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Midvale Irrigation District Hydropower Level II Study Executive Summary of the Final Report




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This document is released under the authority of Skylor W. Wade, P.E. on June 30, 2016.

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1.0 Introduction

In June 2014, the Wyoming Water Development Commission (WWDC) contracted with the team lead by Wenck Associates, Inc. (Wenck) to perform the Midvale Irrigation District Hydropower Level II Study. This study was performed at the request of the sponsor; the Midvale Irrigation District, and under the direction of the Wyoming Water Development Office. Team members included: Baccari & Associates, LLC and Apex Surveying, Inc.

This report presents the results of the expanded potential hydropower evaluation within the district. This investigation includes a review of existing information, detailed site assessments and hydropower feasibility analyses of several drop structures as well as a complete assessment and feasibility analysis of the Pilot Butte Powerplant.

The Midvale Irrigation District (MID) is located in Fremont County and is comprised of lands called the Riverton Unit of the U.S. Department of the Interior, Bureau of Reclamation (Reclamation). Lands of the Riverton Unit were ceded to the United States from the Wind River Indian Reservation in 1905. Major facilities of this unit are Bull Lake Reservoir, Wind River Diversion Dam, Wyoming Canal, Pilot Butte Reservoir and Pilot Butte Powerplant, and the Pilot Canal. Construction of the Wyoming Canal began in 1920, and the diversion dam in 1925. By 1925, project lands were being irrigated, and by 1929 both hydropower units at the Pilot Butte Powerplant were placed in service. Bull Lake Dam was completed in 1938. On New Year's Day 1951, the Bureau of Reclamation transferred the operation and maintenance of the Riverton Unit to the Midvale Irrigation District, which included Bull Lake and Pilot Butte Reservoirs, Wind River Diversion Dam, and part of the Wyoming Canal and pertinent laterals. The project was reauthorized in 1971 (under Public Law 91-409) as the Riverton Unit of the Pick-Sloan Missouri Basin Program.

Direct flow water from Wind River and stored water from Bull Lake and Pilot Butte Reservoirs are used to provide irrigation to approximately 73,000 acres. The principal storage is provided by Bull Lake Reservoir on Bull Lake Creek and supplemental storage is provided by Pilot Butte Reservoir, an off stream reservoir supplied with water diverted from the Wind River via the Wind River Diversion Dam. Water released from Bull Lake Reservoir flows through Bull Lake Creek to the Wind River where it augments the natural flow of the stream. Water for the Riverton Unit lands is delivered through the Wyoming Canal, which leads from the Wind River Diversion Dam to the Pilot Butte Reservoir and beyond to the distribution system serving lands primarily in the northern part of the Riverton Unit. Pilot Canal flows in a generally easterly direction from Pilot Butte Reservoir, servicing lands lying south of those supplied by the Wyoming Canal.

Pilot Butte Powerplant is located at the drop from the Wyoming Canal to Pilot Butte Reservoir. The plant has two generating units, which operate under a maximum head of 105 feet and a rated flow of 100 cubic feet per second (cfs) each. Each unit has a generation capacity of 800 kilowatts (kW) for a total capacity of 1,600 kW. Following an economic analysis the Bureau of Reclamation decided to shut down the powerplant in 2008 due to increasing operation and maintenance costs and needed plant repairs. Part of this study includes the viability of MID taking over operations of the Pilot Butte Powerplant.

2.0 Site Assessment and Feasibility Analysis

There are several drop structures along the Wyoming Canal and Pilot Canal ranging in size from approximately 155 feet of drop to 7 feet of drop. The potential hydropower sites located within the District were identified and a site assessment was performed on 31 canal sites and the Pilot Butte Powerplant to screen all potential sites quickly and reveal those sites and configurations with the most potential to investigate further. If two drop structures were in close proximity (less than ¼ mile), the individual drops were assessed as well as combining both drops. An initial assessment of the potential hydropower sites identified during the site tour was conducted. Part of the assessment identified potential affected parties, fatal flaws, and physical factors that would limit the sites power generation potential. Preliminary head and flow conditions were identified at each site, and based on the head and flow conditions preliminary power generation potential was determined along with cost estimates based on generalized cost indices. The current condition of the canal structures and the Pilot Butte Powerplant were also assessed. The site assessments focused on two separate areas: Pilot Butte Powerplant and Canal Sites.

Table 2-1 summarizes the key points of the feasibility analysis for the preferred sites.

Pilot Butte Powerplant

The site assessment of Pilot Butte Powerplant included the inventory and condition assessment of the existing equipment and review of historic flows and power generation.

The Pilot Butte Powerplant was commissioned in the 1920's and has operated off and on since 1973 when it was deemed economical. Operation, Maintenance and Repair (OM&R) costs have escalated significantly causing the powerplant to be placed out of service in 2008, and has not operated since. When the powerplant was in operation, water was diverted from the Wyoming Canal at a headgate and through a 66-inch concrete penstock and supplied two Francis type hydraulic turbines before being released into Pilot Butte Reservoir. Because the powerplant is not currently in operation, water is now passed through a chute drop from Wyoming Canal to Pilot Butte Reservoir where it is reregulated for use in Pilot Canal. The penstock was replaced in 1990 and is in adequate condition.

The entirety of essentially all significant powerhouse equipment is in a state of condition such that it is not prudent to re-condition for return to service. The powerhouse structure itself is also in poor condition and for the most part should be removed and replaced if the power station is to be returned to service. Condition of the powerhouse foundation could not be fully assessed at this level of investigation, but it is likely that a substantial amount of improvement and revisions to the foundation, including below grade support for new turbine-generator equipment will be required. There is little salvageable value of the existing facilities at the Pilot Butte Powerplant and the only equipment component recommended to remain in service is the penstock and intake headworks. The concrete around the gate and the guide rails of the headworks are in poor condition and need repaired.

