WATER MANAGEMENT IMPROVEMENTS IN CACHE VALLEY IRRIGATION CANALS

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Abstract

Detailed surveys of several Cache Valley, Utah, irrigation canals were conducted and key management and operations personal were interviewed about operations and maintenance practices. After completing a comprehensive survey of existing flow measurement structures in several Cache Valley canals, recommendations were made with regard to calibration shifts and need for maintenance. Management and operations personnel were interviewed about water delivery plans and locations for new flow measurement structures were selected. Seepage losses were measured in several reaches of the selected canals. And, a new, expanded map of the canals was developed for distribution to canal companies and publishing on a web site. Currently, new operation and maintenance plans are being developed in a collaborative and participative manner with the canal management personnel to enhance water delivery service and help improve the management of water resources which are becoming increasingly scarce in the valley.

Keywords: Irrigation, water management, flow measurement, operations and maintenance.

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Introduction

Cache Valley, Utah, has several irrigation canals which take water from streams and rivers flowing into the valley from surrounding mountains. Many of these canals were constructed early in the 20th century and remain mostly unlined. As the population of Cache Valley grows, greater demand for good-quality water has occurred, and the need for improved water management has become more important. Irrigation water users are especially targeted for water management improvements because they still use the largest quantities of water in the valley. The situation is exacerbated by the fact that water measurement capability in the canals is very limited, and the O&M budgets of the canal companies are very low, leading to significant deferred maintenance of the infrastructure.

For these reasons, steps have been taken to assess the current state of water management in several Cache Valley canals, including surveys to develop improved (and expanded) maps of the canals, the state of the infrastructure, and the current management practices. New operation and maintenance plans are being developed for each of the canals, and an overall water allocation plan is to be proposed for the canals included in the study. In addition to these measures, each of the existing flow measurement structures in the main canals have undergone calibration checks, and those structures which cannot function as flow measurement devices have been identified. New flow measurement structures will be built in the coming months to replace severely damaged structures, and to help improve water management at new key locations within the canals.

Methodology

All of the main canals receiving water from the Logan River which flow west and north through the valley were selected for inclusion in this study. The flow in these canals makes up more than half of the irrigation water used in the valley. The process followed by the authors has comprised several related steps, including the following:

1. Detailed physical surveys of selected canals and related infrastructure;
2. Interviews with canal company personnel;

3. Measurement of seepage losses;
4. Preparation of operations and maintenance plans to assist agency managers in achieving improved management of water resources.
5. Calibration of existing flow measurement structures in the main canals;
6. Design and construct several flow measurement structures in appropriate locations in order to improve the flow measurement capability;

Detailed Surveys

Surveys were conducted on the selected Cache Valley canals to determine the present condition and functioning of these canals, including culverts, gates, flumes, and other structures along the main canals. Attention was paid to all the minute physical details by walking in and along the canals, also giving opportunities to meet and talk with some of the water users and canal operations personnel. This type of survey is termed a *Diagnostic Walk-Thru* (Skogerboe and Merkley 1996). The *Diagnostic Walk-Thru* surveys were conducted on nine irrigation canals that carry water from the Logan River to the northern side of Logan River. During the surveys, several hundred digital photographs of flow measurement and water delivery structures, among other noteworthy locations, were taken, along with comments about operations and maintenance issues which were recorded in the field notes at the time each photo was taken. The coordinates of each location (including each of the photos, and others where photos were not taken) were taken with a GPS unit and were also registered in the field notes. A version of the new canal map is given in Fig. 1, and a few of the photographs with GPS coordinates and comment about them are shown in Figs. 2 - 5.

Some inconveniences were encountered during the *Diagnostic Walk-Thru* surveys. These problems included obstacles due to the construction of residential buildings and fences on and in the canals where there was no access, unleashed and aggressive dogs which sometimes blocked the way along the canal, snakes in the canals, lengthy pipe and culvert sections (where the outlet was unknown), and others.

