RECLAMATION

Managing Water in the West
Funding Opportunity No. R12SF80049

Water SMART:
Water and Energy Efficiency Grants
FY 2012

Weber Basin Water Conservancy District Phase 2 Willard Canal Lining and Water Marketing Project

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U.S. Department of Interior
Bureau of Reclamation

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5.0 TECHNICAL PROPSAL

5.1 Executive Summary

The Weber Basin Water Conservancy District is pleased to submit this grant application to the Bureau of Reclamation in response to the WaterSMART: Water and Energy Efficiency Grants for FY2012, funding opportunity number R12SF80049.The Weber Basin Water Conservancy's Administrative offices are located at 2837 East Highway 193, Layton Utah. The proposed project is located along the Willard Canal in Weber County, Utah.

The Weber Basin Water Conservancy District received a grant from the Bureau of Reclamation in October of 2008 to perform a System Optimization Review (SOR). The scope of the SOR addressed the District's entire culinary and secondary water systems, for the purpose of identification of water efficiency and water marketing opportunities. As a result of conducting this SOR, the upper Willard Canal Lining and Water Marketing Project was identified as a high priority project. Further, the project directly addresses the following three eligible project areas (A, B and D) listed in the funding opportunity announcement. These three eligible project areas are described subsequentially. Project Area A, Water Conservation: A detailed analysis of the Willard Canal was done as a part of the District's SOR. While the canal is over 10.5 miles long; on the order of 60% of water loss is occurring in the first 6000-7000 feet of the canal. The District proposes to line this entire segment of the canal in three phases over the next 4 years (Refer to Figure 4). Phase 1 is underway and is being funded by a 2011 WaterSMART grant. Water saved by lining the Willard Canal can be directly used in a water marketing program. The Phase 2 Project (which is the subject of this current grant application) will result in an additional water savings of 4,100 AF/yr. Project Area B, Energy- Water Nexus: The Project will result in directly measurable power savings of approximately 22,000 kilowatt hours (kwh) due to saved pumping costs. Also, the project will utilize solar power for new meters and SCADA stations. Project Area D, Water Markets: Water savings achieved through this project may be physically stored in any of a number of upstream reservoirs in the Weber Basin Project area, or downstream in Willard Bay. The most suitable reservoir is Rockport reservoir, shown in Figure 1. The District owns all the water rights to this reservoir. This is a high altitude reservoir, so losses due to evaporation will be minimized. Saved water could also be stored in the downstream delivery point for the Willard Canal (the Willard Bay Reservoir).The District will market all of the saved water to new customers or existing customers. This will be accomplished by leasing the water to these entities through petition agreements between the customers and the Weber Basin Water Conservancy District, or through water exchange agreements. This method of water sale is currently used for most of the District's current irrigation water customers.

5.2 Background Data

Description of the Weber Basin Water System

The Weber Basin Water Conservancy District, a Utah Conservancy District, is the legal agency representing the people of the five-county area of the project. The counties involved include Davis, Morgan, Summit, Weber, and part of Box Elder. The District administers the sale and delivery of project water, operates and maintains the project facilities, and has contracted with the U.S. Government for repayment of reimbursable costs of the Weber Basin Project. A system map is given in Figure 1.The Weber Basin Project was planned to conserve and utilize practically all of the flows of streams in the natural drainage basin of the Weber River, including the basin of the Ogden River, its principal tributary. Other areas encompassed are those lying between the west slope of the Wasatch Mountains and the east shore of the Great Salt Lake.

Water resources of the area were extensively developed before initiation of the Weber Basin Project. Numerous private developments antedate the Federal projects. Prior Federal reclamation developments include the Weber River Project on the main stem of the Weber River, and the Ogden River Project on the Ogden River. Also, under the Weber River and Provo River Projects, water is diverted from the high reaches of the Weber River for multiple uses on the Provo River. The Weber Basin Project supplements all of the earlier undertakings, and its operation is correlated with them in approaching full practicable development of the area's water resources.

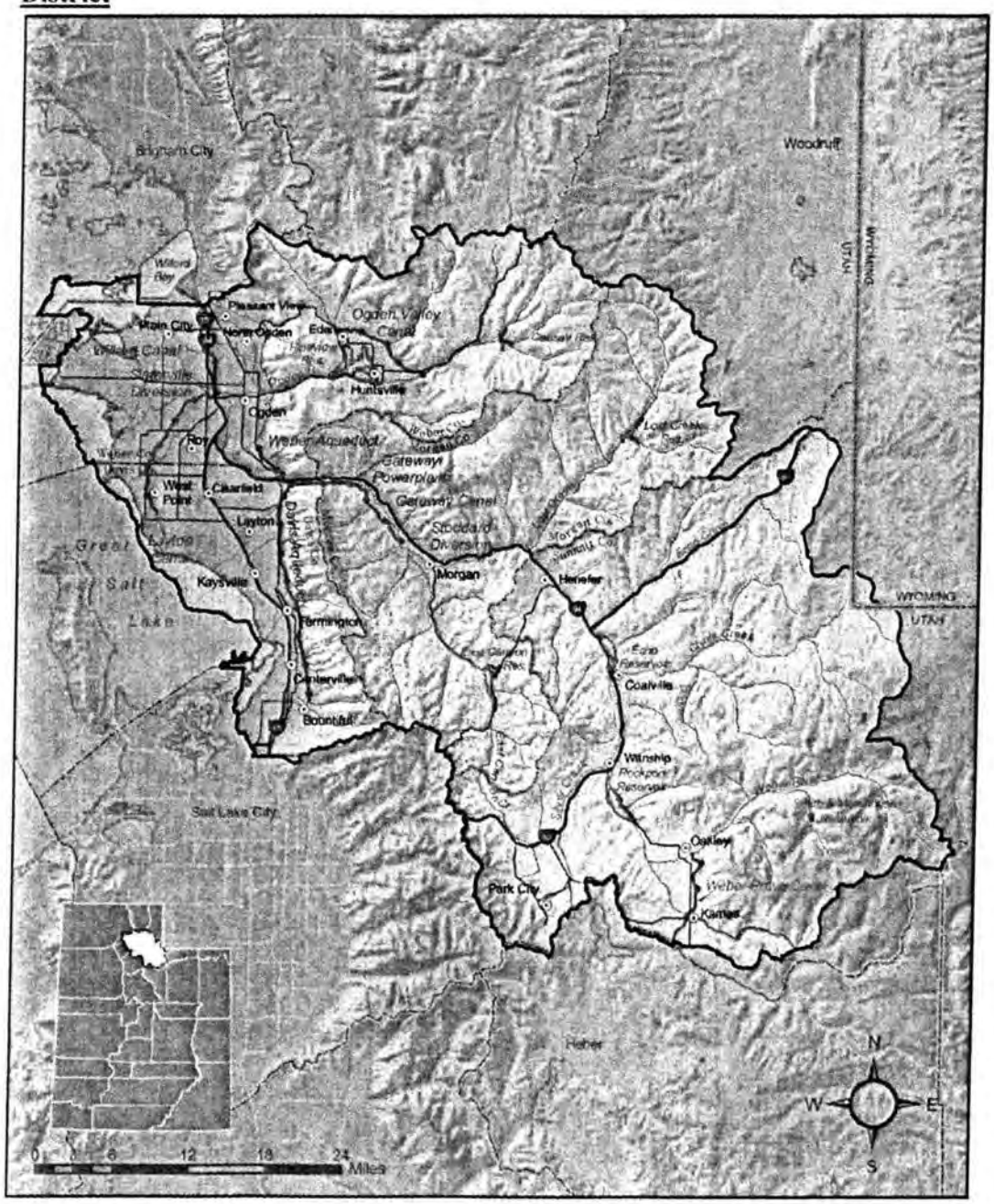
Water is delivered from the Weber River to the District via two aqueducts. The Weber Aqueduct conveys irrigation water to lands on the Uintah Bench, and municipal and industrial water to Ogden and adjacent communities in Weber County. Part of the irrigation water is pumped to lands above the aqueduct and the remainder is delivered by a gravity pressure distribution system. At the terminal of the aqueduct, water is delivered to the District's Weber South Water Treatment Plant (WTP) from which it is distributed to Ogden City and surrounding communities (an approximate population of 240,000 people).

The Davis Aqueduct extends to the south from the Weber Canyon along the foot of the Wasatch Mountains to North Salt Lake. Part of the water is pumped for irrigation of lands above the aqueduct; the remainder of the water is sold by the District to irrigation companies, Improvement Districts, Subconservancy Districts and individual landowners. The remaining water is processed through the District's Davis North WTP for distribution to communities in North Davis County, and through the Davis South WTP for communities in the south end of Davis County (Combined communities of approximately 300,000). A large block of treated and untreated industrial water is also delivered to the Chevron Oil Company in the extreme south end of Davis County.

Project laterals from these aqueducts include pipe systems that distribute irrigation water to farmland and suburban areas. The project includes the Willard Canal extending north, and the Layton Canal extending south from the Weber River in conjunction with other

canals to serve the lower project lands adjacent to Great Salt Lake. The project also includes drains for lower lands in the east shore area. Nineteen deep wells relieve water shortages in dry periods and to meet peak water demands. Streams flowing from the face of the Wasatch Mountains toward the Great Salt Lake contribute small quantities of water for project use. The Ogden Valley Canal distributes Ogden River water to mountain valley lands near Huntsville and Eden.

Figure 1: Overview of Geographic Extent of the Weber Basin Water Conservancy District



Congress authorized the project in 1949 and construction funds were first appropriated in 1952. Before the year ended, a contract was awarded to the Utah Construction Company to build the Gateway Tunnel. During 1954, construction started on the Davis Aqueduct, the Wanship Dam, the Gateway Canal, and the Weber Aqueduct. In 1955, construction starts included the Willard Dam, Pineview Dam enlargement, and the Bountiful Drain. The Wanship and Gateway hydrogenerating power plants and switch yards were started in 1956. By July 8, 1957, the Davis and Weber Aqueducts were all completed and began operating to deliver project water from the Weber River. The District's system serves a geographic area over 2,500 square miles, with five principle water uses:

- Wholesale irrigation: The District supplies water to a number of irrigation, agriculture and other secondary water companies and districts along the Wasatch Front. These organizations then retail water to customers in their service areas. This use accounts for approximately 36% of the District's water contracts.
- Groundwater Replacement: Drinking water purveyors and individuals (either residential or agricultural) may contract with the District for a water supply. An approved exchange application from the State Engineer permits drilling of a well to meet water supply needs. This use accounts for nearly 10% of District contracts currently. By banking water, a potential source of conflict related to ground water rights can be mitigated.
- Retail Secondary Irrigation: The District delivers economical irrigation water to many farmers in Box Elder, Davis, Morgan, Summit and Weber Counties. The District also provides residential customers with irrigation water to many residents in Davis and Weber counties via 211 miles of pipelines. This use accounts for 27% of water contracts.
- Treated Municipal Water: The District wholesales culinary water to nearly 50 cities and water improvement district in Davis and Weber Counties via 69 miles of transmission lines. This use accounts for 22% of the District's contracts.
- Untreated Industrial: This use accounts for 5% of the District's Contracts.

Weber Basin receives its water from the Weber and Ogden Rivers and from various deep groundwater wells. The following tables illustrate a breakdown of the District's existing water resources and distribution facilities:

Summary of Water Supply

	Capacity (AF)
Maximum Annual Yield	541,569
Annual Reliable Yield	266,437
Water Currently Under Contract	220,209

Source and Yield of Supplies

	Maximum Yield (AF)	Reliable Yield (AF)
Project stored water	377,278	206,914
District stored water	7,848	7,848
Wells	68,246	34,123
Stock water	17,552	17,552
Decreed rights	3,960	0
Independent streams	8,700	0
Power water contracts	57,985	0
Total	541,569	266,437

Water Treatment Plants

Name	Location	Capacity (cfs)	MGD	Average (AF)
Weber South WTP	Ogden	48	32	12,000
Davis North WTP	Layton	70	46	22,000
Davis South WTP	Bountiful	25	16	6,000
Totals		**143**	**94**	**40,000**

The District has plans to build an additional water treatment plant (WTP) in West Weber with an initial treatment capacity of 40 to 60 million gallons per day (mgd), and a future treatment capacity of up to 165 mgd. The proposed system efficiency and water banking project, described in this proposal, has the added benefit of allowing for more efficient water delivery to the future West Weber WTP.

A further description of the District's system, including the dates of construction, capacity information, construction types, lengths and capacity of canals, and other information is given in Figure 2, and a map of the District Canals is given in Figure 3.

Figure 2: Weber Basin Water Conservancy District System Summary

Weber Basin Project • PRINCIPAL PROJECT WORKS

RESERVOIRS

Name	Type of Dam	Height (Feet)	Total Capacity	Usable District Capacity	Construction Dates
Causey	Earth & Rock	200	7,870	6,870	1962-1964
East Canyon	Concrete Arch	245	51,200	20,100	1965-1967
Lost Creek	Earth & Rock	220	22,500	20,010	1964-1966
Pineview	Earth & Rock	91	110,150	66,228	1955-1957
Smith & Morehouse	Earth & Rock	82	8,350	6,560	1984-1988
Wanship	Earth & Rock	156	62,120	60,860	1954-1957
Willard	Earth	36	215,000	198,200	1957-1963

DIVERSION DAMS

Name	Location	Pass-Through Capacity	Construction Dates
Ogden Valley	South Fork of Ogden River	2,000 C.F.S.	1962-1964
Slaterville	Weber River west of Ogden	9,000 C.F.S.	1956-1957
Stoddard	Weber River west of Morgan	6,000 C.F.S.	1955-1956

CANALS, TUNNELS & PIPELINES

Name	Type	Length (Miles)	Capacity (CFS)	Construction Dates
Davis Aqueduct	Concrete pipe	23.0	355	1954-1957
Gateway Canal	Concrete-lined	8.5	700	1954-1956
Gateway Tunnel	Concrete-lined	3.3	435	1952-1954
Layton Canal	Earth-lined/pipe	18.0	260	1962-1964
Ogden Valley Canal	Part Earth-lined	9.2	35	1962-1964
Weber Aqueduct	Concrete pipe	5.0	80	1954-1956
Willard Canal	Earth-lined	11.0	1,150	1961-1963
M&I pipelines	Varies 6" – 48"	76.5	–	1955-2002

POWER PLANTS

Name	Type	Capacity (Kilowatts)	Construction Dates
Causey	2-unit	2,100	1999-2000
Gateway	2-unit	4,275	1957-1958
Wanship	1-unit	1,950	1957-1958

PUMPING PLANTS

Name	Location	Capacity (CFS)	Height of Lift (Ft.)
East Bountiful	Davis Aqueduct	18	475
East Layton	Davis Aqueduct	6	165
Gateway	Gateway Canal	150	150
Layton	Layton Canal	260	23
Ray Drought Relief	Layton Canal	150	340
Sand Ridge East	Davis Aqueduct	8	92
Sand Ridge West	Davis Aqueduct	15	138
South Davis	Davis Aqueduct	18	580
Uintah Bench	Weber Aqueduct	18	365
Val Verde	Davis Aqueduct	6	240
Willard No. 1	Willard Canal	500	45
Willard No. 2	Willard Canal	250	20
Antelope Booster	Layton	22	50
Old Post Road Booster	Ogden	6	200

UNDERGROUND WATER

Well	Capacity (CFS)
Ben Lomond	2.0
Bountiful	5.2
Clearfield 1	5.0
Clearfield 2	5.0
Davis Boulevard	2.2
District Well 2	11.0
District Well 3	10.0
Layton	5.0
North Ogden	1.6
Orchard Drive	1.0
Riverdale	6.6
South Weber 1	10.0
South Weber 2	10.0
Fairfield	10.0
Irrigation Wells	
Farmington #1	5.0
Farmington #2	5.0
West Bountiful Golf	2.0
5th South	3.5

WATER TREATMENT PLANT CAPACITIES

Plant	Capacity
Davis North	70 CFS (46 MGD)
Davis South	25 CFS (16 MGD)
Weber South	40 CFS (26 MGD)

Various Uses of Water Supplied by the Weber Basin Water Conservancy District

INDUSTRIAL WATER: Several industries in Davis and Weber Counties rely on water supplied by the District for their manufacturing and other uses.

