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Water Resources Conservation Plan for Orchard Mesa Irrigation District

Proposal for System Improvements

Orchard Mesa Irrigation District

Palisade, Colorado

January 2008

IRRIGATION TRAINING AND RESEARCH CENTER

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Irrigation Training and Research Center
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EXECUTIVE SUMMARY

Orchard Mesa Irrigation District is a local public water agency serving agricultural and residential customers in Grand Junction, Colorado. This proposal provides a comprehensive *Water Resources Conservation* Plan for the district to conserve 17,000 acre-feet of water while incidentally improving the equity and reliability of water service. The total initial budget for this proposal is $15.2 million.

The complexity of water issues in the Colorado River Basin requires a strategic plan for addressing irrigation system improvements through modern water control technology and new operational strategies in order to make the most efficient use of scarce water supplies. Understanding the need to conserve the River's water resources and secure long-term water supplies, Orchard Mesa ID developed this comprehensive proposal for upgrading its canal system. This Plan provides specific, prioritized recommendations for system improvements that will transform water management in the district.

Implementation of this Plan will achieve significant water conservation primarily by recovering and reusing operational spill from the district-operated canal system and the customer owned/operated laterals. It will also provide a foundation for more efficient on-farm water management in the future.

Report Highlights

Major elements of the Water Resources Conservation Plan recommended for implementation include:

- New regulating reservoir inside the district
- Upgraded check structures in the two main canals
- Remote monitoring system and electronic flow meters (SCADA)
- Pumped recirculation system to recover canal spill
- Improved operational procedures
- Inter-ties to route canal spill
- Continuation and expansion of an information management system

Water conservation can be achieved through a combination of physical infrastructure development and advanced SCADA technologies. The legal flow rate entitlement of the district's customers will be preserved and enhanced by increasing the level of equity in water deliveries. Irrigators will benefit in particular by the elimination of short-time flow shortages that have historically afflicted the district at periods of peak demand. By simplifying canal operations and giving district personnel the proper tools, the staff will be able to focus on customer service and verify that turnout flow rates are adequate.

Land use within the district is shifting as agricultural land continues to be urbanized. At the same time more farmers are installing micro-irrigation systems, which have different patterns of use and need more flexibility. These trends create an opportunity for the Board of Directors to provide leadership in re-thinking future strategies for the full protection of the district's water supplies on behalf of its customers.

Water Conservation Estimated Savings

There are five categories of water conservation savings addressed in this proposal:

1. Reducing spill from the main canals (upper portion of the system) =	4,000 acre-feet
2. Reducing lateral spill in the upper agricultural areas =	1,000 acre-feet
3. Recovering spill from main canals in urban areas =	1,600 acre-feet
4. Eliminating spill from the MML system =	900 acre-feet
5. Recovering drain water from urban laterals =	9,500 acre-feet

Total = 17,000 acre-feet

Budget = $15.2 million

plus $340,000/year operation

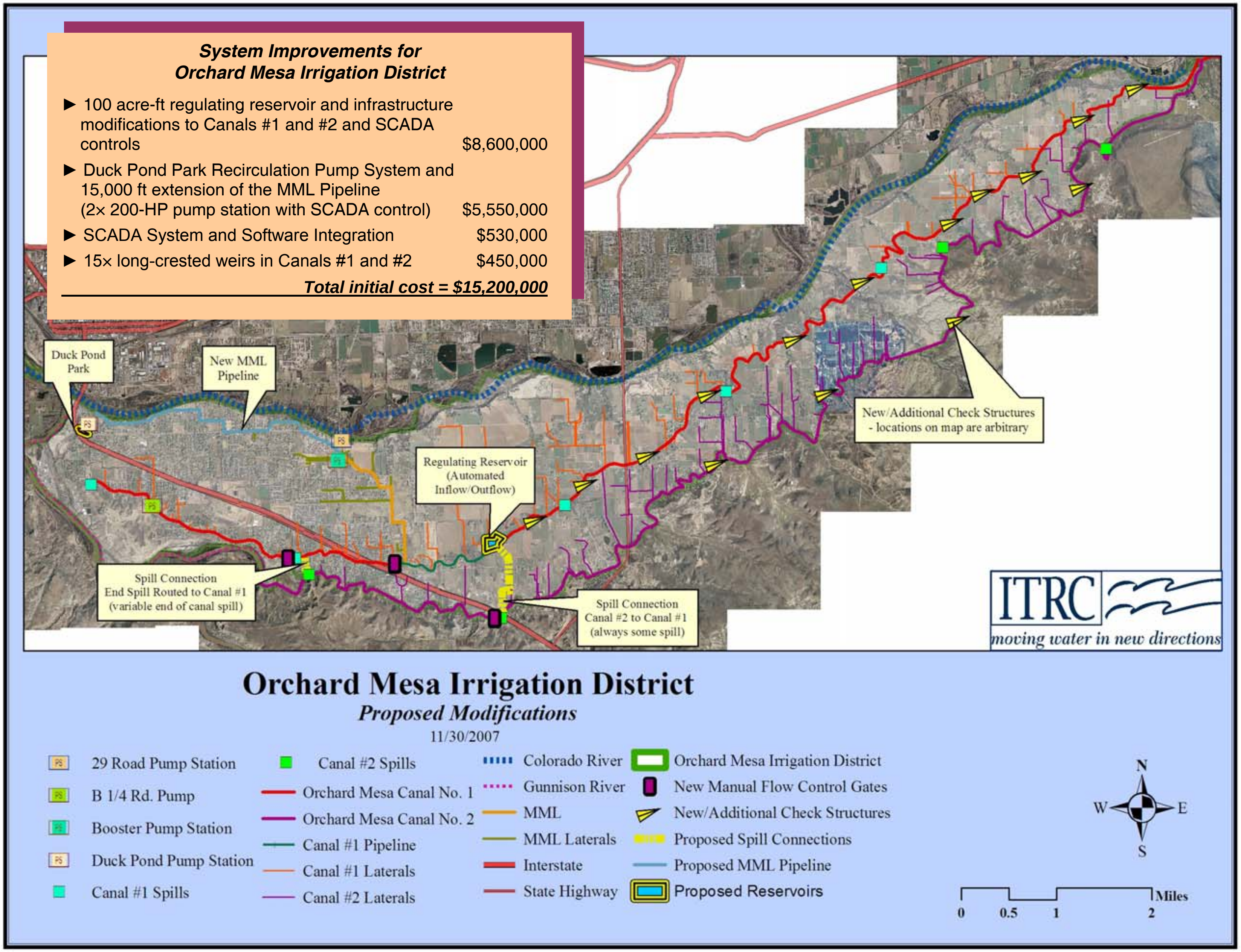

Figure ES-1. System improvements in Orchard Mesa ID for the Water Resources Conservation Plan

Water Conservation Savings

It is estimated that implementation of this proposal will save at least 17,000 acre-feet per year (refer to the *Estimated Water Conservation Savings* section in the main report and **Attachment 1** for details).

The water conservation estimates are reasonable because of two factors:

1. The estimated annual canal flow reduction of 17,000 acre-feet is conservative. A simple water balance indicates that approximately 27,000 acre-feet of water may fall into the five categories of water loss that will be conserved.
2. The proposal focuses on hardware changes within the OMID distribution system, and relatively simple operational rules. This means that the failure/success of the project will depend on hardware and OMID staff, and not require behavior modification by hundreds of water users.

Savings on a Monthly Basis

The monthly water conservation estimates are summarized in **Table ES-1**. Refer to **Attachment 2** for an explanation of the procedures used to derive these monthly estimates.

Table ES-1. Monthly water conservation savings (acre-feet)

April	May	June	July	Aug	Sept	Oct	Total
2,242	2,159	1,511	1,679	2,207	3,080	4,121	17,000

Cost

The project construction cost estimate is $15.2 million as described in the *Cost Estimate Summary* section of the main report and shown in **Table ES-2**. Annual O&M costs are estimated to be about $340,000, of which electric energy for pumping accounts for about $200,000 (~60%). The district intends to fully contract the work described in this proposal, including construction management and inspection, and does not intend to contribute in-kind services towards its completion.

Table ES-2. System Improvements Cost Summary for Construction Costs and SCADA

Component	Total Construction Cost	Annualized Capital Costs	Annual O&M Costs
Regulating Reservoir	$8,600,000	$570,000	$45,000
Reservoir, pumps, control, and earthwork	*($6,990,000)*		
Canal #1 controls and measurement	*($1,340,000)*		
Canal #2 controls and measurement	*($270,000)*		
Duck Pond Park Recirculation System	$5,580,000	$390,000	$260,000
Pump Station, earthwork at Park	*($1,400,000)*		
MML Pipeline extension	*($3,660,000)*		
Booster Pump Station	*($525,000)*		
SCADA System	$530,000	$49,000	$28,000
Long-Crested Weir Check Structures	$450,000	$29,000	$7,000
Canal #1	*($340,000)*		
Canal #2	*($110,000)*		
Total	**$15,200,000**	**$1,040,000**	**$340,000**

Overview of Water Control Strategies

The proposed system improvements represent major shifts in the strategies used to control water in Orchard Mesa ID. Together, they are integrated with a new regulating reservoir and pumped recirculation system. The role and activities of field staff will be transformed by the ability to temporarily store excesses and deficits in the reservoir, as well as automatically recover any canal spill that occurs (refer to **Attachment 3** for a discussion of restructuring staff responsibilities). Flow changes will be made multiple times per day; it is reasonable to expect about 2 to 3 significant changes to become normal instead of the current practice of once per day or less often.

The basic strategy proposed for Orchard Mesa ID is this:

1. The main canals will have the ability to operate at lower flows depending on demands in the system because the new check structures will maintain constant water levels for making deliveries.
2. A regulating reservoir will be built on Canal #1 in the lower one-third of the system near the start of the MML pipeline. It will serve two functions:
    a. Provide flexibility to upstream users by absorbing excesses and deficits from the upper portion of the system.
    b. Provide flexibility to downstream users by having water readily available close to those users, and being able to absorb any flow reductions into the downstream areas.
3. The regulating reservoir is strategically located to act as a physical short term buffer storage water for:
    a. The main canals
    b. The Duck Pond Park recirculation system
    c. The 29 Road Pumping Plant on the Colorado River
4. Operation of the Main Pumping Plant will become coordinated, real-time, with canal and reservoir conditions to minimize diversions for pumping demands and also to minimize canal spill.
5. Control of the reservoir inflows and outflows will be based on maintaining a constant water level in the adjacent pool in Canal #1. The change in the reservoir level will serve as the primary barometer telling the watermaster how closely supplies and demands are matched in the system.
6. Canal spill will be consolidated and recovered at a convenient location. Rather than leaving the district and discharging to the Colorado River downstream of the critical 15-mile stretch, canal spill will be reused as a supplemental supply for turnouts along the MML pipeline.
7. New long-crested weir check structures will permit the watermaster to quickly respond to excess flows into or out of reservoirs – without having to ask users to change their delivery flows. Extra water can be released or withheld from the entrance to the main canals to quickly respond to downstream discrepancies. Those discrepancies, of course, will be buffered in time with the reservoirs.

Figure ES-2 summarizes the proposed control strategies for Orchard Mesa ID.

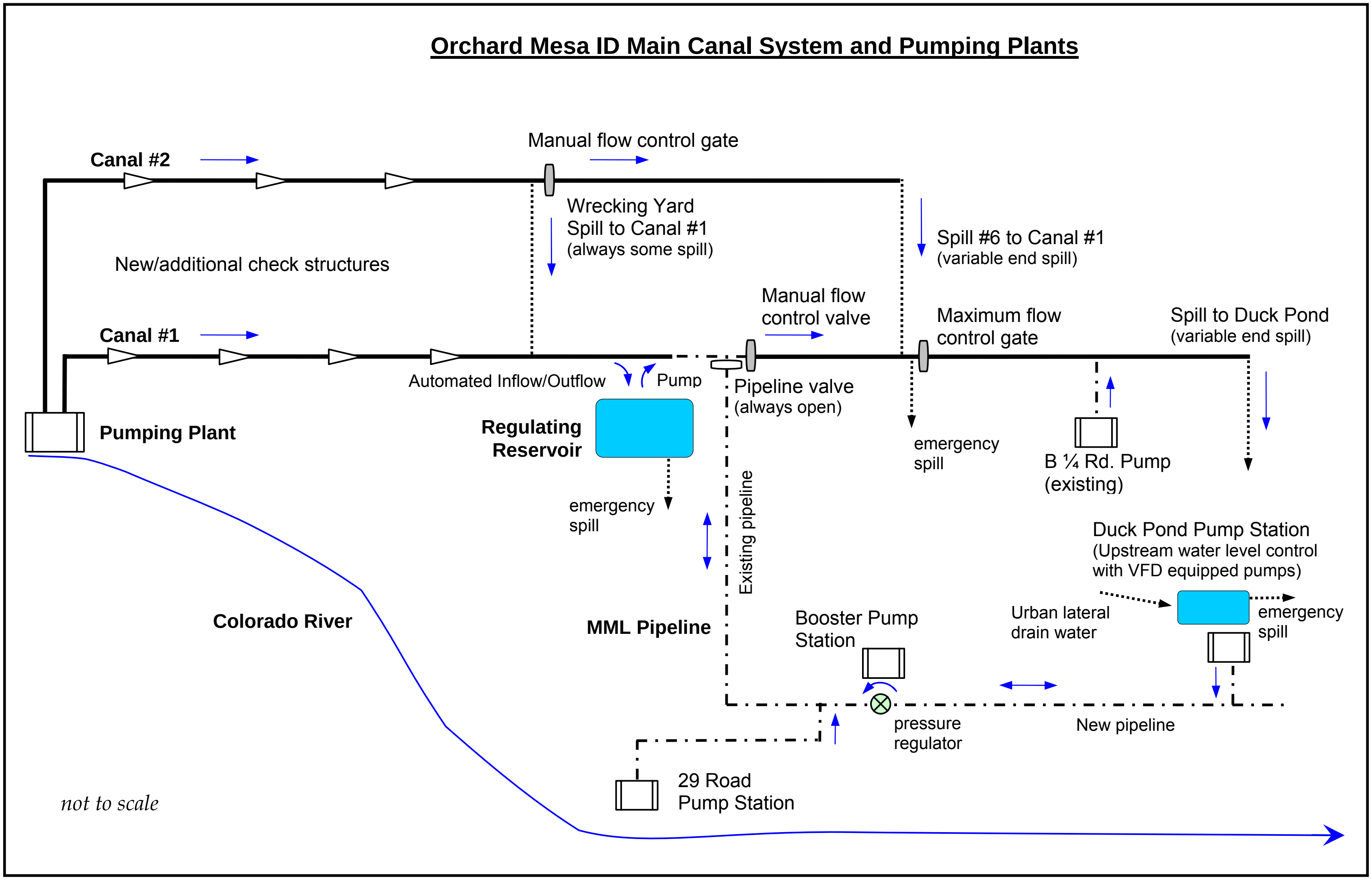

Figure ES-2. Proposed control strategies for Orchard Mesa ID

Key System Operations Points

The following are the key points of the system improvements illustrated in **Figure ES-2** (the design, construction requirements, and function of each sub-project are described in detail in the following sections):

- The inlet and outlet facilities of the new regulating reservoir will automatically maintain a constant water level in a pool in Canal #1. Based on the topography of the potential reservoir sites identified during the preparation of this Plan, the inlet to the reservoir will be gravity flow via a long-crested weir on the northern bank of Canal #1. Any excess water coming from the upstream part of Canal #1 or from the Wrecking Yard spill on Canal #2 will automatically fill the reservoir. The outlet from the reservoir will be pumped from a Variable Frequency Drive[1] (VFD) equipped pump station. If the water flowing in from Canals #1 and #2 is not sufficient to meet downstream demands, the reservoir will automatically provide supplemental supplies from the buffer storage. The reservoir will incorporate an emergency spill to a nearby drain.
- A new flow control gate will be installed in Canal #2 upstream of the existing Wrecking Yard spill (about 85% of the distance down the canal from the headworks). Thus, Canal #2 will be re-started with a known and controlled flow rate based on demand in the lower one-eighth of the canal. The field person on Canal #2 will strive to always have some spill (5-8 cfs) at this point making operations very flexible and providing water "on demand" for the lower downstream section of the canal. This spill will be automatically re-routed to Canal #1 upstream of the regulating reservoir. The operation of the manual flow control gate will depend on the amount of spill from the end of the canal at Spill #6.
- Spill from the end of Canal #2 will be routed to Canal #1 via the existing Spill #6 in the pipe that runs along Rainbow Drive, upstream of the Rainbow Spill to the Gunnison River.
- A new manual flow control valve will be installed in Canal #1 immediately downstream of the start of the MML pipeline. This valve will be operated manually based on demands in the lower one-quarter of the Canal #1 system. The field personnel will adjust the valve using the SCADA system to a new opening based on real-time knowledge of the spill occurring at the end of Canal #1; however, since the spill from the end of Canal #1 will be automatically recovered at the new Duck Pond Park recirculation pumps, the field personnel can operate with some spill at the end of Canal #1 (about 2-6 cfs).
- A (maximum) flow control gate will be installed in Canal #1 downstream of the existing Rainbow spill structure to limit the flow going down the canal to slightly below maximum conveyance capacity. The flow control structure will be a submerged orifice with a fixed capacity; the district field personnel will not adjust the flow routed downstream, but anything over the maximum capacity will automatically be spilled first to an upgraded pipeline (L1-145) and/or then to the Gunnison River. The outlet gate to L1-145 and the pipeline itself will be upgraded to serve as a conveyance for spill that the field personnel want to recover from the B ¼ Road Pump and the Duck Pond Park Pump Stations. The Rainbow spill to the Gunnison River will be upgraded with an ITRC Flap Gate to serve as an emergency spill if the flow temporarily exceeds downstream conveyance capacity in Canal #1 and the spill to the drain via L1-145.

[1] A variable frequency drive or variable speed drive (VFD/VSD) is a system for controlling motor speed. VFD controllers are used in automated pump stations to regulate pumps so a flow rate demand is satisfied without running the motors at full speed. Besides providing excellent control, by ramping up to the required pump RPM, VFDs greatly increase motor life and reduce energy consumption.

- The existing B ¼ Road Pump Station (1,800 gpm) will be upgraded with SCADA equipment to permit remote manual On/Off operation. The district field personnel responsible for Canal #1 will be able to activate the pump to serve as a supplemental supply, with a relatively fast response, depending changing demands in the lower section of the system.
- Operational spill from the end of Canal #1, and any spill from the end of Canal #2 that is recovered and routed down Canal #1 past the (maximum) flow control gate, will continue to flow downslope in the existing drainage network where it will be consolidated at the upgraded Duck Pond Park facilities. All the spill and return flows from agricultural and urban users will flow into the same drainage system until it also shows up at the Duck Pond Park pump station. This means that district field personnel do not have to struggle with managing spills from a large complex area that contains multiple inflow points. Instead, customers in the urban area in the lower one-third of the service area will receive better service, because the turnout deliveries are more stable and water is available practically on demand from the regulating reservoir and integrated recirculation system.
- A new pump station will be built at the Duck Pond Park to lift spill water from a small pond to the MML Pipeline. The small pond will temporarily store spill water (from Canals #1 and #2, plus return flows from private landowners) so it can be pumped into the MML pipeline. The pump station (2 pumps) will operate on upstream water level control so that any inflows, up to the capacity of the pump, will automatically be recovered and recirculated as a supplemental supply for the MML service area. The new pond will also include an emergency spill (to the Gunnison River) to prevent over-topping (i.e., when drain inflows exceed pumping capacity).
- The remaining part of the MML system (15,000 ft) will be pipelined all the way to the end, continuing from the existing pipeline (end of Phase II) at Unaweep Avenue. The capacity of the pipeline at the Duck Pond Park end will be increased to accommodate the pumped inflow from the Duck Pond Park Recirculation system.
- A new booster pump station (2 pumps) will be installed on the MML pipeline on the downstream side of the connection from the 29 Road Pump Station. A pressure regulator will be installed on the MML pipeline to regulate pressure in the downstream section of the pipeline. Therefore, flow from either the upstream section of the pipeline (all the way from Canal #1 and the regulating reservoir) or the 29 Road Pump Station will flow past the pressure regulator to serve demands in the lower section of the MML pipeline. Alternately, if there is less demand in the MML pipeline than the inflow from the new Duck Pond Park recirculation pumps, the booster pump will automatically turn on to lift water upstream in the MML pipeline, all the way to the regulating reservoir depending on demands in the whole MML pipeline.
- The new 29 Road Pump Station that is being built to replace the old pumps on the Colorado River will have the same design and configuration connecting to the MML pipeline near Unaweep Avenue. However, SCADA controls will be added to the pumps to allow the watermaster to remotely turn the pumping plant On or Off. This pump station would only be operated infrequently (at times of peak demand) to provide supplemental flows in the system depending on the water level in the reservoir and field personnel's judgment about the travel time for a flow change at the head of Canals #1 and #2 to reach the reservoir.

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INTRODUCTION

This *Water Resources Conservation Plan for Orchard Mesa Irrigation District* was prepared by the Irrigation Training and Research Center (ITRC), California Polytechnic State University, San Luis Obispo with support from the Western Colorado Area Office, Bureau of Reclamation, U.S. Department of Interior. This technical report expands upon and brings up to date recommendations contained in a comprehensive *Water Management Study* done by ITRC in 2000. An updated plan of system improvements is presented herein for achieving substantial water conservation, along with planning-level estimates of implementation costs for the inter-related project items.

General Background

Orchard Mesa ID serves approximately 5,000 customers in a rapidly urbanizing area around the community of Grand Junction, Colorado. The district has made possible a diverse agricultural economy, where favorable conditions allow growers to produce orchards, vineyards, vegetables, alfalfa and small grains on 8,628 acres (excluding “Vinelands” area). The infrastructure in the district is relatively old, relying on technology and control structures that were in place since the time of original construction or designed by the USBR when it became part of the Grand Valley Project (1924). There have been only minimal improvements done to the irrigation system, even though external pressures and operating conditions have changed dramatically over the years.

Orchard Mesa ID is supplied with water from the Colorado River as part of the Grand Valley Project in the western Colorado portion of the Colorado River Basin. The Orchard Mesa siphon conveys water from the Government Highline Canal to the start of the Orchard Mesa Power Canal (3.5 miles long). The district has an affirmed water right for 450 cfs[2] to be used for irrigation and powering the Orchard Mesa Pumping Plant. Of the entitled 450 cfs, 290 cfs is available for running the hydraulic lift pumps, which lift approximately 90 cfs to Canal #1 (41-ft lift), and approximately 70 cfs to Canal #2 (130-ft lift). These main canals convey water through turnouts to the fields and laterals, which are owned by private landowners. The district’s responsibility ends at the turnouts or headgates along the main canals, which can serve areas from less than 1 acre to over 100 acres. Most of the distribution system is open channel, but as more housing developments have been built some laterals were converted to pipelines.

In December 2000, ITRC completed a modernization study for the district with funding from the USBR. This large technical report provided a multi-year water balance, description of the system, analysis of salinity problems, and specific engineering recommendations for modifications to the canal system. The district was unable to make progress on most of these recommendations without external funding, even though the situation has gradually deteriorated from an operational standpoint and water conservation has continued to be a major priority. Some minor actions have been undertaken such as 4 miles of canal lining (with geomembrane liner) and public outreach efforts to inform customers about water issues.

The service area of Orchard Mesa ID is shown in **Figure 1**.

[2] See District Court of Water Division No. 5, Case No. W-168, March 25, 1972

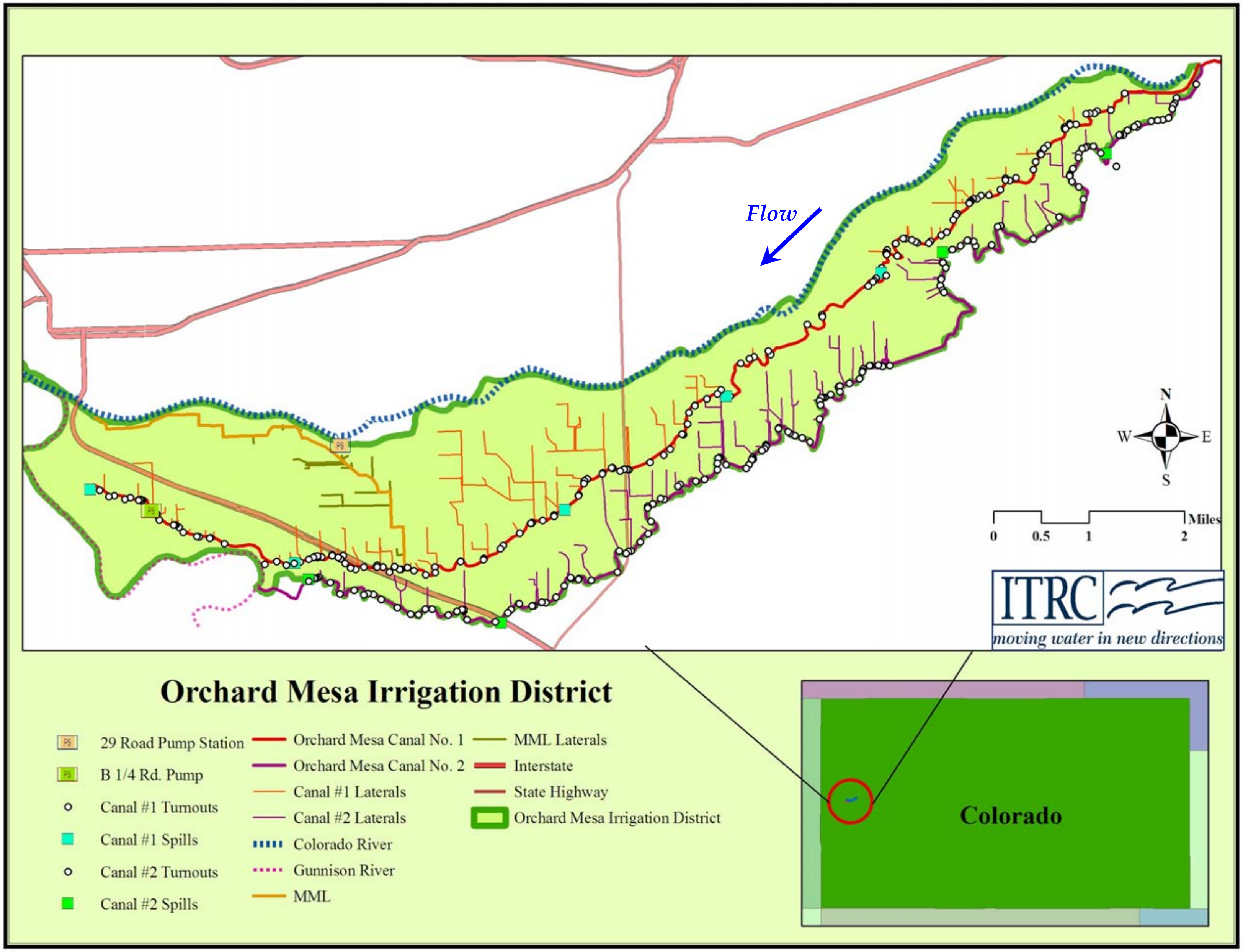

Figure 1. Orchard Mesa ID service area and facility map

Existing District Characteristics and Operational Challenges

Within Orchard Mesa ID operations are presently characterized by the following:

1. The majority of the service area is served by two long canals; Canal #1 is approximately 20 miles long and Canal #2 is approximately 15 miles.
2. One field person is in charge of each of the main canals (2 field personnel) and one additional field staff member (watermaster) operates the Main Pumping Plant.
3. The canals are old, with few control structures, and offer little flexibility.
4. Flow changes are only made at the main pumping plant infrequently. Even though it is possible for the hydraulic pumps to be adjusted with a fairly tight resolution (1-5 cfs), the field person does not have the feedback information needed in order to make frequent adjustments and there is no place to buffer out the fluctuations in the system.
5. The responsibility of the district (at the official point of control) ends at the canal turnouts or turnouts from the MML pipeline.
6. The district has no control or responsibility for deliveries to individual landowners in the urban areas and much of the agricultural areas. Instead, the district supplies water to the head of a lateral ditch or pipeline that can serve from only a few people up to dozens of parcels.
7. Irrigators are entitled to a specific flow rate – not a volume of water.
8. Field personnel do not measure turnout flow rates, unless they need to for some local problem, and do not keep records. Only about 50% of turnouts have flow measurement.
9. The control (and measurement) of flows to turnouts, in proportion to the entitlement, is not very exact.
10. In general, irrigators take water on a demand basis and do not submit water orders to the district. However, the field personnel spend much of their time interacting with the public and handling various issues within the urban areas.
11. In times of water shortages (during peak demand), field personnel have to temporarily "borrow" water from upstream turnouts by closing the gates a certain amount. This typically occurs 4 or more times in a year. For obvious reasons, field personnel will target the turnouts where they think the delivery flow rates are higher than necessary.
12. Each field person carries with him an official binder with the allotted water entitlement to each customer. At maximum pumping rates, each irrigated acre is entitled to 8.2 gpm/acre (assuming 8% conveyance losses). This entitlement drops to 5.8 gpm/acre when the pumping plant is operated at 122 cfs.
13. It takes approximately 12-14 hours for a flow change to travel from the main pumping plant through the entire length of canal and about 24 hours for the system to stabilize.
14. Although there is more than sufficient volume of water available for the irrigation season, there are temporary problems with insufficient flows at some locations during the peak irrigation periods.
15. Flows in the main canals fluctuate depending on the time of day, among other factors. For example, irrigation in the urban areas usually drops off by 8-9 p.m.
16. Urbanization has limited the ease of access to the canals and increased the amount of driving the field personnel have to do to reach district facilities.
17. Urbanization has replaced agricultural fields in many lower parts of the district. The extent of urbanization is illustrated by the before and after comparison of lands in the portion of the service area shown in **Figure 2**.

