IMPROVED IRRIGATION WATER MANAGEMENT--A DIRECT BENEFIT OF A WATER CONSERVATION PROGRAM

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ABSTRACT

Implementation of the 15 projects in the Water Conservation Program (Program) identified in the landmark December 1988 Water Conservation Agreement (Agreement) between Metropolitan Water District of Southern California (Metropolitan) and Imperial Irrigation District (Imperial) and in the December 1989 Approval Agreement among Metropolitan, Imperial, Palo Verde Irrigation District, and Coachella Valley Water District began in January 1990. The last major construction work was completed in December 1997. While the Program has focused primarily on modernizing and rehabilitating Imperial's irrigation distribution system, it has included on-farm water management projects that permit greater water management flexibility for the farmers and opportunities for farmers to apply water more effectively. In actuality, both distribution system and on-farm management improvements are, in some cases, interrelated such that one without the other would reduce the effectiveness of any individual project, of the Program, by itself. The level of the Program's effectiveness has been demonstrated through a process of verifying each project's accomplishments. This paper will review the various projects completed to improve Imperial's overall irrigation system and use of water and how the projects were planned, managed, and the conserved water verified. Additionally, an update on the Program's costs and resulting conserved water volume will be presented.

INTRODUCTION

Imperial distributes between 2.5 and 3 million acre-feet of Colorado River water annually through the All American Canal primarily for gravity irrigation of nearly 500,000 acres of farm land in the Imperial Valley in southeastern California. The Imperial irrigation distribution system consists of approximately 1,600 miles of main and lateral canals, of which over 1,100 miles are concrete lined, and some 1,400 miles of open drains that carry primarily agricultural runoff to the Salton Sea. Metropolitan distributes between 1.6 and 2.5 million acre-feet of Colorado River water and State Water Project water annually to a service area of over 5,100 square miles in six Southern California counties in which over 16 million people reside. Faced with the possibility of water supply shortages in its service area in the future, Metropolitan has been aggressively pursuing various programs aimed at

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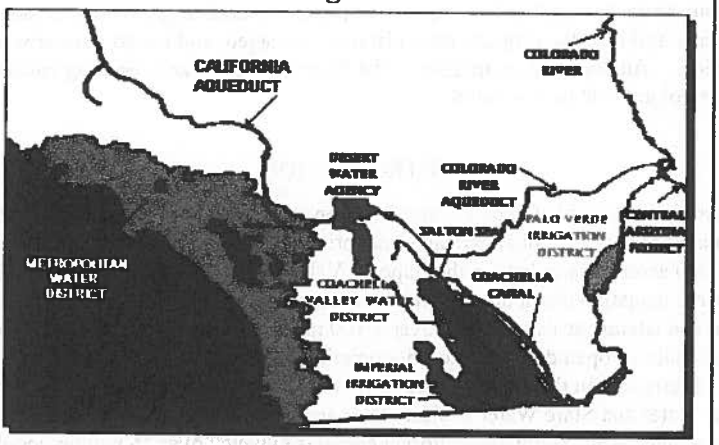
improving the adequacy and reliability of its water supplies. Such programs include the Imperial/Metropolitan Water Conservation Program, Palo Verde Irrigation District/ Metropolitan Test Land Fallowing Program, and water banking/exchange programs with the Coachella Valley Water District, Desert Water Agency, Semitropic Water Storage District, and Arvin-Edison Water Storage District.

The landmark Agreement between Imperial and Metropolitan became effective December 1989 and provided for the implementation by Imperial of 17 projects, two augmentation projects constructed by IID and 15 new projects, estimated to conserve 106,110 acre-feet of water annually upon completion of construction and placing into operation the last project. Metropolitan has funded all the costs of 15 projects of the Program and in return will have available additional water from the Colorado River for diversion through its Colorado River Aqueduct. Figure 1 shows the service areas of Imperial and Metropolitan, the Colorado River, and the Metropolitan Colorado River Aqueduct.

