WaterSMART: Water and Energy Efficiency Grant Program

PROJECT TITLE:
Arnold Coulee Drop Water Savings & Hydropower Development Project

APPLICANT:
Greenfields Irrigation District
P.O. Box 157
Fairfield, Montana 59436

PROJECT MANAGER
Erling A. Juel, P.E., District Manager
Greenfields Irrigation District
P.O. Box 157
Fairfield, Montana 59436
406-467-2533 Office
406-467-2705 Fax
erling@gid-mt.com

Submitted: September 16, 2020
**TABLE OF CONTENTS**

SF-424 - Application cover page
SF-424C – Budget Information – Construction
SF-424D – Assurances – Construction

Title Page.................................................................................................................................1
Table of Contents..................................................................................................................2
Technical Proposal and Evaluation Criteria (limited to 50 pages)...........................................3
  - Executive Summary........................................................................................................3
  - Background Data..........................................................................................................4
  - Project Location........................................................................................................16
  - Technical Project Description.....................................................................................17
  - Evaluation Criteria.......................................................................................................33
Project Budget.......................................................................................................................53
  - Funding Plan and Letters of Commitment.................................................................53
  - Budget Proposal.........................................................................................................54
  - Budget Narrative........................................................................................................55
Required Permits or Approvals............................................................................................58
Letters of Project Support......................................................................................................59
Official Resolutions.............................................................................................................59

**Attachments:**
  #1 - Greenfields Irrigation District Board Resolution.....................................................61
  #2 - Greenfields Irrigation District Commitment Letter..................................................63
  #3 – Project Letters of Support.....................................................................................65-72
  #4 – Original Arnold Coulee Drop Construction Drawing-1913..................................73
  #5 - Greenfields Irrigation District Hydropower Development Strategy
  #6 – Arnold Coulee Hydropower Feasibility Analysis
  #7 – Arnold Coulee Hydropower LOPP Agreement with Reclamation
  #8 – Arnold Coulee Hydropower Preliminary Construction Drawings
  #9 - Greenfields Irrigation District Rubicon Study; 2016
  #10 - Greenfields Irrigation District Canal Modernization (Rogers); 2007
  #11 - GID Water Plan
  #12 – SRWG Strategic Plan
  #13 - Montana State Water Plan
  #14 - Sun River Special Study; 2012
  #15 – USGS Sun River at Simms gage data
  #16 – USGS Muddy Creek at Vaughn gage data
1) Executive Summary

- **Project:** Arnold Coulee Drop Water Savings & Hydropower Development
- **Date:** September 16, 2020
- **Applicant:** Greenfields Irrigation District
- **City:** Fairfield
- **County:** Teton
- **State:** Montana

**Project summary.** This project provides both immediate and future water savings of 2,400 acre-feet/year and 36,000 acre-feet/year respectively by replacing a +100-year old drop structure with a modern piped conveyance structure. This project represents the initial steps the District must undertake in order to completely overhaul the Reclamation/District infrastructure as well as modernize its water operations. This long-term effort is projected to cost up to $75 million over the next 40 to 50 years. The District is faced with the formidable challenge of replacing and modernizing its +100-year old system for future generations while keeping it affordable for today’s producers. This project also consists of incorporating hydropower generation into the new structure. Specifically, a 2,400-kW plant is proposed which will produce on average 6,000,000 kW-hours per season. Based on current electrical tariff rates, this equates to an average revenue stream of nearly $262,000 per season for the first 15 years (before annual operating expenses). This revenue stream will enable the District to accelerate and facilitate its long-term, overhaul and modernization plans. This will result in considerable water savings as the efficiency of water management and the reliability of its water supply are tremendously improved. Currently, the District suffers a water deficiency of approximately 30,000 acre-feet/year and even greater during persistent drought conditions. The long-term water savings projected from District modernization will be at least 36,000 acre-feet/year by reducing waste flows, emergency spills and operational losses into one of the neighboring drainages alone. Not only are the water savings quantifiable, but they are sustainable since this involves a complete and permanent overhaul of District infrastructure and operations. This will enable the District to realize drought resiliency by ensuring water supply reliability simply through water savings and enhanced water management efficiency. The District seeks $2 million assistance under Funding Group II.

- The **FOA goals** met with this proposed project include quantifiable and sustainable water conservation, hydropower implementation, and improving water supply reliability through water savings and improved drought resiliency. This project also supports several DOI priorities including American energy independence and modernizing Reclamation infrastructure.

- **Project length:** three years
- **Estimated completion:** July 31, 2024
- **Proposed project located on a Federal facility:** Yes
(2) **Background Data**

**Greenfields Irrigation District Basic Background Data**

The District comprises the Greenfields Division of the U.S. Bureau of Reclamation Sun River Project, Montana located in central Montana. The District is located in the Sun River drainage 35 miles northwest of the city of Great Falls. It contains over 83,000 irrigable acres serving 362 water users on 1,552 farm units.

The project was authorized by the Secretary of the Interior on February 26, 1906, in accordance with the act of June 17, 1902. Construction on the Greenfields Division began in 1913 and the first water was delivered in 1920. The District operates and maintains the Division facilities. District headquarters are in Fairfield, Montana.

The main storage dam, Gibson, was constructed during 1926 to 1929. Gibson Reservoir is located on the Sun River above Augusta, Montana, and has a total capacity of 99,058 acre-feet. Pishkun Reservoir is an off-stream reservoir, about 15 miles northeast of Gibson Dam, and has a capacity of 46,700 acre-feet. Willow Creek Dam is an earth-filled structure on Willow Creek about 15 miles southeast of Gibson Dam. In addition to storing water from Willow Creek, the reservoir is fed from the Sun River through the Willow Creek Feeder Canal. The Willow Creek Reservoir has a capacity of 32,400 acre-feet of water.

The Sun River Diversion Dam located 3 miles downstream from Gibson Dam feeds the Pishkun Supply Canal at a maximum rate 1,400 cubic feet per second. The Pishkun Supply Canal extends 12 miles from the Sun River Diversion Dam to the Pishkun Reservoir. From the Pishkun Supply Canal, a short distance downstream from the river diversion, the Willow Creek Feeder Canal begins has a maximum design capacity of 300 cubic feet per second and is 7.5 miles long to the point where it enters a natural drainage channel to the Willow Creek Reservoir.

Sun River Slope and Spring Valley Canals combined extend 32 miles from Pishkun Reservoir to A-Drop at Fairfield, Montana. The Pishkun discharge capacity is 1,700 cubic feet per second. Three major drops and various control structures and lateral turnouts are a part of the main canals. Greenfields Main Canal heads at the end of Spring Valley Canal and extends 25.4 miles northeast. It has an initial capacity of 1,200 cubic feet per second but is gradually reduced in size to 10 cubic feet per second at its terminus. Greenfields South Canal is supplied by the Greenfields Main Canal at a point about 2 miles below the start of the main canal. The initial capacity is 425 cubic feet per second and the length is 16.7 miles. Mill Coulee Canal is supplied from the Greenfields South Canal. The initial capacity is 200 cubic feet per second and the length is 10.7 miles. In total, there is about 119 miles of main canal, 384 miles of laterals, and 252 miles of drains for the District.
Hydromet stations at the Diversion Dam and the outlet of Pishkun Reservoir measure all flows to the District. Water measurement devices have also been installed at other key locations to better manage water deliveries. Water Inventory Data Estimation:

- Diverted from Sun River = 250,000 acre-feet
- Delivered to farm units = 150,000 acre-feet
- Transportation losses = range is 100,000 to 124,000 acre-feet depending upon heat and wind
- On-farm efficiency is estimated at 50 - 75% depending upon soils and type of irrigation

District's assessment rates to water users continue to rise to keep pace with increased costs. Because of rising costs and increase in maintenance, the District's board passed in 2019 for 2020 irrigation season, assessment rate increase of $1.50 to $23.50 to all assessed lands within the district. And it was only four years ago when assessment was increased $5.50 to $22.00 in an attempt to catch up on infrastructure repairs.

The District is located in a semi-arid climatic zone and is typical of the northern inter-mountain area. The climate is characterized by light and variable precipitation and warm and sunny days with cool nights throughout the summer months. The average annual precipitation is 11.9 inches, with an average for May through September of 8.7 inches. The Greenfields Bench receives about 30% of its water from precipitation and about 70% from the irrigation supply canals. Gravity irrigation with contour ditches was the only method of irrigation used in since 1920. Since the 1970s, pumps, pivots and sprinklers have been on the increase and now represents about 67% of the area irrigated. The remainder is still flood irrigation. The principal crops are barley, wheat, alfalfa, silage, and pasture.

The average elevation of the District is approximately 3,800 feet above mean sea level. Most of the land lies within an alluvial valley floor or on adjacent terraces. Some undulation exists on those lands adjacent to the valley floor and the steeper slopes. In general, Greenfields Bench is composed up to 30 feet of gravel that overlies thick shale. The Greenfields bench geological cross-section is comprised of Quaternary terrace deposits on top of Marias River Formation (Colorado Shale), which lies on top of the Blackleaf Formation (Colorado Shale). Soils throughout the irrigation District vary significantly. Those in the alluvial valley floor have medium to heavy textures and are underlain with sands and gravels. The old river terraces adjacent to the alluvium have medium gravelly-textured profiles.

Greenfields Irrigation District Past and Current Water Savings Activities
Greenfields is a proactive District that has an ongoing irrigation water conservation program. The process started in 1978 with a Rehabilitation and Betterment (R&B) Program. The R&B Program was completed in 1988 and included lining portions of the main canals and laterals, replacement of several open laterals and buried pipe, installation of automatic and telemetric equipment for control of water regulating facilities at Gibson and Pishkun Dams and at storage points on the irrigation system; and repairing, updating, and replacing of various structures and measuring devices.
The District has lined 120 miles of canal and lateral distribution system. The main canal was lined in areas of high seepage losses near Pishkun Reservoir as well as other areas of need. The major portion of the lateral system has been lined with slip-form concrete.

The District embarked on a water conservation measure to save water by converting many open conveyance facilities to closed pipe facilities. To date, 39 miles of open lateral system have been converted to closed concrete and PVC pipeline. The water saved is used to help make up annual shortages, due to system capacity limitations during periods of high demand or remain in storage for use later in the irrigation season.

Operation and Maintenance Program - Annual operation and maintenance costs have been drastically reduced by the conversion of the open conveyance system to the closed pipeline conveyance system. Approximately 22 miles of existing drains were also converted from an open system to a tiled or closed system to facilitate a better use of the sprinkler systems which are used by the majority of the water users in the District.

The District increased the size of the maintenance building to accommodate pre-casting of the concrete farm and lateral turnout structures, in-line checks and drop structures, division box structures (both open and closed system), in-line crossing structures, Parshall flumes, etc. during the winter months. These structures are then installed as time and weather conditions permit. All precast structures are standardized where possible. The lateral and farm turnout structures have been standardized to accommodate the propeller type water measurement device and to facilitate quick water turn-on, turnoffs, and delivery adjustments by the ditch rider. This has improved the system operation efficiency, therefore reducing wastewater. To date approximately 1,100 structures have been replaced which includes about 425 farm turnout structures and 80 Parshall flumes. Eventually all the farm turnouts will be replaced.

The District Manager has a highly technical background and knowledge in the engineering and irrigation field. The Manager has performed training sessions for the ditch riders to broaden their knowledge in irrigation system operation and maintenance, forecasting deliveries to water users, and maintaining accurate daily water measurements and records. As a result, the District has developed a highly trained staff that can help in developing and improving the systems efficiency. District manager and staff have all had an excellent working knowledge of water conservation and management. The District manager, in conjunction with the board, support the ongoing review and work to improve the overall condition of District facilities for water conservation.

In 2020, the District spent $33,950 modernizing their computerized water ordering and scheduling data base program to improve the management of water orders and scheduling the water supply for distribution to the carriage facilities. The water users can stay better informed by farm unit as to their usage and remaining water supply balance.

The District maintains an annual schedule of canal and lateral ditching and cleaning, berm removal and terrestrial weed control. The cleaning of silt, debris, and vegetative growth from the carriage facilities in order to maintain the capacities to meet the irrigation demand. At the same time a small amount of water savings is realized by removal of the
vegetation in the canal prisms. District staff is active in weed control during the irrigation season from May through September. The ditch riders are trained to reuse drain water whenever possible to reduce spills and conserve water. The overall maintenance program includes items such as caulking and sealing concrete lined canal joints, concrete repairs of irrigation structures, and maintaining turnouts.

Two main checks and two waste way structures were rehabilitated and automated during the R&B Program. The wastewater discharged into two main waste ways are also monitored through the automation system. The District also upgraded a main canal check structure with radial gates with electric hoists and automation equipment. The District recently automated Pishkun Reservoir and Pishkun Supply Canal and the Mary Taylor site to improve overall water management.

The District in cooperation with Reclamation have HYDROMET stations at the North and South Forks of the Sun River, Gibson Reservoir, Diversion Dam, Pishkun Reservoir and Main Supply Canal, Willow Creek Reservoir, and various SNOTEL sites. The District also has eight (8) flow monitoring stations on main canals and over 50 gages on the laterals to help the Water Master manage/track water transportation as it makes its way through the many miles of conveyance system. The District has an Agrimet station to provide valuable data for improving on-farm efficiency of water-use. The basic components provided by Agrimet are a localized weather station capable of calculating evapotranspiration rates for crops grown in a local area and crop water use information for stages of crop growth. Many water users within the District have been participating in the Agrimet Program over the last 25 years.

In summary, the District has calculated that about 40,000 acre-feet/year of water is being saved each year through the efforts of their water conservation program. The overall system efficiency has increased from 45% in 1979 to about 63% in 2019. However, there is a long way to go before the District achieves its system-wide overhaul and modernization objectives. In fact, the District still realizes a water deficiency of approximately 30,000 acre-feet/year during water short years. Fortunately, the water savings and system efficiency will continue to improve as the District continues additional water conservation programs like this one being proposed.

Electricity is supplied to the majority of local communities and irrigators from the Sun River Electric cooperative. As more of the local farmers convert from flood to sprinkler irrigation the Co-Op struggles to meet the new peak summer electric demands. The first major boost to fulfilling those peak demands was accomplished when the District partnered with an engineering firm to install two hydropower units on the District's main canal in 2011 that produces 14 MW combined. Not only does the power units fill a power shortage but it has also increased the District’s revenue, so they have additional funds to deal with ever increasing O&M costs.

That partnership worked so well the District has developed a hydropower development strategy and implementation plan to evaluate and prioritize the best opportunities for future projects within the District. The draft plan describes estimated power generation potential, facility costs and revenue generated. See Attachment #5 for excerpts from the District's Draft Hydropower Development Strategy and Implementation Plan.
Recent working relationships with Reclamation include:

- **2020** – *Electronic Water Management Plan* - awaiting contract. This is a new project funded through a WaterSMART grant to automate manual flow measurements and controls at four key main canal gates.

- **2019** – *Sun River bridge replacement* – ongoing. Due to deficiency repairs will cost more than bridge replacement. District and Reclamation are working diligently on design and project funding so bridge can be replaced before it is condemned.

