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Remote Control and Automation of the Crockett Canal Head Gates

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Remote Control and Automation of the Crockett Canal Head Gates

by

Tyler Richards

A report submitted in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

In

Irrigation Engineering

Approved:

________________________________________  ______________________________________
Gary P. Merkley                         Blake P. Tullis
Committee Chair                         Committee Member

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Joseph A. Caliendo
Committee Member

Utah State University
Logan, Utah
2011
ABSTRACT
Remote Control and Automation of the Crockett Canal Head Gates

by

Tyler Richards, Master of Science
Utah State University

Major Professor: Dr. Gary P. Merkley
Department: Civil and Environmental Engineering

In order to improve the control of the Crockett canal an automated control system for the head gates was proposed and an analysis of design alternatives was conducted. Design alternatives were analyzed based on the criteria of reliability, operational improvement, cost and safety. After the analysis was completed recommendations as to which type of automation system to install were made. A comprehensive design of the recommended design is included. The automation of the head gates has been separated into two phases. Items to be included in phase one are: retrofit each of the existing head gates with a multi-turn gate actuator and, installation of an electrical system to provide power to operate actuators. The electrical system will include provisions for future expansion phases, and a programmable data logger to provide automation. The estimated cost for this phase is $20,000. The second phase includes the installation of a sliding gate for control of the spillway, and installation of a gate actuator to automate the new gate. The estimated cost of phase two is $13,600. The design has been submitted to the canal company for approval.
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CHAPTER I
INTRODUCTION

The irrigation canals taking water from the Logan River in Cache Valley, Utah, have existed for approximately 100 years, and in the past 30 years there has been rapid urbanization of much of the service areas of these canals. As a result, there has been an increasing problem with storm-water runoff entering the canals, especially in the northwest area of Logan City where much of the surface accumulation occurs. Urbanization of natural or agricultural environments leads to higher volumes of storm water runoff, and faster times of concentration. Due to the increase in storm runoff entering the canals over topping occurs, causing damage to adjacent properties and homes.

Historically, all existing irrigation ditches or canals have played a part in Logan City’s storm water facilities since the settlement of the community. When the canals were built they delivered water from the river and intercepted storm water that drained off from uphill. When the canals flooded because of the storm water there were no houses at risk at that time (Logan City, 2010). Recently, the State of Utah and Logan City have assisted the canal companies to alleviate some flooding problems. New design requirements for storm water must account for the base irrigation flow based off of the water rights and account for return flows from upstream canals, but these measures are not enough to prevent over-topping of the canals.

The Crockett Canal delivers water to several other canals in Cache Valley, including the Northwest Field, Benson, Cow Pasture, Southwest Field, and various other
canal companies through bifurcations and extensions to the main canal. When a sudden rain occurs, it is imperative that the gates be closed as quickly as possible to discontinue Logan River water from entering the canal, thereby increasing the capacity to accept storm-water runoff and avoiding canal overtopping and subsequent water damage to adjacent properties. But this is difficult to do when the water masters or other canal company personnel are far from the head gates.

The goal of this study was to provide the Crockett Canal Company with methods for remote control and automation of the Crockett canal head gates. The specific objectives were:

1. Preliminary design and budgeting of the electrical/mechanical system to provide remote control of the Crocket canal head gates; including multiple design alternatives;

2. A detailed design of the recommended system; and,

3. Assistance with the installation of the system, if the canal company approves the project and has the capital to purchase required equipment.
CHAPTER II
LITERATURE REVIEW

Over the past 100 years since the Crockett canal was built improvements have been made in the design, control, operation, and automation of canal systems. The U.S. Bureau of Reclamation has published a technical manual “Canal Systems Automation Manual” that summarizes the work the USBR has done. They define canal automation to be the implementation of a control system that upgrades the conventional method of canal operation. The upgrades lead to more efficient use of water and improved response to demands.

A canal system can be controlled by different methods, local manual control, local automatic control, and supervisory control. Local manual control is done by a ditch rider making adjustments onsite at each check structure along the canal. Historically local manual control has been the conventional method of canal operation. Local automatic control allows for control of each check structure without human intervention. Local automatic systems consist of sensors connected to control devices, the sensors detect changes in the canal, and then through the logic programmed into the controller the check structure is adjusted. Weighted flap gates are a strictly mechanical application of local automatic control. Supervisory control is the operation of the canal by the water master from a central location. Each remote site, such as a check gate structure, is equipped with a remote terminal unit (RTU) that monitors conditions. Information such as water depths and gate settings are sent to a central master station, adjustments are made by the RTU based on instructions received from
the master station by the water master. Combinations of all three control methods are often employed (U.S. Bureau of Reclamation, 1991).

The basic elements of a control system include a sensor, comparator, control element and actuator. Actual conditions in the canal are measured by a sensor and input into the comparator. The comparator is a device that takes the measured value and compares it to the set point and provides an error or difference. A set point is a parameter defined by the designer, maximum water depths or desired flow rates are examples of set points. The control element contains an algorithm or a series of logical steps required to fix the discrepancy between the set point and measured condition. The control element then sends an output signal to the actuator to make adjustments to the check structure.

To increase the stability of the system enhancements to the control loop are made. Filters are added to the sensor to limit the effects of surface waves. A filter will reduce the number of gate movements. A dead band can also be used; the dead band is a predetermined range of values that the measured value can vary from the set point before adjustments are made. Adding more sensors to the feedback control loop can help stabilize the system (U.S. Bureau of Reclamation, 1991).

There are a number of different modes of control that the different algorithms are based on. Proportional control uses a linear relationship between the error and the corrective action. If the error is small a little adjustment in gate height is made, if the error is large the adjustment is also large. Reset or integral control takes into account the size of the deviation from the set point and time. Corrective action is proportional
to the magnitude and length of the error. Rate or deviation control responds to the 
time rate of change of the error. With rate control the initial correction is large, but as 
the error decreases the correction becomes smaller and smaller.

Upstream and downstream control are important concepts in canal control. 
With upstream control the level in the canal pool upstream of the check structure is to 
be maintained. Therefore the sensor is placed upstream of the gates. If the water level 
increases past the set point a positive error occurs and the gate must open, this is 
referred to as direct control. With downstream control the sensor is placed downstream 
of the gate. When the downstream water level is too high, a positive error, the gate 
must close to reduce the water level back to the set point.