IRRIGATION WATER: The Project is a source of economical irrigation water for many farmers in Box Elder, Davis, Morgan, Summit and Weber Counties. Water is delivered either directly to individual farmers or is conveyed by an irrigation company.

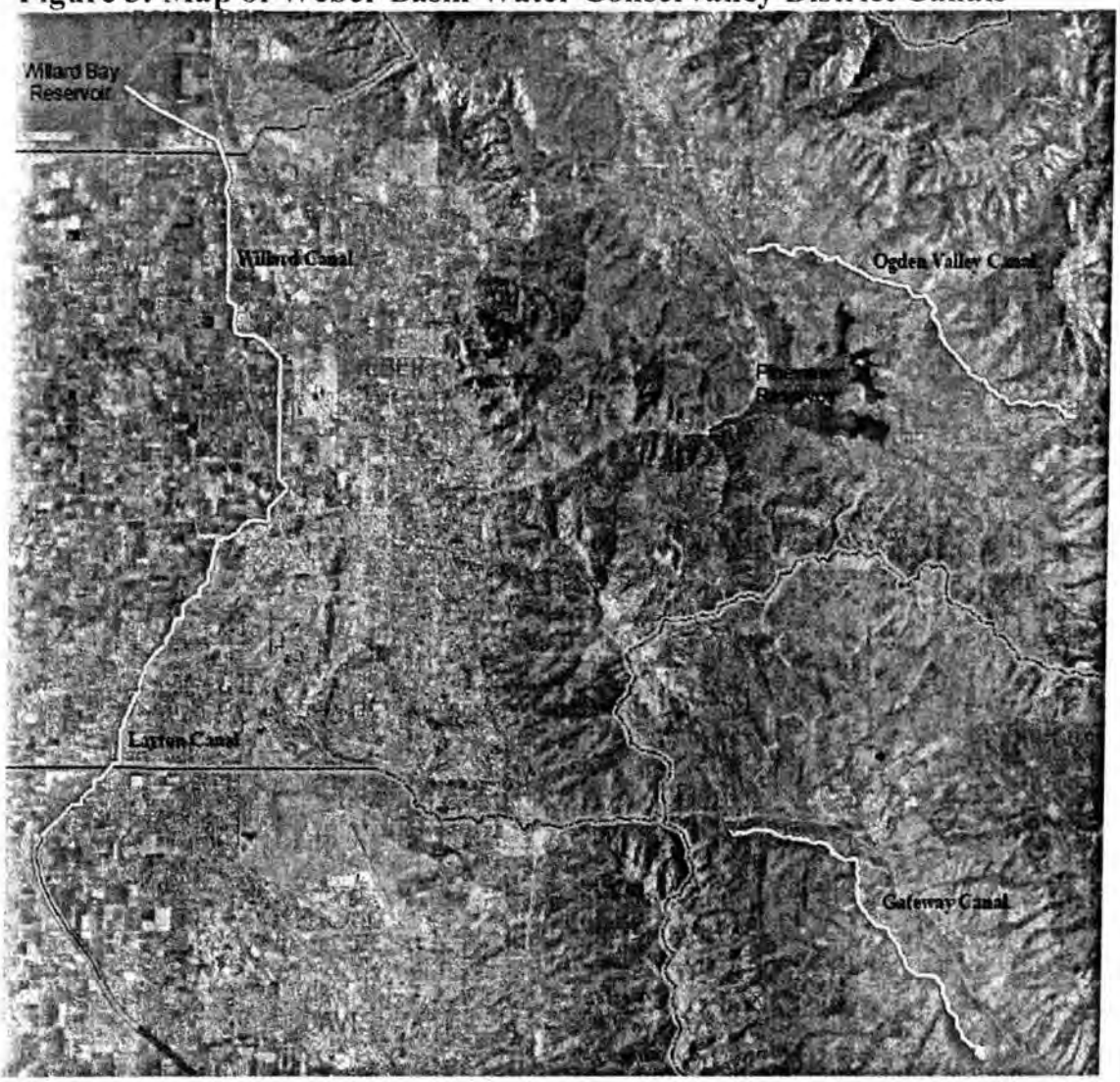
REPLACEMENT WATER: Many residents of the District do not have access to a municipal or community water system and must depend on alternative sources for their domestic water. The District owns storage rights in Morgan County, Summit County and Weber County. Individuals may contract with the District for a water right which, along with an approved exchange application from the State Engineer, permits drilling of a well to meet the needs of these individuals.

SECONDARY WATER: Many residents of Davis and Weber Counties enjoy the use of Weber Basin water to sprinkle their lawns and gardens. The District supplies water to a number of secondary water companies along the Wasatch Front. These organizations then transport water to customers in their respective service areas. Weber Basin also provides secondary water directly to many residents from Ogden to Bountiful.

CULINARY WATER: Weber Basin Water Conservancy District wholesales culinary water to almost every city and water improvement district in Davis and Weber Counties. They provide either all or a portion of this supply to their customers. Future culinary water supplies are anticipated in Morgan and Summit Counties.

CFS=Cubic Feet per Second • MGD=Millions Gallons Per Day

Figure 3: Map of Weber Basin Water Conservancy District Canals



Potential for Conflicts Addressed by this Proposal

Within the Weber Basin Water Conservancy District's service area, there is an ongoing conflict between the demand for irrigation uses and the rapidly increasing demand for municipal and industrial (M&I) treated water. The District serves one of the fastest growing regions in Western United States. The population of the region served is expected to increase by 20% to 30% by 2025. By conserving nearly 7,400 AF per year through the Willard Canal Lining and Water Marketing Project, the District is contributing substantially to conservation efforts and alleviation of potential conflicts.

Past working relationships with the Bureau of Reclamation

The Bureau of Reclamation began planning for the Weber Basin Project in 1942. Between 1952 and 1969, the Bureau of Reclamation constructed the original project consisting of reservoirs, canals, irrigation and drainage systems and power plants. Weber Basin Water Conservancy District was created in June of 1950, by a decree of the Second District Court of Utah, under the guidelines of the Utah Water Conservancy Act. The District entered into a repayment contract with the United States in1952, which will be completed in 2034 to repay all of the original Weber Basin Project costs.

The District has a number of recently completed and ongoing cooperative projects with the Bureau of Reclamation, including:

1) The Layton Canal Lining Project (funded under the 2010 WaterSMART program);
2) The Upper Willard Canal Lining Project, Phase 1, (funded under the 2011 WaterSMART program).
3) The Uintah Bench Retail Secondary Water Meter Project (funded under the 2010 WaterSMART program);
4) A 2008 System Optimization Review (SOR) of the District's entire system;
5) A 2007 Ground Water Recharge Project, know as the ASR Project;
6) Ongoing Gateway Canal Landslide Stabilization Projects.

In addition to these six projects, the proposed upper Willard Canal Lining Project will support the objectives of Reclamation in its intent to raise the height of the Willard Bay (A V Watkins) Dam. This is the case, since the Willard Canal is the only supply source of water for Willard Bay.

5.3 Technical Project Description

The District retained a professional consulting firm, as a part of the District's SOR, to prepare an estimate of water lost in the Willard Canal, as well as prepare construction estimates for a number of canal lining techniques. This estimate was prepared by collection of canal liner data (material type and thicknesses). Empirical data from several publishes sources, including Reclamation reports, were then used to estimate water losses. A summary of these analyses is given in Attachment A. Based on these analyses, it was determined that most of the Willard Canal's water losses are occurring in the upper portion of the canal. The proposed Willard Canal lining project addresses water losses (in these higher water loss areas) by construction of a new concrete liner.

The proposed Weber Basin Water Conservancy District Willard Canal Lining and Water Marketing Project will include three integrated construction components:
1) Final Engineering Design, Bidding and Contractor Selection;
2) Construction; and
3) Creation of the Water Marketing procedures for saved water. These tasks will be accomplished as described below:

Proposed Project Tasks for the Phase 2 Willard Canal Lining and Water Marketing Project:

Task 1) Environment Compliance Review

Schedule: October 2012 to March 2013

Scope to be Accomplished: An environmental compliance review will be conducted as required by Federal Statute.

Task 2) Installation Flow Measurement Equipment, and SCADA Systems and Measurement of Flow for One Full Irrigation Season Prior to Canal Lining

Schedule: March 2013 to October 2013

Scope to be Accomplished: Installation of Flow Measurement Equipment and SCADA Systems
One new flow measurement system will be constructed:
A new flow measurement acoustic meter will be installed at the termination of the Phase II project, as shown in Figure 4. (The ongoing Phase I project, which was funded by a WaterSMART 2011 grant) will have meters in place prior to beginning the proposed Phase II project. This new meter at the termination of the Phase II project will allow for quantification of any losses from the beginning of the project (at the termination of the Phase I project) to the termination of the proposed Phase II project.

Installation of this equipment will allow the District to accurately document actual canal leakage for current conditions and post lining conditions. This will be done by initially installing the meters in the unlined canal in March of 2013, and accumulating an entire irrigation season (March to October) of flow measurement data. Flow measurements will allow refinement of the canal leakage estimates done to date (which were based upon geotechnical testing of the canal lining). Meters will be reinstalled after liner installation. Flow will then be measured after the installation of canal liners. In this way, accurate measures of water savings will be determined. Measured water savings will then be available for water marketing. New SCADA systems will be installed to enable remote monitoring of flow at these locations, and for use in improvements in water management procedures.

The Willard Canal at the Slaterville Diversion Dam is shown in Photograph 1, and the Willard Canal at Pump Station 2 is shown in Photograph 2. Photograph 3 illustrates a typical unlined canal segment. Attachment D contains excerpts of the original Reclamation drawings for the Willard Canal in the area of the proposed lining project.

Task 3) Final Engineering Design, Schedule:

Schedule: March 2013 to August 2013

Scope: The District will retain an engineering consulting firm to prepare final construction documents for the project and assist in bidding and contractor selection.

Task 4) Bidding and Contractor Selection:

Schedule: August 2013 to September 2013

Task 5) Construction of Concrete Liner

This task will include Installation of New Concrete Lining on the Willard Canal from the Termination of the Phase I Project at Siphon at 1200 South Street to the Termination of the Phase II project at 700 South Street in Marriott Slaterville.

Schedule: October 2013 to June 2014

This schedule includes lining construction from October 2013 to April 2014, and two additional months for project closeout.

Scope to be Accomplished: Canal Lining Construction

This task will include Installation of New Concrete Lining on the Willard Canal from the Termination of the Phase I Project at Siphon at 1200 South Street to the Termination of the Phase II project at 700 South Street in Marriott Slaterville.

Task 6) Creation of Water Marketing Mechanism

This will be a continuation of the ongoing effort underway for the Phase I Willard Canal Lining Project.

The Phase II project (which is the subject of this grant request) will improve sustainable water supplies, by directly allowing the District to conserve an additional average of 4,100 AF/yr per year, over the 50 year life of the project.

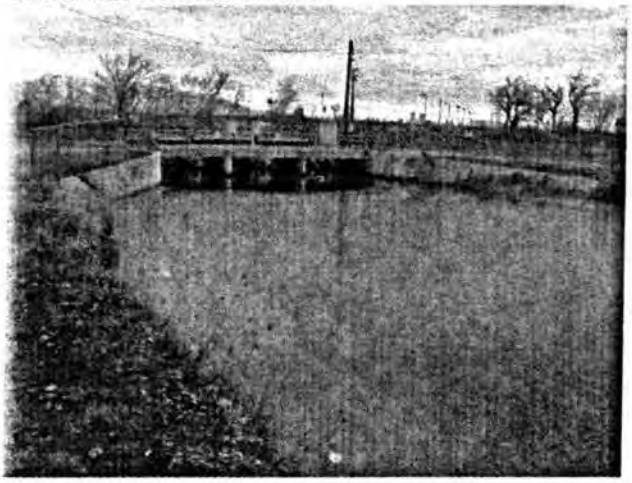
This water can be stored in the existing upstream reservoirs operated by the District. Issues to be addressed in the marketing the saved water are outlined below.

Logistical Issues to be Addressed:
Water savings achieved through these projects may be physically stored in any of a number of upstream reservoirs in the Weber Basin Project area. The most suitable reservoir is the Rockport reservoir. This is a high altitude reservoir, so losses due to evaporation will be minimized.

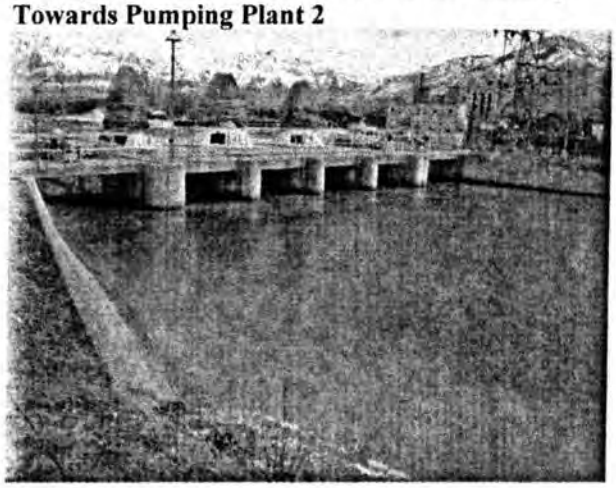
Legal Issues for Marketing Water Savings from Canals:
- Water will be metered before installation of canal lining to further document water losses prior to canal lining;
- Existing petition and water transfer agreement mechanisms will be used to market saved water, and thus avoid issues created by using a new water allocation method;

In large part, these issues will be addressed as a part of the ongoing Phase 1 Willard Canal lining project. Therefore, the District expects to have a water marketing mechanism in place prior the completion of construction of the Phase 2 project.