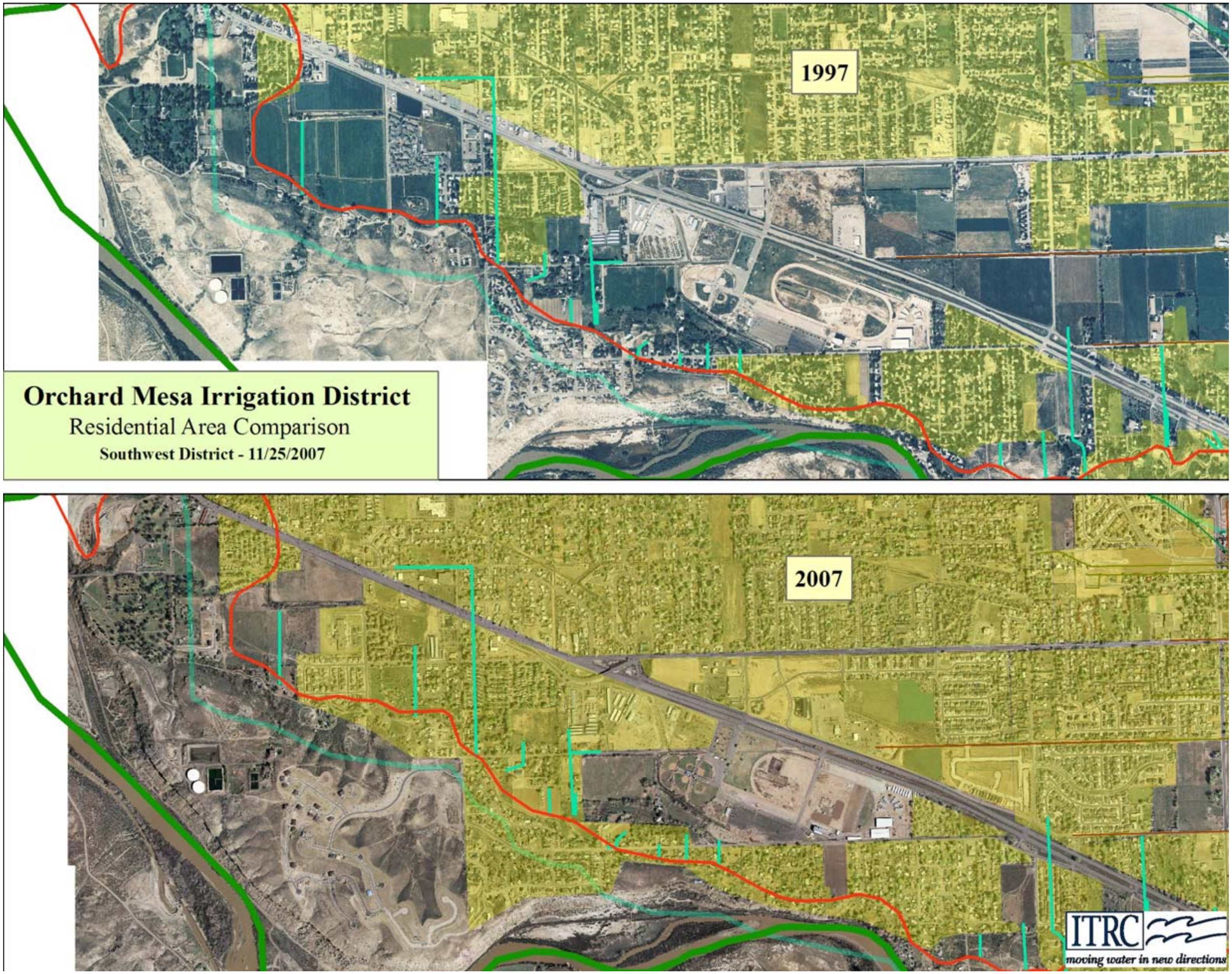

Figure 2. Increase in urbanized/residential land use from 1997 to 2007

Vision for the Future

Selecting the optimal strategy and combination of engineering designs is a complex process. Orchard Mesa ID faces critical future challenges that the existing system is incapable of dealing with effectively. To meet these challenges ITRC has developed a "package" of improvement projects that consists of individual modifications to existing structures and the construction of new facilities.

Key aspects of the future vision for Orchard Mesa ID:

- An integrated package – individual projects in this proposal improve water management in the entire service area.
- Real-time management – taking advantage of advanced SCADA[3] technologies. Information will be available on a minute-by-minute basis so decision-making can benefit from updated data of flows at key points in the system.
- River diversions will match irrigation demands – instead of daily or weekly adjustments, the Main Pumping Plant will be adjusted frequently depending on water needs in the system.
- Recirculation of canal and urban lateral spill – new facilities will recover and buffer operational spills in one central reservoir location so the district has an opportunity to calmly and effectively re-assess current supplies and deliveries, and then re-route flows in an appropriate manner.
- Better water levels control in the main canals – more stable water levels in the canal system mean that district field personnel will not have to divert high flows just to keep the canals full to make water deliveries.
- Achieving equity in water deliveries – the new system will prevent disruptive water shortages from occurring in the future, particularly in the residential neighborhoods with large numbers of users on one turnout.

Water Management Objectives

The Water Resources Conservation Plan achieves these goals:

- Operation with minimal canal spill leaving the boundaries. Spill water is recirculated.
- Simplified water operations for field staff so they can focus primary attention on customer service.
- Water service that is more equitable, reliable and flexible.

The scope of work in this report contains a substantial amount of technical details and analyses that are important for proper design and construction, but it is critical to consider them in terms of an overall roadmap for the future. This vision is intended not only to deal with current issues, but to put in place a modern system that will benefit customers and help with regional hydrology needs for the next 50 years or longer.

Regulatory Compliance

There would be no adverse effects to any endangered, threatened, or migratory bird species, or to any cultural or historical resource.

All State and Federal permit conditions, including NEPA and ESA compliance necessary for the approval, construction and/or operation of the proposed project would be secured. NEPA and ESA compliance costs are expected to be minimal due to the nature of data communication equipment such as for SCADA systems and structural modifications within man-made canals.

[3] SCADA stands for "Supervisory Control and Data Acquisition". Many irrigation districts in the western U.S. have put in radio telemetry, sensors, flow meters, automatic gates and valves, etc. that are generally referred to as SCADA systems.

ESTIMATED WATER CONSERVATION SAVINGS

Implementation of the system improvements presented in this report has the potential to conserve approximately 17,000 acre-feet of water in normal water supply years. Due to the priority date of Orchard Mesa ID's water right, a "normal supply" of water is nearly always available. The district can be forced to operate the Orchard Mesa Check. Operation of the check does decrease the pumping plant capacity; however, this decrease can be made up for by operating the 29 Road Pumping Plant.

This section summarizes the justification for this conservation savings estimate based on detailed water balance analyses in the 2000 report along with information and water records data updated from the 2000-2006 irrigation seasons. Detailed information is also included in **Attachment 1**.

Review of Water Balance Analysis from the 2000 Report

Various water balance estimates were presented in the 2000 report including the estimated spill volumes from the main canals and laterals. The locations of the spill points from the main canal system are shown in **Figure 3**. Except for the Wrecking Yard, Spill #6 and Fuller Bypass sites, any water spilled leaves the district and returns to the Colorado River or Gunnison River, providing important environmental flows for riparian habitat protection. However, a significant portion of this flow returned to the Colorado River, particularly during the critical summer time period, at or near the end of the designated 15-mile reach.

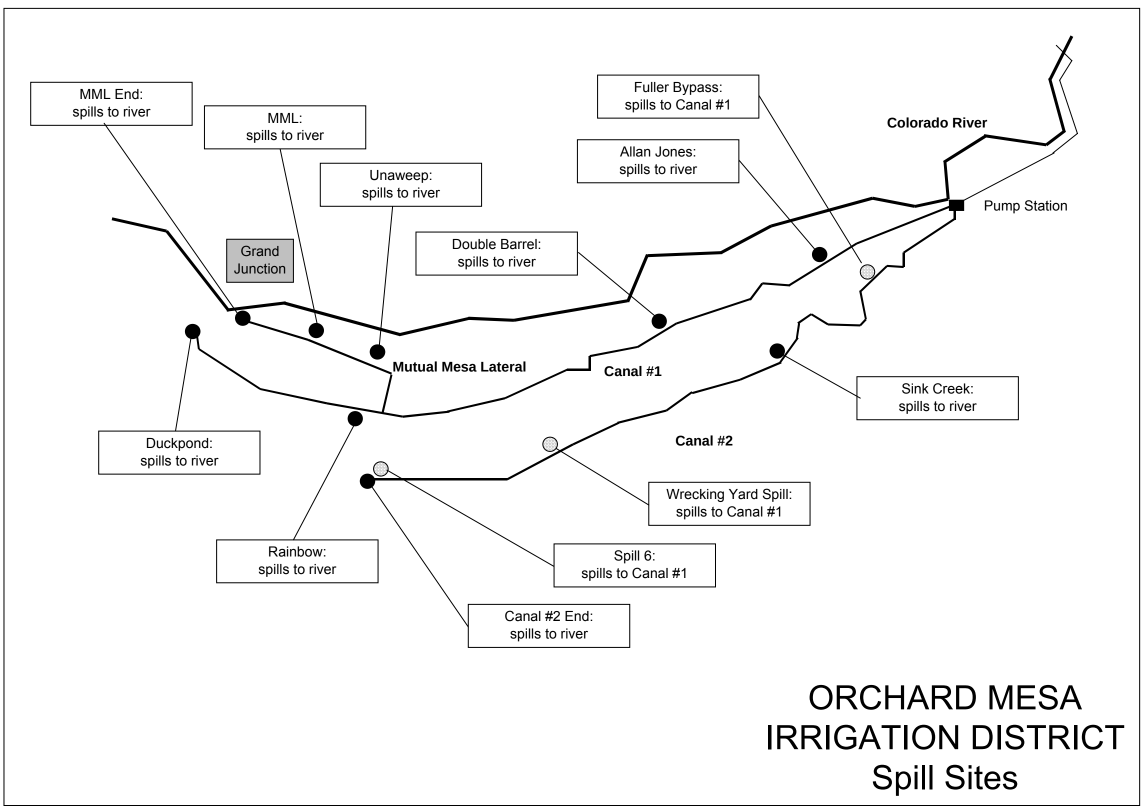

Figure 3. Locations of spill sites along main canals in Orchard Mesa ID

Based on extensive field monitoring done by Orchard Mesa ID and ITRC, spill volumes from the main canals were measured fairly accurately in 1999 and 2000. The total main canal spill volume over the 2-year period averaged approximately 7,900 acre-feet, which represented about 13% of the irrigation water supplies during the same time period. Note: this estimate of main canal spill does not include water that is recycled internally from such places as the Wrecking Yard spill.

Figure 4 shows the estimated main canal spill flow rate (in CFS) on a daily basis in 1999 and 2000. The combined main canal spill flow rate from Canals #1 and #2 varies about 8-10 cfs in the summer months. However, in the spring and fall months the amount of spill leaving the district from the main canals increases up to about 70-90 cfs. The graph also shows the spill as a fraction of the amount of irrigation water supply pumped into Canals #1 and #2.

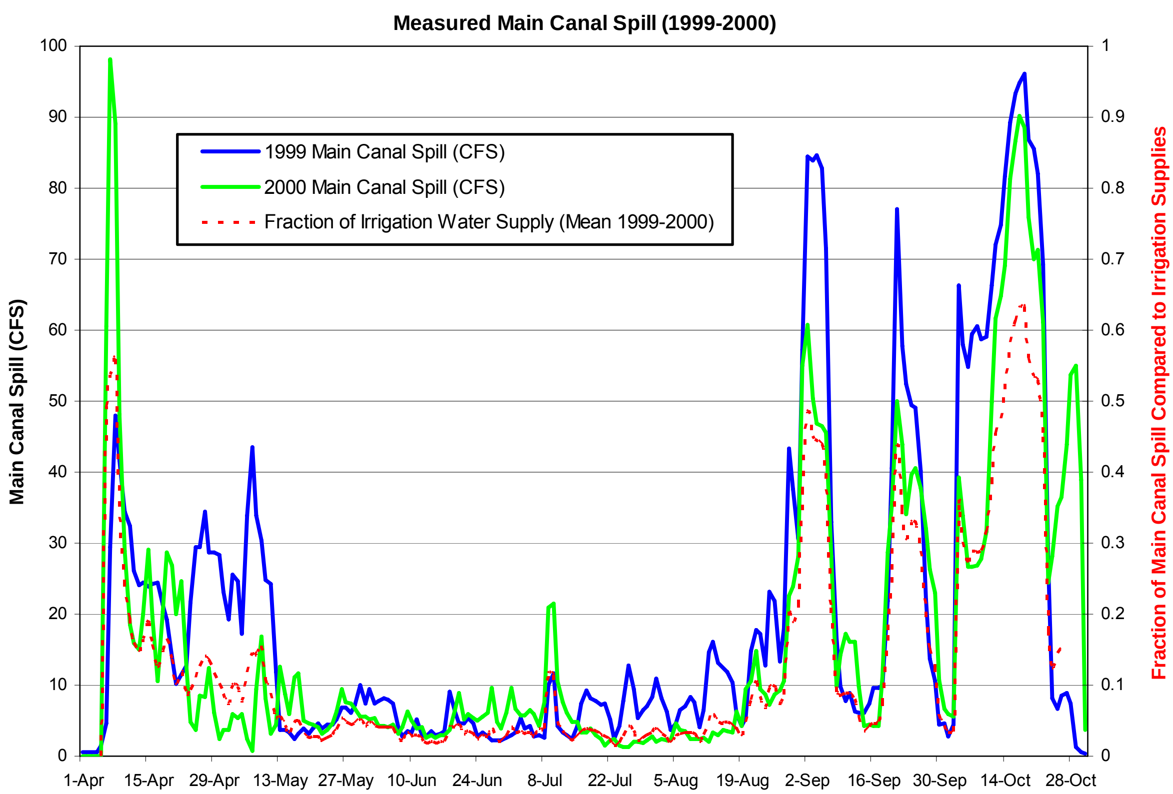

Figure 4. Main canal spill (CFS) in Orchard Mesa ID during 1999 and 2000

Water Conservation Potential from Implementing System Improvements

Background

Water diversions from the Colorado River are much higher than beneficial consumptive use in Orchard Mesa ID. The overall 5-year Irrigation Efficiency (IE) of the district from the water balance study in the 2000 report was only 27%. Of course, there are understandable reasons why this has been the case historically, but primarily it has to do with three factors:

(1) Canal flow rates must be kept high even when deliveries are low just to keep water levels high enough to make deliveries.
(2) The district only has responsibility for operating the main canals.
(3) The infrastructure and technology of the entire delivery system greatly limits what can be done in urban areas to shut off or reduce the deliveries when irrigation is adequate.

From a delivery standpoint, considerably more water is being diverted than is needed for crop water requirements as shown in **Figure 5**. For example, in 2006 the average applied irrigation water in the district was over 8.5 acre-feet per acre (pumped diversions ÷ total acreage). The estimates of net irrigation water requirement in the graph were estimated based on the 2000 water balance data and annual ratios of the reference evapotranspiration measurements (ET_r) measured at the CoAgMet weather station in Grand Junction between 2000 and 2006 (using 2000 as the base year).

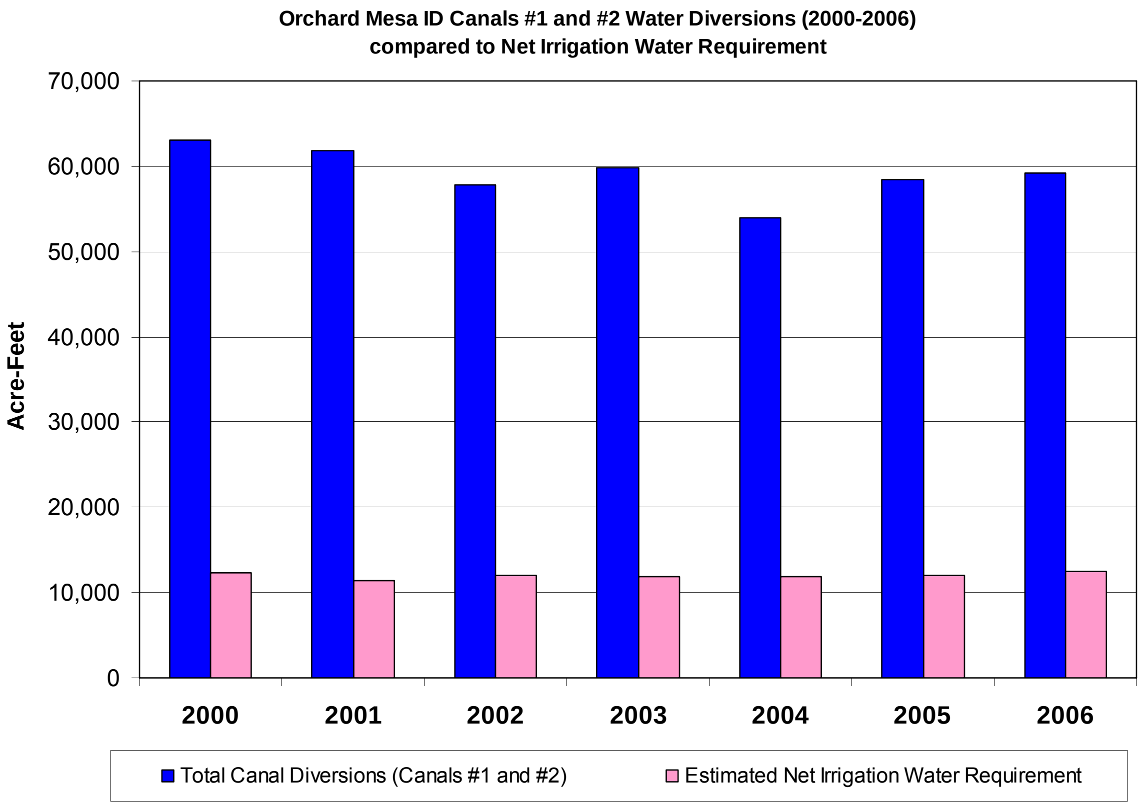

Figure 5. Canal deliveries and estimated net irrigation water requirement during 2000-2006

In terms of the total volume of water deliveries, conditions in the district have remained fairly constant since the 2000 report at about 58,000 to 60,000 acre-feet per year. Water deliveries dropped in 2002 and 2004 but pumping records in the last few years are similar to previous years. Overall, in 2006 there was about a 5% decline in water deliveries compared to 2000-2001. In a gross sense, diversions to the main canal are about five times (5×) consumptive use.

In terms of total crop area, the acreage has also remained fairly constant. As shown in **Figure 6**, the percentage of residential areas increased significantly between 1997 and 2006, going from 1,340 to 1,840 acres (also refer to **Figure 2**, which shows the extent of urbanization in the southwestern part of the service area). This was an important consideration in developing the estimated water conservation savings, as explained below.

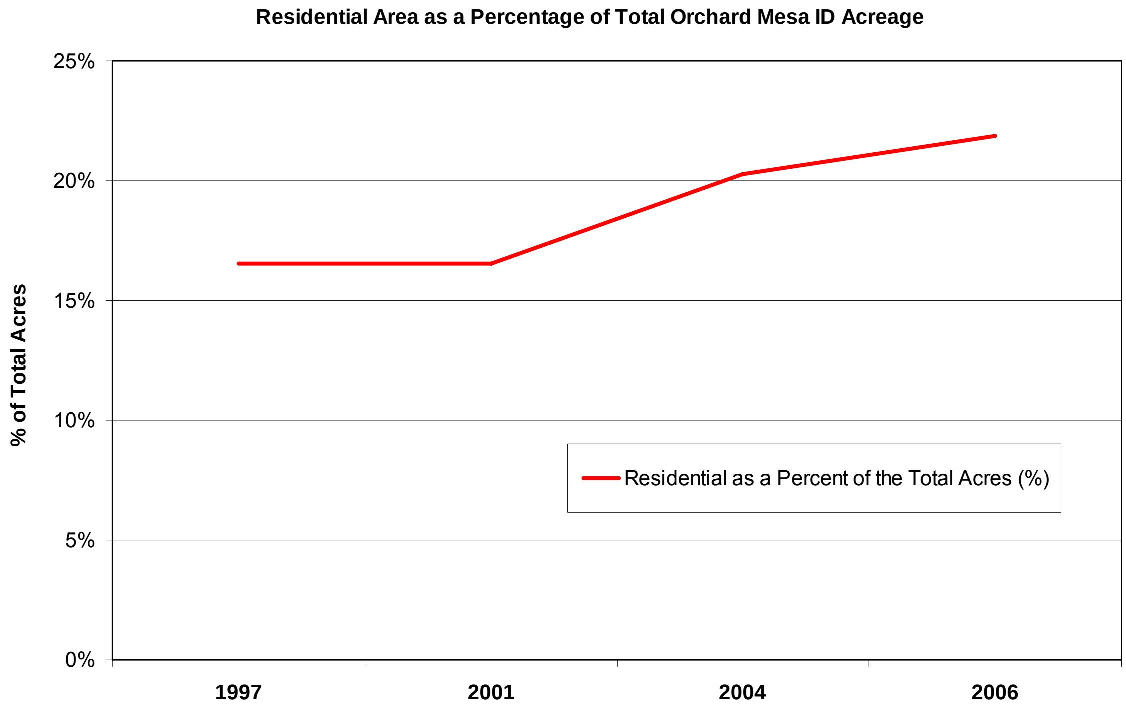

Figure 6. 'Residential' area as a percentage of total acreage between 1997 and 2006

Sources of Water Conservation

Water conservation in this proposal will result from sources broken into five categories:

1. Reducing main canal spill from the sites at Sink Creek, Allan Jones and Double Barrel
2. Reducing lateral spill in the upper agricultural areas
3. Recovering spill from the sites at the ends of Canals #1 and #2 and the Rainbow Spill
4. Eliminating spill from the MML system
5. Recovering drain water from the urban lateral systems in the residential areas

Even though the water savings from all these sources are inter-related, they were broken down into separate components in order to quantify the potential water savings from available hydrological data. It is estimated that about 17,000 acre-feet of water can be conserved from all sources.

The different contributions of the proposed system improvements to water conservation savings are illustrated by the conceptual graph in **Figure 7**. In the present situation, main canal supplies must be kept much higher than the actual irrigation demands due to uncertainties, lag times, etc., and also in order to keep the water level in the canals high enough to serve customers because of the lack of check structures. Thus as shown in the graph, on a particular day the cumulative irrigation demand may be equivalent to about 70-80 cfs but the combined amount of water being diverted into Canals #1 and #2 may be over 150 cfs.

The water conservation benefits of this proposal are indicated by the red dashed line that shows future main canal operations made possible by the re-regulation reservoir and the new long-crested weir check structures, in addition to the recirculation of spill water. Because of the new reservoir, field personnel will be able to make appropriate adjustments to the total amount of water being supplied to the main canals. If the amount of water in the main canal system is more than irrigation demands, it is automatically stored (temporarily) in the reservoir for future use. Later as the demand for irrigation increases, some water can be taken from reservoir storage.

It is important to recognize that the system improvements in this proposal are primarily aimed at the main canal level. However as can be seen in the graph, a considerable portion of the overall canal spill occurs from laterals. While some lateral savings are included in the water conservation savings estimate in this proposal (about 1,000 acre-feet), we envision that by putting in place the recommended system improvements even more water can potentially be saved in the future because field personnel will have the basic tools to implement further advances in district-level water management. The conservative nature of the water savings estimate in this proposal is indicated by the substantial gap between canal diversions and consumptive use previously shown in **Figure 5**. At present, total canal supplies are several orders of magnitude larger than *ET*.

The following sections describe how the water savings for each component were estimated.