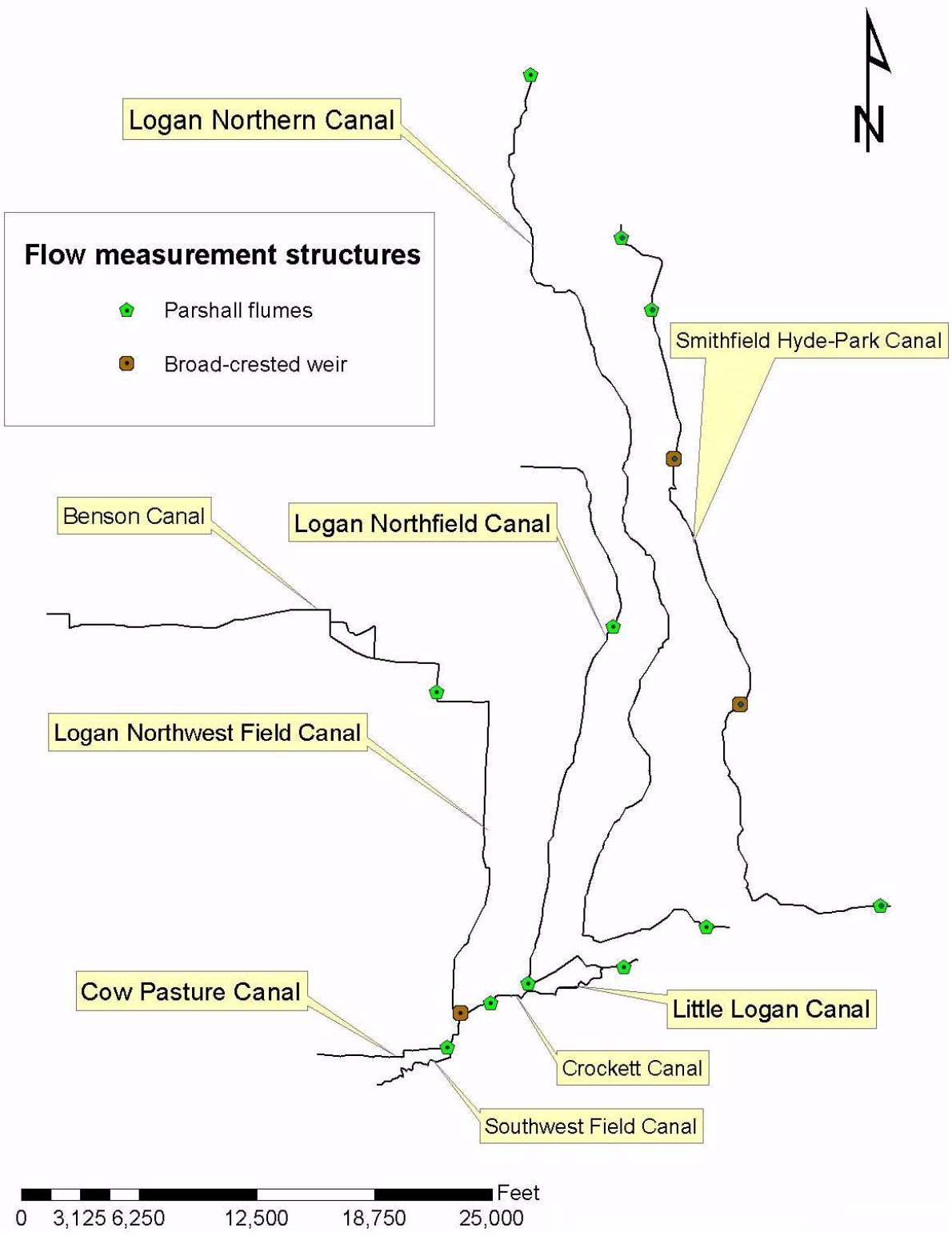

Fig. 1. Selected Cache Valley, Utah, irrigation canals

Fig. 2. Culvert inlet and a deteriorated outlet gate (Northwest Field canal)

Fig. 3. Interviewing a water user (Northwest Field canal)

Fig. 4. Much weed growth and algae and narrow canal width (Logan Northwest Field canal)

Fig. 5. Upstream side of a bridge where debris has collected (Logan Northwest Field canal)

Interviews

The process of developing operations and maintenance plans for irrigation canals should be highly participatory because active participation of these people in making the plans will help their adoption and sustainability. Many of those involved in the canal system played an important role in the entire process of development of these plans for irrigation canals. In this process, efforts were made to communicate with canal management officials, learn their present methods, strategies, concerns, and problems in achieving the goal of meeting irrigation water requirements economically with minimum water losses.

Interviews were conducted with Benson Canal Company President, Mr. Rick Reese, Northwest Field Canal Company President, Mr. Peter Kung, and the Logan

Northern Canal Company ex-President, Mr. Don Hansen, who served as president for 20 years on that canal. At the time of this writing, the other canal company interviews were being arranged.