Photograph 1: Willard Canal Looking Towards the Slaterville Diversion Dam

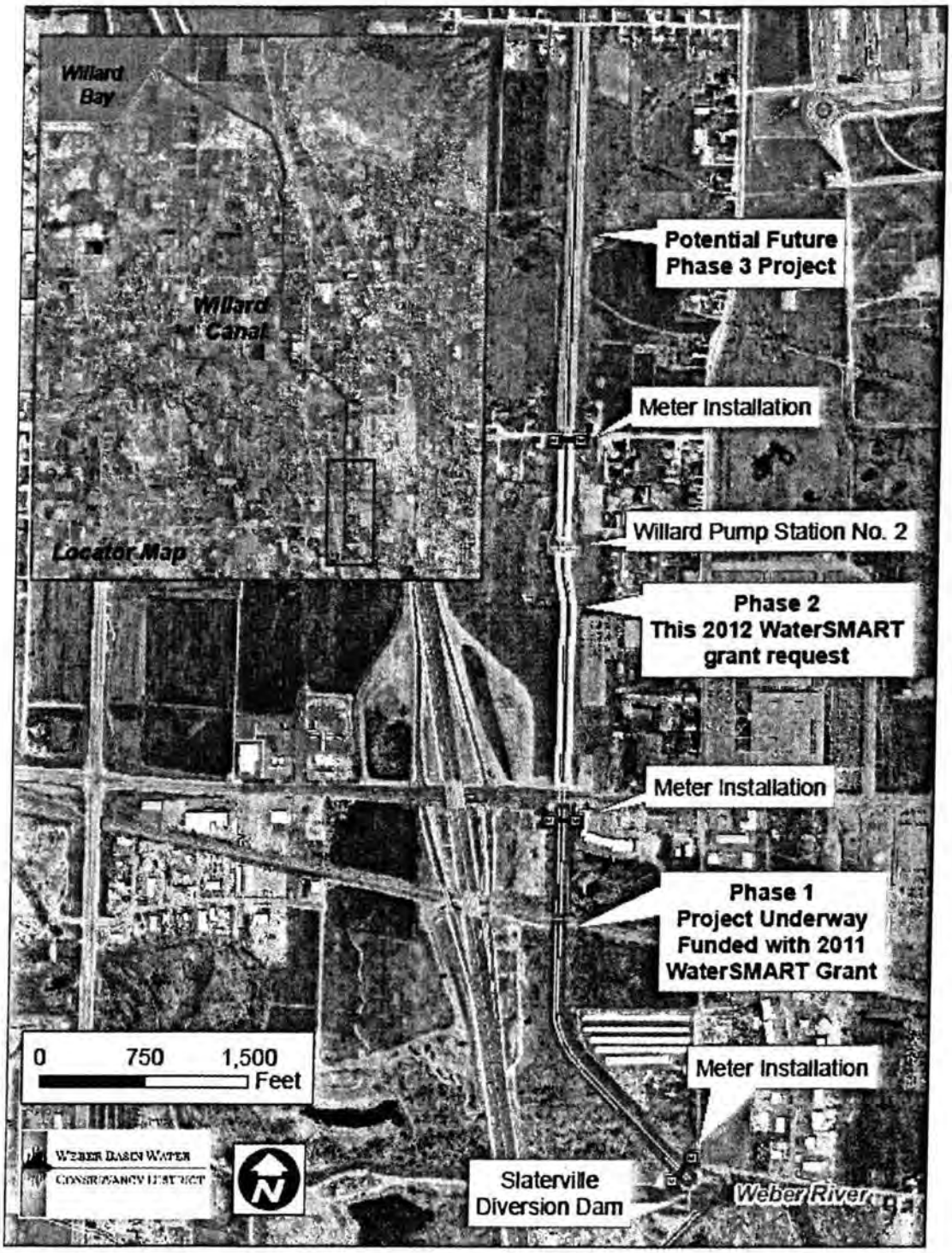


Photograph 2: View of Willard Canal Looking Towards Pumping Plant 2



Photograph 3: Typical Unlined Section of Canal At Location of Leakage Analysis Testing

Figure 4: Map of Project Location and Phases of Work



5.4 Evaluation Criteria

5.4.A.1 Water Conservation

Sub criterion A.1 (a) Quantifiable Water Savings

Amount of water saved and any Improvement to the District's Overall Delivery Efficiency

The overall Weber Basin Water Conservancy District has an expansive service area that covers nearly 2500 square miles, with total annual water deliveries of 220,000 acre feet per year.
The Willard Canal is a key component of the District's secondary water system, since it is the only method of sending water to and getting water from the Willard Bay Reservoir (refer to Figure 3). This reservoir has a current capacity of 215,000 Acre Feet. Long term planning efforts being considered by Reclamation and the District include increasing both the size of the Willard Reservoir and the Capacity of the Willard Canal.

Water loss is occurring in the canal due to seepage. This seepage is occurring due to a number of factors that are described in detail in Attachment A of this grant application. The primary causes of leakage are that the original clay liner has been eroded over the life canal and that seepage is occurring in the sidewalls of the canal, which were not lined during original construction. Therefore, water loss occurs by canal water seeping into the ground.

Water saved by lining the Willard canal can then be stored in Willard Bay. Alternately, saved water could be stored in upstream mountain reservoirs as determined to be feasible through water marketing planning currently underway as a part of the District's two ongoing waterSMART canal lining projects.

Specific questions in the FOA and District responses to these questions concerning the proposed canal lining project are given below:

FOA Questions:

☐ How has the estimated average annual water savings that will result from the project been determined? Please provide all relevant calculations, assumptions, and supporting data.

☐ How have average annual canal seepage losses been determined?
Have ponding and/or inflow/outflow tests been conducted to determine seepage rates under varying conditions? If so, please provide detailed descriptions of testing methods and all results. If not, please provide an explanation of the method(s) used to calculate seepage losses. All estimates should be supported with multiple sets of data/measurements from representative sections of canals.

District Responses to FOA Questions:

The District has conducted an in depth system optimization review (SOR), which was submitted to Reclamation in 2010. As a component (SOR), the District evaluated water looses in existing system canals, described in Attachment A. The SOR identified the upper Willard Canal as an area with high water losses which could be effectively mitigated by canal lining. The methods used to estimate canal water losses were as follows:
1) Research was conducted to ascertain canal lining techniques used by other Districts in the Western United States;
2) Canal system design and maintenance information was reviewed and analyzed by a Geotechnical firm with experience in canal design;
3) Borings were placed along the entire alignment of the Willard Canal;
4) Piezometers were installed at aforementioned boring locations to determine water table levels and fluctuations with respect to canal water levels;
5) Samples of canal lining materials were taken along the entire alignment of the canal;
6) Data from steps 1) through 5) were analyzed and compared to published reports;
7) Operational measurements from existing system operations records were considered; and

FOA Question

☐ What are the expected post-project seepage/leakage losses and how were these estimates determined? (e.g., can data specific to the type of material being used in the project be provided?).

The District has utilized the results in the attached Reclamation Project Report to derive post project leakage estimates. This report states for the project area studied that a complete prism concrete lining method should be 70% to 85 % effective. A value of 75% effectiveness is used to reduce the water savings estimates in the consultant report contained in Attachment A.

Therefore water savings estimates are:

The average water loss estimate for the upper 6000 feet of the Willard Canal is 14,240 acre feet/yr (Refer to Attachment A of this waterSMART Grant Application). The 2012 waterSMART application addresses 2600 of canal. Therefore, water savings of 6160 AF/yr can be inferred from Attachment A data.

This water loss estimate is further reduced by the 75% effectiveness estimate from Attachment E of the District's 2012 grant Application.
The resulting water savings are thus 4,600 AF/year.

FOA Question

☐ What are the anticipated annual transit loss reductions in terms of acre-feet per mile for the overall project and for each section of canal included in the project?

Transit loss rates of 10% were used in the estimate of water saved. This transit loss rate is consist with the current transit loss rates specified by Reclamation for existing canals. This number is conservative because it is based the canals original design configuration with only a 2' clay liner at the base of the canal.

Based on using this value of 10% water savings become (.9)(4,600) = 4100 AF/yr

This final adjusted value of 4,100 AF is thus used in subsequent benefit/cost analyses.

FOA Question

☐ How will actual canal loss seepage reductions be verified?

Actual losses will be measured, as outlined in Section 5.3, Task 2. As a part of the proposed Phase 2 Willard Canal Lining Project, addition flow meters will be installed before the lining is installed to verify loss projections made as a part of the SOR. These new meters will be installed at the termination of the Phase 2 project. It is noted that flow meters will already exist a the beginning point of the Phase 2 project, since these will be installed as a component of the ongoing Phase 1 Willard Canal Lining Project. The same type of meters under similar flow conditions (velocity, depth) will thus exist and collect data both before and after the Phase 2 concrete lining installation.

FOA Question

☐ Include a detailed description of the materials being used.

The project will use material consistent with the now underway Layton Canal Lining Project (funded by a 2009 waterSMART grant).
Specifically:
- The Willard Canal will be restored to a trapezoidal geometry using mostly in-situ material, with some infill possibly needed in selected areas;
- The canal liner will consist of reinforced concrete, with a thickness which will vary from 4" to 6" along the cross section of the canal prism. Construction and expansion joints will include water stops. Alternately, an EDPM liner, with concrete cover, will be considered in the final design, as described in cost estimate data (Attachment B);
- Granular 6" minus and 1.5" minus drain rock, filter fabric and 6" perforated pipe will be used to augment underdrains and prevent concrete liner floatation.

Subcriteria No. A.1 (b) Improved Water Management

Explanation of Improvements to Water Management provided by the Project Through the Use of Measurement, Automation or Other Approaches Where Water Savings that are Not Quantifiable

The District will install acoustic meters to measure canal flow before project completion and after canal lining. Meters will be installed in the locations shown in Figure 4.

Subcriteria No. A.2 Percentage of Total Supply

The water savings achieved by the proposed Phase II Willard Canal Lining Project amount to savings of approximately 1.9% of the total water supply across the entire 5 county area served by the district.

Another relevant number is that this corresponds to approximately 3.7 % of water savings for the average amount of water delivered to Willard Bay annually.

Subcriteria No. A.3 Reasonableness of Costs

Using the criteria in the funding application:

Reasonableness of Project Cost: $2,080,200/ ((4,100 avg. acre feet average water saved) (50 years)) = $10.15/acre foot/year.

As the District's current water retail rate for untreated water is $245/acre foot/year; the project is extremely cost effective.

5.4.B Criterion B, Energy-Water Nexus

Subcriterion No. B.2 Increased Energy Efficiency

Analyses performed as a part of the District's SOR allowed projection of potential savings in pumping costs as a function of AF of water delivered. The proposed Phase 2 Willard Canal lining project will result in direct measurable power savings of approximately 22,000 Kilowatt hours (kwh) due to saved pumping costs of lost water. This estimate is past based upon District Power consumption records for the Willard 2 Pumping Plant.

The District will also increase the energy efficiency of canal operations by utilizing solar energy to power new metering stations.

5.4.D Criterion D, Water Marketing

1) Estimated Water to be Marketed
The District is able to determine the water losses in the current canal configuration based upon geotechnical testing conducted during the SOR. The amount of water to be marketed is approximately 4,100 AF/year.

2) Description of Water Marketing Mechanism
The District will create a flexible water marketing legal structure which will allow this conserved water to be marketed. All of the water saved by constructing the proposed project can be marketed. In this regard, water marketing planning work to be done as a part of the currently underway Willard Canal Phase 1 Canal Lining and Water Marketing project will be directly applicable to this current 2012 waterSMART application.

3) Number and types of users
The proposed approach of storing the water at the Rockport Reservoir (refer to Figure 1) will allow the District considerable flexibility in the number and types of users for the marketed water. As the demand for water is increasing, with few other sources of new water available, the District will have no difficulty in marketing water saved through this project.

4) Description of Legal Issues
Based on the results of water marketing investigations conducted thus far, as a component of the District's SOR, no limitations exist with regard to which types of users the water may be marketed to. Water saved as a result of this project will most likely be marketed using the existing legal structure in place for many of the District's secondary water customers, via water lease petitions. Other mechanisms, such as transfer agreements will however also be considered to identify the best approach to achieve water conservation objectives in the District's Water Conservation Plan.

5) Estimated Duration of Transfer
The specific duration of transfer agreements will need to be determined during the course of the project. If a water transfer agreement (or agreements) is the best approach for water conservation and water management, then the District will negotiate these agreements. Interested parties will likely consist of the District's larger wholesale customers (other canal companies and cities).

5.4.E Criterion E, Other Contributions to Water Supply Sustainability

Utah is the second driest state in the United States. As such, drought relief planning is an essential component of the Weber Basin Water Conservancy District's planning efforts. All of the water saved through this project may be used to meet rapidly increasing demands for water in Weber County.

The Project will address several water sustainability issues that have been identified as a high priority in the District master plan. The proposed project will have an expected life

of at least 50 years, and therefore will be in use until at least 2060. The governor's office projects the population in Weber County to increase from slightly over 200,000 in 2010 to over 400,000 over the 50 year life of the project.

Through development of a water marketing mechanism for the additional 4100 AF/yr or water to be saved the District the will be able to provide more water to wholesale customers in its 5 county service area. Many of these customers are municipalities that have limited or no ability to develop new water sources themselves.

5.4.F Criterion F Implementation and Results

Subcriterion F.1 Project Planning

1) District Wide Planning that Supports the Project

The District has recently completed a District Wide System Optimization Review. This SOR has identified canal lining and metering projects as the top two priorities. This Grant request addresses the canal lining priority. The approached used in the SOR that was used to identify the need for the Willard Canal Lining and Water Marketing Project is shown in Figure 5.