- **2019 – 2020** - *WaterSMART GM100 project grant* – almost complete. The old GM-100 canal head gates at J-Wasteway site were replaced to help reduce tailwater into Muddy Creek. This project along with several others will decrease waste and spills into Muddy Creek to a manageable level.

- **2019** – *Willow Creek Reservoir outlet gates repair* – completed. Project was necessary due to gate stem failure on both the regulating and the emergency gates. District designed, paid for materials and installed replacement parts. Reclamation reviewed and approved project.

- **2017-2019** – *Johnson Drop replacement* due to concrete failure - completed. District designed, paid for materials and installed pipe as replacement to old concrete chute. The District installed pipe and other components to be hydro compatible so will go on-line when the time is right. Reclamation reviewed and approved project.

Greenfields Irrigation District – Current Problems Needing Addressed

In 1982, the Reclamation reviewed the District’s infrastructure status that identified many projects to enhance the District’s efficiencies. Many of those proposed projects were accomplished in the 1980s through a R&B Program. Despite all that activity there is much more to accomplish. In 2007, experts from Reclamation’s TSC visited the District, reviewed the on-going issues, and provided recommendations on a vision to modernize the water operations with water conservation and management efficiency being the objectives (see Attachment 10). The problem areas the District is working on include:

**Greenfields Irrigation District – Problem Identification to Implementing Solutions**

The District is not an organization that sits around waiting for someone else to fix the above problems identified or any other problem that may arise. The District is an organization that tackles problems head on, such as the items listed below:

- **Problem #1**: Aging infrastructure that is getting harder to maintain. See photos below showing deteriorating concrete structure before being replaced.
Solution #1: The District has an ongoing infrastructure maintenance schedule and is ALSO replacing some structures with better products. Examples include converting open ditches to buried PVC pipe and replacing old fashioned checks with “smart” checks that can be networked together and work in unison. See photos below showing conversion to pipeline and Rubicon programable “smart” check that measures, monitors and regulates flow.
Problem #2: shortage of 30,000 acre-feet for water users in most years. So short of water have had to turn off water deliveries to water users by end of August.

Solution #2: The District is tackling this issue from several fronts including a thorough review of how to increase storage in existing reservoirs so can capture some high spring runoff flows; reuse waste water before it leaves the district boundaries such as the J-Lake re-regulating reservoir; pump backs and lining large canals. Overhaul of the District's infrastructure and operations will improve drought resiliency and supply reliability through water conservation. See photos below showing newly installed pumpback unit and canal lining project in-progress.

Problem #3: Controlling wastewaster that enters Big Coulee causing severe erosion. The District has flow gauges tracking waste water in Big Coulee so can reduce excess deliveries to that area. See photo below showing erosion problem on Big Coulee and chart tracking excess water and sediment loads.

Solution #3 – Big Coulee erosion: The District is working with other irrigation projects and SRWG to find solution to reducing waste into Big Coulee and is accomplish some bank-work. See photos below showing bank sloping and volunteers seeding banks.
Problem #4: Controlling wastewater that enters Mill Coulee causing erosion. The District has flow gauges tracking waste water in Mill Coulee so can reduce excess deliveries to that area. See photo below showing serious erosion problem.

Solution #3 – Mill Coulee erosion: The District is working with SRWG to find solutions to reduce waste into Big Coulee and accomplish some bank-work. See photo below showing volunteers installing willow blanket.
Problem #5: Controlling wastewater into Muddy Creek contributing to erosion issues. Photos below showing Muddy Creek at its worst and confluence of Sun River with sediment entering Missouri River.

Solution #5 – Muddy Creek. For the past 25 years, the District has worked with the SRWG implementing projects that have resulted in a real success. A multi-prong approach to the excess wastewater and high erosion problem has been used on this problem that has resulted in a 20% reduction in wastewater and an 80% reduction in erosion that has reduced sediment loads into the Sun River. Considerably more work needs to be done to further reduce waste flows. This will reduce the environmental impacts and lawsuits.
The District in cooperation with Reclamation and SRWG engaged in an extensive monitoring program to identify where the majority of the wastewater and sediment loads were coming from. This data has allowed the District and SRWG to install several proactive projects.

**One-Year of multiple year study on Muddy Creek wastewater**

![Diagram showing flow and sediment calculations with GID spills and gains/losses in sediment and flows for Muddy Creek tributaries.]

**Greenfields Irrigation District – Win-Win Solutions to Complex Water Shortages**

- **Problem #6 – Conflict Resolution.** Finding win-win solutions to sharing a limited water supply. See photos below showing very low flows in Sun River while excess flows in Muddy Creek.
Solution #6 – Conflict Resolution. Solutions to sharing a limited water supply evaded the Sun River drainage for almost a century until the District helped create the nationally recognized Sun River Watershed Group (SRWG) consensus effort that searches for consensus to all-natural resource problems. The SRWG and the District are leading the charge in conflict resolution with the District as a major partner in finding win-win solutions to water shortages occurring more frequent in recent times. For over 25 years the SRWG and the District have been the go-to organizations to ensure everyone in the basin is working towards a common direction to “promote community-based efforts that will preserve our quality of life and livelihoods while promoting an enhancing the natural resources of our watershed”. The SRWG’s hard work is resulting in cleaner water and better water management for all water uses. In 2015, this hard work by so many SRWG partners was recognized as one of 4 finalists for the North American Riverprize. Unfortunately, there are always issues that need addressed in a timely manner to prevent going back to the battles over the limited water supply. See photos below showing better flows in Sun River and less flows in Muddy Creek.
(3) **Project location**

This Water Savings and Hydropower project is located in Teton County, Montana; 28 miles west of Fairfield. The Arnold Coulee site is located at: latitude is 47.662266°N and longitude is 112.582116°.
(4) **Technical Project Description** The technical project description should describe the work in detail, including specific activities that will be accomplished. This description shall have sufficient detail to permit a comprehensive evaluation of the proposal.

**4.1 Overall Project Purpose and Objectives**
This project, the Arnold Coulee Drop Replacement, has multiple benefits and achieves several objectives that are crucial to the long-term sustainability of the District thereby helping to ensure efficient and cost-effective water deliveries for future generations. The majority of District’s infrastructure is over 100 years old and well beyond their design lives (see example below). The District Board of Commissioners is faced with a formidable challenge of replacing and modernizing the District’s infrastructure and water operations for future generations while keeping it affordable for today’s producers. That challenge is compounded by the time this effort will take and the magnitude of the costs ultimately required. It may cost the District well over $75,000,000 over the next 40 to 50 years to replace failing structures and to incorporate modern technology. This cannot be achieved at the current level of annual water/O&M assessments even while taking advantage of all available State and Federal funding programs. The objectives and outcome of this proposed project, as well as similar hydropower opportunities currently in the planning stage, will facilitate and expedite that daunting effort.

Catastrophic failure of a (hydraulic chute) in 2017 which typifies the condition of many of the District’s structures warranting immediate replacement with a modern alternative.

Specifically, this project involves replacing the Arnold Coulee Drop, a critical component of the District’s water supply canal, with a modern structure that is hydropower “ready”. Once completed, a steady and reliable revenue stream will be produced thus helping the District Board and management to expedite and facilitate the complete overhaul and modernization of the District’s conveyance and carriage system.
As was presented in Section 2, the District consists of four dams and three reservoir storage units as well as hundreds of miles of canals and drains from 1,700 cfs down to 10 cfs. All the District's infrastructure is owned by Reclamation; however, the District is fully responsible for its operation, maintenance, and eventual replacement.

Besides replacing the 100-year plus old deteriorating structures, modernization needs to be seriously embraced and incorporated District-wide. The goal is to switch our operational mode from an “upstream supply” mode to a “downstream demand” mode. This will conserve a tremendous volume of water on an annual basis and improve water deliveries. For example, the way the District was designed and built by Reclamation in the early 1900s does not reflect today’s mode of operation, i.e. flood irrigation versus sprinklers. Most GID producers have embraced technology and sprinklers have drastically improved the on-field, irrigation efficiencies and reduced water wasting downstream of the field turnout.

Unfortunately, the District’s conveyance system has become increasingly inefficient. This has happened gradually, but steadily over the last 50 years as pivots and sprinklers have become more prevalent, replacing flood irrigation. Sprinklers use less water but require water daily throughout the irrigation season. In contrast, flood irrigation utilized a rotational flood head and slugs of water were routed to the fields 2 or 3 times per season. The duration of each flood cycle varied from 2 to 7 days based on several factors. Consequently, the adjacent ditches usually went dry until the next cycle of flood irrigation.

As previously mentioned, sprinklers irrigate daily which requires the supplying ditch to be “charged” or flowing throughout the season. The District’s +100-year old system is a gravity system, not a closed system. As a result, considerable water is wasted out the downstream ends of the system. As was discussed previously in Section 2, this wastewater can cause detrimental environmental impacts to landowners downstream of our District. This negative impact is compounded during rain events and power outages. Without electricity, water stays in the ditch and flows out the end or is spilled at dedicated locations for safety reasons.

Currently, the Muddy Creek drainage receives approximately one half of GID’s emergency spills, waste flows, and operational losses. The USGS gage on the Muddy Creek reveals that the magnitude of this flow averages 200 cfs during the irrigation season or volumetrically, nearly 400 ac-ft/day. For an irrigation season lasting 120 days, this equates to almost 48,000 ac-ft. Future full-scale, modernization efforts could easily reduce this by 75% or a 36,000 ac-ft savings. Besides reducing environmental impacts, legal conflicts and lawsuits can be avoided from private landowners downstream.

Recently, the District commissioned an engineering study to investigate opportunities to conserve water and incorporate modernization which would enhance water management efficiency. This study recommended a series of in-canal storage checks and strategically
located regulation ponds to better handle the transient nature of the conveyance system. See examples of recommendations below. Simply put, if being designed and built today by Reclamation, it would most likely incorporate these modern water management characteristics. Attachment 9 includes a portion of the Rubicon study.

Excerpts from study commissioned by District to conserve water, reduce operational losses, eliminate environmental impacts, and avoid legal conflicts through enhanced water management.

The opportunity for water conservation, improving water supply reliability and remediating environmental issues is tremendous but warrants an extensive modernization effort and overhaul of District infrastructure. And in turn, this requires a tremendous source of funding from State and Federal programs for the next 50 years. As an alternative, the District has developed a strategy to convert some Reclamation structures into
hydropower facilities by which the revenue could then be used to help fund this long-term, overhaul plan as well as bring additional hydropower potential, revenue generation sites on-line thus accelerating the overall effort.

The District is a 10% owner of an existing hydropower development situated on Reclamation infrastructure known as the Upper and Lower Turnbull. This development is a private venture and yields the District on average about $180,000 per year in income after expenses. It has been on-line since 2011 and the District recuperated its initial investment within five years. The District’s crews constructed portions of the Turnbull Hydro project. This work was used as leverage towards the District’s buy-in investment.

The District Board would like to emulate this model at other potential sites but at a much larger ownership stake and thus a larger stake of the revenue. At least 6 other hydropower potential feasible sites have been identified along District infrastructure (see map below). Given its experience with the Turnbull sites, District management has the recent and relevant experience to successfully complete another hydropower site.

Photos showing powerhouses at the lower terminiis of Lower (left) and Upper Turnbull Drops (right) which have a combined capacity of 14 MW. The District is a 10% owner.

The intake structure (left) and 6.3MW turbine-generator (right) of the Upper Turnbull site. District crews performed much of the construction as “buy-in” for its ownership.
Excerpt from DRAFT – HYDROPOWER DEVELOPMENT FOR GREENFIELDS IRRIGATION DISTRICT, A Summary of Potential Sites & a Strategy for Implementation, August 2020, showing potential hydropower sites west of Fairfield.

Portions of this study are provided in Attachment 5.
The first site identified for hydropower development is the Arnold Coulee Drop which is also slated for replacement due to its current condition (see photos) and opportunity for water conservation. As such, the District has entered into a Lease Of Power Privilege (LOPP) preliminary agreement with the Great Plains Region of Reclamation to develop hydropower at this site. The LOPP agreement is included as Attachment 7.

Photos showing the floor of Arnold Coulee Drop in 2017. A temporary repair was implemented and the structure was then programed for replacement.

The District is requesting a $2,000,000 grant from this FOA for a 3-year project allowed under this program, to replace and modernize the Arnold Coulee Drop Structure while converting it to a hydropower facility and providing a reliable revenue stream for the District. These funds will then be used for future water conservation projects, the replacement of other failing structures, and the overall modernization of the District.

In summary, the Arnold Coulee Replacement Project will realize an immediate water conservation savings by simply replacing the failing infrastructure with a new pipe drop. The combined seepage losses are estimated to be at least 5 to 10 cfs, or a water savings of nearly 2,400 acre-feet per season.

Also, using the income from the electrical generation for future conservation projects will produce an ultimate water conservation savings on the order of 36,000 acre-feet per year in the Muddy Creek drainage alone. This is an important amount as the District often suffers a water deficiency of approximately 30,000 acre-feet in most years due to seasonal run-off patterns and snowpack and even greater water shortage during drought years. The water savings will help ensure sufficient water for crops as well as providing an opportunity to leave surplus water in the Sun River thus by improving instream flows for fish populations and recreationalists. Reducing operational spills and releases will also reduce related environmental damage and the growing potential for lawsuits and legal conflicts with downstream landowners.
Examples of seepage from the failing Arnold Coulee Drop. Note flowing seepage through drainpipe (left) and upward artesian flow (right). Seepage stops when the supply canal is shut off.

4.2 Hydropower Potential & Design Parameters
The Arnold Coulee Drop site is a grade-change, drop structure built in 1914 and is part of the Pishkun Supply Canal (PSC). The PSC is a 13-mile, one-bank, earthen canal that conveys diverted water from the Sun River to the Pishkun Reservoir. The Arnold Coulee Drop is a monolithic, cast-in-place concrete, inverted siphon which conveys the PSC water 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 static head is approximately 38 feet and hydropower development would require approximately 400 lineal feet of penstock. The PSC O&M road, also used by the general public, will need to be relocated for this project. An aerial view of the Arnold Coulee site and the stilling basin are shown below.

Photo showing an aerial view of the Arnold Coulee Drop site along the Pishkun Supply Canal (PSC) and the outlet stilling basin at a canal flow of +/-1,350 cfs.

The land is owned by the Bureau of Land Management (BLM) on which Reclamation has an easement for operation and maintenance of the PSC and drop structure. A slight
Section C: Eligibility Information / C.1. Eligible Applicants

- An eligible applicant is a state, Indian tribe, irrigation district, water district, or other entity with water or power delivery authority.
- Applicants must also be located in the Western United States or Territories -specifically: Alaska, Arizona, California, Colorado, Hawaii, Idaho, Kansas, Montana, Nebraska, Nevada, New Mexico, North Dakota, Oklahoma, Oregon, South Dakota, Texas, Utah, Washington, Wyoming, American Samoa, Guam, the Northern Mariana Islands, and the Virgin Islands.
- Those not eligible include, but are not limited to, the following entities:
  - Federal governmental entities
  - Individuals
  - Institutes of higher education
  - 501(c)4 organizations
  - 501(c)6 organizations

**Funding Group I** - Up to $500,000 in Federal funds provided through this FOA will be available for smaller, on-the-ground projects that can generally be completed in 2 years.

