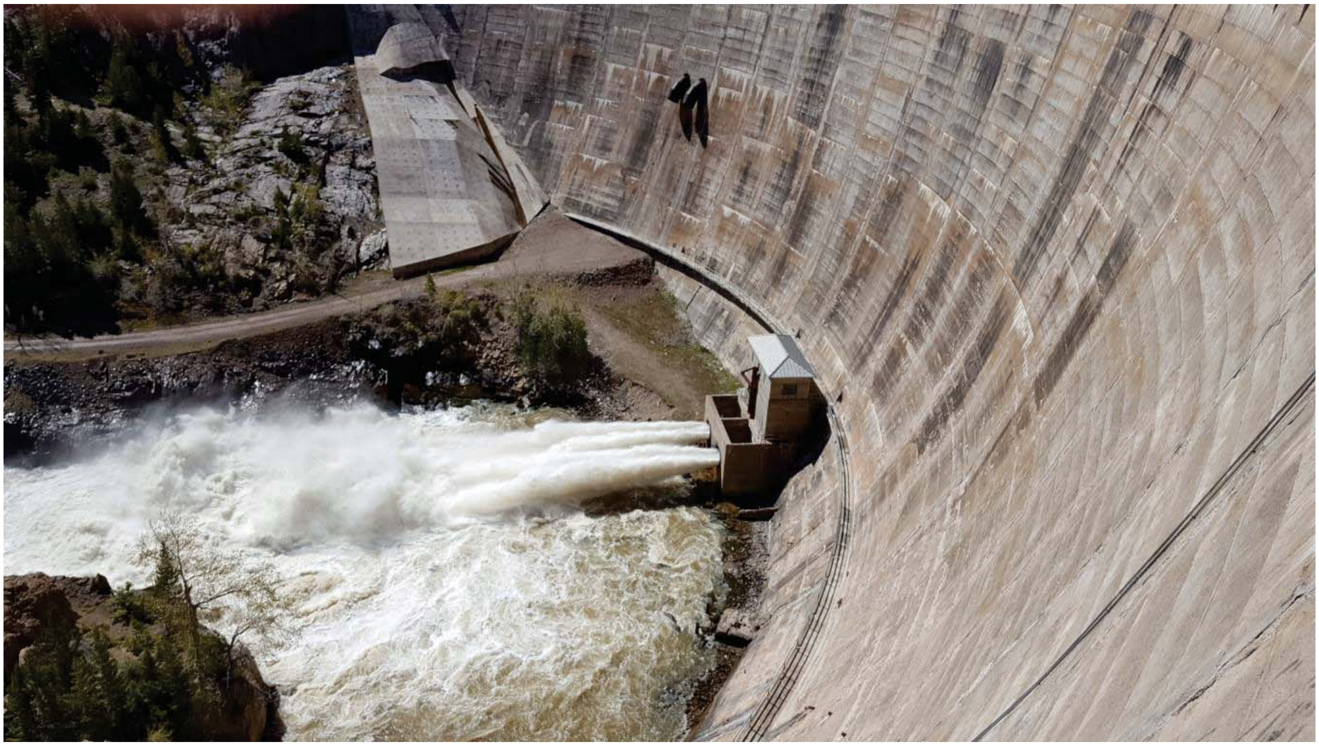

HYDROPOWER DEVELOPMENT FOR GREENFIELDS IRRIGATION DISTRICT

A Summary of Potential Hydropower Sites, Economic Feasibility Analyses, & a Strategy for Implementation

1.0 EXECUTIVE SUMMARY

The GID Board of Commissioners is faced with a formidable challenge of modernizing the infrastructure and water operations for future generations while making it affordable for today's producers. That challenge is compounded by the time this effort will take and the magnitude of the costs required. It may cost GID well over $75,000,000 over the next 30 to 40 years to replace failing structures and incorporate modern technology. This cannot be achieved at the current level of water assessments even while taking advantage of all available State and Federal funding programs