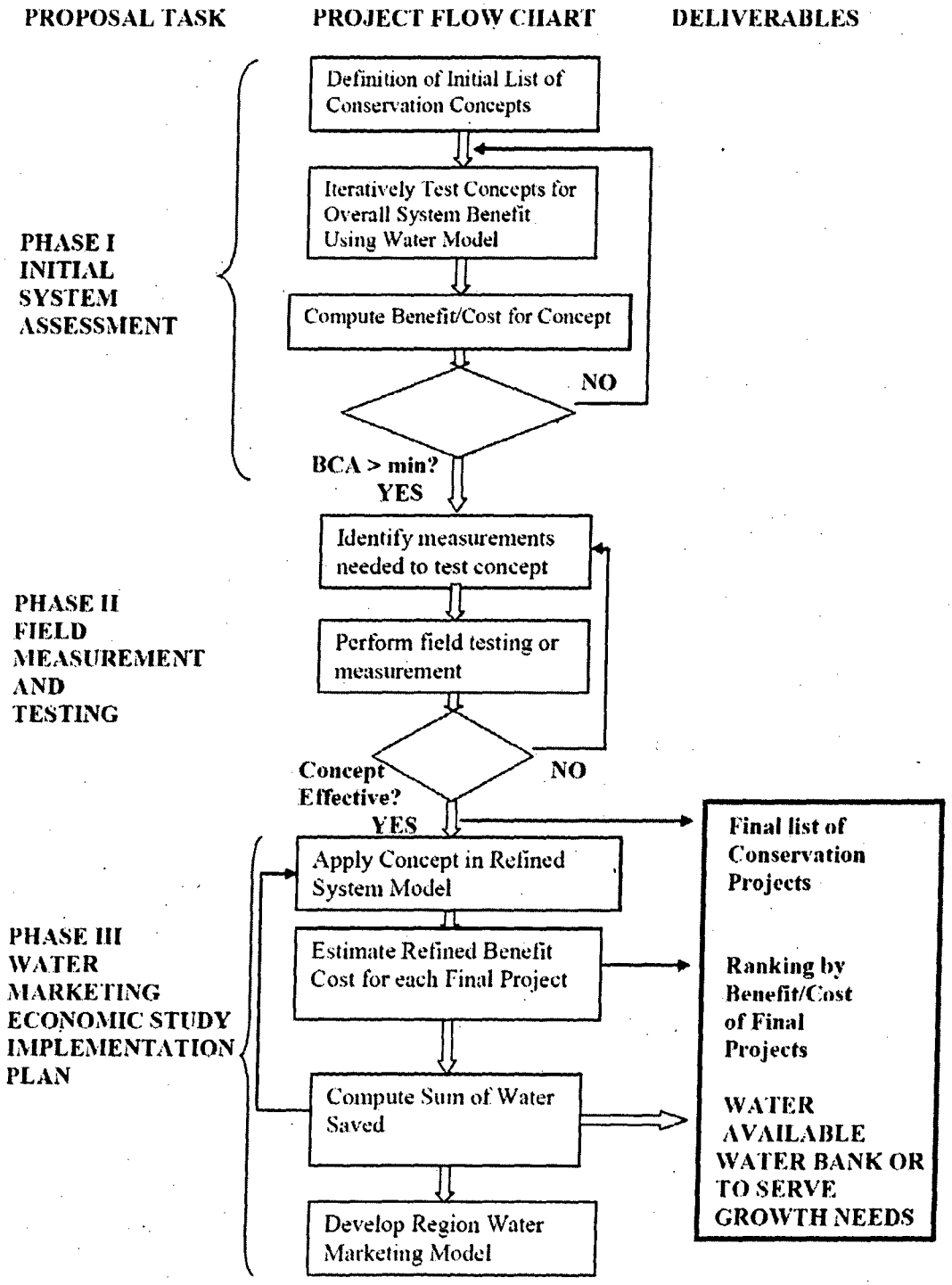
2) Engineering or Design work Performed Specifically in Support of the Proposed Project

The District has performed thorough evaluations of the condition of the liner in the Willard Canal and used this information to estimate leakage rates. This information is in Attachment A. In addition, other engineering work has been done as part of the SOR, including trunk line meter installation. This work enables the District to accurately estimate the cost of installing meters at the Willard Canal Pump Station, for the proposed Willard Canal Lining and Water Marketing Project.

3) How Project Conforms to and Meets Goals of State or Regional Water Plans

The proposed metering project will assist the District in meeting its conservation goal of a 25% reduction by 2050 by saving 4,100 AF of the water currently being lost due to liner leakage in the subject portion of the Willard Canal.

Figure 5: Decision Process Used in the Weber Basin Water SOR to Identify Priority Water Conservation and Water Banking Projects High



Subcriterion F.2 Readiness to Proceed

The District is prepared to proceed with the Phase 2 Willard Canal Lining Project immediately upon funding by Reclamation. The work plan presented above in Section 5.3 of this grant application will be implemented and is summarized in the Table 3 below:

Table 1: Willard Canal Phase 2 Summary of Milestones

Project Component	Start Date	Completion Date
Task 1 Environmental Compliance Audit	October 2012	March 2013
Task 2 Installation Flow *Measurement Equipment, and SCADA Systems and collection of flow measurement data for one complete irrigation season (April to October)	March 2013	October 2013
Task 3) Final Engineering Design	March 2013	August 2013
Task 4) Bidding and Contractor Selection	August 2013	September 2013
Task 5) Construction: Installation of New Concrete Lining on the Willard Canal from the Termination of the Phase I Project at Siphon at 1200 South Street to the Termination of the Phase II project at 700 South Street in Marriott Slaterville	October 2013	June 2014
Task 6) Creation of Water Marketing Mechanism	Underway currently as a component of the Phase I Willard Canal Lining and Water Marketing Project	April 2015

* This schedule enables the District to collect one full year of flow data prior to constructing the lining the following off season. In this way, actual water savings can be verified.

Subcriterion F.3 Performance Measures
The flow measurement equipment, to be installed as a part of this project, will enable the District to confirm water savings achieved. Flow measurement equipment will be installed 6 months prior to canal lining to measure leakage rates, and then reinstalled once lining is completed.

e.4. (g) Project Financing and Cost Sharing

Subcriteria No. 1 Allocation of Costs:

(Grant Criteria: Reasonableness, appropriate for the work proposed, necessary, and predominantly allocated to direct Project work):
The budget proposal identifies direct (construction) costs, indirect costs (design fees), and environment auditing. Since all work is being done in an existing canal alignment, environmental costs should be minimal.

Subcriteria No. 2: Additional Non Federal Funding

The total project cost, as itemized in Table 2 of the budget proposal is: $2,080, 200.00. Of this amount, the District is requesting a Federal share of $998,496.00 (48%).

5.4.F Criterion G Connection to Bureau of Relation Project Activities

The project is directly connected to Reclamations' activities, since the Willard Canal is part of Reclamation's Weber Basin Project. The canal is on land owned by Reclamation. As shown in Figure 4, water to the Willard Canal is diverted from the Weber River at the Slaterville Diversion Dam, which was constructed by Reclamation as part of the original Weber Basin Project. All of the water saved as a result of the project will serve to augment water supplies in the Weber Basin area, thus reducing future conflicts.

6.0 ENVIRONMENTAL COMPLIANCE

The District understands that in order to allow Reclamation to assess the probable environmental impacts and costs associated with each application, all applicants must respond to the following list of questions focusing on the requirements of the National Environmental Policy Act (NEPA), the Endangered Species Act (ESA), and the National Historic Preservation Act (NHPA). The District therefore submits the following responses to the following questions contained in the grant application to the best of the District's knowledge.

(1) Will the project impact the surrounding environment (i.e., soil [dust], air, water [quality and quantity], animal habitat, etc.)? Please briefly describe all earth-disturbing work and any work that will affect the air, water, or animal habitat in the project area.

Please also explain the impacts of such work on the surrounding environment and any steps that could be taken to minimize the impacts.

The project will require a moderate level of earth work. However, this entire earthwork is within the existing canal right of way. Animal habitats will not be negatively impacted.

(2) Are you aware of any endangered or threatened species in the project area? If so, would they be affected by any activities associated with the proposed project?

No endangered species are impacted by this project.

(3) Are there wetlands inside the project boundaries? If so, please estimate how many acres of wetlands there are and describe any impact the project will have on the wetlands.

No wetlands are in the project boundaries.

(4) When was the water delivery system constructed?

The original canal was constructed over a several year period in the early 1960's.

(5) Will the project result in any modification of or effects to, individual features of an irrigation system (e.g., headgates, canals, or flumes)?

Yes, the primary modifications will be canal lining, and meter installation.

(6) Are any buildings, structures, or features in the irrigation district listed or eligible for listing on the National Register of Historic Places?

No.

(7) Are there any know archeological sites in the proposed project area?

No.

(9) Will the project limit access to and ceremonial use of Indian sacred sites or result in other impacts on tribal lands?

No.

(10) Will the project contribute to the introduction, continued existence, or spread of noxious weeds or non-native invasive species known to occur in the area?

No.

7.0 REQUIRED PERMITS OR APPROVALS

The project will be constructed entirely on Reclamation owned lands, and in existing canal right of ways on these lands.
Permitting issues will not be a limiting factor.

8.0 FUNDING PLAN AND LETTERS OF COMMITMENT

Information in this section describes how the non-Reclamation share of project costs will be obtained.

The District will fund all non- Federal contributions entirely with Weber Basin Water Conservancy District funds. The District provides the following responses to questions in the Funding Opportunity Announcement:

(1) How you will make your contribution to the cost-share requirement, e.g., monetary and/or in-kind contributions and source funds contributed by the applicant (e.g., reserve account, tax revenue, and/or assessments).

Answer: The District will fund the project through a combination of proceeds from bonds and current operating revenues.

(2) Describe any in-kind costs incurred before the anticipated project start date that you seek to include as project costs. The description of these costs shall include:

Answer: The District does not request reimbursement for any in-kind costs incurred prior to the project start date.

(3) Provide the identity and amount of funding to be provided by funding partners, as well as the required letters of commitment.

Answer: The District has no other funding partners.

(4) Describe any funding requested or received from other Federal partners.

Answer: None.

(5) Describe any pending funding requests that have not yet been approved, and explain how the project will be affected if such funding is denied.

Answer: None.

9.0 OFFICIAL RESOLUTION

An official resolution will be submitted to Reclamation within 30 days of this application submittal, as required by the FOA. This resolution will be approved by the District's Board of Trustees.

10.0 BUDGET PROPOSAL

10.1 Budget Itemization

The estimated costs for this project are given in the technical proposal and further itemized in this budget proposal. The total cost of the project is as follows:

1) Installation of concrete canal lining for the Willard Canal from the Siphon at 1200 S Street in Marriot Slaterville to the project termination at 700 S Street in Marriott Slaterville (2,600 lineal feet), Includes sub grade and underdrain improvement costs: $1,872,000. (Refer to Attachment B.)

2) Construction of Acoustic Meters, as shown in Figure 4: termination: $18,000/installation.

3) SCADA improvements will be done at District costs as a separate project.

4) District administrative and management cost, and environmental, reporting and regulatory fees as itemized in Table 2: $25,000.

5) Design Engineering and Construction Phase Engineering: 6.5% = $125,500.

(k.2) Project Budget Summary Table

A budget table, in the format specifically given in the grant announcement, is provided in Table 2.

(k.3) Budget Narrative Format

The following budget narrative is provided in the specific format given in the grant announcement.

(a) Salaries and Wages

The District is not requesting reimbursement for District personnel costs.

(b) Fringe Benefits

The District's fringe benefit rate is 42%. However, the District is not asking for reimbursement of internal project costs.

(c) Travel

The District is not requesting any reimbursement of travel.

(d) Equipment.

Costs of new acoustic meters to be directly purchased by the District are $39,700, as described in Attachment B.

(e) Materials and Supplies

Itemizations of construction by major category, unit price, quantity, and purpose, such as whether the items are needed for office use, research, or construction is provided in Attachment B. The District is not asking for reimbursement of any office supplies.

(f) Contractual

The total project design and construction budget is $2,055,200

(g) Environmental and Regulatory Compliance Costs

Environmental costs are expected to be very minimal, as all work is done in the existing canal right of way in the immediate vicinity and/or directly in the location of the existing canal. As instructed in the grant instructions, a cost of no less than 1% of the total project budget is allocated to environmental and regulatory fees. Therefore, a cost of $25,000 is used. All of this cost will be part of the District's cost share agreement between Reclamation and the applicant. If any portion of the funds budgeted for environmental compliance is not required for compliance activities, such funds may be reallocated to the project, if appropriate.

(h) Reporting: The District is not requesting reimbursement for any reporting fee costs.

(i) Other: The District is not asking for reimbursement of any other costs.

(j) Indirect Costs: The District is not asking for reimbursement of any indirect costs.

(k) Total Cost

The total project cost is $2,080,200. The proposed District cost share is 1,081,704 (52%); and the proposed federal share is $998,496 (48%). This cost is itemized in Table 1, below, and is also given in form 424C- Construction programs.

Table 2: Project Budget

BUDGET ITEM DESCRIPTION	COMPUTATION		RECIPIENT FUNDING	RECLAMATION FUNDING	TOTAL COST
	$/Unit and Unit	Quantity			
SALARIES AND WAGES	Reimbursement of District Costs are not requested.				
FRINGE BENEFITS	Reimbursement of District Costs are not requested.				
Full-time employees					
Part-time employees					
TRAVEL	Reimbursement of District Costs are not requested.				
EQUIPMENT					
Acoustic Meters	$39,700 each	1	$39,700		$39,700
SUPPLIES/MATERIALS	Reimbursement of District Costs are not requested.				
Office supplies					
Construction					
CONTRACTUAL/ CONSTRUCTION					
1) Concrete Lining of Phase 2 portion of the Willard Canal	Refer to Attachment Analyses		$873,504	$998,496	$1,872,000
3) Meter Installation	$18,000 per installation	1	$18,000		$18,000
5) SCADA equipment and installation	Cost not estimated; reimbursement for this line item not requested				
ENVIRONMENTAL AND REGULATORY COMPLIANCE			$25,000		$25,000
Engineering Design@5%			$96,500		$96,500
Construction Phase Engineering Services @1.5%			$29,000		$29,000
Reporting					
TOTAL DIRECT COSTS			$1,081,704	$998,496	$2,080,200
INDIRECT COSTS - _0_%					
TOTAL PROJECT COSTS			$1,081,704	$998,496	$2,080,200

Attachment A

Canal Leakage Analysis Report

February 15, 2011

Mr. John Masek
Weber Basin Water Conservatory District
2837 East Highway 193
Layton, UT 84040

Phase 2 Canal Seepage Assessment
Willard Canal
Weber and Box Elder Counties, Utah

Mr. Masek:

Intermountain GeoEnvironmental Services, Inc. (IGES) has performed additional field investigation, sampling, laboratory testing and seepage assessment for the 10 mile stretch of the Willard Canal maintained and operated by the Weber Basin Water Conservancy District (District). This work was intended to supplement the findings of our 2009 subsurface investigation and liner sampling of the canal in order to better quantify the performance of the canal liner. Our liner sampling was performed at an additional 12 locations within the partially empty canal (see Figure A-1). Sample locations were selected to fill in gaps between the 10 locations sampled in 2009. The locations were spaced along the entire length of open canal starting at the Slaterville Diversion Dam and ending near Willard Bay in Box Elder County. Our field services and analysis were performed in accordance with our proposal dated January 27, 2010. This letter provides a summation of field work, laboratory testing, and seepage modeling.