With an understanding of the different methods of canal control a system can be 
designed. For the selection and sizing the different components that make up a control 
system the USBR’s Canal Systems Automation Manual can be referenced. In this manual 
design equations for motor loads are given. An overview of different types of 
communication methods is presented.
CHAPTER III
PROCEDURE

A meeting was held on February 10, 2011, with representatives of the Crockett Canal Company, including Peter Kung president of the Northwest Field Canal Company, Rick Reese President of the Benson Canal Company, Daniel Weber water master for the Crockett Canal Company, Gary Merkley and Tyler Richards. At the meeting, the criteria of the proposed upgrade to the Crockett canal head gates were discussed.

Figure 1. Meeting with the Canal Company, from left to right: Tyler Richards, Rick Reese, Daniel Weber, Chris Weber, and Peter Kung.

With the input received from the canal company canal, several design alternatives were generated.

Design Alternatives
For the remote operation of the Crockett canal head gates, two alternatives are presented: (1) retrofitting the existing gates with electric gate actuators; and, (2) link all three gates together and use one actuator to operate all three gates. For the upstream water level control the alternatives that will be discussed are: (1) A sliding gate placed in the spillway; and, (2) a float gate placed upstream in the concrete lined section of the canal.

Each of the above alternate designs will be judged based on the following criteria: (1) reliable immediate closure during storm events; (2) operational improvement of the canal system, (3) cost of implementation; and, (4) safety for the operators and the public.

For reliable closure during a rain event canal operators would like to be able to operate the head gate controls remotely via telephone or the Internet. The operators should receive messages by the same communication method that the gate closed successfully, or a warning message of failure to close due to a jammed gate, or something else that requires their attention. A power backup system or manual operation of the gates is required in case of a power outage.

**Operational Improvement**

Flow through the head gates is a function of the depth upstream of the gates, so it is critical to maintain the desired depth upstream of the gates. Improvements to the spillway stop log system or diversion structure are desired to facilitate maintaining a
constant head upstream of the gates without manual operation. Canal operators also would like to have local control of the motors on site. Operational data transmitted from the gates needs to include gate opening height and flow rate from the Parshall flume located just downstream of the head gates.

The cost of purchasing the required equipment for each alternative was estimated. The estimated cost does not include labor or installation costs.

Safety Concerns

The head gates are located just off of Crockett Avenue in Logan, UT, and the reach of the canal from the river diversion to the head gates is adjacent to a city park. The electrical and mechanical equipment at the head gates should be lockable, and moving parts need proper protection to prevent someone from becoming entangled and injured. The controls also should have room for expansion as required. Other items or options for future expansion of the control system might include a camera to document gate closure and real-time conditions at the head gates.

Head Gates

The existing inlet control structure on the Crocket canal consist of three sliding gates in parallel, and a side spillway. The head gates are each 5 ft. by 5 ft. by ¼-inch thick with bracing on the downstream side. The gates are operated manually by turning a nut with a wrench. The rising stem on the north gate is missing; that gate has not been operated in several years. Figure 2 shows the existing head gates.
During normal operation of the canal, all three gates are opened to the same level to provide the desired flow downstream with minimal depth in the upstream pool. The flow rate in the canal is controlled by the gate height and the head differential on the gate.

**Three Actuators**

To allow for remote operation of the head gates, a multi-turn gate actuator can be installed on the rising stem of each gate. The actuators would be mounted on the top frame rail of the gates, replacing the existing brass nuts. Each actuator contains a drive motor, hand wheel for manual operation, and local controls all encased in a weather-proof enclosure. The actuator would need to be able to supply at least 74 ft.–
lbs of torque. Multi-turn gate actuators for this application are available in 3 phase models and single phase models. Figure 3 is a simple diagram of the proposed alternative.

![Figure 3](image)

**Figure 3. Head gates operated with three actuators**

**Reliability** Reliable emergency closure of the head gates could be achieved by using three actuators. For instance, if one gate were jammed because of a log or some other obstruction, the other two gates would close independently, thus approximately 2/3 of the canal flow is shut down, giving the operator time to clear the jam without overtopping the canal at a downstream location. This would also be an advantage in case of a motor failure on one of the gates.

**Operational Improvements** With each gate operating independently, the operator has the flexibility to open one gate or all three. This would be useful when debris needs to be cleaned out of the head gates, one gate could be opened fully to let the debris pass
while the other are partially shut down, thus maintaining an essentially constant flow rate.

**Cost** Multi-turn gate actuators for this type of application can be purchased from distributors in Salt Lake City. Table 1 shows a list of distributors of actuators along with a summary of their cost quotes.

<table>
<thead>
<tr>
<th>Distributor</th>
<th>Model</th>
<th>Power Supply</th>
<th>Toque Output</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>phase / Voltage</td>
<td>ft. - lbs.</td>
<td>$</td>
</tr>
<tr>
<td>C.I. Actuation</td>
<td>Limitorque Model L120 - 20</td>
<td>3 / 480</td>
<td>200</td>
<td>5000</td>
</tr>
<tr>
<td>C.I. Actuation</td>
<td>Limitorque Model L120 - 20</td>
<td>1 / 240</td>
<td>200</td>
<td>5550</td>
</tr>
<tr>
<td>Rocky Mnt. Valve</td>
<td>Rotork Model IQ20A</td>
<td>3 / 480</td>
<td>150</td>
<td>4900</td>
</tr>
<tr>
<td>Rocky Mnt. Valve</td>
<td>Rotork Model IQ10</td>
<td>1 / 220</td>
<td></td>
<td>4300</td>
</tr>
</tbody>
</table>

Three multi-turn gate actuators would be needed at an estimated total cost of $15,000.

**Safety** By using three actuators drive shafts or chains are eliminated, minimizing the number of moving parts, thus reducing the risk of someone becoming entangled. The only moving parts on the system are the threaded stems and the gate themselves. The local controls would be locked to prevent unauthorized gate adjustments and vandalism.

**One Actuator**

To reduce costs, one actuator could be mounted on the side of the canal to operate all three gates, whereby each gate would be fitted with a gear box. A drive
chain connecting all three gates together would be driven by the multi-turn gate actuator, operating all three gates at once.

![Diagram of gates operated by one actuator](image)

Figure 4. Gates operated by one actuator

**Reliability** With one actuator operating all three gates together, is not as reliable as operating each gate separately. If one of the gates is jammed and the head gates need to be shut, the one jammed gate will prevent closure of all the gates. The mechanical linkage would need to be protected from weathering. Corrosion of the mechanical linkage could lead to a mechanical failure.

**Operational Improvement** The operational improvements with this design alternative would be limited. The gates could be operated remotely as desired, but the inability to operate the gates separately decreases the flexibility of the canal gates to pass small flow rates.
**Cost** The equipment required for this alternative includes a single multi-turn gate actuator, gear boxes fitted on each rising stem, and the mechanical linkage. Table 2 shows the estimated costs.