If hydropower is to be developed at the Pilot Butte Powerplant, it is recommended a new facility utilizing the existing penstock be constructed adjacent to the existing Pilot Butte Powerplant. The feasibility analysis focused on scenarios that included a new facility adjacent to the existing Pilot Butte Powerplant. Various unit sizes and flow rates were

Table 2-1: Site Assessment and Feasibility Summary

	Location	Kinnear Drop	Ulcer Hill A	Ulcer Hill B	D19.0	Huelle	D37.2	Pilot Butte
Site Conditions	**Net Head (feet)**	37	37	85	17	38	30	80
	Max Turbine Flow (cfs)	350	259	259	392	250	167	403
	Min Turbine Flow (cfs)	90	68	68	102	65	44	105
	Rated Flow (cfs)	304	225	225	341	217	145	350
	Penstock Diameter (inches)	72	66	66	96	66	60	66
	Distance to Interconnect (miles)	Overhead	Overhead	0.25	2.5	1.3	1.0	Overhead
Generation	**Rated Capacity (kW)**	802	593	1375	491	689	363	2029
	Annual Energy Production (kWh)	3,576,101	1,965,471	4,561,281	1,500,000	2,250,000	1,127,960	8,145,096
	Turbine Type	Kaplan	Francis	Francis	Kaplan	Kaplan	Kaplan	Francis
Economics	**Capital Costs**	$3,305,713	$2,835,486	$5,615,678	$2,196,002	$2,731,669	$1,718,199	$5,062,144
	Annual Revenue @ $0.04/kWh	$143,044	$78,619	$182,451	$60,000	$90,000	$45,118	$325,804
	Annual O&M	$35,761	$19,655	$45,613	$15,000	$22,500	$11,280	$81,451
Performance	**Reliability**	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent	Excellent
	Maintenance	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate	Moderate
	Range of Operation	30% - 120%	30% - 120%	30% - 120%	30% - 120%	30% - 120%	30% - 120%	30% - 120%
Construction	**Space Required**	1225 Sq. Ft.	1225 Sq. Ft.	1225 Sq. Ft.	900 Sq. Ft.	900 Sq. Ft.	900 Sq. Ft.	1400 Sq. Ft.
	Permitting	1.5 years	1.5 years	1.5 years	1.5 years	1.5 years	1.5 years	1.5 years
	Time to Construct	1 year	1 year	1 year	1 year	1 year	1 year	1 year
Potential Hydropower Development (Scale 1 to 10)		**6**	**4**	**5**	**3**	**3**	**3**	**8**

analyzed to optimize the net benefits. It was determined a 2029 kW unit with a rated flow rate of 350 cfs was optimal.

Available Flow

Since the Pilot Butte Powerplant is an existing hydropower facility the available flows are readily available. When utilizing the existing 66-inch penstock the design flow was selected to be 350 cfs. A flow rate of 350 cfs would be exceeded approximately 60 percent of the time. This flow rate allows penstock velocities to be kept less than 15 feet per second reducing abrasion and head loss in the pipe.

During winter operation of the powerplant, issues arose with keeping flows in the Wyoming Canal from forming small but treacherous opponent, slush ice. During the cold winter months, the moisture would freeze and formed ice around particles of silt carried downstream by the Wind River. Once the slush ice passes through the Wind River Diversion Dam, it piles against the gates of the Wyoming Canal. The slush tends to slow the canal’s flow, which can have a negative impact on the powerplant’s operation and can damage lined sections of the Wyoming Canal. Floating mounds of slush have raised the river as much as 15 feet in the past. For this reason only irrigation flows were analyzed and it was determined winter operation of the powerplant was not feasible.

Available Head

The total elevation change between water surface at the intake of the penstock to the maximum tail water elevation is 92 feet. Friction losses in the penstock reduce the available head and vary depending on flows through the pipe. Head loss was calculated using Darcy-Weisbach equation for the 66-inch diameter penstock at 350 cfs. At a rated flow of 350 cfs the available head utilizing the existing penstock was calculated to be 79.5 feet.

Conceptual Design

Several concepts were analyzed at the Pilot Butte Powerplant, two utilized the existing penstock and similar sized turbines to the existing installed capacity, and one concept included the construction of a new larger penstock and turbine. It was determined utilizing the existing penstock is most optimal. The proposed new powerhouse would be located adjacent to the existing powerhouse and would make use the existing 66 inch diameter penstock. The existing penstock diverts from the Wyoming Canal and conveys flows approximately 1,000 feet to the new powerhouse. The existing penstock would be bifurcated just above the existing powerhouse and extended to the proposed new powerhouse. The penstock extension is 66 inch diameter. The penstock connects to a proposed horizontal Francis type turbine which discharges to a concrete tailrace which discharges directly to Pilot Butte Reservoir. The proposed powerhouse approximate dimensions are 44 feet by 32 feet. The powerhouse would be of steel frame construction.