CANAL OBSERVATIONS

Sampling and observation of the canal liner in 2009 was complicated by the presence of approximately 7-8 feet of water in the canal during our field investigation. Under the circumstances sample quality was relatively good, but an accurate representation of the existing channel cross section was not available or easily obtainable.

For a period of time in early February 2010 flow was not actively diverted into the Willard Canal from either the Weber River or Willard Bay. Our field investigation was scheduled and performed between February 3rd and 5th, 2010. Due to the relatively flat bottom slope of the canal, ponded water (up to 3 feet deep) and some ice (up to 1.5 feet thick) was encountered at sampling locations throughout the canal. These conditions limited measurement/documentation of canal bottom conditions. For most of the northern portions of the canal (10-6 through 10-12) snow was also present (up to 0.5 feet deep) on top of ice and on the canal side slopes limiting observation of liner conditions on the side slopes of the channel as well.

CROSS-SECTION SURVEY

In order to document the existing ground surface profile, IGES retained the services of a professional land surveyor. A surveyed cross section (ground surface or top of ice) was obtained at seven of the twelve sampling locations. The remaining five were not surveyed because of a scheduling conflict which prevented the surveyors from returning to the site prior to the canal being charged on February 5th. This survey data was combined with field measurements of ice thickness, water depth, liner thickness, laboratory measured permeability rates and previously obtained subsurface stratigraphic data (IGES, 2009) to create seepage models for each canal cross section. The estimated water level (7-8 feet) for the canal cross section(s) carrying 1,150 cfs corresponded with the liner deformation (sidewall sloughing) observed and measured by the surveyors.

LINER SAMPLING

Attempts were made to obtain at least one undisturbed sample of liner material at each of the 12 locations explored in this investigation; additional disturbed samples were collected for correlation of permeability testing results based on index testing of both sample types. The existing liner thickness was probed in the vicinity of collected samples using rebar. For simplicity in identifying sample locations at each cross section they have been identified as Left Bank, Center, and Right Bank. The following tables provide a summary of the estimated liner thickness encountered at each section; additional detail and observations about the sections are included in Appendix B.

10-1

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
		Left Bank	Center	Right Bank
4,565,630	415,209	1.17	1.17	1.17

10-2

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
		Left Bank	Center Bank	Right Bank
4,567,655	415,177	1.0	1.0	1.0

10-3

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
		Left Bank	Center	Right Bank
4,569,170	415,118	1.0	1.17-1.5	1.0

10-4

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,570,134	414,751	Left Bank	Center	Right Bank
		0.67	1.5 - 2.0	0.67

10-5

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,570,431	414,302	Left Bank	Center	Right Bank
		1.0	2.0	1.0

10-6

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,571,011	413,637	Left Bank	Center	Right Bank
		0.5	2.0	0.67

10-7

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,569,170	415,118	Left Bank	Center	Right Bank
		0.5	2.0	1.0

10-8

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,573,337	413,427	Left Bank	Center	Right Bank
		0.5 - 0.67	2.0	0.5 - 0.67

10-9

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,574,664	413,385	Left Bank	Center	Right Bank
		0.5 - 0.67	2.0 - 2.5	0.67

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10-10

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,575,306	413,325	Left Bank	Center	Right Bank
		No Sample	2.5	3.0

10-11

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,576,184	413,275	Left Bank	Center	Right Bank
		Rip Rap*	2.0**	Rip Rap*

* unable able to probe through gravel/cobbles (rip-rap) or excavate through frozen soils with hand tools, did not reach top of liner.
** pushed through 2' of soft material, but could not keep in Shelby tube.

10-12

Sampling Location				
Northing (m)	Easting (m)	Approximate Liner Thickness (ft)		
4,577,228	412,331	Left Bank	Center	Right Bank
		1.0	2.0	1.0

Photographs of sampling locations and the conditions encountered are contained in Appendix B.

The photographs show that during our 2010 investigation, while the canal was not under normal operational water levels, it was also not completely drained. Water, ice and snow obscured the canal/liner surface at the majority of our investigation locations. At the two southernmost locations (10-1 & 10-2) most of the canal cross section was visible and showed that liner soils were not uniformly distributed through the canal in these areas. Samples were collected and liner thickness measured from visible liner soils; however, streams flowing around liner "islands" indicated that little or no liner soils were present in portions of the southern reaches of the canal. This corresponds with our 2009 sampling in the southern reaches of the canal (locations 09-1 and 09-2) where respective liner thickness of 0 and 3 inches were measured.

LABORATORY TEST RESULTS

As mentioned previously general index and soil permeability tests were performed on samples collected during our field investigation. The following table provides a summary of the laboratory testing performed.

SAMPLE LOCATION	NATURAL DRY DENSITY (pcf)	NATURAL MOISTURE CONTENT %	GRADATION (%)			ATTERBERG LIMITS		PERMEABILITY	
Point No.			Gravel >#4	Sand	Silt and Clay <#200	Liquid Limit	Plasticity Index	(cm/s)	(ft/yr)
10-1 C		32.3	0	85.8	14.2	48	18	2.30E-05	2.38E+01
10-1 R									
10-1 L			0.6	45.1	54.3	34	7		
10-2 C			17.9	31.5	50.6	NP	NP	5.60E-04	5.79E+02
10-2 R					34.3	20	5		
10-2 L									
10-3 C		17.7							
10-3 R									
10-3 L			40.6	32.2	27.2	NP	NP		
10-4 C	91.7	23.9			1	NP	NP		
10-4 R					46.4	25	8		
10-4 L									
10-5 C		23.7	0.6	93.8	5.6	24	7	1.30E-04	1.35E+02
10-5 R									
10-5 L			20.2	38.3	41.5	19	3		
10-6 C	89.9	30.6			33.6	NP	NP		
10-6 R			13.1	38.6	48.3	21	5		
10-6 L									
10-7 C									
10-7 R									
10-7 L		20.1			40.8	21	7		
10-8 C	86	32.7			33.8	NP	NP		
10-8 R			7	50.9	42.1	18	3		
10-8 L									
10-9 C		29.5	-	81.2	18.8	NP	NP	1.20E-04	1.24E+02
10-9 R									
10-9 L					59.7	23	8		
10-10 C	88.4	32.6			32.1	NP	NP		
10-10 R					37.5	NP	NP		
10-10 L									
10-11 C	No sample								
10-11 R			88	10.5	1.5	NP	NP		
10-11 L	No sample								
10-12 C		49.8	-	36.4	63.6	34	12	1.00E-04	1.03E+02
10-12 R									
10-12 L		25.4			54.6	22	6		

Detailed results of the individual tests performed are included in Appendix C.

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SEEPAGE LOSSES

A simplistic model was created previously to approximate seepage losses based largely on the design cross section, utilizing an average head (water level in the canal) and average distance to groundwater (arbitrarily set 2.5 feet below the liner). Because the survey performed in February 2010 provided actual surface topography for most of the cross sections, and more accurate measurements of the liner thickness were obtained seepage losses were approximated using the Finite Element Modeling (FEM) capabilities of SLIDE 5.0 by RocScience instead of the simplistic evaluation performed using Darcy's Law in our previous canal assessment (IGES, 2009). Using the FEM method allowed us to accurately account for the variation in driving head along sloped sidewalls of the trapezoidal canal, it also allowed us to more easily model the impacts of groundwater fluctuation on seepage losses. Our 2009 assessment set groundwater 2.5 feet below the bottom of the constructed liner (average distance between bottom/side slopes and the natural groundwater surface); however, piezometer data indicated the water levels within the embankments were above this level. Our revised analysis attempts to quantify the impacts of groundwater fluctuation while also accounting for the variable distance to the water surface on the side slopes of the canal. Assumed values of embankment and native soil permeability were still required to complete the modeling. The same permeability value was assigned to the entire liner thickness at each cross section even though it is possible for the permeability to vary within the liner at that location. Because the canal runs near capacity for the entirety of the irrigation season, a constant water surface elevation (corresponding to 1,150 cfs) was used at each cross section.

As previously discussed, uneven distribution of liner soils was observed in the southern reaches of the canal (locations 10-1, 09-1, 10-2 and 09-2). This was particularly noted in the ~4,900 feet of canal located between the Slaterville Diversion Dam and Willard Pump Station No. 2 where low level flows meandered around liner "islands" on the bottom of the canal (see Figure B-2). We do not know exactly the causes or extent of liner degradation, but have attempted to account for the observed uneven liner distribution in our seepage modeling by removing the liner from 50% of the canal length between the two structures. Combining the removal of liner material with the granular nature of native soils in this area results in a seepage loss rate 33-37 times higher than the same section where a liner is present.

The following table provides a summary of the total annual seepage losses modeled for the entire length of the canal.

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	Scenario	Total Seepage Loss (acre-ft)
1,150 cfs	GW 2.5 feet below bottom of Liner	
	Simplistic (2009)	28,182
	FEM (2010)	29,126
	GW at levels measured in May 2009	
	FEM (2010)	20,903

With the groundwater modeled below the bottom of the liner for the entire length of the irrigation season (200 days) our modeling showed a 3.3% increase in approximated seepage losses by using the FEM method. Modeling the seepage losses using the May 2009 groundwater levels shows a 25% reduction in losses as compared to our previous modeling. Our modeling results approximate a 4.5-6.5% loss of water to seepage during the irrigation season. Further details of seepage modeling are included with this document in Appendix D.

CONCLUSIONS AND RECOMMENDATIONS

Based on construction drawings provided by WBWCD the canal liner was designed/constructed to be at least 2-feet thick (floor and side slopes) for the majority of the canal alignment, and 3 feet thick in the northernmost reach as it approaches Willard Bay. The liner thickness measured by IGES typically showed a reduced thickness on the side slopes, and sloughing of sidewalls was observed near the normal canal water surface and measured in most surveyed cross sections. Some of the soft material encountered/sampled may be comprised of liner material eroded from other areas of the canal or sediment transported by the Weber River. This hydraulically deposited material may be subject to additional movement during canal operation; altering the seepage rates as it changes location. Liner thickness on side slopes was typically measured to be less than that encountered on the canal "floor." Gravel (rip-rap) and frozen soils limited probing/measurement and sampling of liner material in some locations. It is also possible that the gravel encountered is part of the originally installed "liner" material, depending on the material source. Based on our field/laboratory measurements and computer modeling the canal loses between 4.5 and 6.5 percent of its total annual flow by seepage from the canal. Actual seepage rates will vary depending on surrounding groundwater levels and the depth of water in the canal; the canal may also receive water from surrounding groundwater during other times of the year. Our approximation of seepage from the canal does not include water lost during the initial charging of the canal and filling of voids in the "dry" liner or other surrounding soils. It is possible that some areas of the canal have less liner soils and more free-draining sands and gravels than encountered at the points explored. Our seepage modeling has not attempted to account for every variation in liner/native soil conditions between and beyond the points explored during our investigations. Substantial losses may result from a small area of the canal that

has a more free-draining liner/native soil profile. Other losses such as evaporation, or gains from precipitation should also be taken in to account when evaluating the overall canal performance.

Groundwater fluctuation is one key variable in accurately estimating the seepage losses from the canal. Piezometers have been installed to track the seasonal/operational fluctuations but have not been monitored since shortly after their installation in May 2009. Without data we cannot be certain, but because the canal had been full for a time prior to piezometer installation we assume that groundwater levels measured at that time closely reflect "normal" conditions; the stabilized level of groundwater through the majority of the irrigation season. We recommend that periodic readings be taken over the course of the calendar year in order to better understand the fluctuations.

From the differences seen when varying the groundwater levels, it can be inferred that loss rates will be highest during initial charging of the canal (spring) when surrounding groundwater levels are likely at or near their seasonal lows. The more rapid rate of seepage losses associated with low groundwater could be experienced for a larger portion of the season depending on weather. In a drought cycle where snowpack/runoff and rainfall recharge of groundwater is low, a greater percentage of the total canal flow could be lost. These losses become increasingly problematic because of increased demand during dry weather cycles.

By using a soil liner system in the canal some seepage is inevitable; however, based on our observations and measurements of liner variability we conclude the highest rate of seepage losses occur in the southernmost reaches of the canal where liner distribution was observed to be least uniform. Depending on groundwater levels we estimate the losses in this southern portion to be between 12,880 and 15,600 acre-ft per year. This means that a disproportionate 54-62% of the total volume lost is lost within the first 10-14% (5,000-7,000 feet) of the canal length. Considering the District's proposed Phase I lining project, we recommend that rehabilitation efforts be initially focused on the ~5,000 feet between the Slaterville Diversion Dam and Willard Pump Station No. 2. The next priority area should include the 2,000 feet immediately downstream (north) of Pump Station No 2.

Weber Basin Water Note for use in 2012 WaterSMART application:
If an average value of 14,240 acre feet is used from the above data, the water loss estimate per foot for this section of the canal is 2370 AF avg. of loss per 1000 feet of canal. The 2012 waterSMART application addresses 2600 of canal. Therefore, water savings of 6160 AF/can be inferred. This water loss estimate is further reduced by the 75% effectiveness estimate from Attachment E of the District's 2012 grant Application. The resulting water savings is thus 4,600 AF/year.

We appreciate the opportunity to provide you with our services on this project. If you have any questions, please contact us at your convenience (801-270-9400.

Respectfully Submitted,
IGES, Inc.

