a detailed RAP in final preparation.

6. The potential environmental benefits of the Phase I SUEP projects were large as was demonstrated in the previous sections.

7. Potential construction and operational phase impacts of the proposed Phase I projects were adequately assessed and no major issues have been identified. Detailed mitigation and monitoring procedures were prepared which should adequately lessen the overall effect of these potential impacts. Monitoring costs were included for this work and assignments detailed.

8. The overall conclusion was that the potential positive impacts are large, the potential negative construction and operation impacts can be successfully mitigated, and the projects contained no serious problems or "fatal flaws" in its formulation. These project components were essentially environmentally-positive and should be approved. [Note that the project was subsequently approved by the World Bank in 1999.]

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Appendix 8
Sichuan Urban Environment Project
Case Study Gaps Analyses

ISO 14001 Gaps Analysis Codes:

0 = Nothing exists at all;

1 = A program description exists but is not implemented;

2 = A system is developed and partially implemented or is fragmented and uncontrolled;

3 = A system is developed and implemented but does not fully meet the intent of the EMSs;

4 = The system is developed and implemented and meets the intent of the EMSs

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1.0 Project Formulation

1.1 Broad International and National Goals - Dublin Statement and UNCED

1.1.1 International Cooperation and Coordination

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.1	0	1	2	3	4	
1) Implementation of management systems in transboundary river/lake basins						Not applicable
2) Development of regional coordination schemes		■				SUEP facilitating but little coordination with CUEP in Chongqing
3) Implementation of information exchange programs	■					Envir Information System under SUEP to start in future

1.1.2 Framework of International Policies, Strategies and Programs

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.2	0	1	2	3	4	
1) Review of functions of existing intergovernmental bodies dealing with water resources	■					Basin commissions, but little wq focus, mainly conservation
2) Development of a charter of rights and duties of national and international organizations	■					None in effect

1.1.3 Enabling Environment at the Sectoral Level

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.3	0	1	2	3	4	
1) Assessment processes in-place		■				SUEP initiating
2) Adoption of enabling legislation	■					Minimal
3) Cooperative ventures in place		■				SUEP initiating

1.1.4 Capacity Building

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.4	0	1	2	3	4	
1) Policies, strategies and legislation for an equitable allocation of resources		■				SUEP initiating
2) Enhancement of water resource institutions	■					Fragmented management and organization
3) Enhancement of water-related human resource development, including programs for women	■					Minimal
4) Water-related health education programs	■					SUEP initiating
5) Better and more efficient techniques			■			SUEP improving existing programs
6) Strengthened monitoring, evaluation and information management systems		■				SUEP initiating

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1.1.5 Water Resources Protection and Conservation

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.5	0	1	2	3	4	
1) Regulatory tools in place for water pollution control		■				Little enforcement
2) Prevention or mitigation of diffuse pollution	■					Very little action on agricultural and land disposal pollution sources
3) National plans for water resources protection and conservation			■			National and provincial goals, but no action plans for achieving them
4) Water quality and water supply criteria for ecosystems and health protection			■			Rudimentary but moving in right direction
5) Basin action plans	■					Water use management dictates
6) Permanent, multi-sectoral planning and environmental impact assessment process			■			Good EA on projects but little regional or sectoral planning
7) Appropriate legislation, enforcement and economic mechanisms	■					Little in place
8) Tax incentives and other economic benefits for water conservation	■					Agricultural water use is a major water quality / societal issue
9) Strengthened technical and institutional capacities				■		SUEP improving existing institutions

1.1.6 Protection of Quality and Supply of Freshwater Resources

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.6	0	1	2	3	4	
1) Use of freshwater under a dynamic, interactive, iterative and multisectoral approach	■					Little in place
2) Plan for the sustainable and rational utilization and management of water resources	■					
3) Use of freshwater both economically efficient and socially appropriate	■					
4) Strengthened institutional, legal and financial mechanisms			■			SUEP Improving existing systems
5) Assessment technology to ensure assessment information is fully used		■				SUEP initiating
6) Maintenance of ecosystem integrity	■					Complete loss of ecosystem integrity currently
7) Public health protection		■				SUEP initiating
8) Identification of surface and groundwater resources that could be sustainably developed	■					Conjunctive use in future phases
9) Water pollution prevention and control programs			■			SUEP Improving existing systems
10) Biological/health/physical/chemical quality criteria	■					Complete loss of ecosystem integrity currently
11) Environmentally sound management of aquatic and terrestrial ecosystems	■					
12) Planning and implementation of pollution control programs			■			SUEP Improving existing systems
13) Rehabilitation program for polluted and degraded lands, surface water and groundwater bodies		■				
14) Ecotoxicological studies on aquatic biota and related ecosystems	■					
15) Ecological productivity and diversity of the wetland ecosystems	■					
16) Improved capabilities to collect, store and process water-related data			■			SUEP Improving existing systems
17) Research programs on the question of climate change	■					

1.1.7 Groundwater Protection

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.7	0	1	2	3	4	
1) Agricultural practices that prevent the degradation of groundwater	■					Little management of agricultural water relative to wq
2) Potential aquifer pollution through the use of toxic substances and/or impact protection zones	■					

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.7	0	1	2	3	4	
3) Landfills using the best practicable and/or best available technology			■			SUEP Improving existing systems
4) Water quality monitoring of surface and groundwater			■			SUEP Improving existing systems
5) Identification and quantification of major groundwater pollution sources		■				SUEP initiating
6) Sustainable management of groundwater		■				
7) Conservation and environmentally sound practices		■				
8) Promotion of waste minimization, pre-treatment and recycling		■				
9) Establishment of protective zones	■					
10) Measures to mitigate saline intrusion						Not applicable

1.1.8 Ocean Protection

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.8	0	1	2	3	4	
1) Policy of integrated management						Not applicable
2) Preventive and precautionary approaches in project planning and implementation						
3) National resource and environmental accounting						
4) Coastal zone planning with integrated environmental protection						
5) Economic incentives for clean technologies and 'polluter pays' principles						
6) Capabilities to monitor rises in sea-level and related hydrological parameters						
7) Model for likely socioeconomic and environmental impacts of a rise in sea-level						

1.1.9 *Health Impacts*

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.9	0	1	2	3	4	
1) Technical and financial support				■		SUEP Improving existing systems
2) Program of environmental health protection				■		SUEP Improving existing systems
3) Monitoring of relevant health indicators				■		SUEP Improving existing systems
4) WSS components included in all irrigation projects	■					Not applicable

1.1.10 Drinking Water Supply and Sanitation

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.10	0	1	2	3	4	
1) Integrated management of water resources and liquid and solid wastes			■			SUEP Improving existing systems
2) Institutional reform for an integrated approach and full participation by women	■					
3) Strengthened local institutions			■			SUEP Improving existing systems
4) Fostering the attainment of urban goals			■			SUEP Improving existing systems
5) Solid waste quantifiable goals on waste weight, volume and composition for waste reduction			■			SUEP Improving existing systems
6) Fostering the attainment of solid waste management goals			■			SUEP Improving existing systems

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.10	0	1	2	3	4	
7) Fostering the attainment of solid waste and sewage management quantity goals			■			SUEP Improving existing systems
8) Fostering the attainment of sanitation goals			■			
9) Costed proposals for providing services to the urban and rural poor	■					*Urban but not rural*
10) Appropriate procedures for WSS project implementation and services					■	SUEP Target
11) Community ownership, empowerment and management of WSS systems					■	SUEP Target
12) Equitable and efficient use of water	■					
13) WSS sector plans and national programs and optimization and sustainability of existing systems			■			

1.1.11 *Water for Sustainable Food Production and Rural Development*

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.11	0	1	2	3	4	
1) Integrated pest, disease and crop management techniques	■					SUEP targeted at urban water quality only
2) Holistic and integrated environmentally sound management of water resources in a rural context	■					
3) Water supply and sanitation for the unserved rural poor	■					
4) More efficient and productive agricultural water use	■					
5) Waterlogging, salinity and drainage problems	■					
6) Integrated water quality management with cost-effective agricultural water monitoring systems	■					

1.1.12 Environmentally Sound Technology

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.1.12	0	1	2	3	4	
1) Appropriate use of biotechnology		■				
2) Recycling biomass, recovering energy and minimizing waste generation		■				
3) Pollution prevention a major design goal for production processes			■			SUEP Improving existing systems
4) Anticipation of environmental problems such as unintentional discharges of pollutants			■			SUEP Improving existing systems
5) Appropriate technologies for sewage and organic waste					■	SUEP Target
6) Industrial waste discharges evaluated with integrated life-cycle analysis					■	SUEP Target

1.2 Integrated Water Resources Management Concepts

1.2.1 Loan and Donor Targets

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.2.1	0	1	2	3	4	
1) Comprehensive analytical framework for water resources management,			■			SUEP Improving existing systems
2) Incorporation of cross-sectoral and environmental considerations in the design of investments	■					

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.2.1	0	1	2	3	4	
3) Incentives for efficiency and financial accountability			■			SUEP Improving existing systems
4) Pricing as a management device			■			SUEP Improving existing systems
5) Strengthened legal and regulatory framework for water management		■				
6) Decentralization water service delivery responsibilities to local governments				■		SUEP Improving existing systems
7) Support for training in various aspects of water management				■		SUEP Improving existing systems
8) Encouragement of participation of beneficiaries and affected parties		■				Minimal public involvement beyond public officials
9) Assist with protecting, enhancing, and restoring water quality and water dependent ecosystems		■				
10) Assist with efforts to provide adequate water and sanitation services for the poor		■				Not a major SUEP focus
11) Support appropriate technology by supporting research and development of low cost options		■				Not a major SUEP focus

1.2.2 Formulation of sound national water policies

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.2.2	0	1	2	3	4	
1) Support major data collection and dissemination elements			■			SUEP Improving existing systems
2) Support sustained research on understanding the natural water resources system		■				Only minor SUEP analysis
3) Operate under appropriate spatial units for water resources assessment and planning		■				Only minor SUEP analysis
4) Conjunctive management system for quantity and quality of surface water and groundwater		■				Future activity of SUEP

1.2.3 Demand Management

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.2.3	0	1	2	3	4	
1) Adoption of demand management as an integral part of water management		■				Minimal in place
2) Prices as a tool for demand management		■				
3) Reduction of urban water use and transmission losses in the supply system			■			SUEP Improving existing systems
4) Technical means to reduce withdrawal rates for water for industry, especially for cooling	■					Not a major SUEP focus
5) Technical means for reducing irrigation water use	■					Not a major SUEP focus
6) Use of lower-grade water for certain domestic, commercial, industrial and agricultural purposes	■					Not a major SUEP focus
7) Reduction of the generation of pollutants at the source	■					Not a major SUEP focus
8) Implementation of a "polluter pays policy"			■			SUEP Improving existing systems
9) Reduction of water pollution from agricultural, grazing and forestry activities	■					Not a major SUEP focus

1.2.4 Establishment of appropriate mechanisms and institutions

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.2.4	0	1	2	3	4	
1) National water code		■				SUEP facilitates but little currently in place
2) Integration of activities of different water agencies at the planning and implementation stages		■				
3) Unified national objectives and priorities for water resources management		■				

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.2.4	0	1	2	3	4	
4) Constructive international agreements on water management		■				
5) System of guiding national investments in water resources development		■				
6) System of project formulation and valuation criteria		■				
7) Allocation of water/waste assimilation capacity taking account of interdependency of water uses		■				
8) Promotion of public involvement / local participation in project planning and implementation			■			SUEP Improving existing systems
9) Adequate funding of project operation and maintenance			■			SUEP Improving existing systems
10) Recognization of the economic value of water		■				
11) Reduction of public subsidies and an efficient pricing system		■				SUEP initiating
12) Prevention of irreversible damage to the water resource base		■				SUEP initiating
13) Integrating water policies with land, industrial, agricultural and environmental policies	■					
14) System of improved legislative and institutional changes	■					
15) Improved program and project preparation			■			SUEP Improving existing systems
16) Improved planning methodologies			■			SUEP Improving existing systems

1.2.5 Water Resource Management Strategies

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.2.5	0	1	2	3	4	
1) Strategies to foster better and more environmentally sound water resource management		■				Only minor SUEP analysis
2) Conservation and protection of untainted environmental assets		■				
3) Water sector policies complementary to pollution abatement policies			■			SUEP Improving existing systems
4) Careful definition and empowerment of a balanced cluster of required institutions		■				
5) Programs and projects which are consistent with policy objectives			■			SUEP Improving existing systems
6) Capacity building for well-trained and qualified personnel			■			SUEP Improving existing systems

1.3 National Planning Components for Sustainable Water Resources

1.3.1 National Policy

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.3.1	0	1	2	3	4	
1) Develop water resources in environmentally sound, economically efficient and equitable manner		■				
2) All water use sectors considered together in formulating this project			■			SUEP Improving existing systems
3) Reconciliation of conflicting demands for water with environmental concerns			■			SUEP Improving existing systems
4) Comprehensive water resources assessment system			■			SUEP Improving existing systems
5) Integrated approach to water resources development and management		■				
6) System of basinwide, regional and national master water plans	■					Not a major SUEP focus

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.3.1	0	1	2	3	4	
7) Promotion of increased participation by women at all stages/levels of development	■					
8) Water demand assessment and management as an integral part of water management	■					
9) Implementation of an integrated pollution control policy			■			SUEP Improving existing systems
10) Water reservoir components that harmonize conflicting requirements						Not applicable
11) Improved regional cooperation for environmentally sound management of water resources		■				
12) International exchange of relevant hydrological and meteorological data and information						Not applicable
13) Quantifiable performance criteria and indices			■			SUEP Improving existing systems
14) Interregional mass water transfer fully evaluating both source basins and recipient basins			■			SUEP Improving existing systems
15) National prioritization scheme targeting the reconciliation of conflicting demands	■					
16) Flexible and pragmatic planning system	■					
17) Prioritization scheme that identifies problems where actions and resources are most critical	■					
18) Principles of comprehensive analysis	■					
19) Realistic forecast of the demand for water			■			SUEP Improving existing systems
20) Fostering an integrated system of "land and water management"	■					

1.3.2 Institutional Development

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.3.2	0	1	2	3	4	
1) Mitigate the problems of fragmented water management, centralized administration, not treating water as an economic good, neglecting to link the quality of water to health, the environment, and economic development			■			SUEP Improving existing systems
2) Development of human resources in the water sector			■			SUEP Improving existing systems
3) Support self-sustaining, socially relevant programs including community/women's involvement	■					
4) Integrated approach to water resources management and water pollution control			■			SUEP Improving existing systems
5) Responsibilities delegated, to the extent possible, to the lowest appropriate levels					■	SUEP Target
6) Significant role for nongovernmental organizations (NGOs)	■					

1.3.3 Legal Systems

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.3.3	0	1	2	3	4	
1) Facilitate principles of the public trust doctrine		■				Not a major SUEP focus
2) Facilitate principles of the precautionary principle		■				
3) Facilitate principles of the principle of inter-generational equity		■				
4) Facilitate principles of the principle of intra-generational equity		■				
5) Facilitate principles of the subsidiarity principle		■				
6) Facilitate principles of the polluter pays principle (PPP)			■			SUEP initiating
7) Facilitate principles of the user pays principle (UPP)			■			SUEP initiating

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1.3.4 Public Participation

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.3.4	0	1	2	3	4	
1) Encouragement of full public participation in development and management activities			■			SUEP included survey of officials only, no true public input
2) Participatory approach, involving users, players and policy makers, service providers and NGO's			■			
3) Public involvement program conforming to recommended public involvement steps		■				
4) Appropriate guidelines for tradeoffs between costs of public participation and potential benefits		■				

1.3.5 Health Policies

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.3.5	0	1	2	3	4	
1) Quantification of potential hidden and uncomputed costs associated with health and safety		■				Not a major SUEP focus
2) Incorporation of all available information on the health impacts of existing projects			■			SUEP initiating
3) Identification of health objectives in water resources development		■				
4) Assessment of the potential to exacerbate major parasitic diseases		■				
5) Assessment of all potential construction phase health risks		■				
6) Storage components of the project address changes in both the upstream and downstream areas						Not applicable
7) Evaluation of alterations to aquatic ecosystems relative intermediate snail hosts and insect vectors						Not applicable
8) Recognization of recommended critical health needs in rapid development areas		■				Not a major SUEP focus
9) Mitigate failure to appreciate that health problems in water developments are ecological in character		■				
10) Demonstrate the adverse effects of disease on capital projects in economic terms		■				
11) Overcome donor agencies that have a negative or dissociative attitude to health matters		■				
12) Provide technical options or identify intersectoral input for the prevention and control of parasitic diseases			■			SUEP initiating
13) Overcome the assumption that the price of development has to be paid in terms of disease		■				
14) Prevent the completion of only a pro forma document to fulfill the legal requirements	■					
15) Recognize the critical health needs relative to local-level water management policy			■			SUEP initiating
16) Addressed minimum health care systems for major water resources projects		■				
17) Full assessment of the ecology and epidemiology of potential water-related diseases		■				
18) Recognization of relationship between water management and economic/health outcomes			■			SUEP Improving existing systems
19) Recognization that existing technologies can be harnessed for feasible and effective control strategies			■			SUEP Improving existing systems
20) Application of recommended irrigation related project component protection						Not applicable
21) Application of recommended industry related project component protection						Not applicable
22) Application of recommended Fisheries and Aquaculture related project component protection						Not applicable
23) Application of recommended watershed development related project component protection						Not applicable
24) Application of recommended Forestry related project component protection						Not applicable

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.3.5	0	1	2	3	4	
25) Application of recommended land clearing and rehabilitation related project component protection						Not applicable
26) Application of recommended Dams and Reservoir related project component protection						Not applicable
27) Application of recommended mining and mineral processsing related project component protection						Not applicable
28) Application of recommended electricity, oil and gas distribution line related project component protection						Not applicable
29) Application of recommended airport related project component protection						Not applicable
30) Application of recommended highway and road related project component protection						Not applicable
31) Application of recommended Port and Harbor related project component protection						Not applicable
32) Application of recommended Urban Development related project component protection			■			
33) Application of recommended canal related project component protection						Not applicable

1.4 Detailed Water Project Development Processes

1.4.1 Guidelines for Policies and Projects

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.4.1	0	1	2	3	4	
1) Measures to ensure self-renewal of renewable sources		■				Not a major SUEP focus
2) Prevention of unnecessary environmental damage from the extraction and processing of resources		■				
3) Promotion of recycling		■				
4) Avoidance of irreversible environmental effects			■			SUEP Improving existing systems
5) Emphasis on effective protection over rehabilitation on grounds of greater cost-effectiveness		■				
6) Internalizing scarcity and environmental costs			■			SUEP Improving existing systems
7) Assessed and internalized the environmental effects of sectoral and macroeconomic policies	■					
8) Renewable resource rates of use not exceeding the regenerative capacity of these resources	■					
9) Prevention of irreversible deterioration of the environment			■			SUEP Improving existing systems
10) Project components do not unduly compromise the public's health and safety			■			
11) Features that could displace people include sufficient mitigatory and compensatory measures					■	SUEP Social Assessment addressed relocation
12) Conformance with all international environmental agreements						Not applicable
13) No significant impacts-national parks, wildlife refuges, biosphere reserves, World Heritage sites					■	SUEP EA addressed
14) Minimization of unavoidable adverse consequences of projects					■	SUEP EA addressed
15) Balance between short-term development gains against long-term environmental degradation		■				
16) Project design clearly identifies recommended sections.			■			

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1.4.2 Donor Lessons

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.4.2	0	1	2	3	4	
1) Does the project conform with the lesson "Coordinate donor activities"					■	Bi-lateral environmental projects integrated with SUEP
2) Does the project conform with the lesson "Invest in the long-term"			■			SUEP Improving existing systems
3) Does the project conform with the lesson "Support the process "			■			SUEP Improving existing systems
4) Does the project conform with the lesson "Support existing strategies"		■				
5) Does the project conform with the lesson "Do not impose external models"		■				
6) Does the project conform with the lesson "Form and encourage partnerships"			■			SUEP Improving existing systems
7) Does the project conform with the lesson "Seek coherence in aid programmes"			■			SUEP Improving existing systems
8) Does the project conform with the lesson "Devise new forms of assessment"		■				
9) Does the project conform with the lesson "Refocus existing investment"		■				
10) Does the project conform with the lesson "Be flexible and creative in financial arrangements"		■				

1.4.3 Financial Security of Projects

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.4.3	0	1	2	3	4	
1) Inclusion of innovative and flexible financial arrangements	■					
2) Appropriate form of fund for local conditions, whether government-run, private, or a mix			■			SUEP Improving existing systems
3) Analysis of the sustainability of existing development investment			■			SUEP Improving existing systems
4) Specific sustainability analysis including recommended items	■					
5) Analysis of the environmental debts between donors and recipients			■			SUEP initiating
6) Effective programmes incorporating politics, economics and finance, technology, organization		■				

1.4.4 Project Development Steps

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.4.4	0	1	2	3	4	
1) System that has objectives, standards, technical base and general strategic planning			■			SUEP Improving existing systems
2) Project definition includes both affects to and is affects by external environment			■			SUEP Improving existing systems
3) Providing supportive attitude of the affected parties			■			SUEP Improving existing systems
4) Project development moves at the appropriate pace through its development life cycle					■	SUEP Target
5) Organization is good, both internally and with regard to outside parties				■		SUEP Improving existing systems
6) Contracts adequately reflect the project objectives				■		SUEP Improving existing systems
7) Project team includes experienced, strong people who can drive the project forward			■			SUEP initiating
8) Techniques and tools for project planning, monitoring and reporting			■			SUEP initiating
9) Project strategy document cover the recommended items			■			SUEP initiating
10) Project followed the concept "Set priorities carefully"				■		SUEP Improving existing systems
11) Project followed the concept "Go for win-win options first"				■		SUEP Improving existing systems
12) Project followed the concept "Promote cost-effectiveness"			■			

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.4.4	0	1	2	3	4	
13) Project followed the concept "Use market incentives where feasible"		■				Not a major SUEP focus
14) Project followed the concept "Economize on administrative/regulatory capacity"		■				
15) Project followed the concept "Set realistic standards and enforce them"		■				
16) Project followed the concept "Work with the private sector"		■				
17) Project followed the concept "Recognize that public involvement is crucial"		■				
18) Project followed the concept "Build constituencies for change"		■				
19) Project followed the concept "Incorporate environmental concerns from the outset"			■			SUEP Improving existing systems

1.4.5 Water Project Details

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.4.5	0	1	2	3	4	
1) Comprehensive view of water management issues			■			SUEP Improving existing systems
2) Emphasis on improvement of efficiency of existing irrigation systems before creating new ones						Not applicable
3) Encouragement of decentralization and local management of water resources			■			SUEP Improving existing systems
4) Charges for using water that reflect its value as a scarce resource	■					Not a major SUEP focus
5) *Conformance with recommended priority reforms and activities addressed in analytic work*	■					
6) Developed within a comprehensive framework before design and implementation stages		■				
7) Provided detailed guidelines, training, and information should be provided to borrowers			■			SUEP Improving existing systems
8) Used minimum conditions for a healthy expansion of capacity			■			SUEP Improving existing systems
9) Established or assisted with appropriate water agencies and followed arrangements for coordinating their activities				■		SUEP Target
10) *Did not use cost-benefit analysis to justify itself when it failed to consider the environmental* damage caused by borrowers' policies				■		SUEP Target
11) Used poverty relief as a project goal at the design stage		■				
12) Established adequate databases			■			
13) Analyzed O&M capacities				■		SUEP Improving existing systems
14) Facilitated the development of WSS organizations				■		SUEP Improving existing systems
15) Have the water users been given more responsibilities for managing the water			■			
16) Were drainage networks included as an integral part of the basic design of all irrigation systems to protect the environment, the water table continuously monitored						Not applicable
17) For irrigation projects, were better construction standards promoted through the careful review of the final design and bidding documents, a better selection of contractors, and better supervision of construction?						Not applicable
18) Conformance with nine suggested concepts for sustainable water resources engineering			■			SUEP Improving existing systems
19) Evaluation of project components involving inter-basin transfer in sending and receiving zones			■			SUEP Improving existing systems
20) Acceptability review against factors for fixing an acceptable value of post-project streamflow				■		
21) Incorporation of standardized ecological criteria for marginal situations in natural processes		■				
22) Evaluated objective of "Improve the management of renewable water resources"		■				
23) Evaluated objective of "Support the consolidation of small distribution systems"	■					

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
1.4.5	0	1	2	3	4	
24) Evaluated objective of "Support changes in treatment technologies"				■		SUEP Target
25) Evaluated objective of "Accelerated chemical/microbiological risk assessment "			■			
26) Evaluated objective of "Surveillance/alert system for emerging waterborne pathogens"		■				

2.0 Technical and Economic Assessment

2.1 Appropriate Technology

2.1.1 Appropriate Technology Concepts and Training

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.1.1	0	1	2	3	4	
1) Project proponents/developers have training in AT concepts and applications	■					
2) Project proponents/developers have training in Social Infrastructure			■			SUEP Improving existing systems
3) Project working toward Sustainable Infrastructure & Appropriate Technology			■			SUEP Improving existing systems

2.1.2 Appropriate Technology Review Criteria

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.1.2	0	1	2	3	4	
1) Project proponents and developers incorporated AT concepts into the project review criteria	■					
2) Sustainable planning processes used in project development and review			■			SUEP Improving existing systems
3) Engineering and social infrastructure work in concert			■			SUEP Improving existing systems
4) Infrastructure working toward "industrial ecology" concepts	■					

2.1.3 Incorporation of AT at Various Process Levels

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.1.3	0	1	2	3	4	
1) Developed or complied with manuals of practice in AT available for "Policy"	■					
2) Developed or complied with manuals of practice in AT available for "Standards"		■				
3) Developed or complied with manuals of practice in AT available for "Master planning"		■				
4) Developed or complied with manuals of practice in AT available for "Economic analysis"			■			SUEP Improving existing systems
5) Developed or complied with manuals of practice in AT available for "Infrastructure design"			■			SUEP Improving existing systems
6) Developed or complied with manuals of practice in AT available for "Environmental impact assessments"				■		SUEP EA addressed
7) Developed or complied with manuals of practice in AT available for "Monitoring"			■			SUEP Improving existing systems
8) Developed or complied with manuals of practice in AT available for "Operation and Maintenance"			■			SUEP Improving existing systems

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2.2 Conservation and Demand Management

2.2.1 Water Conservation and Pollution Control

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.2.1	0	1	2	3	4	
1) Strong water conservation and pollution control policy		■				SUEP initiating
2) Conservation policy encourages recommended water usage features		■				SUEP initiating
3) Proper accounting of high quality, reliability and value of groundwater resources	■					Not a major SUEP focus
4) All means with economic incentives, legal regulations, administrative measures, public awareness	■					
5) Consideration of reduction of the generation of pollutants at source	■					
6) Municipal and industrial components of the project conform with discharge quality standards			■			SUEP Target
7) Framework of a policy for sustainable and environmentally sound development		■				
8) Strategies for the broader goal of providing sustainable expansion of sanitation services				■		SUEP Target
9) Investigation of a wider range of sanitation technologies and lower-cost sewerage systems			■			SUEP Target