Power Generation

The estimated annual power production is based on the available flow, head, turbine type, turbine performance and flow duration. Turbine performance curves were obtained from a turbine manufacturer and are specific to the site conditions at Pilot Butte. The performance curve shows potential power generation at the turbine shaft for various head and flow conditions and efficiencies. This curve was plotted and an equation was derived to estimate power potential based on head and flow. This is similar to the power formula described in the site assessment section of the report, but takes into account actual turbine performance instead assuming turbine efficiencies. Generator efficiency was assumed to be 94% which is a little conservative but accurate for this level of detail. The historic daily flows from 1990 through 2015, and the net head were inserted into the turbine performance equation and daily generator capacity (kW) was estimated. The estimated capacity was multiplied by the time interval (24 hours in this case) to estimate daily energy production (kWh). The daily energy was summed annually to estimate annual energy generation at the facility. The annual energy generation from 1990 through 2015 was averaged to estimate the potential annual energy generation. Since there is wide variance in flow at Pilot Butte, the turbine cannot handle the entire range of flow. Typically, Francis turbines can operate from 30% to 115% of the rated flow. Flow rates outside this range were clipped when estimating power output.

Table 2-2: Pilot Butte Annual Energy Generation

Estimated Annual Energy Generation					
Scenario	**Rated Flow (cfs)**	**Rated Head (feet)**	**Turbine Type**	**Generator Capacity (kW)**	**Annual Energy Production (kWh)**
66" Penstock 350 cfs, 2029 kW	350	80	Francis	2029	8,145,096

Cost Estimates

Cost estimates were developed for all scenarios at Pilot Butte Powerplant and are based on conceptual design, budgetary quotes received from turbine manufacturers, and from past experience on recent hydropower projects. Additional project cost estimate information is provided in the appendix of the report. A new 2029 kW unit adjacent to the existing Pilot Butte Powerplant and utilizing the existing penstock was estimated to be $5,062,144.

Economic Analysis

The feasibility of the project is based on several variables which when considered together offer a large number of potential scenarios. As previously discussed, several flow scenarios and system sizes were analyzed and the benefit/cost analysis enabled the optimal selection of system size to maximize the net benefits. The assumed value of energy and energy value escalation rate are also variables that play a major role in the feasibility of projects. The following assumptions were made when preparing the benefit/cost analysis:

- Loan Interest Rate: 4.62%
- Discount Rate: 4%
- Assumed Value of Energy: $0.04/kWh
- Energy Value Escalation Rate: 0.0%
- Load Period: 20
- O&M Escalation Rate: 3%

In addition to the benefit/cost analysis other economic evaluations were considered including a simple payback period analysis, present value of net revenue, internal rate of return and cash flow analysis. Table 2-3 summarizes the results of these economic analyses based on the assumptions listed above and the following components:

- Estimated annual energy generation and unit size

- Estimated O&M and Major Equipment Replacement Costs
- Estimated capital costs and debt service
- 6 months of unit operation per year
- No incentives are available

Table 2-3: Economic Feasibility Summary – All Sites

Location	Net Present Value	Internal Rate of Return	Benefit/Cost Ratio	Payback Period (Years)
Huelle Drop	($1,969,968)	-3.3%	0.45	>30
D37.2	($1,370,178)	-4.6%	0.37	>30
Kinnear Drop	($1,993,609)	-1.7%	0.56	>30
Ulcer Hill A	($2,213,548)	-4.3%	0.39	>30
Ulcer Hill B	($4,077,911)	-3.4%	0.45	>30
D19.0	($1,692,403)	-4.1%	0.40	>30
Pilot Butte	($1,931,939)	0.9%	0.75	>30

The economic analysis indicates hydropower development is not favorable at the Pilot Butte Powerplant under the assumptions listed above.

Other economic scenarios were analyzed for Pilot Butte Powerplant including how incentives, grants, and ownership affect project economics. Available incentives improve project feasibility but the returns are still marginal. Since the value of energy is unknown, a sensitivity analysis was completed by varying values of energy. Figure 2-1 shows the estimated benefit/cost ratio (BCR) for the 2092 kW unit at Pilot Butte Powerplant for varying values of energy. A benefit/cost ratio above one indicates a potentially feasible project. For a 2092 kW unit this point occurs at $0.053/kWh.