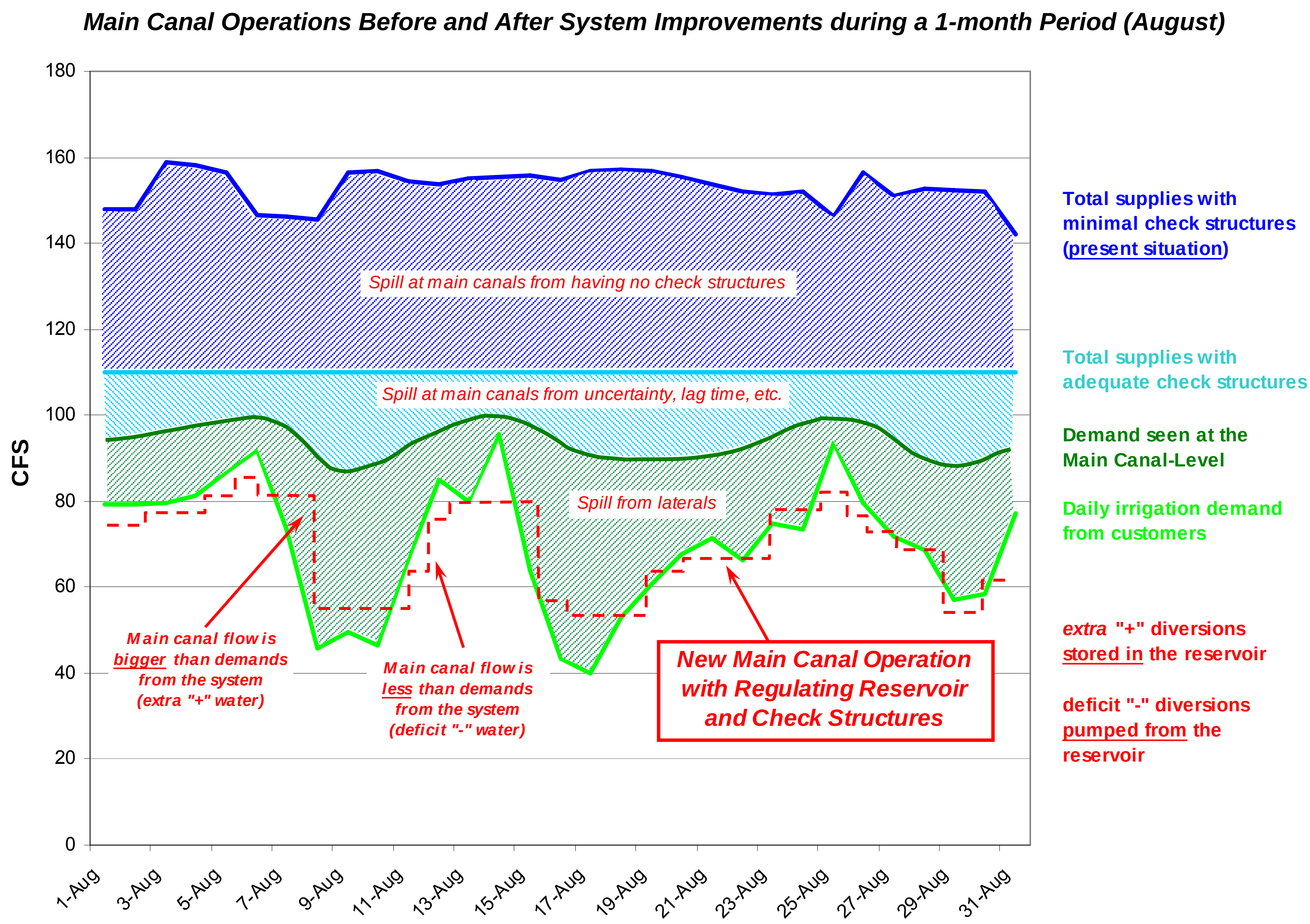

Figure 7. Conceptual illustration of water conservation savings based on estimated flow destinations

Spill Reduction and Recovery from the Main Canals and Laterals in the Upper Agricultural Areas

There are three spill points to the Colorado River from the main canals in the upper agricultural areas, namely: Sink Creek, Allan Jones and Double Barrel. In addition, there are laterals owned and operated by irrigators that spill water at various points in the system. To estimate potential water savings associated with Categories 1 and 2 after the system improvements are implemented, historical spill records were examined for each site in 1999-2000.

Category 1 – Water Savings from Main Canals in East Orchard Mesa

It was assumed that the spill from the upper sites on Canals #1 and #2 (in the East Orchard Mesa area) will be reduced by about 75%. The estimated annual savings based on averages of historical records is approximately 4,000 acre-feet (refer to **Table 1**). This is probably a conservative estimate. It is likely that after several years of experience with the upgraded canals, real-time remote monitoring, and a reservoir to temporarily route discrepancies, district field personnel will be able to reduce main canal spill even further, probably to about 15-20% of what it presently is.

Table 1. Spill reduction from main canals in the upper agricultural areas (acre-feet per year)

Year	Allan Jones	Sink Creek	Double Barrel	Total	75% Savings
1999	313	3,166	2,350	5,829	
2000	313[1]	2,691	1,910	4,914	
Mean	**313**	**2,929**	**880**	**5,372**	**4,029**

[1] No data was available for Allan Jones spill in 1999 so 2000 data was used.

Category 2 – Water Savings from Laterals in Eastern Orchard Mesa

Lateral spill in the district's entire service area was estimated in the 2000 report to be approximately 1,800 acre-feet per year. Assuming that roughly three-quarters of this occurs in the upper agricultural area in East Orchard Mesa (i.e., not including urban laterals) and using the same 75% estimated savings prediction, annual lateral spill reduction will be approximately 1,000 acre-feet.

Urban vs. Agricultural Conservation

Implementation of the Water Resources Conservation Plan will result in major changes to the operation of the Orchard Mesa ID distribution system. Along with the better service provided by the district, growers will have the opportunity to enhance their on-farm water management. Already since the 2000 report, about 10% of the acreage in the upper agricultural part of the district has converted to micro-irrigation, with 4-5 new systems being put in every year.

On-farm Irrigation Efficiency values are certainly low in the agricultural areas in the upper part of the system due to excessive deep percolation and tailwater runoff. Some of these losses can eventually be reduced by having better service to the turnouts and better irrigation scheduling (i.e., providing irrigation water when it is needed and in the right amounts). However, these types of improvements require changes in behavior and investments in the farm's irrigation hardware. By reducing or shutting off the flows into the turnouts or laterals, some water can be conserved, although to some extent irrigators in the upper parts of the system are already doing this (reducing their turnout flows) to minimize water wastage.

The same situation is not true in the urban/residential areas due to the fact that there are many more users who must share the water from a single canal turnout or lateral headgate. It is impossible for so many people to effectively coordinate their irrigations and make the necessary adjustments to a headgate. Moreover, residents want the convenience of irrigating their landscape in the evenings (causing definite trends in demands as well as spills). So the question is: *How can this excess water that is being delivered to urbanized areas be effectively conserved*?

Excess diversions in the mixed residential areas result in drain water that occurs in two ways:

a. Spills that occur from the main canals or the MML pipeline and that go to either the Colorado River or Gunnison River in existing district-maintained drains.
b. Spills that occur from the ends of urban laterals and go into network of drains, most of which end up at Duck Pond Park.

Category 3 – Water Savings from Canal #1 and #2 Spills to the Gunnison River

First, an estimate was made of the spill from the main canals to external points in the lower part of the system bounded by the residential neighborhoods and the junction of the Colorado and Gunnison Rivers. This urban area is shown in **Figure 8**. Below this point, on the west side of the Wrecking Yard Spill, there are about 2,740 acres of land, including all of the MML service area. In a normal year about 1,600 acre-feet of main canal spill occurs in this area that will now be recovered or reduced from the end of Canal #2, Rainbow Spill, and the end of Canal #1 (Duck Pond spill – not the same as "Duck Pond Park").

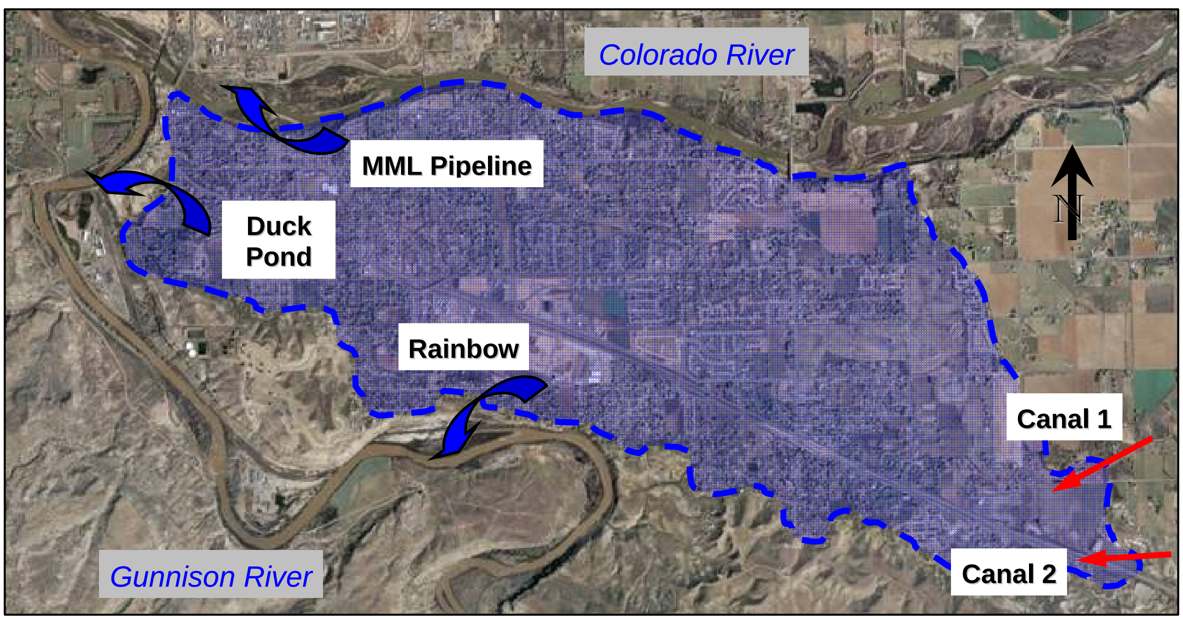

Figure 8. The urban area in the lower one-third of Orchard Mesa ID service boundaries (showing external spill points)

Category 4 – Water Savings from the MML Spills

In addition, there will no longer be any spill to the Colorado River from the three (3) sites along the MML system because the rest of the lateral will be converted to a pipeline (from Phase II to the end). Eliminating this spill will provide the equivalent of 900 acre-feet of water savings each year.

Category 5 – Water Savings from Urban Laterals

The other category of spills in this urbanizing area is from private urban laterals. A complex drainage network consolidates all the internal spills and runoff until it eventually reaches a large drain that runs through the Duck Pond Park. The drain in the Duck Pond Park is shown in **Figure 9**. Approximately 11,000 acre-feet of drain water discharges to the Gunnison River each irrigation season at a point about 1.3 miles upstream of the junction with the Colorado River. A detailed analysis of the amount of water to be recovered and recycled at Duck Pond Park is presented in **Attachment 1**. (Note: the independent method used to estimate the timing and volume of spill from urban laterals was consistent with historical spill records.)

By accounting for the destinations of all water deliveries compared to estimated consumptive use and deep percolation on the irrigated portion of the 2,740-acre residential area, the combined flow rate showing up at the Park would be enough to serve the entire MML service area, plus provide some extra water that can be stored temporarily in the regulating reservoir or utilized downstream in Canal #1.

Figure 9. Surface drain running through Duck Pond Park before it discharges to the Gunnison River

An estimate was made of how much water can be recycled from the drain at Duck Pond Park based on the new capability of pumping up to 25 cfs capacity during the irrigation season. As shown in **Table 2**, historical drain flows at this point on the boundary of the district were estimated to vary between 25 to 30 cfs during August and September in normal years. Even in the summer months, the amount of water reaching this collective spill point averages about 20 cfs.

Table 2. Estimates of the amount of water conservation from recirculation at Duck Pond Park

Mo.	Total Estimate of CFS at Duck Pond Park (CFS)	Recovered Spill CFS at Duck Pond Park (CFS)	Equivalent Acre-Feet of Water Savings (AF)
April	20	20	1,190
May	25	25	1,560
June	19	19	1,130
July	19	19	1,160
Aug	24	24	1,470
Sept	30	**25****	1,490
Oct	26	**25****	1,540
Total			**9,540**

** The design capacity of the Duck Pond Park recirculation pump station will be 25 cfs. Refer to **Attachment 1** for detailed analysis.

The values reported in **Table 2** take into account the fact the B ¼ Road Pump Station (1,800 gpm capacity) would also recover some of this urban lateral spill. It was assumed for the purposes of estimating potential water conservation savings that the B ¼ Road Pump Station would be running approximately 50% of the time (overall).

Total Estimated Water Savings

The estimated water conservation savings developed in this Water Resources Conservation Plan are 17,000 acre-feet as summarized in **Table 3**. An explanation of estimated savings on a monthly basis is provided in **Attachment 2**.

In normal years, the amount of water conservation expected to occur is approximately 17,000 acre-feet. The confidence interval[4] on the measured/estimated spill data is ±20%, so the estimate is in the range of 14,000 to 20,000 acre-feet per year. As indicated in the table, the majority of the savings will be through recovering spill at key points (both from main canals and urban laterals) and re-using it within the system as a supplemental water supply. Thus, the overall water savings account for about a one-third reduction in total spill compared to the average main canal and lateral spill values reported in the water balance in the 2000 report.

Table 3. Potential water savings from system improvements (acre-feet per year)

No.	Category	Savings (AF)**	%
1	Reducing main canal spills (East Orchard Mesa)	4,000	24%
2	Lateral spill (East Orchard Mesa)	1,000	6%
3	Spill recovery from main canals in the urban areas	1,600	9%
4	Eliminating MML spill	900	5%
5	Spill recovery from urban laterals	9,500	56%
Total		**17,000**	**100%**

** Rounded values

[4] The confidence interval reflects an estimate of the uncertainty associated with spill data. A CI of ±20% means that one is 95% certain that the correct value lies between plus or minus 20% of the stated value.

TECHNICAL SCOPE OF WORK

This section provides a summary of the technical elements to be implemented under the proposed Water Resources Conservation Plan. The implementation of these system improvements and control strategies will improve the efficiency of operations and water management in Orchard Mesa ID, while incidentally improving water delivery service provided to customers (by facilitating more equity, reduced turnout variability, and better flexibility).

Overview of Water Control Strategies

The proposed system improvements represent major shifts in the strategies used to control water in Orchard Mesa ID. Together, they are integrated with a new regulating reservoir and pumped recirculation system. The role and activities of field staff will be transformed by the ability to temporarily store excesses and deficits in the reservoir, as well as automatically recovering any canal spill that occurs (refer to **Attachment 3** for a discussion of restructuring staff responsibilities). Flow changes will be made multiple times per day; it is reasonable to expect about 4 to 5 significant changes to become normal instead of the current practice of once per day or less often.

The basic strategy proposed for Orchard Mesa ID is this:

1. The main canals will have the ability to operate at lower flows depending on demands in the system because the new check structures will maintain constant water levels for making deliveries.
2. A regulating reservoir will be built on Canal #1 in the lower one-third of the system near the start of the MML pipeline. It will serve two functions:
    a. Provide flexibility to upstream users by absorbing excesses and deficits from the upper portion of the system.
    b. Provide flexibility to downstream users by having water readily available close to those users, and being able to absorb any flow reductions into the downstream areas.
3. The regulating reservoir is strategically located to as a physical short term buffer storage water for:
    c. The main canals
    d. The Duck Pond Park recirculation system
    e. The 29 Road Pumping Plant on the Colorado River
4. Operation of the Main Pumping Plant will become coordinated, real-time, with canal and reservoir conditions to minimize diversions for pumping demands and to also minimize canal spill.
5. Control of the reservoir inflows and outflows will be based on maintaining a constant water level in Canal #1. The change in the reservoir level will serve as the primary barometer telling the watermaster how closely supplies and demands are matched in the system.
6. Canal spill will be consolidated and recovered at a convenient location. Rather than leaving the district and discharging to the Colorado River downstream of the critical 15-mile stretch, canal spill will be reused as a supplemental supply for turnouts along the MML pipeline.
7. New long-crested weir check structures will permit the watermaster to quickly respond to excess flows into or out of reservoirs – without having to ask users to change their delivery flows. Extra water can be released or withheld from the entrance to the main canals to quickly respond to downstream discrepancies. Those discrepancies, of course, will be buffered in time with the reservoirs.

Figure 10 summarizes the proposed control strategies for Orchard Mesa ID.

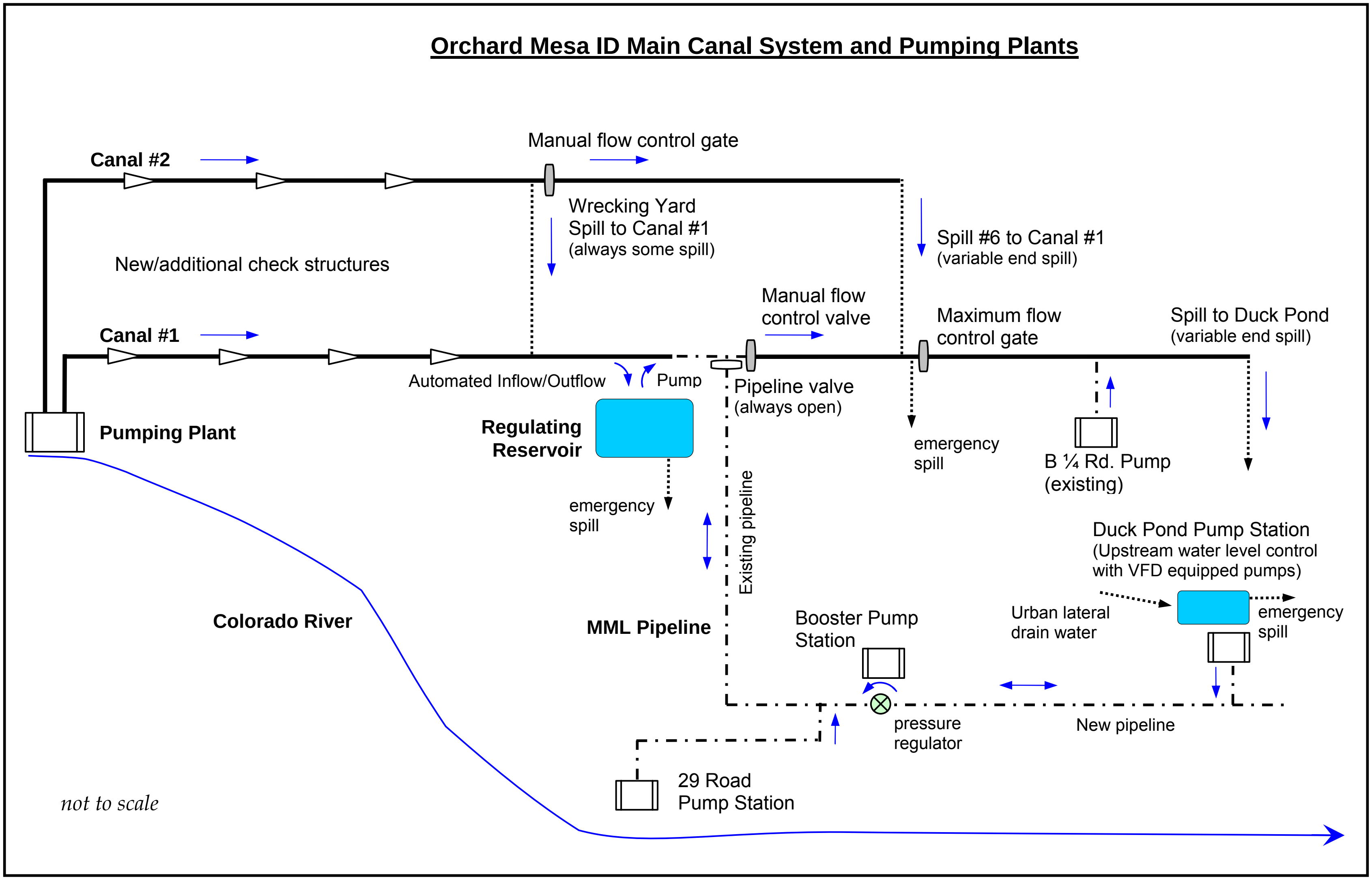

Figure 10. Proposed control strategies for Orchard Mesa ID

Key System Operations Points

The following are the key points of the system improvements illustrated in **Figure 10** (the design, construction requirements, and function of each sub-project are described in detail in the following sections):

- The inlet and outlet facilities of the new regulating reservoir will automatically maintain a constant water level in a pool in Canal #1. Based on the topography of the potential reservoir sites identified during the preparation of this Plan, the inlet to the reservoir will be gravity flow via a long-crested weir on the northern bank of Canal #1. Any excess water coming from the upstream part of Canal #1 or from the Wrecking Yard spill on Canal #2 will automatically fill the reservoir. The outlet from the reservoir will be pumped from a Variable Frequency Drive[5] (VFD) equipped pump station. If the water flowing in from Canals #1 and #2 is not sufficient to meet downstream demands, the reservoir will automatically provide supplemental supplies from the buffer storage. The reservoir will incorporate an emergency spill to a nearby drain.
- A new flow control gate will be installed in Canal #2 upstream of the existing Wrecking Yard spill (about 85% of the distance down the canal from the headworks). Thus, Canal #2 will be re-started with a known and controlled flow rate based on demand in the lower one-eighth of the canal. The field personnel of Canal #2 will strive to always have some spill (5-8 cfs) at this point making operations very flexible and providing water "on demand" for the lower downstream section of the canal. This spill will be automatically re-routed to Canal #1 upstream of the regulating reservoir. The operation of the manual flow control gate will depend on the amount of spill from the end of the canal at Spill #6.
- Spill from the end of Canal #2 will be routed to Canal #1 via the existing Spill #6 in the pipe that runs along Rainbow Drive, upstream of the Rainbow Spill to the Gunnison River.
- A new manual flow control valve will be installed in Canal #1 immediately downstream of the start of the MML pipeline. This valve will be operated manually based on demands in the lower one-quarter of the Canal #1 system. The field personnel will adjust the valve using the SCADA system to a new opening based on real-time knowledge of the spill occurring at the end of Canal #1; however, since the spill from the end of Canal #1 will be automatically recovered at the new Duck Pond Park recirculation pumps, the field personnel can operate with some spill at the end of Canal #1 (about 2-6 cfs).
- A (maximum) flow control gate will be installed in Canal #1 downstream of the existing Rainbow spill structure to limit the flow going down the canal to slightly below maximum conveyance capacity. The flow control structure will be a submerged orifice with a fixed capacity; the district field personnel will not adjust the flow routed downstream, but anything over the maximum capacity will be spilled first to an upgraded pipeline (L1-145) and/or then to the Gunnison River. The outlet gate to L1-145 and the pipeline itself will be upgraded to serve as a conveyance for spill that the field personnel want to recover from the B ¼ Road Pump and the Duck Pond Park Pump Stations. The Rainbow spill to the Gunnison River will be upgraded with an ITRC Flap Gate to serve as an emergency spill if the flow temporarily exceeds downstream conveyance capacity in Canal #1 and the spill to the drain via L1-145.

[5] A variable frequency drive or variable speed drive (VFD/VSD) is a system for controlling motor speed. VFD controllers are used in automated pump stations to regulate pumps so a flow rate demand is satisfied without running the motors at full speed. Besides providing excellent control, by ramping up to the required pump RPM, VFDs greatly increase motor life and reduce energy consumption.

- The existing B ¼ Road Pump Station (1,800 gpm) will be upgraded with SCADA equipment to permit remote manual On/Off operation. The district field personnel responsible for Canal #1 will be able to activate the pump to serve as a supplemental supply, with a relatively fast response, depending changing demands in the lower section of the system.
- Operational spill from the end of Canal #1, and any spill from the end of Canal #2 that is recovered and routed down Canal #1 past the (maximum) flow control gate, will continue to flow downslope in the existing drainage network where it will be consolidated at the upgraded Duck Pond Park facilities. All the spill and return flows from agricultural and urban users will flow into the same drainage system until it also shows up at the Duck Pond Park pump station. This means that district field personnel do not have to struggle with managing spills from a large complex area that contains multiple inflow points. Instead, customers in the urban area in the lower one-third of the service area will receive better service, because the turnout deliveries are more stable and water is available practically on demand from the regulating reservoir and integrated recirculation system.
- A new pump station will be built at the Duck Pond Park to lift spill water from a small pond to the MML Pipeline. The small pond will temporarily store spill water (from Canals #1 and #2, plus return flows from private landowners) so it can be pumped into the MML pipeline. The pump station (2 pumps) will operate on upstream water level control so that any inflows, up to the capacity of the pump, will automatically be recovered and recirculated as a supplemental supply for the MML service area. The new pond will also include an emergency spill (to the Gunnison River) to prevent over-topping (i.e., when drain inflows exceed pumping capacity).
- The remaining part of the MML system (15,000 ft) will be pipelined all the way to the end, continuing from the existing pipeline (end of Phase II) at Unaweep Avenue. The capacity of the pipeline at the Duck Pond Park end will be increased to accommodate the pumped inflow from the Duck Pond Park Recirculation system.
- A new booster pump station (2 pumps) will be installed on the MML pipeline on the downstream side of the connection from the 29 Road Pump Station. A pressure regulator will be installed on the MML pipeline to regulate pressure in the downstream section of the pipeline. Therefore, flow from either the upstream section of the pipeline (all the way from Canal #1 and the regulating reservoir) or the 29 Road Pump Station will flow past the pressure regulator to serve demands in the lower section of the MML pipeline. Alternately, if there is less demand in the MML pipeline than the inflow from the new Duck Pond Park recirculation pumps, the booster pump will automatically turn on to lift water upstream in the MML pipeline, all the way to the regulating reservoir depending on demands in the whole MML pipeline.
- The new 29 Road Pump Station that is being built to replace the old pumps on the Colorado River will have the same design and configuration connecting to the MML pipeline near Unaweep Avenue. However, SCADA controls will be added to the pumps to allow the watermaster to remotely turn the pumping plant On or Off. This pump station would only be operated infrequently (at times of peak demand) to provide supplemental flows in the system depending on the water level in the reservoir and field personnel's judgment about the travel time for a flow change at the head of Canals #1 and #2 to reach the reservoir.

New Central Regulating Reservoir System

A regulating reservoir will be built on Canal #1 in the area between the connection from the Wrecking Yard spill (from Canal #2) and the headgate of the MML pipeline. **This reservoir is essential** for making the proposed system improvements simple and effective. It will tie everything together – Canals #1 and #2 and the MML pipeline – absorbing excesses and deficits of the entire upstream area, as well as receiving surpluses from the Duck Pond Park recirculation system. The regulating reservoir will be the main balancing point for the watermaster and district field personnel indicating the need for adjustments at the Main Pumping Plant.