**Funding Group II** - Up to $2,000,000 in Federal funds provided through this FOA will be available for larger, phased on-the-ground projects that may take up to 3 years to complete.

### SCREENING FACTOR | YES | COMMENTS
--- | --- | ---
1 Application Eligibility requirements
  - Application submitted by FOA deadline | X |
  - Eligible applicant as defined in FOA | X |
  - Minimum required cost share percentage in FOA (50%) | X |
  - Requested Funding is within FOA limitation | X |
  - Length of project
    - Funding Group 1: 24 months / 2 years | X |
    - Funding Group 2: 36 months / 3 years | X |
  - Proposal includes responses to FOA criteria | X |

Application is eligible for consideration by the Application Review Committee.  ![Yes No]

Grants Officer

### SCREENING FACTOR | YES | COMMENTS
--- | --- | ---
2 Proposal Content
  - Technical Proposal Page Count ≤ 50 pages | X |

3 Mandatory Standard Forms
  - SF-424** (authorized signature) | X |
  - SF-424B or SF-424D** (authorized signature) | X |
  - SF-424A or SF-424C** | X |

*The SF-424 forms, letters of project support, and official resolution will not be considered in the total page count.

**Proposals submitted on grants.gov are on current forms. For proposals mailed in, please note if the SF-424 does not have an expiration date of 12/31/2022 & also note if the SF-424A, SF-424B, SF-424C or SF-424D do not have an expiration date of 02/28/2022.

Rev. Sept. 2020
Items for ARC Consideration and/or Determination:

**Determination:** Describe the condition observed. If the ARC needs to make a determination on something such as project eligibility, pose it as a question. Be sure that the question can be answered by the ARC rather than the Grants Office.
- Request clarification and verification that the power produced by the project has a buyer or the roadmap to finding a buyer in their Power Purchase Agreement
- Determine if the timeline for the project is reasonable

**Consideration:** Describe the condition observed and why it is important.
- Applicant is developing a C-Corp or LLC for getting funding and loans to complete the project in addition to State and Federal loans

**Red Flag Review:**
- Identify any items that will need to be resolved at red flag review such as signed resolutions, clarification on Grants or other financing or items that may significantly impact the timeline for completion
- Check the status of loans and project funding

**Other Notes:**
- Identify anything you noticed that will need to be clarified or addressed prior to award
  - Milestones on page 29
  - Funding Plan
    - District is forming a C-Corporation as this will allow access to other sources of funding and tax credits. This would also include USDA’s REAP Grant and SBA loans. This for-profit business would be a wholly owned subsidiary of the District
  - Budget
    - Admin and Support in Budget with a request for indirect
    - Procurement of the Hydropower system will need to be reviewed and checked

Rev. Sept. 2020
increase in the described easement would be required for a new, parallel drop structure. Preliminary discussions with BLM have been initiated regarding an amendment to the current easement.

Based on the data, a 1000-cfs, vertical Kaplan is projected to be the most efficient and cost-effective. In theory, a 1,350 cfs-rated turbine would handle 100% of the canal flow and produce more energy. Although the additional turbine/generator costs may not necessarily justify the increased capacity and resulting revenue. However, the actual size of generator/turbine will be reevaluated just prior to procuring by comparing the estimated costs versus projected revenue generation using a present worth analysis. A used turbine/generator is not anticipated for this project.

The power generation capacity of the Arnold Coulee Drop will be 2,400 kW (2.4 MW) and the energy production is directly related to the operation of the PSC. From the flow data comprising the last 20 years and assuming a 1000 cfs upper limit, it is estimated that annual energy production will be 6,000,000 kW-hrs (6,000 MW-hrs).

The revenue generation model is based on the annual average energy production and Northwestern Energy’s current electrical tariffs/avoided cost rates for produced electricity. These rates are on file with Montana Public Service Commission and represent a competitive electrical purchase rate. Historically, the rates increase each year or at least remain level for a consecutive year or two. The MT Public Service Commission has been pushing for more baseload renewable power such as hydropower due to the unpredictable nature of wind and solar. Although seasonal in nature, the electrical generation profile essentially mirrors the increased, local demand for electricity caused by irrigation equipment when the canal is flowing. The summary of hydropower development parameters is summarized in the tables below. The complete feasibility analysis is provided in Attachment 6 however only one year’s worth of flow data (2019) and calculations was provided as an example.

Excerpt for Feasibility Analysis provided in Attachment 6.

Preliminary construction drawings were prepared to support the feasibility study, confirm buildability as well as generate a list of material quantities for a realistic construction cost.
estimate. A select representation of the preliminary construction drawings is provided in Attachment 8 which shows the proposed hydropower development. The drawings will be finalized once funding is secured.

<table>
<thead>
<tr>
<th>Summary of Arnold Coulee Development Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water Source:</td>
</tr>
<tr>
<td>Pishkun Supply Canal</td>
</tr>
<tr>
<td>Operational Mode:</td>
</tr>
<tr>
<td>Seasonal, mid-Apr. to Sept.</td>
</tr>
<tr>
<td>Turbine Flow Range:</td>
</tr>
<tr>
<td>300 to 1,000 cfs</td>
</tr>
<tr>
<td>Static Head Range:</td>
</tr>
<tr>
<td>+ 38 feet</td>
</tr>
<tr>
<td>Maximum Capacity:</td>
</tr>
<tr>
<td>2,400 kW</td>
</tr>
<tr>
<td>Annual Ave. Energy Production:</td>
</tr>
<tr>
<td>6,000,000 kW-Hrs</td>
</tr>
<tr>
<td>Ave. Annual Revenue, 1st 15 years(1):</td>
</tr>
<tr>
<td>$263,885</td>
</tr>
<tr>
<td>Total Revenue, 1st 15 years(1):</td>
</tr>
<tr>
<td>$3,958,271</td>
</tr>
<tr>
<td>Est. Construction Costs:</td>
</tr>
<tr>
<td>$3,504,000</td>
</tr>
</tbody>
</table>

Note (1): Based on Northwestern 2020 Energy Tariffs/Avoided Cost Rates

4.3 Electrical Transmission Routing

In early 2020, the District commissioned a generation/transmission study to evaluate the options to transmit the generated power. Two options were evaluated, both involving cooperation with the local electric co-op, Sun River Electric Co-Op (SREC). The first consideration utilized SREC’s existing distribution system, including both 1-phase and 3-phase lines. This approach requires numerous improvements to the distribution system to avoid a degradation of service to SREC’s members due to voltage fluctuations from lost generation. The upgraded line would consist of 35-ft poles and 4/0 conductor. The estimated cost for this option is $2,190,000. The proposed route as well as the location of the required distribution improvements are provided with the supporting Feasibility Analysis in Attachment 6.

The second option considered multiple hydropower sites being eventually developed which would warrant a heavier conductor as a stand-alone transmission line. The upgraded distribution line option mentioned above could technically only handle one hydropower site. The transmission line option would consist of 65-ft poles with 336 ACSR conductor. Portions of the transmission line would also include a 3-phase under build to serve SREC’s members, many of whom are also District members. The first phase of transmission line would connect the Arnold Coulee site to SREC’s existing transmission line. The cost of this option is slightly more than the first option at $2,261,000. The cost estimate sheet is provided below as well as a map of the corresponding improvements.
All power will be wheeled to the Boile Substation north of Fairfield, MT where SREC’s transmission line ties into WAPA’s (Western Area Power Authority) regional transmission line. All line improvements and upgrades and new construction would be constructed by SREC’s crews or subcontractor. All work would be situated within SREC’s easements.

### TRANSMISSION COST ESTIMATE

**Greenfields Irrigation District**

**Arnold Coulee Drop Hydro**

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>UNIT PRICE</th>
<th>AMOUNT</th>
<th>ACTUAL COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.1</td>
<td>35-foot poles (350-ft spacing, 60/mile)</td>
<td>45 Ea</td>
<td>385.00</td>
<td>$17,325</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.2</td>
<td>Arms (per pole)</td>
<td>45 Ea</td>
<td>198.04</td>
<td>$8,912</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.3</td>
<td>4/0 Conductor (3+static line)</td>
<td>48,576 Feet</td>
<td>$0.55</td>
<td>$26,717</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.4</td>
<td>Insulators (2 per pole)</td>
<td>90 Ea</td>
<td>19.20</td>
<td>$1,728</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.5</td>
<td>Labor (+/-$57,500/mile)</td>
<td>1 LS</td>
<td>132,250</td>
<td>$132,250</td>
<td></td>
<td></td>
</tr>
<tr>
<td>1.6</td>
<td>Miscellaneous</td>
<td>1.0 LS</td>
<td>$2,500</td>
<td>$2,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.3</td>
<td>336 ACSR Conductor (3+static line)</td>
<td>52,800 Feet</td>
<td>$0.60</td>
<td>$31,680</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.4</td>
<td>Insulators (2 per pole)</td>
<td>76 Ea</td>
<td>19.20</td>
<td>$1,459</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.5</td>
<td>Labor (+/-$75,000/mile)</td>
<td>1 LS</td>
<td>187,500</td>
<td>$187,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>2.6</td>
<td>Miscellaneous</td>
<td>1.0 LS</td>
<td>$2,500</td>
<td>$2,500</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL** | **$189,432** |

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>UNIT PRICE</th>
<th>AMOUNT</th>
<th>ACTUAL COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>3.1</td>
<td>65-foot poles (350-ft spacing, 60/mile)</td>
<td>90 Ea</td>
<td>2,207.83</td>
<td>$198,705</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.2</td>
<td>Arms</td>
<td>90 Ea</td>
<td>198.04</td>
<td>$18,724</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.3</td>
<td>Saddle P. (4 per pole)</td>
<td>360 Ea</td>
<td>21.44</td>
<td>$7,718</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.4</td>
<td>Post Insulators (3 per pole)</td>
<td>270 Ea</td>
<td>92.88</td>
<td>$25,078</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.5</td>
<td>Insulators (4 per pole)</td>
<td>360 Ea</td>
<td>19.20</td>
<td>$6,912</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.6</td>
<td>336 ACSR Conductor (3+static line)</td>
<td>109,824 Feet</td>
<td>$0.60</td>
<td>$65,894</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.7</td>
<td>4/0 Conductor (3+static line)</td>
<td>109,824 Feet</td>
<td>$0.24</td>
<td>$26,358</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.8</td>
<td>Static Support (1 per pole)</td>
<td>90 Ea</td>
<td>31.91</td>
<td>$2,872</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.9</td>
<td>Labor (+/-$93,750/mile)</td>
<td>1 LS</td>
<td>487,500</td>
<td>$487,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.10</td>
<td>Miscellaneous</td>
<td>1.0 LS</td>
<td>$2,500</td>
<td>$2,500</td>
<td></td>
<td></td>
</tr>
<tr>
<td>3.11</td>
<td>SREC Credit</td>
<td>1.0 LS</td>
<td>187,781</td>
<td>$187,781</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL** | **$653,579** |

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>UNIT PRICE</th>
<th>AMOUNT</th>
<th>ACTUAL COSTS</th>
</tr>
</thead>
<tbody>
<tr>
<td>4.1</td>
<td>P2.3 Construct 4.2 miles of 69 kV trans. line with 336 ACSR (no underbuild)</td>
<td>4.2 Miles</td>
<td>$125,344</td>
<td>$526,445</td>
<td></td>
<td></td>
</tr>
<tr>
<td>5.1</td>
<td>P2.2 Replace 4.2 miles of 12.47 kV dist. line with 69 kV trans. line with underbuild</td>
<td>4.6 Miles</td>
<td>$125,688</td>
<td>$578,167</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**TOTAL** | **$2,260,982** | **$0**
Transmission line alternative route necessary for multiple hydropower site developments. New transmission line would connect SREC’s existing transmission line at Jackson’s Corner. The line continues to WAPA regional transmission line at Bole Substation north of Fairfield, MT.
4.4 Project Financing

The critical leg of funding for this project involves the $2,000,000 WaterSMART Water and Energy Efficiency Grant for FY 2021 (this application). The mandated 50% match would be met using District labor, equipment, resources as well as cash reserves or non-Federal grants and loans. Together, this represents $4,000,000 of the estimated $5,600,000 needed for construction. The District is committed to providing the match requirements.

In May 2020, the District submitted an application to the Montana Department of Natural Resources and Conservation (DNRC) for a Renewable Resources Grant. This grant is for $125,000 and would be available after July 1st, 2021. The grant rankings however will be available this Fall and this will provide a good indication of the likelihood of being awarded this grant.

The District also qualifies for low interest loans available through the Montana Department of Commerce, Board of Investments. The current interest for the InterCap loan is 2.5% but most likely this rate will drop considerably early next year due to economic issues related to the pandemic. The interest rates are set each year on February 16th and these variable rates historically tend to lag economic trends. The duration of the loan is normally 15 years but can be lengthened by legislative action. The maximum loan amount is $5,000,000 and that amount involves increased scrutiny and must be approved by the governing Board of the Board of Investments. Lower loan amounts can be approved by the internal loan committee.

The District is aware of other parties and irrigation partners interested in becoming ownership partners on this project and likewise investing. This however negates the District’s goal to maximize ownership and thus maximize the generated revenue. Although comforting to have additional options, this will only be exercised as a last resort.

The District is forming a C-Corporation as this will allow access to other sources of funding and tax credits. This would also include USDA’s REAP Grant and SBA loans. This for-profit business would be a wholly owned subsidiary of the District. The business implications of this possibility are currently being vetted.

4.5 Project Schedule & List of Tasks

The construction schedule is controlled by several factors and due to the complexity of the project will take 3 years to complete. Examples of the controlling factors include:

1. The importance of the Pishkun Supply Canal (PSC) to the District’s members cannot be over-stated and therefore it cannot be taken out of service; not even temporarily to expedite or facilitate construction. The PSC is typically in operation
beginning as early as April 15th and ending around August 31st. Unfortunately, this also represents the nicest time to perform heavy civil construction. As a result, construction adjacent to the PSC and the connection to the Arnold Coulee Replacement and Hydropower Conversion must occur during the off-season.

2. The PSC off-season is then September to March and most of the construction must be performed during this 7-month window. Unfortunately, the remoteness of the construction site and the proximity to the Rocky Mountain Front create winter conditions not conducive to earthwork and placing concrete. The conditions impact both work quality, productivity, and worker safety. Therefore a 3-month winter shutdown from December through February has been programmed into the schedule. Obviously, if weather conditions are favorable, work will be performed.

3. The construction of the transmission lines will occur in the Fall and Winter due to access limitations over wetlands and potential impacts to threatened & endangered species. SREC will coordinate this work and obtain all necessary permits, if any since they have an existing easement.