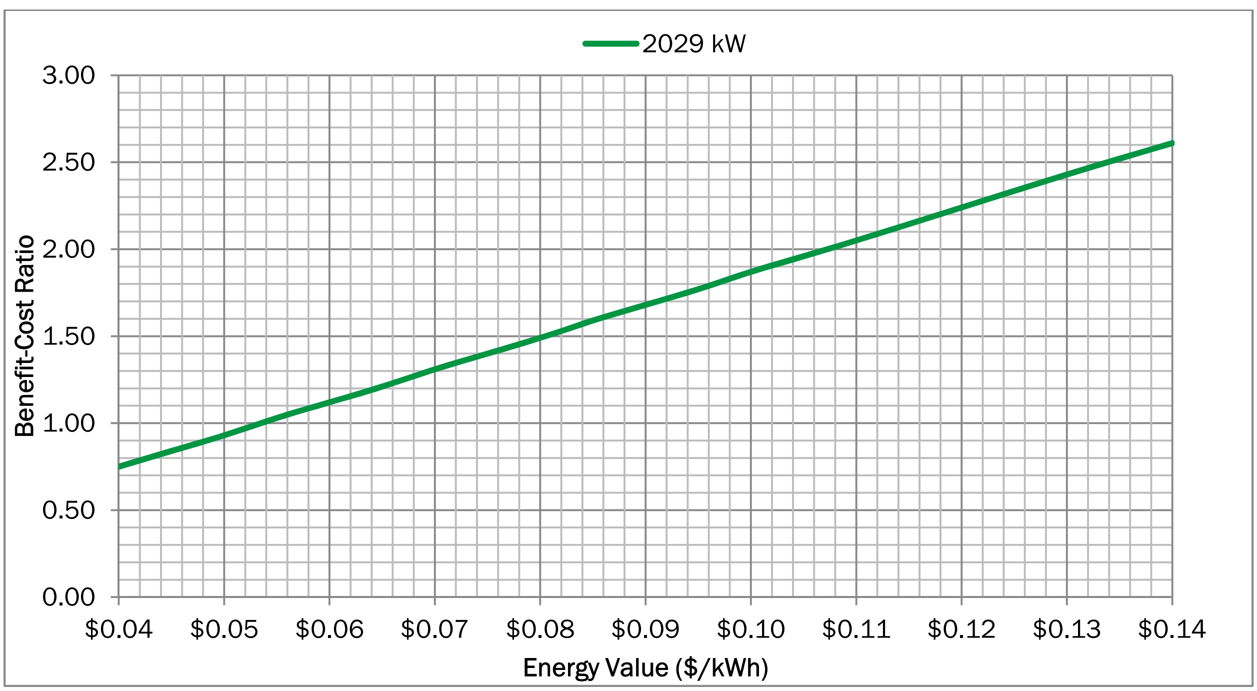

Figure 2-1: Benefit-Cost Ratio vs. Value of Energy Sold – Pilot Butte Powerplant

Figure 2-2 shows the time to positive net cash flow for varying values of energy for a 2092 kW unit. A 2092 kW unit at Pilot Butte has a net positive cash flow occurring in the first year of operation at an energy value greater than $0.063/kWh.

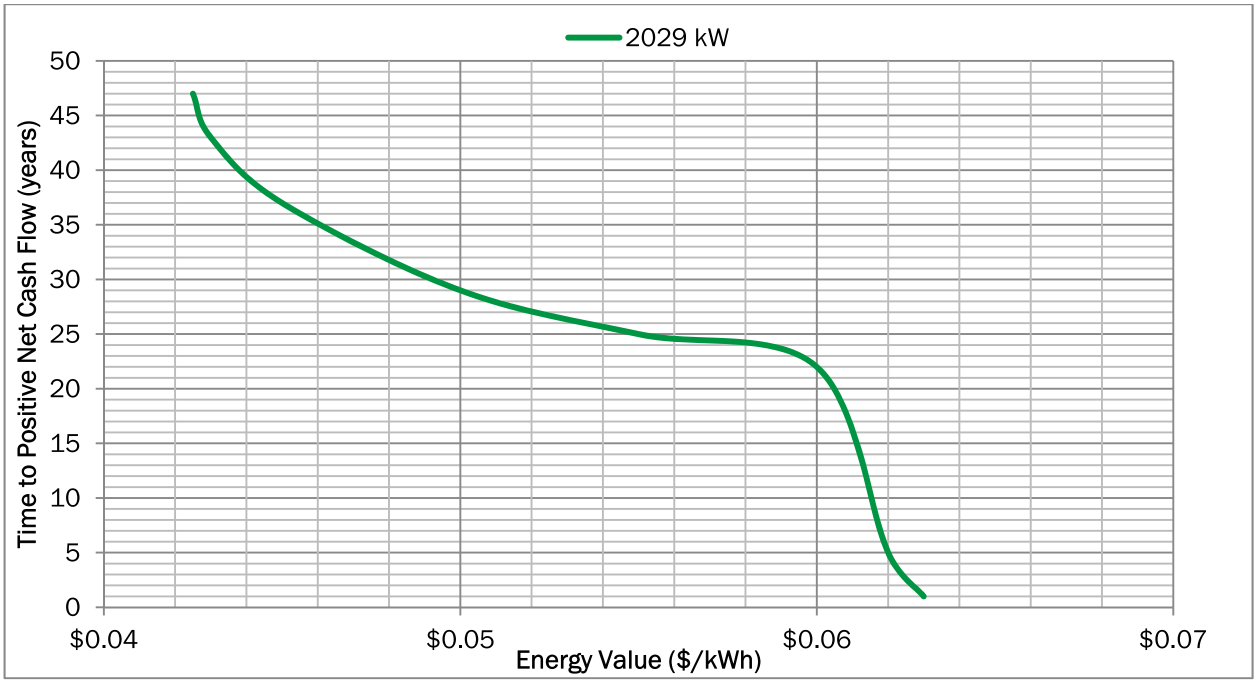

Figure 2-2: Time to Positive Net Cash Flow vs. Value of Energy Sold - Pilot Butte Powerplant

The economic analysis suggests feasibility of a new hydropower facility at Pilot Butte is marginal. It also suggests a unit sized at 2029 kW that utilizes the existing 66-inch penstock is optimized for the greatest net benefits. Irrigation districts are typically reluctant to invest in hydropower if the facility cannot achieve a net positive cash flow during the first year of operation. While successfully negotiating an energy rate of $0.063/kWh is not out of the possibility, it is a little higher than the current market in Wyoming. By design, cost estimates and O&M costs are conservative and may be reduced during final design and through a competitive bid process. These factors coupled with the potential of securing a WaterSMART grant from the Bureau of Reclamation and an escalating value of energy to help offset O&M costs could make a new hydropower facility at Pilot Butte more feasible. Other scenarios to increase the feasibility of hydropower development at Pilot Butte include an ownership structure that includes private sector entities to take advantage of the Investment Tax Credit.