2.2.2 Demand Management

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.2.2	0	1	2	3	4	
1) Full and effective utilization of existing resources in the long term		■				SUEP initiating
2) Consideration of water as economic good with a value consistent with most valuable potential use	■					
3) Agricultural and irrigation components of the project fully incorporated demand management						Not applicable
4) Industrial components of the project fully incorporated demand management concepts		■				SUEP initiating
5) Domestic and municipal sector project components included demand management concepts		■				SUEP initiating
6) Sanitation related options in the project fully incorporate demand-based approaches		■				SUEP initiating

2.2.3 Financing and Institutions

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.2.3	0	1	2	3	4	
1) Financing plan starts supply choices at demand with the goal of minimizing subsidy			■			SUEP Target
2) Supply options address technology, service providers, extent of coverage and tariff level				■		SUEP Target
3) Options evaluate efficiency/demand orientation, service expansion, sustainability and reliability		■				
4) Institutional management plan address the following recommended institutional options			■			SUEP Improving existing systems
5) Provided technical assistance to implement the bottom up demand-oriented process				■		SUEP Target
6) Assist service providers, in their major reorientation of attitudes		■				

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2.3 Environmental Valuation/Pricing Accounting Framework

2.3.1 Capital Stock and Environmental Accounting

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.3.1	0	1	2	3	4	
1) Project environmental accounting framework that recognizes the four categories of capital		■				Not a major SUEP focus
2) Expansion beyond traditional project benefit focus on human-made capital		■				Not a major SUEP focus
3) Project fully addresses the protection and enhancement of natural capital		■				Not a major SUEP focus
4) Recognization that substituting non-natural capital for natural capital is eventually limited		■				Not a major SUEP focus
5) Recognization of importance of human capital formation and its high return on investment			■			SUEP Improving existing systems
6) Recognization of full ramifications of social capital by the project			■			SUEP Improving existing systems
7) Environmental accounting recognized the difficulties in accounting the environmental *obligations*			■			SUEP Improving existing systems
8) Accounting framework incorporates environmental concerns by using recommended definitions			■			SUEP Improving existing systems

2.3.2 Sustainability and the Capital Stock

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.3.2	0	1	2	3	4	
1) Evaluation of promising concept of giving future generations the same, if not more, opportunities	■					
2) Accounting framework allow for defining sustainability in terms of a context of capital thresholds		■				SUEP initiating
3) Incorporating analysis of human capital and natural capital interlinkages		■				
4) Project review includes level of sustainability appropriate for the project		■				
5) Encouraged the growth of natural capital by a pragmatic approach		■				
6) Assists with the improvement of our data bases related to the different kinds of capital			■			SUEP Improving existing systems

2.3.3 Environmental Resource Pricing

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.3.3	0	1	2	3	4	
1) Pricing ensured "true" economic value of water resources accounted for in investment decision		■				Not a major SUEP focus
2) Marginal economic value of the water resources been entered into the accounting procedure			■			SUEP Target
3) Internalization of environmental damage costs to prevent distortions in the economy			■			SUEP Target
4) Pricing of water resources included direct and indirect consumption		■				
5) Price set equal to the extraction cost, plus external costs that extraction causes, plus "user costs"		■				
6) Full evaluation of potential for underpricing of water			■			SUEP Improving existing systems
7) Used recommended (or similar) method for pricing water		■				

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2.3.4 Environmental Valuation

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.3.4	0	1	2	3	4	
1) Measurement of how environmental changes affect observable behavior in conventional markets	■					Not a major SUEP focus
2) Assessment of value of intended actions on replacement cost and shadow project	■					
3) Short of direct market valuation, assessment of indirect market data to determine implicit values	■					
4) Short of market data, simulation of market-like behavior, using marketing experiments or surveys	■					

2.4 Economic Instruments

2.4.1 Selection Criteria: Command-and-Control Versus Economic Strategies

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.4.1	0	1	2	3	4	
1) Developed under and fully incorporated various economic instruments		■				Analyses of economic approaches just beginning under SUEP
2) Instruments determine most efficient and cost-effective means for achieving environmental targets		■				
3) System restores the link between resource scarcity and resource price		■				
4) System insures that recommended goals are met		■				
5) System has information base, strong legal structure, competitive markets, administrative capacity		■				
6) System includes the necessary sophisticated institutions to implement and enforce them		■				
7) System does eliminate the need for regulations, enforcement, and other government participation		■				
8) System overcomes industrial resistance to instruments such as effluent and emissions charges		■				
9) Project considers that not all types of pollution are appropriate for an incentive-based approach		■				
10) System meets the four performance criteria of effectiveness, efficiency, equity, and flexibility		■				

2.4.2 Pollution charges

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.4.2	0	1	2	3	4	
1) Includes fees levied based on the quantity/quality of pollutants discharged into the environment			■			SUEP Improving existing systems
2) Based on optimal mix of water quality objectives, costs, and effluent standards		■				

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.4.2	0	1	2	3	4	
3) Creates required institutional, political, and technical conditions			■			SUEP Improving existing systems
4) Takes full advantage of the advantages of listed effluent and emission charges			■			SUEP Improving existing systems
5) Recognizes and mitigates against the principal disadvantages of effluent charges		■				

2.4.3 User, Product and Administrative Charges

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.4.3	0	1	2	3	4	
1) Considers system of user charges, direct payments for the costs of collective/public treatment		■				
2) Ensures that receiving facility has incentive to improve quality of its effluent discharge			■			SUEP Target
3) Considers product charges, fees added to price of products/product inputs that cause pollution		■				
4) Considers administrative charges, fees paid to authorities for environmental services		■				

2.4.4 Tax Differentiation and Subsidies

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.4.4	0	1	2	3	4	
1) Considers tax differentiation to promote consumption of products that are environmentally safe	■					Not a major SUEP focus
2) Utilizes system of subsidies that act as incentives to polluters to change behavior or reduce costs	■					
3) Uses tax incentives that involve tax credits or accelerated depreciation for industrial investments	■					

2.4.5 Enforcement incentives

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.4.5	0	1	2	3	4	
1) System of enforcement incentives		■				SUEP initiating
2) System of noncompliance fees		■				
3) System of performance bonds	■					Little in place
4) System of liability assignment		■				

2.4.6 Policy Instruments for Implementing Economic Incentives

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.4.6	0	1	2	3	4	
1) System includes recommended broad array of complementary instruments		■				SUEP initiating
2) System includes appropriate mix of policy instruments based on the checklist		■				

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2.5 Financial Planning and Economic Impacts

2.5.1 Keys to Developing a Financially Sustainable Water Sector

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.5.1	0	1	2	3	4	
1) System includes basic principles that water has an economic value		■				Not a major SUEP focus
2) Project based on participatory approach		■				
3) Includes central tenet that use private financing-private goods, public resources-public goods		■				
4) Allows appropriate social units to weigh the costs and benefits of different amounts of investment		■				
5) All costs: abstracting, transporting, storing, treating, distributing, economic cost - input of water			■			SUEP initiating
6) Appropriate management charges based on the opportunity cost levied on users			■			
7) Benefits for household water supply are essentially private, costs by householders themselves			■			
8) Uses user charges to cover the economic costs of inputs			■			
9) Benefits of sanitation & sewerage more complex, households plus more aggregate level				■		SUEP Improving existing systems
10) Sanitation costs assigned to different levels in hierarchy according to the benefits accrued				■		SUEP Improving existing systems
11) Financing: sound economics, economic progress and environmental enhancement with social values				■		SUEP Improving existing systems

2.5.2 Tracing Economic Impacts

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.5.2	0	1	2	3	4	
1) Policy analysis system traces the impacts of the project – beyond classical CBA			■			SUEP Improving existing systems
2) Policy analysis system traces the impacts of the project – under a regional perspective			■			SUEP Improving existing systems
3) Policy analysis system traces the impacts of the project – addressing economy-wide constraints		■				
4) Policy analysis system traces the impacts of the project – addressing international constraints						Not applicable

2.6 Risk Management

2.6.1 Risk-Based Priorities

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.6.1	0	1	2	3	4	
1) Project addresses the recommended key objectives in addressing the water issue at hand			■			SUEP Target
2) Evaluates impacts on criteria of Timing, Novelty, Scope, Severity, Visibility, Probability		■				
3) Addresses and prioritizes actions based on prioritization chart		■				

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2.6.2 Assessing Welfare Risks

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.6.2	0	1	2	3	4	
1) Assesses Ecological Quality, reduced environmental resource quality, decreased human utility		■				SUEP initiating
2) Assesses Resource Sustainability, irreversible losses of ecosystem structure and functions		■				
3) Assesses Direct Economic Effects-physical changes causing adverse economic impacts on humans		■				
4) Assesses Direct Non-Economic Effects- social problems that can include human health effects			■			SUEP Improving existing systems
5) Output of analysis includes numerical estimates of the magnitude of the assessed risk			■			
6) Output of analysis includes type of adverse effect with estimate of magnitude			■			
7) Output of analysis includes discussions of the knowledge base		■				Future SUEP phases under Environmental Information System
8) Analysis chooses appropriate hard or soft version for project considering the pluses and minuses		■				

2.7 Cost Benefit Analysis and Multi-Objective Decision-Making

2.7.1 Improving CBA

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.7.1	0	1	2	3	4	
1) Correct application of shadow prices for opportunity cost, including valuation of externalities			■			SUEP Improving existing systems
2) Project assessment adjusted national accounts based on resulting resource use						
3) Provided for the economic value of environmental impacts in project appraisals				■		SUEP Target
4) Project does not result in the net reduction in the value of the stock of environmental capital		■				
5) Correct market prices, reflect the full costs/benefits, internalizing environmental externalities				■		SUEP Target
6) Used "ability to pay" in conjunction with "willingness to pay" studies	■					Not a major SUEP focus
7) Willingness to pay recognized resource endowment function of different countries (or individuals)	■					
8) Discounting focus more on long-run development in developing economies		■				
9) Augmented CBA with an analysis of the impacts of the program on long-run sustainability		■				
10) Accounts for the costs/benefits which accrue to society including environmental impacts				■		SUEP EA addressed
11) Recognized that environmental effects are "public goods," without measurable market values		■				
12) Mitigated potential undervalued or ignored many environmental functions and services		■				
13) Mitigated inherent inability to deal with irreversible damage to the environment			■			SUEP Improving existing systems
14) Used "least-cost" when environmental goals and objectives are difficult to truly incorporate				■		SUEP Target
15) Used "switching value" approach with least-cost when some benefits are quantifiable		■				Not a major SUEP focus
16) Switching value analysis deals with intangible gains/losses, including aesthetic/recreational values		■				
17) Alternatives described in qualitative or non-economic terms, environmental effects not quantified		■				
18) Used and met "safe minimum standard" analysis		■				

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2.7.2 Multi-objective Decision-making

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
2.7.2	0	1	2	3	4	
1) Process incorporated physical impacts values, multi-objective decision-making, discounting, risk			■			SUEP Improving existing systems
2) Recognized system of broad (national) objectives, some of which cannot be easily quantified		■				
3) Recognized the variety of concerns, with measurement beyond monetary terms		■				
4) MODM fits and used appropriate methods such as optimization or design standard		■				
5) Mitigated against model representing single decision-maker (or group)			■			SUEP Improving existing systems

3.0 Enhanced Environmental Impact Assessment

3.1 Project Specific Criteria

3.1.1 Dams

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.1	0	1	2	3	4	
1) Adequately investigation of alternatives to the proposed dams						Not applicable
2) Recognized and mitigated the main potential impacts due to existence of dams of reservoirs						
3) Recognized and mitigated the main potential impacts due to operation of dams of reservoirs						
4) Work under and conform to a scientifically rigorous set of in-stream flow standards						
5) Recognized/mitigated the potential negative environmental effects of construction						
6) Efficiently and equitably dealt with the dislocation and compensation in kind for resources lost						
7) Analyzed/mitigated loss of land (agricultural, forest, range, wetlands)						
8) Analyzed/mitigated loss of historic, cultural or aesthetic features						
9) Analyzed/mitigated loss of wildlands and wildlife habitat						
10) Analyzed/mitigated the potential for proliferation of aquatic weeds in reservoir and downstream						
11) Analyzed/mitigated potential for deterioration of water quality in the reservoir						
12) Analyzed/mitigated potential for sedimentation of the reservoir and loss of storage capacity						
13) Analyzed/mitigated potential occurrence/intensification of reservoir-induced seismic activity						
14) Investigated potential groundwater impacts within the zone of influence						
15) Analyzed/mitigated potential for seepage						
16) Analyzed/mitigated potential for other major side effects						
17) Incorporated measures to prevent the formation of sediment deposits at reservoir entrance						

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.1	0	1	2	3	4	
18) Incorporated design features to prevent scouring of the riverbed below the dam						
19) Analyzed/mitigated impacts of decreases in floodplain (recession) agriculture						
20) Analyzed/mitigated potential for salinization of floodplain lands and included flow regulation						
21) Analyzed/mitigated potential for salt water intrusion in any downstream estuary areas						
22) Analyzed/mitigated any potential disruption of riverine fisheries						
23) Analyzed/mitigated potential for snagging of fishing nets in submerged vegetation						
24) Integrated a health assessment into the planning						
25) Equitable system used in project development for dealing with conflicting demands for water use						
26) Analyzed/mitigated potential for social disruption and decreased resettled standard of living						
27) Analyzed/mitigated potential for environmental degradation from increased pressure on land						
28) Appropriate design features/mitigations- disruption/destruction of tribal/indigenous groups						
29) Analyzed/mitigated potential for secondary impacts of insect disease vectors						
30) Analyzed/mitigated potential indirect and external impacts adequately						

3.1.2 Fisheries

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.2	0	1	2	3	4	
1) Analyzed/mitigated potential for overexploitation of fisheries stock and long-term degradation						Not applicable
2) Analyzed/mitigated potential capture of non-target species and habitat damage						
3) Ensured mitigation to prevent pollution from oil/fuel spills and leakage, and from bilge flushing						
4) Included measures to minimize diver and anchor damage						
5) Included prohibition and enforcement regulations for explosives and poison						
6) Prohibited direct culture fisheries from clearing/conversion of coastal wetlands						
7) Included in direct culture fisheries erosion and siltation mitigation in the construction phase						
8) Evaluated need for direct culture ponds relative to alternative water and land resources demands						
9) Addressed potential loss of productivity or formation of toxic conditions in direct culture ponds						
10) Analyzed/mitigated potential acidification of pond water due to hydrogen sulfide formation						
11) Included production of larvae and juveniles in a nursery for pond stocking						
12) Analyzed/mitigated potential water pollution from the pond effluent						
13) Included and enforced a ban on exotics to prevent degradation of native stocks						
14) Included measures to prevent the introduction of exotics with subsequent damage to native stocks						
15) Included measures to prevent the spread of disease in aquaculture stocks and into natural stocks						
16) Evaluated regional implications of concentration of pens, pilings, and rafts in natural waters						
17) Analyzed/mitigated external impacts of both Capture Fisheries and Culture Fisheries						

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3.1.3 Flood Protection

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.3	0	1	2	3	4	
1) Complies with institutional system designed to modify susceptibility to flood damage/disruption						Not applicable
2) Complies with institutional system designed to modify the impact of flooding						
3) Incorporates the use of Natural and Cultural Resources for flood protection						
4) Addresses potential for flooding of lesser magnitude, but greater duration						
5) Analyzed/mitigated potential failure, floodwaters exceed capacity of control structures/measures						
6) Regulated discharge, imitating natural flooding for enrichment and groundwater recharge						
7) Analyzed/mitigated potential adverse effects on fisheries and other aquatic resources						
8) Analyzed/mitigated potential negative impacts of channelization measures						
9) Project recommended appropriate mitigation measures						
10) Analyzed/mitigated potential adverse effects of construction						
11) Analyzed/mitigated potential reduction of floodplain grazing						
12) Analyzed/mitigated reduction of recession agriculture, maintaining natural flooding regime						
13) Provided for construction of bridges or special crossing places for wildlife						
14) Analyzed/mitigated loss of wildlands and wildlife habitat						
15) Analyzed/mitigated indirect impacts						

3.1.4 Groundwater

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.4	0	1	2	3	4	
1) Complied with comprehensive system of ambient groundwater quality standards						Not applicable
2) Does not impact groundwater potable water supplies, primary/secondary standards						
3) Complied with applicable groundwater effluent standards for direct/indirect discharges						
4) Complied with standards governing siting/design/construction/installation/operation/closure						
5) Incorporates BMPs for potential source of groundwater contamination						
6) Complies with permitting and project review processes of the local and regional authorities						
7) Complies with land use controls designed to protect groundwater resources, recharge areas						
8) Analyzed/mitigated proposed large-scale use of groundwater resources						
9) Addressed interaction of groundwater with surface watercourses in that the use of groundwater						
10) Addressed potential negative or positive impacts in any irrigation components on drawdown						
11) Analyzed/mitigated potential for excessive abstraction, setting permissible abstraction rate						
12) Analyzed/mitigated possibility of introducing or enhancing sea-water intrusion in the project area						
13) Analyzed/mitigated potential for excessive extraction leading to regional land subsidence						

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3.1.5 Hydroelectric

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.5	0	1	2	3	4	
1) Analyzed/mitigated potential negative environmental effects of hydroelectric facility construction						Not applicable
2) Analyzed/mitigated dislocation of people living in proposed inundation zones						
3) Analyzed/mitigated potential loss of land (agricultural, forest, range, wetlands) by inundation						
4) Analyzed/mitigated loss of historic, cultural or aesthetic features by inundation						
5) Analyzed/mitigated loss of wildlands and wildlife habitat						
6) Analyzed/mitigated potential for proliferation of aquatic weeds in reservoir and downstream						
7) Analyzed/mitigated potential for deterioration of the water quality in reservoirs						
8) Analyzed/mitigated potential for sedimentation of any proposed project reservoirs						
9) Analyzed/mitigated potential for formation of sediment deposits at reservoir entrances						
10) Analyzed/mitigated potential for scouring of the riverbed below proposed dams						
11) Analyzed/mitigated potential decrease in floodplain (recession) agriculture						
12) Analyzed/mitigated potential for salinization of floodplain lands						
13) Analyzed/mitigated potential for salt water intrusion in estuary and upstream						
14) Analyzed/mitigated potential for disruption of riverine fisheries						
15) Analyzed/mitigated potential for other reservoir-related direct and indirect impacts						

3.1.6 Irrigation

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.6	0	1	2	3	4	
1) Analyzed/mitigated potential soil erosion (furrow, surface)						Not applicable
2) Analyzed/mitigated potential soil erosion (with sprinkler irrigation on hilly areas)						
3) Analyzed/mitigated potential for waterlogging of soils						
4) Analyzed/mitigated potential for irrigation water carrying soil entrained fertilizers and pesticides						
5) Analyzed/mitigated potential for excavation of irrigation canals interrupting groundwater flow						
6) Analyzed/mitigated potential for salinization of soils						
7) Analyzed/mitigated potential for scouring of canals						
8) Analyzed/mitigated potential for clogging of canals by sediments						
9) Analyzed/mitigated the potential for leaching of nutrients from soils						
10) Analyzed/mitigated possible formation of algal blooms and weed proliferation						
11) Analyzed/mitigated potential for clogging of canals by weeds						
12) Analyzed/mitigated deterioration of river/groundwater water quality below irrigation project						
13) Analyzed/mitigated potential sea water intrusion into downstream freshwater systems						
14) Analyzed/mitigated reduction of downstream flows affecting flood plain use						
15) Analyzed/mitigated encroachment on swamps and other ecologically sensitive areas						
16) Analyzed/mitigated alteration/destruction of wildlife habitat, impediments to movement						

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.6	0	1	2	3	4	
17) Included passageways to mitigate impediments to movement of livestock and humans						
18) Analyzed/mitigated potential threat to historic, cultural or aesthetic features						
19) Analyzed/mitigated alteration or loss of flood plain vegetation, disturbance of coastal ecosystem						
20) Analyzed/mitigated dislocation of populations and communities						
21) Included health impact assessment to mitigate increase of water-borne or water-related disease						
22) Mitigated health/disease implications of use of wastewater for irrigation						
23) Analyzed/mitigated Indirect and External Impacts						

3.1.7 Water and Sanitation

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.7	0	1	2	3	4	
1) Evaluated water plant sludge quantity/composition, appropriate treatment/dewatering/disposal					■	SUEP Target
2) Complies with rigorous water pollution control program including institutions and policies				■		SUEP Target
3) Includes system of phased improvements, incremental waste treatment improvement				■		SUEP EA addressed
4) Evaluated quantity/composition of municipal wastewater				■		SUEP EA addressed
5) Evaluated potential urban stormwater contribution to the overall urban pollution generation			■			
6) Analyzed/mitigated health effects in areas where wastewater collected but not treated properly		■				SUEP initiating
7) Analyzed/mitigated potential for nutrient content causing eutrophication or nuisance plants					■	SUEP Target
8) Insured that solid waste generated in wastewater treatment handled properly				■		SUEP Improving existing systems
9) Thoroughly investigated potential for wastewater reuse				■		SUEP Improving existing systems
10) Included wastewater project components for "cradle to grave" operation			■			
11) Included listed generic characteristics common to potential impacts and mitigating measures				■		SUEP EA addressed
12) Thoroughly evaluated required level of wastewater treatment				■		SUEP EA addressed
13) Included expansion space reserved for acquiring treatment and disposal sites					■	SUEP Target
14) Analyzed/mitigated against the most common causes of system failure			■			SUEP Improving existing systems
15) Analyzed/mitigated against common institutional weaknesses			■			SUEP Improving existing systems
16) Included concept of appropriate technology in water supply and wastewater systems		■				Not a major SUEP focus
17) Included community participation as key element wastewater management		■				Not a major SUEP focus
18) Ensured industrial pretreatment program developed including hazardous and toxic substances			■			
19) Analyzed/mitigated any involuntary resettlement required for proposed treatment facilities					■	SUEP EA addressed
20) Analyzed/mitigated against nuisances in the immediate vicinity of the facilities					■	SUEP EA addressed
21) Evaluated all potential siting and technological alternatives for wastewater collection				■		SUEP Target
22) Evaluated all potential siting and technological alternatives for wastewater treatment				■		SUEP Target
23) Evaluated all potential siting and technological alternatives for wastewater disposal				■		SUEP Target
24) Evaluated all potential siting and technological alternatives for wastewater sludge management				■		SUEP Target
25) Included sufficient staffing in proposed O&M program			■			SUEP Improving existing systems
26) Included sufficient operator training, starting before system start-up			■			SUEP Improving existing systems
27) Included a start-up plan to ensure that the O&M requirements are met			■			SUEP Improving existing systems

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.1.7	0	1	2	3	4	
28) Included state-of-the-art construction inspection practices		■				Not a major SUEP focus
29) Included detailed multi-objective operational monitoring program			■			SUEP EA addressed
30) Minimized disturbance of stream channels and habitat during construction				■		SUEP EA addressed
31) Analyzed/mitigated potential for alterations in hydrologic balance by wastewater exportation		■				Not a major SUEP focus
32) Analyzed/mitigated potential for degradation overflows, bypasses, or treatment process failure				■		SUEP EA addressed
33) Analyzed/mitigated potential for water quality degradation in normal system operation				■		SUEP EA addressed
34) Analyzed/mitigated potential public health hazards in vicinity of discharges or reuse sites		■				Not a major SUEP focus
35) Analyzed/mitigated potential for soil/crop/groundwater contamination at land application sites						Not applicable
36) Analyzed/mitigated potential failure to achieve desired beneficial uses of receiving waters					■	SUEP EA addressed
37) Analyzed/mitigated potential for odors and noise from treatment or sludge processes				■		SUEP EA addressed
38) Analyzed/mitigated potential for soil/crop/groundwater contamination in sludge management				■		SUEP EA addressed
39) Analyzed/mitigated potential for worker accidents during construction and operation				■		SUEP EA addressed
40) Analyzed/mitigated potential for worker accidents due to gas or hazardous materials in sewers			■			
41) Analyzed/mitigated potential for public and worker health hazard from chlorine accidents				■		
42) Analyzed/mitigated potential for public health hazards from sewer overflows and backups				■		SUEP EA addressed
43) Included sanitation and hygiene education program		■				
44) Analyzed/mitigated potential for accidental destruction of archaeological sites			■			
45) Analyzed/mitigated possibility of induced or facilitated unplanned development		■				
46) Analyzed/mitigated potential for sludge exacerbating regional solid waste management problems			■			
47) Evaluated the importance and protected receiving water for local and regional fisheries				■		SUEP EA addressed

3.2 Bioassessment

3.2.1 Biological Criteria

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.2.1	0	1	2	3	4	
1) Assessed with system of goals, regional reference conditions - attainable biological integrity	■					
2) Biological criteria used in impact assessment protects aquatic ecosystems		■				Limited biological integrity in receiving streams except Yangtze
3) Biological criteria used in impact assessment assesses ecological degradation, ecosystem response		■				
4) Biological criteria used in impact assessment assesses biological resource trends in watershed		■				
5) Biological criteria recognizes limitations relative to point source limitations		■				
6) Analyzed/mitigated cumulative effects of human actions on typical water quality characteristics	■					Not a major SUEP focus
7) Analyzed/mitigated cumulative effects of human actions on habitat structure	■					
8) Analyzed/mitigated cumulative effects of human actions on flow regime	■					
9) Analyzed/mitigated cumulative effects of human actions on energy source	■					
10) Analyzed/mitigated cumulative effects of human actions on biotic interactions	■					

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3.2.3 Reassessment of Water Quality Goals

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.2.3	0	1	2	3	4	
1) Expanded typical goals beyond WWTP effectiveness and cancer risk to biological integrity		■				SUEP initiating
2) Fosters the attainment of long-term biological integrity goals for the local watershed		■				

3.3 Point and Non-Point Source Pollution Control

3.3.1 Comprehensive Assessment

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.3.1	0	1	2	3	4	
1) Project assessed under regional water quality system that evaluated:			■			SUEP Improving existing systems
a. Industrial Point Sources			■			
b. Municipal Point Sources			■			
c. Combined Sewer Overflows			■			
d. Domestic Wastewater Lagoons			■			
e. Agricultural Sources			■			
f. Silvicultural Sources			■			
g. Construction Sources			■			
h. Urban Runoff/Storm Sewers			■			
i. Resource Extraction Impacts			■			
j. Land Disposal Sources			■			
k. Hydromodification Impacts			■			
l. Other Habitat Modification			■			
m. Marinas and Water Vessels			■			
n. Atmospheric Deposition			■			
o. Natural Sources			■			

3.3.2 Valid and Comparable Water Quality Assessments

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.3.2	0	1	2	3	4	
1) Assessed under a system of water quality indicators which are appropriate to the monitoring goal			■			SUEP Improving existing systems
2) Assessed under a system of water quality indicators which are scientifically valid			■			
3) Assessed under a system of water quality indicators which are similar enough to compare results			■			