Fig. 6. Interview with Don Hansen, ex-president of the Logan Northern canal

The observations of the *Diagnostic Walk-Thru* surveys were discussed in the interviews with the canal company presidents and water masters, and photographs taken at the time of survey were shown to them on a notebook computer to get a clear idea of key locations in the canals and their importance. Since it was a participatory program, canal company presidents' issues, their problems with the very small longitudinal bed slopes in some reaches, storm water inflows (often causing the canals to overtop), and so on, other canals were also discussed during the interviews. The Benson Canal Company president, Rick Reese, was very happy to meet with the authors and know about the present study. The authors arranged a meeting in Rick's office and introduced themselves, the study objectives, source of funding, and other details. He discussed various problems of the Benson canal with the authors, such as flooding problems which tend to occur after rainfall events in the valley, especially since the recent developments in which farmland is converted to municipal and industrial areas. There are several

canals on the Eastern side of the valley, and whenever there is surplus of water, it is ultimately diverted into the Benson canal. The Benson canal, with a small cross section cannot accept all of the diverted water after many of the annual rainfall events, so the canal tends to overflow, causing damage to adjacent lands and even flooding onto the roads. The major concern of the Logan Northern canal, as told by Don Hansen in an interview, is the low longitudinal bed slope of the 15-mile-long canal. The Logan Northern canal water users think that due to the small longitudinal bed slope of the canal, the water is ponding upstream of the flow measurement structure (a Parshall flume) constructed in the canal, and this water is seeping through the banks and causing drainage problems in the field along the canal.

For this reason, Logan Northern canal water users removed the flow measurement structure built in the canal. The result of the above-mentioned problem in the Logan Northern canal is a 15-mile-long canal left with a single flow measurement structure near the upstream end, resulting in little quantitative knowledge about water management along the canal. Also, in the interview with Peter Kung of the Logan Northwest Field canal, it has been said that they have lot of storm water drainage into the canal that interrupts operations and sometimes causes flooding problems to the residents near the canal. This is perhaps the greatest operational problem for the canal companies at the present time. Storm water drainage sometimes erodes the channel bed where it enters the canal changing the section of the canal, causing additional maintenance problems.

Secondly, many water users who are beneficiaries of this study were contacted to know their requirements, learn their practices, share their experiences and problems, and welcome their suggestions. During the *Diagnostic Walk-thru* survey, the authors explained the objective of the study to the water users and discussed the issues of the canal from their point of view. Water user involvement has been encouraged in developing and maintaining the water delivery system. Their suggestions and ideas to improve the performance of water delivery subsystem will be included in the operations and maintenance plan that could be served as a set of guidelines for all of them later. Field staff of management agency was also interviewed to know the practical problems involving satisfaction of both water-users and agency management while meeting design

standards. Ryan Weber, water master for the Northwest Field Canal, was interviewed, resulting in a great deal of information regarding the canal water management. These interviews have been helpful to know the practical problems that are not only technical but also practical. The entire discussion of the interviews was then documented in a report and to serve as a good support to propose the solutions for the problems mentioned above.

A meeting was arranged with the Logan River Commissioner, Ms. Colleen Gnehm, by the authors to discuss canal operational issues and observe her work while recording water depth information from flow measurement structures in the main canals. She explained to the authors how she allocates the water to different canal companies, following the *Kimball Decree* chart. After checking the water level recorders on the Logan River and determining the flow rate, she finds how much water should be allocated to each canal. Then she moves on to each water level recorder at the diversion point to each canal. She said that she does this job of checking water level recorders every Saturday. When she was asked by authors whether she has had any complaints or problems on any of these canals, she said that she has not heard of any problems or complaints, except from the Logan Northwest Field canal company. She said that she heard of seepage loss problems from the water master of the Logan Northwest field canal, but that everything is fine with the present system.

Fig 7. Colleen Gnehm with one of the authors, checking a water level recorder

Fig 8. Colleen Gnehm replacing the graph sheet for a water level recorder

Measurement of Seepage Loss

Ryan Weber (2004), water master of Logan Northwest field canal prepared a report on seepage losses on three selected canals of Cache Valley, Utah. In this report, there are indications of significant seepage losses in Cache Valley canals. Surveys will be conducted by the authors on the reaches mentioned in the report and solutions will be proposed to minimize these losses, such as lining those canal reaches that are with the highest losses. Lining of canals is one of the best solutions to be applied to reduce seepage losses, stabilize channel bed and banks, avoid piping through and under channel banks, and control weed growth (Hill 2000). Seepage loss will be determined by selecting a typical reach and measuring the inflows and outflows. The difference between inflow and outflow measurements is the total loss and it is the combination of evaporation and seepage through the canal bed and banks. At the time of this writing, seepage loss measurements have been taken on three canals out of the nine canals. And the results obtained are shown in the results section.

