A NEW DIRECTION FOR ALLOCATING WATER OF THE NILE RIVER IN EGYPT

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ABSTRACT

The Egyptian philosophy of water use is that of an agrarian society even though perhaps only 50 % of foodstuffs are produced domestically. The Egyptian Government is now implementing a plan of action that will spread water over vast new areas of the Western Desert and the Sinai. The objective is to transfer within 20 years as many as 7 million persons from the Nile Valley and the Delta to intensively irrigated areas of the Western Desert. This diversion of Nile River water is to be accomplished even as the nine upstream riparians are demanding more water.

A paradigm shift is required. Those guiding irrigation development in the Western Desert must accept and embrace a model of mixed development based on: 1) the eventual minimization of irrigation of field crops, 2) the identification and filling of now dry water-table aquifers through diversion of excess river flows in wet years, and 3) exploitation of minerals and other important resources of the Western Desert to support the new communities.

Clearly, during the initial stages of New Valley developments, the government needs to divert the entire excesses of wet year flows for over-irrigation of reclamation crops and the filling of pre-identified underground reservoirs. Integrated ground-water-surface-water systems should be established, successively along the path of development, to supply municipal and industrial water and for the irrigation of vegetables and fruit trees. A large component of the water required for creating shaded communities and wind breaks should be derived from reuse of treated wastewater effluents and the pumping of mildly brackish ground water. Thus, through the establishment of water-table aquifers along the route of development and the careful husbanding of the water resource, extensive settlements can be realized in the western Desert without substantial diminishment of the productive capacity of the agriculture of the Nile Valley and Delta.

Sustainability of the colonization will depend equally on the exercise of care in protecting the fragile desert environment in every zone of development and the equitable collection of water user fees from the start of project operations.

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INTRODUCTION

Three aspects of allocation of the water of the Nile River, and its management, are crucial to the water users of Egypt – a) the division and utilization of water and water rights among the ten riparian nations of the Nile River Basin, b) the internal allocations within Egypt, the most downstream riparian, and c) utilization of the flood water excesses. The focus of this paper is the allocation and management of water within Egypt and more specifically the allocation and utilization of excess surface water for environmentally sound and financially sustainable colonization of the Western Desert.

Egyptian Philosophy of Water Use

The Egyptian philosophy of water use is rooted in the achievement of food self-sufficiency through irrigation and the cultivation of cotton for domestic industry and for export. There still is not general recognition that the population of Egypt not only has exceeded the carrying capacity of the agricultural lands of the Nile Valley and the Delta Region but requires quantities of municipal and industrial water which render obsolete the notion of expanded pursuit of traditional flood-irrigated agriculture. The Egyptian Government is now struggling to evolve new policies and a plan of action that recognizes two important truths. First, Egypt must supply water to vast new areas of the Western Desert and the Sinai if the ever-growing population is to be accommodated outside the Nile Valley and the Delta. Secondly, the upstream riparians, particularly Ethiopia and Sudan, increasingly are claiming their heretofore unused rights to the flow of the Nile River.

Required Change of Philosophy

Required is a paradigm shift relative to the design and emphasis of the Egyptian program now under implementation to expand irrigated agriculture. There is adequate river water to service the Nile River Valley and Delta within the 1959 treaty allocation to Egypt of 55.5 billion cubic meters. It is doubtful, however, that even with contemplated changes of the cropping pattern, increased reuse of drainage water from irrigation, and development of ground water of the Western Desert, that the vast areas being planned for irrigation can be adequately watered for intensive agriculture.

Thus, the first of two propositions of this paper posits that, the government needs to consider the duty of water required for creating a *favorable living environment* in the desert instead of the establishment of new exclusively *agricultural communities.* Irrigation water should be used to irrigate vegetables, fruit trees, and date palms for food production and for creating shaded communities. Only through careful husbanding of the water resource can extensive settlements,

largely based on non-agricultural pursuits, be realized without substantial diminishment of the productive capacity of the Delta.