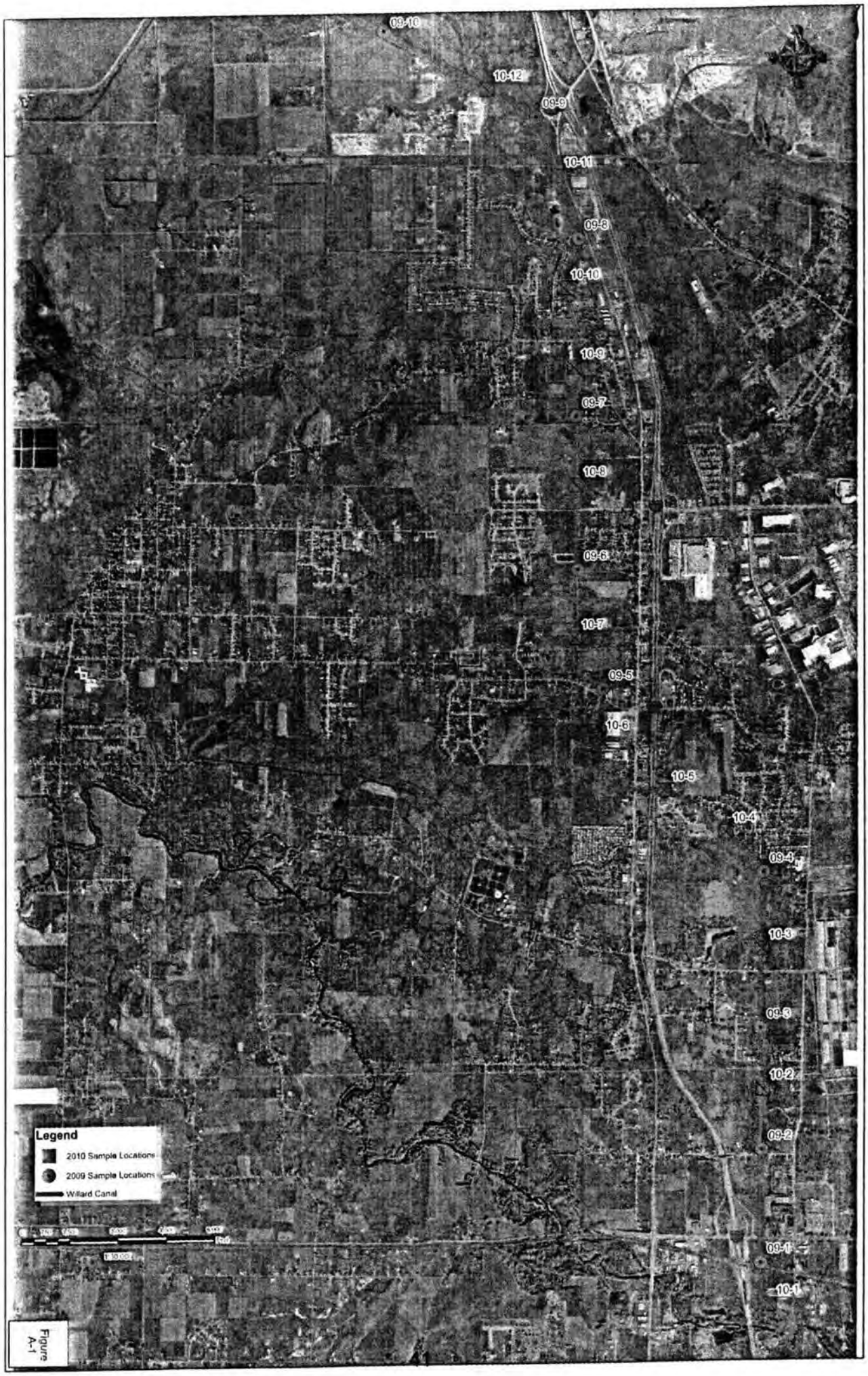
Jared Hawes, P.E.
Project Engineer

Brett Mickelson, P.E.
Principal

Attachments

Appendix A Figure A-1	Site Investigation Location Map
Appendix B Figures B-1 through B-24	Field Investigation Notes and Photographs
Appendix C	Laboratory Test Results
Appendix D	Seepage Modeling Results

APPENDIX A


09-10
10-12
09-9
10-11
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10-8
09-6
10-7
09-5
10-6
10-5
10-4
09-4
10-3
09-3
10-2
09-2
09-1
10-1
Legend
2010 Sample Locations
2009 Sample Locations
Willard Canal

Figure A-1

APPENDIX B

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/2/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 1**

	Proposed	Actual	
UTM Coordinates:	415,191.0 m E	415,209.0 m E	Install and Label T-post ☐
	4,565,797.7 m N	4,565,630.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo; 18 soft for 14", unable to probe beyond 14", no visual indication of seepage, bucket sample collected

\\file server\company\PROJECTS\0

Center/Bottom

Photo: 19 1" ice, some water, soft for 14" then stiff to 3' (~3' of fine-grained soils) shelby tube sample

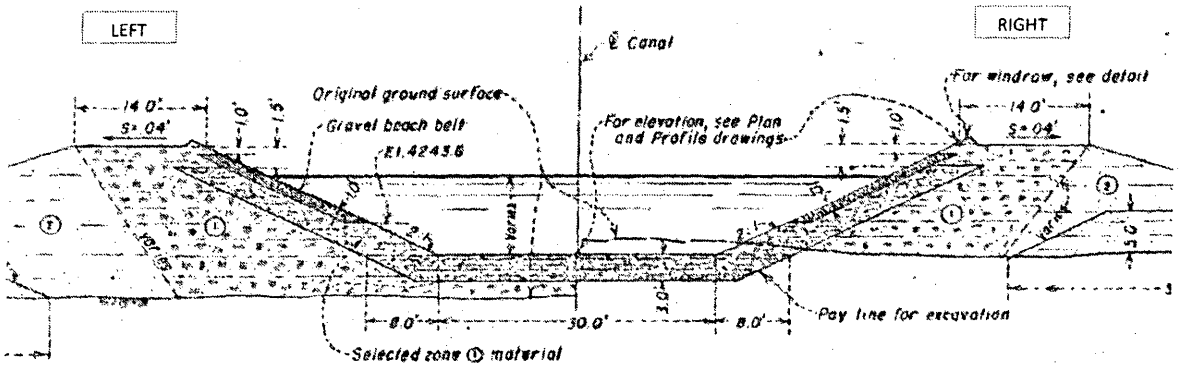
\\file server\company\PROJECTS\0

Left Bank

Photo: 20 soft for 14", unable to probe beyond 14", no visual indication of seepage, bucket sample collected

\\file server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Photo 12: Sample Location

Figure B-1

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/2/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 2**

	Proposed	Actual	
UTM Coordinates:	415,122.3 m E	415,177.0 m E	Install and Label T-post ☐
	4,567,808.8 m N	4,657,655.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 22 Rounded gravel rip-rap on surface ~ 6" thick, silty sand - black, organic, liner ~1' thick (bucket sample)

\\Slc-server\company\PROJECTS\0

Center/Bottom

Photo: 23 12" of liner (shelby sample)

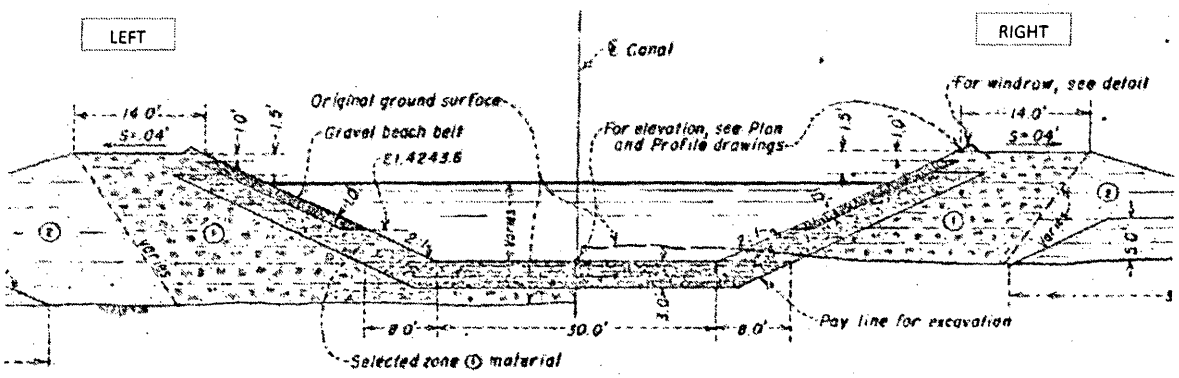
\\Slc-server\company\PROJECTS\0

Left Bank

Photo: 24 Rounded gravel rip-rap on surface ~ 6" thick, silty sand - black, organic, liner ~1' thick (bucket sample)

\\Slc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Figure B-3

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/3/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 3**

	Proposed	Actual	
UTM Coordinates:	415,113.1 m E	415,118.0 m E	Install and Label T-post ☐
	4,569,131.9 m N	4,569,197.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 25 6" gravel over 1' of liner

\\Sfc-server\company\PROJECTS\0

Center/Bottom

Photo: 26 14-18" of liner (shelby sample)

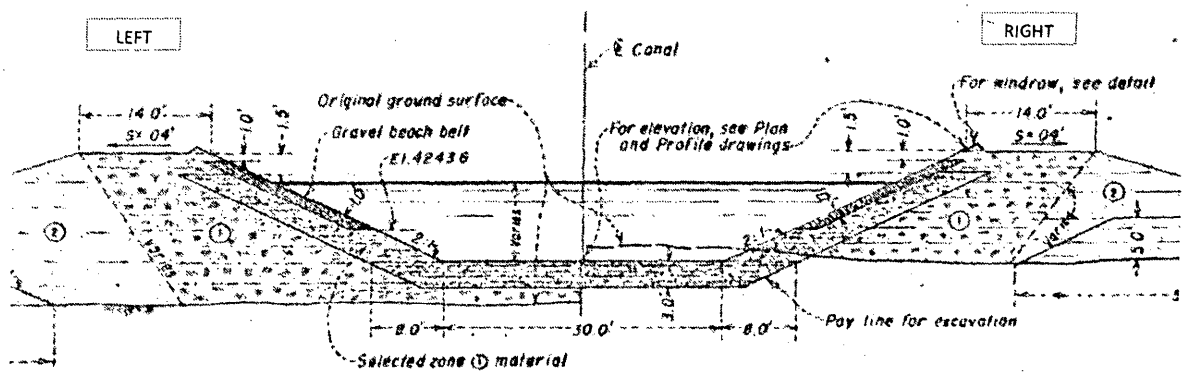
\\Sfc-server\company\PROJECTS\0

Left Bank

Photo: 27 6" gravel over 1' of liner

\\Sfc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Photos 30-31:

Figure B-5

\\Sfc-server\company\PROJECTS\00578 WBWG\011 Willard Canal Phase 2\Photos\IMAG0030.JPG

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2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/3/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 4**

	Proposed	Actual	
UTM Coordinates:	414,770.7 m E	414,751.0 m E	Install and Label T-post ☐
	4,570,242.3 m N	4,570,134.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 32 3" gravel rip-rap over 8" liner (bucket sample)

\\Sfc-server\company\PROJECTS\0

Center/Bottom

Photo: 33 18-24" of liner (shelby sample)

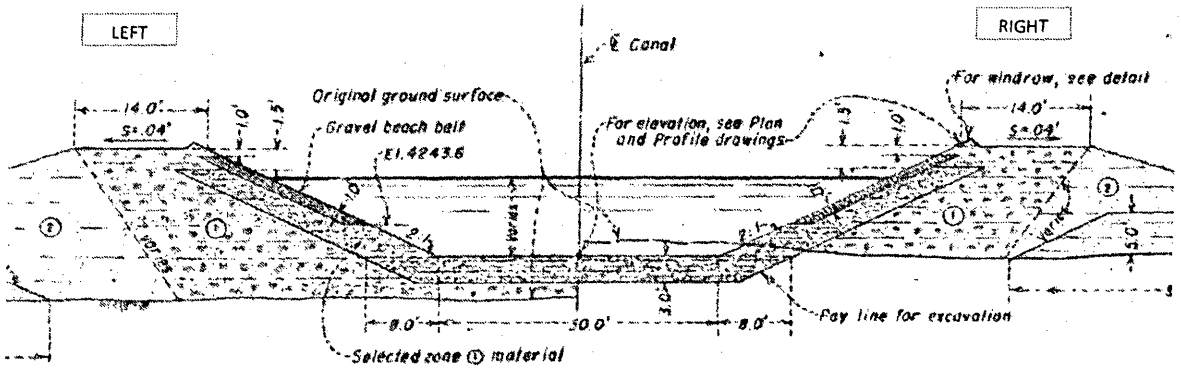
\\Sfc-server\company\PROJECTS\0

Left Bank

Photo: 34 3" gravel rip-rap over 8" liner (bucket sample)

\\Sfc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Figure B-7

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/3/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 5**

	Proposed	Actual	
UTM Coordinates:	414,196.3 m E	414,302.0 m E	Install and Label T-post ☐
	4,570,641.8 m N	4,570,431.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 35 3" rip-rap, 12" liner (bucket)

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Center/Bottom

Photo: 36 24" soft (shelby sample)

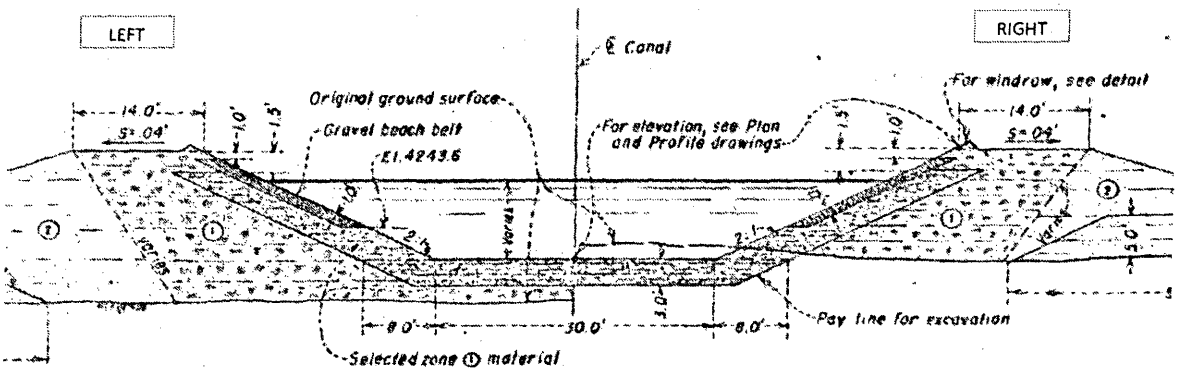
\\Sfc-server\company\PROJECTS\0

Left Bank

Photo: 37 8" ice

\\Sfc-server\company\PROJECTS\0 3" rip rap, 1' liner (bucket sample)

Sketch any observed differences from design cross section shown below



Additional Comments:

Figure B-9

2010 Willard Canal Assessment

Project #:	00578-011		
Date:	2/3/2010		
Staff:	C. Ege, D. Siebach		
Location ID	**WC2010 - 6**		
	Proposed	Actual	
UTM Coordinates:	413,577.5 m E	413,637.0 m E	Install and Label T-post ☐
	4,571,139.9 m N	4,571,011.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 38 Ice/snow 12-18" thick, 3" rip-rap, 8" liner- soft (bucket sample)

\\Slc-server\company\PROJECTS\0

Center/Bottom

Photo: 39 8-10" ice, 3" rip-rap, 2' soft clay (shelby sample)