2.0 INTRODUCTION

2.1 PURPOSE

The Greenfields Division of the Sun River Project first delivered water in 1920 and much of the infrastructure comprising the Greenfields Irrigation District (GID) is over 100 years old. This infrastructure was originally designed and constructed to support a rotational-style, flood-head method of gravity irrigation. Today, much of this infrastructure is well beyond its design life and is in serious need of replacement. In addition, these structures, as well as the water operations and mode of delivery, seriously warrant modernization. This is important in order to embrace current technology, to match current, on-field methods of irrigation, and to implement enhanced management and conservation practices. Each of these will help ensure the long-term viability of GID for future generations. To put this in perspective, if GID was being designed and built today, it would look and operate entirely different.

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In 2009, construction began to reconfigure the Upper and Lower Turnbull hydraulic drop structures into hydropower units to capture the potential energy available. Generation began in 2011 and GID has a 10% ownership of the corporation that owns and operates Turnbull Hydropower. In the first 10 years of operation, GID's annual share of the revenue distribution, after expenses, has averaged over $180,000. GID's initial investment was recuperated within 6 years of start-up. Turnbull Hydro is viewed as both a financial success for GID and as a lost opportunity since a larger percentage of initial buy-in and ownership was reportedly offered to the GID Board.

The GID Board also views the Turnbull Hydro model as an opportunity that could be applied at many other drop structures as well as four dam outlet facilities. Once the initial hydropower development investments are satisfied, the subsequent revenue streams could then be used to ultimately fund the daunting task of replacing and modernizing the District's infrastructure and its water operations. To expedite this ultimate objective, the revenue stream from one hydropower site could then be used to bring additional hydropower sites on-line thus accelerating and increasing the

3.0 FEASIBILTY

3.1 INTRODUCTION

Assessing the feasibility of a potential hydropower site begins with the answering of several key fundamental questions. These questions involve summarizing the physical parameters of the site and reviewing the historical water flow data while making some assumptions regarding future flow trends. Other questions require more assumptions regarding development and construction costs, operating costs, the value of the electricity generated, financing options, and time for construction. Every cost is also dependent on time and subject to change in the future; whether up or down.

Once the feasibility has been completed and determined, it can be readily amended when new or more accurate information becomes available. Initially, some sites may be determined to be unfeasible but may become feasible over time with changes in the some of the governing economic or engineering assumptions. Likewise, a feasible site may become unfeasible over time. This is the primary advantage of preparing this summary report in that the important, background work will have been completed and summarized and the costs can be easily updated if and when necessary.

3.2 FEASIBILITY QUESTIONS

The questions to be answered by the feasibility analysis include:

1) What is the power generating capacity at the site?
2) What type and size of turbine is best suited?
3) How much energy can be produced annually?
4) What are the development and construction costs of the hydro plant?
5) What are the electrical, transmission-related costs?
6) What are the annual operating costs?
7) What is the likely value and marketability of the produced electricity? Another why to address this variable is to is ask, what unit price of electricity is warranted to make a potential site feasible?

3.2.1 – POWER GENERATING CAPACITY. The generating capacity of an individual site is the maximum energy that can be produced with the proposed or actual equipment installed. It is a function of the potential head (water drop) and the volumetric magnitude of water flow. The computed power is than reduced by the turbine and generator inefficiencies as well as accounting for energy losses realized along the transmission lines.

4.0 LIKELY SITES

4.1 INTRODUCTION

This section presents the likely sites along GID's infrastructure that may be capable of being developed as a hydropower plant with a minimum output of 250kW. Background information addressing the history and operations of specific structure is presented. In addition, the physical parameters of each site as it relates to potential hydropower development are summarized along with some basic governing cost assumptions to address the unknown variables. This information was then used to conduct a feasibility assessment with respect to possible development. GID historic drawings and flow data provided the basis of the analysis.

The average annual energy generation (MW-hrs) was modeled and determined using the information referenced above. Northwestern Energy's current electricity purchase price information, aka avoided costs, was utilized to predict a revenue generation stream. A summary of the feasibility is provided in each write-up section below and the complete analysis is presented in the Appendix.