Figure 11 shows several proposed locations for the reservoir along Canal #1. It is expected that the reservoir may be located approximately 1 mile from the MML Pipeline. There are several privately-owned parcels of land in the area that are not being farmed on the north side of Canal #1. A new pipeline (following the alignment of Canal #1) will connect the reservoir to a new control valve vault at the MML pipeline, with a manually-operated outlet valve to serve the downstream portion of Canal #1.

The recommended site(s) has been selected as an ideal general location for receiving upstream errors ("+'s" and "-'s" arising from flexible canal operations) and then re-distributing the water based on demands in the canal system. However, the precise location is not critical and depends on which plot of land is available for purchase by the district.

The reservoir will have 100 acre-feet of total live storage on approximately 15 acres providing a buffer of about ±50 to 60 acre-feet. A 100-HP pump will lift water from the reservoir with a capacity of 30 cfs, which is about 50% of the Canal #1 design size for the pipeline connection downstream of the reservoir.

Explanation of Benefits Upstream and Downstream

The Orchard Mesa ID reservoir will provide service area-level benefits. Advantages will occur both upstream and downstream of the reservoir:

- Upstream, canal spill is not a concern because it will only go the reservoir. This permits flexible operations in Canals #1 and #2 and faster responses in the areas upstream. It also provides the opportunity to reduce diversions.
- The regulating reservoir on Canal #1 will allow the district field personnel to quickly change the flows into upstream laterals and turnouts. These changes will be compensated for at the reservoir in terms of storage volume changes.
- Flows downstream of the reservoirs are re-started with a controlled, constant flow rate at all times.

In operational terms, the reservoir will serve the following functions:

a) Provide water on demand to the MML pipeline
b) Provide water on demand to the downstream service area of Canal #1
c) Accept spill from Canal #2 (via Wrecking Yard)
d) Accept surplus water from the Duck Pond Park Recirculation System or 29 Road Pumping Plant, depending on supply/demand discrepancies in the MML system

The reservoir is necessary for flexible canal operations – buffer storage allows excesses and deficits to persist for some reasonable time. A buffer provides the watermaster an opportunity to calmly and effectively re-assess the current supplies and deliveries, and then district field personnel re-route flows in an appropriate manner. If the buffer reservoir is full and the Duck Pond Park pump station is running high, the watermaster will reduce the main pumping plant accordingly.

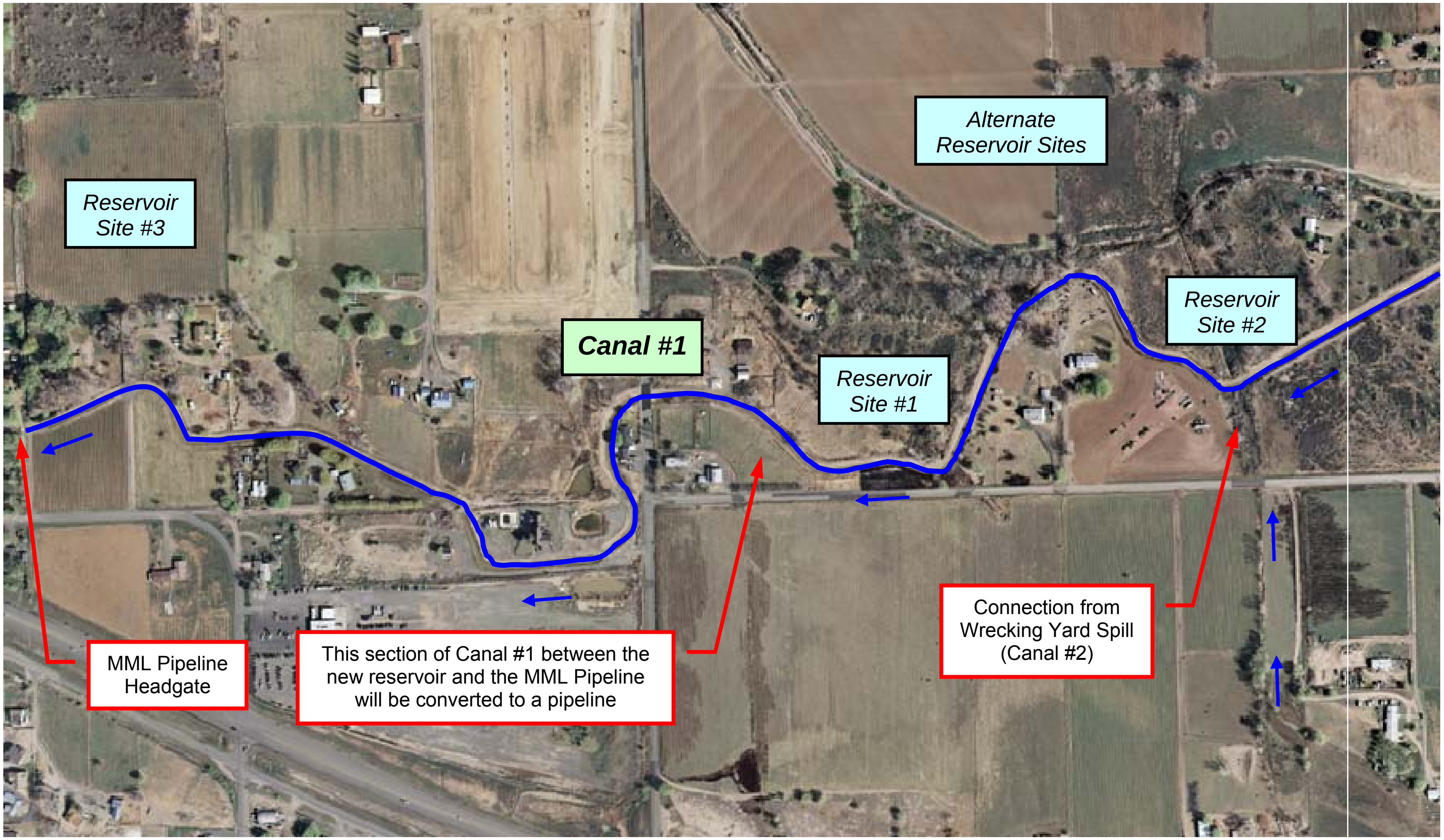

Figure 11. General overview of the new central regulating reservoir sites near the division of Canal #1 and the MML Pipeline

Reservoir Control Strategy and Automation

The control diagram in **Figure 12** summarizes the automated control strategy for the inlet and outlet of the regulating reservoir. The reservoir control strategy will maintain a constant water level in the Canal #1 pool upstream of the entrance to a short pipeline that connects to a new flow control valve at the MML pipeline. A preliminary topographical analysis of potential sites for the reservoir indicates that a gravity inlet will be permitted with a pumped outlet.

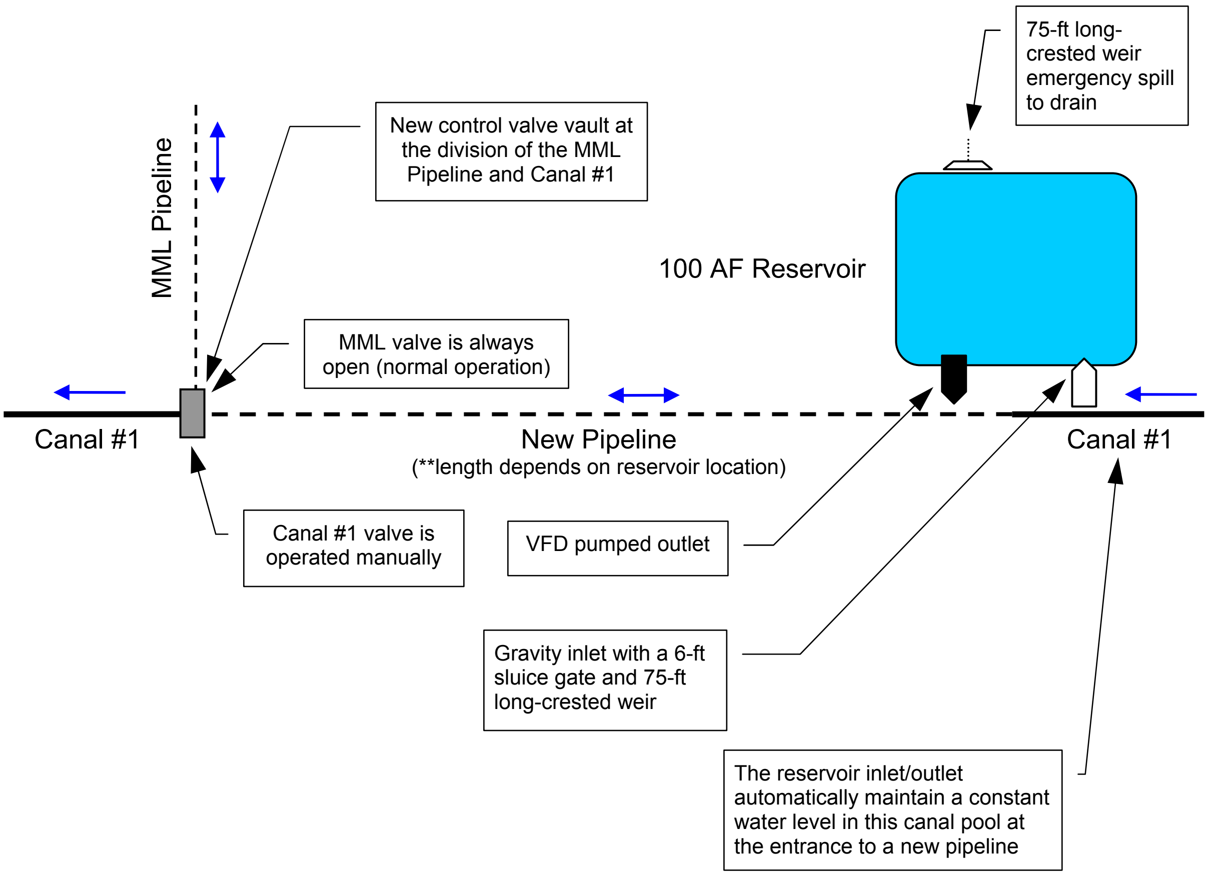

Figure 12. Proposed operational strategy for inlet and outlet of the Canal #1 reservoir

The inlet to the reservoir will be an automated vertical slide gate, with a 75-ft long-crested weir to act as an emergency inflow. The inlet gate will operate automatically to allow gravity flow from the canal pool into the reservoir if the water depth in the canal is higher than the target value.

The pump station is for the flow going out of the reservoir into the canal pool whenever extra water is needed to meet demands in the downstream portion of Canal #1 and the MML pipeline. The pump station will include one pump, which will have a VFD.

ITRC anticipates the following actions related to the automation of reservoir controls:

1. The intake gate for flow into the reservoir and the pump for flow going into the canal will be equipped with one PLC (programmable logic controller) for control, monitoring, and alarming purposes.

2. A SCADA system will allow the watermaster to do the following from the district office for the reservoir:
   - remotely monitor the flow rate in Canal #1 at new flow control valve downstream of the reservoir (via a modified Replogle flume downstream in Canal #1)
   - remotely monitor the water depth in the reservoir
   - remotely change the target water level in the canal pool
   - remotely change the operation mode from automatic to manual, (if necessary)
   - remotely (but via a secure mode) change key controller constants
   - remotely select which of the two redundant sensors (for every measurement) should be considered the "primary" sensor, and if two sensor values should be compared

3. The intake gate and the VFD pump station of the reservoir will be operated automatically to maintain the water level in the canal pool at the start of the new Canal #1 pipeline (and upstream of the new flow control structure).

4. Two secondary, redundant sensors are required for the following:
   - water levels in the canal
   - water levels in the reservoir
   - gate position

   These redundant sensors will be wired through redundant power supplies and A/D converters in the PLCs. Also, it is recommended that the redundant sensors be of a different design than the primary sensors.

5. The pump shall be equipped with an electromagnetic flow meter.

Design Capacity

The buffer capacity of the reservoir defines the flexibility offered by the district to its water users. In order to determine the required capacity of the reservoir, an analysis of reaction times and potential mismatches in supply and demand in the downstream service area was done. The reservoir will have an inlet with a capacity of 40 cfs and an outlet capacity of 30 cfs.

In considering the proper size, it should be noted that the capacity of a regulating reservoir actually provides only slightly less than half as much buffer because reservoirs are kept half-full in order to handle either the "+'s" and "-'s", and to account for the fact that it is often not half-full when a discrepancy in flow begins to arrive.

Inlet Capacity

The modeled simulation of Canal #1 from the 2000 report indicated that the reaction time between making a flow change at the main pumping plant and seeing a response at the proposed reservoir site was approximately 4 hours, with a complete stabilization time of about 12 hours (depending on the initial flow rate).

Another design consideration is that water delivery field personnel need some time to adjust to these flow discrepancies. If there is a temporary excess of +20 cfs, the field personnel can often find farmers who will want to start irrigating earlier – but it takes time to arrange this with the farmers. Since farmers do not order water from the district, field personnel will have to know their customers and their irrigation practices. With the new SCADA system and automated control a 6-hour "buffer time" is probably a conservative estimate of how long the reservoir could either absorb excess flows or provide water in the event that downstream demands are higher than the incoming flow in Canal #1 (from both directions in case some water is also coming from the Duck Pond Park recirculation system via the MML pipeline).

Taking these factors into consideration, the total response time that must be accommodated by the buffer storage in the reservoir is 14 hours.

The inlet capacity of the reservoir must pass the maximum rejection flow rate upstream of the reservoir, plus any water being pumped from the Duck Pond Park recirculation system that is not being used in the combined service area of lower Canal #1 and the MML pipeline. For determining an engineering design value for inflow into the reservoir, it was also anticipated that patterns of usage may change because the Duck Pond Park recirculation system will provide a water supply of about 25 cfs, which reduces the pumped flow being diverted into the main canals.

To get a sense of the potential errors that would have to be handled by a reservoir, several years of spill data were analyzed in the 2000 report. The results of the Canal #1 spill analysis indicated that on a daily basis there could be swings in canal flow of up to 20-25 cfs of spills in the system due to changes at night or mismatches when a person starts/stops a delivery. These spills represent the uncertainties associated with hour-by-hour operations and is the portion of the pumped diversions that will be stored temporarily in the reservoir.

It is impossible to know precisely how much of a combined effect will result from field personnel modifying their practices and the mismatches between deliveries and recirculation in the new MML pipeline. However, considering that the reservoir will now be tasked with handling peaks in spill flows routed from several sites along Canal #2, the inflow capacity of the reservoir should be at least 40 cfs. This inlet capacity represents the maximum expected canal flow conditions, which would rarely occur, but the design will provide excellent operational flexibility for district field personnel.

An automated sluice gate (5-ft wide) would permit the full inflow to the reservoir of approximately 40 cfs. The reservoir will be designed so that the inlet gate is always free flow and the gate bottom will be set low enough to maintain the critical submergence depth at the opening (estimated to be about 3 ft submergence, but it depends on the final configuration). A 75-ft long-crested weir will be incorporated into the inlet design to allow inflow to the reservoir in an emergency situation (e.g., power outage). A 75-ft long-crested weir will pass 30 cfs with a head of 0.25 ft, which is within the safe freeboard of the canal.

Required Buffer Storage Size

The storage capacity of the reservoir is based on accepting the maximum inlet flow capacity for the designated response time period, taking into account that the reservoir will typically be about half-full when a change starts to arrive:

$$\text{Reservoir live storage capacity (acre-feet)} = 2 \times \text{Inlet Capacity} \times \text{Response Time}$$

$$\text{Reservoir live storage capacity} = 2 \times \frac{40\ \text{ft}^3}{\text{s}} \times 14\ \text{hrs} \times \left[\frac{60\ \text{min}}{\text{hr}} \times \frac{60\ \text{s}}{\text{min}} \times \frac{\text{acre}}{43{,}560\ \text{ft}^2}\right]$$

Reservoir live storage capacity = 92 acre-feet ≅ 100 acre-feet

Thus, the active storage capacity of the reservoir should be at least 100 acre-feet. The total reservoir volume will depend on the acreage of the land parcel that is eventually purchased by the district for the facility. To provide an estimate of the reservoir depth and earthwork involved with different parcel sizes, several conceptual reservoir designs are summarized in **Table 4**. The calculations specify that for a parcel 10-12 acres in size, the reservoir will be approximately 15 ft deep. Note: the parcel values in the table include one (1) additional acre for the pumping platform, control building, vehicle parking, security fencing, etc. A separate parcel of about 5 acres will be needed to store or dispose of silt removed from the reservoir.

Another way of understanding the benefit of a buffer storage size of 50 acre-feet is that it represents about 24 hours of storage for a system-wide discrepancy of ±25% (when the canal system is operating at high flows).

Table 4. Conceptual reservoir design dimensions for 100-acre-feet of buffer storage

Reservoir Depth[1] (feet)	Active Storage (acre-feet)	Total Storage (acre-feet)	Parcel Size[2] (acres)
10	100	140	15
12	100	130	14
15	100	125	11
20	100	120	9
25	100	115	8

[1] Includes 2 ft dead storage
[2] Assumes 3:1 slope on reservoir banks, 1.5 ft freeboard, and 20 ft wide roads.

Outlet Capacity

The pumped outlet will have a total capacity of 30 cfs, consisting of one high-performance pump. A VFD-equipped control system will automatically pump water into Canal #1 if the pool level goes below the target level. The VFD pump will be controlled by the SCADA system at the site. Another advantage of the pump station design is that it incorporates redundancy for safe, reliable operation.

Emergency Spill

The reservoir will include a 75-ft long-crested weir to act as an emergency spill. Any excess water entering the reservoir from the Canal #1 pool will spill to a nearby drain on the north side of the proposed sites.

Silt Removal

The reservoir design includes 2 ft of dead storage, which will allow some sediment to settle in the reservoir each year. Conditions in the Colorado River can cause substantial amounts of silt to enter the canal system. Several acres of land will be acquired for temporarily storing the accumulated silt, so it can be removed periodically to prevent deteriorating the effectiveness of the reservoir. The process of silt removal and disposal must be carefully considered.

Canal #1 Pipeline

The section of Canal #1 between the regulating reservoir and the MML Pipeline will be converted to a pipeline, ending at a new control valve vault near the MML Pipeline entrance. It is proposed to use 54-inch HDPE pressure pipe because of its structural flexibility, as the pipeline will be laid in the existing canal. So many curves in the alignment would cause difficulties with other types of more rigid pipe materials. Since the pipeline will be installed with thermal fusion (welded) joints, this eliminates the need for many expensive fittings and thrust restraints.

The design flow rate required in the new pipeline is 60 cfs. Depending on the final reservoir site location, the length of the pipeline is estimated to be about 5,000 ft (4,800-6,300 ft). Approximately 10 service turnouts will have to be replaced with branch saddle outlets. A new inlet structure will be constructed at the start of the pipeline immediately downstream of the reservoir. Because the pipeline will be fed directly from the canal system, an automatic trash screen will be installed as part of the entrance structure.

Canal #1 Flow Control Valve

The service area of Canal #1 below the outlet to the MML Pipeline will be supplied by the new pipeline connecting to the regulating reservoir. A manual flow control valve inside a new vault structure will allow the district field personnel to adjust the flow rate into the downstream portion of Canal #1. This valve can also be operated by remote-manual control using the SCADA system. If the valve is closed (reducing the flow) the water will automatically back up in the pipeline to the reservoir. Likewise, if more flow is needed to meet downstream demands in Canal #1, the district field personnel can open the valve and more flow will automatically flow into the pipeline. The approximate location of the new vault structure is shown in **Figure 13**.

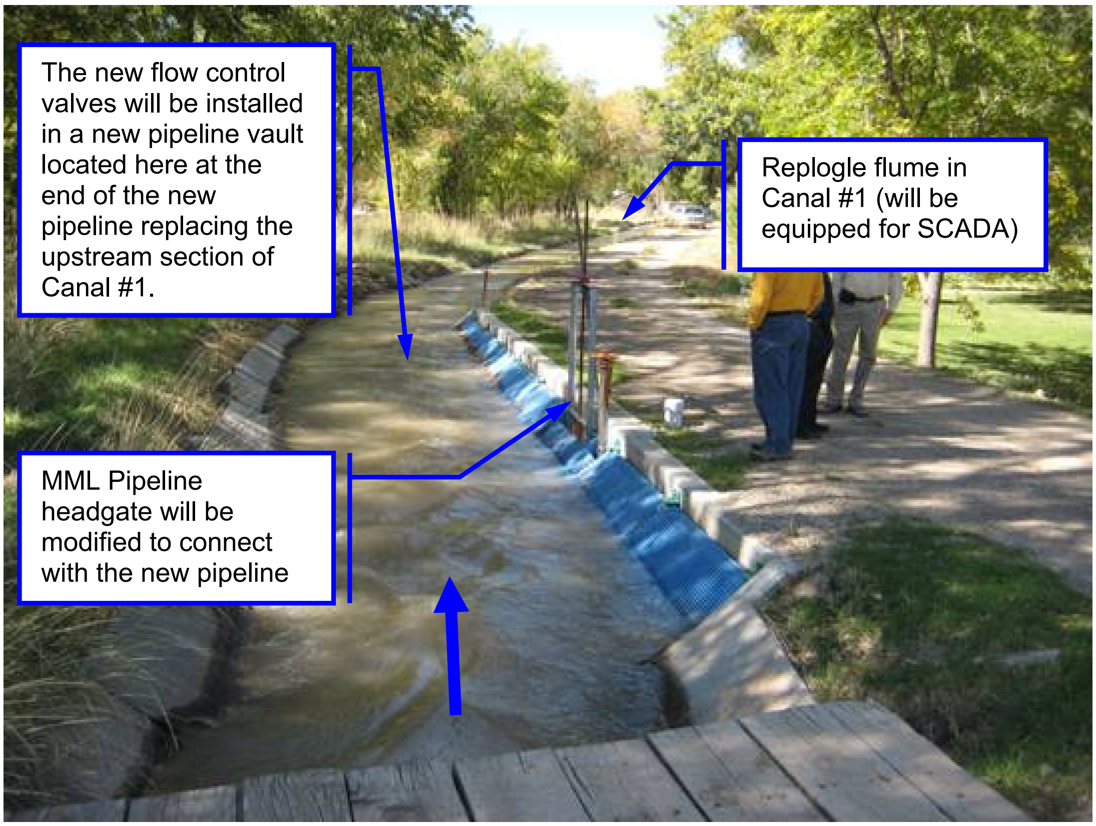

Figure 13. Canal #1 at the entrance to the MML Pipeline (looking downstream). A new concrete vault with flow control valves will be installed at the junction with the MML Pipeline.

The Replogle flume located several hundred feet downstream of the MML pipeline entrance will be modified and equipped with SCADA to allow district field personnel and the watermaster to monitor the flow rate being released into Canal #1 at this point. The new SCADA system will also allow the district field personnel to remotely monitor the spill, if any, from the end of Canal #1 at the existing Duck Pond spill.

Conceptual sketches of the pipeline entrance structure and the exit vault with the flow control valves are shown in **Figure 14**. The headworks of the MML Pipeline will be reconfigured to allow flow to go into the new Canal #1 Pipeline (flow in both directions). The flow control valve at the entrance to the MML Pipeline will always be left wide open, unless it is shut down for maintenance or repairs. Shut-off valves and air vents will be installed at both ends of the Canal #1 Pipeline.

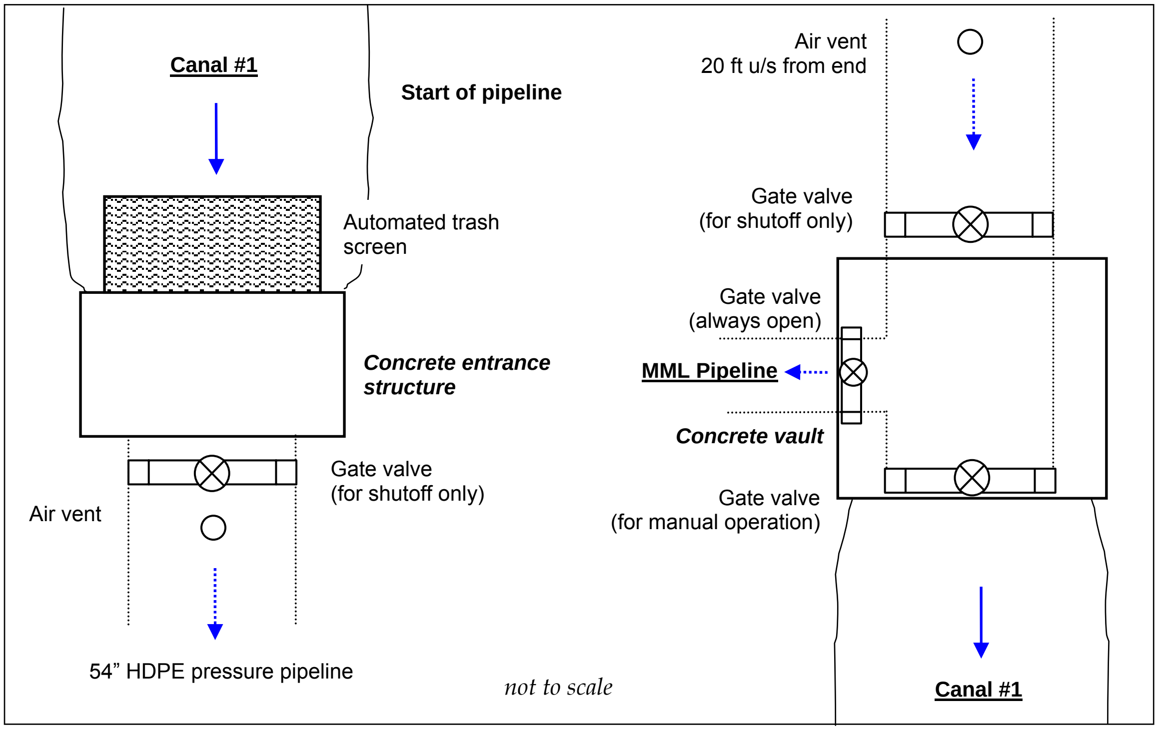

Figure 14. Schematics design of the entrance (left) and exit (right) structures for the Canal #1 pipeline

Canal #1 Maximum Flow Control Gate at Rainbow Spill

An existing pipeline conveys spill from Spill #6 at the end of Canal #2 to Canal #1 at Rainbow Drive. About 600 ft downstream of this junction there is a spill on Canal #1 to the Gunnison River (called Rainbow Spill) as shown in **Figure 15**. To prevent the chance of exceeding the conveyance capacity of Canal #1, a new flow control structure will be installed immediately downstream of the Rainbow Spill. The structure will consist of a rated orifice created in the rectangular cross-section immediately downstream of the existing trash rack.

A steel plate, flush with the sides of the rectangular walls, will be placed across the top of the canal. As soon as the flow reaches the plate, it will abruptly raise the upstream water level (i.e., switching to orifice flow), but it can not overtop the canal because of the Rainbow Spill immediately upstream.