<table>
<thead>
<tr>
<th>Description</th>
<th>Quan ty</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Multi turn gate actuator</td>
<td>1</td>
<td>5,000</td>
<td>5,000</td>
</tr>
<tr>
<td>Gear reduction box</td>
<td>3</td>
<td>1,000</td>
<td>3,000</td>
</tr>
<tr>
<td>Mechanical linkage</td>
<td>3</td>
<td>700</td>
<td>2,100</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td>10,100</td>
</tr>
</tbody>
</table>

**Safety** When the canal gates are automated or operated remotely, the gates and the drive chains could move without warning. If children are playing around the head gates they could become entangled and injured, and with this alternative there are more moving parts and, therefore, an increased risk of becoming entangled.

**Upstream Water Level**

By controlling the water level upstream of the head gates, more effective operation of the canal is obtained. When the head gates are shut it is necessary to open the spillway to prevent a deep pool of water from developing upstream of the head gates.
The overflow spillway is located 20 yards upstream of the head gates. Excess water from the diversion is returned into the river at this location. The existing method for controlling the flow in the spillway and the water level upstream of the head gates is by placing stop logs in the two openings, as seen in Fig. 5. The openings into the spillway are 82 inches wide with channels (slots) on both sides to hold the stop logs in place.

**Sliding Gate**

By replacing one bank of the stop logs with a sliding sluice gate, the spillway and head gates could be fully automated to maintain the desired flow rate through the head gates, as well as to discharge the entire canal flow back to the river when the canal head gates are shut down. Figure 5 shows the proposed alternative.
The equipment required to automate the spillway includes a sliding gate, a gate actuator, and a level sensor installed upstream of the head gates.

**Reliability** Stop logs placed on one side would be used to set maximum water level in the canal. The slide gate on the other half of the spillway would account for fluctuations in the river diversion. The combination of the two would be able to maintain a constant water depth upstream of the gates, even when the head gates are shut and the spillway gate is fully opened.

**Operational Improvement** With the use of a slide gate, a constant water depth upstream of the gate can be maintained for all flow rates in the canal and for all head gate settings.
Cost

The cost estimation for installing a head gate and automating the control of the spill gate is shown in Table 3.

Table 3. Sliding gate Costs for the canal spillway

<table>
<thead>
<tr>
<th>Description</th>
<th>Quanty</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>82&quot; x 40&quot; Head Gate</td>
<td>1</td>
<td>7600</td>
<td>7600</td>
</tr>
<tr>
<td>Water level sensor</td>
<td>1</td>
<td>1000</td>
<td>1000</td>
</tr>
<tr>
<td>Multi turn Gate actuator</td>
<td>1</td>
<td>5000</td>
<td>5000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>13600</td>
</tr>
</tbody>
</table>

The $7,600 price quote is for a Waterman gate. Other vendors could possibly manufacture a quality gate for less.

Safety

By automating the spillway with a sliding gate, the canal head gates could be shut without a deep pool developing upstream of the gates. Currently the ditch rider (operator) has to get into the canal with waders on to remove the stop log, when the head gates are shut. Having the canal operator in the canal can be quite dangerous, and the slide gate would eliminate the need for the canal operator to be in the canal.

Float Gate

A float gate regulates the flow passing through the gate, maintaining a constant water depth downstream of the gate.
As seen in Fig. 6, the gate is made up of a radial leaf balanced about a pivot by a float. The force of the water on the upstream face of the leaf is counter balanced by the float. If the water level downstream drops, the float lowers and the gate opens. When the water level is high, the float rises up and the gate closes down.

**Reliability** A float gate would provide reliable control of water levels upstream of the gate during normal operating conditions. During spring runoff the float gate would close down, sending more water over the diversion in the river, possibly causing problems. Also, the gate would easily be plugged with debris associated with runoff.

**Operational Improvement** Due to the distance between the river diversion and the head gates, the lag time would become an issue. When the canal head gates are shut, water would have to back up for several hundred yards before the float gate would start to close.
**Cost**  A float gate that would fit in the concrete lined section of the canal just downstream of the diversion has an estimated cost of $28,000. This is the purchase price for a Waterman Type “A” constant downstream level control gate.

**Safety**  The section of river upstream of the diversion is a popular swimming and tubing location and the diversion in the river often diverts “tubers” down the canal. Someone could easily become caught under the gate, especially a smaller child. The section of canal has tall vertical walls that make it difficult to climb out of, and if someone tried to climb out of the canal by climbing on the gate the gate would close down, trapping them.

**Automation**

By using a programmable data logger the operation of the canal gates could be automated to maintain a constant flow rate through the head gates. With the addition of a phone modem the operator could call the head gates to adjust the flow rate or close because of storm water runoff. There are two options for programming the data logger for automating the control of the flow rate. By connecting the flow measurement device in the existing Parshall flume to the data logger, the gate could be programmed to compare the measured value from the flume to the desired flow rate set by the canal operator. The gates would adjust themselves according to the difference between the set point and the measured value. The sampling rate and an acceptable variation from the set point would be implemented to prevent the gate from
open and closing constantly. The other way the gates could be programmed is with the addition of a level sensor upstream of the gates, whereby a stage discharge relationship would be developed and programmed into the controller. From the stage discharge relationships the gates could adjust to the correct gate opening for the desired flow rate accounting for the fluctuations in the upstream water level. A combination of both methods could also be employed.

The equipment needed to provide remote control and automation of the canal head gates is listed in Table 4

Table 4 Cost of Equipment needed to Automate Control of Head gates

<table>
<thead>
<tr>
<th>Description</th>
<th>Quanty</th>
<th>Cost</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Programable Data logger</td>
<td>1</td>
<td>1400</td>
<td>1400</td>
</tr>
<tr>
<td>Phone modem</td>
<td>1</td>
<td>500</td>
<td>500</td>
</tr>
<tr>
<td>Software</td>
<td>1</td>
<td>600</td>
<td>600</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td><strong>2500</strong></td>
</tr>
</tbody>
</table>

There are numerous programmable data loggers on the market, the prices in Table 4 are based on a Campbell Scientific CR1000 and its components.