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.3.2	0	1	2	3	4	
4) Assessed under a system of water quality indicators which are grounded in developed matrices		■				SUEP initiating
5) Assessment indicators with standard base monitoring indicators established for designated uses		■				
6) Assessment indicators with ecological condition/aquatic life indicators developed		■				
7) Assessment and monitoring of groundwater using a suite of ground water indicators		■				
8) Assessed using valid/comparable field and scientifically valid laboratory methods		■				
9) Assessment uses specified methods able to yield comparable data of known quality		■				
10) Assessed using endorsed/documented reference condition approaches for aquatic life assessments		■				
11) Monitoring system proposed works under and complies with regional monitoring designs			■			SUEP Improving existing systems
12) Regional system includes a high degree of institutional collaboration and agreement	■					
13) Regional system contains flexible, targeted monitoring strategy			■			SUEP Improving existing systems
14) Adequate documentation of assessment quality allowing users to determine data compatibility		■				
15) Uses standard interfaces and data handling formats for individual water data systems		■				
16) Assessed under classification system of pollution cause categories		■				
17) Analyzed/mitigated potential water quality impacts to an existing lake/reservoir impoundments				■		SUEP EA addressed
18) Analyzed/mitigated potential impacts to groundwater including Agricultural Activities		■				
19) Analyzed/mitigated potential impacts to groundwater including Storage and Treatment Activities		■				
20) Analyzed/mitigated potential impacts to groundwater including Disposal Activities		■				
21) Analyzed/mitigated potential impacts to groundwater including Miscellaneous Sources		■				
22) Groundwater projection system contains recommended legislative and administrative protection	■					
23) Used all available information sources relative to industrial and municipal point source evaluations				■		SUEP EA addressed
24) Used all available information sources relative to agricultural point source evaluations				■		SUEP EA addressed
25) Used all available information sources relative to agricultural non-point source evaluations	■					Not a major SUEP focus
26) Used all available information sources relative to silviculture nonpoint source evaluations	■					
27) Used all available information sources relative to construction point/nonpoint source evaluations	■					
28) Used all available information sources relative to urban runoff nonpoint source evaluations		■				SUEP initiating
29) Used all available information sources-petroleum extraction point/nonpoint source evaluations		■				
30) Used all available information sources relative to surface mining extraction evaluations	■					
31) Used all available information sources relative to land disposal evaluations		■				
32) Used all available information sources relative to hydromodification evaluations		■				
33) Used all available information sources relative to channel hydromodification		■				Not a major SUEP focus
34) Used all available information sources relative to natural source point and nonpoint sources				■		SUEP EA addressed

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3.4 Minimum Stream Flows

3.4.1 Instream Flow Problems

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.4.1	0	1	2	3	4	
1) Proposed reservoirs address flooding and the resulting streamflow regulation						Not applicable
2) Proposed abstraction of surface water addresses instream flow reductions downstream				■		SUEP EA addressed
3) Economic comparison of abstraction against instream flow, ecological and other impacts				■		SUEP EA addressed
4) Proposed peak power production recognizes the impacts on downstream ecological systems						Not applicable

3.4.2 Minimum acceptable flow

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.4.2	0	1	2	3	4	
1) Assessment determined reasonable/cost-effective/environmentally-sensitive method to minflow			■			EA addressed lack of dry season flows for dilution
2) Reviewed its findings against 1966 ECE approximate values for fixing minimum flows	■					Not a major SUEP focus
3) Reviewed its findings against 1974 ECE "quantitative and qualitative constraints/requirements"	■					
4) Determined minimum flow insures "flow of water sufficient to prevent stagnation of water"	■					Monsoon precipitation pattern drives wq problems in dry season
5) Determined minimum flow insures "sufficient dilution of dispersed pollution"			■			EA addressed lack of dry season flows for dilution
6) Determined minimum flow insures "biological balance of the natural aquatic environment"		■				SUEP Improving existing systems
7) Determined minimum flow insures "necessary flows for unorganized water supplies (eg. livestock)"		■				
8) Determined minimum flow insures "prevention of sedimentation and other flow phenomena"		■				
9) Determined minimum flow insures "preservation of natural beauty"		■				
10) Determined minimum flow insures "sufficient to avoid the formation of clay and mud zones"		■				

3.5 Regional, Sectoral and Cumulative Impacts

3.5.1 Regional and Sectoral EIA

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.5.1	0	1	2	3	4	
1) Developed and assessed under a regional and/or sectoral perspective			■			Evaluated potential impacts to Three Gorges Dam
2) Used multidisciplinary approach with broad environmental policy, institution building, etc.		■				
3) Regional/sectoral perspective augments economic deficiencies (qualitative and intangible effects)		■				
4) Perspective analyzed how, whether or where the project should happen				■		SUEP Improving existing systems
5) Project emerged from a tiered process of policy, program and plan review				■		SUEP Improving existing systems
6) Regional/sectoral approach used to determine conformity with sustainability goals and principles			■			

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.5.1	0	1	2	3	4	
7) Regional/sectoral approach used to determine environmental costs of development program			■			
8) Regional/sectoral approach used to determine resource and land use zoning systems			■			
9) Regional/sectoral approach used to determine in-kind compensation for loss of natural capital		■				
10) Regional/sectoral approach used to determine if project is environmentally sound				■		SUEP EA addressed
11) Regional/sectoral approach used to determine combined impacts of other projects being pursued				■		SUEP EA addressed
12) Regional/sectoral approach used for cumulative impacts/synergisms/interactions/competition		■				
13) Regional/sectoral approach analyzed institutional problems in "Human Resources"			■			
14) Regional/sectoral approach analyzed problems in "Environmental Policy/Laws/Regulations"		■				
15) Regional/sectoral approach analyzed problems in "Organizational Structure"			■			
16) Regional/sectoral approach analyzed "EA and Environmental Management Procedures"					■	SUEP EA addressed
17) Regional/sectoral approach analyzed "Financial issues"					■	SUEP EA addressed
18) Used criterion of the productivity and full functioning of the natural resource base				■		
19) Analyzed all resources including exhaustible resources, renewable resources, life-support resources		■				
20) Assigned full environmental and resource costs to the project					■	SUEP EA addressed
21) Determined total amount of financing required for the project to meet sustainability conditions			■			
22) Used early screen to identify the potential environmental consequences				■		SUEP EA addressed
23) Definitive aspects cover complex policies or that have global or cumulative environmental effects		■				
24) System contains the listed recommended components				■		SUEP EA addressed
25) System provides benefit of "Provides a baseline overview of environmental conditions"			■			
26) System provides benefit of "Increases the transparency of the planning process"			■			
27) System provides benefit of "Analyzes the institutional and legal framework"		■				
28) System provides benefit of "Organizes regional environmental data and identifies data gaps"			■			
29) System provides benefit of "Identifies broad institutional, resources and technological needs "		■				
30) System provides benefit of "Provides basis for collaboration and coordination"		■				
31) System provides benefit of "Sets criteria for environmental screening, standards and guidelines"				■		SUEP EA addressed
32) System provides benefit of "Provides a vehicle for public participation"			■			Limited

3.5.2 Cumulative Impact Assessment

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.5.2	0	1	2	3	4	
1) Developed under formalized approach to cumulative impact assessment (CIA) that encourages listed benefits		■				Not a major SUEP focus
2) Any drawdown of natural capital offset by resource conservation, rehabilitation or replacement		■				
3) Proposed in-kind compensation/mitigation applied to conforming/non-conforming development		■				
4) EIA incorporates considerations of the cumulative impacts of the proposed project		■				
5) CIA relate integrated impacts (over time) on each relevant environmental resource		■				

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6)	CIA relate impacts across all relevant environmental resources at a given point in time					
7)	CIA includes all existing projects or impact-causing factors in the geographical area					
8)	CIA evaluates synergistic or antagonistic reactions related to environmental effects					

3.6 Environmental Indicators

3.6.1 Defining Environmental Conditions

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.6.1	0	1	2	3	4	
1) Impacts compared with indicators showing the proximate pressure on the environment						SUEP Objectively Verifiable Indicators are starting point
2) Pressure indicators then measured in terms of state of the environment (SOE) indicators						
3) SOE indicators translated into effects indicators, measuring asset economic value						
4) Indicators used in accounting framework which includes monetized measures of damage						
5) Indicators value the effects of and rank urban environmental problems						
6) Key measures included Health and Safety, Productivity, Equity, Ecology, Amenity						
7) Effect on Level 1 system showing ambient qualities of the receiving environment						
8) Effect on Level 2 indicators, Level 1 related to some other variable, usually an economic one						
9) System of satellite accounting used and integrated into a wider accounting framework						
10) Sustainability measurement-Monetization, Expert assessments, Compliance (official policy goals)						
11) Addressed all three branches of the *OECD* indicator model using Pressure-State-Response(PSR)						
12) Fosters goals-oriented approach, relating descriptive indicators to target values						
13) Produce definitive measures of progress or set priorities for further monitoring and data collection						
14) Indicators use criteria of Focal Variable, Time Stretch, Relativity, Appropriate Units						

3.6.2 Water Project Performance

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.6.2	0	1	2	3	4	
1) Meets suggested criteria for "Continued delivery of services and production of benefits"						SUEP OVIs work as performance indicators
2) Meets suggested criteria for "Maintenance of physical infrastructure"						
3) Meets suggested criteria for "Long-term institutional capacity"						
4) Meets suggested criteria for "Political support"						

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3.6.3 Sustainability Indicators

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
3.6.3	0	1	2	3	4	
1) Project addresses policy analysis aspect of "finance"						SUEP Improving existing systems. Little currently in place
2) Project addresses policy analysis aspect of "costs/benefits per sector"						
3) Project addresses policy analysis aspect of "effects on the balance of trade and payments"						
4) Project addresses policy analysis aspect of "effects on distribution of income"						
5) Project addresses policy analysis aspect of "effects on cultural heritage"						
6) Project addresses policy analysis aspect of "effects on landscape"						
7) Project addresses policy analysis aspect of "social basis"						
8) Project addresses policy analysis aspect of "management, legal and institutional aspects"						
9) Project addresses policy analysis aspect of "vulnerabilities and risks"						
10) Project addresses all "Environmental pressure indicators"						
11) Project addresses all "Effects on nature and the environment"						
12) Project addresses policy analysis aspect of "Effects on health, safety and well-being"						
13) Project addresses policy analysis aspect of "Structural socioeconomic development"						
14) Project addresses policy analysis aspect of "Use of the environmental utilization space"						
15) Project addresses "Opportunities for conserving or enlarging environmental utilization space"						
16) Project addresses "Flexibility and sustainable quality of structures and management"						
17) Fosters regional sustainable development (acceptable level of welfare compatible with ecology)						
18) Ensures activities within ecological boundaries commensurate with global sustainability						
19) Included environmental amenities as a second welfare attribute						
20) Costs included all uses of natural resources and the by-products of outputs						
21) Operationalized sustainability criterion considering five sustainability dimensions						
22) Sustainability criterion plays dominant role in appraisal by applying recommended criteria						
23) Utilized a strict sustainability criterion limiting production function substitution						

4.0 Project Implementation and Tracking – *(Project Not Yet Constructed)*

4.1 Integration of Environmental and Social Impact Assessments

4.1.1 Beneficiaries

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.1.1	0	1	2	3	4	
1) Addressed social benefits for those directly involved and longer term and 'downstream'						SUEP Improving existing systems
2) Recognize benefit significance of improving water and sanitation environment for urban poor						SUEP Target
3) Distinguishes multiple beneficiaries likely to arise in all levels of government						SUEP Target
4) Distinguishes between time-related benefits in long and short terms						SUEP Target

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4.1.2 Disbenefits from the Project

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.1.2	0	1	2	3	4	
1) Analyzed/mitigated temporary or permanent relocation of households or enterprises					■	SUEP Target
2) Identified groups of people who stand to be negatively affected by the proposed project				■		
3) Analyzed/mitigated temporary construction impacts in the resettlement action plan					■	SUEP EA addressed
4) Identified all potential financial costs associated with needed relocations					■	SUEP EA addressed
5) Analyzed/mitigated past problems from survey of people previously relocated				■		

4.1.3 Intra-household issues

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.1.3	0	1	2	3	4	
1) Components developed with full participation of both men and women		■				Not a major SUEP focus
2) Addressed intra-household distributions of resources and domestic roles in economic analyses		■				
3) Included household questionnaire survey to determine household management roles		■				
4) Included expanded socioeconomic and health "willingness to pay" survey			■			SUEP EA addressed

4.1.4 Community Participation

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.1.4	0	1	2	3	4	
1) Appropriate community participation process used in the EA with proper consultation			■			SUEP EA addressed
2) Public participation process used all means to ensure that significant public concerns addressed			■			
3) Participation process included cost recovery and willingness to pay issues			■			
4) Participation process explored options for community involvement in the project implementation		■				Public officials only

4.1.5 Health

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.1.5	0	1	2	3	4	
1) Household survey included questions on water-related health issues			■			SUEP Improving existing systems
2) Health issues related to a wide range of socio-economic and environmental variables			■			
3) Reviewed all potential negative impacts to the regional health that could be induced by project			■			SUEP EA addressed

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4.1.6 Social Impact Assessment Methodology

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.1.6	0	1	2	3	4	
1) SIA included process that "Identified/involved all potentially affected groups and individuals"		■				Not a major SUEP focus
2) SIA included process that "Identified who will win and who will lose"		■				
3) SIA included process that "Emphasize vulnerability of under-represented groups"		■				
4) SIA included process that "Dealt with issues and public concerns that really count"		■				
5) SIA included process that "Defines process, assumptions used, how significance were selected"		■				
6) SIA included process that "Identified problems that could be solved with project changes"		■				
7) SIA included process that "Used trained social scientists employing social science methods"		■				
8) SIA included process that "Managed uncertainty by monitoring/ mitigating adverse impacts"		■				
9) SIA included process that "Identified data sources, scientific literature, secondary data, etc."		■				
10) SIA included process that "Plan included for gaps in data"		■				

4.2 Environmental Mitigation and Monitoring

4.2.1 Mitigation Plan Development

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.2.1	0	1	2	3	4	
1) Evaluated all relevant laws, regulations and standards, included appropriate mitigation measures				■		SUEP EA addressed
2) Dealt with all direct and indirect potential construction phase impacts				■		SUEP EA addressed
3) Delineated specific responsibilities for implementing the mitigation program				■		SUEP EA addressed
4) Included procurement of independent environmental supervision and management specialists		■				Not a major SUEP focus
5) Careful coordination of local government responsibilities with the mitigation management agency			■			SUEP Improving existing systems
6) Includes specific monitoring measures during both the construction and operation phases				■		SUEP EA addressed
7) Ultimate management includes careful coordination of local, city and regional authorities			■			SUEP Improving existing systems
8) Program includes non-structural measures to improve the effectiveness of the project		■				Not a major SUEP focus

4.2.2 Mitigation Program Monitoring

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.2.2	0	1	2	3	4	
1) Rigorous mitigation monitoring program included to minimize impacts, enhance quality				■		SUEP EA addressed
2) Directed toward measuring and evaluating changes, assessing the mitigation effectiveness			■			
3) Reporting system insures successful implementation of proposed project mitigation measures				■		SUEP EA addressed
4) Contains Environmental Performance Indicators (EPIs) assist with gaging project effectiveness				■		
5) Identifies predicted and unanticipated changes to physical, biological and social environment				■		
6) Contains appropriate "triggers" for deviations which start corrective actions					■	SUEP Target

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.2.2	0	1	2	3	4	
7) Contains detailed environmental supervision system				■		
8) Contains detailed Environmental Management Plans (EMPS) with recommended items			■			SUEP initiating
9) Contains key element of "monitoring objectives"			■			
10) Contains key element of "description of performance, indicators"			■			
11) Contains key elements "parameters, methods, sampling locations / frequency / detection / thresholds"			■			
12) Contains key element of "institutional responsibilities, timing and timescales"			■			
13) Contains key element of "reporting arrangements"				■		SUEP Improving existing systems
14) Contains key element of "costs and financing provisions"				■		SUEP Improving existing systems
15) Shows linkages between specific impacts identified in the EA and indicators to be measured				■		SUEP EA addressed

4.2.3 Monitoring Recommendations to Allow Better Future Assessments

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.2.3	0	1	2	3	4	
1) Recognize problems of quality assurance, lack of integrated water quality and quantity data		■				Not a major SUEP focus
2) Includes appropriate precautions, allowing national government to make cost-effective judgments		■				
3) Conformance with inventories of environmental, resource and developmental data		■				
4) Assists with addressing gaps in listed Agenda 21 data collection and assessment programs		■				
5) Measures to deal with sustainability issue "observing the capacity of land resources"		■				
6) Measures to deal with sustainability issue "loss of natural areas and biodiversity"		■				
7) Measures to deal with sustainability issue "protection of the atmosphere"		■				
8) Measures to deal with sustainability issue "quantity and quality of freshwater resources"				■		SUEP Target
9) Measures to deal with sustainability issue "state of oceans and coastal areas"		■				
10) Measures to deal with sustainability issue "human health and environmental quality of life"		■				
11) Measures to deal with sustainability issue "accumulation of wastes"				■		SUEP Target
12) Measures to deal with sustainability issue " risks of biotechnology"		■				
13) Conformance with listed broad goals for environmental monitoring systems in national plans		■				
14) Monitoring system based on a set of indicators that can communicate complex findings		■				
15) Monitoring system based on recommended information system		■				
16) Monitoring system identified the problem being addressed with listed aspects		■				
17) Included appropriate spatial/temporal scales, costs (collecting/not-collecting data), technology		■				
18) Analysis framework makes sense, is transparent in data and method, and is independent		■				
19) Information system includes reports and indicators in a relevant form for policy-makers		■				
20) Indicators are reliable, measurable, compared against valid norm, clear societal goal			■			SUEP initiating
21) Objectives based on all factors and activities which exert an influence on water quality				■		SUEP Target
22) Included preliminary surveys, determining time and space variability, key descriptors, costs		■				
23) Mitigated assessment problem of "objectives of the assessment were not properly defined"		■				
24) Mitigated assessment problem of "system installed with insufficient knowledge of the water			■			SUEP Improving existing systems

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Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.2.3	0	1	2	3	4	
body"			■			
25) Mitigated assessment problem of "poor planning-sample collection/handling/storage/analysis"			■			
26) Mitigated assessment problem of "data were poorly archived"		■				
27) Mitigated assessment problem of "data were improperly interpreted and reported"		■				
28) Followed success rule "objectives must be defined first and the programme adapted to them"	■					
29) Followed success rule "type and nature of the water body must be fully understood"			■			SUEP Improving existing systems
30) Followed success rule "appropriate media (water, particulate matter, biota) must be chosen"			■			
31) Followed success rule "variables, sample type/frequency, chosen with respect to the objectives"		■				
32) Followed success rule "field, equipment and laboratory facilities selected in relation to objectives"		■				
33) Followed success rule "complete, and operational, data treatment scheme must be established"		■				
34) Followed success rule "quality monitoring coupled with the appropriate hydrological monitoring"			■			Monitoring programs to be improved with SUEP
35) Followed success rule "analytical quality of data regularly checked, internal and external control"		■				
36) Followed success rule "data interpreted and assessed by experts with relevant recommendations"		■				
37) Followed success rule "programme evaluated periodically"			■			
38) Monitoring system fosters listed long-term information needs			■			Environmental Information system in future

4.3 Performance Auditing and Management Indicators

4.3.1 Performance Auditing

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.3.1	0	1	2	3	4	
1) Assessment uses effectiveness attribute of "management direction and objectives"			■			SUEP Improving existing systems
2) Assessment uses effectiveness attribute of "relevance to problems which intended to respond"			■			
3) Assessment uses effectiveness attribute of "appropriateness, logical to specific objectives"			■			
4) Assessment uses effectiveness attribute of "extent which goals and objectives have been realized"			■			
5) Assessment uses effectiveness attribute of "acceptance, constituencies judge it to be satisfactory"			■			
6) Assessment uses effectiveness attribute of "secondary impacts occurrence"			■			
7) Assessment uses effectiveness attribute of "relationships among costs, inputs and outputs"			■			
8) Assessment uses effectiveness attribute of "responsiveness, ability to adapt to changes"			■			
9) Assessment uses effectiveness attribute of "matching of, and accounting for, revenues and costs"			■			

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4.3.2 Management Indicators

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.3.2	0	1	2	3	4	
1) Includes recommended Indicators of Service Efforts				■		SUEP Target
2) Includes recommended Indicators of Service Accomplishments				■		
3) Includes recommended Indicators That Relate Service Efforts to Service Accomplishments				■		
4) Conforms with audit assurance guideline "all applicable attributes of effectiveness considered"			■			SUEP Improving existing systems
5) Conforms with audit assurance guideline "represent full range of information generated"			■			
6) Conforms with audit assurance guideline "take into account the interests of governing bodies"			■			
7) Conforms with audit assurance guideline "representations made at highest meaningful level"				■		SUEP Target
8) Conforms with audit assurance guideline "comprehensive strategy - management representation"			■			
9) Service efforts and accomplishments (SEA) indicators included for "inputs"				■		SUEP Target, with Objectively Verifiable Indicators (OVIs)
10) SEA indicators included for "outputs"				■		
11) SEA indicators included for "outcomes"				■		
12) SEA indicators included for "efficiency (and cost-effectiveness)"				■		
13) SEA indicators included for "explanatory information"				■		

4.4 Operation and Maintenance

4.4.1 Management Issues

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.4.1	0	1	2	3	4	
1) Includes sufficient operational budgets to ensure efficiency of operations				■		SUEP Target
2) Utility revenues cover the costs of operating the facilities in an enterprise fashion				■		SUEP Target
3) Applied sensitivity analysis, allowing management to handle unforeseen circumstances or changes		■				
4) Budgets include sufficient funds for short-term and long-term equipment replacement			■			SUEP Improving existing systems
5) Includes proper training of both management and operational staff			■			SUEP Improving existing systems
6) Performance system that rewards environmental efficiency rather than minimizes costs		■				
7) Short-term environmental monitoring evolves into long-term performance assessment system			■			SUEP improving monitoring programs
8) Includes provisions for public oversight of operations, provides for triggers and corrective action		■				

4.4.2 Technology Issues

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.4.2	0	1	2	3	4	
1) Technology appropriate with provisions to enlarge and upgrade easily				■		SUEP Target
2) Monitoring system reports on percentage of components operating at design levels				■		SUEP Target

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.4.2	0	1	2	3	4	
3) Actual operating costs, especially energy and utility usage, consistent with projected				■		SUEP Target
4) Measures included to ensure that the project production meets projected levels				■		SUEP Target
5) Measures included to ensure the ability to obtain necessary spare parts				■		SUEP Target

4.5 Feedback Mechanism - Project Formulation Stage

4.5.1 Feedback Loop

Review Criteria	ISO 14001 Gaps Status					COMMENTS:
4.5.1	0	1	2	3	4	
1) Assessments well documented and stored in a case-based system, including successes and failures		■				Not a major SUEP focus
2) Successes, failures and complementary needs of the project well communicated to others		■				
3) Identified institutional deficiencies well documented and changes undertaken		■				
4) Assessment system improves review criteria that are insufficient or redundant or adds new ones		■				
5) Feeds into national system of environmental indicators working with economic indicators		■				
6) Fosters international efforts on environmental reporting/accountability/public involvement		■				

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Appendix 9

LITERATURE SUMMARY

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9.1 Environmentally Sustainable Development

The United Nations World Commission on Environment and Development defined sustainable development as development that "meets the needs of the present without compromising the ability of future generations to meet their own needs" (WCED, 1987). This is one of a host of definitions that are currently in use on the subject. The general principles of sustainable development are widely accepted and endorsed. However, the great disparity of local conditions in the developed and developing worlds, in one continent from another, in one culture from another, etc., causes problems in translating these principles into practical programs and projects.

The issue of economic growth within economic development is subject to some debate. Some feel that economic growth can be compatible with sustainable development (as long as it is proper and non-resource depleting economic growth). It is also perceived as needed to relieve poverty and generate the resources for development and prevent further environmental degradation. Others think that "sustainable growth" is a contradiction in terms and that redistribution of wealth not growth is the way to combat poverty.

All countries are different, and in particular, there are many differences in the conditions experienced in the rich, industrialized countries and the poor, primarily rural, countries of the world. In all contexts, there is a need for simultaneous progress along each of several different dimensions of sustainable development. The World Resources Institute identified four critical, interacting dimensions of sustainable development: economic, human, environmental, and technological (World Resources, 1995). The technological component refers to industrial development with improved (modern and clean) technology to minimize potential pollution impacts previously associated with such development. Important interrelationships between these critical dimensions should be addressed systematically rather than providing disjointed solutions to individual segments of the problems. There are many subtle influences and impacts induced by development projects in a sector relative to environmental sustainability that are often not readily grasp by decision-makers.

The American Association of Engineering Societies (AAES) and the World Engineering Partnership for Sustainable Development (WEPSD) jointly published "The Role of Engineering in Sustainable Development" (AAES/WEPSD, 1994). These prestigious groups called for the following action principles for engineering profession:

- Engineer engagement in shaping decisions
- Sustainable development education for the profession and the public
- Integrated systems thinking and synthesis
- New environmental-economic measures and analysis
- Sustainable technologies and processes
- Expanded multidisciplinary partnerships

as a way to foster the following objectives:

- Sustainable planning processes
- Application of technological systems for sustainable development
- Advancement of industrial ecology and sustainable productive systems
- Focus of information on implementing sustainable development
- Focus of engineering ethics and education on sustainable development

The Civil Engineering Research Foundation (CERF, 1996 published "Engineering and Construction for Sustainable Development in the 21st Century: Assessing Global Research Needs." This report indicated that only through continued and accelerated development will the quality of life be improved for the growing world population. This accelerated development, the physical manifestations of which are the domain of the engineering and construction industry, should be undertaken in the context of the principles of sustainability. Engineering and construction are inextricably linked to sustainability in that all elements of the built

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environment modify the natural environment in some manner; the built environment is designed, engineered, and constructed by the engineering and construction community.

CERF (1996) maintained that sustainable development represents a new way of thinking in planning, designing, building, operating, and maintaining infrastructure facilities, such as roads, buildings, and bridges. Sustainable development is the challenge of meeting growing human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future generations. This definition recognizes that meeting long-term human needs will be impossible unless we also conserve the earth's natural physical, chemical, and biological systems.

CERF (1996) also recognized that sustainability has geopolitical aspects and that the approach of industrial nations toward development and environmental quality can differ from that of developing nations. The challenge is to find the common ground where international collaboration and the application of research may bridge any apparent gaps through the comprehensive assessment of global research needs.

CERF's definition of "sustainable development" was to meet "growing human needs for natural resources, industrial products, energy, food, transportation, shelter, and effective waste management while conserving and protecting environmental quality and the natural resource base essential for future development." Sustainable development is a process of harmoniously exploiting resources, directing investment, and accomplishing institutional change so as to enhance both current and future potential to meet human needs and aspirations. Implicit in these definitions is a focus on human interest and a concept that there are universally definable "needs" that ought to be met, possibly without regard for the many differences in context, values and cultural perspectives that characterize the human condition. CERF noted that the concepts were still far from being able to provide practical guidance for how designers should design, build, and manage the environment. The international design community is struggling to reach a comprehensive understanding of what "sustainability," and "sustainable development," really mean and how, in practical terms, these concepts should influence future actions (CERF, 1996).