Figure 1



IID & MWD Service Areas

PROGRAM ORGANIZATION

As a means of managing the Program to provide prompt and orderly review and approval of budgeting, planning, design, and construction activities the Agreement called for the establishment of a Program Coordinating Committee (PCC) consisting of three professional engineers competent and experienced in the agricultural and civil engineering fields. The PCC is composed of one representative from Imperial, one representative from Metropolitan, and one representative selected by both parties to the Agreement.

Additionally, to oversee and direct the activities to verify the quantity of water conserved by the individual projects as well as for the total Program, a Water Conservation Measurement Committee (WCMC) was established. The WCMC is composed of the three PCC members plus one representative each from the Coachella Valley Water District (CVWD) and the Palo Verde Irrigation District (PVID). CVWD and PVID hold intervening priorities to use of Colorado River water in California, hence their interest in verifying the amount of water conserved by the Program. The WCMC is assisted in carrying out its responsibilities by the Conservation Verification Consultants (CVC) consisting of three consultants specialized in water resources engineering.

The primary budgeting, planning, design, and construction activities were carried out by the Imperial staff supported, as required, by consultants and contractors. The on-going operation and maintenance activities, for the next 35 years, will be conducted and managed by Imperial staff and, when required, with consultant support.

IRRIGATION WATER MANAGEMENT

Originally the Program's projects targeted operational spill as the primary water to be conserved. However, as monitoring equipment was installed throughout the district, analysis of the considerable data gathered established the baseline operational spills to be captured and also provided detailed insight into the interaction among the various projects to include substantial water savings from improved irrigation water management at the farm level. While certain on-farm water savings resulted from providing the farmers improved tools such as 12-hour deliveries (ordering water for a 12 hour period) versus the normal 24-hour deliveries and tailwater return systems it became evident that additional water savings resulted due to the availability of other system facilities such as reservoirs, lateral interceptors, and system automation. In other words, by having improved system facilities the potential on-farm savings were maximized and these facilities afforded the farmers greater flexibility in managing the water ordered resulting in more effective application of water to the crop. Prior to describing this project

interaction which results in improved irrigation water management a brief description of each of the projects involved follows:

12-Hour Delivery--This project permits the farmer to order water for a 12-hour period rather than the standard 24-hour period. This allows the irrigation application rate to more closely match the rate required by the soil and crop rather than the less flexible 24-hour basis which, even if the irrigation event was completed, had to run the total 24-hour period, resulting in substantially more tailwater runoff discharged to the drains. This project was made available, through the Program, to the farmers in February 1990.

Reservoirs--One regulating reservoir, the Galleano (425 acre-feet (AF)), was constructed to capture the operational spill occurring at the "Z" spill at the end of the East Highline Canal. Additionally, improvements (construction of a pumping plant in 1998 to allow stored water to be discharged to the East Highline Canal) to the existing IID constructed Singh Reservoir (enhancing the 12-Hour Delivery and System Automation projects water savings opportunities) will make it a fully regulating reservoir of 323 AF capacity.

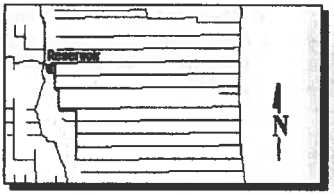
Lateral Interceptors--Three lateral interceptors-the Plum-Oasis, Mulberry-D, and Trifolium-were constructed including the Bevins Reservoir (253 AF); Young (275 AF) and Russell (200 AF) reservoirs, and Willey Reservoir (300 AF) and a pipeline respectively. A lateral interceptor consists of an open concrete lined canal which collects and transports operational discharge and farm delivery water which remains in the distribution system when a turnout is closed (returned water) from the ends of several laterals to a storage reservoir for use in another part of the distribution system. (See Figures 2, 3, & 4) All of the reservoir facilities were automated and the flow from the intercepted laterals controlled by automated drop-leaf gates. The three lateral interceptor projects cover a service area of some 83,436 acres, approximately 18 percent of Imperial's service area covered by its distribution system.