**Electrical System**

There are two options for the electrical service supplying power for the gate actuators. The nearest power supply is single-phase 240/120 volts, but Logan City could be asked to bring in a 3-phase, 480-volt power supply to the site.
Normally, operating equipment at the higher voltage is more cost effective in terms of power consumption. The motors operating the gates are ½-horsepower motors. The single-phase gate actuator operating at 220 volts has a full load rating of 3.4 amps; power consumption per unit would be 750 watts. The three-phase unit operating at 480 volts has a full-load amp rating of 1.7 amps, and power consumption per unit is 816 watts. Due to the small size of the motors the single-phase system uses less power. Power cost will be minimal with either system, because the gates will not be operating continuously.

Three-phase motors are more durable motors because of the simpler design. The single phase gate actuator by “Limiterque” is a three-phase motor that is powered by a variable frequency drive that converts the single phase to three-phase. This is a great option to combine the durability of a three-phase motor with the closest available power supply.

Cost

The electrical equipment need to connect the motors to the utility power includes a meter base, distribution panel, and disconnects for each motor. Table 5 shows the estimated cost for the main components of the electrical system listed above.
Table 5. Electrical equipment cost

<table>
<thead>
<tr>
<th>Description</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>single phase / 240 volt</td>
<td>700</td>
</tr>
<tr>
<td>3 phase / 480 volt</td>
<td>2200</td>
</tr>
</tbody>
</table>

This estimated cost does not include the conduit, wire, excavation, and labor cost; these would be the same for both systems. For the three-phase system the cost for the utility company to bring in three-phase power to the site needs to be included. Also, if 120 volt service outlets are desired at the site, a step down transformer from 480 volts to 208 volts would be required.
CHAPTER IV

RESULTS AND RECOMMENDATIONS

Based on the criteria of reliability, operational improvement, cost and safety, it is recommended to install a multi-turn gate actuator on each head gate, along with replacing one section of the spillway stop logs with a sliding gate. To power the gate actuators, the available single-phase, 240-volt utility would be the most economical. And, to make the implementation of the improvements to the Crockett canal head gates less cost prohibitive, the installation could be done in phases. Phase 1 would include:

1. Installation of three gate actuators. An actuator would be installed on each gate;
2. Installation of electrical system from the Logan City utility line to the gate actuators. This would entail mounting a meter main and distribution panel on a pad adjacent to the canal head gates, and running conduit to connect actuators to power source; and,
3. Installation of a programmable data logger and control wiring.

The cost for three actuators is estimated at $15,000. The cost of the main components in the electrical system is estimated at $700. Considerations for future expansion should be taken into account; extra conduits should be stubbed out of the panel for future use. The data logger and modem needed for remote control of the gates have an estimated combined cost of $2500. The estimated cost for the first phase is $20,000
The second phase of the improvements to the Crockett canal would include the following:

1. Installation of a slide gate in one of the spillway openings.
2. Installation of an actuator to operate the new slide gate.
3. Connecting the actuator to the existing power supply and controls.

The estimated cost for the spillway improvement is estimated at $13,600. The estimated total for all the improvements is $34,000.

**Design Process**

The final design stage of the automation system for the Crockett canal head gates, involved the sizing of equipment for the recommended design alternative. Field measurements of the existing head gates were taken, in order to properly size the equipment. Based on the specified equipment, power requirement calculations were made to size the electrical power supply source. A programmable data logger was specified that was compatible with the equipment and is able to provide the desired controls.

**Motor Sizing**

To lift a head gate, the gate operator must lift the weight of the gate, and overcome the friction resistance between the gate frame and gate leaf (Appendix 1). The amount of friction is proportional to the hydrostatic force on the gate leaf, Eq. 1 was used to calculate the load on the gate operator.
\[ L = W + \mu \frac{1}{2} \gamma h^2 w \]  

where \( L \) is the load on the operator (lbs); \( W \) is the weight of the gate; \( \mu \) is a coefficient of friction; \( \gamma \) is the specific weight, which was taken to be 62.4 lb/ft\(^3\); \( h \) is the height of water against the closed leaf measured from the bottom of the channel; and \( w \) is the width of the gate. The USBR recommends using a \( \mu \) value of 0.35 (U.S. Bureau of Reclamation, 1991). The load \( L \) was calculated for two upstream water depths \( h \), the first is the high water mark in the canal from years of operation at 40 inches. The other depth is a worst-case scenario with the water overtopping the canal head gates, at the full gate height of 60 inches. The load on the operator when the canal is at normal operating depth is 992 lbs., if the water is at the top of the gate the load is 1750 lbs. (Appendix 1).

Once the load on the lift is found the required motor torque to lift the load is calculated. The torque required is found using Eq. 2.

\[ M = L \times r \times \tan(\theta + \phi) \]  

where \( M \) is the torque (ft lbs); \( L \) is the load on the operator; \( r \) is the radius of the rising stem; \( \theta \) is the lead angle of the rising stem; and, \( \phi \) is the friction angle between the rising stem and the brass nut. The friction angle, \( \phi \), is equal to the arctangent of the coefficient of friction. Tabulated values for friction between brass and steel vary from 0.44 to 0.51 (Bhushan & Gupta, 1991). In order to make a better estimate of the coefficient of friction, the torque required to open the existing head gates was
measured with a torque wrench (Fig 8.). Using the measured torque equation 2 was solved to find the friction angle, $\phi$.

Fig 8. Measuring torque required to operate the canal head gate

With the upstream depth of 40 inches and the gate all the way closed the required torque is 42 ft –lbs. If water depth upstream of gates is at 60 inches the required torque is 74 ft –lbs. (Appendix 1).

**Power Requirement**

The electrical system should have enough capacity to operate all three gate actuators simultaneously, and allow for future expansion. The Limitorque model L 120-20 actuator specified has a full load amps rating of 3.4 amps. For three actuators 11 amps is required. Electrical meter bases, and distribution panels come in nominal sizes.
The smallest available meter base is rated at 125 amps. The actuators will operate at 240 volts; this requires a two pole breaker for each actuator. The total number of circuit breakers for the system would be seven; a small 12 circuit, 100-amp distribution panel would be sufficient. The one line diagram in the technical drawings shows wire and breaker sizes. Electrical equipment can be purchased at any of the local electrical supply houses.

