TECHNOLOGY TRANSFER LESSONS FROM A U.S. WATER DISTRICT

Douglas Welch[1] and Karen McLaughlin[2]

ABSTRACT

An interceptor canal will be constructed near the end of eight laterals to collect and transport operational discharge and returned farm deliveries to a reservoir for temporary storage. The water will then be pumped over to an adjacent canal system for delivery. This project is being funded by the Imperial Irrigation District - Metropolitan Water District of Southern California (IID-MWD) Water Conservation Agreement. This paper describes the planning process for the project.

INTRODUCTION

The IID is located at the southern end of California, about 100 miles east of San Diego and 50 miles west of the Colorado River. Colorado River water is conveyed to the IID through the All-American Canal, which was built by the U.S. Bureau of Reclamation in the 1930s. The IID's 1,675 miles of canals, deliver approximately 2.6 million acre-feet of Colorado River water to nearly 490,000 acres of agricultural lands in the Imperial Valley. There are five regulating reservoirs with a combined storage capacity of 1,904 acre-feet situated at strategic locations in the irrigation system. As water is moved through the gravity flow system's 3,228 check structures, a combination of remote and manual gate adjustments are made to maintain the appropriate water level upstream of the check.

The IID and MWD entered into an agreement, in 1988, to conserve 106,110 acre-feet of water. The agreement calls for MWD to pay for the capital, annual direct and indirect costs of various conservation projects that IID will implement over a five-year period.

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[1]Water Resources Planner, Imperial Irrigation District Imperial, CA
[2]Senior Engineer, Imperial Irrigation District, Imperial, CA

POTENTIAL FOR WATER CONSERVATION

The lateral interceptor concept was initially conceived in order to reduce operational discharge which occurs at the ends of lateral canals. A canal would be constructed near the end of a group of laterals to collect operational discharge. The water would be stored in a reservoir and then pumped over to an adjacent canal system for delivery. (see figure 1) During the planning process, it was determined that two other sources of water loss, tailwater and excess deep percolation, could be reduced by providing increased delivery flexibility. The increased flexibility would allow farmers to terminate the delivery when the field is sufficiently irrigated.

A certain amount of operational discharge is inevitable in the daily operation and management of a lateral. There are several reasons for this. When a portable pump is being used to irrigate a field, the pump will occasionally break down and the delivery gate will be closed by the irrigator. If the breakdown will only occur for a short period of time, the water will be spilled. Otherwise, the IID will be notified

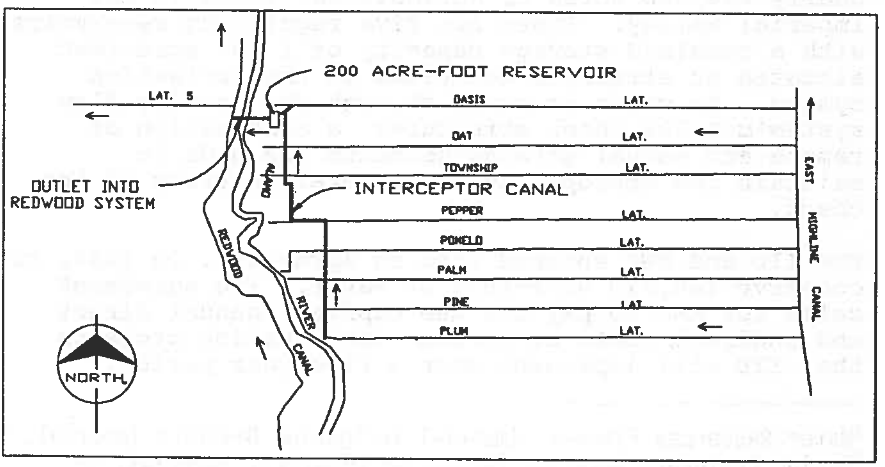

Figure 1 Plum-Oasis Lateral Interceptor

and the appropriate adjustments will be made in the lateral to prevent or reduce operational discharge. Second, as the irrigator irrigates different portions of a field, the back pressure on the delivery gate can change as he checks the water up at different locations in the farm ditch, resulting in a change in the delivery flow. When the delivery is reduced, by an increase in the backwater on the delivery, the rejected flows are transported downstream and may result in increased operational discharge. Third, a certain amount of water is carriage water. This carriage water is required to fill ponds, allow for seepage and evaporation, and to provide for incidental over deliveries to insure that enough water reaches every delivery being made from the lateral.