Figure 15. Canal #1 at Rainbow spill. A new flow control structure (fixed orifice) will be installed here to limit the flow into the downstream portion of Canal #1 to its maximum carrying capacity.

To provide automatic spill capability, an ITRC Flap Gate will be installed in the entrance to the existing spill outlet as shown in **Figure 16**. Due to the age of this existing structure and questionable stability, the outlet structure to hold the flap gate will be replaced. In addition, the field personnel can decide to divert some spill to the B ¼ Road Pump via the existing adjacent Turnout L1-145, which spills to a drain on the northside of Highway 50.

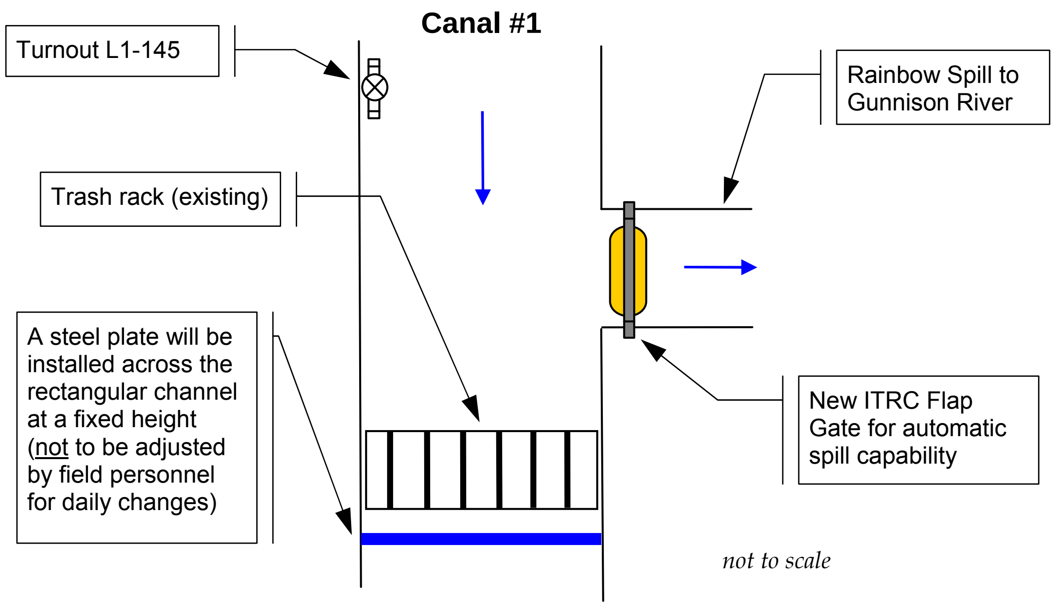

Figure 16. Schematic of proposed modifications to Canal #1 at the Rainbow Spill

Canal #2 Manual Flow Control Gate at Wrecking Yard

A new flow control gate will be installed in Canal #2 near the Wrecking Yard to integrate operations of this system with the new regulating reservoir. The new gate will be located approximately 200 feet upstream from where Canal #2 crosses Highway 50, near the site shown in **Figure 17**. As part of the new operations strategy, Canal #2 will be re-started at this point for manual flow control. To achieve this, a new sluice gate structure will be installed in the canal. The gate will be operated manually. Field personnel will make real-time decisions about the operation of this flow control gate based on downstream demands; however, some spill (5 cfs) will always be occurring here so that the field personnel always water available on demand to increase canal flow for peak periods or to prevent temporary water shortages due to reductions from upstream.

A long-crested weir side spill will be built on the channel bank at the entrance to a new 24-inch pipeline that will convey spill following the alignment along Highway 50 and then discharge into the existing drainage channel (Wrecking Yard spill channel), where it will be routed to Canal #1 and the new regulating reservoir (refer to the proposed alignment in **Figure 18**).

The long-crested weir and pipeline must be able to pass the majority of the spills that have historically occurred at the Fuller Bypass, Wrecking Yard, Spill #6, and the End Spill sites because these will no longer be used except in emergencies. An analysis of spill data (1999-2000) indicated that the maximum daily flow rate from all four sites was 8.2 cfs (2-yr average). Assuming the worst case scenario when the maximum measured spill would all occur at the same time, the peak flow rate would have been about 18 cfs. This is unlikely to occur except on rare occasions but since the canal is being re-started here, it is necessary to provide enough capacity to safely route any peak flows to the regulating reservoir where is can be stored or safely spilled.

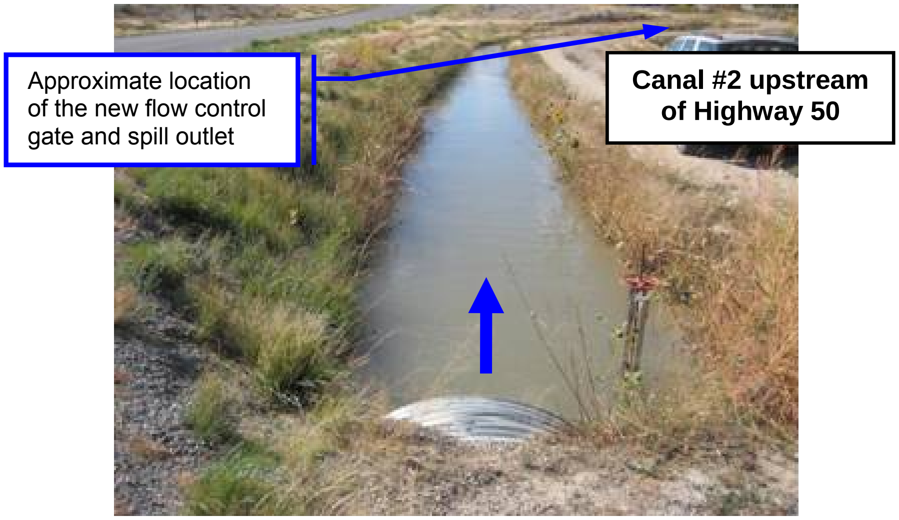

Figure 17. Canal #2 at the Highway 50 crossing. The new flow control gate will be installed in this section of canal and a pipeline will connect to the existing alignment of the Wrecking Yard drain channel.

Therefore, in order to handle peak spill flow rates and to provide operational flexibility so the field staff can decide to route some water from Canal #2 to the regulating reservoir, the design flow rate for the pipeline and drainage channel connecting the two main canals is 15 cfs. The estimated elevation change from Canal #2 along the 800-ft alignment to the existing drainage channel is 35 ft. A 21-inch pipeline can safely convey the design flow rate with the existing gradient. The drain channel will be excavated to create extra flow capacity and will continue to serve as an open drain for adjacent fields. According to the district, the elevation change from Canal #2 to Canal #1 along the alignment of the drain is approximately 73 ft (refer to p. 132 in the 2000 report), which corresponds to elevations shown on USGS quad sheets.

The location of the new flow control gate and pipeline alignment are shown in **Figure 18**.

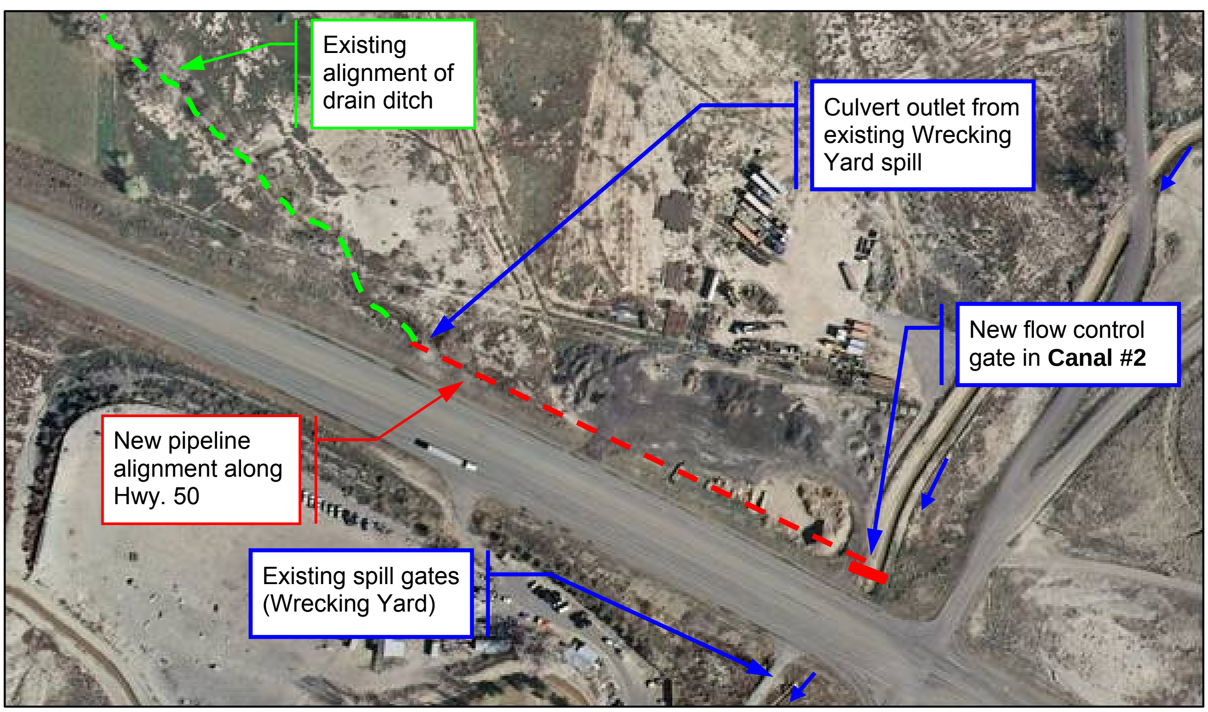

Figure 18. Layout of modifications to Canal #2 at the Wrecking Yard spill site

There are several reasons for locating the new flow control gate upstream of Highway 50 (north side) including:

- It eliminates the need for any (expensive) pipe boring to increase the capacity of the culvert crossing under Highway 50.
- It is expected that with the new operational strategy and upgraded check structures in the upper part of the canal, the flow rates in Canal #2 may be higher than presently as the field personnel will want to keep water in the canal that previously would have been spilled at Fuller Bypass or Sink Creek. If the spill outlet for Wrecking Yard is moved upstream of the highway, it eliminates the need to increase the capacity of the road crossing.

The spill flow rate into the pipeline will be measured on a real-time basis with an electromagnetic flow meter (SCADA-compatible) installed in a concrete vault approximately 25 ft downstream of the entrance.

The schematic in **Figure 19** shows the layout of the modifications to Canal #2 at the Wrecking Yard site. A 4-ft wide sluice gate will be installed in a new reinforced concrete structure. (Note: a rectangular gate is preferable, as opposed to a round canal gate, because the flow rate calibration is simpler and more accurate.) The canal banks upstream of the sluice gate may have to be raised in order to have at least 1 foot of head across the sluice gate.

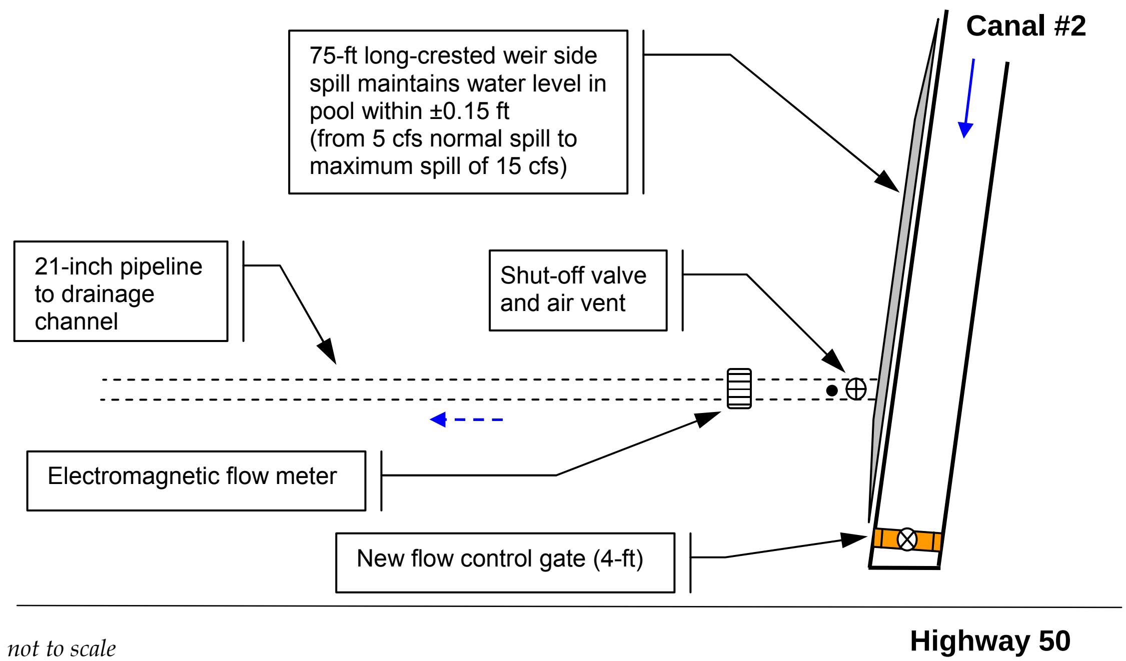

Figure 19. Schematic design the flow control gate and long-crested weir spill in Canal #2 at the Wrecking Yard site

Upgrades to Canal #2 End Spill

Spill at the end of Canal #2 will be routed to Canal #1 via the existing Spill #6 pipeline along Rainbow Drive (**Figure 20**). Historically the combined spill flow rate at the end of Canal #2 (combining Spill #6 and the End Spill) averages about 2 cfs with temporary peaks up to 12-14 cfs (1999-2000). With the modifications to the Wrecking Yard spill and the new pipeline/drain ditch connection to the regulating reservoir, the spill at the end of Canal #2 will be less than it has been in the past. However, for simple and flexible operations Canal #2 will be run with a minimum amount of flow into Spill #6, perhaps 2-5 cfs. It is estimated that the existing pipeline has a capacity of about 4-5 cfs.

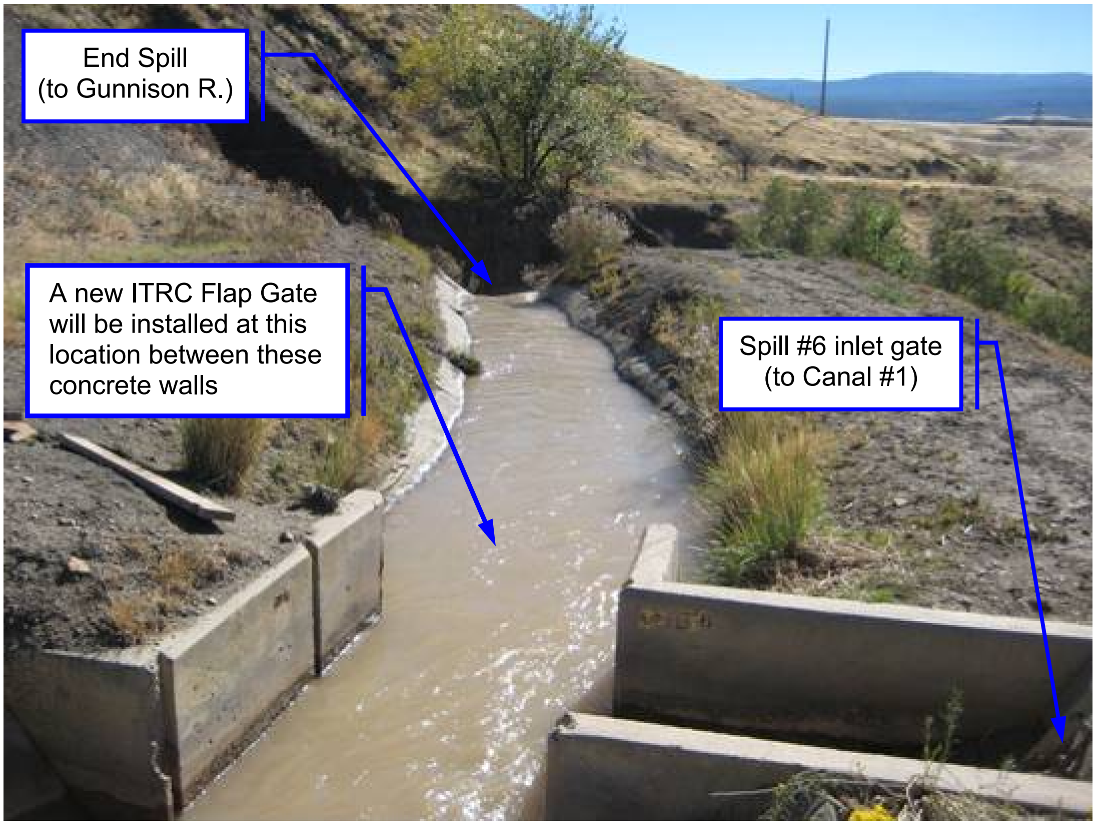

Figure 20. End of Canal #2 upstream of spill outlet to the Gunnison River

The proposed modifications to the end of Canal #2 are illustrated by the schematic sketch in **Figure 21**. To facilitate spill recovery from the end of Canal #2 several modifications will be made. First, an ITRC Flap Gate will be put in the canal immediately downstream of the inlet to the Spill #6 pipeline. An example flap gate installation is shown in **Figure 22**. The flap gate will maintain a constant water level at the entrance to the spill pipeline. To provide for emergency spill, the flap gate will be built to pass a maximum capacity of 30 cfs without overtopping the canal. Under normal conditions, the flap gate will stay closed until the water level starts to encroach on freeboard. Then, if the water gets above the target level, either because of a temporary surge in flow from upstream or because the Spill #6 gate is closed, the flap gate will automatically open and maintain the canal level within ±0.1 ft.

A Replogle flume will be constructed in a modified section of the canal to measure the spill flow rate at this point. Because of the steep slope in the last part of the canal, a 20-ft section of canal upstream of the Spill 6 inlet gate will be excavated and set with a flat horizontal bottom. A SCADA system consisting of a water level sensor, data radio, and solar power system will be installed at the flume to allow field personnel to remotely monitor any spill that occurs at this point.

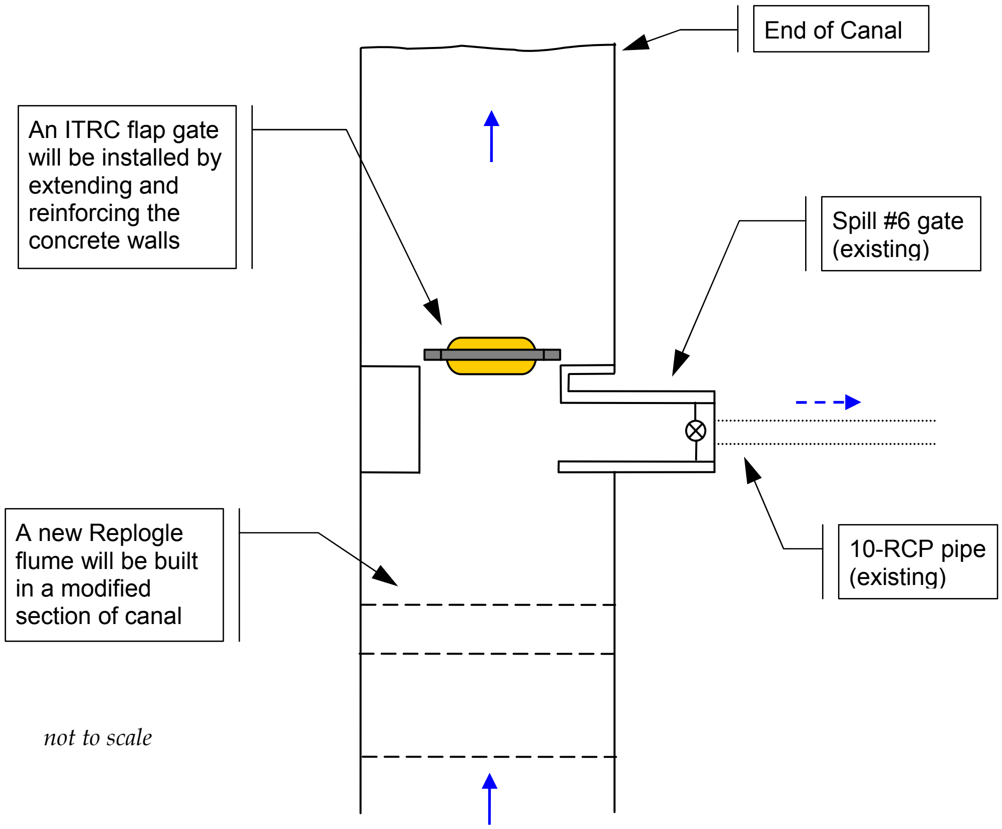

Figure 21. Proposed modifications to the end of Canal #2 at Spill #6

Figure 22. ITRC Flap Gate installed in a canal spill structure (Imperial Irrigation District, Calif.)

Reservoir and Canal Modifications Cost Estimate

The proposed regulating reservoir system is composed of the system improvements summarized in **Table 5** and listed in the *Cost Estimate Summary*. Based on planning-level cost estimates developed for this Conservation Plan, the construction of the reservoir and associated facilities will cost approximately $8.6 million.

Table 5. Cost estimate for the regulating reservoir and associated modifications to Canals #1 and #2

Item	Description	Total Capital Cost ($)
Regulating Reservoir	Land purchase, earthwork, inlet works, VFD-pumped outlet, emergency spill	$6,990,000
Canal #1	Control valves and vault, pipeline from reservoir, earthwork, automated trash screen, modifications to Replogle flume, ITRC Flap Gate, modifications to Rainbow Spill	$1,340,000
Canal #2	Flow control gate, long-crested weir side spill, pipeline to Canal #1, ITRC Flap Gate, modifications to Spill #6	$270,000
Total		**$8,600,000**

Proposed Duck Pond Park and MML Pipeline Recirculation System

Return flows and canal spill from about one-third of the district is conveyed and consolidated in a network of drains that eventually reach Duck Pond Park (the lowest part of the system before water discharges to the Gunnison River). A large drain runs through the park providing an attractive water feature and landscape for the local community as shown in **Figure 23**. Before the park was remodeled there used to be a small pond that covered most of the site.

This proposal envisions making district-level recirculation possible and enhancing the urban wildlife area in the park by expanding the storage capacity of the existing drain with a small buffer pond so that a new pump station can re-capture this drain water before it goes to the Gunnison River. By pumping this water to the end of the new MML pipeline, this recovered water will provide an important supplemental water supply for water conservation in the district.

Figure 23. Drain channel running through the center of Duck Pond Park (looking west)

The pump station will consist of two (2×) 200-HP pumps automated with high-efficiency VFD controllers (each size: 250 HP) to maintain a target water elevation in the pond. The pump will supplement water supplies in the MML pipeline all the way to the booster pump station at Unaweep Avenue. When the inflow to the pond exceeds pumping capacity for short time periods, a long-crested weir outlet will pass spill via the existing culvert crossing and drain to the Gunnison River.

Figure 24 shows that the new pump station in the Park will be easily accessible to the alignment of the end of the MML Pipeline at the corner of Santa Clara Avenue and Aspen Street. The length of the first section of pipeline alignment along Santa Clara Avenue is approximately 1,500 ft with another 300-ft buried connection under the Park to the pump house (total connection length=1,850 ft). The MML Pipeline extension (Phase III) will convey water another 13,000 ft between this junction at Aspen Street and the new booster station at Unaweep Avenue.

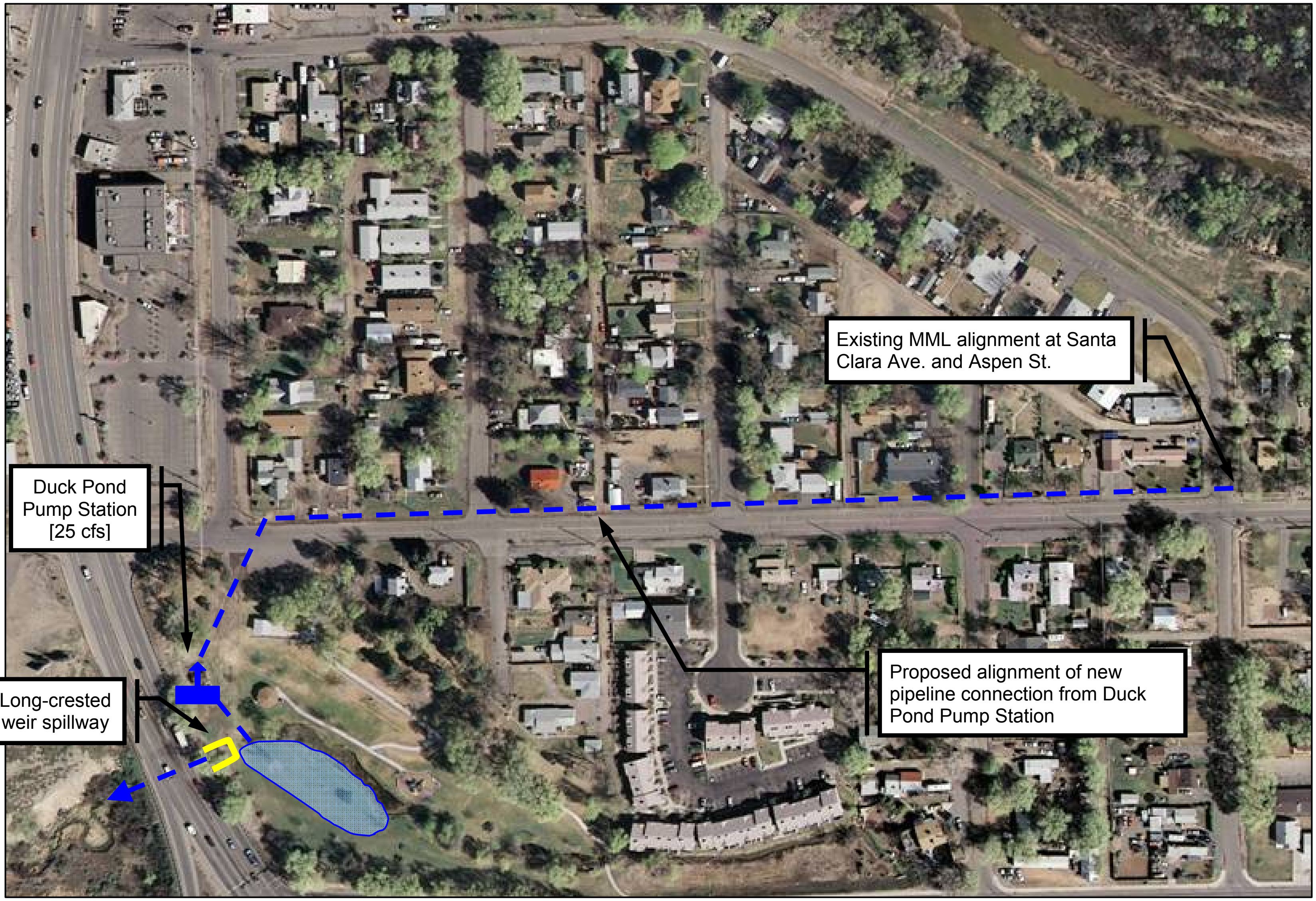

Figure 24. General overview of Duck Pond Park showing proposed system improvements and pipeline connection to the MML system

Extension of the MML Pipeline

The upper portion of the MML lateral has already been converted to a pipeline from the source at Canal #1 down to Unaweep Avenue in two phases (Phases I and II). Separate from this proposal, a pumping plant is being built on the Colorado River near 29 Road (in Grand Junction). This new plant is to replace an existing one that was recently torn down when the 29 Road Bridge was built across the river. However, the system improvements in this proposal will enhance the benefit from the 29 Road Pumping Plant and fully integrate its operation with the Duck Pond Park Recirculation regulating reservoir. It is expected that with the recirculation system and the extension of the MML Pipeline, the 29 Road pumps will operate infrequently, but provide an important supplemental supply.