CERF (1996) called for translating general philosophical statements into objectives and criteria for design decision-making. These objectives and criteria should influence life-cycle costs of facilities, the waste and pollution produced in the course of facility development and operations, and the facilities' impact on productivity of the activities they shelter and support. Many current judgments depend on past experience and comparisons, but there is little institutional incentive to collect and manage the data that would support such judgments. To have sound bases for determining whether design decisions are contributing to sustainability, designers will need to collect or "bank" experience, i.e., the technical, economic, and cultural factors that can be used by designers and their clients to improve suitability and adaptation of design solutions and technology to local conditions. Managing such data and making such data available in a useful form could give rise to innovative technology and practices.

CERF (1996) also noted that one barrier to implementing life-cycle engineering is that information needed to develop the required models is unavailable. In particular, there is a need for a centralized, comprehensive source of technical data. In other cases, historical data exist but are inaccessible due to volume, location or format. Regulations, codes and standards that constrain an engineer's ability to adopt innovations or respond to unusual conditions are also contributing factors. The fragmented nature of the industry is another barrier to life-cycle engineering; different parties design, build and operate structures. CERF concluded with the following Initial Recommendations for Consideration:

- Develop tools for predicting structural service life of new and retrofit structures,
- Compile historical data on maintenance and repair of infrastructure systems in readily accessible electronic format; the database should also include initial costs, the cost of recycling and disposal, and any other costs associated with the application,

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- Conduct research to quantify and document the value of life-cycle cost technology in major infrastructure and building construction projects,
- Develop user-friendly decision-support software to help analysts compute the life-cycle cost savings from using advanced materials, and
- Develop training and information tools that promote life-cycle cost approaches to infrastructure and construction applications and encourage its implementation in building codes and regulations.

One important conclusion of the CERF report (1996) was that a primary barrier to sustainable design is that the financial consequences of environmental impacts (due to system design or construction deficiencies) generally do not fall upon those who cause these conditions. "A mechanism is needed that returns the burden for mitigating long-term environmental damage back to the responsible parties." Before one can return these costs, a rigorous evaluation and monitoring system must trace these impacts through the process.

The Stockholm Environment Institute in 1993 prepared a cogent overview of the status of the world's freshwater resources (Gleick, 1993). In this report the following observations were made:

- There has been little integration of water issues following the International Hydrological Decade in the 1960's or the Water and Sanitation Decade of the 1980's.
- Over a billion people worldwide are served by sewage treatment systems not up to the standards of ancient Rome.
- Water quality is being affected by several overlapping trends:
  - population growth, urbanization and poverty
  - industrial expansion (increase in industrial effluents and increased risks of chemical spills and accidents)
  - agricultural pollution - traditional problems of sedimentation and eutrophication, along with newer problems of nitrate and pesticide contamination
  - water supply development - accelerated eutrophication, exacerbated water-vector and water-habitat diseases (malaria and schistosomiasis) and methyl mercury concentrations, along with impacts indirect to the water usage
  - changes in land use - deforestation, wetland conversion, etc.
- The more efficient use of available water resources is not possible without:
  - technical competence to compensate for variations in water availability over time and space,
  - presence of geological and topographical features for stored water to be economically and safely retrieved, and
  - ability to manage shared water resources successfully, including a way of including the true cost of water in the price people pay for it.

Conventional wisdom typically focuses on evaluating water needs for different purposes. It asks: how much water do we need and how should that amount be made accessible? Instead, some analysts (Gleick, 1993) take a non-traditional approach to evaluating water needs and ask: how much water is there and what future demand levels could realistically be met given regional constraints on availability?

In their analysis, a country's water predicament is related to its population, total water availability, and the fraction of gross water availability that can be made accessible, which depends on technology, economy, topography, and climate. As populations continue to grow, the principal options are demand reduction through rationing, improved distribution of available supplies, increased efficiency of water use, restructuring of societal activities, such as cultivating low-water use crops, and avoiding water pollution as human activities per unit of water intensify.

According to this way of thinking, sustainable development of our water resources will require eco-management of the interactions among water, natural ecosystems and society. The scale of the problems makes

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it impossible to rely sole the top-down solutions with which most water experts in developed nations are generally familiar, and local initiatives must also be encouraged and facilitated.

Gleick (1993) points out that the key to peaceful solutions of disputes over shared water resources is continued communication between the states concerned, preferably on the technical level, over everything from hydrologic and meteorological data to basin-wide development plans. Experience has shown that such communication can most effectively occur through some form of joint mechanism, such as a commission composed of experts from all basin states. Unfortunately, political frictions often prevent the formation of such bodies precisely in the cases where they are needed most.

Until recently, fresh water has been considered subsidiary to today's other major environmental problems, such as climate change, food production, forest destruction, and energy development. The work of the World Commission on Environment and Development, which has played such an important role in bringing international environment and development issues onto the political agenda, included separate sections on population, food, species and ecosystems, energy, industry, the urban challenge, peace and security, and even Antarctica, but no section on water resources (WCED, 1987). No single international agency is responsible for water resources. Even at the national level, rarely is one agency or ministry responsible for water, rather water issues are often distributed widely among resource and mining agencies, agricultural agencies. or environmental protection ministries.

These problems also stem from the failure to see the connections among environmental problems. Individual waterborne diseases, like cholera or malaria, are treated rather than addressing questions of widespread poverty, adequate water supply, illiteracy, and community health. Preservation of selected species of endangered fish is a goal rather than the protecting the entire ecosystem that is being modified or destroyed. Massive water storage and waterway projects are constructed without proper attention to the social, cultural, and ecological ramifications of these projects.

To arrive at an integrated concept of land and water conservation and management, an appropriate philosophical underpinning should be developed. The present concept of "environment" is usually used to describe that which surrounds a central object (Lundkvist and Falkenmark, 1997). Talk about environment typically focuses on local scales, and often excludes the role of humans. The concept of the landscape focuses on the mesoscale surroundings of all those living the humans as well as other species. The landscape concept may be better adapted for the interprofessional, intersectoral, and interdisciplinary dialogue needed to integrate land and water management." In this conceptualization, humans live in, and are part of, a landscape, which is sustained in part because of the water provided from the atmosphere. To access all resources in that landscape (water, biomass production, minerals, energy), humans manipulate the land. Through the intricate interactions among the different components of the ecosystem, secondary, sometimes unintended effects will be produced. Consequently, sustainable development of that landscape is equivalent to a careful management of our interaction with it so as to meet three basic criteria for ecological security (Gleick, 1993):

1. Ground water must remain drinkable, land productive, and fish edible.
2. Biological diversity should be conserved.
3. Long-term overdraft of renewable resources should be avoided.

Until recently, hydrological sciences have too often been viewed only as a background necessary for constructing water use facilities or as the knowledge base needed to repair earlier environmental mismanagement. This view has diminished hydrology's potential to anticipate and prevent problems. In the future, hydrology will become central to water policy decisions. The solution of current and future water problems involves a complex integration of ecological and economic components and long-term, strategic interdisciplinary research.

According to Gleick (1993), fresh water touches every aspect of life, from the health of aquatic ecosystems to human health, from the need to grow food for the Earth's growing population to the need to provide

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energy. Only in the last few years have the complexities and connections among these issues become more apparent.

As population grows, and as the level of economic development increases, human needs for water will grow. To meet these needs humans already modify all aspects of the hydrologic cycle by moving vast quantities of water from one region to another, building huge reservoirs, seeding clouds to squeeze more moisture out of them, diverting entire rivers from their beds, harnessing the power of falling water for electricity, pumping great quantities of water from underground aquifers, and stripping the salt from sea water.

Even with such enormous efforts to control water, man is failing to meet many of the most basic human needs. Biological and chemical contamination of surface and ground water is a growing problem. Vast and growing numbers of people lack clean drinking water and even rudimentary sanitation services. Water-related diseases such as malaria, typhoid, and cholera kill millions of people every year, and the spread of some diseases is out of control. Aquatic ecosystems are threatened everywhere by water developments and diversions. And human needs in other sectors drain the economic and human resources needed for new efforts to reduce these problems.

To reverse some of these trends, Gleick (1993) suggests some improvements in the way water is managed:

- **Water resources data collection and sharing**. Mankind remains ignorant about the state of many basic water resources conditions in this day of satellite observation, geographical information systems, and increasing sophistication and dispersion of computers. Efforts must be intensified to gather fundamental water data, organize it into usable and accessible forms, and disseminate it.
- **The economics of water**. Water is a scarce resource in man of the world, yet it is still often treated as a free good, available charge to whoever can pump it from the ground or remove it from or lake. We pay to move water from one place to another, and perhaps treat it following use, but we tend to ignore the so-called "opportunity cost" of putting water to one use at the expense of another. Water can be polluted for free and the costs of waste disposal are not included in the accounting framework.
- **New water developments**. In the last decade, the development of major new water projects has slowed greatly. In industrialized nations, new developments are constrained by growing environmental opposition, the fact that the best sites in many places have already been developed, and high costs. In developing nations, new projects are increasingly constrained by high costs and funding problems, competing demands for water, and local opposition from groups that will be affected by either the project itself or the changes in water quality and availability it would entail. Some new developments may be necessary, particularly in the poorer regions of the world where flood control, irrigation supply, or hydroelectricity are desperately needed. The inevitability of such developments, however, does not mean that they should be pursued in the same style as earlier projects; indeed, there is a growing realization that national governments and major international funders have a responsibility to review more carefully the wide range of direct and indirect environmental and social impacts such projects entail, to mitigate those impacts wherever possible, and to ensure that the benefits from the project are distributed equitably.
- **Traditional solutions**. We have much to re-learn from traditional water management experience. Small-scale, indigenous systems can often be more effective at meeting community needs without the large, unexpected impacts of large-scale developments, and community-level participation in water supply development and management often leads to other economical, educational, or health benefits as well.
- **Reducing the risks of water-related conflicts**. The disturbing trend toward the use of force in resource-related disputes, the apparent willingness of some nations to use water supply systems as

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targets and tools of war, and growing disparities in water availability and demand among nations makes it urgent that mankind reduces the probability and consequences of water-related conflicts.

- **A sustainable goal.** Sustaining an adequate quality of life for the world's people, both those now alive and the generations to come, requires matching our use of resources to our goals and desires. One of those resources, fundamental to life, is fresh water. Better understanding of the connections between water and all of our other concerns will lead to better understanding of proper and successful approaches to water management.

Whipple (1996) indicated that it is clear that the more important aspects of planning and decision making for water resources and associated land areas should be comprehensive, in that key economic and environmental objectives should all be considered. In the United States, the leading role in planning for water resources development has moved from federal level to the states with the following positions/goals:

1) Meaningful intergovernmental and inter-institutional partnerships are essential to water resources planning and management.
2) Water resources analyses are most appropriately conducted by watershed (or "problem-shed").
3) An integrated natural systems approach is necessary. It is sometimes called "ecosystem thinking" or "comprehensive, coordinated, multipurpose basin-wide water and related land use," "multi-objective management," or "natural resource planning." Whatever the exact terminology, a comprehensive approach is generally recommended.
4) A better balance is needed between flexibility and predictability.
5) States should play the fundamental role in water planning and management

Water quality criteria are based on considerations of both human health and ecological damage (whichever requirement calls for the stricter criteria). Whipple (1996) indicated that it is important to realize that the environment affected by water resources development is only one of a number of national objectives that should be taken into account. These include general economic prosperity, full employment, and that general freedom of personal action summarized in the Declaration of Independence as "life, liberty, and the pursuit of happiness." All of these national objectives are important, but no one class of objective should be mandated as an absolute, irrespective of the others.

Specifically, the environmental requirements for water quality criteria, with their rather uncertain relationships to a wide variety of public health and ecological results, lack the logical force of direct, clear-cut relationships such as the taking of the habitat of an endangered species. Absolute mandates of an environmental nature should not be imposed automatically through some general rule.

According to Environmental Economics and Natural Resource Management in Developing Countries (World Bank, 1993c), the following elements of environmental concerns need to be considered for integration in the project cycle adopted by development assistance organizations and governmental/non-governmental institutions:

- Identification - priority use of country resources to achieve development needs, and costs commensurate with expected benefits
- Preparation - refinements of project in all dimensions; technical, economic, environmental, financial, social, institutional
- Appraisal - assessment of the overall soundness of the project and justification for its implementation
- Implementation - actual development of the project until it becomes operational including monitoring and supervision
- Evaluation - ex post evaluation to determine the extent the project objectives have been realized and lessons for future projects

Project design should clearly identify the following (World Bank, 1993c):

- Problems or issues the project intends to address

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- Long and short term objectives of the project
- Target groups or main project beneficiaries
- Activities required to achieve the objectives
- Financial and human resources required to achieve the set objectives
- Management responsibility and structure
- Implementation modalities

The project should be designed to lead an equitable distribution of benefits among and within target groups and not to exacerbate any inequities among local populations. The financial analysis should determine the ideal recovery policy. This is normally a policy that secures maximum financial benefits to the economy from a project, taking into account its impact on the distribution of income and on the government fiscal policy. The financial profitability of a project can be measured by the internal financial rate of return.

The difference between the financial and economic rate of return is that the latter adjusts various costs and prices to eliminate the impact of transfer payments such as subsidies, duties, taxes, and other distortions in the valuation of traded and nontraded goods by using shadow prices that reflect their true value to the economy. The economic analysis should be considered within the context of projects promoting development rather than growth in its strict sense. Development includes all factors that lead to increases in the well-being of the population concerned, with economic growth being one of the important sources of increases in welfare (World Bank, 1993c).

The World Bank (1993c) states that the environmental analysis should be designed to achieve the greatest present benefit possible from the use of natural resources without reducing their potential to meet future needs and the carrying capacity of the environment. A more comprehensive approach is needed than project by project analysis. This approach would be integrated into economic and social policy. In almost every sector of the economy, the World Bank has noted that incorporating environmental safeguards enhanced economic and social benefits or reduced economic and social costs when compared with the risk of irreversible damage or the cost of remedial action that could result. A project level EIA should be performed and linked to the CBA at the earliest stage of project development and it should be a natural extension of previous sectoral level environmental impact analyses.

The Asia Technical Department of the World Bank (World Bank, 1994g) indicated that a program of regular monitoring of environmental quality is essential. Relative to urban areas (the report's focus), measures are needed for individual urban areas; data at the national or regional level are of little use for urban strategic planning where the use of environmental monitoring can have the highest potential to motivate action. Ideal monitoring systems and databases are often contemplated but rarely implemented. It may make more sense to begin with a limited set of indicators for a few cities and then ensure that they are updated on a regular basis. Additional and more refined indicators can be added later, and the program can be expanded to additional cities as capacity permits.

Miller (Third World, 1995) addresses such environmental solutions in various levels:

- **Strategies at the Global Level.**

  Although Third World countries owe an enormous economic debt to the developed country institutions, the developed world owes the Third World an enormous ecological debt. An argument for debt forgiveness on these grounds is not likely to be taken seriously by the industrialized countries. The nations of the Third World emphasize the values of equity and justice and countries of the industrialized world emphasize the values of efficiency and technological progress. Regardless of the perspectives, a single biosphere imposes a shared destiny on the earth's citizens.

- **Strategies at the Regional Level.** Regional environmental institutions represent an important strata of environmental governance and they provide support for global regimes and often involve fewer

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transactions costs than global institutions because the participants more readily identify common interests. Regional organizations are in the position to monitor and support global/national initiatives.

- **Strategies at the National Level.** Third World governments do not really have the option of de-linking from the global economy; nor can they depend on the ethics or beneficence of other global actors. They must seek and create their own opportunities. Developing countries need to adopt a twofold strategy for their participation in global environmental politics. One plank of this strategy should be the continued use of linkage politics. These countries have had some modest success with this approach, and they should continue to use it when the circumstances are propitious, such as to target global institutions and to lobby for structural change.
- **Strategies at the Local Level.** Local and community forces have two major roles to play in the push for sustainable development. They must provide a counterforce to global forces that serve to devalue and discount them, and they need to support environmental and development strategies that maintain or improve their quality of life. Addressing extreme inequities at the community, national, and global levels is an important prerequisite for the achievement of sustainable development.

In 1995, the World Bank (Mainstreaming the Environment, 1995a) listed "Ten Hallmarks of the New Environmentalism" as follows:

- **Set priorities carefully.** Not all problems can be addressed at once. Priorities need to be set using a combination of modem valuation techniques and participatory input from citizens and experts.
- **Go for win-win options first.** Although tradeoffs exist, there is often scope for improving the environment by adopting policies and investments that are justified for reasons other than the environment.
- **Promote cost-effectiveness.** Huge opportunities exist for saving resources by carefully analyzing costs. This has rarely been the practice in industrial-country policymaking.
- **Use market incentives where feasible.** A growing body of evidence points to the gains from market-based instruments.
- **Economize on administrative and regulatory capacity.** Administrative and enforcement capacity is often as scarce as money. In these cases, blunter instruments (with fewer points of intervention) and self-enforcing policies (for example, deposit-refund schemes) can help. So can involving local communities and NGOS in enforcement and monitoring.
- **Set realistic standards and enforce them.** The old approach of adopting Western standards, failing to meet them is giving way to a new approach whereby realistic and phased targets are set and enforced.
- **Work with the private sector.** Much of the investment required to improve the environment will come from private businesses and farmers. A shift in attitude is required (and in many places is occurring), with an emphasis on incentives, consultation, good business citizenship, and public disclosure of good as well as bad corporate performance.
- **Recognize that public involvement is crucial.** Success or failure often depends more on the commitment of stakeholders, including local communities, than that of the central government. Protecting natural habitats, forests, and even river basins requires genuine community involvement in planning and implementation.
- **Build constituencies for change.** Sustained improvements in environmental policymaking, which will usually involve losers as well as winners, are more likely with a well-informed public and active support from citizens. The most effective governments are building constituencies for change-through education and awareness programs and through promotion of an active civil society.
- **Incorporate environmental concerns from the outset.** Prevention is usually much cheaper than cure. Environmental concerns need to be built not only into the beginning of each investment, but also

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into the fabric of economic policymaking, including tax and regulatory policy, and even into the national accounts.

Chapter 40 of Agenda 21 (UN, 1992a) dealt with environmental information and decision-making. It was noted that in sustainable development, everyone is a user and/or provider of information (data, information, appropriately packaged experience and knowledge) in the broad sense. The need for information arises at all levels, from that of senior decision makers at the national and international levels to grass-roots and individual activities. Methods for assessing interactions between different sectoral environmental, demographic, social and developmental parameters are not sufficiently developed or applied. Indicators of sustainable development need to be developed to provide solid bases for decision-making at all levels and to contribute to a self-regulating sustainability of integrated environment and development systems. National and international data and information centers should set up continuous and accurate data-collection systems and make use of geographic information systems, expert systems, models and a variety of other techniques for the assessment and analysis of data (UN, 1992a).

Holmberg (1992) indicated that one important consequence of a shift in rights and responsibilities from central government to the local level should be an improvement in the management of resources - human, physical and financial. But for the system to work in this way, a local community must be able to obtain decision-making power over its own affairs. In other words, there must be an enabling environment - in particular, a framework of law and an organizational infrastructure through which representative bodies at community level can inform themselves on issues of the day and then transmit their views or decisions both to other communities and to the higher authorities. For this infrastructure to be effective, three essential requirements must be borne in mind:

- **Transparency**, which means that the processes of decision-making must be open to public view and thus be seen to be free of interference from special interests;
- **Accountability**, not only in the financial sense to guard against the poor management or misappropriation of funds, but also politically to ensure that agreed policies and programs are carried through; and
- **Freedom of information**, which requires independence for the press and other news media so that the people's right to participate is backed up by the right to know.

In 1994, the IUCN provided background into the range of principles or approaches to sustainable development are now being expressed more frequently in international agreements and domestic legislation (Carew-Reid et al, 1994). Although they all encapsulate ideas that have been common in political philosophies for a long time, most have only recently been expressed as basic tenets of environmental policy. All these approaches are expressed in some form or other within the Rio Declaration and Agenda 21. The principles need to be cast in a manner that reflects the cultural, political and economic nature of a country and the different communities within it. They work best when applied together, especially when special circumstances would mean that the rigorous application of one principle alone might be impracticable or inequitable.

The IUCN provided the following information on sustainable legal principles (Carew-Reid et al, 1994):

- The **public trust doctrine** has its origins in Roman Law. It has been extended in recent years, placing a duty on the state to hold environmental resources in trust for the benefit of the public. At its widest, it can be used by the courts as a tool to protect the environment from many kinds of degradation. In some countries, the doctrine has formed the basis of environmental policy legislation, allowing private rights of action by citizens for violations by the state (directly or indirectly) of the public trust.
- The **precautionary principle** as defined in the Rio declaration holds that where there are threats of serious or irreversible damage, lack of full scientific certainty shall not be used as a reason for postponing cost-effective measures to prevent environmental degradation (or expressed more

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liberally, when in doubt about the impact of development, manage according to the worst-case scenario of its effect on the environment). Politically, this principle is difficult to apply and is, in fact, ignored in most countries.

- The **principle of inter-generational equity** is at the heart of the definition of sustainable development and requires that the needs of the present are met without compromising the ability of future generations to meet their own needs. It depends on the effective application of the other principles for sustainable development combined.
- The **principle of intra-generational equity** requires that people within the present generation have the right to benefit equally from the exploitation of resources, and that they have an equal right to a clean and healthy environment. This principle applies to the relationship between groups of people within and between countries. This principle is being applied more and more in international negotiations.
- The **subsidiarity principle** is resurfacing worldwide after many decades of centralized planning and decision-making. In essence, it is the principle that decisions should be made by the communities affected or, on their behalf, by the authorities closest to them. Decisions should rest at the national rather than international level and local rather than national level. This has been the basic principle governing the devolution of planning systems worldwide and is intended to encourage local ownership over resources and responsibility for environmental problems and their solutions. These growing pressures for devolution in government need to be balanced by a recognition that local areas are part of larger systems and cannot function in isolation. Often, environmental problems may come from forces outside of local control, such as upstream pollution from a neighboring country or community. In such cases, the other principles for sustainable development would override the subsidiarity principle.
- The **polluter pays principle** (PPP) suggests that the polluter should bear the cost of preventing and controlling pollution. The intent is to force polluters to internalize all the environmental costs of their activities so that these are fully reflected in the costs of the goods and services they provide. Problems will be inevitable if an industry or plant would go out of business if this principle were enforced rigorously. A community might decide, for example, that the employment benefits of keeping a factory open outweigh the health and other environmental costs of pollution. Environmental agencies in developed countries have usually taken a flexible approach, with the continuation of government subsidies in special cases and the negotiation of individual programs to allow certain polluters to meet new environmental standards gradually.
- The **user pays principle** (UPP) applies the PPP more broadly so that the cost of a resource to a user includes all the environmental costs associated with its extraction, transformation and use (including the costs of alternative or future uses foregone). The PPP and UPP can be expressed in similar ways through market systems and government regulation.

These are the ten main lessons for donors (for simplicity, both development assistance agencies and lending institutions/banks are here called donors), which have been learned through more than ten years of their involvement in strategies (Carew-Reid et al, 1994).

1) **Coordinate donor activities:** Recipient governments must be supported in taking a leading role in coordinating external contributions to the strategy process.
2) **Invest in the long-term:** Low-level continuous external backing over a long period is almost always much better than short, high-level, one-off inputs (unless contributing to a strategy trust fund).
3) **Support the process:** Program funding is needed for the capacity-building process; not just the products of strategic planning. Program-oriented approaches are often more valuable than projects that are not an integral part of a strategy.

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4) **Support existing strategies:** If funding is conditional, the conditions should respect alternative approaches to strategies that exist locally. Buy in to existing processes, even if they do not quite fit the bill.

5) **Do not impose external models:** The corollary to supporting 'homemade' or tailor-made strategies is the need to guard against designing for schedules, budgets and skills which do not fit with local norms and capacities.

6) **Form and encourage partnerships:** Close working links with other donors and partnerships, and support for a variety of participants in a strategy, both governmental and non-governmental, add momentum and stability to the process. A good first step is to help governments identify stakeholders and their potential contributions.

7) **Seek coherence in aid programs:** Each donor needs to ensure that all components of its support interrelate and build upon each other within the strategy process.

8) **Devise new forms of assessment:** Donors need to develop new indicators for sustainability and evaluation to reflect and give greater importance to the qualitative and process elements of strategies.

9) **Refocus existing investment:** Donors need to review all elements of their aid programs and help governments refocus existing investments towards sustainable development principles and objectives defined through the strategy process.This refocusing will be more important than initiating new 'environment' projects.

10) **Be flexible and creative in financial arrangements:** Support innovative financing mechanisms; for example, National Environment Funds, which lead to consistency and self-reliance in maintaining the strategy process.

There are three issues of special importance to the financial security of strategies for sustainable development and future role of international organizations (Carew-Reid et al, 1994).

1. **Innovative and flexible financial arrangements.**

These can bring greater local control and security to the strategy process. There are various forms of trusts or endowments that work on a consistent level of return through interest on a principal sum. Also, grant funding can be particularly useful in the early years of a strategy. These need to be tested more widely, particularly in the least developed countries where government budgets and capacities are constrained through structural adjustments. Donors will need to invest in the process of discussion and design leading to the most appropriate form of fund for local conditions, whether government-run, private, or a mix of the two. In some cases, it is better to create an NGO-dominated fund, focusing on support to smaller scale activities, so that government commitment to internalizing investment for environment protection is not diminished. Although NEFs are an important way to organize and coordinate external funding in a country, ultimately they must aim to mobilize national resources. They should explore, for example, ways of channeling taxes, charges or fines associated with the use of natural resources or maintenance of environmental quality to the fund. Biodiversity-rich but economically-poor countries might consider special visa charges for tourists, as a form of biodiversity rental that would replenish the fund instead of a consolidated revenue account. Pollution fines, park entry fees, and various charges for the use of what may previously have been free environmental goods might also go to the fund. Creative financing options such as these should move away from dependency in strategy implementation and build a local sense of environmental responsibility.

2. **Analysis of the sustainability of existing development investment.**

The current approach to national strategies, encouraged through the World Bank-promoted NEAPs, is to define a portfolio of environment-related projects that are marketed to donors. This approach has a number of problems, the most important being that it can divert attention from a more detailed assessment of how existing government and donor budgets are allocated. A priority in strategy implementation needs to be applying forms of environmental or sustainable use assessment to the major development financing so that

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modifications, adjustments and reallocations can be made consistent with strategy objectives. Otherwise, the impacts of specific environmental projects will be insignificant in terms of the mainstream of development. Sustainability analysis might include:

- Comprehensive regional reviews followed by investment programs through an extensive consultative process within the framework;
- Various forms of environmental auditing, for example, the procedures governing industry performance within the European Community; and
- Green reporting process as introduced recently in Norway.