It should be noted, while the Wyoming Water Development Commission's (WWDC) current policy is not to fund hydropower projects, if the policy should change and hydropower projects receive the standard WWDC financing package of 67% grant and 33% loan, a hydropower project at Pilot Butte Powerplant would be very feasible and provide the District with great returns. With a 33% loan the simple payback period would be approximately seven years. The benefit/cost ratio would be 1.48 and the internal rate of return would be 13.1%

Canal Sites

Of the 31 canal sites, six of those sites were found to have potential need for further investigation. The Kinnear Drop, Ulcer Hill (2 locations), D19.0, Huelle Drop, and D37.2 were screened as having potential and need for further study. The basis for eliminating the remaining canal sites was primarily due to the head and flow conditions at the site. The head and flow conditions at these sites were not conducive to power generation, and as a result the sites were not economically feasible to develop hydropower.

Available Flow

MID operates several flow measuring devices throughout the system; however, according to the MID Manager the majority of the data is not to be considered reliable or even useful for various reasons. Flow data was requested from MID early on in the project, and it quickly became apparent additional means to collect flow data was necessary to fully assess the potential hydropower sites. HOBO water level data loggers were deployed in early April 2015 before irrigation flows were turned on at four of the preferred sites: Kinnear Drop, Ulcer Hill, Huelle Drop, and D37.2. The data loggers measure and record the water pressure and can be correlated to a water depth. The loggers were set to record pressure every 15 minutes. In August 2015, each canal cross section where the data loggers were deployed was gauged using an Acoustic Doppler Current Profiler (ADCP). An ADCP measures the change in source light or sound frequency to measure velocity and are capable of measuring multiple directions of flow velocity simultaneously. The velocity, flow rate and canal cross section was measured at each data logger site. A rating curve was then developed to correlate the pressure to a flow rate. The data loggers and ADCP provide an accurate way to measure flow rates throughout the irrigation season. In October after canal flows were shut off for the season the data loggers where retrieved and data was analyzed. Flow duration curves were developed at each of the four sites and this information was used to size the hydropower turbines.

Available Head

Initially the available head for power generation was determined using a handheld GPS. Points were taken at the approximate high water line above and below the drop and the elevation difference was used as the gross head available at the site. The available head at the preferred sites was further refined during the feasibility analysis. Record drawings were obtained for D19.0 and D37.2 and the as-built elevations were used to estimate the available head at these sites. Surveys of Kinnear Drop, Ulcer Hill, and Huelle Drop were completed to get an accurate estimate of the static head at each of the preferred sites. Head loss was calculated using Darcy-Weisbach equation for various penstock sizes and flow rates, and the net head available for hydropower was calculated at each of the preferred sites.

Power System Inventory

Another factor that impacts the site assessment is the distance the proposed hydropower facility is to the grid interconnection point. The point of interconnection is where the hydropower generator connects the electric grid. Generated energy is metered prior to the point of interconnection and marketed to the electric utility at that point. Several factors dictate the feasibility of interconnection. First, the location of the point of interconnection related to the hydropower facility should be assessed. Powerlines are fairly expensive to construct and construction costs at remote sites limit the potential revenue from the hydropower facility. The powerlines also need to be large enough to handle the additional capacity from the hydropower generation. Typical generators in the sizes identified in this study are 3-phase, 480 volts. Therefore, the existing powerlines should be 3-phase as well. Before interconnection can take place the electric utility will conduct an interconnection study to determine what effects the hydropower generation would have on its system. This process is described in more detail in the permitting section of the report.

All of the proposed hydropower sites are located in High Plains Power service area. High Plains Power is a Rural Electric Association and a member of Tri-State Generation and Transmission, Inc. (Tri-State). High Plains Power was contacted early in this study and GIS shapefiles of their electric infrastructure was obtained. This allowed for a preliminary determination of the point of interconnection.

Conceptual Design

Conceptual designs were developed for each of the preferred sites and were based on the head and flow conditions at each site. Several flow rates and penstock/turbine sizes were analyzed at each site to determine the optimal turbine size. The optimal system size was selected to maximize the benefits versus costs. The conceptual designs for each canal site were similar and included an intake structure, penstock, powerhouse and tailrace, along with the turbine and generator, electrical interconnection equipment and controls.

An intake structure would be incorporated into the existing concrete check structure to divert flows into the penstock. The concrete intake structure consists of a sediment wall, trash rack, and inlet gate. The structure and trash rack is sized to divert the max turbine flow into the penstock and operate with some blocked trash rack area. The existing check structure is utilized as an overflow bypass.

The penstock was sized to minimize headloss to the turbine and remain small enough to keep cost down. The optimal size was driven by economic cost-benefit. Design penstock velocities were limited to 15 feet per second.

The turbine selection for each canal site is a horizontal Kaplan tube type turbine ranging in flows from 145 cubic feet per second (cfs) to 300 cfs and generator capacities from 363 kilowatts (kW) to 1375 kW. Turbine runner diameters range from approximately 36 inches to 60 inches, and the specific speed for these units is approximately 620.

The proposed powerhouses would be of concrete construction and approximate dimensions are 44 feet by 32 feet. The powerhouse is excavate into the existing canal bank and sits below grade. Access hatches provide entry and removal of the turbine equipment. A control building sits on top of the powerhouse and houses electrical and control equipment. The control building is of steel frame construction and approximate dimensions are 32 feet by 16 feet. The turbine and draft tube discharges to a concrete tailrace which discharges back to the canal.

The powerplant would be automated and operated remotely through a SCADA system. The plant would not need to be manned on a 24 hour basis, but would require at least one daily inspection by District staff. The operation of the hydroelectric turbine(s) would be controlled by a programmable logic controller (PLC) in the powerhouse. The PLC would communicate with the District's SCADA system to monitor the flow through the turbine(s), power levels for the unit(s), and other critical turbine parameter such as bearing temperature and inlet and outlet pressures. In addition the units will be alarmed for mechanical and electrical faults that would automatically shut down the equipment and alert the operator via the SCADA system. In the event of an emergency shut down the required flow would automatically be diverted through the existing drop structure. Any excess flows beyond the capacity of the turbine would also be routed through the existing drop structure. The utility will require the generating facility to disconnect from the grid in the event grid power goes down. When grid power goes down the turbine's switchgear will automatically disconnect the turbine from the grid, the generator will lose excitation and loading and the turbine will go into run-away speed mode.