4. Items on the Task List and Schedule which represent a potential critical path include the following:
   a. **Procurement of the generator/turbine.** This is a big ticket, complex item whose purchase will most likely involve a Foreign manufacturer. The U.S. State Department’s rules and sanctions, which are subject to change, may limit available vendors.
   b. **Securing a Power Purchase Agreement (PPA)** may take several years and as it can be a function of the energy market. Developing a site with the published electric tariffs/avoid cost rates and satisfying MT Public Service Commission’s goals for greater baseload reliability, greatly increases the chance of obtaining a PPA.
   c. **The interconnect agreement with WAPA** also represents an uncertain path that must be negotiated on the fly.
   d. **This $2 million grant.** Obviously, the inability to secure the proper level of financing and funding could delay the project.

<table>
<thead>
<tr>
<th>TASK</th>
<th>DESCRIPTION</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hydropower Feasibility Analysis</td>
<td>DONE</td>
</tr>
<tr>
<td>2</td>
<td>Hydropower Development Strategy &amp; Implementation Plan</td>
<td>DRAFT</td>
</tr>
<tr>
<td>3</td>
<td>Generation/Transmission Routing Study</td>
<td>DONE</td>
</tr>
<tr>
<td>4</td>
<td>Initiate Easement Discussions with BLM</td>
<td>DONE</td>
</tr>
<tr>
<td>5</td>
<td>Submit $125k DNRC RRGL Grant App</td>
<td>DONE</td>
</tr>
<tr>
<td>6</td>
<td>Obtain Lease of Power Privilege (LOPP) w/ Reclamation</td>
<td>DONE</td>
</tr>
<tr>
<td>7</td>
<td>Submit $2 Million WaterSMART Water &amp; Energy Eff. Grant App</td>
<td>DONE</td>
</tr>
<tr>
<td>8</td>
<td>Review DNRC RRGL Grant Rankings</td>
<td>Fall 2020</td>
</tr>
<tr>
<td>9</td>
<td>Notice of Award $2M WaterSMART Water &amp; Energy Eff. Grant</td>
<td>Winter 2020</td>
</tr>
<tr>
<td>10</td>
<td>Grant Administration &amp; Reporting</td>
<td>Quarterly</td>
</tr>
<tr>
<td></td>
<td>Description</td>
<td>Start Date</td>
</tr>
<tr>
<td>---</td>
<td>-----------------------------------------------------------------------------</td>
<td>--------------------</td>
</tr>
<tr>
<td>11</td>
<td>Reclamation to complete NEPA and NHPA</td>
<td>Spring 2021</td>
</tr>
<tr>
<td>12</td>
<td>Finalize Site Topo Survey/Conduct Geotech Investigation</td>
<td>Spring 2021</td>
</tr>
<tr>
<td></td>
<td><strong>Pishkun Supply Canal Start Date (Typical)</strong></td>
<td>April 15th</td>
</tr>
<tr>
<td>13</td>
<td>Finalize Construction Drawings and Specs – Submit to USBR</td>
<td>May 2021</td>
</tr>
<tr>
<td>14</td>
<td>Finalize Modification of Existing Easement with BLM</td>
<td>June 2021</td>
</tr>
<tr>
<td>15</td>
<td>Begin Search and Negotiations for Power Purchase Agreement</td>
<td>June 2021</td>
</tr>
<tr>
<td>16</td>
<td>Initiate Procurement Negotiations for Turbine and Generator</td>
<td>June 2021</td>
</tr>
<tr>
<td>17</td>
<td>Receive and Incorporate USBR Review Comments</td>
<td>July 2021</td>
</tr>
<tr>
<td>18</td>
<td>Procure and Delivery 11-ft Diameter Penstock</td>
<td>August 2021</td>
</tr>
<tr>
<td></td>
<td><strong>Pishkun Supply Canal Finish Date (Typical)</strong></td>
<td>August 31st</td>
</tr>
<tr>
<td>19</td>
<td>Install Penstock and Drain Line</td>
<td>Sept-Nov 2021</td>
</tr>
<tr>
<td>20</td>
<td><strong>1st Phase of Transmission Line Improvements</strong></td>
<td>Fall 2021</td>
</tr>
<tr>
<td></td>
<td><strong>Winter shutdown</strong></td>
<td>Dec to Feb</td>
</tr>
<tr>
<td>21</td>
<td>Grant Administration &amp; Reporting</td>
<td>Quarterly</td>
</tr>
<tr>
<td>22</td>
<td>Perform Site Prep Work &amp; Canal Modifications for Intake Structure</td>
<td>Mar-Apr 2022</td>
</tr>
<tr>
<td></td>
<td><strong>Pishkun Supply Canal Start Date (Typical)</strong></td>
<td>April 15th</td>
</tr>
<tr>
<td>23</td>
<td>Procure Flared Transition Pipe and Air Vent Pipe</td>
<td>May 2022</td>
</tr>
<tr>
<td>24</td>
<td>Procure Roller Gates and Hardware</td>
<td>June 2022</td>
</tr>
<tr>
<td>25</td>
<td>Procure Reinforcing Steel for Intake Structure</td>
<td>July 2022</td>
</tr>
<tr>
<td></td>
<td><strong>Pishkun Supply Canal Finish Date (Typical)</strong></td>
<td>August 31st</td>
</tr>
<tr>
<td>26</td>
<td>Start Intake Structure and Canal Approach Apron</td>
<td>Sept 2022</td>
</tr>
<tr>
<td>27</td>
<td><strong>2nd Phase of Transmission Line Improvements</strong></td>
<td>Fall 2022</td>
</tr>
<tr>
<td>28</td>
<td>Finalize WAPA Interconnect Agreement</td>
<td>Fall 2022</td>
</tr>
<tr>
<td></td>
<td><strong>Winter shutdown</strong></td>
<td>Dec to Feb</td>
</tr>
<tr>
<td>29</td>
<td>Grant Administration &amp; Reporting</td>
<td>Quarterly</td>
</tr>
<tr>
<td>30</td>
<td>Finalize Intake Structure and Build Isolation Bulkhead</td>
<td>Mar-Apr 2023</td>
</tr>
<tr>
<td>31</td>
<td>Commission Roller Gates</td>
<td>Apr 2023</td>
</tr>
<tr>
<td></td>
<td><strong>Pishkun Supply Canal Start Date (Typical)</strong></td>
<td>April 15th</td>
</tr>
<tr>
<td>32</td>
<td>Procure Scroll Cage &amp; Draft Tube</td>
<td>May 2023</td>
</tr>
<tr>
<td>33</td>
<td>Procure Reinforcing Steel for Intake Structure</td>
<td>May 2023</td>
</tr>
<tr>
<td>34</td>
<td>Begin Powerhouse Found., Scroll Cage and Penstock Tie-In</td>
<td>May-Aug 2023</td>
</tr>
<tr>
<td>35</td>
<td><strong>Pishkun Supply Canal Finish Date (Typical)</strong></td>
<td>August 31st</td>
</tr>
<tr>
<td>36</td>
<td>Finish Powerhouse Found., Draft Tube and Canal Tie-in</td>
<td>Sept-Nov 2023</td>
</tr>
<tr>
<td>37</td>
<td><strong>3rd Phase of Transmission Line Improvements</strong></td>
<td>Fall 2023</td>
</tr>
<tr>
<td>38</td>
<td>On-site Electrical Yard &amp; Set-up Power</td>
<td>Fall 2023</td>
</tr>
<tr>
<td>39</td>
<td>Powerhouse Shell &amp; Interior</td>
<td>Nov-Mar 2024</td>
</tr>
<tr>
<td></td>
<td><strong>Winter shutdown (site work only) Powerhouse Interior to Cont.</strong></td>
<td>Dec to Feb</td>
</tr>
<tr>
<td>40</td>
<td>Grant Administration &amp; Reporting</td>
<td>Quarterly</td>
</tr>
<tr>
<td>41</td>
<td>Deliver &amp; Set Turbine &amp; Generator</td>
<td>Feb 2024</td>
</tr>
<tr>
<td>42</td>
<td>Commission Plant</td>
<td>Mar-Apr 2024</td>
</tr>
<tr>
<td></td>
<td><strong>Pishkun Supply Canal Start Date (Typical)</strong></td>
<td>April 15th</td>
</tr>
<tr>
<td>43</td>
<td>Producing Electricity</td>
<td>April 2024</td>
</tr>
<tr>
<td>44</td>
<td>Security Fencing and Site Restoration</td>
<td>May 2024</td>
</tr>
<tr>
<td>45</td>
<td>Project Closeout</td>
<td>June 2024</td>
</tr>
</tbody>
</table>
4.6 Project Summary

This project, the Arnold Coulee Drop Replacement, has multiple benefits and achieves several objectives that are crucial to the long-term sustainability of the District.

1. Quantifiable Water Savings
   a. Replacement of the major failing structure on the Pishkun Supply Canal will directly save up to 2,400 acre-feet/year of critically important water per season. This is observed as the related seepage stops when the PSC is shut-off for the season.
   b. The revenue stream from the hydropower will help allow the District to accelerate its long-term overhaul plans to replace many other failing, leaking conveyance structures. This money, as well as revenue from other sites proposed for hydropower development, will also allow the District to modernize its operations and improve water management efficiencies such that additional water conservation can be realized. It is conservatively estimated that up to 36,000 acre-feet/year can be conserved by simply cutting waste flows, emergency spills and operational losses entering the Muddy Creek drainage. This will happen with an overhaul of the District infrastructure and the modernization of its operations.

2. Water Supply Reliability
   a. Immediately replacing the failing structure on the PSC helps maintain a reliable water supply for the District. The PSC is the lifeline for irrigated agriculture on the District and the Arnold Coulee Drop structure is a critical component.
   b. In the long-term, overhauling the District by replacing the 100-year old infrastructure and modernizing the operations will help ensure reliability of the water supply through conservation. Due to the size of the District, our operations are directly related to water storage. When the seasonal storage is depleted, the irrigation season is over for the year. Many years, the District producers fall short of a full season due to a water short year or an early run-off event. An overhaul of the District and modernization will improve water management and reduce water losses thereby extend the irrigation season.

3. Implementing Hydropower
   a. This project implements hydropower. 6,000,000 kW-hrs of energy are projected to be generated on an annual basis. If the power is sold locally, the generation profile matches the corresponding local demand for electricity created by irrigators for their pumps and pivots. The result will be to free-up availability and capacity on the regional transmission lines for
other needs. Also, the hydropower helps meet Montana’s need for more baseline energy production due to the closing of several coal-fired plants based in Montana.

b. The hydropower component of this project also provides for the opportunity to bring additional hydropower sites on-line. The District may elect to use the revenue from this project, or a portion of it, to help accelerate their plans to develop other hydropower sites thus increasing the revenue stream for their primary objective to overhaul the District. The next logical site to be developed for hydropower is the Pishkun Inlet Drop which is 4 miles downstream from the Arnold Coulee.

4. **Addressing DOI Priorities**
   1. This project addresses at least two priorities established by the Department of the Interior. First, the energy produced is American energy and thus strengthens our Nation’s energy independence and security.
   2. The second priority is to find creative ways to modernize Reclamation infrastructure to ensure sustainability and viability for future generations.
(5) **Evaluation Criteria**

*Evaluation Criterion A — Quantifiable Water Savings*

**Describe the amount of estimated water saved.** For projects that conserve water, please state the estimated amount of water expected to be conserved (in acre-feet per year) as a direct result of this project. 2,400 acre-feet per year of water is expected to be conserved immediately as a direct result of this project. Another 36,000 acre-feet per year would be realized in the Muddy Creek drainage alone as the District achieves its long-term objectives to completely overhaul the +100-year old, Reclamation structures and modernize water operations.

**Describe the current losses.** Please explain where the water that will be conserved is currently going (e.g., back to the stream, spilled at the end of the ditch, seeping into the ground)?

The 2,400 acre-feet per year water losses to be conserved currently seeps back into the ground; or evaporates from the pot holes the water seeps into; or drains into a short-lived stream that dries up at the end of irrigation season. See below aerial to see seep area.

Photos showing examples of seepage originating from the failing Arnold Coulee Drop. Note flowing seepage through drainpipe (left) and upward artesian flow (right). Seepage stops when the supply canal is shut off.
The 36,000 ac-ft per year water savings will be realized in the Muddy Creek drainage by reducing waste flows, emergency spills and operational losses. This will be achieved when the original infrastructure is replaced with modern alternatives as well as revamping our mode of operations. Mill Coulee and Big Coulee are two other drainages causing serious erosion problems in the Sun and Missouri Rivers from excess District flows.

Describe the support/documentation of estimated water savings. Please provide sufficient detail supporting how the estimate was determined, including all supporting calculations. Note: projects that do not provide sufficient supporting detail/calculations may not receive credit under this section. Please be sure to consider the questions associated with your project type (listed below) when determining the estimated water savings, along with the necessary support needed for a full review of your proposal. In addition, please note that the use of visual observations alone to calculate water savings, without additional documentation/data, are not sufficient to receive credit under this section. Further, the water savings must be the result of reducing or eliminating a current, ongoing loss, not the result of an expected future loss.

Please address the following questions according to the type of infrastructure improvement you are proposing for funding.

(1) Canal Lining/Piping: Canal lining/piping projects can provide water savings when irrigation delivery systems experience significant losses due to canal seepage. Applicants proposing lining/piping projects should address the following:

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

The current concrete drop structure was built in 1915 and leaks during use at several locations as discussed earlier. Direct measurement is difficult but is conservatively estimated to be between 5 to 10 cfs. Based approximately 120 days of operation, this equates to 2,400 ac-ft per season.

The 36,000 ac-ft of water savings is based on USGS data from the Muddy Creek gage which shows that the District losses at least 200 cfs during the irrigation
season or 400 ac-ft per day. Once the District overhaul and modernization are complete, a 75% savings is expected, or 36,000 ac-ft per season. Water savings will actually be realized systematically as each failed structure is replaced.

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

The estimated annual canal seepage losses were calculated by measuring flows above and below Arnold Coulee over a three-year period. No ponding test was accomplished but verification of gage accuracy was taken in 2017. By using gage data average over three years varying weather conditions were observed that included a wet year, very dry year when off in August, and an average year. Results of using gage data tallied is in above question.

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

The estimated post-project seepage losses were calculated by assuming conversion from the failing concrete structure to a new steel piped conveyance system the seepage/leakage will be negligible.

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

The anticipated annual transit loss reductions will be “0” since the project area will be in a piped conveyance system.

e. How will actual canal loss seepage reductions be verified?

The actual canal loss seepage reductions will be verified post-project by continuing to monitor flow gages above and below the project site. If the project is successful, the amount of loss should be “0”.

f. Include a detailed description of the materials being used.

The existing failing concrete drop will be replaced with an 11-ft diameter steel penstock.

(2) Municipal Metering: NOT APPLICABLE

(3) Irrigation Flow Measurement: Irrigation flow measurement improvements can provide water savings when improved measurement accuracy results in reduced spills and over-deliveries to irrigators.
a. How have average annual water savings estimates been determined? Please provide all relevant calculations, assumptions, and supporting data. The District in cooperation with Reclamation, USGS and the (SRWG) have flow gages located above and below the project so accurate “before” flow data has already been acquired and those same gages will be used to acquire post-construction flow data. Comparing pre and post project flow data will enable the District to document total water savings from this project.

b. Have current operational losses been determined? If water savings are based on a reduction of spills, please provide support for the amount of water currently being lost to spills. YES, current operational losses have been determined. The losses are computed using pre-project flow gage data located above and below project described above in Section (3) a.

c. Are flows currently measured at proposed sites and if so what is the accuracy of existing devices? How has the existing measurement accuracy been established? YES, flows are currently measured above and below project site as well as sites throughout the District. Their accuracy remains high because the District verifies them every 5 years. Where the accuracy is very important, i.e. Gibson and Pishkun outlets, Reclamation staff frequently verifies gage accuracy. Many of the gage locations are USGS sites and frequent stream checks are made to ensure reliability.