The end of the existing MML Pipeline, where it will connect to the new incoming pipeline from the 29 Road Pumping Plant, is a 27-inch 125 psi PIP pipeline. The new connection from the 29 Road Pumping Plant will be a 24-inch PVC pipeline (with a flow meter vault near Unaweep Avenue). The 29 Road Pumping Plant will have a design capacity of 14 cfs. This three-way pipe junction will be located on the southside of Unaweep Avenue, just upstream of turnout M34A (at the end of Phase II) (refer to **Figure 1-2** in **Attachment 1**).

Phase III of the extension of the MML Pipeline will run from Unaweep Avenue (at sta. 121+00) to the corner of Santa Clara Avenue and Aspen Street (at sta. 251+07) for a total distance of approximately 13,000 ft (2.5 miles). A 30-inch pipeline will be used for the entire length for ease of installation and cost advantages. There are approximately 50 turnouts that will be upgraded with new control valves on the pipeline.

A short 1,000 ft extension will also be constructed from the corner junction at Aspen Street to replace the open channel of the MML that currently runs along Grand Mesa Avenue. The end of the MML lateral at the spill point to the Colorado River is shown in **Figure 25**.

Figure 25. End of the MML system. The MML spills to the Colorado River at the site shown on the left.

Proposed Duck Pond Park Recirculation Pumping Station

The Duck Pond Park recirculation pump will have a capacity of 25 cfs (2× 12.5-cfs pumps); although the amount of water being pumped will vary from only a few cfs up to 10-20 cfs the rest of the time. The plant will be equipped with a VFD so that the water level in the new expanded pond is maintained within fairly tight tolerances. Because of this control strategy – upstream water level control – the pond level will not fluctuate up and down, which is desirable for recreation in the park. In addition, a long-crested weir outlet will eliminate the possibility of over-topping or flooding – any excess flow will be safely passed through the same drainage channel to the Gunnison River.

A new pump building is proposed to be built in the west end of the Park in the approximate area shown in **Figure 26**. The pumps and VFD will be housed in an air-conditioned control building. Physical upgrades will include a new spillway, trash screen, pump intake and pipelines. The pump house will be built to minimize disturbance or excessive noise. In addition, funds have been included in this proposal for upgrading benches, gazebos, etc. to further add to the public facilities in the park.

Figure 26. Proposed location for new lift pump station and control building

Booster Pump Station

A key component of making the proposed system improvements work effectively is the installation of a new booster pump station at the junction of the MML pipeline extension near Unaweep Avenue (2× 125-HP pumps). The control strategy for the booster pumps will work with a VFD controller and sensors that turn the pumps on when the pressure on the Duck Pond Park side is 11 psi and then off at 5 psi (refer to the control diagram in **Figure 27**). The final selection of control pressures for the design will depend on the pump curves. It is expected that the control logic will attempt to maintain a target pressure in the pipeline of approximately 8 psi. The SCADA controls will have additional functionality to not allow the booster pump to turn on if the regulating reservoir is already full.

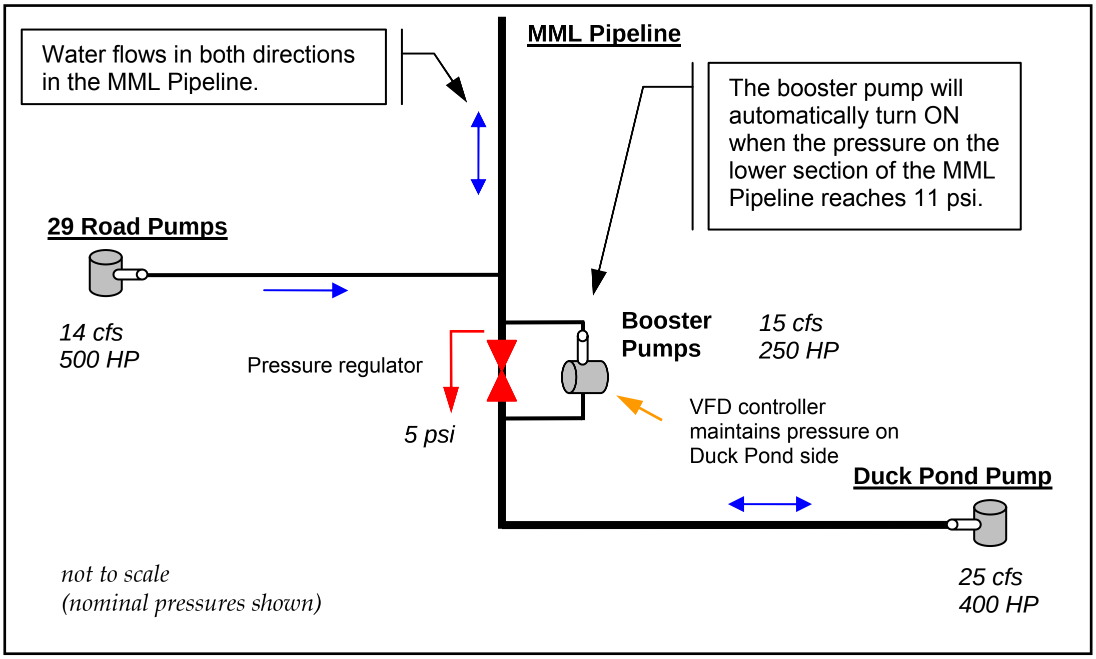

Figure 27. Control diagram for the MML Pipeline booster pump station

Duck Pond Park Recirculation System Cost Estimate

The proposed recirculation system at Duck Pond Park is composed of the system improvements summarized in **Table 6** and listed in the *Cost Estimate Summary*. Based on planning-level cost estimates developed for this Conservation Plan, the construction of the lift pump station, pipeline, and associated facilities will cost approximately $5.6 million.

Table 6. Cost estimate for the Duck Pond Park Recirculation System

Item	Description	Total Capital Cost ($)
Duck Pond Park Pump Station	Pump, VFD, SCADA, earthwork, pipeline connection to the MML Pipeline	$1,380,000
Booster Pump Station	Pump, controls, junction vault	$510,000
MML Pipeline Extension	Pipeline, road crossings, replacement turnouts and valves	$3,660,000
Total		**$5,550,000**

SCADA System

SCADA is a valuable tool with potential for enhancing water management in Orchard Mesa ID. The SCADA component of this proposal will involve the design, deployment, calibration, documentation, and verification of industrially-hardened hardware and software for new pump and canal control infrastructure that can be remotely accessed in real-time from a base station computer and mobile interface terminals running human-machine interface (HMI) software.

The proposed SCADA system will improve the reliability and flexibility of water deliveries throughout the service area. Other benefits of SCADA, besides real-time water accounting for decision-making about where and how to adjust the system, will be upgraded record keeping capabilities for historical analysis and forecasting, and faster response times to user inputs and alarms. Web-based reporting of public access for water use or water quality datasets will also be facilitated by this well-designed SCADA system.

The SCADA sites covered in this section are listed in **Table 7** with a summary of their functional purpose. The project encompasses automated VFD-equipped pumps controls, automated control of canal sluice gates, electronic flow measurement devices, mobile interface terminals, and computer and communications support systems at the office with alarming, report generation, and data management capabilities.

Table 7. Orchard Mesa ID SCADA sites and functions

No.	Location (Name)	Automatic Control	Remote Manual Control	Remote Monitoring	Base Station	Radio System
1	Main Pumping Plant			√		
2	Regulating Reservoir	√				
3	Duck Pond Park Pump Station	√				
4	29 Road Pumping Plant		√			
5	B ¼ Road Pump Station		√			
6	Booster Pump Station	√				
7	Canal #1 Flow Control Valve		√			
8	Canal #2 Flow Control Gate			√		
9	Canal #1 Rainbow Spill			√		
10	Canal #1 End Spill (Duck Pond spill)			√		
11	Canal #2 End Spill (Spill #6)			√		
12	Wrecking Yard Spill			√		
13	Office and Mobile Base Station				√	
14	Radio Repeater Station					√

General Guidelines

The major components of the SCADA system will be the Remote Terminal Units (RTUs) containing the Programmable Logic Controllers (PLCs) and various electrical components, the master base station (hardware and software) at the office, radio communications equipment, and various field instruments and measurement devices (refer to **Figure 28**). The new SCADA sites will utilize leading-edge technology compatible with ITRC's control code algorithms.

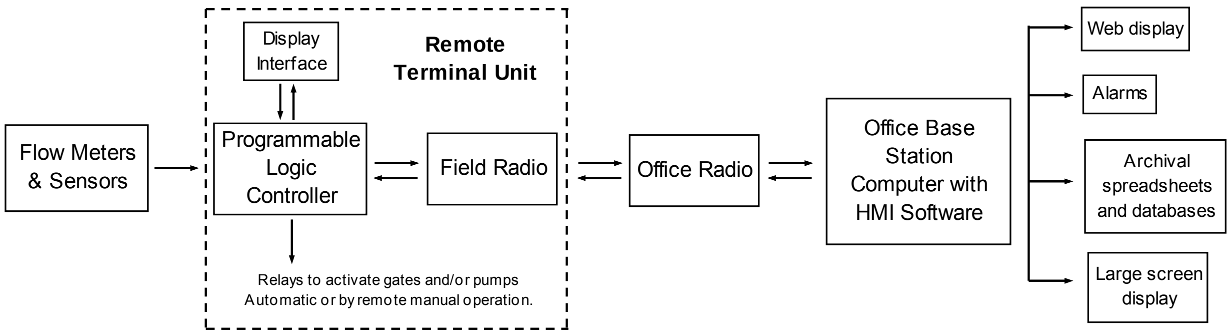

Figure 28. Components of an irrigation district SCADA system

The use of robust equipment and software conforming to standardized specifications, along with following some basic rules and practical techniques, will ensure the implementation of a properly engineered SCADA system that is reliable and prepared for future expansion. The design of the new SCADA system shall be guided by the following overall requirements:

- Open system architecture
- A robust high-speed data radio network
- Industry standard hardware components
- System scalability
- High system reliability with redundancy of critical systems
- Configuration using off-the-shelf Windows-based software
- Distributed environment with automatic recovery and restart

The final details of the SCADA system will be defined in an *Automation Plan and SCADA Specifications* technical report (part of the RFP to be prepared by the district). There are several integration firms with experience working with water agencies in the western Colorado that can bid to set up the SCADA system once the final specifications are prepared. The specific products they use vary depending on the job, but the design and implementation of the Orchard Mesa ID system will conform to detailed performance-based specifications developed in coordination with the district.

The development of SCADA specifications involves a series of steps:

1. Meetings and field visits to identified sites to determine hardware and software requirements, along with any construction or structural modifications involved
2. Presentation to district staff and board members of the automation and monitoring plan
3. Simulation modeling and developing of the control code and algorithms constants
4. Radio testing and a thorough evaluation of the communication options
5. Preparation of the final SCADA & Engineering Specifications
6. Requests for Proposals (RFP)
7. Construction, implementation, calibration, testing, etc.
8. Field verification
9. Training and on-site service support

Base Station and HMI Specifications

Remote monitoring of the project sites in the SCADA system shall be done from the base station located at the headquarters office in Palisade, California (located adjacent to the Main Pumping Plant). The base station shall be equipped with the tools required to communicate with the SCADA sites, display information on a computer screen, make changes to devices at the RTUs, and store historical data accumulated from the RTUs. This will be accomplished using a dedicated desktop computer running specialized Human-Machine Interface (HMI) software. All operational data, system setup, and configuration data, and all information regarding the status of monitored input channels, will be accessible in the HMI software.

The SCADA base station at the headquarters office will operate as a stand-alone, autonomous system, monitoring sensors, displaying data, outputting controls, activating alarms and logging information to facilitate on-going operations. Control Microsystems ClearSCADA management software (version 2007), or an approved equivalent, will be installed and configured with user-customizable screens as the HMI platform for the base station and web-based clients. The base station shall be capable of polling, transmitting and receiving data (both analog and digital), via secure high-speed digital radios, with multi-level password security.

The arrangement, readability, and sequencing of the HMI screens have a major influence on how easy it is for managers and field personnel to use the SCADA system. The basic configuration of the required HMI screen layering is illustrated in **Figure 29**. An example of a well-designed HMI engineering screen for an irrigation pumping plant is shown in **Figure 30**. As the detailed HMI planning is becomes more defined, it is expected that Orchard Mesa ID may choose to add additional features to some sites and/or re-arrange how grouped sites are navigated. Careful preparation at this stage shall save money and hassles later and make it easier for the HMI programmer to deliver a product that meets the district's needs.

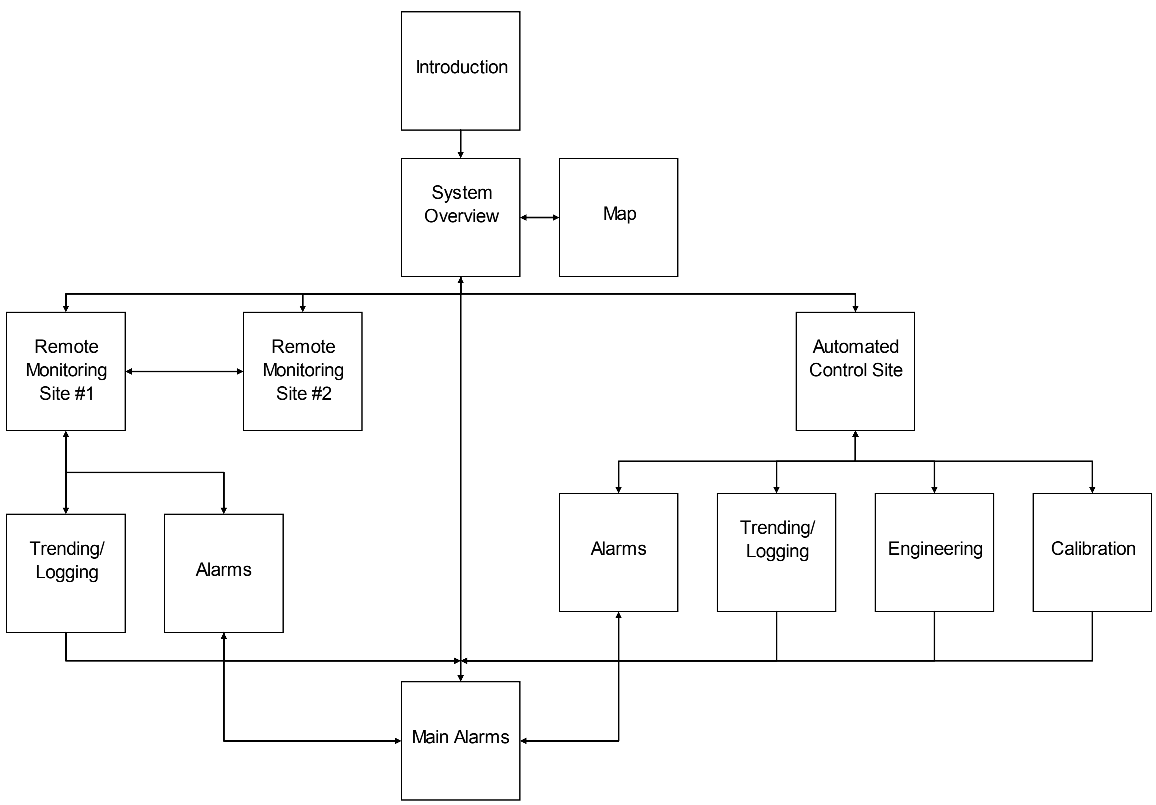

Figure 29. Basic navigation configuration of HMI screens

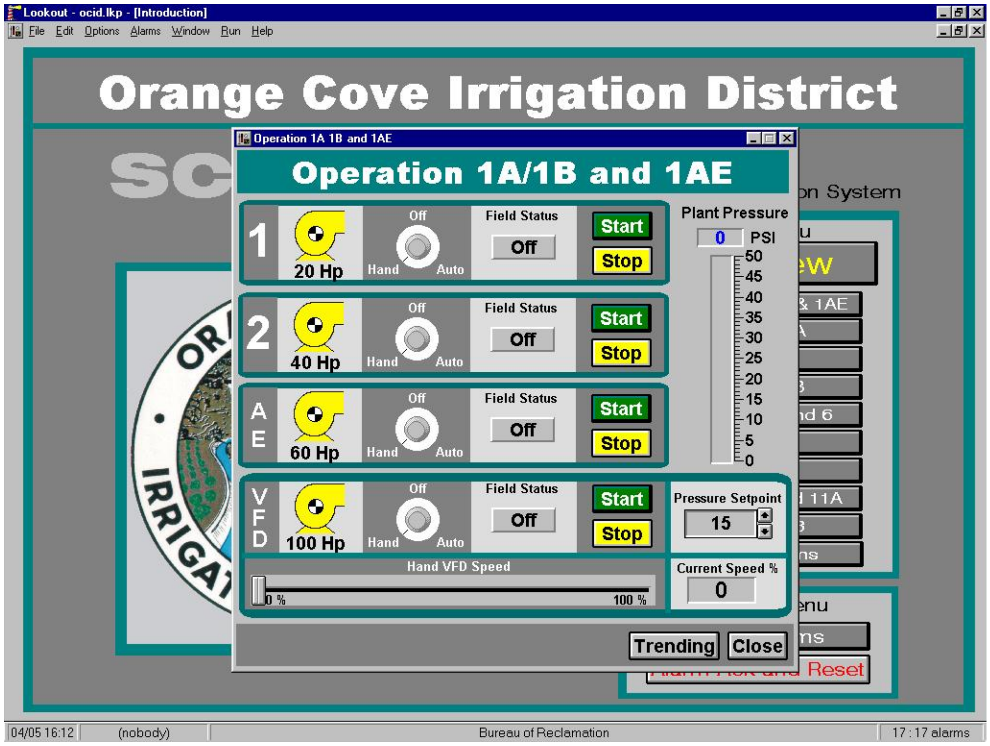

Figure 30. Example of a well-designed HMI engineering screen for an irrigation pumping plant (Orange Cove ID, Calif.)

Radio Test Results

As part of the 2000 report, ITRC and the USBR conducted preliminary radio frequency engineering analysis with signal path testing to determine if communications with an unlicensed (900 MHz spread spectrum) would be reliable and reach all sites in Orchard Mesa ID. 900 MHz spread spectrum radios have several advantages over other types of radios including high speed, security, cost, and the fact that no FCC license is required. The radio test results indicated that signal strengths and signal-to-noise ratios were in acceptable ranges (refer to Attachment P in the 2000 report). A potential location was identified for a repeater station on a small hill (elevation 5,040 ft) southwest of the district office.

Final radio testing will have to be done prior to arranging the lease in order to verify good communications between each of the 12 field sites, the radio repeater, and the district office.

Equipment Requirements at the Base Station

The following items will be provided and installed at the Orchard Mesa ID Base Station:

- Office computer system (high-performance dual hard-drive server)
- 24-inch widescreen monitor
- 2× mobile SCADA laptops (hardened)
- HMI software program
- Color laser printer (network enabled)
- 900 MHz master data transceiver radio
- Alarm autodialer system
- UPS
- Omni antenna
- Antenna mast or tower
- Antenna cable

Equipment Requirements for Sites with Automatic or Remote Manual Control

Regulating Reservoir

The following items will be provided and installed at the Regulating Reservoir:

- RTU (district standard)
- LCD display (touch screen)
- 4× water level sensors
- 2× gate position sensors
- Electromagnetic flow meter
- 900 MHz master data transceiver radio
- 2× stilling wells
- 2× staff gauges
- VFD
- Control panels, misc. electrical hardware
- Limit switches
- HOA switches
- Control building
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Duck Pond Park Pump Station

The following items will be provided and installed at the pump station in Duck Pond Park:

- RTU (district standard)
- LCD display (touch screen)
- 2× water level sensors
- 2× Electromagnetic flow meters
- 900 MHz master data transceiver radio
- 2× stilling wells
- Staff gauges
- 2× VFDs
- Control panels, misc. electrical hardware
- HOA switches
- Control building
- Yagi antenna
- Antenna mast or tower
- Antenna cable

29 Road Pumping Plant

The following items will be provided and installed at the pump station in the 29 Road Pumping Plant (this SCADA equipment will be incorporated into the construction of the new plant):

- RTU (district standard)
- LCD display (touch screen)
- 900 MHz master data transceiver radio
- Yagi antenna
- Antenna mast or tower
- Antenna cable

B ¼ Road Pump Station

The following items will be provided and installed at the pump station in the B ¼ Road Pump Station:

- RTU (district standard)
- LCD display (touch screen)
- 900 MHz master data transceiver radio
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Booster Pump Station

The following items will be provided and installed at the pump station in the Booster Pump Station:

- RTU (district standard)
- LCD display (touch screen)
- 2× pressure sensors
- 2× Electromagnetic flow meters
- 900 MHz master data transceiver radio
- Control building
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Canal #1 Flow Control Valve

The following items will be provided and installed at the Canal #1 Flow Control Valve:

- RTU (district standard)
- LCD display (touch screen)
- 2× water level sensors
- 2× gate position sensors
- 900 MHz master data transceiver radio
- Stilling well
- Staff gauge
- Vandalism enclosure
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Equipment Requirements for the Remote Monitoring Sites

Main Pumping Plant

The following items will be provided and installed at the Main Pumping Plant:

- Computer that is linked to the base station
- RTU (district standard)
- LCD display (touch screen)
- 4× electromagnetic flow meters
- 4× water level sensors
- 8× thermistors
- Vibration sensor system
- 900 MHz master data transceiver radio
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Canal #2 Flow Control Gate and Wrecking Yard Spill

The following items will be provided and installed at the Canal #2 Flow Control Gate (including the Wrecking Yard Spill because they will share a single RTU):

- RTU (district standard)
- LCD display
- 2× water level sensors
- Gate position sensor
- Electromagnetic flow meter
- Solar power charging system (12 V)
- 900 MHz master data transceiver radio
- 2× stilling wells
- 2× staff gauges
- Vandalism enclosure
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Canal #1 Rainbow Spill

The following items will be provided and installed at the Canal #1 End Spill:

- RTU (district standard)
- LCD display
- Water level sensor (ultrasonic)
- Solar power charging system (12 V)
- 900 MHz master data transceiver radio
- Staff gauge
- Vandalism enclosure
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Canal #1 End Spill (Duck Pond Spill)

The following items will be provided and installed at the Canal #1 End Spill:

- Replogle flume
- Modified trash rack
- RTU (district standard)
- LCD display
- Water level sensor
- Solar power charging system (12 V)
- 900 MHz master data transceiver radio
- Stilling well
- Staff gauge
- Vandalism enclosure
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Canal #2 End Spill (Spill #6)

The following items will be provided and installed at the Canal #2 End Spill (Spill #6):

- Replogle Flume
- RTU (district standard)
- LCD display
- Water level sensor
- Solar power charging system (12 V)
- 900 MHz master data transceiver radio
- Stilling well
- Staff gauge
- Vandalism enclosure
- Yagi antenna
- Antenna mast or tower
- Antenna cable

Cost Estimate for the SCADA System

The proposed SCADA components to be installed as part of the system improvements are summarized in **Table 8** and listed in the *Cost Estimate Summary*. Based on planning-level cost estimates developed for this Conservation Plan, the implementation of the SCADA system will cost approximately $525,000, although the final cost depends on many factors including how much of the engineering and electrical work is done by the district.

Table 8. SCADA system cost summary

Item	Total Capital Cost[1] ($)
Base Station	$64,800
29 Road Pumping Plant	$25,700
B ¼ Road Pump Station	$37,000
Canal #1 Flow Control Valve	$49,200
Main Pumping Plant	$111,700
Canal #2 Flow Control Gate	$47,800
Wrecking Yard Spill	$14,400
Canal #1 Rainbow Spill	$36,100
Canal #1 End Spill (Duck Pond Spill)	$36,800
Canal #2 End Spill (Spill #6)	$36,800
Radio Repeater Station	$65,000
Total	**$525,000**

[1]This does not include the SCADA-related costs for the Regulating Reservoir, the Duck Pond Park recirculation system. Those costs are embedded in separate budgets with the pumps and control systems.

Upgraded Check Structures in Canals #1 and #2

Modernization of the Orchard Mesa ID canal system will involve upgrading the existing main canal check structures to improve water level control and installing several new additional check structures at selected locations. The operation of the main canals will be simplified while allowing flow changes to occur without causing large fluctuations in canal water levels. Present canal operations are characterized by high diversions that are necessary to keep the canals full enough for the turnouts to be operated with sufficient head. If the canal flow is reduced then the lower water surfaces will not provide enough head on the turnouts for irrigators to take their entitled flow rates. There are only a few functioning check structures in the system. This contributes to the amount of canal spill that leaves the boundaries of the district, creates operational hassles, and results in less than optimum service for users.

The selected design is a *long-crested weir*. Long-crested weirs are a practical solution for upgrading canal check structures; many irrigation districts have implemented programs to progressively upgrade their systems with long-crested weirs using a wide variety of construction techniques. Several design recommendations are emphasized in this section that incorporate technical features ITRC has observed in successful applications elsewhere.

These new check structures will also be an integral component of the future modernization strategy to utilize the regulating reservoir to buffer discrepancies in main canal flows. By upgrading the regular flashboard checks in the main canals, flow rate changes can be routed through the system faster with minimal impact on turnout deliveries or the flows set into laterals.

An example of an existing Orchard Mesa check structure is shown in **Figure 31**. Each time the flow in the canal is adjusted to meet changes in demand at some point in the system, all intervening check structures and turnouts have to be re-regulated, along with adjusting spill structures, to ensure turnout flows remain constant. Because of the travel time in the canal and the fact that field personnel cannot make all these changes at exactly the right moment or in precisely correct amount, variations in turnout flows take place. Thus, even when only a few turnouts are taking deliveries, the canals are kept nearly full.