**Control Wiring**

To facilitate remote operation of the gates, each actuator must be connected to the data logger. The Limitorque L 120-20 actuator can send and receive a number of signals. For control over the gate position the actuator sends and receives a 4 to 20 mA signal that can either be 18 VAC or 24 VDC. When the actuator is installed the gate is adjusted to the fully close position, with the gate closed, the potentiometer is adjusted until the output signal reads 4 mA. The gate is opened and the potentiometer is adjusted to read 20 mA. With the potentiometer set, the gate can be adjusted to any position remotely by the data logger sending a signal from 4 to 20 mA. The actuator also has a number of indication terminals. One set of terminals sends a signal to the data logger when the operating switch on the actuator is set to remote control. The other indication parameters are open and close. The actuator has open and close limit switches, with four contacts on each limit switch. A pair of these contacts sends a signal to the data logger when the gate is open or closed; these are set at the factory to be normally open. See Appendix 3 for a simple wiring diagram.
Data logger

The data logger will receive indication signals from each actuator. Signals received include; which mode of operation the actuator is in remote control or local manual control / off, open, closed, and gate position. The data logger will send a signal to each gate to adjust the gate position. A Campbell Scientific model CR1000 data logger is capable of interpreting and sending the required signals.

The open/close and operation mode, control signals from the actuator vary from 18 VAC to 120 VAC or 24 VDC. The maximum voltage the CR1000 can handle is 16 VDC. To prevent damage to the data logger relays would be needed. A relay properly rated for the signal voltage from the actuator would be used, the relay would open or close a low voltage circuit powered by the data logger, the data logger input would measure the low voltage circuit.

The gate position input and output signal from the data logger is a 4 to 20 mA signal. A value of 4 mA corresponds with the gate being fully closed, like wise 20 mA corresponds with the gate fully open. For gate intermediate gate positions the signal values are linearly interpolated to find to corresponding gate opening. To enable the CR1000 to output a 4 to 20 mA signal an additional module needs to be added to the data logger. A SDM – CV04 is a Campbell Scientific 4 channel current/voltage output module that output a 4 to 20 mA signal. This module is compatible with the CR1000.
Equipment

Table 6 lists equipment specified for phase 1 of the automation of the Crockett canal head gate. The prices quoted were received in April to May of 2011. Therefore, the prices should be used for reference only, actual price may vary.

Table 6. Specified Automation Equipment

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QUANTITY</th>
<th>DISTRIBUTER</th>
<th>COST</th>
</tr>
</thead>
<tbody>
<tr>
<td>Actuator</td>
<td>Limitorque model L120-20</td>
<td>3</td>
<td>C.I. Actuation</td>
<td>$16,650</td>
</tr>
<tr>
<td>Data Logger</td>
<td>Campbell Scientific CR1000</td>
<td>1</td>
<td>Intermountain</td>
<td>$2,500</td>
</tr>
</tbody>
</table>

Other local distributors of gate actuators include Rocky Mountain Valves & Automation Inc., and Intermountain Environmental Inc. (Appendix 2). The Limitorque model L120 – 20 can provide up to 200 ft – lbs of torque. The reason this model was selected over the smaller model is because of the rising stem diameter. The maximum rising stem diameter that it is compatible the smaller model is 1.25 inches. The stem on the head gates is 1.5 inches in diameter; therefore the larger model was selected. The actuator will need to be ordered with the following features: 240 volt single phase power supply, allowance for 36 inches of gate travel, 4 -20 mA position feedback, lockable local controls, a weather proof enclosure, and counter clock wise to close (right-handed thread).
Technical Drawings

Construction drawings for the automation and remote control of the Crockett Canal head gates are in Appendix 3. The drawings include locations of equipment, a one line wiring diagram, and details on the installation of the specified equipment.
REFERENCES


APPENDICES
Appendix 1. Required Torque to Operate the Head Gates

Dimensions and weights of existing canal head gates (AISC, 1991).

<table>
<thead>
<tr>
<th>Description</th>
<th>Dimension</th>
<th>Weight / Length</th>
<th>Quantity</th>
<th>Length</th>
<th>Total Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Gate leaf</td>
<td>Plate 60 x 60 x 1/4</td>
<td>51</td>
<td>1</td>
<td>60</td>
<td>255.0</td>
</tr>
<tr>
<td>Leaf bracing</td>
<td>Angle 3 x 3 x 1 1/4</td>
<td>4.9</td>
<td>3</td>
<td>54</td>
<td>66.2</td>
</tr>
<tr>
<td>Slide guide 1</td>
<td>Angle 1.5 x 1.5 x 3/16</td>
<td>1.8</td>
<td>2</td>
<td>52.5</td>
<td>15.8</td>
</tr>
<tr>
<td>Slide guide 2</td>
<td>Plate 1.5 x 5/16</td>
<td>1.59</td>
<td>2</td>
<td>52.5</td>
<td>13.9</td>
</tr>
<tr>
<td>Rising Stem</td>
<td>Threaded Rod 1.5</td>
<td>7.65</td>
<td>1</td>
<td>53</td>
<td>33.8</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td><strong>385</strong></td>
</tr>
</tbody>
</table>

Torque Calculations

<table>
<thead>
<tr>
<th>Gate</th>
<th>Rising Stem</th>
<th>Hydorstatic</th>
<th>Calculated</th>
<th>Measured</th>
<th>Calculated</th>
</tr>
</thead>
<tbody>
<tr>
<td>Width =</td>
<td>width = 60 inches</td>
<td>diameter = 1.5 inches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Weight =</td>
<td>385 lbs.</td>
<td>lead = 0.3125 inches</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>µ =</td>
<td>0.35</td>
<td>lead angleΘ = 0.066218 rad</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>γ =</td>
<td>62.4 lbs/ft³</td>
<td>µ = 0.58</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>φ =</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.525584 rad</td>
</tr>
</tbody>
</table>

Water Depth | Force | Load | Torque | Measured Torque | friction |
<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>[ inches ]</td>
<td>[ lbs. ]</td>
<td>[ lbs. ]</td>
<td>[ lb - ft ]</td>
<td>[ lb - ft ]</td>
<td>µ</td>
</tr>
<tr>
<td>18</td>
<td>351.0</td>
<td>508</td>
<td>21</td>
<td>20</td>
<td>0.54</td>
</tr>
<tr>
<td>42</td>
<td>1911.0</td>
<td>1054</td>
<td>44</td>
<td>48</td>
<td>0.63</td>
</tr>
<tr>
<td>40</td>
<td>1733.3</td>
<td>992</td>
<td>42</td>
<td></td>
<td></td>
</tr>
<tr>
<td>60</td>
<td>3900.0</td>
<td>1750</td>
<td>74</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Notes: Two water Depths and the respective torque where measured. Equation 2 was used to back calculate values for the coefficient of friction µ. The average of the two values was used to compensate for in accuracy in the measurements. This value is more conservative than the tabulated values.
Appendix 2. Distributors of Automation Equipment

Local distributors of automation equipment address and phone numbers are current as of October 2011. Intermountain Environmental will also repackage gate actuators from other distributors and supply them to a project.