Best Use of Flood Water Which Is Excess to the Treaty Allocation

The second philosophical point of this paper is technical in nature. It relates to utilization of the extra-ordinary floods that originate in the upper basin and which are as yet uncontrolled by the upstream riparians. For example, some 110 billion cubic meters of flow occurred from August to October of 1998. Such flows present an ephemeral opportunity to divert the large quantities of water needed to establish the vast new settlements of the western Desert. It is essential, for the realization of sustainable development of the Western Desert that such high-volume, uncontrolled flows from upstream be used for the charging of new water-table aquifers and to improve the quality of recharge to existing, ground-water reservoirs.

Supporting decisions and policies are needed to assure that any excess water available during the coming decade is used to achieve the high multiplier effect that can be achieved through the development and use of water-table aquifers as reservoirs and as underground transmission systems.

VISION AND OBJECTIVES

The government of Egypt long has recognized that the population of the Nation, which has quadrupled over the past forty years, can not continue to be domiciled exclusively in the area of the Nile Valley and the Delta without extensive sacrifice of fertile lands. Even now these lands produce only about 50% of the nation's requirements for foodstuffs. The resulting crisis, which may be viewed in terms of national survival and economic independence, has prompted national leaders to articulate a vision with objectives of expanding irrigation to the Sinai and to the Western Desert to support the transfer of population away from the Delta.

The extension of irrigation to the Sinai is based on use of water at the tail of the existing irrigation system where reuse of irrigation return flows and treated municipal and industrial return flows from the Metropolitan Cairo area potentially are major components of the required water resources.

By contrast irrigation of the Western Desert requires: 1) the division of Nile flows at Lake Nasser into a new river flowing to the Western Desert, and 2) the maintenance of flows through the hydro-power plant at Aswan and on down river

to service the Valley, Delta, and Sinai. Important to the establishment of colonies and irrigation in the Western Desert is the extent and quality of the developable deep ground water reservoir that underlies most zones of the area. And as emphasized in this paper, the establishment of a series of shallow ground-water reservoirs that extend along the alignment-for-development, from Lake Nasser northwesterly toward the Qatarrah Depression.

Thus, it is the vision of the government that relates to the Western Desert that requires scrutiny and re-articulation. Determinants of the review should be the water resource base that may appropriately be mobilized to support extensive colonization and the water consuming nature of those colonies.

Vision

Current Vision: *The Government of Egypt is programming and working toward agriculture-based colonization of the Western Desert on an alignment extending from Lake Nasser toward the Qatarrah depression, incorporating the oases of Kharga, Dakhla, Farafra, and Bahariya, Figure1.*

Limitations of the Vision: The current vision anticipates the successive development of a chain of traditional agricultural based settlements extending ever farther away from Lake Nasser. While Egypt may initially divert enough water to create one or two agricultural communities, the flow of the Nile River will, in the future, be inadequate to sustain a whole chain of new communities dedicated to intensive irrigated agriculture in a very hot desert climate.

Objectives

Objective: *The current objective of the government of Egypt is to convince excess population of the Delta and Valley to migrate to the Western Desert and the Sinai to relieve further decline of the agriculture of the traditional areas.* The goal is to encourage some seven million citizens to settle in the Western Desert during the next two decades.

Discussion: It is recognized that no desert civilization can arise without ample water resources. To achieve this objective, it is planned to pump water from Lake Nasser, as a first stage, and to convey it over the western escarpment of the reservoir to irrigate agricultural crops on the sandy soils of the New Valley including the East Uwainat and Toshka areas. The initial areas were selected to minimize pump lift, to serve the most suitable nearby soils, and to attract non-governmental investment.