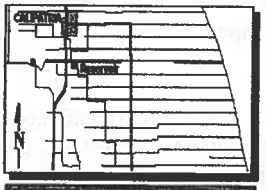
System Automation--In addition to the automation of the five lateral interceptor reservoirs and the Singh Reservoir some 57 major and minor main canal flow control structures were automated either by modernizing existing facilities or installation of new automation equipment at existing sites including upgrading the existing communication system. Major sites include complete communications, monitoring and control facilities such as equipment building, generator, a Programmable Logic Controller (PLC) while the minor sites do not have the building or generator. Certain minor sites included the installation of automated drop-leaf gates at 13 Westside Main Canal and 9 East Highline Canal sites. This extensive system automation project including a new Water Control Center (WCC) provides for better overall system control, more water user flexibility, and improved water delivery.

Throughout the implementation of the Program a considerable number of automated sites (currently over 100 sites), some of which were installed to monitor

Figure 2

- **Plum/Oasis Lateral Interceptor**
  - Lateral interceptor canal intercepts 8 laterals.
  - Service area = 24,000 acres
  - Operational in 1992.
  - Area (Bevins Reservoir) = 37 acres.
  - Capacity (Bevins Reservoir) = 253 acre feet.
  - Gravity Inlet with a pump outlet into the Redwood Canal system





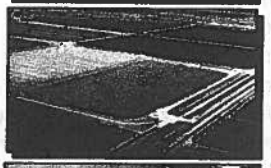
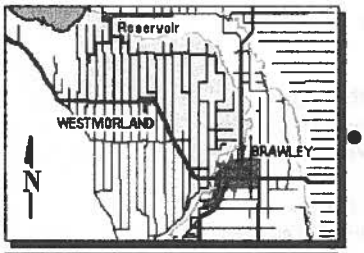


Figure 3

- **Mulberry - "D" Interceptor**
  - Lateral interceptor canal intercepts 11 laterals.
  - Service area = 31,000 acres
- **Area:**
  - Young Reservoir = 47 acres.
  - Russell Reservoir = 29 acres.
- **Capacity:**
  - Young Reservoir = 275 acre feet
  - Russell Reservoir = 200 acre feet
- Gravity flow on inlet and outlet for Young Reservoir.
- Gravity flow on inlet and pumps on outlet for Russell Reservoir

Figure 4



- **Trifolium Interceptor**
  - Lateral interceptor canal intercepts 15 laterals.
  - Service area = 30,190 acres
  - Operational in December, 1997.
  - Reservoir Area = 61 acres.
  - Reservoir Capacity = 300 acre feet.
  - Gravity flow on inlet and pumps on outlet with 21,900 feet of 45" diameter pipeline.

main/lateral canal and drain flows, resulted in a substantial amount of data being gathered. Most of this data gathering will continue for the 35-year period. This data was analyzed and the resulting information used in the planning, design, and verification activities of the Program. This permitted the PCC to take maximum advantage of all the overlapping operational opportunities resulting in improved water conservation and cost savings to the Program.

To illustrate this overlapping operational functionality of the above mentioned projects an example using the 12-Hour Delivery Project will be presented. As a 12-Hour water delivery is being shut off, which is affording greater water management flexibility and improved water use effectiveness to the farmer, the backing out of this water into the distribution system can cause operational difficulties for Imperial and result in spillage. IID orders water from the USBR four days in advance based on past year's usage, current weather conditions, crops being grown in the valley, and current level of farmer's orders (both 12-Hour and 24-Hour orders). Hence, once the water is released by USBR into the Colorado River any returned water that cannot be stored or used at another location must be spilled. However, Imperial now has a greater array of management tools at its disposal and therefore an increased number of options to manage (in many cases directly from the WCC) the flows backed out in the system as follows:

A. If the water delivery is shut off within an interceptor system service area Imperial can:

1. Have the Zanjero (ditch rider) make a gate adjustment to accommodate the flow if the flow can be used at another turnout along the lateral,

2. If action 1 is not possible the flow can be conveyed to the interceptor canal and transported, for storage, to the interceptor reservoir for later use.