Fig. 9. Current metering in a canal to determine seepage losses

Preparation of O&M Plans

One of the objectives of this study is to develop Operation and Maintenance plans for the selected irrigation canals. In this plan, all the practical problems witnessed during the present study will be shown with the remedies adopted to solve them. This plan will also present a set of guidelines for periodic maintenance of the system with active participation of all who are involved in this water delivery subsystem. This plan will comprise all the maintenance works classified according to their urgency of attention and economic considerations. Some of the main maintenance works are:

- Periodical removal of weed growth;
- Clearance of debris at the screens;
- Lubrication of outlet gates and head gates;
- Repair of flow measurement structures (where necessary);
- Removal of sediment from the canals; and,
- Repair of side walls damaged by trees growing near the canals.

The above-listed maintenance works were among those observed at the time of the *Diagnostic Walk-thru* surveys and they will be discussed in detail in operations and maintenance plans to be developed in the near future as a part of this study.

Calibration of Existing Flow Measurement Structures

A work schedule was made in order to define the steps to implement this study. Also, the required materials and instruments to develop the present study were prepared. These materials and instruments included:

1. Forms for recording current metering data;
2. Open-channel current meter;
3. Tape measures;
4. Topographic level;
5. GPS (Global Positioning System) unit; and,
6. Digital photographic camera.

The existing measurement structures were calibrated using a current meter to measure the flow rate, taking several measurements, such as upstream and downstream depths at the structure, water surface elevations, and the channel cross section downstream of the structure. For Parshall flumes, the authors checked to determine whether it has standard dimensions. Finally, all the data were processed and the results of the current metering was compared to the standard calibration of the measurement structures.

There are some non-functional flow measurement structures found in the canals. For instance, the Logan Smithfield-Hyde Park canal has three Parshall flumes and two broad-crested weirs. One out of the three Parshall flumes was observed to be operating under submerged-flow conditions, but the measurement arrangements at the structure were made only for free-flow conditions, thereby causing large measurement errors. Two of the broad-crested weirs appear to be newly built, but they are completely submerged, so their free-flow calibrations are not applicable and the structures serve no apparent purpose.

Fig 10. Taking measurements to check the calibration of a flume

Fig 11. Current metering to check the calibration of a broad-crested weir

Design and Construction of Flow Measurement Structures

Locations for new flow measurement structures were selected according with the results of the previous procedure. Some of these will replace existing flow measurement structures which are too deteriorated to repair, and are not currently functioning. The types of the new structures will be determined by taking in consideration the advantages and disadvantages of the different types measurement structures. In addition, to design these new structures, some calculations will be performed using spreadsheet or software such as the ACA program (Merkley 2004). Finally, these new structures will be build at the selected locations in the fall of 2005.

Operations

The terms “operations” and “water management” overlap in meaning when applied to irrigation canals. Thus, it is important to have an operations plan in order to achieve water management improvements, and it is equally important to have flow measurement capability in order to successfully implement an operations plan. The most significant operational problem for the Cache Valley canals in the Logan city is storm water drainage into the canals. The development of many new commercial buildings has including the construction of many parking lots which, by themselves, have very little capacity to retain rainwater. The collected storm water tends to gush into the irrigation canals which pass in the vicinity (or downhill) of the paved areas. The Logan Northfield canal in Logan City that conveys water to the Benson canal is one of the canals suffering from such problem. Because of this storm water drainage into the canal, the Canal Company does not have any control on the water flow in the canal when they have surplus water in the canal. There are many problems like flooding, channel bed erosion in the canal due to this storm water drainage.

So, in this regard, the canal companies should have an operational plan that can address these water management problems. To achieve this, the water flow in the canal should be regulated, monitored, and quantitatively measured, including water deliveries to individual users and secondary/tertiary channels. In this process, flow measurement structures, head gates, diversion gates, and outlet gates play an important role. Based on

the demand and supply of irrigation water, a simple operations plan will be developed for the equitable distribution of available water to fulfill the requirements of the water-users. Operational monitoring includes periodically checking discharge rates and issues such as water-logging, seepage losses, and runoff inflows, and maintaining records for the improvement of the water delivery system in future. Flow measurement structures play an important role in the process of regulating and monitoring the water thus by ensuring equitable distribution and proper management of the canal system. The hydraulic data plays a major role in preparing hydraulic performance report based on which improvements in the canal system can be made and also maintenance works can be undertaken. These data helps to determine any losses, such as seepage, occurring in the canals.