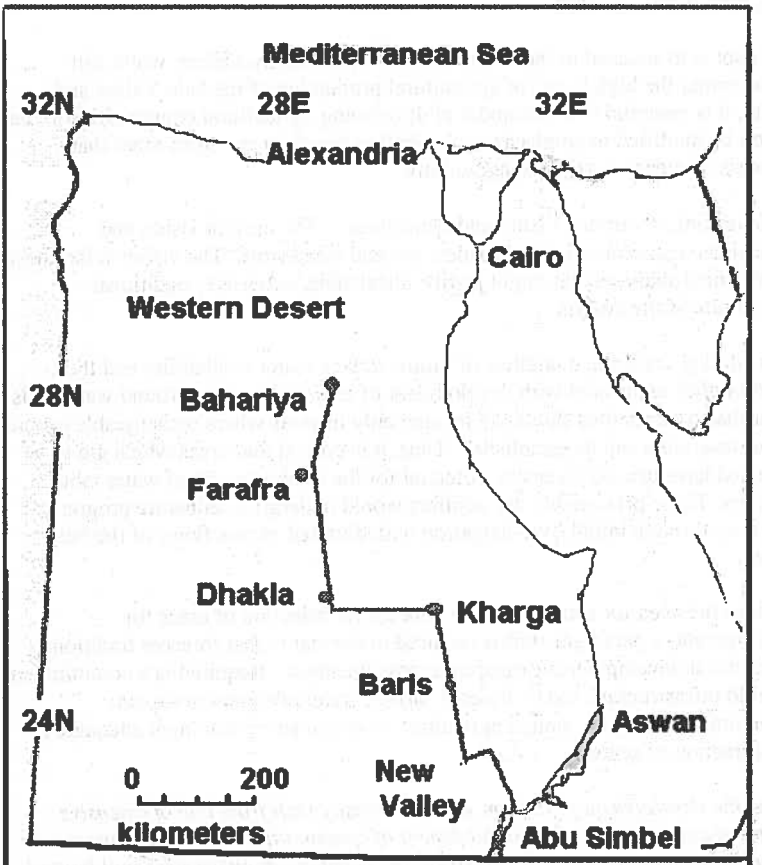

Fig. 1. Alignment for Settlement of Western Desert

Required Paradigm Shift

If Egypt is to succeed in the colonization of the Western Desert, while still maintaining the high levels of agricultural production of the Nile Valley and Delta, it is essential that the model of developing agricultural communities in the desert be modified to emphasize colonization based on strengths other than extensive, intensive irrigated agriculture.

Deficiencies of Current Vision and Objectives -- The current vision and objectives represent only the broadest societal framework. The vision is far ahead of technical analyses that might justify sustainable, extensive, traditional agriculture in the deserts

Considering the finite quantities of future surface water availability and the uncertainties associated with development of exploitable deep ground water, it is clear that communities should be located only in areas where rechargeable ground water reservoirs can be established. Thus, it is critical that areas which are to be irrigated have proved extensive potential for the establishment of water table aquifers. These presumably dry aquifers would undergo a deliberate program of charging through initial over-irrigation with diverted excess flows of the Nile River.

Besides the need for a change in the concept for selection of areas for development, a paradigm shift is required in the vision that foresees traditional agricultural developments extending across the desert. Required is a commitment to build infrastructure and to allocate surface water adequate to support communities with just enough agriculture to create an environment adequate to the attraction of settlers.

Thus, *the development paradigm will of necessity shift from one of extensive irrigated agriculture to the establishment of communities with water resources adequate to support a mix of industrial and commercial enterprises and limited water-efficient agriculture.*

Possibly with the exception of mining, only industrial enterprises that consume minimal quantities of water should be permitted, and irrigation mostly should be dedicated to productive date palms that shade streets and parks and to vegetables, fruit, and other high value crops adequate to supply local markets.

GEOGRAPHY AND SETTING

Nile River

Source: The Nile River rises in nine countries that lie to the south of Egypt. Two major tributaries, the White Nile and the Blue Nile, join at Omdurman outside Khartoum, Sudan. The Atabara is tributary some 200 kilometers downstream. The Blue Nile and the Atabara rise in the Ethiopian Highlands, where the summer monsoons contribute flood flows in Egypt from July to October.

Tropical rains that maintain a relatively constant flow originating in the lake districts of Burundi, Zaire, Tanzania, Kenya and Uganda feed the White Nile. The White Nile branches into a series of channels in the Sudd, an extensive marsh in the southern Sudan. The Sudd regulates not only the upland flows but also the flood flows of the rainy season of the savanna of central Sudan.

Egyptian Conditions: The flow of the Nile River is almost totally regulated as it enters Egypt through Lake Nasser. The river channel of the Nile Valley and the channels of the Delta have been, essentially, canalized since construction of the Aswan High Dam during the 1960s.