3. Depending on the location of the returned flow(s) along the lateral an adjustment to the lateral heading gate (called a shut down) can be made by the Hydrogapher (main canal operator) effectively "backing the water out" into the main canal for use in another part of the distribution system or transported to a reservoir to be stored for later use.

B. For service areas outside an interceptor system Imperial can:

1. Carry out gate adjustments as stated in A, 1 above.

2. Absent the ability to implement action B, 1 the Zanjero must manually reduce the flows along the lateral, by adjusting the lateral check gates, as the Hydrographer shuts down the lateral heading gate to "back the water out" into the main canal. Once in the main canal system via the upgraded and new automated facilities this water can be transported to another part of the distribution system for immediate use or to a regulating reservoir, such as the Singh and/or Galleano, for storage and use later or to other lateral interceptor reservoirs for use in those respective systems.

VERIFICATION

It was and remains critical that all Program conserved water, including that resulting from improved on-farm water management, be verified as having been conserved. As an integral part of the Program a verification process was developed and put into place to identify consequential effects for each project and the most accurate method for establishing the volume of conserved water. This process becomes even more critical given the fact that IID deliveries have increased since the implementation of the Program and has verified that water is being conserved even with IID's increased deliveries. A very important element of all this verification effort was the gathering, archiving, and analysis of accurate data. The details of this process have been detailed in other papers and presentations at this conference and won't be repeated in this paper. It was essential, from the start, that a set of Conservation Verification Principles and Guidelines be established for use as a guide in developing the process and methods which have been used to establish the conserved water volumes for each project. The final result has been the documentation of the conserved water verification for each project through a Verification Summary Report plus detailed documentation (Annexes, etc.). This will institutionalize the verification process, for each project,

for the Agreement term of 35 years. While the process and methods can be modified with the acquisition of new data and the resulting analysis of such, this documentation will set the stage for the Program's conserved water estimates in the future.

During the course of developing the verification strategies and processes it became evident that verification activities, for any water conservation program, should be one of the first activities initiated. It is important to gather pre-project data to establish a baseline of water use against which use after implementation of a conservation program can be compared. Additionally, this will permit validation checks to be developed which will support and assist in establishing verification processes for the long haul as well as for the immediate planning and design of specific projects. It is important to be flexible and make adjustments as field data dictates. An example would be the planning and design of the lateral interceptors. As additional field data was gathered on lateral spills for each of the interceptor projects, subsequent to the construction of the first project, the Plum-Oasis Lateral Interceptor, analysis of such indicated that the size of the interceptor lateral canal could be reduced. This revised design of the canal capacity provided for handling of all potential flows plus reduced the capital costs of the subsequent two lateral interceptor projects.

Another aspect of the verification program was the establishment of the Systemwide Monitoring (SWM) program. It is inevitable that other water conservation programs will be carried out in the Imperial Valley in the future. Based on our knowledge that any conservation project can have a negative, positive, or neutral impact on another project it was important to be able to monitor the overall Imperial distribution system. The SWM program will allow the WCMC to monitor trends, changes, etc. in the overall distribution system, both physically and operationally, to alert them to review certain projects or areas in the system for potential and/or actual changes that may affect the Imperial/Metropolitan Program conserved water volume. Adjustments can then be made, if required, to the verification process and/or the conserved water volume.

CURRENT STATUS OF THE PROGRAM

As of December 31, 1997, with the exception of pumping plant construction at the Singh Reservoir, all of the major construction work implemented under the Program has been completed. It is expected that the Singh improvement work will be completed in 1998. For the calendar year 1998 the estimated volume of conserved water is 107,160 acre-feet which is available for use by Metropolitan. It is important to note that of this total approximately 52 per cent of the volume has the verification process and analysis procedures finalized with the balance of 48 per cent being of a provisional status but expected to be finalized during 1998.