3. **Awareness of the forces shaping development.**

In the least developed countries, for example, these forces include the terms of international trade under the General Agreement on Tariffs and Trade (GATT), structural adjustment policies required by the IMF and the overall economic philosophy and loan policy pursued by the World Bank. A principal aim of the framework for trade and the policies of these organizations is to encourage export-oriented integration of developing countries in the world economy. Such policies are driven by economic values. Balancing those values with the other objectives of sustainable development needs to be a central concern of international and national strategy processes in both the developed and developing worlds. Increasing economic links between countries creates complex environmental relationships, which will need to be accounted for in terms of trade and aid. Special commodity-related environmental agreements between two countries will be needed, so as to address the environmental impacts embodied in a country's imports and exports of goods and services.

The International Institute for Sustainable Development (IISD) held a meeting in November 1996 at the Rockefeller Foundation's Study and Conference Center in Bellagio, Italy. Rather than debating the choice of ideal indicators of sustainable development, the discussion that ensued was oriented to a more basic level. Overarching principles were sought that would provide a link between theory and practice. The "Bellagio Principles for Assessment" that ultimately emerged (Hardi and Zdan, 1997). Such principles are a pragmatic expression of core values. They can serve as practical guidelines for the whole of the assessment process from system design and identification of indicators, through field measurement and compilation, to interpretation and communication of the result. With broad acceptance, a common foundation could emerge, even though details of system design and indicator choice might vary greatly in any given application. They are intended for use in starting and improving assessment activities of community groups, non-government organizations, corporations, national and sub-national governments, and international institutions. Little guidance was provided on implementing such principles at the project level, and EMSs can provide a convenient protocol to move from philosophic positioning to real-world application.

Donor countries must begin to more effectively match their aid policies with analysis of the environmental debts (and importation of carrying capacity) that may be hidden in their relationship with recipients. If Western consumption patterns encourage the production of various export products, then the aid programs of importing countries need to help address the significant environmental externalities associated with these products. Relying simply on the producing country to apply the Polluter Pays Principle, when the necessary capacities are lacking, can worsen inequities and ruin local community economies. Special policies and phased programs of support to the industries concerned may be needed and should be built in to the national strategies of both the donor and recipient countries.

Structural adjustment involves major injections of external funds into the economy of a country (on highly concessional terms) on the understanding that certain changes will be made in how the economy is managed. Usually, these changes involve trimming back the public sector, reducing or eliminating subsidies, greatly increased emphasis on private investment and giving priority to increasing export earnings.

Structural adjustment policies could be designed to achieve sustainable development objectives but, to date, the process has not been oriented in this way, nor has it included mechanisms to integrate environmental

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concerns. On the contrary, the Asian Development Bank has found that structural adjustment policies in a number of countries in its region may have led to environmental degradation (ADB, 1990a).

National sustainable development strategies provide an opportunity to expose many of the inequities and imbalances that result from economic policies and past trading relationships among countries. More importantly, they provide an opportunity to introduce mechanisms for correcting these imbalances.

There have been a wide variety of efforts to develop sustainability reviews through the use of Decision Support Systems (DSS) with varying success. Thierauf (1988) indicates that an important part of user-oriented DSS is the capability of the user not only to solve problems in a traditional manner, by using the problem-solving process, but also to engage in problem finding. The main thrust of problem finding is looking into the future and identifying problems that should be solved now.

DSS are fundamentally systems designed to support the decisions of managers and some operating personnel. They can be defined as an approach to effective decision-making involving an interface between the individual and the computer, from problem formulation to solution. The capability of combining subjectivity (individual judgment) and objectivity (computer output) permits a more thorough examination of the problem.

Traditionally, an organization is said to have five resources: people, machines, money, materials, and management. Today information can be regarded as the sixth resource of a typical organization. A DSS emphasizes helping a manager make decisions rather than on making decisions for the manager. The interplay is greater than either the manager or the computer working independently, fostering synergistic decision-making. (strategic planning - organizational goals and methods, management control - assuring goals are being accomplished effectively and efficiently, operational control - assuring that specific tasks are being accomplished effectively and efficiently).

Information centers can be defined as places where end users can get information about all different types of hardware and software, databases, and other needed knowledge in the computer area, including that for DSS development and use.

Giaoutzi and Nijkamp (1993) presented an overview of the use of DSS and Geographic Information Systems (GIS) in a case study of sustainability in the Greek Sporades Islands. They used a formal welfare concept that took for granted that all elements which are utility constituents (including e.g. toxic material loads, ionizing radiation, deforestation, species diversity, beauty of landscape etc) are to be included as arguments of a social welfare function, no matter whether such elements can be measured in monetary terms or not (provided these elements lead at least to a satisfaction of needs for scarce goods or services). For instance, in a more limited context of agricultural activities the welfare gains from agriculture should not only be measured by income generated in agriculture, but should also be corrected for negative impacts on landscape, species diversity or eco-stability. Various changes in land use patterns may be due to external factors (such as a rise in temperature or change in precipitation).

To Giaoutzi and Nijkamp (1993), it was evident that a formal welfare concept does not imply a conflict between conventional goods (e.g., a house, a car) and environmental goods (e.g., a forest, clean water) as both types may contribute to human welfare. Since there are mutual interactions between the use of conventional and environmental goods, their effects are by definition mutually supportive (at least not in the short run), so that it is ultimately trade-off between these types that determines the final welfare change. From a longer perspective, however, the question arises whether a mutually reconcilable trajectory of economic and environmental systems may arise. Whether structural changes in economic and/or environmental systems will enhance quality without affecting quantity is not easy to answer.

In their context, economic development referred to a situation marked by qualitative shifts in the economy that lead to a positive contribution to welfare. Development and sustainability are concepts that do not take for granted a stable evolution. Consequently, economic or environment policies aiming at a permanent steady state of a dynamic system may threaten the ultimate long-term stability, because its resilience potential may then decline.

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To Giaoutzi and Nijkamp (1993), sustainability involved the normative definition of a desired state of the environment. Resource use in excess of threshold levels implied non-sustainability. Possible thresholds are: "safe minimum levels", "natural" levels, and - perhaps the most popular point of reference - present levels. The last policy featured in two well-known approaches of sustainability, known as "strong sustainability" and "weak sustainability". The former stresses the complementary nature of man-made and natural capital and therefore puts non-negative constraints on each factor of production separately. The latter takes a more optimistic view on the possibility to substitute man-made products for environmental amenities, and only requires that the sum of man-made and natural capital does not decrease. Obviously, "strong' sustainability policies impose much stronger constraints on the use of ecological resources than "weak" approaches. Whether policy actions will involve resource use commensurate with sustainable levels as defined above is often not known with certainty. Therefore, acceptable levels of risk (probabilities of possible events are known) and uncertainty (probabilities, and perhaps even the nature of possible events themselves are unknown) should be formulated.

System theory offers a fruitful background and frame of reference for assessing various effects in a compound spatial economic and environmental system. In the Giaoutzi and Nijkamp (1993) study, they used the adjusted system's approach developed by Passet in 1979, as this seemed to provide an appropriate approach to environmental issues. Passet distinguished three subsystems - viz. economic, human and natural. The internal system is the economic system that comprises all economic activities of man. The middle system is the human system which includes all human activities, while the exterior system, the biosphere system, is formed by the whole natural environment of our planet and the layers of the atmosphere. For the sake of simplicity, he called this the environment or natural system. It is evident that the natural system includes all material and non-material elements of our planet.

According to the founder of systems theory (Bertalanffy, 1975), a system can be defined as a group of elements with mutual relations. Subgroups of the elements may form subsystems in the largest system, provided there is a relationship between the elements of these subgroups (the connectivity condition). Dynamic systems analysis seeks to analyze (i.e., describe and predict) the driving forces and their interdependence in a relevant system. It is evident that this approach should investigate the guiding principles of all three subsystems that make up the whole and examine the material basis on which these rules are based (Passet, 1979). In the Giaoutzi and Nijkamp (1993) case it was thus necessary to look at the causal linkages in an economic-environmental-human system. Such a systems representation formed also the basis for their impact model.

Impact analysis serves to assess and quantify the relationships between the subsystems' functions. In addition, the relationships between the principles governing each subsystem are revealed in such an analysis. Impact analysis is a scientific tool that is widely used to assess the results of policies or projects at national, regional or local levels. It is a flexible tool as it permits us to use several types of analytical methods like econometric models, input-output models, simulation and scenario methods, goals achievement methods and qualitative decision support models. In order to examine in a more operational way all effects of different development strategies, Giaoutzi and Nijkamp (1993) constructed a so-called impact matrix. On the horizontal axis they listed the alternatives or the development strategies under consideration in the form of policy scenarios. On the vertical axis were listed the relevant elements of their system; they can be classified for the relevant subsystems they pertained to.

In general, any development policy can influence a complex system in many ways, but three aspects were especially interesting for the purposes of Giaoutzi and Nijkamp (1993):

1) Efficiency - the aim of economic efficiency (or high benefits)
2) Equity - the aim of socioeconomic equity (or distribution)
3) Sustainability - the aim of environmental protection (or sustainability)

Shepherd and Ortolano (1996) outlined a concept called a critiquing expert system. Such a system was designed to improve the planning and analysis of water resource management systems, including design

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and operations. Such a critiquing expert system fits the template of ISO14001 gaps analyses, and can be considered a complementary or similar approach to these issues. According to Shepherd and Ortolano (1996), outputs from the critiquing expert system may include the following:

1. Restatement of the input data, which includes the operator's proposed plan
2. Suggested alternative plan(s), which may be preferable to the operator's plan
3. Reasons why the alternative plan(s) may be preferred
4. Warnings about negative ramifications of the proposed plan
5. Confirmation of appropriate elements of the proposed plan
6. Advice on obtaining additional information to refine the plan
7. Recommendations about factors to consider in making a final decision

Another similar concept and approach was addressed by the National Academy of Engineering in 1994, in a book entitled "The Greening of Industrial Ecosystems" (NAE, 1994). This book addressed a concept entitled industrial ecology, based on a unique systems approach within which environmental issues could be comprehensively addressed. It was based on an analogy of industrial systems to natural ecological systems.

According to Greening (1994), a series of policy or sustainability accounts could be used in a manner comparable to the use of macroeconomic accounts such as gross national product or gross domestic product in shaping macro-policy choices. The development of such accounts could clarify the idea of sustainability and the development of performance measures for monitoring progress toward achieving a sustainable world. Such accounts, which would comprise a much richer set of metrics than the standard economic accounts, might include one or more of the following elements:

- Ecological summary, including characteristics of the production/consumer web such as total flows among sectors; materials "value in use" assessments that can assist trade-off comparisons; and others.
- Environmental performance indicators, including estimates of impacts on the environment with measures of the certainty of the assessments. In all of the accounts, estimates of uncertainty are critical, particularly if the so-called precautionary principle is to become a standard part of the industrial ecological policy-setting algorithm.
- Technology balance sheet, indicating the maturity of existing products and processes and some measure of potential for innovation.
- Infrastructure balance sheet, indicating the degree to which social and technical infrastructure is adequate to support, or can adapt to, changes.
- Economic indicators, including conventional and environmentally enhanced measures.
- Political balance sheet, including the various interests affected by the set of issues under consideration with some assessment of the distribution of power.

One of the most cogent and relevant references to project appraisal is a book entitled "Ecological Sustainability and Project Appraisal" by Michael van Pelt (1993). He indicated that there is a consensus that the sustainability concept emphasizes:

a) Long-term perspective, particularly a concern for future generations, and
b) Two-way interrelationships between socio-economic and environmental variables, which leads to
c) View that limits should be imposed on the use of natural resources in production and consumption processes.

In van Pelt's study (1993), sustainability was defined in terms of environmental resources. Development is ecologically-sustainable provided successive generations have sufficient environmental goods and services to meet their needs. More precise, achieving their (per capita) social welfare objectives should not be impeded by environmental deterioration, either directly (appreciation of environmental capital) or indirectly (the environment as a productive input), or through a combination of the two.

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According to van Pelt (1993), operationalizing the concept of sustainable development starts with outlining the objectives of development itself, and the relations between environment and welfare. Equity considerations apart, this book focused on two constituents of welfare, viz. the availability of man-made goods and services, and the appreciation of environmental amenities. Welfare, socio-economic factors and the environment are linked in numerous ways. The concept of ecologically sustainable development integrates objectives regarding welfare and intergenerational equity, and knowledge about the role of the environment in creating welfare. Natural resources should be considered both a source of and a constraint on development. Whatever the precise definition of sustainability, a guideline for policy is that limits should be imposed on the use of natural resources.

In project appraisal, decision-makers will need to operationalize a sustainability criterion. To understand the complex nature of this process, van Pelt (1993) considered the following five dimensions:

1. Expressed in one or more parameters,
2. Target (sustainability) levels are defined,
3. Acceptable corresponding risks identified,
4. Time path for achieving those levels included,
5. With specific spatial levels.

A sustainability criterion will play a dominant role in project appraisal if a) strict limits are imposed on natural resource use, b) limits apply to specific environmental groups without the possibility of substitution, c) all ecological risks should be avoided, d) sustainability should be achieved in the short-run, and e) all these requirements are to be met at the lowest spatial level, i.e. the project level.

The incorporation of sustainability concerns in decision-making frameworks in project appraisal starts with the definition of alternatives. Probably the most efficient way to arrive at ecologically sound project selection is to design alternatives that clearly reflect environmental objectives, and to compare them with alternatives that are more oriented towards efficiency and equity. Project appraisal results will then immediately show trade-offs.

Like Munasinghe (World Bank, 1993c), van Pelt (1993) was in favor of considering cost-benefit analysis (CBA) and multi-criteria analysis (MCA) as potentially complementary appraisal tools. The approach would apply MCA to two criteria: the outcomes of a partial CBA, and the non-monetary environmental impacts. The partial economic internal rate of return (IRR) may exclude, for instance, all intangible externalities, like environmental effects that are diffuse in time and space, synergic or irreversible effects, or impacts on complex ecosystems. MCA could assist in arriving at an overall efficiency score by weighting this partial economic IRR and the intangibles. If CBA would only fail to incorporate some environmental effects of minor importance, the economic IRR could be assigned a higher weight in MCA calculations than if most ecologically significant impacts would be beyond its scope. If CBA can account for just a minor part of efficiency attributes, it may not make sense to conduct a partial CBA. MCA would then be the only tool available to determine the efficiency score.

According to Trzyna (1995), a review of sustainable development issues by the IUCN resulted in the following conclusions and corollary challenges, with notes by the author:

1. Sustainable development requires cutting across many professions and disciplines, and this cross-cutting is a strength and a weakness; how can we break down the barriers between them?

EMSs can be used under a variety of criteria from many professions and disciplines.

2. Among other things sustainable development is a social and political process and the ultimate challenge is not a scientific or technical one, but one that requires changing human behavior; what works?

EMSs can deal with social and political issues, as well as help to build a case history of successes and failures.

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3. Above all, sustainable development is a moral principle, not so much about what is but what should be; how can we build it into decision-making?

EMSs can provide a convenient and internationally standardized protocol for assessing proposed projects for sustainability concerns.

The World Bank (2001) recently published a summary of their current strategy for environmental protection. The Bank indicated that EA is only one element of a larger environmental management system used by the Bank and its borrowers to both "do no harm" and promote good environmental management.

9.2 Sustainable Water Resources

Water in rivers, lakes and underground is in permanent contact with other environment compartments and, more importantly, with a variety socioeconomic activities. Some of socioeconomic sectors of importance are agriculture, forestry, water, urbanization, industry, atmosphere, health impact (drinking water supply). The protection and sustainable management of freshwater resources require an ecosystem approach and an adequate knowledge and appraisal of linkages with environmental and social economic issues. First, there is a need to understand the nature and bio-geographical implications of freshwater resources at the global, regional and local levels. Second there is a need to recognize the cause-effect relationships between the environmental issues and the development (UN, 1992b).

The UN (1992b) indicates that integrated water planning and management based on a comprehensive ecosystem assessment, taking account of the use of water in human activities, should therefore be the main principle behind environmentally sound, sustainable development management of water resources. Human use of environment is an essential part of every day life and is essential component in development. Integrated planning and management of water resources must therefore take full consideration of the use and potential benefits environmental processes in human activities and in managing activities and resources with due consideration.

The use of systems analysis techniques, in conjunction with national master water plans, helps find solutions that can achieve optimum social and economic benefits while observing a series of conditions (UN, 1992b). A commitment to integrated management must usually arise through legislation, planning or regulation to be put into effective action. Integrated water resource planning and management may be achieved through close cooperation between existing institutions or a new institution may be established to perform basin-wide integrated management. In any event, integration will require the best use of the resource compatible with development objectives, harmonization of methodologies and analysis, good communication and inter-sectoral cooperation (UN, 1992b).

The essential elements of a national water policy may be grouped under two broad categories as preservation of the integrity of the natural water resources system and provision of water and water-related services to people in an economically efficient, equitable, environmentally sound and sustainable manner, using an integrated approach to water resources planning and management (UN, 1992c).

To achieve sustainable development and environmentally sound management of water resources in urban areas, greater attention should be paid to the formulation and implementation of a national policy, the general objectives of which are (UN, 1993):

1) To ensure on a sustainable basis adequate water supplies for present and future needs of urban users;
2) To prevent water pollution and to reverse current trends of water resources degradation and depletion.

Water development and management policies should be formulated within the context of regional water management based on a river basin approach. Urban water management should, therefore, be integrated with all aspects of regional planning processes affecting the region and the river basin in which the project areas are situated.

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In order to effectively meet the challenge ahead in the water and sanitation sector, a much greater synergism in terms of linkage between sector monitoring, planning, and advocacy is paramount. Planning should evolve into a more flexible and pragmatic approach. It should include all or some of the following in a sequential manner (UN, 1993):

1) Detailed situation analysis including an estimation of available resources and of the resource gap;
2) Optimal policy package to breach, of minimize the resource gap;
3) Selection of optimal technology/strategy options for maximum acceleration of sustainable coverage;
4) Setting of realistic sector goals; and
5) Establishment of a pragmatic planning/ monitoring framework

Most societies have managed water resources as if the biological systems associated were indeed incidental to society. Five realities point to a need to change this view (Davis and Simon, 1995):

1) Biological components of water resources are in steep decline,
2) Reasons for the decline are broader than simple chemical contamination, the primary focus of conventional water quality programs,
3) Legal and regulatory framework in place today cannot respond in a timely manner to these two realities,
4) Long-term success in protecting water resources requires careful thought about assessment endpoints, including the development of biological criteria, and
5) Quantitative expectations for attributes that constitute biological health or the integrity of a water resource system vary geographically.

It is necessary to adopt a broader concept of "water resources," redefine societal goals based on that concept, forge partnerships among scientists, policy-makers, resource managers, and citizens to develop approaches for attaining those goals, revise the legal framework guiding water resource policy, and redouble efforts to protect existing resources and restore those that are degraded. Davis and Simon (1995) describe the need for the emergence of "policy entrepreneurs," with the technical expertise and negotiating ability to converge the three streams of problem, politics and policy in water resources management issues.

Some of the well-recognized problems in international water management have already been addressed. The World Bank Integrated Water Policy seeks to balance two fundamental considerations (World Bank, 1993b):

1) The need for a holistic management approach that gives due weight to longer term factors and to protecting the ecosystems.
2) The advantages of relying more on markets and pricing to improve the allocation of water among competing users.

The World Bank (1993b) has summarized some of the weaknesses of current water resource management practices:

- Fragmented water resources management leading to wasteful investments and uncoordinated management
- Excessive reliance on over-extended governmental agencies lacking the proper incentive structure and leading to poor service quality
- Under-pricing of water and lack of cost recovery, resulting in excessive and wasteful water use, misallocation, and unviable water service entities
- Inadequate delivery of water and sewage services to the poor
- Over-centralization of the delivery of water services and the lack of stakeholder, community, and private-sector involvement, yielding a vicious cycle of unreliable service, low willingness to pay, and a further decline in capacity to provide adequate water service

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- The neglect of water quality, health and environmental concerns leading to environmental degradation, poor water quality, and human suffering.

At the core of the World Bank policy is the adoption of a comprehensive management framework that calls for water to be treated as an economic good with multiple potential uses. It recommends a more decentralized system of service delivery, greater reliance on pricing, and fuller participation of water users in the management of water supply systems. It encourages countries to develop national water strategies with coherent and consistent policies and regulations across sectors. Some of the main features of the Bank's approach are (World Bank, 1993b):

- Assisting countries in the development of a comprehensive analytical framework for water resources, management that is suitable for a country's needs, resources, and capabilities. Such a framework will allow the incorporation of cross-sectoral and environmental considerations in the design of investments and policies by recognizing the interactions between the various elements of a river basin's ecosystem.
- Supporting reforms placing greater emphasis on incentives for efficiency and financial accountability by promoting financially autonomous water entities, privatization, and community ownership. This would entail increased reliance on pricing as a management device that reflects scarcity and encourages efficient utilization of the resource.
- Helping governments in establishing a strong legal and regulatory framework for dealing with the pricing, monopoly organizations, environmental protection, and other aspects of water management that are not adequately handled by unrestrained market forces.
- Supporting governments' efforts to decentralize water service delivery responsibilities to local governments and to transfer some of these functions to the private sector, to financially autonomous entities, and to community organizations, such as water user associations.
- Enhancing the capacity of governments, staff, and related institutions at the central and local levels to manage water resources through support for training in various aspects of water management.
- Prescribing and encouraging the participation of beneficiaries and affected parties in planning, designing, implementation, and management of water activities.
- Assisting governments in taking an active role in protecting, enhancing, and restoring water quality and water dependent ecosystems, and in abating water pollution. The Bank will increase its support to governments' efforts to improve and expand sanitation and wastewater collection and treatment.
- Prompting and supporting greater priority to the provision of adequate water and sanitation services for the poor, thus helping to stop the spread of disease in crowded low-income areas.
- Supporting research, development of low cost options, and adaptation of technology for irrigation distribution, water supply and sanitation, flood control, pollution monitoring, and waste treatment.

In the United States, the US Water Resources Council (1973) developed the Principles and Standards (P&S) for Planning in 1973. The P&S indicated that the overall purpose of water and land resource planning was to promote the quality of life, by reflecting society's preferences for attainment of the following objectives, with full accounting of the adverse and beneficial effects associated:

A. Enhance national economic development by increasing the value of the Nation's output of goods and services and improving national economic efficiency, and
B. Enhance the quality of the environment by the management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems.

President Reagan terminated the Water Resources Council in 1981, but the Council still exists in law, although it does not meet and has no staff. The US Principles and Standards could be updated to include

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sustainability concerns and be translated into international practice. The ISO14000 system essentially accomplishes this for multi-media environmental assets.

The US Army Corps of Engineers in 1993 developed nine concepts designed to serve as the foundation for sustainable engineering. The Corps has used many of these concepts for years, but now their challenge is to use them to the optimum level to facilitate sustainable development (Reuss, 1993):

1) The first concept is **education**. As facilitators of sustainable development, engineers must have the skills, knowledge, and information that are the stepping-stones to a sustainable future. Whatever their specialty, engineers need to understand environmental and economic issues and problems, especially the risks and potential impacts of engineering actions.
2) The second concept is **"ecosystems" thinking**. Engineers are traditionally taught linear problem-solving techniques: they break each problem into its simplest pieces, study each piece, and then move on to the next challenge. Ecosystems thinking calls for synthesis - the combining of separate elements to form an integrated and coherent whole. If we are to approach sustainable development in a manner that imitates the natural processes around us, then engineering must become a unifying, not a partitioning, discipline.
3) The third concept, which is related to the second, is to **emphasize the aggregate consequences of what we are recommending**. Practicing "ecosystems" thinking requires that engineers begin to examine more carefully the aggregate long-term consequences of decisions in terms of both time and space. We must understand the net contribution of individual impacts or decisions. This approach moves well beyond what we refer to as "environmental protection," which is not synonymous with sustainable development.
4) The fourth concept is to **acquire environmental economic tools** to integrate the environment and social conditions into market economics. History has taught us that a market economy based on a free enterprise system affords the best opportunity to achieve the level of global economic development necessary to support growing populations and achieve sustainable development. It is not a questions of either/or; it must be both. Within the context of market economics, we must grapple with the need to develop and practice "environmental economics."
5) The fifth concept is the search for **sustainable alternatives**. The engineer as a project team leader or member bears much of the responsibility for recommending the technical alternative solutions. We should not be satisfied with engineering studies that have not considered alternatives.
6) The sixth concept is to **develop and apply technology to serve sustainability**. We need new technologies - new materials, and manufacturing processes that meet and then surpass today's dreams. Technology focused on sustainable development is the key to solving problems created in the past and preventing new ones in the future. The engineering and scientific communities must advance technology to let us use our resources more efficiently, reduce waste, and minimize environmental impacts.
7) The seventh concept is **listening to those we serve**. We must consider sustainable development as a dynamic process that responds to the continually changing needs and expanded knowledge base of the specific society, culture, and community we serve. Unless we can be truly relevant to societal needs, we will doom even the best engineering efforts leading us towards sustainable development.
8) The eighth concept is to **cultivate a multidisciplinary team approach**. The approach is not new. We have been doing it for a long time, but "multidisciplinary" in this concept goes well beyond getting the electrical and the mechanical engineers together. It goes beyond the array of engineering disciplines to include many others. We must bring together the knowledge, skills, and insights of the natural, social, and physical sciences and firmly integrate them into the engineering process.
9) The ninth concept addresses external education. We must continually **educate those we serve and promote the adoption of a sustainable development ethic** among all elements of society. Perhaps

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special efforts should be directed toward private and public sector decision makers; investors; and local, regional, national, and even international governing bodies.

To meet the requirements of environmentally sound, sustainable development and management of water resources, the water policy should promote a multi-sectoral and multidisciplinary approach to integrated water resources planning and management that optimizes the interests of environmental protection and sustainable socio-economic development (United Nations, 1997a).

Integrated water planning and management endeavor to reconcile the conflicting demands of people to use water for different purposes in different places and on different time-scales with the environmental concerns that reflect all the functions of freshwater systems. A single framework for effective integrated water resources planning is not possible for all countries and regions, given a wide diversity of their natural resources, population distribution and styles of living, economies, political, institutional, and legal structures, and other characteristics. However, some overall principles of planning may be identified based on experiences with planning in many developing countries and the tools that are available for assessment and analysis (United Nations, 1997a).

In the Asia-Pacific region, four main issues have been identified for priority attention (United Nations, 1997b):

1. Minimization of fragmentation of water resources development and management among sectors and institutions;
2. Reduction of dependence on central administration to develop, operate, and maintain water systems;
3. Need for water to be created as an economic good in view of the finite availability of renewable water resources;
4. Reorientation of national water management policies toward demand management policies in order to meet the increasing demand, with the limited available supplies. In this integrated approach, an appropriate balance needs to be achieved between all the relevant benefits of water use, and the "costs" of water supply and use.

These Asian priorities are directly relevant to the upcoming case study on the Sichuan Province of China.