Treaties: In 1929 the Nile Water Agreement, to apportion use, was sponsored by Great Britain. During 1959 Egypt and Sudan signed a bilateral utilization agreement that stipulated an increase of Sudan's share from 4.0 to 18.5 billion cubic meters per year and that of Egypt was fixed as 55.5 billion cubic meters per year. The 1959 agreement freed Egypt to build Aswan Dam, Sudan to develop the Rosieres Dam, and Egypt and Sudan to carry out the Jonglei Canal channelization of the Sudd, a project designed to conserve large quantities of water lost to evaporation in the swamps.

Lake Nasser

An evaluation of the potentials for water conservation within the present day Nile River system, requires a full appreciation of the huge size of Lake Nasser and its geographic and geological setting. The surface area of the lake when the water level is at the crest of the emergency spillway, is some 5600 km2.and the annual evaporation is approximately two meters of water depth. Thus the evaporation loss approximates 11 billion m3/yr during periods the lake is full. Besides, there are subsurface losses from the reservoir.

Western Desert

Features of the Western Desert that are key to extensive development there include: 1) the deep Nubian aquifer, probably a glacial remnant that is not recharged. It underlies much of the Western Desert extending from the oases south to Sudan and west to central Libya, 2) the presence of sands and gravel strata at shallow depths along the approximate alignment of development, 3) rechargeable aquifers as indicated by the springs at the oases, and 4) exploitable mineral deposits.

The topography of the Western Desert is such that a gravity-feed canal can be built to carry water from diversion at Lake Nasser toward the Toshka Depression and then along an alignment extending successively to the oases of Baris, Kharga, Dakhla, Farafra, and Bahariya.

INDICATED INVESTIGATIONS AND STUDIES

To achieve effective development and the financing and settlement of millions of citizens in the Western Desert, the government will have to carry out field investigations, compile and analyze data and information, and study and model expected outcomes for a series of scenarios of water availability, water use, and water-user charges. These analyses will require updating on a periodic basis as development progresses. Only through such an approach will water and financial resources be mobilized and allocated on a timely basis. Timely mobilization of adequate resources will persuade the populace that settlement is the correct option It also will assure that the fragile desert environment can be protected and that it will sustain the ever growing numbers of settlers. Among actions required are the following:

1) Conduct of extensive field investigations at the reconnaissance level to: a) determine topography along the development alignment, b) identify potentials for developing shallow, water-table reservoirs along the development alignment, c) identify the source of spring water at oases, d) identify deep ground water potentials, e) identify potential reservoirs of usable brackish ground water, and f) survey all resources of the area including minerals, tourism and health spa potentials, soil suitability for agricultural and community developments, and quality of ground water, both brackish and sweet.
2) Conduct of office investigations and studies to: a) prepare and disseminate records of Nile River flows entering Lake Nasser, b) define appropriate allocations to canal commands of the Nile Valley, Delta, and Sinai, and c)

assess evaporation, seepage and leakage from Lake Nasser over a range of water surface levels.

3) Development of scenarios for the modeling of water supply factors which are key to successful colonization of the Western Desert, including: a) a time based scenario of developments and water use by upstream riparians considering political stability and consequent capacity of those riparians to mobilize domestic and international financing, b) time-based scenarios for developments in the Western Desert and concomitant water and financing requirements, and c) requirements for wastewater treatment for reuse for agriculture and for greenbelt development.
4) Integration of studies and investigations for the modeling of water available, considering: a) exploitable deep ground-water contribution, b) differing levels of Lake Nasser and effects on water availability and hydro-power production, c) impacts of upstream developments over several time horizons, d) salt balances of the several aquifers, e) reuse potentials of wastewater and irrigation return flows, and f) the quality of water required for mining and other industrial activities.
5) Integration of water availability, over time and space, with development scenarios for the Western Desert communities. Postulate potential developments in the Western Desert considering sequenced developments with respect to distances along the alignment of colonization and the efficacy of filling and utilizing water-table reservoirs.
6) Determine water-user fees for immediate implementation. There should be no forgiveness. If it is necessary initially to provide incentives, then subsidies or other means should be used rather than the provision of free water. A civilization, based on costly water that is available in limited quantities, can not sustain itself if the commodity is provided without cost or accountability. Sustainability can be achieved only if the user must pay a fair share.