The following Figures show the locations of potential hydropower sites which are discussed in this report.

4.2 DAM RELEASES

GID operates and maintains four dams that are owned by US Bureau of Reclamation. Three of these dams have a storage reservoir component and the fourth is strictly a diversion dam. Two of the reservoirs are operated only on a seasonal basis and the other two have year-round flow. One dam has been considered for hydropower development for nearly 100 years and has been studied numerous times since then. The other three dams have received only limited attention with respect to potential development.

4.2.1 – GIBSON DAM –

4.2.1.1 Background and History – Gibson Dam and Reservoir is the largest of GID's storage units and is most the critical component for the success of the District's primary purpose, that being irrigation. Gibson Dam is a run-of-river, 199-foot tall, concrete arch structure situated on the Sun River. The releases are facilitated by two, 72-inch diameter steel conduits (shown below), The outlet has a rated combined capacity of approximately 3,050 cfs at full pool. A gated, emergency spillway has a capacity of 30,000 cfs at full pool.

Gibson Reservoir typically fills each year to the top of the emergency spillway gates (Forebay Elev. 4724) around the end of May to the first part of June. Typically, by mid-June, or shortly thereafter, the reservoir level begins to drop as the magnitude of the release for irrigation requirements exceeds that of the combined inflow of the North and South Forks of the Sun River. Releases are intended for the Pishkun Supply Canal (+/-1,4000 cfs max.) and for minimum in-stream flows during the summer (+/-125 cfs). Releases continue until the reservoir level reaches approximately 4608 which equates to approximately 5% of the available storage.

Photo showing typical release from outlet gates; approximately 2,200 cfs.

Once Gibson Reservoir reaches its winter shut-off level (4608), the dam releases are generally lowered to match the reservoir inflows so that the reservoir level does not change appreciable. This mode of operation may be amended if snowpack accumulation falls below normal thus creating a need to slowly retain water in the Reservoir over the Winter months and into early Spring.

As Spring approaches, and depending on the snowpack level in the watershed, the outlet release is adjusted accordingly. If adequate snow-water equivalent exists above Gibson Reservoir, the outlet release is gradually ramped up to match the increasing inflows. Although Gibson Dam is not a flood-control structure, this practice helps to reduce the impact of downstream flooding by maintaining a storage buffer to adsorb rapid run-off or a rain-on-snow event.

If the snow-water equivalent is below normal and concerning, then the approach would be to fill the Reservoir as the inflows began to increase with the melting snowpack. The feasibility analysis summarizes the historic data that describes the releases from the lower outlet works and the corresponding reservoir pool elevation.

Two other outlets exist that would allow water to pass through the dam. These could also be tapped to develop hydropower. During construction, two 72-inch diameter steel penstocks were installed at an invert elevation 4660 for the sole purpose of facilitating future hydropower development. Those upper penstocks are considered auxiliary to the lower outlet works which were also envisioned to be converted to capture the potential energy. GID paid for the design and construction of Gibson Dam which was completed in 1929 therefore GID has a vested interest in those auxiliary penstocks and their hydropower potential.

The combined capacity of the lower outlet pipes is approximately 3,050 cfs at full pool. There are numerous times when water is released through the gated, emergency spillway when inflows exceed 3,050 cfs and the reservoir is near full. The spillway crest elevation is 4712 and six spillway gates allow for another 12 feet of storage to elevation 4724. It is customary for Reclamation to request that the spillway gates not be closed until the snowpack is sufficiently reduced and the risk of a rain-on-snow event is comfortably abated. As such, excess water is lost through the spillway that could otherwise be used to produce power if the upper penstocks were plumbed to turbines at the base of the dam. This opportunity warrants further evaluation. The photo below shows the upper penstocks.

Photo showing two power penstocks constructed at elevation 4660. Note the top of the concrete wall on the dam crest has an elevation of 4729.