Hydroelectric equipment is designed for continuous long term duty. With well specified and maintained equipment it is realistic to expect a lifetime of greater than 30 years for turbine-generator equipment for any of the options discussed in the report. After 30 years of operation more extensive maintenance could be required including replacement or refurbishment of the turbine runner, bearings or generator.

Power Generation

The estimated annual power production is based on the available flow, head, turbine type, turbine performance and flow duration. Turbine performance curves were obtained from a turbine manufacturer and are specific to the site conditions at each canal site. The performance curves show potential power generation at the turbine shaft for various head and flow conditions and efficiencies. The curves were plotted and an equation was derived to estimate power potential based on head and flow. This is similar to the power formula described in the site assessment section of the report, but takes into account actual turbine performance instead assuming turbine efficiencies. Generator efficiency was assumed to be 94% which is a little conservative but accurate for this level of detail. Flow data obtained from the data loggers for the 2015 irrigation season, and the net head were inserted into the turbine performance equation and daily generator capacity (kW) was estimated. The estimated capacity was multiplied by the time interval to estimate daily energy production (kWh). The daily energy was summed annually to estimate 2015 energy generation at the facilities. Typically, semi-Kaplan turbines can operate from 30% to 115% of the rated flow. Flow rates outside this range were clipped when estimating power output.

Cost Estimates

Cost estimates were developed for all scenarios at the canal sites and are based on conceptual design, budgetary quotes received from turbine manufacturers, and from past experience on recent hydropower projects. Additional project cost estimate information is provided in the appendix of the report.

Power Market

The power market evaluation for this study focused on the available markets in Wyoming. There are other markets in surrounding states, but the transmission capacity out of Wyoming is limited and it may be difficult to negotiate capacity on these lines, even for this small amount.

A general observation of the published Wyoming tariffs and prior experience with Power Purchase Agreements (PPA) in Wyoming (Tri-State Generation and Transmission, Rocky Mountain Power, Black Hills Energy, High Plains Power) is that the rates are quite low, and it appears energy in Wyoming is greatly undervalued. The wholesale rates in surrounding states are considerably higher.

Given the absence of significant on-site power demands at any of the potential power generation sites, it is not anticipated that MID would be a direct user of the power generated by the proposed projects and a net-metering agreement would not be possible.

All of the potential hydropower sites are within High Plains Power's service area and it is anticipated any generation would be marketed to High Plains Power through its local distribution system. High Plains Power is a member of Tri-State Generation and Transmission (Tri-State) and Tri-State would likely have input on any PPA. High Plains Power does not have avoided costs on file with the Public Service Commission, and when contacted to inquire about their interest in purchasing hydropower and at what rate, they indicated the rates for any generators above 25 kW were negotiated on a case-by-case basis and were reluctant to discuss specifics at this point in the process. Recent experience with successfully negotiated PPA's in Wyoming suggests the value of energy could be around $0.04/kWh and a firm capacity payment could be approximately $4.50/kW-month at a 40% load factor. These rates were used in the economic analysis.

Economic Feasibility

The same economic analysis described above for the Pilot Butte Powerplant was conducted on the preferred canal sites. The summary of the economic analysis is shown in Table 2-3.

The economic analysis suggests feasibility of a new hydropower facility at any of the canal sites is poor. It also suggests a unit sized at 802 kW at the Kinnear Drop is the most feasible canal site.

Other economic scenarios were analyzed for the Kinnear Drop including how incentives, grants, and ownership affect project economics. Available incentives improve project feasibility but the returns are still poor. Since the value of energy is unknown, a sensitivity analysis was completed by varying values of energy. Figure 2-3 shows the estimated benefit/cost ratio (BCR) for the 802 kW unit at Kinnear Drop for varying values of energy. A benefit/cost ratio above one indicates a potentially feasible project. For a 802 kW unit this point occurs at $0.071/kWh.