PROPOSED NEW APPROACH TO SETTLEMENT OF WESTERN DESERT

Non-nomadic civilizations rise in the desert where adequate, exploitable water resources are available. Thus, any approach to settlement of the Western Desert will be driven by the quantity, quality, and timing of water availability. Further, the population that may be supported is dependent on the total resource base rather than just agriculture.

Water Demand

Irrigated agriculture, industry and population will drive the demand for water. Diversion requirements from the Nile River will be driven by quantities of ground water available; early implementation of measures to treat and reuse municipal and industrial water; capacity to capture irrigation waste and return flows; and the adaptation of agriculture, forestry, and industry to use brackish water.

Gross Estimate of Water Demand: If seven persons can be fed from the produce of one hectare of land irrigated year round, then some one million hectares of land must be cultivated to support a populace of seven million. And, if two meters of water per year is required to flood-irrigate land year-round in the desert, irrigation use will total 20 billion cubic meters. Some two billion cubic meters per year likely will be required for municipal and industrial demand. Thus, if flood irrigation were used some 22 billion cubic meters of high quality water must be pumped from ground water and diverted from the Nile River to provide food self sufficiency and to support domestic, commercial, and light industrial uses of the settlers.

Although it is doubtful that such a large quantity of water could be allocated to the Western Desert, demand could be met from a number of sources, and the demand also could be reduced through implementation of various measures if programmed from the beginning of development.

Measures to Reduce Demand: There is little that can be done to reduce the municipal and industrial demand short of reducing the population. Thus, it is in the sphere of irrigation that demand-reducing measures should be taken. An obvious effort should be made to implement drip irrigation, but only after land reclamation is completed through flood irrigation, hopefully, using major flood flows as they occur. There is a tradeoff to be explored, however. With flood irrigation of lands overlying shallow ground water reservoirs, the multiplier effect of successively re-pumping groundwater throughput can approximate 30%. Thus, there is available to flood irrigation some 130% of surface water input and deep ground water pumpage.

Water Availability

Water demand can be met from diversion of the Nile River, by ground water pumping, and through reuse.

Surface Water Availability: Constant or maintenance flow from the Nile River should be diverted from Lake Nasser at such a rate that agriculture along the Nile Valley and in the Delta will not be degraded. Depending on allocations to the Sinai Region, there should be several billion cubic meters per year available on average. Savings additional to those to be achieved in the Nile Valley and Delta,

could be realized by lowering the level of Lake Nasser to reduce annual evaporation by, say, one to two billion cubic meters. This measure should likely be implemented only after floodwaters entering Lake Nasser are reduced by new upstream developments and diversions, perhaps one to two decades in the future.

It is the large volume floods in wet years that provide the best opportunity for establishing colonies in the Western Desert. It should be determined at what level Lake Nasser may be operated in future, and flood flows should be diverted through deep-cut canals and tunnels at that operational level. With a facility adequate to divert high-rate flood flows by gravity, the pumping facility now under construction could be used to pump maintenance water when the reservoir is below the gravity offtake.

Diversion of flood flows likely will not occur every year, but the diversions should be regulated to the extent possible. The objective of high-rate diversion of flood flow is to reclaim lands and to simultaneously fill any shallow aquifers identified. A shift to sprinkler or drip irrigation can follow as areas are successively reclaimed.

Ground Water: The Nubian sandstone aquifer is mostly confined deep below the desert. It underlies essentially the entire area planned for development. This aquifer is said to be non-rechargeable, although investigators during the 1970s and 1980s, were divided regarding whether there is a recharge area in the southern most reaches of the Sahara Region to the south of Libya. There exists a body of reconnaissance level ground-water data that derives from oil exploration that may be used to reanalyze whether there are possible recharge zones.