Tailwater is water that runs off the end of a field during the normal course of an irrigation. Tailwater is usually discharged into an IID drain. In order to adequately replace soil moisture that has been removed from the field by the process of evapotranspiration, enough opportunity time must be allowed for the irrigation water to infiltrate into the soil. On a sloping field, this means that the stream of water that has advanced down the field must continue to run until the soil moisture in the field is adequately replenished. During this time tailwater occurs. It is difficult to estimate the exact amount of water that will infiltrate into a field during an irrigation. Tailwater in excess of what is needed occurs when the farmer overestimates the amount of water needed. Allowing irrigators to terminate the delivery when the field is sufficiently irrigated will reduce excess tailwater.

Poor distribution uniformity can occur when an irrigator must match the irrigation stream size and set times to match the IID's 24 hour delivery system. The result can be deep percolation in excess of what is required to maintain a favorable salt balance. Allowing irrigators to select stream sizes and set times that are appropriate for the field being irrigated would improve distribution uniformity and reduce excess deep percolation.

PROJECT PLANNING

At the beginning of the planning process for this project, a general planning meeting was held with operations, design, construction and management personnel, to discuss the overall purpose of the project, how operations would be affected, and the data needed for the planning, design and construction of the project. As more data became available, subsequent meetings were held with all the interested parties to keep them updated and to deal with specific issues. Farmers in the affected area were also contacted to get their ideas. This process insured that all of the affected parties concerns were addressed.

Operational Strategy

The lateral interceptor system will provide increased delivery flexibility to the irrigator, making it possible for the irrigator to irrigate more efficiently. The less restrictions that are placed on the irrigator the more likely it will be that the irrigator will utilize the flexibility to conserve water. The lateral interceptor system will provide the District with the "tools" to allow this flexibility, while maintaining control of the canal operations.

Initially irrigators will be required to request permission to return water to the laterals. The irrigator will be instructed to adjust his delivery gate appropriately or a zanjero (ditch rider) will make the changes. This will allow irrigators and District staff time to acquaint themselves with the intricacies of the lateral interceptor system. During this time, operational procedures to optimize the amount of water conserved by the lateral interceptor system will be determined. An operational procedure manual will be prepared that describes the responsibilities of irrigators and District staff and the new procedures will be instituted.

Interceptor Location

Two alternatives for locating the interceptor were considered: (1) at the end of the laterals; or (2) about two-thirds of the way down the laterals. Locating the interceptor at the end of the laterals would allow farmers to shut off their delivery with very little or no notification. Locating the interceptor about two-thirds of the way down the laterals would allow delivery of a portion of the operational discharge and returned deliveries to the last third of laterals it intercepts, however, locating the interceptor two-thirds of the way down the laterals would make it necessary for farmers downstream of the interceptor to notify the IID in advance of their intended shutoff, to allow the zanjero time to divert the water into the interceptor. The majority of the early shutoffs may occur one hour or less before the normal shutoff time. The logistics and time involved to notify the zanjero of the need to end the irrigation would probably result in many of the irrigators not making the effort to end the irrigation less than one hour early. This could substantially reduce the amount of water conserved. It was felt that the small advantage of being able to deliver water from the interceptor into the last third of the laterals was outweighed by the potential conservation achievable with very little or no notification.

Interceptor Sizing

The Plum-Oasis Lateral Interceptor is a pilot project designed to study the potential for conserving operational discharge and on-farm losses and to determine the flow conditions to design for in future interceptor systems. Restricting the amount of flexibility in the pilot project could reduce the overall effectiveness of the program. With this in mind, liberal sizing was recommended.
The size at the upstream end of the interceptor was set to have the capacity, 90 percent of the time, to allow for the possibility of all deliveries running in the first lateral to be returned. The remaining 10 percent of the time a portion of the returned deliveries will need to be backed out of the lateral and rerouted to one of the reservoirs on the main canal. The size at the downstream end of the interceptor was set to have the capacity, 90 percent of the time, to allow for the possibility of all ending deliveries on the eight laterals to be returned. The remaining 10 percent of the time a portion of the ending deliveries will need to be rerouted to one of the reservoirs on the main canal.

Lateral Canal Sizing

The capacity at the downstream end of some of the laterals will be increased to have the capacity, 90 percent of the time, to allow for the possibility of all deliveries running in a lateral to be returned without notice. The remaining 10 percent of the time notification will be required on a portion of the deliveries, so that the zanjero can cut the water out at the head of the lateral, prior to the delivery gate being closed.