The land comprising Tunnel No. 1 as well as that needed for the proposed hydropower facility is situated within the boundaries of the Lewis & Clark National Forest and on Reclamation-withdrawn land for GID's benefit.

4.3.2 – TUNNEL No.3 OUTLET –

<u>4.3.2.1 Background and History –</u> Tunnel No.3 is a concrete-lined, tunnel excavation through mostly hard and durable, thinly-bedded to massive sandstone. Weaker interbeds warranted a timber-framed support prior to the concrete liner section for approximately the first 160 lineal feet near the upstream, western portal. The tunnel has an overall length of 2,235 feet and an additional 40-foot, open transition at both portals. The cross-sectional flow area is slightly greater than 90 ft^2 and has a slight horse-shoe shape with a width and height of 10'-8". Based on Reclamation design drawings, the overall invert to invert elevation drop is 11.3 feet.

Photo showing outlet releases from Tunnel No.3, +/-1,350 cfs

<u>4.3.2.2 Power Potential –</u> The power generation capacity of the Tunnel No. 3 site is directly related to the operation of the PSC. Similar to Tunnel No. 1, the likely design element for Tunnel No. 3 would be to install a steel liner or penstock inside of the tunnel. This would convert the vented tunnel conduit into a pressure conduit.

The land comprising Tunnel No. 3 as well as that needed for the proposed hydropower facility is on Reclamation withdrawn land. A 3-phase line would convey electricity downstream along the canal approximately 1.3 miles to the Arnold Coulee hydro-power site.

Table 4.3.2 Summary of Tunnel No.3 Development Parameters	
Location:	N47°39'15", W112°36'08"
Water Source:	Pishkun Supply Canal
Operational Mode:	Seasonal
Turbine Flow Range:	600 to 1,400 cfs
Static Head Range:	11.3 feet
Maximum Capacity:	0.3 MW
Est. Annual Ave. Energy Production:	940 MW-Hrs
Ave. Annual Revenue, 1st 15 years(1):	$
Est. Construction Costs:	$
Est. Transmission Costs:	$

Note 1: Based on Northwestern 2020 Energy Tariffs

4.3.3 – ARNOLD COULEE DROP –

<u>4.3.3.1 Background and History –</u> The Arnold Coulee Drop is a monolithic concrete, inverted siphon which conveys the PSC across the Arnold Coulee drainage. The pipe has a circular cross-section that is 9 feet in diameter at the inlet and quickly transitions to a diameter of 7.5 feet. The condition of the drop is such that a replacement structure is warranted. This Arnold Coulee terminal stilling basin is shown below.

A feasibility study was completed on this structure by Sorenson Engineering in 2018. The conclusion of that effort was that the project is technically feasible and could be financially viable if 40% of the development costs could be covered with grants, tax credits and low interest loans.

<u>4.3.3.2 Power Potential –</u> The power generation capacity of the Arnold Coulee Drop is directly related to the operation of the PSC. The static head is approximately 38 feet and would require approximately 400 lineal feet of penstock. A parallel pipe drop (penstock) would be constructed which would allow continued use of the existing drop structure during emergencies. The land is owned by the Bureau of Land Management on which Reclamation has an easement for operation and maintenance of the PSC and drop structure. An additional easement is required for a new, parallel drop structure.

Photo showing outlet releases from Arnold Coulee Drop, +/-1,350 cfs

Table 4.3.3 Summary of Arnold Coulee Development Parameters	
Location:	N47°39’45”, W112°34’55”
Water Source:	Pishkun Supply Canal
Operational Mode:	Seasonal
Turbine Flow Range:	400 to 1,300 cfs
Static Head Range:	38 feet
Maximum Capacity:	2.4 MW
Est. Annual Ave. Energy Production:	6,600 MW-Hrs
Ave. Annual Revenue, 1st 15 years(1):	$299,100
Est. Construction Costs:	$3,426,525
Est. Transmission Costs:	$2,189,986

Note 1: Based on Northwestern 2020 Energy Tariffs