A Task Committee on Sustainability Criteria of the Water Resources Planning and Management Division of ASCE and the Working Group of UNESCO/IHP Project M-4.3 published "Sustainability Criteria for Water Resource Systems" in 1998 (ASCE/UNESCO 1998). The book defined sustainable water resource systems are "those designed and managed to meet the needs of people living in the future as well as those of us living today." An essential aspect in the planning, design and management of sustainable systems is the anticipation of change. Sustainable water resource systems are those designed and operated in ways that make them more adaptive, robust, and resilient to these uncertain changes. Sustainable water resource systems are "water resource systems designed and managed to fully contribute to the objectives of society, now and in the future, while maintaining their ecological, environmental and hydrological integrity."

Guidelines for the development and management of sustainable water resource systems can be defined with respect to (1) the design, management and operation of physical infrastructure; (2) the quality of the environment or the health of ecosystems; (3) economics and finance; (4) institutions and society; (5) human health and welfare; and (6) planning and technology. The word "sustainability" implies the continuance or maintenance of a certain situation or condition over time. Development, on the other hand, usually involves an improvement of a situation or condition over time. Sustainable development can be viewed as the maintenance of a positive rate of improvement (ASCE/UNESCO 1998).

Closely related to the sustainability approach is the so-called adaptive approach to ecosystem and water resources planning and management. This is a goal-driven approach to restoring and sustaining healthy natural resource ecosystems and their functions and values. It is based on a collaboratively developed or shared vision of desired future conditions, a vision integrating ecological, economic and social factors

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affecting a management unit defined primarily by ecological boundaries. It is adaptive in the sense that it assumes this vision will change over time in ways that we cannot predict. The adaptive development and management approach emphasizes:

- Ensuring that all relevant and identifiable short and long-term ecological, economic and social consequences are considered.
- Improving coordination with and forming partnerships with all concerned stakeholders.
- Carrying out responsibilities more effectively and in a cost-effective manner.
- Using the best science currently available.
- Continually improving information and data management for decision-making
- Monitoring the systems being managed and adjusting management decisions as new information becomes available (ASCE/UNESCO 1998).

In 1999, the US Army Corps of Engineers released "Sustainable Development: Concepts, Goals and Relevance to the Civil Works Program." (USACOE, 1999) This report was produced partially in response to the President's Council on Sustainable Development (PCSD) report, "Sustainable America: A New Consensus for Prosperity, Opportunity, and a Healthy Environment for the Future" in February 1996. The PCSD report highlighted a triad of economic prosperity, environmental health and social well-being and equity.

The PCSD proposed the following national goals for achieving sustainable development as well as related indicators:

Goal 1: Health And The Environment: *ensure that every person enjoys the benefits of clean air, clean water, and a healthy environment at home, at work, and at play.* Indicators: the number of incidents of noncompliance with air and water quality standards; levels of toxic exposure; and disease and mortality rates.

Goal 2: Economic Prosperity: *sustain a healthy U.S. economy that grows sufficiently to create meaningful jobs, reduce poverty, and provide the opportunity for a high quality of life for all in an increasingly competitive world.* Indicators: GDP and NDP; employment and poverty rates; savings and investment rates; natural resources and environmental accounting; and worker productivity.

Goal 3: Equity: *ensure that all Americans are afforded justice and have the opportunity to achieve economic, environmental, and social well-being.* Indicators: income trends; and environmental and social equity measures.

Goal 4: Conservation Of Nature: *use, conserve, protect, and restore natural resources - land, air, water and biodiversity -- in ways that help ensure long-term social, economic, and environmental benefits for ourselves and future generations.* Indicators: soil loss rates, acres of wetlands or grasslands, habitat loss; threatened or endangered species; introduction and spread of exotics; releases of nutrients and toxics; and emission of greenhouse gases and compounds that damage the ozone layer.

Goal 5: Stewardship: *create a widely held ethic of stewardship that encourages individuals, institutions, and corporations to take full responsibility for the economic, environmental, and social consequences of their actions.* Indicators: efficiency of materials use; waste reduction through source reduction, reuse, recovery and recycling; energy efficiency; and renewable resource use and regeneration.

Goal 6: Sustainable Communities: *encourage people to work together to create healthy communities where natural and historic resources are preserved, jobs are available, sprawl is contained, neighborhoods are secure, education is lifelong, transportation and health care are accessible, and all citizens have opportunities to improve the quality of their lives.* Indicators: local per capita income and employment; crime rate; acres of public parks and green spaces; traffic congestion and use of public transportation; number of homeless; disparity in income

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between urban and suburban areas-, resources for health care education and training; infant mortality rates.

Goal 7: Civic Engagement: *create a full opportunity for citizens, businesses, and communities to participate in and influence the natural resource, environmental and economic decisions that affect them.* Indicators: measures or public participation; social capit4 citizen participation; and use of civic collaboration via partnerships, community-based planning and goal-setting projects.

Goal 8: Population: *move toward a stabilization of U.S. population.* Indicators: population growth rate; educational and income opportunities for women; number of unintended and teen pregnancies; immigration rates.

Goal 9: International Responsibility: *take a leadership role in the development and implementation of global sustainable development policies, standards of conduct, and trade and foreign policies that further the achievement of sustainability.* Indicators: levels of international development and -environmental assistance; environmental technology exports; and research on global environmental problems.

Goal 10: Education: *all Americans have equal access to education and lifelong learning opportunities that will prepare them for meaningful work, a high quality of life, and an understanding of the concepts involved in sustainable development.* Indicators: access to government, research and other public information; community participation opportunities for lifelong learning; curriculum reform and national standards that reaches principles of sustainable development; graduation and continuing education rates.

According to the USACOE (1999), equity is an overarching principle that addresses and suffuses the manner in which the other nine PCSD goals are attained. Equity, in common terms, is defined as the state or ideal of being fair, just and impartial. There is an elemental virtue in the uniform applications of rules, procedures, criteria and standards. A uniform, procedural approach, however, does not guarantee uniformity of outcomes. An important sub-component of procedural equity, as applied to water resources management, is the principle of direct participation or representation in decision-making by those who are affected by the decisions, particularly in the planning process. Besides procedural equity, another aspect of equity is associated with the outcomes of decisions or consequentialist equity. This deals with the distribution of adverse impacts and costs, and identifying the bearers of benefits, actions, regulations or water projects.

The Principles and Standards (P&S) published in the Federal Register in 1973 emphasized the need to balance the pros and cons of water resources development alternatives and stated two objectives for water resources planning. The goals were (1) to enhance national economic development by increasing the value of the nation's output of goods and services and improving national economic efficiency, and (2) to enhance the quality of the environment by management, conservation, preservation, creation, restoration, or improvement of the quality of certain natural and cultural resources and ecological systems. In addition to the two planning objectives, there were four impact accounts: national economic development (NED), environmental quality (EQ), regional development (RD), and social well-being (SWB). A number of changes were made to the P&S in 1980 and in 1983 the P&S were replaced with the Economic and Environmental Principles and Guidelines for Water and Related Land Resources Implementation Studies (P&G). The P&G changed the focus from two coequal objectives to a single objective of contributing to national economic development consistent with protecting the nation's environment, pursuant to national environmental statutes, applicable executive orders and other federal planning requirements. The P&G used principles of economic benefit-cost analysis, to demonstrate that recommended projects were economically justified. While use of the NED is mandatory, the COE uses the other three accounts when they contain information that may bear on decision-making (USACOE, 1999).

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The National Environmental Policy Act of 1969 (NEPA) serves as a prime illustration of the early embodiment of sustainable development ideas. The sustainable development concept of an integrated, holistic approach to environmental management and maintaining human welfare is a fundamental feature of NEPA. Although NEPA represented an attempt at a coordinated national systematic, interdisciplinary approach to environmental management, federal agencies have generally focused on the procedural requirements of NEPA (EA and EIS) rather than the underlying philosophy of NEPA.

The COE believes that the elements, principles, and objectives of sustainable development presented by the PCSD are so broad and intertwined, that it is impossible to develop a comprehensive set of guidelines that could be uniformly applied to all levels of decision-making. They do believe that there is a role for the federal agencies to provide an integrated and consistent framework for within which related resource management problems can be addressed in a uniform manner, with each agency and level of government exercising their respective decision making and implementation obligations.

The COE believes that the concept of sustainable development in water resources management may be most useful in reminding people of the complexity that exists in decisions about resource use. The following paragraph from the COE report could be directly applicable to the use of ISO14000 review techniques for water resource projects:

> An inclusive set of information on effects and tradeoffs can help provided a better understanding of both the intended and unintended consequences of the decisions. While difficulties in making tradeoffs persist, the increased availability of the information can help reduce uninformed decision-making. Displaying the categories of information could help advance the goals of sustainable development (USACOE, 1999).

In the European Commission (EU, 2000), the major issue consists in recreating a culture which involves managing water as an irregular and scarce resource, in which the scarcity is determined not only by physical reasons, but also by socioeconomic and ecological costs. In principle, the decisions related to resources management should be 'economically efficient, politically feasible, territorially equitable and socially acceptable.' In accordance with the criteria of sustainability, the new institutional management mechanisms should encompass a combination of regulatory means and market instruments, designed to introduce 'scarcity indicators' as incentives to water savings (EU, 2000).

Sustainable demand management requires integrated objectives of water issues with other policy areas. Horizontal integration of water policy and agricultural policy is a key point in achieving sustainable water management. The main priorities identified in these countries were as follows (EU, 2000):

1. Improving knowledge on the resource, ecosystems, and use
2. Reducing agricultural water demand
3. Improving and restoring water quality
4. Managing crises such as droughts

The EU (2000) vision of integrated water resources management involves the following components:

- Considerations of all health, socioeconomic and environmental aspects,
- Involvement of all stakeholders, and involving public, private and other organizations in developing an efficient and accountable sector,
- Development of an appropriate institutional environment which optimizes the use of available resources and helps to establish responsibility for management at the lowest appropriate levels,
- Dealing with water resources as a social and economic commodity, in order to ensure efficient allocation and use of water,
- Development of reliable information on policies, programs, projects and innovative solutions, to facilitate water resources management in the future.

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The EC (EC, 2000) promulgated Framework for Community Action in the Field of Water Policy in October of 2000. The purpose of this Directive was to establish a framework for the protection of inland surface waters, transitional waters, coastal waters and groundwater which:

(a) prevents further deterioration and protects and enhances the status of aquatic ecosystems and, with regard to their water needs, terrestrial ecosystems and wetlands directly depending on the aquatic ecosystems;

(b) promotes sustainable water use based on a long-term protection of available water resources;

(c) aims at enhanced protection and improvement of the aquatic environment inter alia through specific measures for the progressive reduction of discharges, emissions and losses of priority substances and the cessation or phasing-out of discharges, emissions and losses of the priority hazardous substances;

(d) ensures the progressive reduction of pollution of groundwater and prevents its further pollution, and

(e) contributes to mitigating the effects of floods and droughts

and thereby contributes to:

– the provision of the sufficient supply of good quality surface water and groundwater as needed for sustainable, balanced and equitable water use;

– a significant reduction in pollution of groundwater;

– the protection of territorial and marine waters, and

– achieving the objectives of relevant international agreements, including those which aim to prevent and eliminate pollution of the marine environment, by Community action under Article 16(3) to cease or phase out discharges, emissions and losses of priority hazardous substances, with the ultimate aim of achieving concentrations in the marine environment near background values for naturally occurring substances and close to zero for man-made synthetic substances.

The EU Water Framework (EU, 2000) provided a comprehensive framework and compliance timelines, as well as specific environmental objectives for surface waters, groundwater, protected areas.

The World Bank (2001) recently published a summary of their current strategy for environmental protection. The Bank indicated that the world is experiencing a systemic crisis as a result of unsustainable use and management of water resources. A rapidly increasing population is exacerbating the traditional problems of providing water supply and sanitation services. The Bank indicates that environmental sustainability is a fundamental element of sound water resource management. The integration of environmental objectives remains an important challenge in the water policy reform and management process. The lack of clear environmental sustainability criteria for the water sector, capacity constraints, and lack of commitment to follow through with politically-difficult decisions hinder the effective integration of environmental issues in water projects.

9.3 Project Formulation

The International Conference on Water and the Environment, held in Dublin, Ireland, in January 1992, was the most all-embracing conference dealing with global water management issues since the United Nations Water Conference held in Mar del Plata, Argentina in 1977. Its purpose was to examine current priority issues in the freshwater field and, drawing on expert opinion from a very wide array of nations, institutions and organizations, to recommend the action necessary to alleviate problems. These recommendations were initially taken to the fourth Preparatory Committee for the United Nations Conference on Environment and Development held at the United Nations in New York in March 1992. From there they went to the Earth Summit itself in Rio de Janeiro, Brazil in June 1992.

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The United Nations Conference on the Environment and Development (UNCED) held in 1992 in Rio de Janeiro attempted to forge new global strategies that both the "north" and the "south" could embrace. As with any such ambitious political challenge, this goal was only partially realized. The main product that emanated from the conference regarding development and pollution control was Agenda 21, a blueprint for action into the 21st century (UN, 1992b).

Agenda 21 provided a consistent focus for national planning in the areas of pollution control and waste management with an international consistency. However, there was minimal effort relative to a quantification of these provisions into trackable goals and objectives. In addition, the relationship of individual development programs and projects in a particular sector to the overlapping and interrelated potential environmental consequences was been not completely presented. There is a need to assist decision-makers facing questions of sectoral development proposals relative to the fostering of sustainability of development, the potential environmental consequences, and whether the proposal assists or detracts from national adherence to the goals of Agenda 21.

The challenge of sustainable development and the goals of Agenda 21 call into question some fundamental assumptions and long-held opinions of the environment. Increasingly, there is irrefutable evidence of the intricate interdependence of both the world's economy and the world's ecology. It is now understood that the issues of poverty, population growth, industrial development, depletion of natural resources and destruction of the environment are all very closely related.

The Dublin Conference and Agenda 21 provided a wide array of definable goals and objectives for water resources and water quality related issues. **Appendix 1** contains a detailed summary of these water-related goals and objectives. An Earth Summit Plus 10 conference is now being planned for 2002 in South Africa. Many of the Agenda 21 goals and objectives have not been met and new achievable targets will be a main focus of the new conference. The following are major objectives contained in Agenda 21(water-related topics):

- Prevent, halt and reverse environmental degradation through the appropriate use of biotechnology in conjunction with other technologies
- Coastal state commitment to integrated management and sustainable development of coastal areas and marine environment
- Protect marine environment by:

a) applying preventive, precautionary and anticipatory approaches to avoid degradation of the marine environment
b) ensuring prior assessment of activities that may have adverse impacts
c) integrating environmental protection into other development policies
d) applying economic incentives for clean technologies and "polluter pays" principles
e) improving living standards for coastal inhabitants in developed countries

- Promote a dynamic, interactive, iterative and multi-sectoral approach to water resources management that integrated technological, socio-economic, environmental and human health considerations
- Plan for the sustainable and rational utilization and management of water resources based on community needs and priorities within the framework of national economic development policy
- Design, implement and evaluate projects and programs that are both economically efficient and socially appropriate within clearly defined strategies, based on full public participation in decision-making
- Strengthen institutional, legal and financial mechanisms to ensure water policy and its implementation are a catalyst for sustainable social progress and economic growth
- Integrate water-quality elements into water resource management by:

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- maintaining ecosystem integrity, according to a management principle of preserving aquatic ecosystems, including living resources, and of effectively protecting them from any form of degradation on a drainage basin basis
- protecting public health, a task requiring not only the provision of safe drinking water but also the control of disease vectors in the aquatic environment
- developing human resources, a key to capacity-building and a prerequisite for implementing water-quality management

- By 2000, have ensured that urban residents have access to at least 40 liters per capita per day of safe water and that 75 per cent of the urban population are provided with on-site or community sanitation facilities
- By 2000, have established and applied quantitative and qualitative discharge standards for municipal and industrial effluents
- By 2000, establish waste treatment and disposal quality criteria, objectives and standards based on the nature and assimilative capacity of the receiving environment
- By 2000, establish sufficient capacity to undertake waste-related pollution impact monitoring and conduct regular surveillance
- By 1995, in industrialized countries, and by 2005 for developed countries, ensure that at least 50 per cent of all sewage, waste waters and solid wastes are treated or disposed of in conformity with national/international environmental and health quality guidelines
- By the year 2005, dispose of all sewage, waste waters and solid wastes in conformity with national/international environmental quality guidelines
- By 2000, have the technical, financial and human resource capacity to provide waste collection services commensurate with needs
- By 2025, provide all urban populations with adequate waste services
- By 2025, ensure full urban waste service coverage is maintained and sanitation coverage achieved in rural areas

In the long term, countries will be developing detailed Agenda 21 implementation plans with definitive environmental targets, based on the upcoming "Rio + 10" World Conference of 2002. Many developing countries may take many years to develop such plans, however, and these general goals and objectives can serve as surrogates for detailed national-level planning.

In implementing the 1993 Bank policy for managing water resources (World Bank 1993b), Bank support is continuing to shift toward four imperatives:

1. **Support a comprehensive view of water management issues.** The Bank is encouraging policies that are sustainable from economic, social, and environmental perspectives, particularly the case in fostering cooperation among riparian countries.
2. **Emphasize improvement of the efficiency of existing irrigation systems before creating new ones.** Since issuing the new policy, the Bank has focused its irrigation portfolio on rehabilitating existing systems and their management. This has meant increasing user participation in the design of irrigation and drainage projects, as well as institutional strengthening for water management.
3. **Encourage decentralization and local management of water resources.** In an effort to improve efficiency and accountability of public sector irrigation management agencies, more than half of Bank irrigation projects approved over the last two years included user participation in project management.
4. **Impose charges for using water that reflect its value as a scarce resource.** More than one-third of irrigation water in developing countries is typically lost between farm gate and crops, leading to water scarcity, soil salinity, and. groundwater pollution. A growing number of Bank projects support the implementation of equitable user charges for water.

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The general understanding of what is required to ensure successful aid projects became generally well accepted during the 1980s. The World Bank has worked hard to add to understanding of how to manage development projects. "Investing in Development" (Baum and Tolbert, 1987) reviewed the Bank's experience between 1945 and 1985. A major review of rural development experience concluded that more attention needed to be given to the adequacy of technology and scale of development, that the project design needed to be more appropriate to the intended beneficiaries, and that more attention needed to be paid to institution building and integrated rural development. Rural development could only be pursued if various production and consumption-orientated services were introduced concurrently and in an integrated fashion (Baum and Tolbert, 1987).

These conclusions were generally in agreement with those of Jon Moris in 1981 who comprehensively reviewed the challenges presented by Third World development programs and drew on an extensive literature review to distill some general tactics and principles for effective program development, notably:

- location is a political matter and the political dimension is often under-appreciated by outside experts;
- under-developed countries often have over-developed institutions; events should synchronized with the political timetable;
- develop effective public relations,
- cost-benefit analyses may be misleading for a large period of the project's life;
- loan financing should be avoided in the early stages and adequacy of funding should be ensured for recurrent (as much as for capital) costs,
- innovations should be kept to a minimum and the systems consequences of technology transfer should be understood,
- for the organization, emphasis should be placed on finding the key people and people should be developed from successful projects;
- the greater the number of organizational levels, the greater is the uncertainty of outcome and structures that overlap bureaucratic jurisdictions should be avoided.

Moris (1981) proposed a framework for the management of international (directly applicable to water resources) projects, and indicated that the framework should include the following aspects:

1) A project will be in great danger of encountering serious problems if its definition is not right and is not developed properly, if its objectives, standards, technical base and general strategic planning are inadequately considered or poorly developed, or if its design is not firmly managed in line with its strategic plans.
2) The project's definition both affects and is affected by its external environment (such as politics, community views, economic and geophysical conditions, availability of financing, and project phasing and duration), therefore these interactions must be managed actively and well. (Many of these interactions operate, of course, through the forecast performance of the product(s) that the project will deliver once completed.)
3) The project's definition, its interaction with these external, financial and other matters, and its implementation will be much harder to manage and may be seriously prejudiced if the attitudes of the parties essential to its success are not positive and supportive.
4) Realization of the project as it is defined, developed, built and tested involves:
   - crucial skill of moving the project at the appropriate pace through its development life cycle - doing the right thing at the right time (neither too soon nor too late) through careful planning and integrative decision making,
   - organizing the project properly, both internally and with regard to outside parties, and getting the right balance between the owner (or, sponsor and operator) and the project implementation specialists,

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- ➢ having contracts that adequately reflect the project objectives, are motivational, and appropriately reflect risks involved and the ability of the parties of bear these risks,
- ➢ having experienced, strong people who will drive the project forward and lead those involved with the project, but also establishing checks and balances between their enthusiasm and proper caution of project's sponsors,
- ➢ treating project personnel as team members, with great emphasis on active communication and productive conflict,
- ➢ using techniques and having tools for project planning, monitoring and reporting which properly identify the real technical, financial, schedule and other issues, are user-friendly, and allow project staff to develop the project effectively and to predict final outcomes reliably.

The World Bank (2001) recently published a summary of their current strategy for environmental protection. The Bank indicated that addressing environmental priorities that affect the long-term sustainability of development requires a proactive approach to find and implement cost-effective solutions through investment projects and addressing key policy issues through projects and programs. Some of the key strategies mentioned were:

- Improving the design and performance of environmental projects and components.
- Improving the use of project-level indicators.
- Coordinating investments and policy reforms.
- Applying a location-specific focus.
- Supporting capacity development.
- Enhancing the environmental outcome of adjustment lending.

9.4 Technical and Economic Assessment

Baum and Tolbert (1987), in their review of several decades of World Bank experience, define a project as 'a discrete package of investments, policy measures, and institutional and other actions designed to achieve a specific development objective (or set of objectives) within a designated period'. It may be useful to emphasize that projects usually refer to packages of activities that are implemented at the micro level, as opposed to the sector, regional or national level.

Project appraisal or feasibility study is an important stage in the evolution of a project. It is important to consider alternatives, identify and assess risks, at a time when data are uncertain or unavailable. The individual project, however significant and potentially beneficial to the promoting organization, will only constitute part of corporate business. In most engineering projects the rate of expenditure changes dramatically as the project moves from the early stages of studies and evaluations, which consume mainly human expertise and analytical skills, to design, manufacture and construction of a physical facility.

According to Engineering Project Management (N. J. Smith, 1995), the life cycle of the project splits into three major phases: appraisal and implementation of the project followed by operation of the completed facility. In the public sector, appraisal may extend over many years and be subjected to several intermediate decisions to proceed. In a commercial situation the need for early entry into a competitive market may outweigh all other considerations.

In the economic literature on developing countries, project appraisal is often regarded as synonymous with cost-benefit analysis. However, project appraisal involves a systematic analysis of the extent to which a project contributes to a set of development objectives, taking account of different priorities

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that may be assigned to these objectives as well as the scarcity of resources that would be used in the implementation of the project.

In the past the main tools for project appraisal were cost-benefit analysis and cost-effectiveness analysis: both logical and quantitative methods for identifying whether or not a project was worth implementing. Many publicly funded projects, such as water supply systems, were assumed to have such overwhelming benefits that only the costs were assessed in order to determine which of the various alternative methods of achieving the project objectives was the most cost-effective. It is now recognized that all projects will result in some unquantifiable costs and benefits, and therefore today these appraisal methods are supplemented by environmental impact analysis and assessment. By its nature, environmental impact assessment (EIA) requires a much more qualitative approach to project appraisal than cost-benefit analysis, although this is gradually changing as new methods for valuing environmental impacts emerge and develop.

According to N.J. Smith (1995), developing countries require new construction technologies and management expertise in order to develop, but only if those technologies and techniques are appropriate. The long-term benefits acquired when new technology is introduced and used for one short contract will be negligible, and its introduction may possibly even be detrimental to the achievement of long-term goals. However, if there is a real commitment to the ideal of technology transfer in terms of the acquisition of knowledge, skills and equipment, the benefits may be considerable.

N.J. Smith (1995) summarized the project management process as follows:

1) The success of a project or contract depends on the management effort expended by the promoter prior to sanction and by both parties prior to award of a contract.
2) The promoter commits himself to investment in the project on the basis of the appraisal completed prior to sanction. The appraisal must be realistic and identify all risk, uncertainties, potential problem areas and opportunities. Single-figure estimates are misleading and should be supported a range of likely outcomes of the investment.

The overriding conclusion drawn from recent research is that promoters and all parties involved in construction projects and contracts benefit greatly from reduction in uncertainty prior to their financial commitment. Money spent early buys more than money spent late. Willingness to invest in anticipating risk is a test of a promoter's wish for a successful project.

It is essential that project management ensure that the promoter clearly defines the project objectives together with the ranking of their relative importance. The likelihood of a successful project is greatly improved when all key managers of design, construction and supporting groups are fully informed and committed to these objectives. The project objectives should also be communicated to the other parties involved in project implementation. The dominant considerations must be fitness for purpose of the completed project and safety during both the implementation and operation phases (Smith, 1995).

Management is concerned with the setting and achievement of realistic objectives for the project. This will demand effort; it will not happen as a matter of course, and it will require the dedication and motivation of people. The provision and training of an adequate management team is therefore an essential prerequisite for a successful job, for it is their drive and judgment, their ability to persuade and lead, which will ensure that the project objectives are achieved (Smith, 1995).

The distinctive nature of public and private sector operations in developing countries suggests alternative approaches to the design, construction, and management of projects. The application of appropriate technology is one approach that has been promoted as a way to overcome some of the problems associated with the implementation and long-term sustainability of development projects in the Third World. Appropriate technology should be able to satisfy the requirements for fitness for purpose in the particular environment in which it is to be used. It should also be maintainable using local resources, and it should be affordable. Many would argue that all technology should be appropriate, and perhaps therefore it is intermediate technology that we should be focusing our attention upon (Smith, 1995).

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The concept of intermediate technology was first developed by E.F. Schumacher (1973) who defined it in terms of the equipment cost per workplace. He suggested that the traditional indigenous technology of the Third World could be represented as a 1$ technology, while that of the industrialized world was a 1000$ technology. Schumacher advocated an intermediate technology - a 100$ technology that would be affordable to people in the Third World, but which would improve efficiency, reduce drudgery, and help develop and improve the economy.

There are critics of the use of intermediate technology, including many from developing countries themselves, who point to the rapidly expanding economies of Korea, Malaysia, and Taiwan as examples, and argue that, without access to the most advanced technology available, the Third World will never catch up with the industrialized world. There are numerous examples illustrating the unsustainability of advanced technology: the factories operating at a fraction of their design capacity because of inadequate distribution networks, or lack of maintenance staff or spare parts; the water and wastewater treatment plants that are not functioning because of lack of funds for consumables and spare parts; and the impassable sealed roads, which have not been resurfaced owing to lack of suitable plant or materials.

N. J. Smith (1995) indicates that the project manager must decide on what is or is not appropriate in any given context, and needs to address the questions of fitness of purpose, maintainability, cost, and sustainability. Whether 'local indigenous', 'intermediate', or 'advanced' technology is the most appropriate will depend on the physical, social, cultural and economic environment of the particular developing country in which the project is set.