Table 1 shows the amount of water conserved each year and Table 2 shows the volume of water conserved by each of the projects of the Program.

Table 1
Total Water Conserved

	Water Conserved (Acre-Feet)	Water Available for Diversion by MWD (Acre-Feet)
1989 (Augmentation)	6,110	-
1990	20,590	6,110
1991	7,229	26,700
1992	20,901	33,929
1993	18,040	54,830
1994	1,700	72,870
1995	16,310	74,570
1996	6,860	90,880
1997	9,800	97,740
1998	9,420	107,160

Table 2
Project Conservation Summary

Projects	Water Conserved (Acre Feet)
• Reservoirs	9,700
• Concrete Lining	26,060
• 12 Hour Delivery	22,290
• Irrigation Water Management	5,180
• Non-Leak Gates	630
• System Automation	13,490
• Lateral Interceptors	29,810
Total	107,610

Through December 31, 1997 a total of $110,142,125 in capital expenditures have been made which, in 1988 dollars, is estimated to be $94,828,297. O&M costs totaled $24,111,142 over an eight-year period and the one time indirect costs totaled $23,000,000. This has resulted in a total actual cost of $157 million. a portion of which has been paid from interest earned on funds advance to Imperial by Metropolitan. Table 3 provides a cost breakdown by year.

Table 3
Total Expenditures

	Capital	Annual Direct	Indirect	Total
1990 (Actual)	$ 15,225,804	$ 980,514	$ 4,600,000	$ 20,806,319
1991 (Actual)	$ 26,879,776	$ 1,822,537	$ 4,600,000	$ 33,302,315
1992 (Actual)	$ 18,847,594	$ 2,522,125	$ 4,600,000	$ 25,969,719
1993 (Actual)	$ 17,219,098	$ 2,634,128	$ 4,600,000	$ 24,453,225
1994 (Actual)	$ 7,489,396	$ 4,077,599	$ 4,600,000	$ 16,166,995
1995 (Actual)	$ 7,731,874	$ 3,505,880	$ -	$ 11,237,754
1996 (Actual)	$ 6,725,418	$ 4,184,736	$ -	$ 10,910,154
1997 (Actual)	$ 10,023,163	$ 4,383,624	$ -	$ 14,406,787
Total	$ 110,142,125	$ 24,111,142	$ 23,000,000	$ 157,253,267

Based on the costs, to be paid in 1998 for work performed in 1997, on the Trifolium Lateral Interceptor plus the Singh Reservoir improvements being constructed in 1998, we expect the total capital expenditures to come in under budget, when measured in 1988 dollars. Upon completion of the Singh improvements the Program will enter a total operations and maintenance phase for the next 35 years.

SUMMARY

It has taken some eight plus years to bring this landmark Program to a successful conclusion. The Program organization managed through the PCC along with the WCMC's verification work has functioned exceedingly well being very effective in responding to the Program's technical requirements as well as budgetary needs and constraints. Even with the delay, caused by the Regional Water Quality Control Board, Colorado River Basin Region requirement to prepare an Environmental

Impact Report in 1993 and 1994, the Program anticipates completing construction under the original capital estimate of $97,758,000 in 1988 dollars.

One of the major successes of the Program has been the overlapping functionality of various projects such as 12-Hour Delivery, Reservoirs, Lateral Interceptors, and System Automation which has resulted in substantial water savings from improved irrigation water management on-farm as well as within the distribution system. This has afforded the farmers greater flexibility in managing the water they order which translates into more effective application of the water to the crop and for Imperial's more efficient transporting and delivery of water to the farm turnout. The verification process and procedures have played a major role in shaping the planning, design, and operation of the projects.

As a final but important note, the success of this Program must be attributed to a dedicated, professional, and hard working Imperial/Metropolitan team effort. With all of the posturing that exists and negotiating that takes place between agricultural and urban areas with respect to further conservation agreements this success says much and hopefully can be built upon in the future.