Lateral Discharge to Interceptor

Automated gates will be installed to regulate the discharge from the laterals into the interceptor. If the capacity of the reach of the interceptor immediately downstream of the lateral discharge would be exceeded by discharging additional water into the interceptor, the automated gate will divert the excess water to the lateral spill. If this occurs, an alarm will be activated at operating headquarters and the inflow into the lateral will be reduced, if warranted. The flow rate and duration of any operational discharge will be recorded and taken into consideration when sizing future interceptor systems. It is believed that operational discharge to the drains will be minimal, due to the liberal capacity of the interceptor.

Reservoir and Pump Sizing

For the purposes of analysis a maximum scenario where 50 percent of the ending deliveries would shut off two hours early and 50 percent of the ending deliveries would shut off four hours early was assumed. In addition, two acre-feet of operational discharge from each of the eight laterals was assumed daily. A computer model was prepared to simulate the daily change in reservoir storage under these assumed conditions. The model calculates the daily amount of water to pump into the Redwood Canal, taking into consideration the demand on the Redwood Canal, and the volume of water that will be in the reservoir at the end of the day. The model demonstrated that a 100 acre-foot reservoir would allow all of the returned deliveries on 92 percent of the operating days to flow into the reservoir. During periods of high flows (eight percent of the time) some of the returned deliveries would need to be backed out of the lateral.

The model only considers the amount of water in storage at the end of the day. The hourly changes in storage must also be considered. A second model was prepared to model the hourly flows and reservoir water levels. A maximum scenario where 165 cfs is discharged for four hours, one cfs per lateral continues to discharge for the remaining 20 hours and 30 cfs is being pumped into the Redwood Canal, during the 24 hour period, was simulated. An additional 48 acre-feet storage capacity would be required.

Finally, an additional 52 acre-feet of storage, for a total of 200 acre-feet, was added to allow for possible contingencies such as: the addition of other laterals to the interceptor system, increased flexibility in operating the reservoir, and any changes in on-farm irrigation practices or cropping patterns that may increase the amount of water returned.

The computer model used for reservoir sizing was also used to determine the minimum pumping capacity. The model indicated that the minimum pumping capacity should be 25 cfs. A capacity of 50 cfs was selected to provide added flexibility for the operation of the reservoir.

Modification of Check Structures

When a delivery is returned, it will flow down the lateral into the interceptor. With the present manually operated checks, it would be necessary for the zanjero to manually adjust each of the affected checks each time a farmer returned a delivery. Besides the increased labor requirement, advance notice of each delivery return would be required. Modification of the check will therefore be required. A study was initiated to compare three alternative modifications: two variations of a long-crested weir; a drop-leaf gate regulated by a programmable logic controller; and an Amil Constant Upstream Level Gate. The annualized costs of the three alternatives were within $162 dollars of each other. The long-crested weirs were found to have the least things that could go wrong with them, however, the three day installation time (1 day for the others) would cause unacceptable disruptions in canal operations. The Amil gate had problems with sticking, which resulted in the lateral overtopping several times. The drop-leaf gate provided the best water level control and will be installed on three of the eight laterals where the operation and maintenance costs will be observed for a period of time. The drop-leaf gates will be installed on the other five laterals if the gate's operation and maintenance prove satisfactory. A method for pre-fabricating and installing the long-crested weirs in one day will also be studied.

Estimate of Cost and Conservation

The estimated capital cost for the interceptor system is $8.1 million dollars and the annual operation and maintenance costs are estimated to be $136,000 dollars. The amount of water that is estimated will be conserved by the project annually is 8,318 acre-feet. Assuming a 35 year project life and eight percent interest, the cost of the conserved water is about $100 per acre-foot.

SUMMARY

An interceptor canal will be constructed near the end of eight laterals to collect and transport operational discharge and returned farm deliveries to a reservoir for temporary storage. The water will then be pumped over to an adjacent canal system for delivery. Throughout the planning process, input from operations, design, construction, management and farmers was solicited to insure that the planning process addressed all the areas of concern for all parties. The interceptor is a pilot project designed to study the potential for conserving operational discharge and on-farm losses and to determine the flow conditions to design for in future interceptors. Liberal sizing of the interceptor, reservoir and pumps was recommended to reduce the amount of notification that will be required of irrigators. Automated drop-leaf gates will be installed on the checks to control the water level upstream of the checks. The lateral interceptor system will provide increased delivery flexibility to the irrigator, making it possible for the irrigator to irrigate more efficiently. The less restrictions that are placed on the irrigator the more likely it will be that the irrigator will utilize the flexibility to conserve water.

Appendix I - SI unit conversions

1 acre	=	0.40486 ha
1 mile	=	1.6093 km
1 acre-foot	=	1233.4 m^3
1 cfs	=	0.02832 m^3/sec