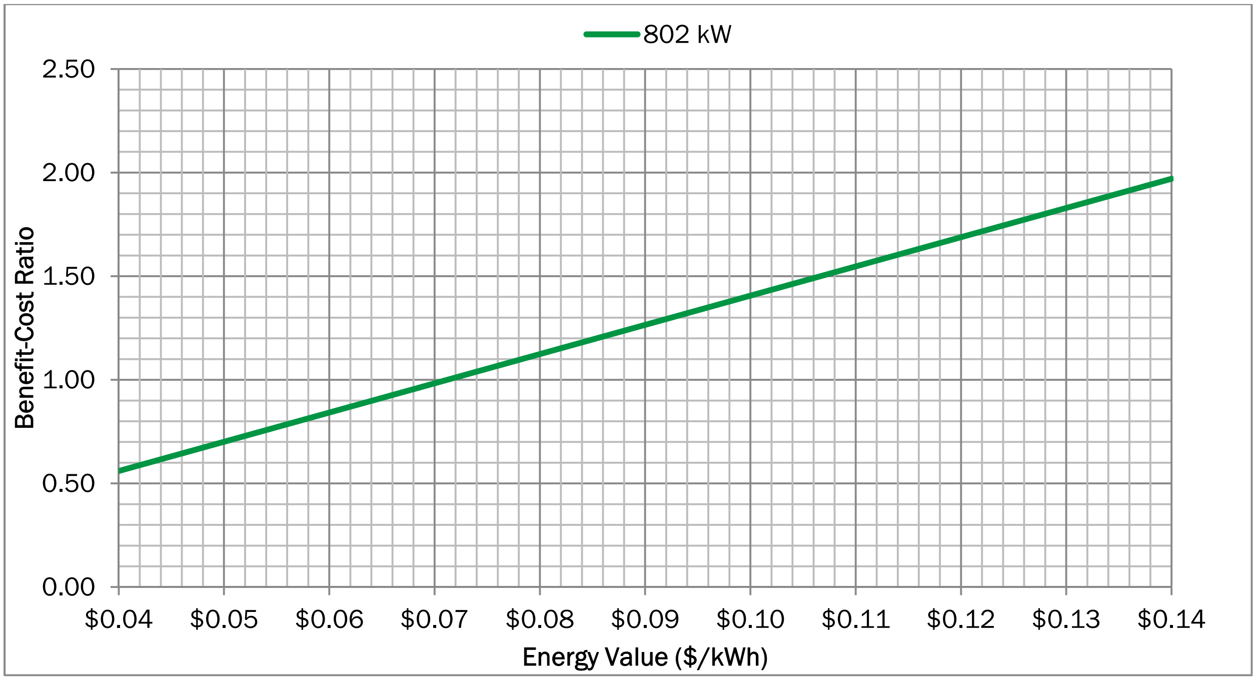

Figure 2-3: Benefit-Cost Ratio vs. Value of Energy Sold - Kinnear Drop

Figure 2-4 shows the time to positive net cash flow for varying values of energy for a 802 kW unit. An 802 kW unit at Kinnear Drop has a net positive cash flow occurring in the first year of operation at an energy value greater than $0.085/kWh.

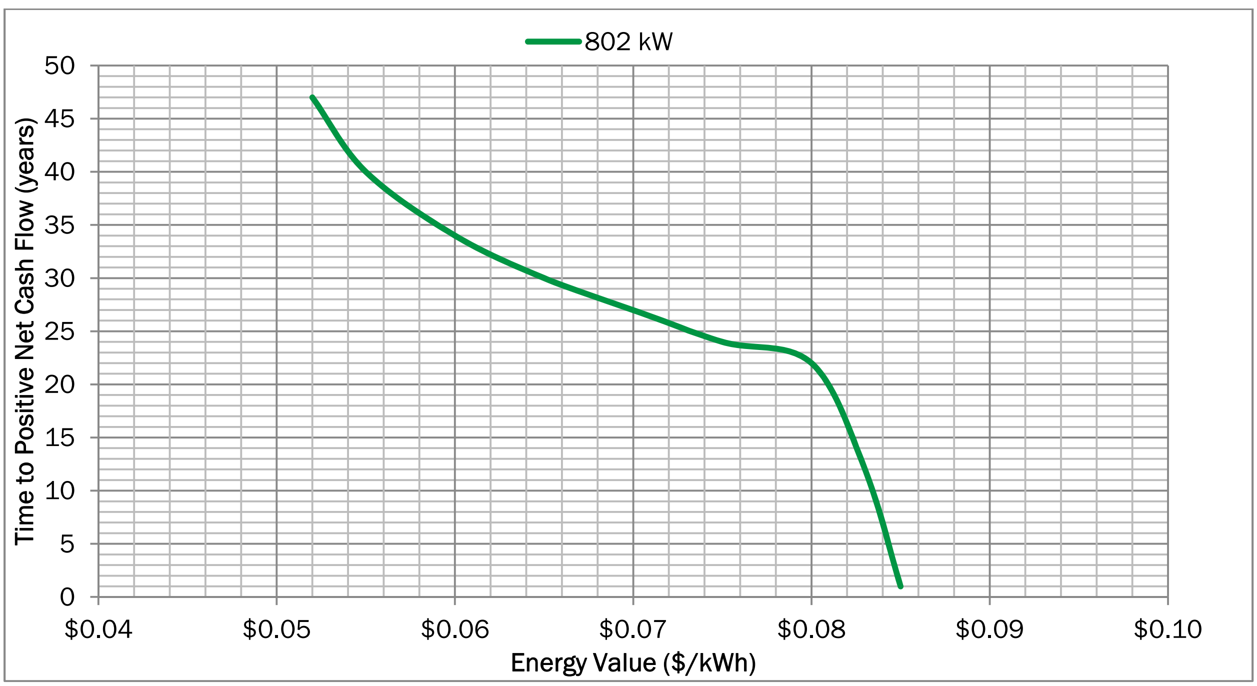

Figure 2-4: Time to Positive Net Cash Flow vs. Value of Energy Sold - Kinnear Drop

Based on these results it is not recommended to pursue any of the canal sites until the power market improves in Wyoming. Irrigation districts are typically reluctant to invest in hydropower if the facility cannot achieve a net positive cash flow during the first year of operation. While successfully negotiating an energy rate of $0.085/kWh is not out the possibility, it is significantly higher than the current market in Wyoming. By design, cost estimates and O&M costs are conservative and may be reduce during final design and through a competitive bid process. These factors coupled with the potential of securing a WaterSMART grant from the Bureau of Reclamation and an escalating value of energy to help offset O&M costs could make a new hydropower facility at Kinner Drop more feasible.

3.0 Funding Sources

Midvale Irrigation District is eligible to receive loan funds from the Office of State Lands and Investments State Loan and Investment Board (SLIB) for the construction of a hydropower facility. SLIB requires a WWDC funded feasibility study prior to issuing loans and the completion of this study would satisfy this requirement. The current interest rate is 4.62% with a 1% application fee for a term no longer than 30 years. The term of the loan may be shorter as determined by financial strength, repayment ability, security and other factors. Loans shall be repaid in annual installments.