Wells have been in operation in the areas of the oases at least since the 1950s. During that period investigators of the U S Geological Survey studied the corrosive electro-chemical properties of the water and the effects on well screens and materials. The fact that the springs of the oases have flowed for millennia without the benefit of mechanical pumps indicates that there may be recharge in some zones of the Western Desert. Considering the low average annual rainfall, wadis must flow infrequently.

There undoubtedly are or will be shallow brackish water reservoirs. These should be exploited by pumping from relatively low-cost, shallow wells to grow windbreaks and to create greenbelts near settlements. This approach was employed near Basrah, Iraq to establish plantations of tamarisk through the pumpage of highly saline ground water for just a few years, Afterwards the tamarisk rooted to 15 meters of depth and thrived on the saline aquifer water.

The purpose of this discussion is intended to highlight three points. First that there is a considerable ground water resource underlying the Western Desert, second it is not certain if there is recharge to part or all of the aquifer, and third fairly high

cost wells will be required for pumping deep water. The ground-water situation currently is being studied by the Ministry of Public Works and Water Resources. That ministry should be funded to carry out the above specified reconnaissance level investigations.

Population Support

Should the water resource be adequate to intensively cultivate a million acres year round, then some 150,000 farm families or, say 500,000 people will be directly engaged in agricultural production. If another 150,000 persons are engaged in governmental and non-governmental services to farmers, maintaining wells, and in maintaining green belts, parks, etc, then agriculture will support a population of one million. It therefore will be necessary to employ another 1.5 million workers in food processing, tourism, transport, mining, manufacturing, schools and universities, health care, communications, and government service. Thus it is essential that institutions and infrastructure be created in parallel with water development to attract not only farmers but also professionals from all walks of life.

SUMMATION

It is crucial that the government promptly re-articulates its vision, reexamines its objectives, and formulates a detailed plan that defines water availability and the means to achieve sustainable, environmentally friendly colonization of the Western Desert. A key element of success will be early government definition of the availability, over time, of Nile River flows considering probable upstream uses. All future flows of the Nile River entering Egypt in excess of the treaty allocation should no longer be delivered to the Valley and Delta. There now is over watering in these areas especially during periods of high flow. Water in excess of the treaty allocation should be turned to the desert where the benefits will be measurably greater.

An objective will be to divert these large volumes of floodwater to reclaim lands for irrigated agriculture and to simultaneously fill any water table reservoirs available. This program of aquifer creation and land reclamation will require the early construction of large canals to carry water to as many of the predefined development areas as possible during the next two decades. It will not be necessary to line these transmission canals along reaches where water losses seep to water table aquifers targeted for filling.

Structures designed for intermittent high-rate gravity diversions from Lake Nasser also may be required. This diversion capacity would be in addition to the pumping plants now being built.

Once the lands are reclaimed, through flood irrigation of rice and other field crops, highly efficient irrigation delivery systems may be installed. Further decisions may be taken regarding which reclaimed areas may be dedicated to green belts and community uses. Any newly established ground water reservoir may be maintained by the application of leaching water during periods of high Nile River flows.

Protection of the quality of ground water will be fundamental to the maintenance of the desert communities in perpetuity. It will be necessary to export salts to undeveloped desert areas or down basin at a rate equal to the input of salts from the Nile River and the salts accumulated during leaching operations. Further the aquifers will have to be protected from overuse of fertilizers, herbicides and pesticides. Industrial developments will have to be limited to those with low water use. From the outset no discharge of pollutants to canals, streams, and aquifers should be permitted.

The vision will have to be supported by carefully defined investment schedules, public and private, and identifiable bench marks. Policies will have to be devised to maximize private inputs even though massive government inputs of capital will be essential to initially catalyze adequate infrastructure construction in all sectors. All infrastructure will have to be adequate to protect water quality and the environment. Foremost among the measures required will be those which provide for the proper control, collection, treatment, recycling, and disposal of human and industrial wastes.

An inviolate policy of water charges will have to be implemented from the beginning of each development. The schedule of charges will have to account for whether water is totally government developed or whether the user has invested in wells or other facilities.

Sustainability of the colonies will depend equally on the twin pillars of maintenance of the environment and generation of water user revenues that are adequate to fully perform operation, maintenance, rehabilitation and replacement of facilities.