Figure 31. Check structure in Orchard Mesa ID in Canal #1 at Turnout 1-68

Locations

There are a total of six (6×) existing check structures in Canal #1 between the headworks and the start of the MML Pipeline. Canal #2 has two (2×) functioning check structures that are used by field personnel. All these existing check structures will be upgraded with long-crested weirs, plus several more will be installed at key locations.

As part of the 2000 report, ITRC conducted hydraulic simulation modeling of existing and expected flow conditions in Canal #1to determine the appropriate location of new 5 check structures. **Table 9** summarizes the locations for the new long-crested weir check structures in both Canals #1 and #2. A total of 15 long-crested weirs will be built under this proposal.

Table 9. Locations and dimensions of proposed long-crested weir check structures

No.	Canal	Location (Sta.)[1]	Existing or New	Estimated Design Flow	Weir Crest Length
1	Canal #1	1064+64	Upgrade existing	90	65
2	Canal #1	1099+00	New	90	65
3	Canal #1	1144+96	Upgrade existing	80	60
4	Canal #1	1195+62	New	80	60
5	Canal #1	1246+29	Upgrade existing	75	60
6	Canal #1	1305+02	New	65	55
7	Canal #1	1363+76	Upgrade existing	60	50
8	Canal #1	1486+00	New	50	45
9	Canal #1	1532+74	Upgrade existing	50	45
10	Canal #1	1580+40	New	50	45
11	Canal #1	1635+80	Upgrade existing	50	45
12	Canal #2	171+60	New	70	60
13	Canal #2	343+20	Upgrade existing	60	50
14	Canal #2	500+00	New	50	50
15	Canal #2	686+40	Upgrade existing	40	40

[1] Refer to the 2000 report for stationing information in Canal #1. Canal #2 stations were estimated.

A plot of the proposed weir locations in Canal #1 and the modeled water profile results is shown in **Figure 32**.

The concept of a long-crested weir design is simple – the additional (longer) weir length makes it possible to pass a variety of flow rates through the canal with only a small change in the elevation of the water surface. From an operations point of view this means that compared to shorter crested check structures, large changes in flow rate over the long-crested weir will result in smaller changes in head, leading to minimal changes in the flow into the upstream laterals. Long-crested weirs are recommended in many cases (as opposed to solely computerized canal gates) because they are simple, reliable, and easy to construct. (Note: Long-crested weirs are used to control the water surface elevation and are not intended to be used for flow measurement.)

OMID Canal #1

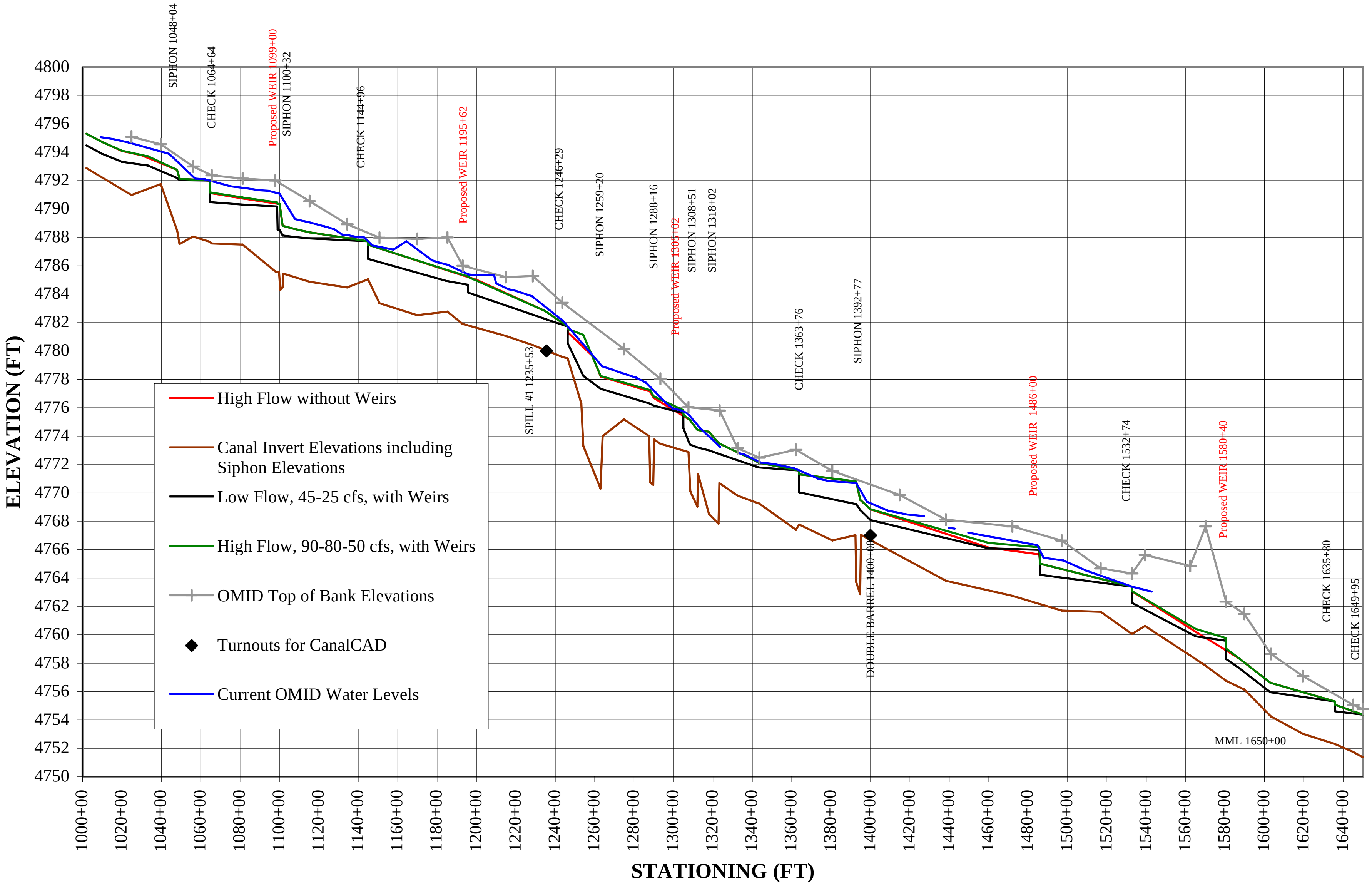

Figure 32. Locations of proposed long-crested weir check structures in Canal #1
(Source: Water Management Study, Orchard Mesa Irrigation District, December 2000)

Advantages of Long-Crested Weir Designs

Long-crested weirs allow for a simple operation, creating more constant flow rates at turnouts and lateral headgates while at the same time allowing canals to be operated more flexibly. Reasons for installing long-crested weirs include:

a. Better water delivery service to turnouts. The head on turnout gates does not vary nearly as much with time.
b. Less rodent damage to canal banks. If the water levels are more stable, the rodents will not have as much opportunity to dig into wet, but unsaturated, soil.
c. Fewer accidental spills; low-risk inherent safety
d. Ability to operate at higher flow rates. If the water can be maintained at more stable levels, with a high degree of confidence, then the canals can be operated with less freeboard – allowing higher flow rates.
e. Less need for frequent visits by field personnel to check on and adjust the settings of flashboards or gates.
f. More effective water level control with less labor input, an essential part of the vision for modernization. The adding or removing of weir boards should only be needed for pre-planned large flow rate changes.

Design Criteria

Key design elements are the length of the weir crest and the elevation of the weir crest relative to the target canal water level. Typical design criteria are based on keeping main canal water level fluctuations to within a range of 0.10-0.25 ft, even after a major change in flow rate. The specific design criteria used to determine the design length, layout, and elevation of the long-crested weirs in main canals are as follows:

- For a major change in the canal flow rate (e.g., up to a ±50% increase or decrease), the turnout/headgate delivery flow rate should not change by more than ±10% without any adjustment to either the check structure or the turnout gate; this criteria is based on an assumed critical turnout head of 1.0 ft. This considers future operational demands in the system, not just what is needed now.
- Long-crested weir check structures at the downstream end of the canals should be designed to handle large enough flows to deal with emergency inflows from storm runoff or unexpected gate closures.
- The top 0.5 feet of the walls consists of a row of flashboards or angle iron to permit easy post-construction field adjustment of the final controlled water elevation.
- There must be a mechanism for flushing accumulated sediment from upstream of the weir. For example, an 18-inch canal gate on the downstream end will allow easy flushing whenever necessary. These gates should be left open about 6 inches for continuous flushing.
- The longer the weir, the better it can control the water level upstream of the weir for a large change in flow rate. Long-crested weirs provide a robust structure for safely handling emergency spills.

For medium-sized canals (30-60 cfs) like most cases in Orchard Mesa, a practical design has been developed based on a steel frame and walkway structure with multiple flashboard bays. An example of a steel and flashboard long-crested weir is shown in **Figure 33**. First, a 12-inch concrete pad is placed, with footings if necessary (weep holes are needed for ones pointing upstream). Steel angle iron and channel iron provide structural strength and can be fabricated in a variety of customized sizes. The concrete floor also prevents erosion problems. This design should be built with a tapered nose to avoid having to widen the canal around the structure.

Figure 33. Recommended long-crested weir design (example from Chowchilla WD, Calif.)

Another example using concrete walls is shown in **Figure 34**. This type of design is compatible with the existing conditions in upper parts of the main canals and basically consists of 6-inch concrete walls with a row of flashboards on top. However, the designs in Orchard Mesa ID should be pointed downstream to allow easy silt flushing.

Figure 34. Recommended long-crested weir design (example from San Luis Canal Co., Calif.)

Figure 35 shows the recommended configuration and layout of the new check structures to be installed in Canals #1 and #2.

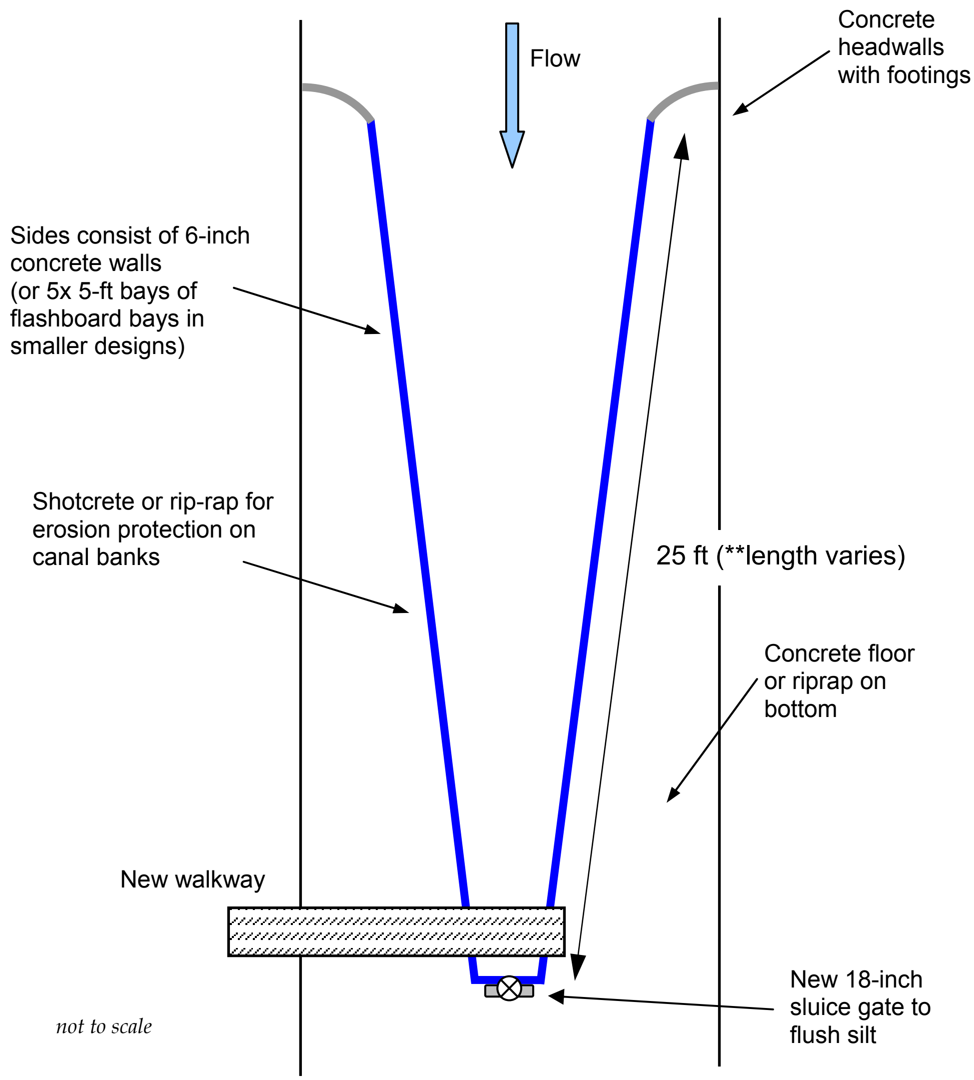

Figure 35. Conceptual layout of a 50-ft long-crested weir check structure in Orchard Mesa ID

Construction Features

Long-crested weirs have been built from a variety of materials including concrete, wood and steel. The best design is one that is easy to build, robust, flexible in operation, and cost-effective. The design in **Figures 3s** and **35** has the following features:

- The structures are inherently stable and strong. In the flashboard design, the walkway provides structural stability for the walls.
- Slotted flashboard bays allow field personnel maximum flexibility in setting the final target water level elevation. In the concrete design, the row of boards on the concrete walls serves the same function.
- Silt can be easily flushed anytime by removing one set of flashboards at the downstream end or opening the 18-inch silt flushing gate.
- The same basic design can be utilized for different weir crest lengths. In the flashboard designs this is done by adding more 5-ft flashboard bays on the sides of the structure.

Cost Estimate for Long-Crested Weirs

The proposed check structures (new and upgrades) to be done as part of the system improvements are summarized in **Table 10** and listed in the *Cost Estimate Summary*. Based on planning-level cost estimates developed for this Conservation Plan, the construction of the long-crested weirs will cost approximately $450,000, depending on the extent of engineering and construction done by the district.

Table 10. Long-crested weir cost summary

Item	No.	Total Capital Cost ($)
Canal #1	11	$340,000
Canal #2	4	$110,000
Total	**15**	**$450,000**

COST ESTIMATE SUMMARY

As presented in **Table 11**, a planning-level cost estimate for the complete system improvements in this Water Resources Conservation Plan is approximately $15.5 million (annualized at $1.2 million; assuming a 6% discounted interest rate). The Regulating Reservoir, with associated canal improvements, and Duck Pond Park Recirculation Systems account for the majority of the implementation budget at $9 million and $5.5 million, respectively.

For planning purposes, detailed estimates for the required infrastructure modifications, reservoir controls and pump station hardware, and control and monitoring equipment are summarized in **Attachment 4**. The project budgets include estimates for the final design and engineering expenses, civil works and excavation, plus contingencies. Reported estimates are based on a preliminary analysis of the required physical modifications, without having a completed topographic survey database of the proposed civil works alignments, right-of-ways, land purchase agreements, etc.

Table 11. System Improvements Cost Summary for Construction Costs and SCADA

Component	Total Construction Cost	Annualized Capital Costs	Annual O&M Costs
Regulating Reservoir	$8,600,000	$570,000	$45,000
Reservoir, pumps, control, and earthwork	*($6,990,000)*		
Canal #1 controls and measurement	*($1,340,000)*		
Canal #2 controls and measurement	*($270,000)*		
Duck Pond Park Recirculation System	$5,580,000	$390,000	$260,000
Pump Station, earthwork at Park	*($1,400,000)*		
MML Pipeline extension	*($3,660,000)*		
Booster Pump Station	*($525,000)*		
SCADA System	$530,000	$49,000	$28,000
Long-Crested Weir Check Structures	$450,000	$29,000	$7,000
Canal #1	*($340,000)*		
Canal #2	*($110,000)*		
Total	**$15,200,000**	**$1,040,000**	**$340,000**

Orchard Mesa ID intends to fully contract the work described in this proposal, including construction management and inspection, and does not intend to contribute in-kind services towards its completion.

Annual O&M costs are estimated to be about $340,000, of which electric energy for pumping accounts for about $200,000 (~60%).

ATTACHMENT 1
Estimate of Spill Water from Urban Laterals in Mixed Residential Areas

Attachment 1
Spill Water Recycling at Duck Pond Park

In order to estimate the amount of water that will be recycled from the drain in Duck Pond Park, an analysis was done of water deliveries, consumptive use (*ET*), and spill in the MML area according to the following assumptions. This representative area was selected because it is a well-defined part of the urban/residential area below the Wrecking Yard Spill site (2,740 acres), and importantly all the spill points in this were measured in 1999 and 2000. Thus, values for spill on a *per unit area basis* could be developed.

- Roughly 50% of the service area in the urban/residential areas is "landscape" (i.e., is physical area that is irrigated).
- The amount of water consumption of these landscaped areas is approximately equal to grass reference evapotranspiration (i.e., the ET_o from a well-watered grass).
- The amount of deep percolation is based on an assumed application efficiency of 50%.
- The remaining amount of water delivered to the area either spills from the main canals or laterals, or goes into the community drains.

Using a hydrologic balance approach for the sub-region defined by the 2,740-acre urban area, the various destinations and quantities of the supplied irrigation water were estimated using available historical data. As shown in **Figure 1-1**, the remaining part of the irrigation water that is supplied to the area for consumptive use (*ET*) can either deep percolate or result in spill from the MML and/or from urban laterals. Under this proposal the amount of applied irrigation water will stay the same, but the system improvements will target water savings from the spill that results from the MML system and urban laterals.

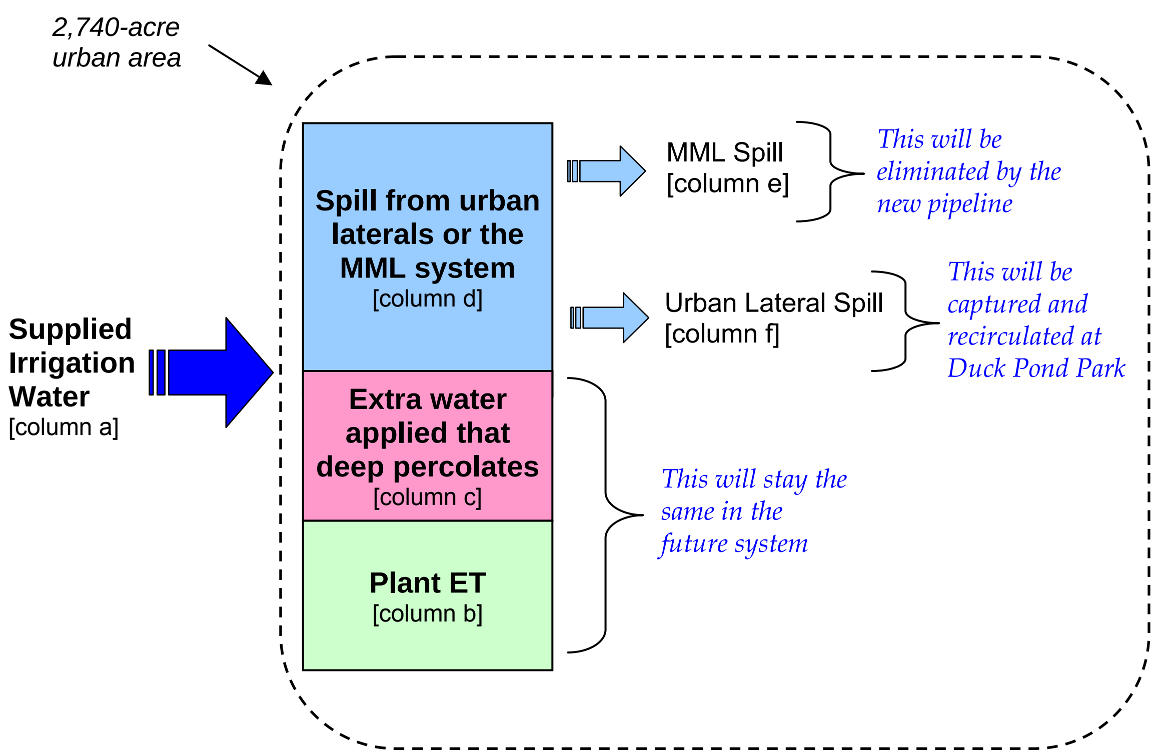

Figure 1-1. Destinations of supplied irrigation water in the urban area showing the potential for future water conservation savings (refer to the columns in Table 1-1 for estimates on per unit area basis)

The calculation of the amount of spill water that routes to the Duck Pond Park from urban/residential areas (via urban laterals) is summarized in **Table 1-1**. A key assumption in the development of the system-level control strategy described in this report deals with the near impossibility of getting large numbers of homeowners and tenants to collectively change their behavior by reducing their turnouts from the MML pipeline or other laterals. Instead, the most effective strategy is one that focuses on recovering the spill that occurs and recycling it so that overall demand from the main pumping plant can be reduced accordingly.

Mean water deliveries in the MML service area are in the range of 7 to almost 10 gpm per acre based on delivery records for 2000 to 2006. At maximum pumping rates, the established water right is approximately 9 gpm per acre (when 171 cfs is pumped into Canals #1 and #2). During the site visit to the district in October 2007, the flow rate being delivered to 520 acres in the lower part of the MML lateral (below the end of the existing Phase II pipeline) was measured to be 7 gpm per acre (8.1 cfs in the area). In the summer, water deliveries to this part of the MML lateral are about 20% higher (8.5 gpm/acre), which was roughly verified during the visit by measuring the flow again after the in-line control valve was adjusted to normal summertime settings.

Figure 1-2. Current metering in the MML lateral (October 2007) at Unaweep Avenue (at turnout M34A)

The mean ET_o measured at the Grand Junction CoAgMet station ranged from approximately 1.6 to 5.4 gpm per acre between April and October, with the peak demand in June and July. Assuming that only 50% of the land surface is actually landscaped <u>and</u> irrigated in typical residential areas, the equivalent consumptive demand is about 0.8-2.7 gpm per acre (refer to column b in **Table 1-1**). Deep percolation was estimated based on an assumed application efficiency of 50% as shown by column c in the table.

Of the possible destinations for the canal water entering the area, the spill is the amount of water remaining after consumptive use and deep percolation occurs. Therefore, the estimated amount of spill from the irrigated areas of land would be 4 to 6 gpm per acre as shown in column d of the table. If this total area-wide estimate is reduced in order to account for the spill that was measured at the external spills along the MML – which does not go to Duck Pond Park – the urban lateral portion of spill accounts for about 3-5 gpm per acre as summarized in column f. In other words, for example, if 9.0 gpm per acre is delivered in September, then about 5.2 gpm per acre shows up as potentially recoverable spill at the Duck Pond Park.

Table 1-1. Calculation of estimated per unit area spill flow rates during the irrigation season that reach the Duck Pond Park and can be recycled in the Orchard Mesa ID system

Mo.	[a] Mean water deliveries[1] (gpm/acre)	[b] Consumptive use in residential area[2] (gpm/acre)	[c] Deep percolation (gpm/acre)	[d=a-b-c] Total amount that spills either from canal or runs into a drain (gpm/acre)	[e] Total Spill from the MML to the River[3] (gpm/acre)	[f=d-e] Spill from urban laterals that goes to Duck Pond Park (gpm/acre)
April	7.2	1.5	1.5	4.2	0.6	3.6
May	9.3	2.1	2.1	5.1	0.6	4.5
June	9.5	2.7	2.7	4.1	0.7	3.4
July	9.6	2.7	2.7	4.1	0.7	3.4
Aug	9.3	2.2	2.2	5.0	0.8	4.2
Sept	9.0	1.5	1.5	6.0	0.8	5.2
Oct	7.0	0.8	0.8	5.4	0.8	4.6

[1] Based on the average amount of water pumped into Canals #1 and #2 between 2000-2006
[2] Based on mean reference evapotranspiration data from CoAgMet weather station in Grand Junction, Colorado between 2000-2006
[3] Includes Unaweep, MML and MML End spill points

At the Duck Pond Park, this historical spill estimate ends up being the equivalent of up to 30 cfs in the fall [2,740 acres × 5.2 gpm/acre × 1 cfs/449 gpm = 31.7 cfs] and about 20 cfs in the summer. However, this gross value has to be reduced to account for the fact that some of the spill in this area is recovered from the B ¼ Road Pump Station. Assuming that the B ¼ Road pumps would be operated on average about 50% of the time, then the equivalent CFS is approximately 19 to 30 cfs as shown in column c of **Table 1-2**.

Table 1-2. Estimated urban lateral spill in the lower residential/urban 2,740-acre portion of Orchard Mesa ID

Mo.	[a] Total GPM of historical urban lateral spill at Duck Pond Park (column f in Table 1-1 multiplied by 2,740 acres)	[b] Net Spill GPM reduced based on B ¼ Road Pumps operating 50% of the time	[c] Column b converted to CFS
April	9,840	8,940	20
May	12,270	11,370	25
June	9,400	8,500	19
July	9,380	8,480	19
Aug	11,630	10,730	24
Sept	14,310	13,410	30
Oct	12,630	11,730	26

ATTACHMENT 2
Monthly Water Conservation Estimates

Attachment 2
Water Conservation Estimates

This attachment addresses two issues:

1. Are the annual conservation estimates reasonable?
2. What are the monthly water conservation estimates?

Reasonableness

Five categories of annual water conservation savings are addressed in this proposal:

1.	Reducing spill from the main canals (upper portion of the system) =	4,000 acre-feet
2.	Reducing lateral spill in the upper agricultural areas =	1,000 acre-feet
3.	Recovering spill from main canals in urban areas =	1,600 acre-feet
4.	Eliminating spill from the MML system =	900 acre-feet
5.	Recovering drain water from urban laterals =	9,500 acre-feet
	Total:	*17,000 acre-feet*

Reviewers of any proposal must always question whether the claimed benefits are reasonable – especially if many of the values in question do not have many years of excellent data.

For this project, a **sense of magnitude** can be obtained using the following **approximate** *annual* numbers:

Average total canal flow:	59,000 acre-feet
Net usage (ET, salt leaching) of irrigation water:	16,000 acre-feet
Difference:	43,000 acre-feet

Of course, not all of the 43,000 acre-feet difference is conservable. There are always some inefficiencies. For example, one might assume on a gross basis that field/residential irrigation efficiencies are only 50%. This proposal does not directly claim any change in those efficiencies – rather, this proposal focuses on eliminating and recovering main canal and lateral spills.

But assuming a field/residential irrigation efficiency of 50%, the numbers above become:

Average total canal flow:	59,000 acre-feet
Gross field applied usage of irrigation water:	32,000 acre-feet
Difference:	27,000 acre-feet

The estimated water conservation savings of 17,000 acre-feet are substantially lower than the potential of 27,000 acre-feet that fall into the 5 listed categories of conservation.

Monthly Conservation Estimates

Table 2-1 provides estimates of monthly conservation volumes. The procedures to estimate total acre-feet values by category (Categories 1-5) are described in detail in the body of the report.