<table>
<thead>
<tr>
<th>Company</th>
<th>Address</th>
<th>Phone</th>
<th>Items Available</th>
</tr>
</thead>
<tbody>
<tr>
<td>C.I. Actuation</td>
<td>2987 South 300 West Salt Lake City, UT 84115</td>
<td>(801)-487-8110</td>
<td>Limitorque Actuator</td>
</tr>
<tr>
<td>Rocky Mountain Valves &amp; Automation</td>
<td>8160 South Highland Drive # 106 Sandy, Utah 84093</td>
<td>(801)-438-1038</td>
<td>Rotork Actuator</td>
</tr>
<tr>
<td>Intermountain Environmental Inc.</td>
<td>601 West 1700 South, Suite B Logan, Utah 84321</td>
<td>(435)-755-0774</td>
<td>Campbell Scientific Data loggers</td>
</tr>
</tbody>
</table>
Appendix 3. Technical Drawings

The following working drawings are for the construction and installation of the automation system for the Crockett Canal Head Gates.
CROCKETT CANAL HEAD-GATES AUTOMATION

INDEX OF DRAWINGS

<table>
<thead>
<tr>
<th>SHT NO.</th>
<th>DWG NO.</th>
<th>DESCRIPTION</th>
</tr>
</thead>
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<td>G - 1</td>
<td>TITLE PAGE / LOCATION MAP</td>
</tr>
<tr>
<td>2</td>
<td>G - 2</td>
<td>GENERAL NOTES / SYMBOLS</td>
</tr>
<tr>
<td>3</td>
<td>C - 1</td>
<td>CIVIL SITE PLAN</td>
</tr>
<tr>
<td>4</td>
<td>C - 2</td>
<td>HEAD GATES DETAILS</td>
</tr>
<tr>
<td>5</td>
<td>E - 1</td>
<td>ELECTRICAL SITE PLAN</td>
</tr>
<tr>
<td>6</td>
<td>E - 2</td>
<td>ELECTRICAL ONE LINE</td>
</tr>
<tr>
<td>7</td>
<td>E - 3</td>
<td>ELECTRICAL DETAILS</td>
</tr>
</tbody>
</table>

PROJECT LOCATION

CROCKETT CANAL HEAD GATES
GENERAL NOTES

1. ALL CONSTRUCTION SHALL MEET CITY OF LOGAN STANDARDS AND SPECIFICATIONS (APRIL 2007, AS AMENDED BY LOGAN CITY AS OF DATE APPROVED FOR CONSTRUCTION BY ENGINEER). STANDARDS AND SPECIFICATIONS CAN BE VIEWED AND PRINTED AT WWW.LOGANUTAH.ORG/PUBLICWORKS/ENGINEERING/SPECINDEX.CFM

2. UTILITY LOCATIONS SHOWN ON THE PLANS ARE APPROXIMATE ONLY. CONTRACTOR SHALL VERIFY ALL UTILITY LOCATIONS BY CONTACTING BLUE STAKES AT 1-800-662-4110 OR 811 AND OTHER APPLICABLE UTILITIES PRIOR TO EXCAVATION. CONTRACTOR SHALL ALSO POT- HOLE AND LOCATE UTILITIES AT THE CONTRACTOR’S EXPENSE WHEN REQUIRED. CONTRACTOR SHALL BE SOLELY RESPONSIBLE FOR COSTS AND REPAIRS DUE TO DAMAGE OF EXISTING UTILITIES. ALL UTILITIES MAY NOT BE SHOWN ON PLANS.

3. CONTRACTOR SHALL POT-HOLE ALL GAS SERVICES, COMMUNICATION LINES, AND POSSIBLE INTERERING WATER SERVICES IN ORDER TO VERIFY ADEQUATE CLEARANCE TO THE NEW CONSTRUCTION.

4. CONTRACTOR SHALL PROVIDE ADEQUATE TRAFFIC CONTROL, SIGNING, BARRI CADING, AND PEDESTRIAN DIRECTION THROUGH AND AROUND THE CONSTRUCTION WORK ZONE COMPLIANCE WITH THE MUTCD, 2009 EDITION.

5. CONTRACTOR SHALL REPAIR DAMAGED SURFACES TO EXISTING CONDITIONS, INCLUDING, BUT NOT LIMITED TO UTILITY LINES AND SERVICES, ASPHALT REPAIR, DRIVEWAYS, PLANTER STRIPS, SPRINKLER AND IRRIGATION SYSTEMS AND GENERAL CLEANUP EXCEPT WHERE INSTRUCTED OTHERWISE.

6. ALL UTILITY LOCATIONS WILL BE KEPT IN WORKING ORDER EXCEPT FOR THE MINIMUM TIME NEEDED FOR EXCAVATION, TRENCHING, CONNECTIONS, ETC.

7. ALL PERSONNEL ARE REQUIRED TO WEAR PERSONAL PROTECTIVE EQUIPMENT, AND CONFORM TO APPLICABLE OSHA RULES AND REGULATIONS WHILE WORKING ON THIS PROJECT.

PERMITS

1. CONTRACTOR SHALL COMPLY WITH THE TERMS OF ALL PERMITS REQUIRED FOR THIS PROJECT.

2. CONTRACTOR SHALL COMPLY WITH ALL REQUIREMENTS OF THE STORM WATER POLLUTION PREVENTION PLAN (SWPPP) INCLUDED ON THIS SHEET AND THE EROSION CONTROL PLAN. CONTRACTOR SHALL MAINTAIN A COPY OF THE SWPPP AT THE PROJECT SITE. SWPPP SHALL BE AVAILABLE FOR REVIEW DURING WORK HOURS.

CONSTRUCTION NOTES

CONSTRUCTION STAKING

1. CONTRACTOR SHALL COORDINATE LOCATIONS OF ELECTRICAL EQUIPMENT WITH THE LANDOWNER AND THE CANAL COMPANY.

2. CONTRACTOR SHALL COORDINATE LOCATIONS OF ELECTRICAL EQUIPMENT AND COMMUNICATIONS WITH THE LANDOWNER AND THE CANAL COMPANY.