One facet of appropriate construction technology is the use of less plant and equipment, and more labor. This is termed labor-based or labor-intensive construction. Much of the infrastructure - sewers, aqueducts, canals, railways - in industrialized countries was built using labor-based methods, and it is only fairly recently that extensive use has been made of heavy machinery for construction and building. With the change to machine-based construction, engineers and project managers, in both industrialized and developing countries, became less familiar with labor-based methods. Training for civil engineers has become based on equipment-intensive methods, and this has become the norm throughout most of the world. This situation was encouraged in many developing countries through the provision of aid, particularly bilateral tied aid, by funding agencies, expecting or requiring trade and business as a condition for loans and grants.

N.J. Smith (1995) points out that the reliance on plant-intensive construction has a number of drawbacks for developing countries, the main one being the high expenditure of foreign exchange, something that few Third World countries can afford. In contrast, labor-based construction actually generates employment and produces an income for those engaged on the project.

The implicit choice of equipment-based construction methods has an influence on the planning and design of the works, and a fair comparison between the financial costs of labor-based and equipment-based methods may be difficult once the design is finalized. Therefore, if labor-based methods are to be given an unprejudiced assessment, alternative designs suited to labor-based construction should be considered. This is sometimes referred to as design equivalence. For an even more comprehensive comparison, a full economic appraisal should be carried out, whereby the economic benefits of enhanced employment and the potential for growth and development are included as benefits of the project.

Market failure exists when markets fail to reflect fully environmental values (Barbier et al, 1989). This can also be interpreted as directly related to project assessments affecting these markets. The presence of open-access resource exploitation, public environmental goods, externalities, incomplete information and markets, and imperfect competition all contribute to market failure. Usually some form of corrective public or collective action, involving regulation, incentives or institutional measures, is required - provided that the costs of such measures do not exceed the potential welfare benefits. **Policy failure** occurs when the public policies required to correct for market failure over or under-correct for the problem. It also occurs when government decisions or policies, in areas where there are no market failures, are themselves responsible for excessive environmental

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degradation. For example, environmental damage may arise from policies designed to promote economic growth or to improve income distribution, due to inadequate attention to their impact on the environment.

Market and policy failures lead to a distortion of economic incentives (Barbier et al, 1989). That is, the private costs of activities that result in environmental degradation (e.g. problem projects) do not reflect the full social cost of that damage, in terms of environmental values foregone. The failure to take full account of these social costs may result in excessive levels of environmental degradation.

Certain environmental benefits may be defined as public goods - that is, they are freely available to everyone, and consumption by any one individual does not significantly diminish the quality of consumption by another. Problems arise because the cost to any individual of producing (or preserving) the environmental public good always exceeds the potential benefits they can anticipate. Hence market mechanisms tend to under-supply public goods.

Existence values, such as the satisfaction derived from the knowledge that an endangered species continues to survive, are examples of public goods. Once the existence of the panda, the rhino or the blue whales is assured there is no way to exclude others from taking part in the feeling of ethical or emotional satisfaction. Nor does one person's enjoyment subtract from that of another. Given that the existence benefits of saving endangered species do not pass through formal markets and are open to all who care to entertain them, there is little economic incentive for individuals to put up the costs of conservation. There is a tendency to wait and see if others will contribute first, thereby giving the opportunity to obtain the benefits without paying (Barbier et al, 1989).

Externalities are those costs or benefits that arise through the production or consumption process but are not reflected in market prices. Externalities may be difficult to identify, since they are usually unintended and have indirect and diffuse effects. The ecological functions and non-timber products of the forest provide salient examples of the external, on- and off-site impacts of logging activities. The sedimentation of reservoirs, hydroelectric facilities or irrigation channels due to soil erosion arising from logging activities are typical examples of negative off-site externalities. Meanwhile, the economic contribution of wild foods and other natural products collected from the forest by rural producers (such as game meat, plant medicines, fuel and construction materials) are often lost when the forest is cleared or disturbed (Barbier et al, 1989).

Imperfect information on market trends and government policy in developing countries often leads the private sector to consume natural resources rapidly and deters investment in sustainable methods of production. From a social perspective, the resulting environmental degradation will be excessive. The many risks and high uncertainty confronting private individuals translate into short planning horizons, causing individuals to prefer immediate to long-term returns from conservation investments. On the other hand, societies as a whole are risk averse and must balance immediate returns from resource exploitation against ensuing losses of future productivity and other environmental values. Where resources without viable substitutes are being irreversibly degraded, or when the future value of resources is uncertain, society will prefer less consumption of those resources and greater investment in conservation than the individual or firm (Barbier et al, 1989).

There has been a significant effort in the field of environmental economics to incorporate environmental considerations into standard economic analyses and project evaluations. The efforts range from broadened and strengthened EIA procedures to national environmental accounts similar to national economic accounts. The concept of "environmental capital depletion" has been emerging as a method of tracking the sustainability of policies and projects (Barbier et al, 1989).

As pointed out by the authors of the classic United Nations Industrial Development Organization Guidelines (1972), the main rationale for conducting social cost-benefit analysis is 'to subject project choice to a consistent set of general objectives of national policy' (UNIDO, 1972). As perceptions of national policy objectives in developing countries have changed, project appraisal and planning methods have changed accordingly. The recent emphasis on the role of environmental quality and the long-term productivity of natural resource systems in sustaining economic development has led to further extensions of social cost-benefit

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analysis, to include environmental impacts. In contrast with traditional project evaluation, which considers only direct project benefits and costs, the expanded approach includes the external and environmental improvement benefits (plus the benefits from environmental protection), as well as the costs of external and/or environmental damages and of environmental control measures (UNIDO, 1972).

The basic methodology comprises two steps: first, identify and measure environmental impacts in physical terms; secondly, translate these impacts into monetary terms for inclusion in the cost-benefit framework. The extension of CBA to incorporate the environmental impacts of projects is hindered by a number of empirical problems. Physical estimation of environmental effects may be hampered by lack of necessary data. Also, most environmental resources are non-marketed common-property goods, and the valuation of their benefits is not straightforward. Moreover, there is considerable debate concerning the validity of methods used for the evaluation of intangible environmental benefits in monetary terms and the nature of those benefits, such as the need to preserve unknown species for their intrinsic value.

As this expanded approach inevitably raises issues of intertemporal choice, the interest rate chosen to discount the future may determine the degree, if any, to which environmental degradation is 'optimal'. It is often stressed that the appropriate discount rate should emerge from the project appraisal process. In practice, imperfect capital markets, inconsistent data on the productivity of capital and large variances in domestic borrowing for investment make it difficult to establish an economic accounting rate of interest for developing countries (UNIDO, 1972).

Introducing environmental considerations further complicates the picture. As Markandya and Pearce (1988) observed, natural resources are more likely to be over-exploited at high discount rates than at low ones, but, at the same time, consistent use of low discount rates can lead to greater levels of investment in projects which degrade the environment. Given the additional problems posed by environmental risk and irreversible impacts, the authors concluded that it is generally preferable to adjust project costs and benefits and adopt additional sustainability criteria, rather than to adjust the discount rate.

A serious limitation to the resource accounting approach is that it limits itself to a consideration of environmental assets, assets that produce valuable and marketed raw material, can only cover part of the economic costs of environmental degradation. Such an approach does not include all the external, off-site environmental quality effects (the indirect use value of environmental assets in assimilating waste and providing ecological support for economic systems and human welfare). Despite such difficulties, resource accounting is a major advance over the present procedure, which essentially values natural capital at zero. Moreover, by starting to measure environmental values, resource accounting approaches ensure that better techniques for measuring such values will be developed (Markandya and Pearce, 1988).

Efforts to undertake resource accounting are part of the larger initiative to design economic policies that can balance economic efficiency with the need to correct problems of environmental degradation in developing countries. This agenda has two primary components (World Bank, 1993c):

1. Design of investment programs supporting environmental and natural resource objectives; and
2. Promotion of economic, social and institutional policies and incentives that influence the behavior of government agencies, major resource users and countless small-scale resource-using activities which occur throughout a nation's economy.

The appeal of such an approach is the reliance on traditional economic tools and concepts, such as marginal opportunity cost, to measure the total costs of resource degradation borne by society. Moreover, some existing economic policies in developing countries may be encouraging both environmental degradation and economic inefficiency. Correcting these policies may therefore offer the opportunity to pursue both environmental and efficiency goals.

In designing appropriate incentives for sustainable development, a distinction should be made between **user-enabling incentives** focused on the resource user (such as changes in land and resource rights, increased participation in decision-making and appropriate projects); **policy-enabling incentives** focused on

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the policy-maker and implementing agencies (such as institutional incentives and flexibility, and political conditions); and **variable incentives** focused on price changes facing producers and consumers (such as altering input and output pricing, exchange rate modification, tax and subsidy reform, and restraining middlemen margins) (World Bank, 1993c). User-enabling incentives are the main micro-level concerns for sustainable development, whereas appropriate policy-enabling and variable incentives are macro-level issues. Working with only one set of incentives is likely to be ineffective and at least one policy instrument is needed for each objective. The challenge for economic policy is to design the right combination of incentives for a given target group and a given environmental problem.

Donor agencies, led by the World Bank, are making a major effort in cooperation with the governments of some developing countries to conduct studies of how best to design an appropriate natural resource and economic policy framework for sustainable development. Before any practical policy guidelines can be successfully formulated, there is a need for substantive and extensive analysis of the natural resource implications of various macro-economic, trade and sectoral policies in developing countries. At the more micro level, there is a need for more analysis of the economic costs of environmental degradation and of the natural resource allocation decisions made by rural populations. This should be coordinated and reviewed consistently at the national level so as to be useful for policy and investment decisions (World Bank, 1993c).

The application of methodologies and evaluation criteria used in CBA to account for environmental considerations are not straightforward, since the environmental costs and benefits often occur over a long period of time and are difficult to predict and quantify (World Bank, 1993c). Nevertheless, the extent to which environmental costs and benefits are incorporated into CBA, with values assigned to environmental services and damages, will serve to establish the fact that environmental services are not free and damages accruing from a project should be accounted for. For environmental costs and benefits to be incorporated into CBA, the environmental impacts of a project must first be identified and quantified. Since natural systems are very complex and their reaction to exogenous impacts are characterized by uncertainty, a comprehensive EIA should be carried out to systematically identify and quantify the impacts of the project on the natural environment.

Because there exists market failures, such as the presence of monopoly and external costs and benefits, market mechanisms will not automatically secure an optimal allocation of resources. For example, the market prices of assets, such as water, neither reflect the environmental services they provide, nor the irreversible loss or damage of natural resources if environmental degradation exceeds a threshold level. In order to interpret sustainability in economic terms, the environment has to be looked at as providing three main functions (Barbier et al, 1989):

1) source of raw materials and energy,
2) sink for assimilating emitted wastes, and
3) natural or environmental services such as recreation, health and life support systems, genetic diversity, scientific and cultural benefits.

No consensus exists on how CBA should be modified or supplemented to properly incorporate environmental considerations. The following are some suggested modifications within the context of a package of reforms (World Bank, 1993c):

- **Adjusting national accounts system** to reflect the relation of changes in the environment to changes in economy (environmental and natural resource accounting)
- **Adjusting or correcting market prices** (for example with the use of taxes) to reflect the full costs and benefits of using the environment
- Providing for the **economic value of environmental impacts** in project appraisals

Correcting market prices to reflect the full costs and benefits of using the environment involves internalizing environmental externalities. One suggestion is that depletion of natural resources can only be acceptable if it leads to the creation of other forms of capital whether human or physical that can substitute for

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any of the environment's functions. In order to attain this objective, environmental losses, as well as investments for their substitutes, must be properly valued. A stricter sustainability criterion claims that a constant environment stock must be maintained over time. Thus, apart from passing a CBA test, a project should not result in the net reduction in the value of the stock of environmental capital. That means that if a project entails such negative effects on the environment, it would be necessary to include in the investment program measures to compensate for this environmental loss.

In January of 1992, the Committee of International Institutions of the Environment (CIDIE) organized a conference to discuss emerging techniques for incorporating environmental considerations into natural resource management decisions (World Bank, 1993c). CIDIE believes that there is a growing need to incorporate environmental concerns into projects and that a consensus must be arrived at on the appropriate application of economic instruments for environmental management and protection. Guidelines should be developed which establish a standardized methological approach for the implementation of these techniques. Projects should be examined within the context of an integrated framework for sustainable development, in order to ensure adequate recognition and funding, and to achieve quantitatively specified environmental targets in a given sectoral and geographical area.

Environmental evaluation techniques are considered a useful extension of standard cost-benefit analysis (CBA), despite the dearth of applications in the developing world and problems of identifying environmental changes (particularly in the case of complex biological systems). The linkages between environmental impact assessment, traditional CBA, and environmental economics need to be more clearly defined.

The appraisal of projects in developing countries has received much attention in the 1970s and 1980s, strongly stimulated by the emphasis on projects in aid programs of multilateral and bilateral donor agencies. Economic appraisal of projects has focused on allocative efficiency: how to maximize aggregate welfare, given available resources. CBA has been routinely been applied by many aid agencies and governments of developing countries. They tend to use a special CBA version that differs in several respects from traditional CBA, as applied in the developed world.

World market prices are commonly recommended as a valuation basis, rather than domestic prices. This is a response to serious market distortions in many developing countries. In many developing countries (and regions), the existing distribution of income is relatively unequal. Economic CBA ignores distributive aspects, as it only allows an assessment of efficiency. Therefore social CBA has been developed, whereby outcomes of economic CBA are adjusted to account for ethical views on a fair distribution of income (equity). Experience shows, however, a large gap between the theoretical potentialities of social CBA and the actual use of this tool. In practice, this sophisticated approach has nowhere been applied on a large scale. Both economists, faced with enormous data requirements, and policy-makers, who need to make their value judgments explicit in the framework of a rather inaccessible technique, have been reluctant to embark on such an exercise (World Bank, 1993c).

The theoretical principles for treating externalities, particularly in the field of the environment, were identical to those in traditional CBA, they were to a great extent neglected in standard textbooks for CBA for developing countries. Moreover, applications in developing countries have suffered much more from insufficient data about environmental impacts and their value. Faced with, on the one hand, CBA's requirement to monetize all relevant effects, and on the other hand, the severe difficulties in collecting data on several types of effects, economists have frequently failed to incorporate all costs and benefits of development projects (World Bank, 1993c). MCA has mainly been applied in the developed world, and experiences with this approach in developing countries are modest. The applicability of MCA can be analyzed from two perspectives simultaneously: the treatment of sustainability-related issues and the special features of developing countries regarding particularly distributive aspects, environmental and socioeconomic systems, and availability of statistics (van Pelt, 1993).

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EIA results can directly determine the score on a sustainability criterion (van Pelt, 1993). The sustainability score can be assessed by comparing a) threshold levels for resource use (i.e. the environmental utilization space), and b) estimated environmental effects. Sustainability may be measured on several scales, including a binary scale (a project either is or is not sustainable) and a continuous scale (showing the degree of (non) sustainability). More sophisticated approaches distinguish between sustainability objectives for specific groups of environmental attributes, as well as for different spatial levels.

The CBA approach is to take the score on one particular criterion as a point of reference, and to adjust it for scores on the remaining criteria. The 'rod of money' is the criteria, and results are in terms of indicators such as the internal rate of return (IRR) or net present value (NPV). It may be possible to incorporate sustainability concerns in social CBA, which would then cover the three key criteria simultaneously (van Pelt, 1993).

The MCA approach treats criteria on the same footing, without selecting a single criterion (and hence its measurement scale) as a benchmark. Through arithmetical operations, combinations of criteria scores and criteria weights are used to arrive at a ranking of project alternatives (van Pelt, 1993).

In its basic form economic CBA may be unsuited to account for sustainability concerns. A major reason is the Kaldor-Hicks principle underlying CBA theory that states that any type of cost to society is acceptable as long as a project generates greater benefits (van Pelt, 1993). While benefits may potentially compensate for costs, CBA is indifferent as regards the question whether actual compensation takes place. Environmental damage is acceptable if benefits are valued higher. No CBA principle prescribes that part of the benefits should actually be invested in measures to avoid or compensate the environmental damage. In other words, substitution between natural and man-made resources is considered perfect. This is opposed to the sustainability principle, which says that beyond a certain limit environmental damage is undesirable or even unacceptable, and that dissatisfaction increases with the size of the gap between expected and normative resource use. In CBA, any future cost may be compensated for by any present benefit. Through discounting, the weight of present benefits becomes more pronounced. In contrast, sustainability concerns are long-term concerns. The present generation expresses its willingness to sacrifice present welfare to avoid unacceptable welfare losses in the future. Again, the sustainability criterion calls for limits to resource use, whereas CBA permits unlimited trade-offs (van Pelt, 1993).

Shadow-pricing of environmental resources may not solve these problems. Assume for the moment that it is technically possible to assign a price to all natural resources, covering all their functions and use and non-use values alike. In this situation, CBA outcomes would undoubtedly become more acceptable from a sustainability point of view. However, even then there would be no guarantee that environmental thresholds would be satisfied. Pearce (1989) for instance, argued that the applicability of CBA reaches its limits when the assimilative capacity of ecosystems is exceeded. According to Pearce, CBA will not avoid this or the resulting, often irreversible deterioration of ecosystems. Pearce proposed the use of biological standards (now interpreted as sustainability thresholds) instead of CBA as guides to acceptable levels of pollution.

Much attention has been paid to the incorporation of the environment in national income accounts. Sustainable income is considered the maximum income level that can be maintained in the long run and which is commensurate with sustainable development. It has been proposed to focus on the maximum constant income flow available for consumption over time. At this level the chosen capital stock does not decrease. In principle, this idea may be applied to project appraisal as well in two steps. If a project would lead to a reduction in the relevant capital stock, a) actually (as opposed to potentially) compensating activities should be implemented, and b) the costs of these stock-increasing activities should be accounted for in economic CBA by decreasing benefits or increasing costs (van Pelt, 1993).

One suggested approach would combine monetized environmental effects and project setting sustainability indicators (van Pelt, 1993). In a first step, environmental effects would be measured and valued (possibly by looking at the costs of mitigation measures). Next, sustainability weights would be developed,

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which reflect the distance between existing and sustainable resource use patterns in the project area. Such a weight should equal one if existing pollution levels are considered just sustainable, and increase with the degree of non-sustainability. This measurement scale explains why these weights are not equal to, but can be derived from the sustainability indicators for the project setting. In a third and final step, environmental benefits and costs would be multiplied by the sustainability weight.

Another idea involves the multiplication for each alternative of the economic IRR by a factor derived from the score of a project on the sustainability criterion (van Pelt, 1993). This factor should equal one if the project is marginally sustainable, and increase (decrease) in proportion to degree of (non-)sustainability. The higher the resulting score becomes, the more attractive the project is. Non-sustainability may still occur if the economic IRR is sufficiently high. A sound methodology needs to be developed.

Social CBA has appeared to be an inappropriate tool to assess efficiency and equity simultaneously due to conceptual and empirical reasons. From a purely theoretical viewpoint it may therefore be of interest to explore possibilities to expand social CBA by incorporating sustainability concerns as well. If poverty is considered an important cause of environmental degradation, project benefits accruing to the poor could be valued even higher than in traditional social CBA. Similarly, investments in environmentally sound practices might be valued higher than investments in unsustainable practices (van Pelt, 1993).

To conduct such an expanded social CBA would be a major undertaking. From a practical perspective, there seems to be little scope for or interest in such a complex technique. This leads to the conclusion that CBA cannot be considered a tool to address the three criteria of efficiency, equity and sustainability simultaneously (van Pelt, 1993).

In the MCA approach the separate scores on the three key criteria would be the starting point for integrated evaluation. The choice of technique would depend on the dimension of the scores on the criteria of efficiency, equity and sustainability. The main options were summarized by van Pelt (1993) as follows:

- The scores on the efficiency criterion may be of three kinds. If a CBA study allows full coverage and monetization of environmental (and other) effects, comprehensive economic IRRs or NPVs result. If all or the greater part of ecological costs and benefits cannot be monetized, MCA may be applied. An intermediate solution is to apply MCA to a) the outcome of a partial CBA and b) a group of intangibles, externalities and so on. If MCA is applied, a ranking of alternatives on the efficiency criterion results.
- The (intratemporal) equity criterion can take several forms. Quantitative indicators may show, for instance, which part of project benefits accrues to target groups. It may be possible to obtain quantitative indicators involving a weighting mechanism (for instance on the basis of land distribution). MCA may be applied to rank alternatives regarding their overall equity performance.
- An estimation of the score on the sustainability criterion may take the form of quantitative sustainability indicators. Alternatively, alternatives may be ranked with regard to their sustainability.

Because societies differ from country to country with relation to the level of economic development, cultural and religious background, population density etc., the importance societies place on specific-functional benefits of the water resources system will vary. This, however, does not mean that making a framework of functions and values of these irrelevant. Tangible functions may be assigned a (monetary) value, such as hydropower generation or irrigation water supply. Natural conservation values are a typical example of intangible values. In between are the environmental functions, of which may be given a value directly (in transportation) and others indirectly, by using a shadow price. (United Nations, 1992c)

The United Nations (1992c) identified five distinct functional classifications for water resources as follows:

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1. Subsistence functions

Local communities are, to a large extent, dependent on ambient water resources which provide domestic water to households and for irrigating home gardens and for irrigation plots. Moreover, they use the streams for fishing activities. These uses are often overlooked in national economic accounts, as they are not marketed or otherwise assigned a monetary value.

2. Commercial functions

Commercial uses of water resources are reflected in national economic accounts because they are marketed or otherwise given a monetary value, such as the price to be paid for domestic water supplies. Fishing for the market by individuals and commercial enterprises is either example of commercial use of the water system. Besides the commercial value these uses have in common, most (if these uses are also largely consumptive.

3. Environmental functions

The drainage basin of a river fulfills a series of functions for man that require no human intervention, i.e., with no need of investment or regulatory systems. These environmental functions include the so-called regulation functions, such as the water purification capacity, and non-consumptive uses, such as recreational and tourism functions. Environmental functions are sometimes difficult to assign a value. The value of regulation functions may be assessed by using a shadow price that is calculated as the costs for artificial regulation, for example, the price of a sewage waste treatment plant. Recreational and tourism functions may be calculated by assessing the economic benefits accruing from the use of tourist facilities like hotels, and/or the revenues from fishing licenses, for example.

4. Option value

The future is uncertain, and extinction is forever. Option value is a means of assigning a value to risk aversion in the face of uncertainty. Water is an essential substance of life, as life is impossible without the presence of water. Besides offering an environment for aquatic species, rivers, streams and lakes are often bordered by wetlands, like reed beds, floodplains and marshes. These land-water ecotones are known to harbor a rich assemblage of species. Nature areas preserve a reservoir of continually evolving genetic material, irrespective of whether the values of that material have yet been recognized, which enables the various species to adapt to changing conditions. These areas can therefore be seen as a means by which nations can keep at least a part of their biological resources intact for the future benefit of their people.

5. Existence value

Many people, especially in the industrial nations, attach value to the existence of a species or habitat that they have no intention of ever visiting or using they might hope that their descendants (or future generations) may derive some benefit from the existence of these species. Other indicators of existence value are rarity, which may be defined at various levels of scale (for example, national and international), and natural areas, which depends on the virginity of an ecosystem, i.e., the extent to which the ecosystem is undisturbed.

9.5 Enhanced Environmental Impact Assessment

Initially resisted by many in the project community, the Environmental Impact Assessment (EIA) process allows consultation and dialogue between developers, the community, regulators and others, and ensures that time is spent at the 'front end' in examining options and ensuring that the project appears viable. Through these twin benefits the likelihood of community opposition and unforeseen external shocks is diminished, and project developers are forced to spend time planning at the front end - precisely the stage of the project that they traditionally rushed, despite the obvious dangers - and communicating their ideas clearly to those who will be affected. The lack of time spent at the front end been a problem often in the past as has been

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the lack of effective communication. A positively-presented proposal can make all the difference in a cost-benefit analysis being positive.

All policy measures and investments require information. Environmental information is often the most difficult to assemble because it requires that a system of environmental monitoring be in place. In many developing countries such monitoring is often rudimentary, and what monitoring there is often has unknown bounds of uncertainty. Monitoring systems involve two dimensions (UNEP, 1994a):

1) measurement of emissions and waste arisings, for example emissions of sulfur oxides (SOx) and the quantities of solid waste generated; and land use change;
2) measurement of environmental impact from a given level of emissions or waste arisings, for example the reduction in water quality as measured by levels of dissolved oxygen (DO) in the water.

In the context of the environmental impact of projects, and the discipline of EIA, the term 'environment' is taken in its widest context to include all the physical, chemical, biological and socioeconomic factors that influence individuals or communities. It not only includes the air, water and land, and all living species of plants, animals, birds, insects, and microorganisms, but also man-made artifacts and structures, and factors of importance to the social, cultural, and economic aspects of human existence (Smith, 1995).

In this context, all projects have an effect or impact on the environment. Some of these may be seen as positive impacts (benefits), while others will have a detrimental effect (costs). The purpose of EIA is to evaluate these positive and negative effects as objectively as possible and present the information in a manner that is accessible to decision makers so that it can be used in conjunction with other appraisal tools, such as cost--benefit analysis. However, as has been previously discussed, the quantification of environmental benefits remains problematic.

Engineering projects may have an impact on the full range of environmental features including air, water, land, ecology, sound, human aspects, economics, and natural resources. Many of these impacts can be measured in terms of changes to specific quality parameters such as concentration of particulates or hydrocarbons in the air, or dissolved oxygen concentration in water. Other impacts, such as the aesthetic qualities of a landscape or a structure, or the importance of preserving an historic building, are not so easily quantified.

Some of the impacts will be directly attributable to the project - such as noise from an airport or road, the visual impact of a structure, or the pollution of the air or water from a factory. These are referred to as direct or primary impacts. Other impacts may arise indirectly through the use of materials and resources required for the project. Impacts may affect areas remote from the project itself and are termed the indirect or secondary impacts. Lower-order impacts can also be identified, such as the impacts on the environment caused by the supporting equipment or infrastructure (Smith, 1995).

The range of environmental impacts arising from a project will continue throughout the operating life of the project, and can therefore be regarded as permanent or long-term impacts. The pollution of the air caused by the operation of a thermal power station is thus an example of a long-term impact. Short-term or temporary impacts, on the other hand, are those arising from the planning, design, and construction phases of the project. Typically these might include the noise and dust generated by the construction process itself, or temporary changes to water table levels, for example.

In industrialized countries, the general public may be involved in the sanction and approval stage of projects through public enquiries or public protest, but they are unlikely to be involved in the planning and design of projects, and it is even less conceivable that they would participate in their construction or operation. For projects in developing countries, particularly small projects in rural areas, the concept of 'community' or 'beneficiary' participation is now accepted as being expedient, if not essential, for success (Smith, 1995).

The participation of the community for whom the project was intended was initially employed to provide assistance with the construction of rural projects, such as the development of water, sanitation, and irrigation schemes. This was primarily to reduce costs and to ensure that the local community would have

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sufficient expertise to enable them to operate and maintain the schemes once they had been constructed. The idea has since been developed further to encompass identification, planning and even design of projects, the argument being that the community have a much better local knowledge, they know what they want, and of course they are aware of all the social, cultural and religious factors that may affect the design.