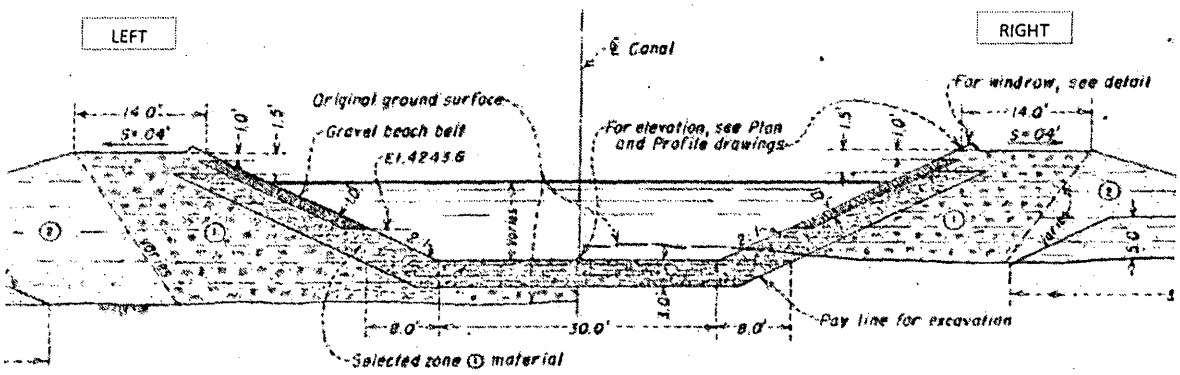
\\Slc-server\company\PROJECTS\0

Left Bank

Photo: 40 6" ice, 3" rip-rap, 6" soft, hard below (bucket sample)

\\Slc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

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Figure B-11

2010 Willard Canal Assessment

Project #:	00578-011
Date:	2/3/2010
Staff:	C. Ege, D. Siebach
Location ID	**WC2010 - 7**

	Proposed	Actual	
UTM Coordinates:	413,348.1 m E	413,373.0 m E	Install and Label T-post ☐
	4,572,102.5 m N	4,572,361.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 42 Ice ~6" thick, soft to 12" unable to probe/sample below (bucket sample)

\\Slc-server\company\PROJECTS\0

Center/Bottom

Photo: 43 Ice 8-10" thick, 3" gravel rip-rap, soft for 2' below (shelby sample)

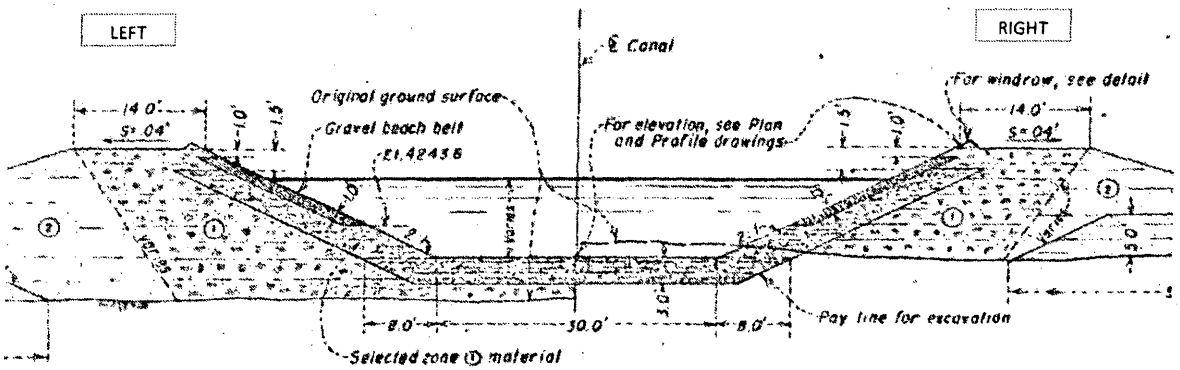
\\Slc-server\company\PROJECTS\0

Left Bank

Photo: 44 Ice ~6" thick, 3' rip-rap, soft for 6" unable to probe/sample deeper (bucket sample)

\\Slc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

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Photo 45

Figure B-13

2010 Willard Canal Assessment

Project #:	00578-011
Date:	2/3/2010
Staff:	C. Ege, D. Siebach
Location ID	**WC2010 - 8**

	Proposed	Actual	
UTM Coordinates:	413,365.5 m E	413,427.0 m E	Install and Label T-post ☐
	4,573,550.5 m N	4,573,337.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 46 Ice ~ 2" thick, 2 inches of gravel rip-rap over 6-8" soft clay (bucket sample)

\\Sfc-server\company\PROJECTS\0

Center/Bottom

Photo: 47 ice 12-15" thick, soft clay liner ~2' thick unable to probe/sample beyond 2' deep (shelby sample)

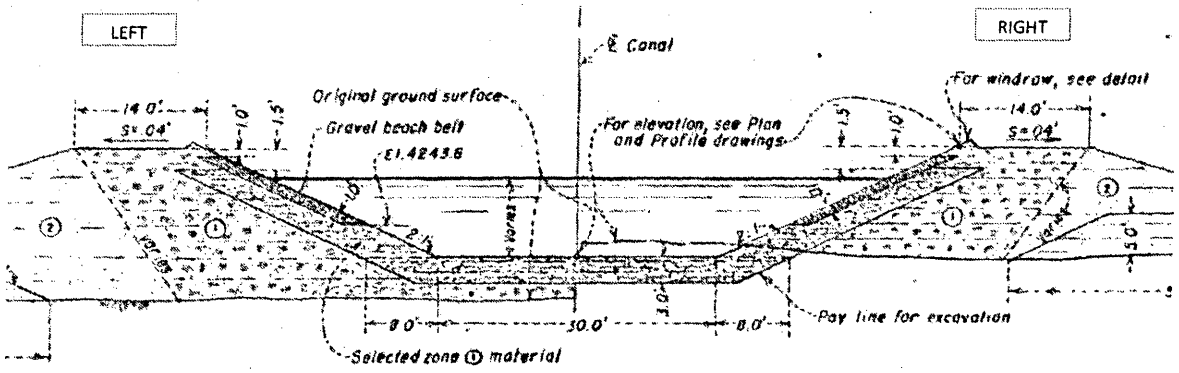
\\Sfc-server\company\PROJECTS\0

Left Bank

Photo: 48 Ice ~ 2" thick, 2 inches of gravel rip-rap over 6-8" soft clay (bucket sample)

\\Sfc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Photo #49

\\Sfc-server\company\PROJECTS\00578 WBWCP\011 Willard Canal Phase 2\Photos\IMAG0049.JPG

Figure B-15

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/4/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 9**

	Proposed	Actual	
UTM Coordinates:	413,342.8 m E	413,385.0 m E	Install and Label T-post ☐
	4,574,664.6 m N	4,574,664.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 50 6" subrounded gravel (rip-rap) 8" soft clay - bucket sample

\\Sfc-server\company\PROJECTS\0

Center/Bottom

Photo: 51 2-2.5' of soft clay, ~4-6" organics on top (shelby sample)

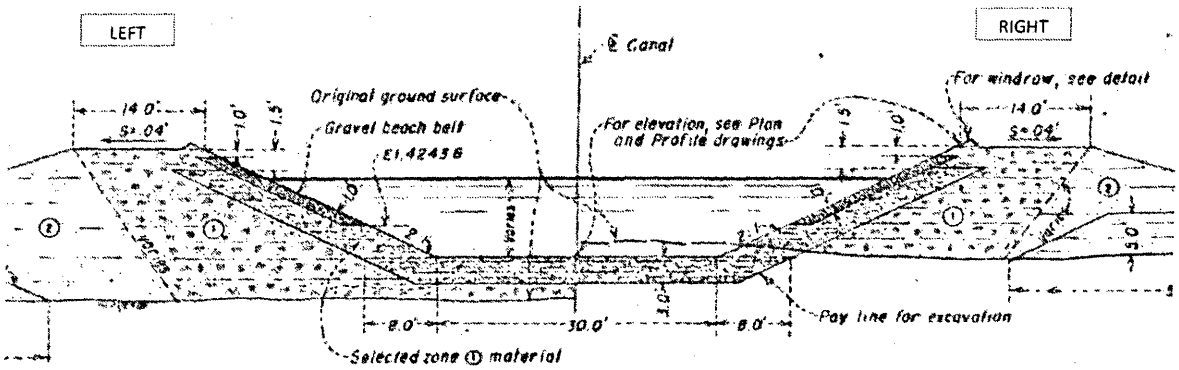
\\Sfc-server\company\PROJECTS\0

Left Bank

Photo: 52 3 to 6" subrounded gravel rip-rap over 6-8" clay (bucket sample)

\\Sfc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Figure B-17

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/4/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 10**

	Proposed	Actual	
UTM Coordinates:	413,244.6 m E	413,325.0 m E	Install and Label T-post ☐
	4,575,411.0 m N	4,575,306.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 53 Ice ~3" thick, no gravel, very soft, organic smell in upper 3', grass on slope, no apparent slumping

\\Sfc-server\company\PROJECTS\0 (bucket sample)

Center/Bottom

Photo: 54 Ice ~12" thick, some water, very soft to 24-30" below water (shelby sample)

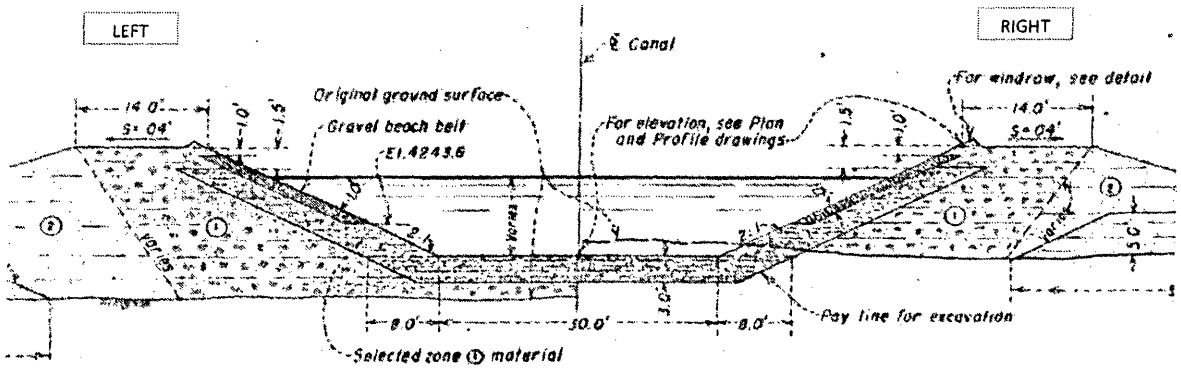
\\Sfc-server\company\PROJECTS\0

Left Bank

Photo: 55 Upper 3' exposed grass, no apparent slumping, no seeps (did not collect sample)

\\Sfc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Figure B-19

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/4/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 11**

	Proposed	Actual	
UTM Coordinates:	413,187.4 m E	413,275.0 m E	Install and Label T-post ☐
	4,576,460.6 m N	4,576,184.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 56 6" of ice, gravel (subrounded to rounded) at least 12 " thick, unable to locate liner (bucket sample)

\\Slc-server\company\PROJECTS\0

Center/Bottom

Photo: 57 Ice up to 18" thick, soft for 2' below, could not keep sample in shelby tube

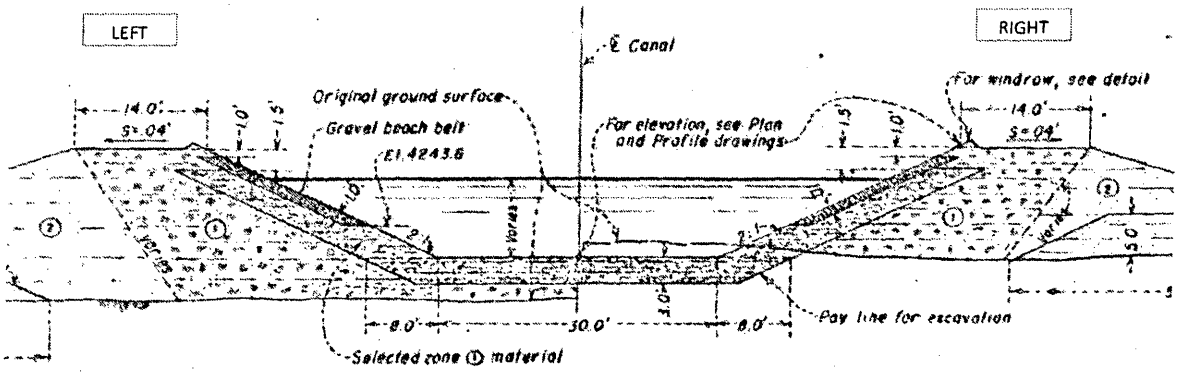
\\Slc-server\company\PROJECTS\0

Left Bank

Photo: 58 upper 2'3 feet of slope exposed grass, snow 3-6" thick, ice ~6" thick (no sample)

\\Slc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Figure B-21

2010 Willard Canal Assessment

Project #: 00578-011
Date: 2/4/2010
Staff: C. Ege, D. Siebach
Location ID **WC2010 - 12**

	Proposed	Actual	
UTM Coordinates:	412,513.6 m E	412,331.0 m E	Install and Label T-post ☐
	4,577,275.5 m N	4,577,228.0 m N	

Canal Description: include water/snow depth and ice thickness, probe liner thickness (describe location and resistance) Describe type and location of samples; describe vegetation (any indication of seepage)

Right Bank

Photo: 59 Exposed face (gravel and cobbles) gravel ~3" thick, soft for 1' below (liner - bucket sample)

\\Sfc-server\company\PROJECTS\0

Center/Bottom

Photo: 60 ice 12-18" thick, water ~3' deep, liner ~2' thick (soft) shelby sample

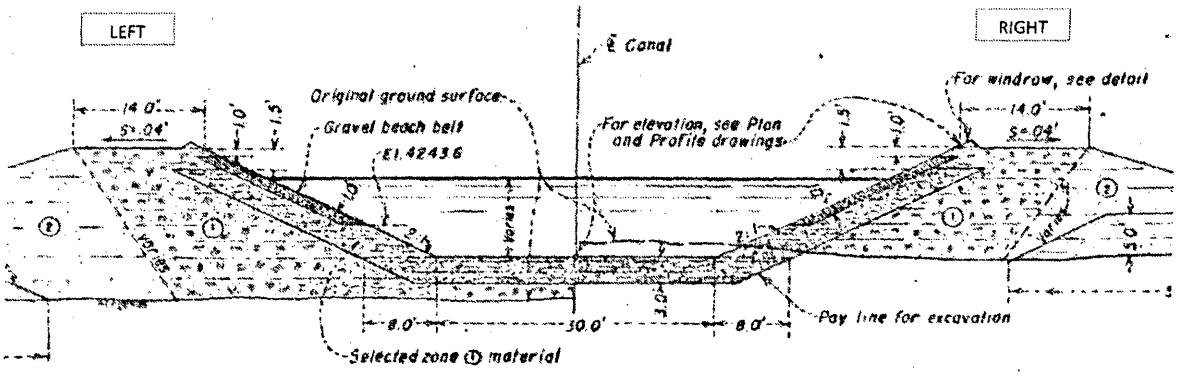
\\Sfc-server\company\PROJECTS\0

Left Bank

Photo: 61 Covered with snow and ice, soft (liner) is ~1' thick (liner - bucket sample)

\\Sfc-server\company\PROJECTS\0

Sketch any observed differences from design cross section shown below



Additional Comments:

Figure B-23

Attachment C

Acoustic Meter Data and Cost Estimates

Attachment C
Acoustic Meter Cost Analysis

The Weber Basin Water Conservancy District has estimated the cost of acoustic meter installation along the Willard Canal by reviewing published data from other similar projects, and by obtaining a cost estimate from a manufacturer that has installed similar meters for similar canals.