These gage sites were initially established in cooperation with Reclamation. To ensure a high level of accuracy was maintained over the decades, many sites had flumes or concrete pads installed. Some sites remain stable because of consistent flows. All sites are calibrated every 5 years to ensure they remain accurate.
d. Provide detailed descriptions of all proposed flow measurement devices, including accuracy and the basis for the accuracy.
   The majority of the District’s gage sites utilize Sutron bubblers and dataloggers that fit into the Montana Reclamation’s monitoring program. Due to new innovative programs when automating canal gates, the District is now converting canals to Rubicon “smart” gates and checks that incorporate flow measurements.

e. Will annual farm delivery volumes be reduced by more efficient and timely deliveries? If so, how has this reduction been estimated?
   Annual on-farm delivery volumes are not expected to change because of this specific project however the current and proposed on-farm projects led by NRCS and the SRWG are expected to improve irrigation efficiency. By comparing each specific farm unit pre and post project deliveries, amount of efficiency improvements will be documented.

f. How will actual water savings be verified upon completion of the project?
   As described in the above (3) a., the water savings will be verified by comparing pre and post project flow data from the above and below project flow gages.

(4) Turf Removal: NOT APPLICABLE

(5) Smart Irrigation Controllers and High-Efficiency Nozzles: NOT APPLICABLE

Evaluation Criterion B: Water Supply Reliability
Please address how the project will increase water supply reliability. Proposals that will address more significant water supply shortfalls benefitting multiple sectors and multiple water users, will be prioritized. General water supply reliability benefits (e.g., proposals that will increase resiliency to drought) will also be considered. Please provide sufficient explanation of the project benefits and their significance. These benefits may include, but are not limited to, the following:

1. Will the project address a specific water reliability concern? Please address the following:

   • Explain and provide detail of the specific issue(s) in the area that is impacting water reliability, such as shortages due to drought, increased demand, or reduced deliveries. Will the project directly address a heightened competition for finite water supplies and over-allocation (e.g., population growth)?

   Through the use of the Montana water right records, the total Sun River Watershed water rights are over three times the average available water supply. Because of what Montana allowed to happen over the past decades, the water conflict for this limited water supply become VERY contentious in the 1980s and early 1990s. The tension even heightened more during those periods of persistent drought. When the SRWG was formed in 1995, the warring factions decided to put aside their differences by finding win-win solutions. This has worked well but in recent years snowmelt and in-
turn water runoff changes due to climate change have put a strain on these partnerships. Since there is less water available during the irrigation season for the irrigators and the aquatic life it has taken everyone to step up to ensure the win-win process is not lost. So, ANY water savings like this project that is beneficial for the District and the river need to be installed as soon as possible to help ensure the water wars do not return.

The District relies on storage from 3 reservoirs for its irrigation. Early or accelerated snow/melt run-off patterns causes a lot of water to be lost because of limited storage. The available storage is not sufficient for the District’s needs. Therefore, enhanced modernization of our infrastructure and improved water management efficiencies are needed to use our available water and not waste it. This requires a complete overhaul of Reclamation’s irrigation system.

- Describe how the project will address the water reliability concern? In your response, please address where the conserved water will go and how it will be used, including whether the conserved water will be used to offset groundwater pumping, used to reduce diversions, used to address shortages that impact groundwater pumping, or reduce deliveries, made available for transfer, left in the river system, or used to meet another intended use.

Water availability in Sun River almost annually less than all the demand including irrigation, livestock and fisheries. The availability of the amount needed during irrigation season is actually becoming less because the spring runoff is coming off earlier and faster than previous years because of climate change. Because of the changes and more demands being placed on this limited water supply — just like other projects in the past two decades, this project will take a shared approach on where the water savings will go. Although the amount may not seem like much, when combined with other projects and improved water management, the savings will help fulfill some instream flows shortfall and part of the 30,000 acre-feet shortfall the District’s water users see in most years. The instream flows see the biggest benefit when the District does not have to divert as much water at critical times when the river reaches critical low levels. Water supply reliability will be achieved through conservation and improved operations.

- Provide a description of the mechanism that will be used, if necessary, to put the conserved water to the intended use.

The District mechanism to ensure water conserved is put to its intended use will be through its extensive flow gage stations that will: 1) ensure a limited amount is wasted at the end of the canal system; 2) ensure there is not too much or too little instream flows but as close to meeting the fisheries needs as much as possible. See below 2020 river gage data used to ensure instream flow targets are met; and 3) track water requests to water availability so the District can be another step forward to reducing the 30,000 acre-feet annual shortage for water users.

- Indicate the quantity of conserved water that will be used for the intended purpose.
The entire 2,400 acre-feet conserved will be used for its intended purposes and for which it was diverted from the river for.

2. Will the project make water available to achieve multiple benefits or to benefit multiple water users? Consider the following:

- Will the project benefit multiple sectors and/or users (e.g., agriculture, municipal and industrial, environmental, recreation, or others)?
  - Will the project benefit species (e.g., federally threatened or endangered, a federally recognized candidate species, a state listed species, or a species of particular recreational, or economic importance)? Please describe the relationship of the species to the water supply, and whether the species is adversely affected by a Reclamation project.
    - No, the water will not benefit any endangered species unless you count the limited farmers in this area as endangered. But it will help improve flows in the Sun River that will benefit other water users including the fisheries.
  - Will the project benefit a larger initiative to address water reliability?
    - Yes, the project will benefit a larger initiative. GID is participating in the SRWG collaborative effort that is trying to find win-win solutions to complex natural resource issues. Water savings and water management will meet three watershed goals: 1) reducing wastewater that causes water quality/erosion problems; 2) instream flow shortages during the hottest part of the year; and 3) reducing the 30,000 acre-feet shortage for District’s water users. All of these objectives will require tremendous financial resources. The revenue stream from the Arnold Coulee hydro plant and future plants will help fund these projects.

- Will the project benefit Indian tribes? No.
- Will the project benefit rural or economically disadvantaged communities?
  - Yes, the project will benefit several small rural communities by improving a reliable water source for: 1) farmers that need a reliable water source to ensure a steady income so they will buy more supplies locally; 2) fisheries so the recreating community continue to show up in the watershed and spend money locally while having fun; and 3) reducing erosion so landowners lose less productive farm land and it costs less to clean the water for drinking use.

- Describe how the project will help to achieve these multiple benefits. In your response, please address where the conserved water will go and where it will be used, including whether the conserved water will be used to offset groundwater pumping, used to reduce diversions, used to address shortages that impact diversions or reduce deliveries, made available for transfer, left in the river system, or used to meet another intended use.
  - As state above, the water availability in Sun River almost annually is less than all the demand including irrigation, livestock and fisheries. The availability of the amount needed during irrigation season is actually becoming less because the spring runoff is coming off earlier and faster than previous years because of climate change. Because of the changes and more demands being placed on this limited
water supply – just like other projects in the past two decades, this project will take a shared approach on where the water savings will go. Although the amount may not seem like much, when combined with other projects and improved water management, the savings will help fulfil some instream flows shortfall and part of the 30,000 acre-feet shortfall the District’s water users see in most years. The instream flows see the biggest benefit when the District does not have to divert as much water at critical times when the river reaches critical low levels.

3. Does the project promote and encourage collaboration among parties in a way that helps increase the reliability of the water supply?

- **Is there widespread support for the project?**
  Yes, there is widespread support for this project. The SRWG project support is crucial since they are comprised of over 40 different groups and agencies including recreational, communities, businesses, other irrigation projects and state and federal agencies. For over 25 years the SRWG has worked hard to bring together these diverse groups to help solve natural resource issues. There have been many success stories including the other GID projects that have conserved annually almost 40,000 acre-feet of water with part of that remaining in-stream. Also, see the attached letters of support from local entities.

- **What is the significance of the collaboration/support?**
  The significance of this collaboration is when the SRWG was formed 25 years ago the area was in turmoil with irrigators fighting irrigators and irrigators fighting recreationists over the limited supply of this very important resource. Through hard-work and MANY meetings, the SRWG partners now seek win-win solutions rather than adversity. To keep this team effort moving forward, more projects like this one must be accomplished so even more water is put to beneficial use - share even in drought years.

- **Is the possibility of future water conservation improvements by other water users enhanced by completion of this project?**
  Yes, the revenue stream from the hydro plant will increase the likelihood of implementing other water conservation improvements that will benefit all water users. This teamwork on sharing ideas and assistance for other projects is already being accomplished by irrigation projects including Fort Shaw ID, Broken O Ranch, Nilan Water Users and Sun River Valley Ditch Company. With support from NRCS, the individual water users are taking advantage of this teamwork.

- **Will the project help to prevent a water-related crisis or conflict? Is there frequently tension or litigation over water in the basin?**
  Yes, the project will help divert a water related crisis in this watershed. The projected revenue stream from this project and other similar sites will fund water conservation projects thereby reducing detrimental waste flows and subsequent environmental damage. These issues have looming legal conflicts and lawsuits which are trying to be avoided. Even though the SRWG has brought people together to solve local problems through local solutions there is a long way to go.
The Sun River every year is unable to fulfill all demands placed on it. So as long as there are water shortages there will be conflicts. The SRWG and the District are working VERY hard to prevent the water wars of the past where death threats were common as well as people cutting headgate chains. During the Sun River adjudication process, there was lots of money spent on lawyers to protect each water user’s water right instead of on much needed infrastructure projects. To go back to the days of water wars seem unlikely at this time but when farmers start seeing their crops dry up and anglers see the river dry – look out for what people may do to get water they so desperately need. So help this District build on the many success stories of finding win-win solutions to complex problems. With sharing a limited water supply, there will always be a fragile relationship between water users but projects like this one will prevent it from failing.

The project will also reduce a major conflict between water users and people who live along and/or downstream of Muddy Creek, Mill Coulee and Big Coulee. This erosion and water quality issue has people ready to sue if the problem is not fixed in the near future. The hard feelings are elevated when there is so much water wasted in Muddy Creek, Mill Coulee and Big Coulee during the summer months when it could help increase instream flows in the Sun River and reduce irrigators water shortages.

- Describe the roles of any partners in the process. Please attach any relevant supporting documents.
  The roles of the partners for this project are to ensure this project moves forward so there can be many more like it to meet the goals of reducing erosion and meeting all water users water needs. That increases collaboration the SRWG works so hard to “promote community-based efforts that will preserve our quality of life and livelihoods while promoting an enhancing the natural resources of our watershed”. This partnership includes federal, state and local government agencies, Fort Shaw Irrigation District, Greenfields Irrigation District, Sun River Valley Ditch Company, Trout Unlimited, Missouri River Fly Fisherman, Broken O Ranch, local Audubon chapter, and MANY landowners. See letters of support from the SRWG and Trout Unlimited.

4. Will the project address water supply reliability in other ways not described above?
Yes, the project will benefit a segment of the Sun River that routinely gets too low in the summer to sustain any aquatic life. Even the small amount of 10 cfs may be enough to help turn around the low numbers of fish in this stretch of the Sun River. Fish numbers are approximately 40 per mile and should be around 400 per mile. Money from the electrical generation will help fund conservation projects that benefit all watershed partners.

**Evaluation Criterion C—Implementing Hydropower**

The Arnold Coulee hydropower component of this project has a planned site capacity of 2,400 kW. The Table below represents a summary of the hydropower parameters and is an excerpt from the overall feasibility analysis. See Attachment 6 for additional details.
regarding the hydropower feasibility and background data. This information includes the energy generation model, the revenue generation model, a finance funding strategy, the supporting calculations, a cost estimate and map for the transmission lines and grid improvements, and one year’s data (2019) as an example of the input and calculations.

<table>
<thead>
<tr>
<th>Location:</th>
<th>Pishkun Supply Canal</th>
<th>Latitude:</th>
<th>47°39'45&quot;</th>
<th>Analyzed by:</th>
<th>EAJ</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flow Years:</td>
<td>2000 to 2019</td>
<td>Longitude:</td>
<td>112°34'55&quot;</td>
<td>Last Saved:</td>
<td>9/10/2020</td>
</tr>
<tr>
<td>Data Source:</td>
<td>USBR, GIBR, QJ PSC</td>
<td>Elevation:</td>
<td>4447 to 4411</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Turbine Style:</td>
<td>Kaplan</td>
<td>Forebay FSL</td>
<td>4440.0</td>
<td>Approx. Penstock Length:</td>
<td>392 feet</td>
</tr>
<tr>
<td>Max. Turbine Flow</td>
<td>1000 cfs</td>
<td>Tailrace FSL</td>
<td>4492.0</td>
<td>Penstock Material:</td>
<td>Steel</td>
</tr>
<tr>
<td>Min. Turbine Flow</td>
<td>300 cfs</td>
<td>Design Static Head:</td>
<td>38.0 feet</td>
<td>Hazen-Williams Coeff:</td>
<td>130</td>
</tr>
<tr>
<td>Turbine Eff</td>
<td>0.95</td>
<td>Egress Head:</td>
<td>34.9 feet</td>
<td>Max. Penstock Velocity:</td>
<td>12 fps</td>
</tr>
<tr>
<td>Generator Eff</td>
<td>0.87</td>
<td>Min. Penstock Diam:</td>
<td>10.3 feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Comb. Eff</td>
<td>0.82</td>
<td>Actual Penstock Diam:</td>
<td>11 feet</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Max. Site Capacity</td>
<td>2441 kW</td>
<td>Flow Area</td>
<td>95.03 ft²</td>
<td>Actual Penstock Velocity:</td>
<td>10.52 fps</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>ARNOLD COULEE DROP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location:</td>
</tr>
<tr>
<td>Elevation:</td>
</tr>
<tr>
<td>Turbine Style:</td>
</tr>
<tr>
<td>Max. Turbine Flow</td>
</tr>
<tr>
<td>Min. Turbine Flow</td>
</tr>
<tr>
<td>Turbine Eff</td>
</tr>
<tr>
<td>Generator Eff</td>
</tr>
<tr>
<td>Comb. Eff</td>
</tr>
<tr>
<td>Max. Site Capacity</td>
</tr>
</tbody>
</table>

Describe the amount of energy generated.
Electrical generation would be seasonal in nature and corresponds to the operation of the Pishkun Supply Canal. The annual energy generation profile extends for approximately four months from middle April to middle August. The annual average energy production is 6,000,000 kW-hrs based on twenty years of data and specifically the last ten years. The supporting calculations are provided in Attachment 6. The daily generation is relatively consistent with the biggest variation in the annual energy generation being related to the length of the irrigation season. On the plus side, this generation profile coincides and matches the local increase in demand for electricity directly related to and required for irrigation pumps and pivots. Having the local, seasonal generation match the local, seasonal demand supports the opportunity for the energy to be utilized on a local to regional basis, in theory, freeing up transmission line capacity.