The data collected by authors to measure the seepage loss and checking the calibration of flow measurement structures will help in preparing a structural maintenance plan and also an operations plan in near future.

Irrigation system mapping plays a vital role in understanding the system, and in developing and implementing operation and maintenance plans. Every irrigation system should have complete maps of that system depicting flow control structures, outlet gates, tertiary takeoff (if any), and water user information. The authors recorded the GPS coordinates at the noteworthy locations during the *Diagnostic Walk-thru* surveys. These GPS coordinates were then transformed to a UTM projection. Finally, this transformation was overlaid on aerial photographs of Cache Valley. Each canal and flow measurement structures have been labeled using ARCGIS software. The work of hyper-linking some selected photographs to this map is still in progress at the time of writing this paper.

Results

There are several hundred photographs with GPS coordinates of important locations in each of the nine canals that were surveyed. With the help of these photographs and comments, interviews with canal company personnel have been successful to obtain quality information about operations and maintenance issues, and

provided a better understanding of the situations from which solutions could be proposed for each of the problems. Seepage loss measurements were taken on three out of the nine selected canals. The results of these measurements are shown below:

- The Logan North Field canal, which is also called the "Twin Canals," has been found to have a seepage loss of 7.7%. It showed a loss of 1.82 cfs from beginning of the canal where the flow rate was 23.7 cfs for a length of 1,450 ft.
- The Smithfield-Hyde Park canal was found to have a seepage loss of 6.5%. It showed a loss of 3.3 cfs from beginning of the canal where the flow rate was measured 50.5 cfs for a length of 1,440 ft.
- The Southwest Field canal has been found to have a seepage loss of 17%. The total flow at the upstream was found to be 2.3 cfs. It showed a loss of 0.41 cfs over a length of 1,470 ft in a reach where there is much vegetation.

All these seepage loss measurements were done by current metering by using a Pygmy meter and applying the velocity–area method. An electromagnetic current meter was initially used in some of the measurements, but the Pygmy meter was found to provide much more consistent and accurate results. The GPS coordinates were transformed to UTM values and plotted in a GIS over a background mosaic of aerial photographs of Cache Valley, highlighting all the flow measurement structures and also labeling all the different canal companies. Figure 1 is a simplified version of the final GIS product. The process of hyper-linking selected photographs to this GIS map was in progress at the time this paper was being prepared.

During the *Diagnostic Walk-thru* surveys, it was found that at many places along these canals there is no further access because some residential buildings have been built on the canal. This is also a problem for the canal company field staff to walk along the canal to perform operation and maintenance activities (Fig. 12).

Fig. 12. Obstructions along a reach of the Logan Northfield Canal

Conclusions

The *Diagnostic Walk-thru* Surveys on the canals helped the authors to better understand the current condition of the canals. The pictures taken during surveys gave an opportunity to view them and discuss proposed solutions to the problems which were identified. The GPS coordinates are useful for mapping the canals so that everyone can view and know about these canals when they are completed and placed on a website. PDF files of this study will be presented to the nine canal companies, the Logan River Commissioner, and the Utah State Division of Water Rights so that they can improvise and maintain the canal system with the guidelines provided. Seepage loss studies on this canal so far have not shown much since the work is in progress; however, depending on the seepage loss magnitudes, solutions to minimize these losses will be provided such as lining the canal if the reach is small, or lining the canal with plastic cover as done by Benson Canal company in Cache Valley.

Some of the canal company personnel are not familiar with the technical aspects of the flow measurement structures installed and functioning in their canals. For instance, the Parshall flume, a flow measurement structure installed and designed to work

under free-flow conditions with only an upstream depth measurement was found to be working under submerged-flow conditions in the Smithfield-Hyde Park canal. At this location there is no provision to measure downstream depth to determine the flow rate under submerged-flow conditions. Thus, the assumption of free-flow at this flume yields large errors in the measurement of flow rate at that location.

When these observations were discussed during the interviews with canal company personnel, they were unaware of the situation and also they did not know how to respond to the problem. A maintenance and operations plan would definitely help canal company personnel to be aware of the canal management that yields better performance of the system. All the flow measurement structures were checked and most of them are working well. Based on the surveys conducted, the maintenance works can be classified into many categories and guidelines can be given to be followed in the operations and maintenance manual. The Logan Northern canal is the longest canal with an approximately 15-mile distance, yet it has only one flow measurement structure. The authors intend to build one flow measurement structure in this canal in the coming days.

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