Table 2-1. Monthly conservation estimates

Category	Description	Estimation Procedure	Acre-Feet per month							Total AF
			April	May	June	July	Aug	Sept	Oct	
1	Main canal spill in East OMID	Proportional to historical total, minus #3 and #4	792	269	2	0	151	1,151	1,636	**4,000**
2	East OMID laterals	Proportional to MML	74	94	111	151	173	126	270	**1,000**
3	Canals #1 and #2 in urban areas	Proportional to MML historical spill. Some of the historical end spill at these	119	151	178	242	277	201	432	**1,600**
4	MML spill	Historical spill (work file "OMID Summary 12-20")	67	85	100	136	156	113	243	**900**
5	Urban laterals	Table 3	1,190	1,560	1,120	1,150	1,450	1,490	1,540	**9,500**
		Totals	2,242	2,159	1,511	1,679	2,207	3,080	4,121	**17,000**

The explanations for each of the category estimates are as follows:

Category 5. This is explained in **Table 2** of the main report.

Category 4. Two years of good spill data at the main canal spill sites were available. The total spills are shown in **Figure 4** in the main body of the report. Individual spill data from the 3 spill locations on the MML were used to determine these values, using an average of 2 years of data.

Category 3. It was assumed that in the future, Canals #1 and #2 in the urban area (West Orchard Mesa) will operate in a manner that is similar to the historical MML operation. Individual spill data from 2 years, for this area of OMID, were adjusted in proportion to MML historical spill.

Category 2. The total acre-feet for this category is relatively small, which reflects the uncertainty in this number. However, the East Orchard Mesa laterals will probably operate in a manner similar to the historical MML operation.

Category 1. The main canal spill in East Orchard Mesa reflects the new operation with appropriate check structures that will eliminate the need to operate with high flow rates down the canals just to make deliveries to a few locations. The primary savings will occur in September and October. There will be little-no savings during the middle of the summer. Historical total canal spills were used for this estimate.

ATTACHMENT 3
Restructuring of Staff Responsibilities

Attachment 3
Restructuring of Staff Responsibilities

Effective implementation of the proposed physical infrastructure enhancements and water management practices in Orchard Mesa ID will involve everyone successfully adapting to new roles and responsibilities. The intent of the system improvements is to provide appropriate *tools* so that both managers and field staff can do their jobs more productively.

The Water Resources Conservation Plan envisions the restructuring and reallocation of day-to-day responsibilities of staff as follows:

- One person in the office/main pumping plant will observe flows at key points throughout the district and the water level in the reservoir via the new SCADA system and feedback from field staff. This will indicate where there are excesses and deficits. This watermaster will make decisions on an hourly basis in consultation with the field personnel as to whether the flows into Canals #1 and #2 should be adjusted. New hardware makes this possible, but perhaps more importantly, this involves active, real-time, centralized *management* of the major flows by one individual. The watermaster will be responsible for seeing that the district field personnel for Canals #1 and #2 have sufficient water available.
- The field personnel will have important new tools to do their jobs. This includes access to real-time information from the SCADA system about canal flows and spills in their area of responsibility.
- By re-starting Canals #1 and #2 much further down into the system, closer to the complicated residential areas, staff will be able to make better decisions about the flows required to meet demands. As a result they will have more time to focus on addressing customer-related issues.
- Any adjustments that the field personnel make to the manual flow control settings of Canal #1 (near the start of MML pipeline) and Canal #2 (near Wrecking Yard) will automatically show up and be evident to the watermaster. So even though field personnel are still operating water supplies in their area, the watermaster will have the information and tools to make adjustments to the overall water supply.
- There will be some need for training the operations staff to effectively use the SCADA system. However, the SCADA system and new control features will be robust, user-friendly, and above all designed to serve a useful function. Experience has shown in many other irrigation districts that field personnel quickly appreciate the benefits of new technologies if it helps them do their job better. Furthermore, only high-quality, industrially hardened hardware and software will be used, to minimize the need for troubleshooting and maintenance.
- Paperwork and record-keeping in the office will also be transformed by the implementation of this plan. The new base station will be set up to automatically collect, organize, consolidate, and publish monthly and annual reports. This helps the district staff, as well as Board members, better understand trends in water use, and hopefully identify ways to further improve the efficiency of the system. New computer systems always have some learning curves and adjustments associated with them, but the HMI (Human Machine Interface) software utilized in the system, while sophisticated and powerful, will have interfaces for the users that are custom-designed in a simple and clear way. Staff will not have to be programmers to use the system.

ATTACHMENT 4
Detailed Cost Estimates and Design Notes

Orchard Mesa Irrigation District

Water Resources Conservation Plan

Date: ***December 28, 2007***

Planning-Level Cost Estimate

Item	Description	Total Construction Costs	Total Annualized Cost	Annual O&M
I	Regulating Reservoir	$8,600,000	$568,000	$45,000
	Reservoir, pumps, controls, and earthwork	*6,990,000*		
	Canal #1 physical modifications, controls and measurement	*1,340,000*		
	Canal #2 physical modifications, controls and measurement	*269,000*		
II	Duck Pond Recirculation System and MML Pipeline	5,580,000	394,000	258,000
III	SCADA System	530,000	49,000	28,000
IV	Long-Crested Check Structures	450,000	29,000	7,000
	Total	**$15,200,000**	**$1,040,000**	**$340,000**

Orchard Mesa Irrigation District

Water Resources Conservation Plan

Regulating Reservoir

Construction Costs

Item	Description	Quantity	Unit Cost ($/unit)	Total	Annualized Cost
a	Regulating Reservoir (including inlet, pump station and SCADA)	L.S.	$5,056,300	$5,056,300	$353,444
b	Emergency spill from reservoir and connection to drain	L.S.	$25,000	$25,000	$1,586
c	Pipeline connection to MML Headgate (Canal #1)	5,000	$150	$750,000	$47,583
d	Canal earthwork, pipe bed preparation (Canal #1)	5,000	$25	$125,000	$7,931
e	Entrance and trash screen for pipeline (Canal #1)	L.S.	$20,000	$20,000	$1,269
f	Replace field/residential turnouts (Canal #1)	10	$1,000	$10,000	$634
g	Control Valve Vault (including modifications to MML Pipeline entrance)	L.S.	$20,000	$20,000	$1,269
h	Road crossing (30 Road)	L.S.	$25,000	$25,000	$1,586
i	Modifications to the Canal #1 Replogle flume	L.S.	$10,000	$10,000	$634
j	Canal #2 sluice gate and concrete structure	L.S.	$15,000	$15,000	$952
k	Long-crested side spill at Wrecking Yard	L.S.	$12,000	$12,000	$761
l	Electromagnetic flow meter (Wrecking Yard spill)	1	$10,000	$10,000	$1,030
m	Concrete vault for flow meter	L.S.	$5,000	$5,000	$317
n	Pipeline connection from Canal #2 to Wrecking Yard drainage ditch	800	$85	$68,000	$4,314
o	Channel (ditch) earthwork (Wrecking Yard)	3000	$20	$60,000	$3,807
p	Flap Gate (Canal #2 at Spill 6)	L.S.	$12,500	$10,000	$634
q	Concrete Replogle flume (Canal #2 at Spill 6)	L.S.	$5,000	$5,000	$317
r	Modifications and repairs to concrete lining (Canal #2 at Spill 6)	L.S.	$10,000	$10,000	$634
s	Flap Gate (Canal #1 at Rainbow Spill)	L.S.	$10,000	$10,000	$634
t	Steel orifice plate for maximum flow capacity (Canal #1 at Rainbow Spill)	L.S.	$2,500	$2,500	$159
u	Engineering and Project Management			$624,880	$39,645
v	Contingency			$1,718,420	$109,024
w	**Construction sub-total**			$8,592,100	

Item	Total
Regulating reservoir	$6,990,000
Canal #1 modifications	$1,340,000
Canal #2 modifications	$269,000
	$8,599,000

Annual Costs

Item	Description	Total	Annualized Cost	
w	Construction sub-total	$8,600,000	$578,166	includes annual power
x	Annual maintenance		$33,673	
	Total	**$8,600,000**	**$612,000**	

Regulating Reservoir

Cost Estimate for Reservoir, SCADA (Control and Remote Monitoring) and Pump Outlet

Features: Reservoir with storage capacity **100** **acre-feet**
Gravity inflow via long-crested side weir and pump outlet
Remote monitoring and control of reservoir operations

Part 1. Remote monitoring of reservoir operations

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	SCADA				
a	Remote Terminal Unit	$25,000	1	**$25,000**	
b	Water level sensor	1,200	4	**$4,800**	
c	Gate position sensor	1,500	2	**$3,000**	
d	Control algorithm, testing, verification	45,000	L.S.	**$45,000**	
e	Integration and programming	40,000	L.S.	**$40,000**	
f	Sensor mount assembly	1,000	4	**$4,000**	
g	Antenna, Mast and Cable	2,500	1	**$2,500**	
h	Misc. fuses, wiring, terminals, etc.	10,000	L.S.	**$10,000**	
i	Buried Conduit	5,000	L.S.	**$5,000**	
j	**Sub-Total**			**$139,300**	**$14,343**

Part 2. Reservoir inlet

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	Automated entrance gate with long-crested weir				
k	Entrance structure with gate and overflow weir	$100,000	L.S.	**$100,000**	
l	Inlet pipe: 42 inch RCP	250	50	**12,500**	
m	**Sub-Total**			**$112,500**	**$7,137**

Part 3. Reservoir outlet

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	VFD Pumps				
n	Pump - 100 HP (30 CFS @ 21 ft TDH)	$40,000	1	**$40,000**	
o	Pump motor	$8,000	1	**$8,000**	
p	ULH VFD	$30,000	1	**$30,000**	
q	Pump platform	$60,000	1	**$60,000**	
r	Electrical service drop and transformer	$125,000	1	**$125,000**	
s	Standard electric pump panel with HOA	$5,000	1	**$5,000**	
t	Pump discharge pipe	$200	100	**$20,000**	
u	Flow meter (pipeline)	$12,000	1	**$12,000**	
v	Misc. fittings and valves	$50,000	L.S.	**$50,000**	
w	Air conditioner system for VFD	$10,000	1	**$10,000**	
x	Buried conduit	$7,500	L.S.	**$7,500**	
y	Building/enclosure for cabinets	$20,000	L.S.	**$20,000**	
z	**Sub-Total**			**$387,500**	**$30,816**

Part 4. Reservoir

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	Reservoir description				
aa	Land acquisition	$40,000	15	**$600,000**	
bb	Stripping	$6	8,100	**$48,600**	
cc	Excavation for embankment	$6	16,000	**$96,000**	
dd	Excavation and waste	$15	88,100	**$1,321,500**	
ee	Compacted embankment	$7	11,300	**$79,100**	
ff	Compacted Liner (Cut)	$12	48,000	**$576,000**	
gg	Gravel drain	$50	5,300	**$265,000**	
hh	Pit run	$50	15,900	**$795,000**	
ii	French drain	$50	6,700	**$335,000**	
jj	Geotextile	$6	31,800	**$190,800**	
kk	Fence	$25	3,200	**$80,000**	
ll	**Sub-Total**			**$4,387,000**	**$278,330**

Summary		Initial Cost	Annualized Cost
mm	Construction costs	**$5,026,300**	**$330,627**
nn	Surveying and Soil Testing	**$30,000**	**$1,903**
oo	Annual Maintenance (parts and labor)		**$19,823**
pp	Annual sediment removal		**$10,000**
qq	Annual Power Cost		**$8,175**
rr	Annual Energy Demand		**$2,739**
	Total Implementation Cost	**$5,056,300**	**$373,267**

Orchard Mesa Irrigation District

Water Resources Conservation Plan

Duck Pond Recirculation System

Construction Costs

Item	Description	Quantity	Unit Cost ($/unit)	Total	Annualized Cost
a	Duck Pond Pump Station	L.S.	$682,000	$682,000	$200,889
b	Pipeline connection from the pump station to the MML pipeline	1850	$180	$333,000	$21,127
c	MML pipeline from booster pump station to Aspen Street	13,007	$180	$2,341,260	$148,540
d	Pipeline extension along Grand Mesa Avenue	1,000	$80	$80,000	$5,076
e	Replacement turnouts (M34a to end)	53	$2,000	$106,000	$6,725
f	Road crossings	9	$15,000	$135,000	$8,565
g	Booster pump station	L.S.	$361,500	$361,500	$103,261
h	Pressure regulator and manifold for pipeline connection	L.S.	$20,000	$20,000	$1,744
i	Engineering and Project Management			$403,876	$25,624
j	Contingency			$1,115,659	$70,782
k	**Construction sub-total**			$5,578,295	

Item	Total
Duck Pond Pump Station	$1,396,000
MML Pipeline Extension	$3,661,000
Booster Pump Station	$525,000
	$5,582,000

Annual Costs

Item	Description	Total	Annualized Cost	
k	Construction sub-total	$5,580,000	$592,332	includes annual power
l	Annual maintenance		$58,532	
	Total	**$5,580,000**	**$651,000**	

Duck Pond Pump Station and Reservoir

Cost Estimate for SCADA (Control and Remote Monitoring) and VFD Pump Station

Features: Small reservoir with storage capacity **5** **acre-feet**
Long-crested weir and spillway
Auotmated upstream control pump with VFD

Part 1. Remote monitoring of reservoir operations

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	SCADA				
a	Remote Terminal Unit	$25,000	1	$25,000	
b	Pressure sensors and controllers	$2,000	2	$4,000	
c	Control algorithm, testing, verification	$40,000	L.S.	$20,000	
d	Integration and programming	$30,000	L.S.	$20,000	
e	Antenna, Mast and Cable	$2,500	1	$2,500	
f	Misc. fuses, wiring, terminals, etc.	$10,000	L.S.	$10,000	
g	Buried Conduit	$5,000	L.S.	$5,000	
h	**Sub-Total**			**$86,500**	**$8,906**

Part 2. Reservoir outlet (Long-crested weir)

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	Automated entrance gate with long-crested weir				
i	Overflow weir (60-ft long-crested weir with sluice gate)	$30,000	L.S.	**$30,000**	
j	Modifications to entrance at road culvert crossing	$10,000	L.S.	**$8,000**	
k	**Sub-Total**			**$38,000**	**$2,411**

Part 3. Pumps and controls

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	VFD Pumps				
l	Pump - 200 HP	$55,000	2	$110,000	
m	Pump motor - 250 HP	$15,000	2	$30,000	
n	ULH VFD	$60,000	2	$120,000	
o	Electrical service drop and transformer	$50,000	1	$50,000	
p	Standard electric pump panel with HOA	$5,000	1	$5,000	
q	Pump discharge pipe	$200	180	$36,000	
r	Flow meter (pipeline)	$12,000	2	$24,000	
s	Misc. fittings and valves	$20,000	L.S.	$20,000	
t	Air conditioner system for VFD	$10,000	1	$10,000	
u	Buried conduit	$7,500	L.S.	$7,500	
v	Building/enclosure for cabinets	$50,000	L.S.	$50,000	
w	**Sub-Total**			**$462,500**	**$39,136**

Part 4. Pump sump and earthwork

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	Reservoir description				
x	Site preparation, compaction, drainage works	$30,000	L.S.	**$30,000**	
y	Misc, earthwork, landscaping	$50,000	L.S.	**$50,000**	
z	**Sub-Total**			**$80,000**	**$5,076**

Summary		**Initial Cost**	**Annualized Cost**
aa	Construction costs	**$667,000**	**$55,529**
bb	Surveying and Soil Testing	**$15,000**	**$952**
cc	Annual Maintenance (parts and labor)		**$17,750**
dd	Annual Power Cost		**$112,519**
ee	Annual Energy Demand		**$14,140**
	Total Implementation Cost	**$682,000**	**$200,889**

Booster Pump Station

Cost Estimate for SCADA (Control and Remote Monitoring) and VFD Pump Station

Features: Automated pumping plant

Part 1. Remote monitoring of booster operations

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	SCADA				
a	Remote Terminal Unit, radio, box, etc.	$6,000	1	**$6,000**	
b	Pressure sensors and controllers	$2,000	2	**$4,000**	
c	Electromagnetic flow meter	$10,000	2	**$20,000**	
d	Control algorithm, testing, verification	$20,000	L.S.	**$20,000**	
e	Integration and programming	$20,000	L.S.	**$20,000**	
f	Antenna, Mast and Cable	$2,500	1	**$2,500**	
g	Misc. fuses, wiring, terminals, etc.	$10,000	L.S.	**$10,000**	
h	Buried Conduit	$5,000	L.S.	**$5,000**	
i	**Sub-Total**			**$87,500**	**$9,009**

Part 2. Pumps and controls

Item		Unit Cost	Quantity	Total Cost	Annualized Cost
	VFD Pump - Booster pump				
j	Pump - 125 HP (7.5 CFS @ 98 ft TDH)	$38,500	2	**$77,000**	
k	Pump motor - 125 HP	$7,500	2	**$15,000**	
l	ULH VFD - 125 HP	$27,000	2	**$54,000**	
m	Electrical service drop and transformer	$60,000	1	**$60,000**	
n	Standard electric pump panel with HOA	$5,000	1	**$5,000**	
o	Pump manifold	$6,000	1	**$6,000**	
p	Misc. fittings and valves	$20,000	L.S.	**$20,000**	
q	Air conditioner system for VFD	$10,000	1	**$10,000**	
r	Buried conduit	$2,000	L.S.	**$2,000**	
s	Building/enclosure for cabinets	$20,000	L.S.	**$20,000**	
t	**Sub-Total**			**$269,000**	**$22,028**

Summary		**Initial Cost**	**Annualized Cost**
u	Construction costs	**$356,500**	**$31,037**
v	Surveying and Soil Testing	**$5,000**	**$317**
w	Annual Maintenance (parts and labor)		**$11,788**
x	Annual Power Cost		**$53,407**
y	Annual Energy Demand		**$6,712**
	Total Implementation Cost	**$361,500**	**$103,261**

Orchard Mesa Irrigation District

Water Resources Conservation Plan

SCADA System

Construction Costs

Item	Description	Quantity	Unit Cost ($/unit)	Total	Annualized Cost
a	Base Station	L.S.	$45,050	$45,050	$4,638
b	29 Road Pumping Plant	L.S.	$17,850	$17,850	$1,838
c	B 1/4 Road Pump Station	L.S.	$25,700	$25,700	$2,646
d	Canal #1 Flow Control Valve	L.S.	$34,200	$34,200	$3,521
e	Main Pumping Plant	L.S.	$77,650	$77,650	$7,995
f	Canal #2 Flow Control Gate	L.S.	$33,200	$33,200	$3,418
g	Wrecking Yard Spill	L.S.	$10,000	$10,000	$1,030
h	Canal #1 Rainbow Spill	L.S.	$25,100	$25,100	$2,584
i	Canal #1 End Spill	L.S.	$25,600	$25,600	$2,636
j	Canal #2 End Spill	L.S.	$25,600	$25,600	$2,636
k	Radio Repeater Station	L.S.	$45,200	$45,200	$4,654
l	Engineering and Project Management			$54,773	$3,475
m	Contingency			$104,981	$6,660
n	**Construction sub-total**			**$525,000**	

Cost Summary by Site	Total
Base Station	$64,800
29 Road Pumping Plant	$25,700
B 1/4 Road Pump	$37,000
Canal #1 Flow Control Valve	$49,200
Main Pumping Plant	$111,700
Canal #2 Flow Control Gate	$47,800
Wrecking Yard Spill	$14,400
Rainbow Spill	$36,100
Canal #1 End Spill	$36,800
Canal #2 End Spill	$36,800
Radio Repeater	$65,000
	$525,000

Annual Costs

Item	Description	Total	Annualized Cost
o	Construction sub-total	$525,000	$47,732
p	Annual maintenance		$27,386
	Total	**$525,000**	**$76,000**

Orchard Mesa Irrigation District

Water Resources Conservation Plan

Detailed SCADA Costs for Components

	Item	Sites	Base Station	29 Road Pumping Plant	B 1/4 Road Pump	Canal #1 Flow Valve	Main Pumping Plant	Canal #2 Flow Gate	Wrecking Yard Spill	Rainbow Spill	Canal #1 End Spill	Canal #2 End Spill	Radio Repeater	Total
1	RTU – Automated or Remote Manual Control			1	1	1		1						4
2	RTU - Remote Monitoring						1			1	1	1	1	5
3	Operator Interface Terminal (touchscreen)			1		1							1	2
4	LCD Display				1.6		1.6	1		1	1	1		7
5	Radio		1	1	1	1	1	1		1	1	1	2	11
6	Electromagnetic pipeline flow meters						4		1					5
7	Pressure transmitter (0-5 psi)					1	2	1			1	1		6
8	Ultrasonic water level sensor					1	2	1		1				5
9	Hollow shaft absolute encoder					1		1						2
10	Cable-extension potentiometer					1								1
11	Thermistor						8							8
12	Vibration sensor system						1							1
13	Stilling well					1		2			1	1		5
14	Staff gauge					2		2		1	1	1		7
15	Limit switches (pair)					1		1						2
16	Antenna (yagi)			1	1	1	1	1		1	1	1	1	9
17	Antenna (omni)		1										1	1
18	Antenna mast		1	1	1	1	1	1		1	1	1	1	10
19	Antenna cable (length varies)		1	1	1	1	1	1		1	1	1	1	10
20	Antenna lighting arrestor		1	1		1	1	1		1	1	1	1	9
21	Vandalism enclosure					1		1		1	1	1		5
22	Control building												1	
23	Sensor lighting arrestor					4		3		1	1	1		10
24	Battery back-up system					1		1		1	1	1	1	6
25	Office computer system (HMI base station)		1											1
26	Hardened laptops (mobile SCADA access)		2											2
27	HMI Software (incl. ISaGRAF license)		1											1
28	Site integration, programming				1	1	1	1		1	1	1	1	8
29	UPS		1	1	1		1							4
30	Alarm autodialer		1											1

	Item	Unit Cost	Base Station	29 Road Pumping Plant	B 1/4 Road Pump	Canal #1 Flow Valve	Main Pumping Plant	Canal #2 Flow Gate	Wrecking Yard Spill	Rainbow Spill	Canal #1 End Spill	Canal #2 End Spill	Radio Repeater
1	RTU – Automated or Remote Manual Control	$12,000	$0	$12,000	$12,000	$12,000	$0	$12,000	$0	$0	$0	$0	$0
2	RTU - Remote Monitoring	8,000	0	0	0	0	8,000	0	0	8,000	8,000	8,000	8,000
3	Operator Interface Terminal (touchscreen)	1,200	0	1,200	0	1,200	0	0	0	0	0	0	1,200
4	LCD Display	750	0	0	1,200	0	1,200	750	0	750	750	750	0
5	Radio	2,000	2,000	2,000	2,000	2,000	2,000	2,000	0	2,000	2,000	2,000	4,000
6	Electromagnetic pipeline flow meters	10,000	0	0	0	0	40,000	0	10,000	0	0	0	0
7	Pressure transmitter (0-5 psi)	1,200	0	0	0	1,200	2,400	1,200	0	0	1,200	1,200	0
8	Ultrasonic water level sensor	1,200	0	0	0	1,200	2,400	1,200	0	1,200	0	0	0
9	Hollow shaft absolute encoder	1,000	0	0	0	1,000	0	1,000	0	0	0	0	0
10	Cable-extension potentiometer	900	0	0	0	900	0	0	0	0	0	0	0
11	Thermistor	1,000	0	0	0	0	8,000	0	0	0	0	0	0
12	Vibration sensor system	3,000	0	0	0	0	3,000	0	0	0	0	0	0
13	Stilling well	500	0	0	0	500	0	1,000	0	0	500	500	0
14	Staff gauge	100	0	0	0	200	0	200	0	100	100	100	0
15	Limit switches (pair)	500	0	0	0	500	0	500	0	0	0	0	0
16	Antenna (yagi)	200	0	200	200	200	200	200	0	200	200	200	200
17	Antenna (omni)	600	600	0	0	0	0	0	0	0	0	0	600
18	Antenna mast	1,250	1,250	1,250	1,250	1,250	1,250	1,250	0	1,250	1,250	1,250	1,250
19	Antenna cable (length varies)	300	300	300	300	300	300	300	0	300	300	300	300
20	Antenna lighting arrestor	150	150	150	0	150	150	150	0	150	150	150	150
21	Vandalism enclosure	1,500	0	0	0	1,500	0	1,500	0	1,500	1,500	1,500	0
22	Control building	15,000	0	0	0	0	0	0	0	0	0	0	20,000
23	Sensor lighting arrestor	150	0	0	0	600	0	450	0	150	150	150	0
24	Battery back-up system	1,500	0	0	0	1,500	0	1,500	0	1,500	1,500	1,500	1,500
25	Office computer system (HMI base station)	6,000	6,000	0	0	0	0	0	0	0	0	0	0
26	Hardened laptops (mobile SCADA access)	3,500	7,000	0	0	0	0	0	0	0	0	0	0
27	HMI Software (incl. ISaGRAF license)	25,000	25,000	0	0	0	0	0	0	0	0	0	0
28	Site integration, programming	8,000	0	0	8,000	8,000	8,000	8,000	0	8,000	8,000	8,000	8,000
29	UPS	750	750	750	750	0	750	0	0	0	0	0	0
30	Alarm autodialer	2,000	2,000	0	0	0	0	0	0	0	0	0	0
	Total		**$45,050**	**$17,850**	**$25,700**	**$34,200**	**$77,650**	**$33,200**	**$10,000**	**$25,100**	**$25,600**	**$25,600**	**$45,200**

Orchard Mesa Irrigation District

Water Resources Conservation Plan

Upgraded Check Structures

Construction Costs

Item	Description	Quantity	Unit Cost ($/unit)	Total	Annualized Cost
a	65-ft long-crested weir (new)	1	$27,000	$27,000	$1,713
b	65-ft long-crested weir (upgraded)	1	$27,000	$27,000	$1,713
c	60-ft long-crested weir (new)	2	$25,000	$50,000	$3,172
d	60-ft long-crested weir (upgraded)	2	$25,000	$50,000	$3,172
e	55-ft long-crested weir (new)	1	$22,000	$22,000	$1,396
f	50-ft long-crested weir (new)	2	$20,000	$40,000	$2,538
g	50-ft long-crested weir (upgraded)	1	$20,000	$20,000	$1,269
h	45-ft long-crested weir (new)	2	$17,500	$35,000	$2,221
i	45-ft long-crested weir (upgraded)	2	$17,500	$35,000	$2,221
j	40-ft long-crested weir (upgraded)	1	$15,000	$15,000	$952
k	Engineering and Project Management			$32,100	$2,037
l	Contingency			$88,275	$5,601
m	**Construction sub-total**			**$450,000**	

Description	Sub-Total
Canal #1	$340,000
Canal #2	$110,000
Total	**$450,000**

Annual Costs

Item	Description	Total	Annualized Cost
m	Construction sub-total	$450,000	$28,003
n	Annual maintenance		$6,420
	Total	**$450,000**	**$35,000**