Describe any other benefits of the hydropower project.

- Any expected reduction in the use of energy currently supplied through a Reclamation project. There is NO energy supplied to the District by Reclamation.
- Anticipated benefits to other sectors/entities. The anticipated benefits to others include:
  - **District Members and Water Users** will benefit directly from all conservation efforts and water savings as this translates to additional water available for irrigation. Since our irrigation season is a function of stored water, any water savings would theoretically lengthen the irrigation season. This would be extremely valuable during water-short years or when experiencing persistent drought conditions.

District members will also benefit from the anticipated hydropower revenue stream as this will be used to replace failing structures and facilitate modernization of the District. Both of those items will ensure District viability for future generations. Also, replacement structures and modernization will incorporate numerous opportunities for added water conservation and improved water management efficiencies which will provide enhanced drought resiliency. Water conservation and improved water management capabilities realized from the hydropower revenue stream will lessen
the potential for legal conflicts with landowners downstream of the District that experience detrimental environmental impacts from operational losses, waste flows and emergency spills from power outages.

- **Sun River Watershed Partners** including Fort Shaw Irrigation District (another Reclamation Project), other irrigation companies, private water right holders, landowners, fishermen, river recreationalists, and others will experience the same general benefits as GID members. Water conservation and improved water management efficiency will save water and reduced wastes. Water diverted for irrigation but spilled or lost prior to on-field use must be replaced with more diverted water whether from the Sun River or from storage. When not need for irrigation, conserved water can be left in the river to enhance natural stream flows. This is essential during the hottest months when fish populations are stressed to do low flows and elevated temperatures.

- **Expected water needs, if any, of the system.** There is NO expected water needs.

**Evaluation Criterion D—Complementing On-Farm Irrigation Improvements**

If the proposed project will complement an on-farm improvement eligible for NRCS assistance, please address the following:

- **Describe any planned or ongoing projects by farmers/ranchers that receive water from the applicant to improve on-farm efficiencies.**
  The SRWG and NRCS are actively working on MANY on-farm projects that complement the many projects the District is accomplishing and/or pursuing. The following responses to the questions will be only a small part of this united effort. The collaboration that has been going on for more than 20 years has been the key to many positive outcomes for the local farmers/ranchers, the District, all those who use or enjoy the natural resources in the Sun River Watershed and those entities that are adjacent to the Sun River Watershed.

  - Provide a detailed description of the on-farm efficiency improvements. The SRWG is working with the local NRCS field offices to better understand on-farm needs. They are exploring funding options such as TIP and RCPP and may be applying for those this fall.

  - Have the farmers requested technical or financial assistance from NRCS for the on-farm efficiency projects, or do they plan to in the future? Yes, the local farmers have requested assistance. Many are and/or have received assistance to accomplish projects that benefit the District and Sun River Watershed. The NRCS staff are applying for USDA funds to support many of the farmer’s requests to implement projects that benefit the entire watershed.

  - If available, provide documentation that the on-farm projects are eligible for NRCS assistance, that such assistance has or will be requested, and the number or percentage of farms that plan to participate in available NRCS programs.
The SRWG is currently working with NRCS local field offices on a strategy to apply for both TIP and RCPP funding to support on-farm efficiency projects. The scope of these projects has yet to be determined. SRWG is working with the Great Falls and Choteau field office regional and district supervisors on this effort.

- Applicants should provide letters of intent from farmers/ranchers in the affected project areas.

  Since the local farmers are not directly providing financial assistance to this project, there are no letters of intent. In Attachment 3, SRWG’s letter of support explains several NRCS and SRWG projects that are in-work or being applied for.

- Describe how the proposed WaterSMART project would complement any ongoing or planned on-farm improvement.

  - Will the proposed WaterSMART project complement the on-farm project by maximizing efficiency in the area? If so, how?

    This project will directly compliment SRWG and NRCS work in the Sun River Watershed as described in Attachment 3 as projects that “benefit from waste reduction and improved water availability”. The NRCS on-farm projects are “irrigation efficiency” through conversion from flood to sprinkler irrigation to reduce tail-water leaving each farm that in-turn will reduce excess water in Muddy Creek, the primary cause of erosion.

    The SRWG is implementing: 1) WaterSMART Watershed project to reduce erosion on Muddy Creek; 2) two EPA 319 Nonpoint Source pollution projects to reduce erosion at a specific site on Muddy Creek; 3) a Water Quality improvement project on Muddy Creek to eliminate culverts that are causing erosion; 4) nutrient study to identify where nutrient contributions are coming from so they can be dealt with; and 5) cost-sharing with USGS and others to pay for flow gages across the watershed.

- Describe the on-farm water conservation or water use efficiency benefits that are expected to result from any on-farm work.

  - Estimate the potential on-farm water savings that could result in acre-feet per year. Include support or backup documentation for any calculations or assumptions.

    No estimate of water savings was calculated because the on-farm projects discussed above will not be used for this project.

**Evaluation Criterion E—Department of the Interior Priorities**

1. *Creating a conservation stewardship legacy second only to Teddy Roosevelt*
   a. Utilize science to identify best practices to manage land and water resources and adapt to changes in the environment;

    The District utilizes science to identify best management practices for all major decisions. For this project the District reached out to new innovative tools from Rubicon to control water deliveries in the main canal. For adapting to changes, the
climate issue with snow melt coming off earlier and faster is why the District is looking into expanding reservoir storage – one of the few ways to take advantage of mountain water that is no longer lasting later into the summer.

b. Examine land use planning processes and land use designations that govern public use and access;
The District is an active participant in the SRWG collaborative effort where land use planning is always a discussion item. With all the major players at the table the issues of public use and access are addressed before they become a thorn to anyone. The SRWG receiving national recognition for its many achievements is proof in itself.

c. Revise and streamline the environmental and regulatory review process while maintaining environmental standards;
The SRWG’s consensus process in projects evaluation reduces conflict and speeds up getting ideas permitted while maintain environmental standards. The best way to ensure everyone is doing the right thing with projects like this is to get opinions early before going through official regulatory processes.

d. Review Department water storage, transportation, and distribution systems to identify opportunities to resolve conflicts and expand capacity;
The District has identified several sites where water storage can be expanded which will help reduce conflicts. The largest single water storage project is enlarging Pishkun Reservoir to capture water early on during snowmelt. The next that the District is just starting is in-canal storage using larger checks to control and hold more water. That is why this project is so important – can reduce waste which reduces water being transported so less waste.

e. Foster relationships with conservation organizations advocating for balanced stewardship and use of public lands;
The District actively participates in the SRWG consensus process with over 30 other groups that are involved, resolving differences upfront instead of later when conflicts can become very heated.

f. Identify and implement initiatives to expand access to Department lands for hunting and fishing;
The District already allows full access to anyone wanting to hunt or fish on lands the District manages or owns. So, nothing to expand at this time.

g. Shift the balance towards providing greater public access to public lands over restrictions to access.
The District already allows access to Reclamation lands the District manages.

2. Utilizing our natural resources
a. Ensure American Energy is available to meet our security and economic needs;
The energy to be produced by this Project and future sites will enhance American energy independence as well as America’s security by not having to rely on other
nations. Power is an off-stream, “green” renewable resource that improves the baseload component normally supplemented by coal and natural gas.

b. Ensure access to mineral resources, especially the critical and rare earth minerals needed for scientific, technological, or military applications;

   NOT APPLICABLE

c. Refocus timber programs to embrace the entire ‘healthy forests’ lifecycle;

   NOT APPLICABLE

d. Manage competition for grazing resources.
The District uses bid process to allow all local farmers a chance to use nearly 24,000 acres of lands for grazing that are owned by Reclamation and managed by the District.

3. Restoring trust with local communities
   a. Be a better neighbor with those closest to our resources by improving dialogue and relationships with persons and entities bordering our lands;
   The District is an active participant in the SRWG consensus process that has been crucial tool to improving dialogue and relationships. With human interaction, there will always be new issues that surface so staying on top of them as they occur has been a great way the SRWG resolves conflicts.

   b. Expand the lines of communication with Governors, state natural resource offices, Fish and Wildlife offices, water authorities, county commissioners, Tribes, and local communities.
   The SRWG includes all levels of government to help keep lines of communication open. The Montana Public Service Commission which regulates utilities in the State has expressed considerable interest in the District’s Hydropower Development Strategy and Implementation Plan.

4. Striking a regulatory balance
   a. Reduce the administrative and regulatory burden imposed on U.S. industry and the public;

   NOT APPLICABLE

   b. Ensure that Endangered Species Act decisions are based on strong science and thorough analysis.

   NOT APPLICABLE

5. Modernizing our infrastructure
   a. Support the White House Public/Private Partnership Initiative to modernize U.S. infrastructure;
   The District is actively engaged in infrastructure modernization which includes Reclamation grants, Montana Renewable Resource grants, private companies donating time to help find new ways to improve infrastructure. Infrastructure costs are increasing and funding opportunities are decreasing. The hydro-project partnership is a recent collaborative project completed that is already helping pay for other projects.
b. Remove impediments to infrastructure development and facilitate private sector efforts to construct infrastructure projects serving American needs; The District is taking advantage of simplifying hydro-power projects on irrigation projects. The District is combining several more infrastructure improvements by making them hydro-power compatible.

c. Prioritize Department infrastructure needs to highlight:
   1. Construction of infrastructure;
      The District has an aggressive infrastructure replacement program. Currently, the District has completed one major project with four more starting right now. The District is up against the clock when considering the aging infrastructure and money is the limiting factor. Funding programs are limited. Additional revenue is needed to expedite and facilitate the overhaul plans the District is proposing. The hydropower revenue stream will help find those projects.

   2. Cyclical maintenance;
      The District has always maintained its infrastructures. Keeping up with canal cleaning, concrete repairs or actual structure replacement when it is time has been best way for the District to on top of cyclical maintenance.

   3. Deferred maintenance.
      The District has a long-deferred maintenance list because it is handling many major projects before tackling many minor ones. But as the District is in the area of a deferred maintenance, they try to accomplish any repair necessary.

Evaluation Criterion F: Implementation and Results

Subcriterion F.1—Project Planning

Does the applicant have a Water Conservation Plan and/or System Optimization Review (SOR) in place? Please self-certify or provide copies of these plans where appropriate to verify that such a plan is in place.

Provide the following information regarding project planning:

(1) Identify any district-wide, or system-wide, planning that provides support for the proposed project. This could include a Water Conservation Plan, SOR, Drought Contingency Plan or other planning efforts done to determine the priority of this project in relation to other potential projects.

A modernization plan was completed by Rubicon in 2016 to quantify the potential water savings that could be realized by enhanced water management techniques (Attachment 9). The District is currently preparing a Hydropower Development Strategy and Implementation Plan to help fund the massive overhaul of Reclamation infrastructure and modernization of its operations (Attachment 5). This year the District completed a hydropower feasibility analysis and generation/transmission study to evaluate the hydropower potential and the
logistics of wheeling it to the nearest WAPA line. The District completed a Water Management and Water Conservation Plan on June 20, 2006 with Attachment 11. The District prepared this plan as a management tool to improve the efficient use of available water, prioritize projects, improve water quality in the Sun River, improve the agricultural economy within the district, and fulfill the water conservation planning requirements stipulated in the Reclamation Reform Act of 1982. The plan list as one water management tool to reduce waste water included pipelines throughout GiD project.

(2) Describe how the project conforms to and meets the goals of any applicable planning efforts and identify any aspect of the project that implements a feature of an existing water plan(s).

This project applies to several planning efforts including:
2) Montana’s 2004 Sun River Water Quality Restoration Plan and TMDL. This project fits the Plan’s water quality improvements through the reduction of sediment loads.
3) SRWG’s Water Quality Restoration Plan (WRP). This project fits the WRP through improvements in water quality by reducing sediment loads.
4) SRWG’s Strategic Plan that includes finding win-win solutions addressing water shortages and improving water quality in the Sun River and tributaries.
5) District’s Water Management Plan that this project fits under the areas of improving water management, long-term infrastructure needs, hydropower ideas, water conservation projects to reduce waste water, and tools to reduce erosion in Mill Coulee, Big Coulee and Muddy Creek.

Subcriterion F.2— Performance Measures

Provide a brief summary describing the performance measure that will be used to quantify actual benefits upon completion of the project (e.g., water saved or better managed, energy generated or saved). For more information calculating performance measure, see Appendix A: Benefit Quantification and Performance Measure Guidance.

All Water and Energy Efficiency Grants applicants are required to propose a “performance measure” (a method of quantifying the actual benefits of their project once it is completed). A provision will be included in all assistance agreements with Water and Energy Efficiency Grants recipients describing the performance measure and requiring the recipient to quantify the actual project benefits in their final report to Reclamation upon completion of the project. If information regarding project benefits is not available immediately upon completion of the project, the financial assistance agreement may be modified to remain open until such information is available and until a Final Report is submitted. Quantifying project benefits is an important means to determine the relative effectiveness of various water management efforts, as well as the overall effectiveness of Water and Energy Efficiency Grants.
Estimated water savings of approximately 2,400 acre/feet annually benefitting the reliability of water for the irrigation district while improving the water quality and quantity for all other uses in the basin. The water savings projected from District modernization will be at least 36,000 acre-feet/year by reducing waste flows, emergency spills and operational losses into one of the neighboring drainages alone.

Pre-project: Flow measurements have already been taken to identify potential savings.

Post-project: Gauges on the Sun River, flow measurements on the canals, flow measurements on the wastewater by the District and SRWG will help track all water savings. See attachment #15 Sun River flow data and attachment #16 for Muddy Creek flow data.

Subcriterion F.3—Readiness to Proceed

Applicants that describe a detailed plan (e.g., estimated project schedule that shows the stages and duration of the proposed work, including major tasks, milestones, and dates) will receive the most points under this criterion.

- Describe the implementation plan of the proposed project. Please include an estimated project schedule that shows the stages and duration of the proposed work, including major tasks, milestones, and dates.

Project Schedule & List of Tasks

The construction schedule is controlled by several factors and due to the complexity of the project will take 3 years to complete. Examples of the controlling factors include:

1. The importance of the Pishkun Supply Canal (PSC) to the District’s members cannot be over-stated and therefore it cannot be taken out of service; not even temporarily to expedite or facilitate construction. The PSC is typically in operation beginning as early as April 15th and ending around August 31st. Unfortunately, this also represents the nicest time to perform heavy civil construction. As a result, construction adjacent to the PSC and the connection to the Arnold Coulee Replacement and Hydropower Conversion must occur during the off-season.

2. The PSC off-season is then September to March and most of the construction must be performed during this 7-month window. Unfortunately, the remoteness of the construction site and the proximity to the Rocky Mountain Front create winter conditions not conducive to earthwork and placing concrete. The conditions impact both work quality, productivity, and worker safety. Therefore a 3-month winter shutdown from December through February has been programmed into the schedule. Obviously, if weather conditions are favorable, work will be performed.