ACTUATOR SPECIFICATIONS

1. ACTUATOR SHALL BE RATED FOR A MINIMUM OF 74 FT-LBS OF TORQUE.

2. USE A LIMITROQUE MODEL L20-20 OR EQUIVALENT.

3. BEFORE PURCHASING ENSURE THAT THE SELECTED ACTUATOR IS COMPATIBLE WITH THE EXISTING GATE STEM.

4. LOCAL CONTROLS SHALL BE LOCKABLE, ACTUATOR SHALL BE DESIGNED FOR LOCAL CONTROL AS WELL.

5. A LIMITROQUE ELECTRIC ACTUATOR MODEL L120 - 20 - 7.54 - BIC - MOD - D2 was used in this design.

6. THE ACTUATOR LISTED ABOVE HAS THE FOLLOWING FEATURES:

   - SINGLE-PHASE 220 VAC POWER SUPPLY
   - VARIABLE FREQUENCY DRIVE TO CONVERT TO THREE-PHASE, 4 - 20 MILLI AMP GATE POSITION FEEDBACK TO PLC

PLC SPECIFICATIONS

1. THE DATA LOGGER SHALL BE A Campbell Scientific Model CR1000.

2. CONTRACTOR TO PROVIDE A WEATHER PROOF, LOCKABLE CABINET INCLOSE TO HOUSE THE DATA LOGGER.

3. PROVIDE A BATTERY BACK UP FOR THE DATA LOGGER.

ENDANGERED SPECIES

THERE ARE NO ENDANGERED SPECIES WITH THIS SITE.

HISTORIC PRESERVATION

THERE ARE NO HISTORIC SITES ASSOCIATED WITH THIS PROJECT.

GENERAL LOCATION MAP

FOR THE GENERAL LOCATION MAP SEE SHEET 1, TITLE PAGE.

POTENTIAL SOURCES OF POLLUTION

<table>
<thead>
<tr>
<th>POTENTIAL POLLUTANT MATERIAL</th>
<th>ACTUAL POLLUTANT</th>
<th>POLLUTANT SOURCE</th>
<th>MANAGEMENT PRACTICE</th>
</tr>
</thead>
<tbody>
<tr>
<td>SEDIMENT/TOTAL SUSPENDED SOLIDS</td>
<td>SEDIMENT</td>
<td>EROSION OF DISTURBED SOILS</td>
<td>MINIMIZE SOIL DISTURBANCE. INSTALL BARRIERS LISTED</td>
</tr>
<tr>
<td>CONCRETE - WHITE/ SOLID GREEN</td>
<td>LIMESTONE, SAND</td>
<td>pH, CHROMIUM</td>
<td>EXTRA CONCRETE WHEN PURGING CONCRETE</td>
</tr>
<tr>
<td>OILS/BROWN OIL</td>
<td>MINERAL OIL, HYDRAULIC FLUID</td>
<td>OILS USED IN CONSTRUCTION</td>
<td>NO OILS WILL BE CHANGED ON SITE. LEAKS WILL BE REPAIRED IMMEDIATELY</td>
</tr>
<tr>
<td>WATER</td>
<td>GREASE</td>
<td>GREASE AND LUBE OIL</td>
<td>GREASE AND LUBE OIL AND EQUIPMENT USED IN CONSTRUCTION</td>
</tr>
<tr>
<td>ANTIFREEZE</td>
<td>ETHYLENE GLYCOL</td>
<td>ENGINE COOLANT</td>
<td>ENGINE COOLANT</td>
</tr>
<tr>
<td>FUELS</td>
<td>BZENENE, ETHYL BENZENE, TOLUENE, XYLENE, MTBE, PETROLEUM DISTILLATE, OILS/GREASES, NAPHTHALENI, COL</td>
<td>OIL</td>
<td>OIL USED IN VEHICLES AND EQUIPMENT</td>
</tr>
<tr>
<td>CONCRETE CURING COMPOUNDS - CREAMY WHITE LIQUID</td>
<td>NAPHTHA</td>
<td>USED TO CONTROL CURING AND SEALING OF CONCRETE</td>
<td>EXCESS COMPOUND WILL BE REMOVED FROM SITE</td>
</tr>
<tr>
<td>CONCRETE</td>
<td>WASHOUT WATER</td>
<td>pH</td>
<td>CONCRETE TRUCKS AND PUMP</td>
</tr>
<tr>
<td>TRASH</td>
<td>SOLID WASTES</td>
<td>TRASH LEFT OVER FROM CONSTRUCTION</td>
<td>TRASH Defender IN USE</td>
</tr>
<tr>
<td>SANITARY WASTE MANAGEMENT</td>
<td>BACTERIA, PARASITES, VIRUSES</td>
<td>Fecal Coliform, Bacteria Associated With Human or Animal Waste</td>
<td>PUBLIC RESTROOMS ARE AVAILABLE ON SITE AND WILL BE AVAILABLE TO CONSTRUCTION WORKERS</td>
</tr>
</tbody>
</table>

STORM WATER POLLUTION PREVENTION PLAN

SITE EVALUATION, ASSESSMENT, AND PLANNING

PROJECT SITE/NAME: CROCKETT CANAL HEAD GATE AUTOMATION PROJECT LOCATION: 175 NORTH CROCKETT AVENUE CITY: LOGAN, UT 84321 COUNTY: CACHÉ

CONTACT INFORMATION AND RESPONSIBLE PARTIES:

OWNER:

NAME AND ADDRESS:

SANDIEGO CANAL AUTOMATION

NORTH CROCKETT STREET

LOGAN, UT 84321

GENERAL NOTES

1. ELECTRICAL CONTRACTOR SHALL COORDINATE WITH LOGAN CITY LIGHT AND POWER, ON THE LOCATION OF THE UTILITY POWER SOURCE USED OR INSTALLATION METHOD.

2. ALL ELECTRICAL WIRING SHALL BE INSTALLED IN COMPLIANCE WITH THE NATIONAL ELECTRICAL CODE. ADDITIONAL REQUIREMENTS BY LOGAN CITY IN REGARDS TO EQUIPMENT USED SHALL ALSO BE MET.

3. COORDINATE WITH THE PHONE COMPANY ON LOCATION OF PHONE LINE BEFORE BEGIN WORK.

4. ALL EXPOSED CONDUITS SHOULD BE METALIC RIGID CONDUIT.

NATURE AND SzEQUENCE OF CONSTRUCTION

THE CROCKETT CANAL HEAD GATE COMPANY IS UPGRADING THE CONTROL SYSTEM OF THE CROCKETT CANAL HEAD GATES. ELECTRIC GATE ACTUATORS AND CONTROLS WILL BE INSTALLED ON THE EXISTING GATES.

THE CONSTRUCTION ACTIVITIES FOR THIS PROJECT WILL INCLUDE TRENCHING, INSTALLATION OF ELECTRICAL CONDUITS, ACTUATOR INSTALLATION, AND SITE RESTORATION.

SOILS, SLOPES, VEGETATION, AND CURRENT DRAINAGE PATTERNS

THE SITES ARE A GRAVELY SANDY LOAMS AS OBTAINED BY INSPECTION.