For project managers this can entail a great deal of additional work, and it can delay the start and completion of a project. The reported advantages are that it will help to ensure that the project is used, and that it can and will be successfully operated and maintained. In some cases, such as the improvement of water quality, rural communities may not be aware of the advantages of a project, and community training and education may be necessary. The construction of pilot schemes can be necessary in order to convince villagers of the benefits to be derived from a project and to obtain their views on the design and possible improvements. This all places an extra burden on the project manager, and highlights the importance of communication skills and the ability to work with a variety of different people and organizations (Smith, 1995).

Regional environmental assessments (REAs) are desirable when a number of development activities are planned or proposed for a relatively localized geographic area, such as several projects in one watershed. They serve a number of useful purposes, for example (World Bank, 1996):

- Definition of study areas in terms which make environmental sense (e.g., river catchment basin, airshed, coastal zone);
- Selection of sustainable development patterns from alternatives in a region under development pressure or being programd for development for the first time;
- Identification of cumulative impacts of different activities (e.g., the combined effects on receiving water quality of the effluents of several municipal and industrial treated wastewater discharges), and design or implementation schedule changes and other measures to avoid or mitigate them;
- Identification of environmental interactions or conflicting demands on resources among projects in which the impacts of one project may reduce the benefits of another, and of measures to avoid such a result;
- Formulation of criteria for environmentally sustainable development in the region, including treatment of environmentally sensitive areas and resources, site selection criteria, design criteria, region-specific measures to mitigate adverse impacts, and land-use planning guidelines;
- Identification of monitoring data needs and definition of data collection programs to support EA and development decisions; and
- Examination of policy alternatives and institutional elements needed for achieving sustainable development in the region.

Like regional EAs, a sectoral EA (SEA) can be used to examine the cumulative impacts of multiple projects planned in the same sector. The other purposes of SEAs are somewhat different (World Bank, 1993e):

- Review of the environmental impacts of sector investment alternatives, e.g., centralized or decentralized wastewater treatment;
- Evaluation of the environmental effects of sector policy changes, e.g., implementation of industrial waste minimization standards, pricing water to reflect true cost of service, modification of criteria for reuse of treated effluents, and
- Assessment of (1) requirements in the sector for environmental review, implementation of environmental management and mitigation measures, and monitoring programs, (2) the capacities of sectoral institutions to carry out those activities, and (3) needs for training, development of guidelines, or other aspects of institutional strengthening.

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Life-cycle EIA (LEIA) is a procedure for evaluating environmental impacts of a product, process, or activity, throughout its whole life cycle, cradle to grave (Gilpin, 1995). An LEIA is designed to (Gilpin, 1995):

- Assess the environmental effects of the retrieval and consumption of the raw materials and other inputs during the different life cycle phases of a product, process or an activity, including the fate of all pollutants and residuals,
- Assess the disposal problem, if any, of the superseded product, process or activity,
- Provide information useful for an aggregated EIA of products, processes and activities throughout the life cycle
- Evaluate the environmental consequences of alternative processes and design concepts, permitting a comparison between products, processes and activities.

Each phase may be accorded a score on an environmental index, for example, for: natural resources, raw materials, land use; emissions to air, water and soil; noise; manufacturing procedures about economy, energy, work and the public safety; waste handling; recycling, and ultimate disposal. It is distinct from project level EIA which is much concerned with location, focusing on the life cycle of individual projects rather than the life cycle of infrastructure.

EIA is essentially about optimizing resources through an allocation of resources to maintain a balance between sustainable development and environmental protection. The concept of Pareto optimality is an economic situation from which it is impossible to deviate so as to make one person or group better off without placing some other person or group at a disadvantage. The optimum does not address income distribution and it is not necessarily the optimum social state (Gilpin, 1995).

Discussions on environmental soundness and sustainability are hampered by a lack of generally accepted indicators. Actually, the intention of environmental soundness and sustainability may be clear, but practically the concepts are not yet well defined. The use of proper indicators of environmental soundness and sustainability, may solve this problem. Only after accepting practical indicators, will it be possible to define standards and to design and evaluate strategies.

For the planning of water resources development, a philosophy is as valuable as its practical usefulness. The basic question is: how can sustainability and environmental soundness be measured in reality, i.e., what are the practical indicators? For this purpose, a comparison can be made with the way the objective of socioeconomic well-being has been translated into operational objectives (UN, 1992c).

Traditionally, the Gross National Product (GNP) is a widely-used indicator for well-being, although it only indicates the material welfare part of well-being. Other socioeconomic indicators could be, for example, employment, income distribution, stability of prices, level of education, etc. To assess the level of well-being the present values of such indicators are compared with reference values, i.e., certain standards. Such a standard may be the gross national product that is pursued, the desired employment, etc. In the context of water resources development, standards are related to the water resources system. Planning of water resources development, traditionally, aimed at reaching certain socioeconomic standards. In the planning process, alternative water resources development strategies are evaluated on their contribution to achieve a higher level of well-being (UN, 1992c).

The GNP is one of the outputs of the System of National Accounts (SNA), a framework for the systematic and integrated recording of the flows and stocks of an economy. It is observed that the value of GNP does not give information about the quality of production. In some literature, the importance of expanding and improving the conventional SNA with Natural Resources Accounting (NRA) has been stressed. To this end, one distinguishes renewable, semi-renewable and nonrenewable resources. Water, for instance, is a renewable resource, soil and ecosystems are semi-renewable resources and minerals, metals and fossil fuels are nonrenewable resources (UN, 1992c).

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Many economists are trying to adjust conventional notions of GNP and define a Green GNP. Negative impacts on the environment are subtracted from conventional measures of GNP. Shadow prices are used to quantity the loss of environmental quality. A Green GNP would be an indicator of both the economy and the environment. Critics argue, however, that adjusting the conventional GNP will never result in the calculation of a real Green GNP. It would be better to work with several indicators taking into account all aspects of a sound economy and a sound environment (UN, 1992c).

To incorporate environmental soundness in the evaluation of water resources development may best done with the additional use of environmental indicators. When looking for environmental indicators, the problem arises as with indicators for well-being, one single indicator cannot be found. Indicators of sustainability should refer to the dynamic equilibrium between society and the environment. These indicators will relate to the human pressure on the environment and environmental vulnerability to this pressure. Indicators of sustainability should refer to the human pressure on the environment and/or to environmental vulnerability to this pressure. Environmental pressure indicators describe aspects such as the use of resources, the size of emissions, discharges, and disturbances. Environmental vulnerability indicators should provide information about the availability of resources. The carrying capacity of a soil or ecosystem, resilience of an ecosystem after a disturbance, the buffering, capacity of a system, the purifying capacity to degrade harmful substances, the accumulation of toxic chemicals, etc. Also relevant to sustainability are indicators describing the extent to which the pathway of a substance forms a cycle (Adriaanse, 1993).

Environmental impact can be measured in "biophysical" terms (as with the measure of DO) and in economic terms, i.e., with a money value attached to the impact. Typically, economic approaches require a biophysical measure to exist before any monetary valuation can be carried out. Monetary valuation can therefore be seen to be dependent upon detailed physical and biological information. In turn, the cost-benefit approach requires that environmental impacts be valued in monetary terms whenever this is feasible and credible. Monetization is one method currently used to assess the importance of environmental impacts. Other means of doing this include some indicator of ecological stress, or a measure of health impact (Adriaanse, 1993).

Emissions and waste arisings are simply indicators of the proximate pressure on the environment. They reflect underlying pressures arising from sectoral change in the economy which in turn reflects population change, public policy (including any changes in property rights regimes and public opinion - the latter being especially important in developed economies) and macroeconomic changes to prices, international trade and overall GNP. The various sectoral impacts can then be measured in terms of state of the environment (SOE) indicators, e.g., changes in length of river with a particular classification of water quality, or change in DO levels in a given river over time, and so on. In order to make the transition to measures of importance, SOE indicators need to be translated into effects indicators, i.e., usually measures of damage (or improvement) in assets, natural and man-made, that have economic value to individuals. Thus, an SOE indicator might be the ambient level of SOx, but an effects indicator might be the rate of corrosion of exposed metal surfaces. In turn, the effects indicator can be measured in biophysical terms and monetary terms (World Resources, 1995).

Environmental indicators exist at various levels. At their simplest, indicators measure changes in the state of the environment, e.g., a change in ambient air quality. This is level 1. Level 2 links the state indicators to some measure of underlying pressure. The most common of these links measures of environmental quality or damage to a measure of economic activity such as GNP. While there are many reasons to engage in this linking operation, the most obvious is that it can facilitate environmental impact forecasting (World Resources, 1995).

A third level of indicators seeks to put them into an accounting framework. This would include monetized measures of damage since these are generally required in order to fit into some other schema such as cost-benefit analysis. But in some circumstances monetary measures may themselves be linked back to indicators of economic activity as in Level 2. The two most developed accounting frameworks, however, are:

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satellite accounts and modified national income accounting. While satellite accounts do not involve monetization of impacts, modified national income accounting does involve monetization.

The need exists for definitive environmental progress measures for both international sustainability plans and for improved accountability of national environmental expenditures. This has caused renewed in interest in "environmental indicators" at the national and international levels. The growing awareness of the interconnectedness of socio-economic development issues and environmental consequences demands a more scientific and statistical quantification of the status and trends in natural resources and pollution. New requirements for environmental information and assessments, stipulated, for example, in Agenda 21 include (UN, 1992a):

a) Integrated and timely access to data and information from many different sources and disciplines;
b) Analysis of environment-development interactions and policy/management options
c) Identifying cause and effect relationship as well as emerging issues of potential international importance; and
d) Assessing potential impacts and long-term sustainability of alternative development, policy or management scenarios.

In addition, there is growing pressure in the more developed countries to justify and quantify the need for environmental expenditures as they have increased as a percentage of GNP (World Resources, 1995).

Environmental monitoring leads to measurements and raw data. This raw data is translated into statistics for review and plotting of trends. Indicators have an added significance as compared to the underlying statistics in that they are linked to specific policy purposes. The policy applications include early warning and the evaluation of policy performance. Indicators are by design developed to "steer action." The reliability of indicators is mainly determined by the reliability of the underlying statistics and raw data. Environmental monitoring will be much more re-directed toward the ultimate use of "information" and the processing of the information into policy performance indicators rather than merely volumetric data collection (UNEP, 1994).

According to UNEP in 1994, indicators must have certain properties. First, they must have wider significance than its immediate meaning as a measured value; it must represent a larger phenomenon. Second, an indicator is principally normative, that is: comparable with an aim or reference value. In practice, the reference values encountered are sometimes indeed the targeted levels of environmental stress or quality of environmental response, or less direct 'standards' such as the indicator value for other countries, regions or economic sectors, or an historical value.

The Organization for Economic Cooperation and Development (OECD, 1993) identified the following criteria for indicator selection:

- **Policy Relevance and Utility for Users**
  - provide a representative picture of environmental conditions, pressure on the environment or society's response
  - be simple, easy to interpret and be able to show trends over time
  - be responsive to changes in the environment and related human activities
  - provide a basis for international comparisons
  - be either national in scope or applicable to regional environmental issues of national significance
  - have a target or threshold against which to compare it so that users are able to assess the significance of the values associated with it
- **Analytical Soundness**
  - be theoretically well founded in technical and scientific terms
  - be based on international standards and international consensus about its validity
  - lend itself to be linked to economic models, forecasting and information systems

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- **Measurability (data should be)**
  - readily available or made available at a reasonable cost/benefit ratio
  - adequately documented and of known quality
  - updated at regular intervals in accordance with reliable procedures

According to UNEP (1994), the classification of indicators may be looked at in three different but complementary ways yielding a three dimensional classification:

1. By use such as early warning, general policy or scientific development.
2. By subject by a compartment of the environment such as air or water or by a theme such as fertilization or acidification.
3. By position in causality chains such as environmental stress, status of the environment, or societal response including policy effects.

According to the UNEP overview (1994), a system of indicators will be needed to achieve sustainable development. This implies a quantitative description of a dynamic system which is both evolving and responding to outside interference. Within this system, attention must be given to the dynamic relations between five sub-systems:

1. Size and health of the human population
2. Production, consumption and technology
3. Renewable and non-renewable resources
4. Environmental compartments
5. Integrity of ecosystems

Ideally speaking, a systems concept should be developed on the basis of an integrated model, with a system of linked sub-models. Such a system is thought to be quite distant in attainment. In the short term, indicators must track specific problem areas that can only provide insights in a general way on overall sustainability goals. UNEP may consider stimulating the development of tools (methods, concepts, models and indicators) to support integrative reporting in the framework of the bi-annual Statements of UNEP's Executive Director and 10-year State of the Environment Reports.

There are many efforts on a global basis on the development of environmental indicators. The Netherlands has been a leader for many years in environmental indicators and they have a very detailed National Environmental Management Plan that uses indicators. According to the book "In Search of Indicators of Sustainable Development" by Kruk and Verbruggen (1991) of the Netherlands Institute for Environmental Studies, a measure of sustainable development should include indicators for the pressure from society on the environment (pollution, resource use), and indicators for the state of the environment (ecological integrity or biodiversity). Both (sets of) indicators should confront actual flows or states with sustainable flows or states. The Netherlands operates under the "Environmental Policy Performance Indicators" of April 1993 by Dr. Albert Adriaanse.

Environment Canada has produced a set of indicators. Some international agencies have worked in the area including the Organization for Economic Cooperation and Development (OECD, 1991). The United Nations Environment Program (UNEP) published a technical report in June of 1994 entitled An Overview of Environmental Indicators: State of the Art and Perspectives (UNEP, 1994). This document provided a complete review of the indicator development process throughout the world. UNEP also held a workshop in July of 1993 in conjunction with Delft Hydraulics to test a procedure for evaluating the sustainability characteristics of proposed projects (Delft, 1993).

A Rome Conference of the OECD in 1999 (OECD, 2000) reviewed progress in meeting goals for development of sustainability indicators. The discussions showed considerable interest in indicators that better reflect the linkages between the three dimensions of sustainable development and their interactions (positive and negative). There was also interest in reduced and balanced sets of indicators that provide signals on key dimensions of sustainable development to policy-makers and the general public. There was

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general agreement that sets of indicators reflecting key trends and policy variables are useful to respond to common policy goals, and to demands for simplified indicator lists. The conference highlighted four key areas (OECD, 2000):

1. The importance of a pragmatic approach to developing indicators (i.e. insuring that they are useful to decision-makers and to stakeholders) was stressed.
2. It was emphasized that work on communicative indicators needs to be linked more closely to an understanding of citizens' interests and information needs.
3. It was suggested that there is a need to demonstrate the "value-added" that indicators have for advancing sustainable development, especially in order to secure resources for further work in both capitals and international organizations.
4. Work is required to strengthen links between institutions; links to institutions with expertise on social issues was considered particularly important, in light of the need to better reflect the social dimensions of sustainable development in indicator sets.

In the United States, an Interagency Working Group (IWG) has been convened to develop approaches to sustainable development indicators. This group published an "Experimental Set of Indicators" in September 2001 (US IWG, 2001). The IWG are not trying to define and measure sustainability with sufficient precision to show when it has been achieved. The IWG felt it to be more practical to develop indicators useful in assessing progress in that general direction. The IWG believes that it is more appropriate to regard sustainability as a dynamic condition than as a static end point. Note that this fits the main premise of this research that water projects need to be continually steered toward a sustainability objective that is not yet clearly defined (US IWG, 2001).

The IWG believes that to integrate the concept of sustainability into an Indicator Framework requires that the concept deal equally with the economic, environmental and social realms. As a starting point, the IWG included sustainability concepts from economics and ecology. The economic sustainability principle most useful to IWG purposes was "don't spend principal." This concept was developed by Hicks who defined income as the amount that can be spent for consumption without decreasing the productive capacity of the capital from which the income is derived (US IWG, 2001).

Internationally, the issue of "sustainable development" is the major driving force for indicator development and the integration of environmental and economic planning. The ultimate goal of many of these efforts is an "Index of Environmental Indicators" and/or an integrated "Index of Environmental and Economic Indicators" to supplement or replace the common economic planning tools.

In the United States, the EPA has been seeking to develop a workable set of environmental indicators (based more risk-based science than sustainability) for several years. This effort corresponds to similar efforts in many areas internationally to develop indicators of sustainable development and/or integrated economic and environmental indicators.

The EPA published a Five-Year Strategic Plan in July 1994 entitled "The New Generation of Environmental Protection" (EPA, 1994). The plan indicated that EPA is at a crossroads and must pursue a new generation of environmental protection - one founded on renewed commitment to broad environmental goals combined with common sense, innovation and flexibility. It was noted that future strategic planning would target meeting the environmental goals currently being developed in the National Goals Project. Principles were identified for guiding how EPA will meet its goals. Specific objectives, strategies, measures of progress and key activities are listed for each of seven major principles. These major efforts and the move toward "management by risk-based objectives" by the EPA signals a move into an entirely new era of environmental management in the US. Since then, the EPA has published a 1997-2002 Strategic Plan and a Year 2000 Strategic Plan, with specific goals and objectives for multi-media environmental protection and control (US EPA, 2000). The Year 2000 Strategic Plan includes goals for clean and safe water, preventing pollution and reducing risk, better waste management and restoration of waste sites, reduction of global and cross-border

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environmental threats, quality environmental information, sound science – improved understanding of environmental risk – greater innovation, credible deterrents and credible environmental management. Each of these goals is explained relative to importance, specific time based objectives, results they intend to achieve, means and strategies available to assist them, connecting annual performance goals to strategic goals, and external factors.

9.6 Project Implementation and Tracking

Project appraisal has generally centered on an economic appraisal, with a supplemental environmental review. Implementation of the project was given little emphasis, and has directly been causal to the high failure rate of water resource projects, even without sustainability concerns. Even when the environmental review has been done adequately, there has been a general failure to ensure that recommendations, mitigations and monitoring programs are followed through during project construction and operation. There are a wide variety of institutional issues and problems during construction and with operations and maintenance (O&M). In addition, there has not been a reasonable tracking mechanism to provide insights into the reasons why projects succeed or fail, to assist with the formulation of new projects in the sector and project area.

The development of competent and sustainable institutions that are capable of managing the proposed infrastructure is a problem in many parts of the world. The problem can be eloquently developed, the solutions optimal from various multi-criteria perspectives, but the project can fail to meet its objectives because of management issues. As such, it is incumbent on the proposed development project (affecting water resources) to ensure that management systems are developed and in place to ensure that project objectives are met. This is one objective of the proposed EMSs in this category.

The physical sustainability of water resource projects has been hampered by poor maintenance. Insufficient funding, poor construction standards, and weak planning at the appraisal stage have been cited as reasons for the inadequacy. There has been a tendency to support project construction and not operation and maintenance (O&M). World Bank reviews of water resource projects have highlighted the need for the Bank not to detach itself from post construction activities (Serageldin and Steer, 1993).

The World Bank has placed a great deal of emphasis on developing institutions. Despite these efforts, O&M, financial management, and planning have often been unsatisfactory. Lack of administrative capacity, poor institutional arrangements, and political interference contribute to this poor performance. Furthermore, too many agencies have overlapping responsibilities, and interagency coordination is limited. In a Bank review of 120 Bank water and sanitation projects, management organization was often mentioned as a problem. Governmental interference was linked to inappropriate senior appointments, overstaffing, and rapid turnover of staff.

Finally, there is a definitive need for feedback and "lessons learned" from projects, whether they successfully meet their objectives or not. This feedback will assist with:

- Development and refinement of sustainability indicators,
- Improvements in the project development processes,
- Enhancements in the project assessment and environmental reviews, and
- Provide a source of information to outside reviews and the public.

9.7 ISO 14000 Standards

The International Standards Organization (ISO) is a federation of non-governmental organizations established in 1947 to develop international standards, improve international communication and collaboration, and facilitate the exchange of goods and services. The federation is currently comprised of

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close to 100 national standards bodies (member bodies) from countries representing approximately 95 percent of the world's industrial production. The headquarters of the ISO secretariat is in Geneva, Switzerland (Conway, 1996).

The following principles outline the goals of an EMS (Conway, 1996):

- Recognize environmental management as among the highest corporate priorities.
- Establish/maintain communications with internal and external interested parties.
- Determine the legislative requirements and environmental aspects associated with the organization's activities, products and services.
- Develop management and employee commitment to the protection of the environment, with clear assignment of accountability and responsibility.
- Encourage environmental planning throughout the product and process life-cycle.
- Establish management process for achieving targeted performance levels.
- Provide appropriate and sufficient resources, including training, to achieve targeted performance levels on an ongoing basis.
- Evaluate environmental performance against appropriate policies, objectives, and targets and seek improvement where appropriate.
- Establish a management process to review and audit the EMS and to identify opportunities for improvement of the system and resulting environmental performance.
- Encourage contractors and suppliers to establish an EMS.

In preparation for UNCED, the ISO established a Strategic Advisory Group on the Environment (SAGE) in 1991 to assess the need for international environmental management standards. SAGE recommended that ISO proceed with an environmental standard by 1992 and that a technical committee be established to carry it through. On June 1, 1993, ISO's Technical Committee 207 (TC 207) held its first plenary meeting. TC 207 was directed to establish environmental standards in five areas of environmental management (Conway, 1996):

1) Environmental management systems;
2) Environmental auditing and related environmental investigation;
3) Environmental labeling;
4) Environmental performance evaluation; and
5) Life-cycle assessment.

The key factor that propelled the ISO 14000 series of standards forward throughout the 1990s was the increase in national environmental standards. With the proliferation of environmental standards, concerns have been expressed that these standards would fragment international markets and unduly favor the companies of the countries or of the regions where these standards were developed, unless they were developed by authoritative and broadly based international bodies. The ISO was to serve this role.

It is not intuitively obvious how ISO 14000 helps to meet the global need to move toward sustainable development, especially in non-industrial settings. Implementation of a management system based approach will help companies (or water management developers or operators) focus attention on environmental issues, and bring them into the main stream of decision-making. ISO 14000 is designed to provide the public with a reasonable assurance that the performance claims of an entity are accurate (Conway, 1996).

ISO 14000 was developed to meet the demand for an environmental management system that will be consistent for many sorts of organizations. The ISO 14000 set of standards and guidelines defines the core environmental management system itself, and the auditing procedures necessary for verification. It also defines three sets of tools that are important in implementing an EMS: life cycle assessment, environmental performance evaluation, and environmental labeling (IISD, 1996).

In broad terms, ISO 14000 can fill two requirements in an organization (IISD, 1996):

1. The internal need for a system that will help the organization address all of the legal, commercial and other challenges related to the environment that it faces.

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2. The need to be able to assure those outside of the organization that the organization is meeting its stated environmental policies.

Internal to the organization, a systematic approach to managing environmental issues can help to ensure that environmental incidents and liability are reduced. A systematic approach can help to identify opportunities to conserve material and energy inputs, to reduce wastes and to improve process efficiency. A systematic approach to management leads indirectly to improved environmental performance and improved cost control. Top management commitment to improved environmental management, clearly defined goals, responsibilities and accountabilities, creates a greater awareness and understanding of environmental issues and an improved organization culture (IISD, 1996). Although these internal benefits are directed at industrial entities, it is easy to make the correlation with water management and water projects.

External to the organization, third party assurance and recognition demonstrates that the organization products and services meet certain conditions. This is exactly what standards do efficiently, especially when combined with third party conformity assessment programs. They reduce or eliminate the need of companies to individually inspect each supplier's products and services with its own auditors. International standards such as the ISO 14000 series provide the widest possible recognition of this assurance. Again, the accountability of water management agencies and development projects is also a problem that could be solved with such international protocols (IISD, 1996).

ISO 14000 does not set environmental performance standards. It leaves these up to the organization, saying only that its policies must include a commitment to comply with all relevant laws and regulations. How then can those interested in improving environmental performance make use of the system? First, ISO 14000 provides a useful tool with which to hold entities accountable. When an entity does establish a positive environmental policy, the ISO 14000 system can be used to check that it is actually accomplishing its goals, and reporting appropriately on them. Furthermore, entities can be encouraged to insist that all of their suppliers meet the environmental policy goals. Finally, just the existence of an EMS in an entity will usually lead to environmental performance improvements (IISD, 1996).

Although developed in the corporate context, the following definition developed by the International Institute for Sustainable Development (IISD, 1996) is equally useful for water projects:

> *For the business enterprise, sustainable development means adopting business strategies and activities that meet the needs of the enterprise and its stakeholders today while protecting, sustaining and enhancing the human and natural resources that will be needed in the future.*

This definition captures the spirit of the concept proposed in the report of the World Commission on Environment and Development and focuses attention on areas of specific interest and concern to enterprises (read water management or water development). It recognizes that economic development must meet the needs of the enterprise and its stakeholders. The latter include shareholders, lenders, customers, employees, suppliers and communities who are affected (either positively or negatively) by the enterprise's business activities. The definition also highlights the dependence of the enterprise's economic activities on human and natural resources, in addition to physical and financial capital.

ISO 14000 will contribute to sustainable development to the extent that it helps organizations meet the above definition. A key aspect of the ISO 14000 standards is their international acceptability. They will be available for use by enterprises all over the world, as the common international approach to environmental management and verification of environmental performance claims. This can simplify international trade and inter-company procurement (IISD, 1996).

The ISO 14000 series environmental management and environmental auditing standards are not about environmental performance *per se* but about management systems. The difference is fundamental, and can be the source of much confusion if not clearly understood. Rather than dealing with the values and limits of performance, with energy efficiency ratings and emission levels, a management system standard

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establishes what the organization needs to do in order to manage itself so as to meet its goals. It is a fundamental principle of ISO 14000 that organizations set their own goals, based on whatever considerations they wish to include, including the demands of customers, regulators, communities, lenders or environmental groups. That is, an entity can set its own objectives and targets for performance. The ISO 14000 management system provides a framework to develop plans to meet those targets and to produce information about whether or not the targets are met.

When put into the context of ISO 14001, a gap is the difference between what the standard requires and what existing environmental management practices actually exist in an organization. The gaps analysis compares the existing environmental management practices, methods, and techniques with the requirements of ISO 14001. The results of the study enable management to determine the degree of conformance with the ISO 14001 requirements. A gaps analysis is performed by using a matrix of individual ISO 14001 requirements as a baseline.

The management of the business, with or without outside help, assesses the current state of affairs relative to each item and records the results. This assessment is not intended to be a complete environmental management system audit; rather, it is an overview of each area of practice to determine what is being done and how that activity meets the ISO 14001 requirements (Voorhees and Woellner, 1998).

The use of ISO 14000 and 14001 techniques in the public sector is a relatively new concept. Most think of industrial companies obtaining certification in the same way that many did for the ISO 9000 Total Quality Management standards. The US National Science Foundation has been working on grants from the US EPA related to applying ISO14001 principles to water management entities in the United States. Although there are few examples of the use of ISO14001 in the public sector, the principles remain relevant to water management and the development of international projects affecting water resources.

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