3. The construction of the transmission lines will occur in the Fall and Winter due to access limitations over wetlands. SREC will coordinate this work and obtain all necessary permits, if any since they have an existing easement.
4. Items on the Task List and Schedule which represent a potential critical path include the following:

   a. **Procurement of the generator/turbine.** This is a big ticket, complex item whose purchase will most likely involve a Foreign manufacturer. The U.S. State Department’s rules and sanctions, which are subject to change, may limit available vendors.

   b. **Securing a Power Purchase Agreement (PPA)** may take several years and as it can be a function of the energy market. Developing a site with the published electric tariffs/avoid cost rates and satisfying MT Public Service Commission’s goals for greater baseload reliability, greatly increases the chance of obtaining a PPA.

   c. **The interconnect agreement with WAPA** also represents an uncertain path that must be negotiated on the fly.

   d. **This $2 million grant.** Obviously, the inability to secure the proper level of financing and funding could delay the project.

<table>
<thead>
<tr>
<th>TASK</th>
<th>DESCRIPTION</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Hydropower Feasibility Analysis</td>
<td>DONE</td>
</tr>
<tr>
<td>2</td>
<td>Hydropower Development Strategy &amp; Implementation Plan</td>
<td>DRAFT</td>
</tr>
<tr>
<td>3</td>
<td>Generation/Transmission Routing Study</td>
<td>DONE</td>
</tr>
<tr>
<td>4</td>
<td>Initiate Easement Discussions with BLM</td>
<td>DONE</td>
</tr>
<tr>
<td>5</td>
<td>Submit $125k DNRC RRGL Grant App</td>
<td>DONE</td>
</tr>
<tr>
<td>6</td>
<td>Obtain Lease of Power Privilege (LOPP) w/ Reclamation</td>
<td>DONE</td>
</tr>
<tr>
<td>7</td>
<td>Submit $2 Million WaterSMART Water &amp; Energy Eff. Grant App</td>
<td>DONE</td>
</tr>
<tr>
<td>8</td>
<td>Review DNRC RRGL Grant Rankings</td>
<td>Fall 2020</td>
</tr>
<tr>
<td>9</td>
<td>Notice of Award $2M WaterSMART Water &amp; Energy Eff. Grant</td>
<td>Winter 2020</td>
</tr>
<tr>
<td>10</td>
<td>Grant Administration &amp; Reporting</td>
<td>Quarterly</td>
</tr>
<tr>
<td>11</td>
<td>Reclamation to complete NEPA and NHPA</td>
<td>Spring 2021</td>
</tr>
<tr>
<td>12</td>
<td>Finalize Site Topo Survey/Conduct Geotech Investigation</td>
<td>Spring 2021</td>
</tr>
</tbody>
</table>

**Pishkun Supply Canal Start Date (Typical)**: April 15th

<table>
<thead>
<tr>
<th>TASK</th>
<th>DESCRIPTION</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>13</td>
<td>Finalize Construction Drawings and Specs – Submit to USBR</td>
<td>May 2021</td>
</tr>
<tr>
<td>14</td>
<td>Finalize Modification of Existing Easement with BLM</td>
<td>June 2021</td>
</tr>
<tr>
<td>15</td>
<td>Begin Search and Negotiations for Power Purchase Agreement</td>
<td>June 2021</td>
</tr>
<tr>
<td>16</td>
<td>Initiate Procurement Negotiations for Turbine and Generator</td>
<td>June 2021</td>
</tr>
<tr>
<td>17</td>
<td>Receive and Incorporate USBR Review Comments</td>
<td>July 2021</td>
</tr>
<tr>
<td>18</td>
<td>Procure and Delivery 11-ft Diameter Penstock</td>
<td>August 2021</td>
</tr>
</tbody>
</table>

**Pishkun Supply Canal Finish Date (Typical)**: August 31st

<table>
<thead>
<tr>
<th>TASK</th>
<th>DESCRIPTION</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>19</td>
<td>Install Penstock and Drain Line</td>
<td>Sept-Nov 2021</td>
</tr>
<tr>
<td>20</td>
<td>1st Phase of Transmission Line Improvements</td>
<td>Fall 2021</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>TASK</th>
<th>DESCRIPTION</th>
<th>DATE</th>
</tr>
</thead>
<tbody>
<tr>
<td>21</td>
<td>Grant Administration &amp; Reporting</td>
<td>Quarterly</td>
</tr>
<tr>
<td>22</td>
<td>Perform Site Prep Work &amp; Canal Modifications for Intake Struc.</td>
<td>Mar-Apr 2022</td>
</tr>
</tbody>
</table>

**Pishkun Supply Canal Start Date (Typical)**: April 15th
Describe any permits that will be required, along with the process for obtaining such permits. None required

Identify and describe any engineering or design work performed specifically in support of the proposed project.

Work already completed includes:
1. Hydropower Development Strategy and Implementation Plan (Attachment 5)
2. Hydropower Feasibility Analysis (Attachment 6)
3. Lease of Power Privilege (LOPP) Agreement w/ Reclamation (Attachment 7)
4. Preliminary construction drawings (Attachment 8)
5. Generation/Transmission Study to evaluate wheeling through SREC’s system.
6. Preliminary discussions with BLM regarding an amendment to the existing easement
7. Preliminary discussions with MT Public Service Commission regarding the marketability of the generated power.
8. Submitted an application for a $125,000 MT DNRC-RRGL Grant as part of the non-Federal cost share.
• Describe any new policies or administrative actions required to implement the project. NONE

• Describe how the environmental compliance estimate was developed. Has the compliance cost been discussed with the local Reclamation office? Compliance costs for projects the District has proposed has been discussed on general costs. Exact cost has not been established yet since unsure if these tasks will be accomplished by Reclamation or contracted out.

**Evaluation Criterion G— Nexus to Reclamation Project Activities**
Is the proposed project connected to Reclamation project activities? If so, how? Please consider the following:
Reclamation started construction of District as part of the Sun River project in 1913 with first water delivery in 1920. Another part of the Sun River project is the Fort Shaw Irrigation District which this project will benefit also by increasing water availability to the river. Reclamation continues to be a major partner in District water conservation projects by providing people resources to design best ideas for the District and the SRWG collaborative effort.

• Does the applicant receive Reclamation project water? 
  Yes, the District does receive Reclamation project water.

• Is the project on Reclamation project lands or involving Reclamation facilities? 
  Yes, project is on Reclamation lands and consists of Reclamation-owned facilities.

• Is the project in the same basin as a Reclamation project or activity? 
  Yes, the project is in same basin (Sun River) as a Reclamation project or activity.

• Will the proposed work contribute water to a basin where a Reclamation project is located? 
  Yes, the proposed work will contribute water to same basin where Reclamation project is located. This project will be especially useful helping to meet Sun River flow targets when combined with the other ongoing projects in the watershed.

• Will the project benefit any tribe(s)? 
  NO. Project will not help Reclamation meet trust responsibilities to any tribe.

**Evaluation Criterion H— Additional Non-Federal Funding**
Non-Federal Funding = $3,688,807

Total Project Cost = $5,688,805
These non-Reclamation funds and in-kind services exceed the 50% match required from this Challenge Grant program. Match is at 65%.
PROJECT BUDGET

(1) Funding plan and letters of commitment -

**Project Financing**

The critical leg of funding for this project involves the $2,000,000 WaterSMART Water and Energy Efficiency Grant for FY 2021 (this application). The mandated 50% match would be met using District labor, equipment, resources as well as cash reserves or non-Federal grants and loans. Together, this represents $4,000,000 of the estimated $5,690,000 needed for construction. The District is committed to providing the match requirements.

In May 2020, the District submitted an application to the Montana Department of Natural Resources and Conservation (DNRC) for a Renewable Resources Grant. This grant is for $125,000 and would be available after July 1\textsuperscript{st}, 2021. The grant rankings however will be available this Fall and this will provide a good indication of the likelihood of being awarded this grant.

The District also qualifies for low interest loans available through the Montana Department of Commerce, Board of Investments. The current interest for the InterCap loan is 2.5% but most likely this rate will drop considerably early next year due to economic issues related to the pandemic. The interest rates are set each year on February 16\textsuperscript{th} and these variable rates historically tend to lag economic trends. The duration of the loan is normally 15 years but can be lengthened by legislative action. The maximum loan amount is $5,000,000 and that amount involves increased scrutiny and must be approved by the governing Board of the Board of Investments. Lower loan amounts can be approved by the internal loan committee.

The District is aware of other parties and irrigation partners interested in becoming ownership partners on this project and likewise investing. This however negates the District's goal to maximize ownership and thus maximize the generated revenue. Although comforting to have additional options, this will only be exercised as a last resort.

The District is forming a C-Corporation as this will allow access to other sources of funding and tax credits. This would also include USDA’s REAP Grant and SBA loans. This for-profit business would be a wholly owned subsidiary of the District. The business implications of this possibility are currently being vetted.

Describe how the non-Federal share of project costs will be obtained -

- District contributions to this project are \textcolor{red}{$3,688,807$} labor and equipment in-kind services.
o District funds and resources will be ready to begin July 2021.
o District has all of the equipment and manpower to accomplish project of pouring concrete in place for the new automated, hydro-ready structure.
- Program grant funds for $1,999,998 are requested.
- Total project cost is $5,688,805.

The District’s commitment to providing the necessary funds to complete this Project is detailed in the Commitment Letter provided in Attachment 2.

(2) Budget Proposal

Table 1.—Total Project Cost Table

<table>
<thead>
<tr>
<th>SOURCE</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td>Costs to be reimbursed with the requested Federal funding</td>
<td>$ 1,999,998</td>
</tr>
<tr>
<td>Costs to be paid by the applicant</td>
<td>$ 3,688,807</td>
</tr>
<tr>
<td>Value of third-party contributions</td>
<td>0</td>
</tr>
<tr>
<td>TOTAL PROJECT COST</td>
<td>$ 5,688,805</td>
</tr>
</tbody>
</table>

Table 2.—Budget Proposal

<table>
<thead>
<tr>
<th>ARNOLD COULEE HYDRO DROP BUDGET ITEM/DESCRIPTION</th>
<th>COMPUTATION</th>
<th>GID-RECIPIENT MATCH</th>
<th>RECLAMATION GRANT FUNDING</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Units</td>
<td>Quantity</td>
<td>Unit Price</td>
</tr>
<tr>
<td>SALARIES AND WAGES</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>District Engineer</td>
<td>Hours</td>
<td>75</td>
<td>$80.61</td>
</tr>
<tr>
<td>O&amp;M Foreman</td>
<td>Hours</td>
<td>150</td>
<td>$53.94</td>
</tr>
<tr>
<td>Water Master/SCDA</td>
<td>Hours</td>
<td>52</td>
<td>$38.84</td>
</tr>
<tr>
<td>Equipment Operator</td>
<td>Hours</td>
<td>550</td>
<td>$35.89</td>
</tr>
<tr>
<td>Construction Laborer</td>
<td>Hours</td>
<td>4,500</td>
<td>$34.09</td>
</tr>
<tr>
<td>Truck Driver</td>
<td>Hours</td>
<td>500</td>
<td>$33.84</td>
</tr>
<tr>
<td>Clerical</td>
<td>Hours</td>
<td>32</td>
<td>$34.27</td>
</tr>
<tr>
<td>GIS/Drafting</td>
<td>Hours</td>
<td>16</td>
<td>$30.38</td>
</tr>
<tr>
<td>FRINGE BENEFITS - NONE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TRAVEL – NONE INCLUDED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>EQUIPMENT (no operator)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>CAT 326 Lg Boom Excavator</td>
<td>Hours</td>
<td>120</td>
<td>$66.01</td>
</tr>
<tr>
<td>CAT 320 Excavator</td>
<td>Hours</td>
<td>165</td>
<td>$56.76</td>
</tr>
<tr>
<td>D-7 Dozer</td>
<td>Hours</td>
<td>30</td>
<td>$147.92</td>
</tr>
<tr>
<td>CAT 926M Wheel Loader</td>
<td>Hours</td>
<td>160</td>
<td>$57.22</td>
</tr>
<tr>
<td>CAT 14G Road Grader</td>
<td>Hours</td>
<td>20</td>
<td>$100.82</td>
</tr>
<tr>
<td>End Dump Truck</td>
<td>Miles</td>
<td>850</td>
<td>$1.75</td>
</tr>
<tr>
<td>Semi-Tractor/Trailer</td>
<td>Miles</td>
<td>10,500</td>
<td>$3.25</td>
</tr>
<tr>
<td>Portable Generator</td>
<td>Days</td>
<td>120</td>
<td>$62.50</td>
</tr>
<tr>
<td>Dewatering Equip.</td>
<td>Days</td>
<td>12</td>
<td>$85.00</td>
</tr>
<tr>
<td>Portable Compressor</td>
<td>Days</td>
<td>8</td>
<td>$175.00</td>
</tr>
<tr>
<td>Bomag Compactor</td>
<td>Hours</td>
<td>320</td>
<td>$26.56</td>
</tr>
<tr>
<td>Project Job/Office Trailer</td>
<td>Months</td>
<td>6</td>
<td>$750.00</td>
</tr>
<tr>
<td>SUPPLIES and MATERIALS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Redi-Mix Concrete, w/travel</td>
<td>CY</td>
<td>850</td>
<td>$185.00</td>
</tr>
<tr>
<td>Reinforcement Steel</td>
<td>kips</td>
<td>62</td>
<td>$625.00</td>
</tr>
<tr>
<td>Framing Lumber/Forms/Misc</td>
<td>LS</td>
<td>1</td>
<td>$3,500.00</td>
</tr>
<tr>
<td>Misc Steel, Hardware &amp; Items</td>
<td>LS</td>
<td>1</td>
<td>$3,250.00</td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td>Unit</td>
<td>Direct Cost</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>----------</td>
<td>------</td>
<td>-------------</td>
</tr>
<tr>
<td>Roller Gates &amp; Controls</td>
<td>Each</td>
<td>2</td>
<td>$62,500.00</td>
</tr>
<tr>
<td>11-ft Diameter Penstock</td>
<td>LF</td>
<td>392</td>
<td>$684.77</td>
</tr>
<tr>
<td>Penstock Reducer &amp; Vents</td>
<td>LS</td>
<td>1</td>
<td>$55,000.00</td>
</tr>
<tr>
<td>Canal Bank Rip-Rap Rock</td>
<td>CY</td>
<td>450</td>
<td>$15,750</td>
</tr>
<tr>
<td>3/4 minus CBC/Structural Fill</td>
<td>CY</td>
<td>750</td>
<td>$18,750</td>
</tr>
<tr>
<td>Flowable Fill, w/travel</td>
<td>CY</td>
<td>450</td>
<td>$65,250</td>
</tr>
<tr>
<td>Concrete Curing Heating</td>
<td>Days</td>
<td>14</td>
<td>$225.00</td>
</tr>
<tr>
<td>Penstock Welding</td>
<td>LS</td>
<td>1</td>
<td>$65,000.00</td>
</tr>
<tr>
<td>Crane Service</td>
<td>LS</td>
<td>1</td>
<td>$75,500.00</td>
</tr>
<tr>
<td>Grant Administration</td>
<td>Hours</td>
<td>80</td>
<td>$25.00</td>
</tr>
<tr>
<td>CONSTRUCTION/CONSTRUCTION</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NEPA - USBR</td>
<td>LS</td>
<td>1</td>
<td>$3,000.00</td>
</tr>
<tr>
<td>NHPA - USBR</td>
<td>LS</td>
<td>1</td>
<td>$5,000.00</td>
</tr>
<tr>
<td>Reclamation oversight</td>
<td>LS</td>
<td>1</td>
<td>$4,000.00</td>
</tr>
<tr>
<td>Engineer design &amp; oversight</td>
<td>LS</td>
<td>1</td>
<td>$240,000.00</td>
</tr>
<tr>
<td>Water Conservation Measurements</td>
<td>Hours</td>
<td>20</td>
<td>$25.00</td>
</tr>
<tr>
<td>Site Security Fencing</td>
<td>LS</td>
<td>1</td>
<td>$65,000.00</td>
</tr>
<tr>
<td>Concrete Pumping</td>
<td>LS</td>
<td>1</td>
<td>$40,000.00</td>
</tr>
<tr>
<td>Penstock Welding</td>
<td>LS</td>
<td>1</td>
<td>$65,000.00</td>
</tr>
<tr>
<td>Crane Service</td>
<td>LS</td>
<td>1</td>
<td>$75,500.00</td>
</tr>
<tr>
<td>Grant Administration</td>
<td>Hours</td>
<td>80</td>
<td>$25.00</td>
</tr>
<tr>
<td>THIRD-PARTY CONTRIBUTIONS - NONE</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OTHER – HYDRO COMPONENTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Electrical Transmission</td>
<td>LS</td>
<td>1</td>
<td>$2,190,000</td>
</tr>
<tr>
<td>Kaplan Turbine/Generator &amp; brushless Exciter</td>
<td>LS</td>
<td>1</td>
<td>$1,200,000</td>
</tr>
<tr>
<td>Related Mechanical &amp; Electrical</td>
<td>LS</td>
<td>1</td>
<td>$375,000</td>
</tr>
<tr>
<td>Powerhouse</td>
<td>LS</td>
<td>1</td>
<td>$274,000</td>
</tr>
<tr>
<td>TOTAL DIRECT COSTS</td>
<td></td>
<td></td>
<td>$3,688,807</td>
</tr>
<tr>
<td>INDIRECT COSTS</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Rate</td>
<td></td>
<td>10%</td>
<td>$181,818</td>
</tr>
<tr>
<td>TOTAL GRANT FUNDS REQUESTED</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>TOTAL ESTIMATED PROJECT COST</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