SLOPES: THE SITE HAS LITTLE TO NO SLOPE, AREAS ADJACENT TO THE CANAL ARE WELL VEGETATED AND NOT SUBJECT TO EROSION.

DRAINAGE PATTERNS: DRAINAGE IS GENERALLY SOUTH TO NORTH IN THE SITE.

VEGETATION: VEGETATION ON SITE IS GRASS AND TREES.

CONSTRUCTION SITE ESTIMATES

CONSTRUCTION SITE AREA TO BE DISTURBED: 0.2 ACRES REVERSED FROM THE DISTURBED SITE: 0.2 ACRES

PERCENT IMPERVIOUS AREA BEFORE CONSTRUCTION: 1%

PERCENT IMPERVIOUS AREA AFTER CONSTRUCTION: 1%

100-YEAR PEAK RUNOFF BEFORE CONSTRUCTION: 3.88 CFS

100-YEAR PEAK RUNOFF AFTER CONSTRUCTION: 3.88 CFS

DETECTION REQUIREMENTS:

- A LIMITROQUE ELECTRIC ACTUATOR MODEL L120 - 20 - 7.54 - BIC - MOD - D2 was used in this design.

- THE ACTUATOR LISTED ABOVE HAS THE FOLLOWING FEATURES:

   - SINGLE-PHASE 220 VAC POWER SUPPLY
   - VARIABLE FREQUENCY DRIVE TO CONVERT TO THREE-PHASE, 4 - 20 MILLI AMP GATE POSITION FEEDBACK TO PLC

- RECEIVING WATERS

- THE RECEIVING WATERS FOR THIS PROJECT IS THE LOGAN RIVER AND THE CROCKETT CANAL.

- THERE ARE NO WETLANDS ON THIS SITE.

- SITE FEATURES AND SITE SENSITIVE AREAS TO BE PROTECTED

- THERE ARE NO SENSITIVE SITE FEATURES OR SENSITIVE AREAS ASSOCIATED WITH THIS PROJECT.

- SCALE:

- Sheet: 2 of 7
## HEAD GATE DETAILS

**EXISTING GATES**

<table>
<thead>
<tr>
<th>DESCRIPTION</th>
<th>WEIGHT / FOOT (LBS./FT)</th>
<th>LENGTH (IN.)</th>
<th>NO.</th>
<th>WEIGHT (LBS.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GATE LEAF 60 X 60 X 1/4</td>
<td>51.0</td>
<td>60</td>
<td>1</td>
<td>255.0</td>
</tr>
<tr>
<td>ANGLE BRACE 3 X 3 X 1/4</td>
<td>4.9</td>
<td>54</td>
<td>3</td>
<td>66.2</td>
</tr>
<tr>
<td>ANGLE GUIDES 1.5 X 1.5 X 3/16</td>
<td>1.8</td>
<td>52.5</td>
<td>2</td>
<td>15.8</td>
</tr>
<tr>
<td>GUIDE RAILS 1.5 X 5/16</td>
<td>1.59</td>
<td>52.5</td>
<td>2</td>
<td>14.0</td>
</tr>
<tr>
<td>THREADED ROD 1.5&quot; DIA.</td>
<td>7.65</td>
<td>53</td>
<td>1</td>
<td>33.8</td>
</tr>
</tbody>
</table>

**TOTAL** 385.0

---

**NOTE**

1. ACTUATORS TURN CLOCKWISE TO CLOSE (LEFT HAND THREAD). IF REVERSE ROTATION IS REQUIRED IT MUST BE SPECIFIED. THE EXISTING RISING STEMS ON THE HEAD GATES ARE RIGHT HAND THREAD.

2. ALL THREE GATES SHOULD HAVE THE SAME DIAMETER AND THREAD ON THE RISING STEMS.

---

**NORTH HEAD GATE RISING STEM IS DIFFERENT THAN OTHERS. CHANGE RISING STEMS TO MATCH.**

**RETROFIT EACH EXISTING GATE WITH AN ELECTRIC ACTUATOR.**

**MODIFY TOP RAIL OF HEAD GATES TO ACCOMMODATE FOR ACTUATORS.**

**EXISTING CANAL HEAD GATES, LOOKING DOWN STREAM**

**SCALE: 1" = 4'**

---

**CROCKETT CANAL HEAD GATES**

**SCALE: 1" = 2'**

---

**Drawing No. C - 2**

---

**Date: September, 2011**

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**Designed: Tyler Richards**

**Drawn: Tyler Richards**

**Checked:**
FUTURE CROCKETT AVENUE STORM WATER DRAIN
COORDINATE LOCATION OF BURIED CONDUITS WITH LOGAN CITY TO AVOID CONFLICTS WITH FUTURE CONSTRUCTION

INSTALL ELECTRICAL PANEL AND CONCRETE PAD COORDINATE EXACT LOCATION WITH LANDOWNER.

P01 TO NEAREST POWER POLE

C01 TO PARSHAL FLUME

POWER AND CONTROL CONDUITS FOR SPILLWAY. COORDINATE WITH LOGAN CITY THESE COULD BE PLACED UNDER THE CANAL WHEN THE DRAIN LINE IS PUT IN.

INSTALL ELECTRICAL PANEL AND CONCRETE PAD COORDINATE EXACT LOCATION WITH LANDOWNER.
1. A Campbell Scientific CR1000 shall be used for the data logger. The supply voltage for a CR1000 is 24 Volts DC. A transformer powered by the UPS battery backup shall supply the data logger.

2. For remote gate positioning a 4 - 20 mA DC signal is sent between the actuator and PLC. The DC control wires are to be shielded signal wire. See manufacturer's recommendations.

3. A second control conduit for the shielded wire would be needed.

**Label Legend**
- C06 - Conduit name
- 3/4" - Conduit size
- 3 # 12 - Number and size of conductors
NOTES

1. REFER TO ONE-LINE DIAGRAM FOR CONDUIT SIZE AND NUMBER

2. BURIED CONDUITS TO BE SCHEDULE 40 PVC ELECTRICAL PIPE (GRAY)

3. USE METALIC RIGID CONDUIT ELBOW TO PENTRATE GROUND

NOTES

1. CONTROL WIRING MAY DIFFER DEPENDING ON MODEL AND FEATURES SPECIFIED. CHECK MANUFACTURES WIRING DIAGRAM.

2. THE CAMPBELL SCIENTIFIC SDM - CV04 IS A CURRENT / VOLTAGE OUTPUT MODULE. REQUIRED FOR REMOTE GATE POSITIONING.