Other funding sources include the U.S. Department of the Interior WaterSMART Grants. Through the WaterSMART Grants Reclamation provides 50/50 cost share funding to irrigation and water districts, Tribes, States and other entities with water or power delivery authority. Projects should seek to conserve and use water more efficiently, increase the use of renewable energy, protect endangered species, or facilitate water markets. Projects are selected through a competitive process and the focus is on projects that can be completed within 24 to 36 months that will help sustainable water supplies in the western United States.

The Internal Revenue Service (IRS) has established an energy investment tax credit program that allows taxpayers to take advantage of federal tax incentives. Hydro projects greater than 150 kW are eligible for the Investment Tax Credit (ITC). The ITC can be claimed in year one of a project for 30 percent of depreciable capital costs and reduces the project's depreciable basis by 15 percent. Only private sector entities are able to take advantage of these tax credit incentives, and the eligible systems must be placed in service on or before December 31, 2016. In general, the original use of the equipment must begin with the taxpayer, or the system must be constructed by the taxpayer. Businesses that receive other incentives are advised to consult with a tax professional regarding how to calculate this federal tax credit.

4.0 Licensing and Permitting

All hydropower projects in the United States are regulated by either the Federal Energy Regulatory Commission (FERC) or the Bureau of Reclamation. Permitting authority is mutually exclusive; a Reclamation facility is either within the Reclamation's or FERC's permitting jurisdiction. Accordingly, development proceeds through either Reclamation's lease of power privilege (LOPP) or FERC license/exemption, but not both. Hydropower developers are free to choose which agency to contact and it is up to the Reclamation or FERC to determine the lead permitting authority.

Since all the sites identified in this study are less than 5 MW and on Reclamation facilities, Reclamation will have jurisdiction. Reclamation will be the lead permitting authority and there will be no requirements from FERC.

A lease of power privilege (LOPP) is a contractual right given to a non-federal entity to use a Bureau of Reclamation (Reclamation) facility (e.g. dam or conduit) for electric power generation consistent with Reclamation project purposes. A LOPP project must not impair the efficiency of Reclamation generated power or water deliveries, jeopardize public safety, or negatively affect any other Reclamation project purpose. A LOPP is used on Reclamation dams authorized for Federal hydropower development and all Reclamation conduits. Pursuant to the Bureau of Reclamation Small Conduit Hydropower Development and Rural Jobs Act (Public Law 113-24), all development of non-federal hydropower on Reclamation conduits requires a LOPP. The Act further requires LOPPs be offered first to the irrigation district operating or receiving water from the Reclamation conduit. It should be noted that Reclamation would need to determine the kind of contractual arrangement that would be appropriate based upon a specific request. For example, a LOPP may be the correct vehicle if MID were to propose construction of a new powerhouse and facility adjacent to the existing Pilot Butte Powerplant; however, another agreement type may be applicable if MID were to propose to rehabilitate the existing Pilot Butte Powerplant. The following description is an example of the LOPP process.

5.0 Conclusions and Recommendations

Constructing a new hydropower facility adjacent to the existing Pilot Butte Powerplant, and utilizing the existing penstock, was determined to be the most feasible site in this study. The economic analysis was marginally feasible and may prove to be more feasible if some of the assumptions made during the economic analysis are more favorable than anticipated. If alternative funding, such as grants, or the Investment Tax Credit, or a slightly higher than estimated energy price could be negotiated, a new hydropower facility at Pilot Butte could become feasible. It was estimated an energy price would need to be approximately $0.063/kWh or greater to see a net positive cash flow in the first year of opeartion, without any additional incentives. If a grant of $1,000,000 could be secured the energy price would need to be $0.05/kWh or greater to see a net positive cash flow in the first year of operation. If MID is willing to invest in a hydropower facility, this rate could be lower and MID would start making revenue after the loan principal was paid off.

The transmission of power out of the State will be difficult to negotiate and could add significant costs to the value of energy. It would be most advantgeous to work out an agreement with High Plains Power or possiblity Tri-State.

The canal sites will not be feasible until electric rates rise significantly relative to construction costs. The most feasible canal site is Kinnear Drop. It is not recommended to progress any of the canal sites to further investigation.

The following recommendations and areas of further study are made if MID chooses to progress a project at Pilot Butte to final design:

- Conduct detailed discussions with High Plains Power about interconnection with their facilities. The discussions should include the expected rate at which they would purchase energy and capacity and interconnection requirements they may have.

- If discussions with High Plains Power are beneficial to both parties, MID should start the negotiation of a Power Purchase Agreement. It is adventagous for MID to negotiate the sale of capacity as well as energy. It is also adventagous to include an energy escalation factor in the Power Purchase Agreement. The term of the PPA should correspond to the term of the loan payment to ensure the sale of energy and capacity can pay the principal and interest of the loan.

- If a PPA is likely to be executed, then MID should initiate the Lease of Power Privelage with Reclamation.

- It is recommended the design of a new facility adjacent to the existing Pilot Butte Powerplant look at utilizing the existing penstock and leaving the existing powerplant as is.

- It is recommended MID look further into extending the flows through Pilot Butte during non-irrigation season to increase hydropower generation.

It is recommended MID look into applying for a WaterSMART grant from Reclamation. If a grant of $1,000,000 could be secured the energy price would need to be $0.05/kWh or greater to see a net positive cash flow in the first year of operation.

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