This attachment also includes manufacturer's information for the types of meters that are proposed for this project. Based on the attached proposal, the meter installation costs for the Willard Canal Lining Project will be $39,700.

Additional costs associated with installation of conduit and SCADA systems will be self performed by the District. The cost estimate for these items is $18,000. This includes the cost of solar units to power transducers and to transmit SCADA. This cost has been estimated based recent data from installation of solar powered meters on the District's SOR project.

REFERENCE NO.	RD020911-R1
DATE	February 9, 2011
TERMS	Net 30 Days
SHIPMENT	FOB shipping point.
DELIVERY	5-6 weeks ARO
VALIDITY	90 Days

ACCUSONIC TECHNOLOGIES

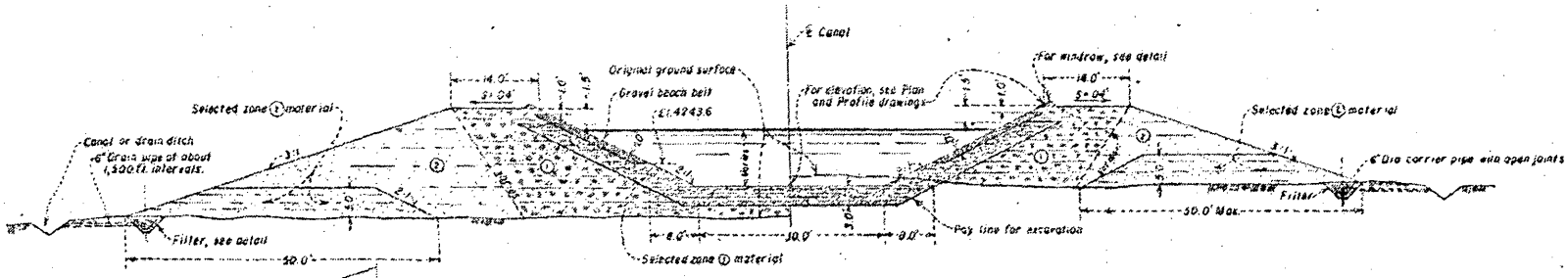
Weber Basin WCD
Willard Canal Lining Project

ITEM	QTY	Material and Equipment List	
1	2	7510+C-4-MO-H0-AC-Hand- Flowmeter • NEMA 4 Wall Mount Enclosure • 12-24 VDC, External Source Power • 4-Path Measurement Capability • 4 Isolated 4-20 mA Outputs • 4 Isolated 4-20 mA Inputs • Embedded Data Logging Capability • AccuFlow Windows-Based PC-Interface Software • RS-232 Serial Communication • Hand Held Keypad	
2.	16	Model 7612 Transducer with SS brackets • 2 Transducers per acoustic path for a 4path array • All Transducers at 45 degree angles	
3.	0	Ultrasonic Level Meter with remote sensor, purchase from Waterford System	
		Equipment only Cost	$59,770.
4.	Lot	*Accusonic Field Technical Services for installation supervision, commissioning and training. (Not to exceed 11 days including travel time. Additional days will be invoiced $1,150/day.) Travel and living expenses incurred while traveling to/from the project site and during the performance of the field service are included. Any incidental materials or equipment purchased which is required to complete the services will be invoiced at cost plus 15%.* Estimate based on: • 5 man-days for transducer installation supervision • 2 man-day for flowmeter commissioning and training, requires flowing channel • 4 man-days of travel (One trip, transducer installation, commissioning and training) Total estimated time is 11 days, expenses are included.	$19,592.
		Total Equipment and Field Service	**$79,372.**

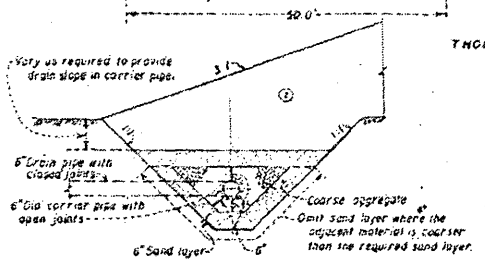
2001-2003 Accusonic Technologies

Attachment D

Selected Original Reclamation Drawings for the Willard Canal

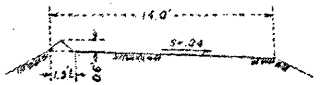


TYPICAL LINED CANAL SECTION
STA. 430+00 TO STA. 483+62



FILTER DETAIL
STA. 430+00 TO STA. 483+62
(Continuous)

SCALE OF FEET

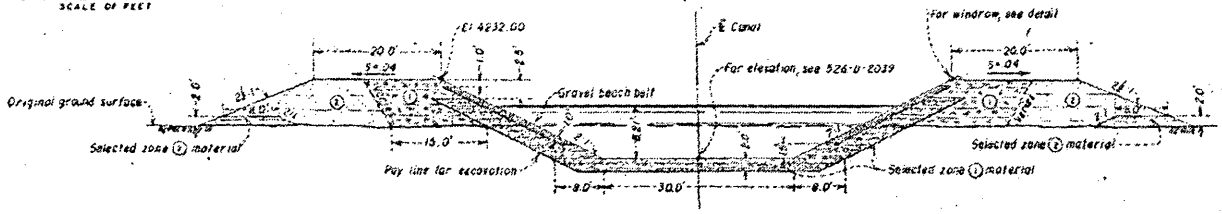


WINDROW DETAIL

SCALE OF FEET

EMBANKMENT EXPLANATION

① Clay, silt, and sand compacted by tamping rollers to 6" layers.
② Silty sand compacted by crawler type tractor to 8" layers
③ Miscellaneous compacted embankment.

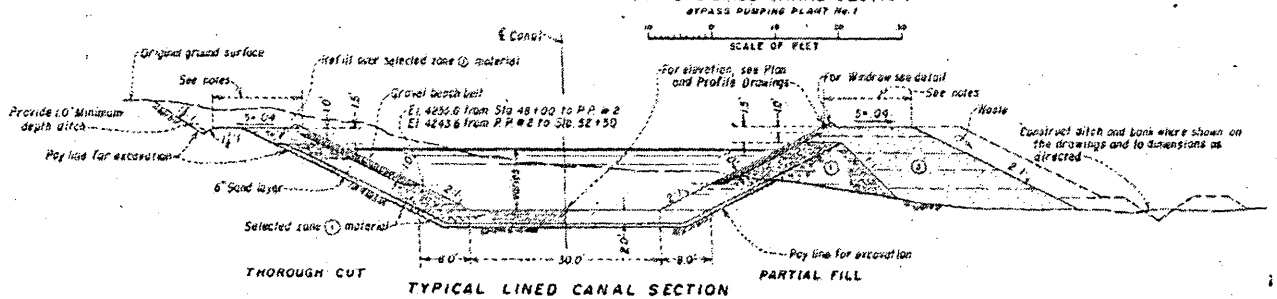


TYPICAL LINED CANAL SECTION
BYPASS PUMPING PLANT No. 1

SCALE OF FEET

NOTES

For general notes, see 526-D-2042 and 2052
Carrier pipe in filter to be sloped to drain
From Sta 48+00 to 52+50 omit the 6" sand layer under selected zone ① material where foundation material is finer than the required sand layer.
Roadway width to be 14.0' except as shown on 526-D-1949
Gravel beach belt not in this contract. Replace gravel beach belt with adjacent material.



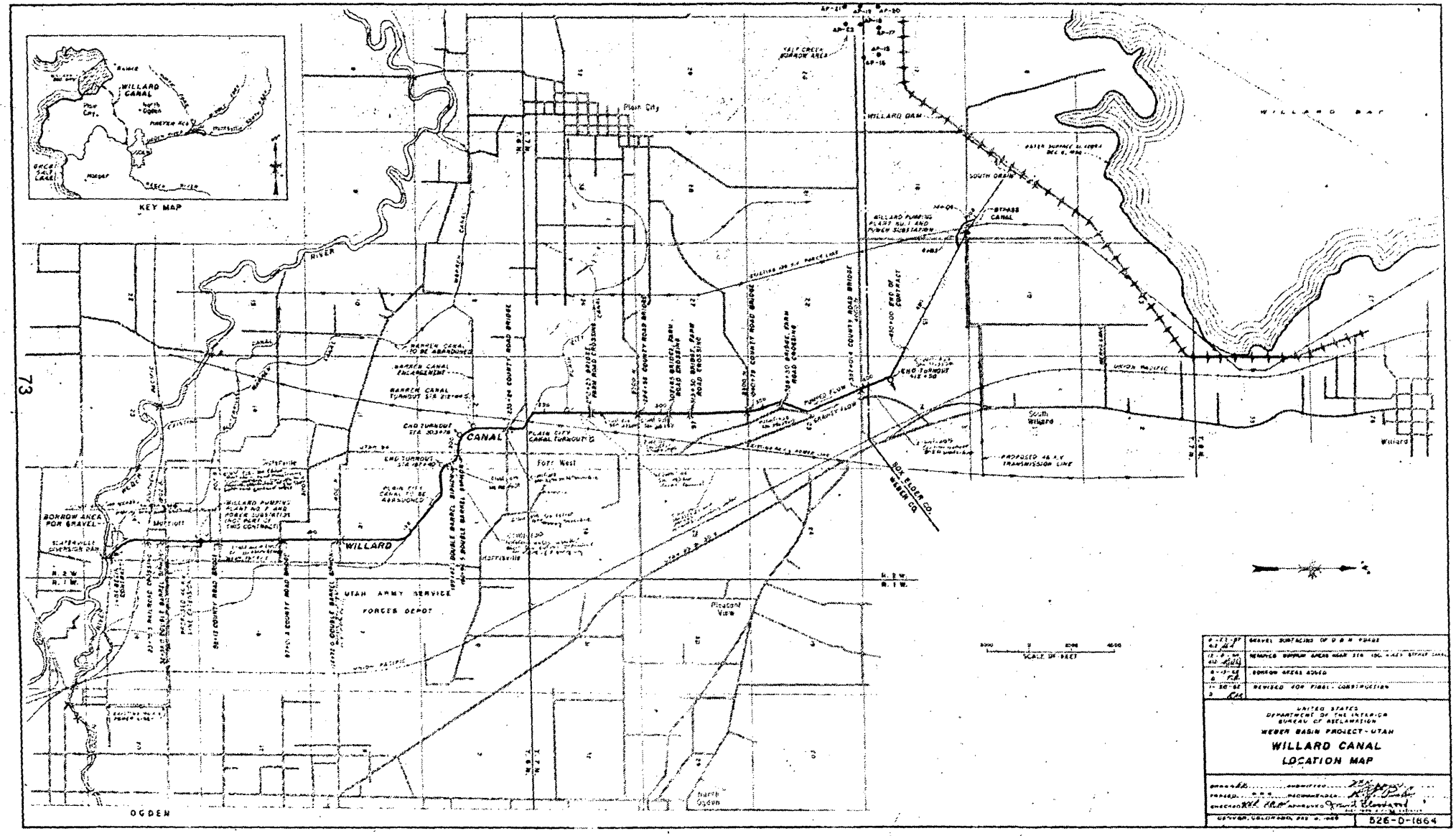
TYPICAL LINED CANAL SECTION
STA. 48+00 TO STA. 52+50
(UNDERDRAINS NOT SHOWN)
(FOR DETAILS SEE 526-D-2036)

UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WEBER BASIN PROJECT-UTAH

WILLARD CANAL
TYPICAL CANAL SECTIONS

DRAWN R.R.S. SUBMITTED
TRACED R.M.G. RECOMMENDED
CHECKED J.B. APPROVED
DENVER, COLORADO, FEB 10, 1961

526-D-1882


KEY MAP
WILLARD CANAL
Plain City
WILLARD DAM
WILLARD BAY
SOUTH DRAIN
BYPASS CANAL
WILLARD PUMPING PLANT NO. 1 AND POWER SUBSTATION
RIVER
CANAL
WILLARD
Fort West
South Willard
Willard
BOX ELDER CO.
WEBER CO.
PROPOSED 46 K.V. TRANSMISSION LINE
BORROW AREA FOR GRAVEL
UTAH ARMY SERVICE FORCES DEPOT
Pleasant View
North Ogden
OGDEN
SCALE OF FEET
GRAVEL SURFACING OF O & M ROADS
BORROW AREAS ADDED
REVISED FOR FINAL CONSTRUCTION
UNITED STATES
DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
WEBER BASIN PROJECT - UTAH
WILLARD CANAL
LOCATION MAP
526-D-1864

Attachment E

Post Canal Lining Leakage Estimate Basis

Attachment E Narrative
Post Willard Canal Lining Leakage Estimate

The District has utilized the results from the "R-00-01 CANAL-LINING DEMONSTRATION PROJECT 2000 SUPPLEMENTAL REPORT" to derive post project leakage estimates. This report states for the project area studied that a complete prism concrete lining method should be 70% to 85 % effective. A value of 75% effectiveness is used to reduce the water savings estimates in the consultant report contained in Attachment A. This report is not attached to the District Grant Application to keep within prescribed page limits for the total application.

Therefore water savings estimates are:

The average water loss estimate for the upper 6000 feet of the Willard Canal is 14,240 acre feet/yr (Refer to Attachment A of this waterSMART Grant Application). The 2012 waterSMART application addresses 2600 of canal. Therefore, water savings of 6170 AF/yr can be inferred from Attachment A data.

Using the above effectiveness percentage of 75%:
The resulting water savings for the Phase 2 Willard Canal Lining Project is
4,600 AF/year.