(3) Budget Narrative

Salaries & Wages
- District Engineer/Program manager/, Erling Juel
  - 75 total hours @ $80.61/hour for the following work:
  - Manager will accomplish project reports, project oversight, compliance review, design and permitting, BLM refined easement, and power purchase agreement.
- District O&M Foreman
  - 150 total hours @ $53.94/hour for all construction relating work including:
    - employee safety briefings, direct project oversight, and ordering materials/supplies to build concrete structure, install pipeline, and automated gates and hydro components
- District Water Master/SCDA
  - 52 total hours @ $38.84/hour for gage components of project:
    - wire in all electronic gages, sensors, controllers and ensure new system is compatible with current system.
- District equipment operator
  - 550 total hours @ $35.89/hour for all construction work
  - to operate excavators, dozer, and other equipment for this project and install new pipeline and hydro components.

- District truck driver
  - 500 total hours # $33.84/hour for all construction work
  - to drive to companies to pick up supplies including hydro components.

- District laborers -- 3-12 person crew depending upon specific project
  - 4,500 total hours @ $34.09/hour for all construction work
  - to help install & remove concrete forms, pour concrete, install pipe and hydro components.

- District clerical
  - 32 hours @ $34.27 hour for all work including
  - helping with reports, material bids and grant tracking finances.

- District GIS/Drafting
  - 16 hours @ $30.38 hour for all work including
  - assisting with reports and maps.

**Fringe Benefits** - NONE

**Travel** - NONE

**Equipment**
- District CAT 326 Long Boom excavator
  - 120 hours @ $66.99/hour which is going rate per Corps worksheet #H25KC030
  - to assist with installation of new pipe and hydro power components.

- District CAT 320
  - 165 hours @ $62.36/hour which is going rate per Corps worksheet #H25KC029
  - to assist with installation of new pipe and hydro power components.

- District D-7 dozer
  - 30 hours @ $70/hour which is going rate per Corps worksheet #T15CA012
  - to assist with installation of new pipe and hydro power components.

- District CAT 926M Wheel Loader
  - 160 hours @ $65/hour which is going rate per Corps worksheet #L40CA002
  - to assist with installation of new pipe and hydro power components.

- District CAT 14G Road Grader
  - 20 hours @ $65/hour which is going rate per Corps worksheet #G15CA005
  - to level out work areas and level area post project.

- District End Dump Truck
  - 850 miles @ $1.75/mile which is per GID billing rate
  - used to haul away old material and haul in rock/materials

- District Semi-Tractor/Trailer to ............
  - 10,500 miles @3.25 which is per GID billing rate
  - used to haul equipment to and from construction site AND to pickup materials.

- District portable generator
  - 120 days @ $62.50/day which is per GID billing rate
  - to be used for on-site power since no other power in the area.
- District dewatering equipment
  - 12 days @ $85.00/day which is per GID billing rate
  - to pump water out of “pit” while constructing new structures.
- District portable compressor
  - 8 days @ $175.00/day which is per GID billing rate
  - to supply air for tools for construction
- District Bomag compactor
  - 320 hours @ $26.56/hour which is going rate per Corps worksheet #C10BO013
  - compacting soil prior to pouring concrete
- District Job trailer that is heated building
  - 6 months @ $750.00/month which is per GID billing rate
  - used for on-site meetings, briefings, storage for tools and parts

**Materials & Supplies**

All materials below are for construction purposes and were estimated by acquiring quotes from local distributors or based on recent experience:
- Redi-Mix concrete, counting travel costs – 850 cubic yards at $185.00/yard
- reinforcement steel – 62 kips at $625.00/kips
- framing lumber and forms – flat expense at $3,500
- miscellaneous steel, hardware items – flat expense at $3,250
- roller gates and controls – 2 for $62,500 each
- 11-foot diameter penstock pipe – 392 liner foot at $684.77/linear foot
- penstock reducer and vents – flat expense at $55,000
- canal bank rip-rap rock – 450 cubic yards at $35.00/yard
- ¾ minus CBC/structural fill – 750 cubic yards at $25.00/yard
- pit run gravel – 975 cubic yards at $12.50/yard
- flowable fill, counting travel costs – 450 cubic yards at $145.00/yard
- concrete curing heating – 14 days at $225.00/day

**Contractual**

The procurement methods for goods and services as well as professional services shall comply with all applicable State requirements.

All contractual services are were estimated by acquiring quotes from local vendors and/or based on recent experience

District will contract with Reclamation or approved contractor for the NEPA and NHPA approvals. Reclamation will also provide engineering review and approval of the final design including periodic construction inspection. These activities are estimated as follows:

- NEPA requirements - $3,000.00
- NHPA requirements - $5,000.00
- Project oversight - $4,000.00
- Contracted Engineer design review and oversight - $275,000, this represents less than 8% (approximately half) of the construction costs excluding the transmission line costs.
- Contracted water conservation tracking/flow measurements – 20 hours at $25/hour
- Contracted site security fencing – flat rate at $6,500.00
- Contracted “concrete pumper” – flat rate for cubic yard - $48,000.00
- Contracted penstock welding – flat rate at $88,750.00
- Contracted crane service – flat rate at $75,500.00
- Contracted services to assist with grant administration – 80 hours at $25.00/hour

**Third-Party In-Kind Contributions** - NONE

**Environmental and Regulatory Compliance Costs**
- Part of Reclamation contractual costs listed above

**Reporting**
- District Engineer/Program manager, Erling Juel
  - $80.61/hour for all work
  - 40 hours assisting in compliance review, permitting and project reporting
- District clerical
  - $34.27 hour for all work
  - 40 hours to specifically help with writing financial, program performance, semi-annual and final reports

**Other Expenses – Hydropower Components**
All estimated hydromachinery costs and related tasks were obtained from the hydropower developer whom the District is partnered with on the existing Upper and Lower Turnbull hydroelectric projects.
- Electrical transmission line hook-up for new hydro power – flat fee at $2,190,000
- Kaplan turbine/generator and brushless exciter – flat fee at $1,200,000
- Mechanical and electrical hook-up – flat fee at $375,000
- Powerhouse to hold new hydro power turbines – flat fee at $274,000

**Indirect Costs**
- 10% rate allowed per Reclamation - remaining costs not listed above including inflation, unknown items and other unknown labor. 10% x $1,818,180 = $181,818

**Contingency Costs** - NONE

**Total costs**
- Entire project = $5,688,805
- Non-federal cost-share = $3,688,807
- Federal cost-share = $1,999,998

(4). **BUDGET FORM** – SF-424C, Budget Information
REQUIRED PERMITS OR APPROVALS

No permits are anticipated. The approvals required and their status are:
- LOPP Agreement – completed. See Attachment 7 for signed agreement
- Reclamation approval of construction drawings – waiting for funding
- Reclamation approval of NEPA & NHPA documents – waiting for funding
- Power Purchase Agreement & Inter-Tie & Wheeling Agreement – awaiting Project commencement.

LETTERS OF PROJECT SUPPORT

See Attachment #3 for Letters of Support

OFFICIAL RESOLUTION

See Attachment #1 for District Board Resolution
Attachment #1

GID BOARD OF COMMISSIONERS

BOARD RESOLUTION
WHEREAS Greenfields Irrigation District's overall infrastructure portfolio is aging, beyond its design life, and is in critical need of replacement to avoid mid-season, catastrophic failure and to ensure water delivery service, which is essential to GID's water users, and

WHEREAS, Greenfields Irrigation District’s 100-year old, irrigation infrastructure is in dire need of modernization and improvements to conserve water, to improve water management efficiency and to protect water delivery to GID’s agricultural producers as well as to provide energy efficiency and power generation that will benefit future generations of water users, and

WHEREAS Greenfields Irrigation District's Arnold Coulee Drop Replacement Project provides the opportunity to incorporate hydropower generation so that electrical power can be marketed to provide a continuous revenue stream for the District, making it self-reliant such that future infrastructure replacement projects and modernization efforts can be self-funded, therefore

BE IT RESOLVED, the Greenfields Irrigation District's Board of Commissioners has reviewed the WaterSMART Grant requirements and authorizes the District Manager to pursue a Bureau of Reclamation 2021 WaterSMART Water and Energy Efficiency Grant; and

BE IT FURTHER RESOLVED that the Greenfields Irrigation District's Board of Commissioners by the authority given to it by the State of Montana is committing the necessary resources and funds to complete the infrastructure project by August 31st, 2023.

Dated this 11th day of August 2020.

President, Tim Brunner

Attest: Jenny Gulick, Board Secretary

Vice President, Bill Norris

Commissioner, Dave Gulick

Commissioner, Pat Brosten

Commissioner, Chase Brady
Attachment #2

GID BOARD LETTER OF COMMITMENT
September 16, 2020

Bureau of Reclamation
Financial Assistance Support Section
Attn: Ned Weakland
P.O. Box 25007, MS 84-27815
Denver, CO 80225

RE: WaterSMART- FY2021 Water and Energy Efficiency Grant Commitment Letter for the Arnold Coulee Drop Water Savings and Hydropower Development Project

Dear Mr. Weakland:

The Greenfields Irrigation District (GID) is writing this Letter of Commitment for the 2021 Reclamation WaterSMART Water and Energy Efficiency Grant application. GID will commit the necessary financial resources, estimated to be $3,690,000, as matching funds for the $2,000,000 grant being sought. Such resources will include in-kind District labor, equipment, and materials as well as non-Federal grants, low-interest loans and cash reserves required to construct the Arnold Coulee Drop Water Savings and Hydropower Development Project.

The in-kind resources will be provided by GID’s maintenance/construction crews and fleet of heavy equipment. The GID District Manager is a licensed engineer with +35 years of design and construction management experience. The staff and management of GID, 18 FTEs, are very experienced in heavy, civil construction having previously and successfully completed two multi-million-dollar, hydroelectric projects as well as numerous other infrastructure replacement projects. USBR quality assurance oversight personnel located in the Montana Area Office can attest to our ability to complete major construction projects.

Call me at 406-467-2533 if have any questions concerning this project or GID’s commitment. I look forward to working with you on this project.

Respectfully,
Greenfields Irrigation District

Erling A. Juel, P.E.
District Manager

c: GID Board
Attachment #3

LETTERS OF SUPPORT
September 11, 2020

RE:   Greenfields Irrigation District Proposal Support
      Arnold Coulee Hydropower Development Project

To Whom it May Concern:

The Sun River Watershed Group would like to express our support for Greenfields Irrigation District’s Arnold Coulee Hydropower Development Project. We believe this project has long- and short-term benefits to the watershed, and when considered in concert with GID and SRWG’s other projects, will dramatically mitigate multiple resource concerns and make drastic improvements to watershed health.

The replacement of a 100-year-old drop structure along the Pishkun Supply Canal will enable GID to reliably manage water in the system without risk of infrastructure failure. In addition, hydropower development has the potential to provide a revenue stream that can be used to support projects across the watershed to modernize other infrastructure, improving water management, efficiency, and conservation.

The Sun River Watershed Group works collaboratively to restore and protect the health of the Sun River watershed resources and communities. Some of our strategic goals include ensuring adequate year-round stream flows, improving water quality, enhancing fish and wildlife habitat, and restoring hydrological processes. SRWG is supportive of GID’s Arnold Coulee and other projects because they promote these SRWG objectives.

It is important to note that SRWG is doing work across the watershed and the impacts of GID’s Arnold Coulee and other projects are part of a greater watershed-scale effort to improve watershed health. Due to our close relationship, SRWG and GID are able to bring significantly more benefits to the watershed’s natural resources than either group would alone. Some of SRWG’s efforts that tie closely to this GID project include:

- **Water quality monitoring.** For nearly 20 years, SRWG has collected water quality data from six sites, recently adding a seventh, throughout the watershed. SRWG’s water quality data are available on Montana State University Extension Water Quality Division’s Data Hub, and in 2019 MSU performed a Nutrient Trend Analysis using the first 15 years of data. This monitoring and analysis helps describe changes in the watershed over time as GID, SRWG, and others implement projects. Monitoring will continue for the foreseeable future and similar Nutrient Trend Analysis will occur at regular intervals.

- **Stream Gage monitoring.** USGS and other entities have stream gages on the Sun River and tributaries that provide real-time flow or stage height information. In addition, SRWG manages and maintains six seasonal gages that provide flow or height data April through October. Flow monitoring is an important measure of the impacts of on-the-ground projects like those GID proposes.
- **Muddy Creek Projects.** SRWG has three projects in progress to improve water quality on Muddy Creek through various strategies.
  
  o On Upper Muddy Creek, SRWG is working with a landowner to install riparian fencing that will keep cattle from trampling and eating stream-side vegetation. Once cattle are excluded, the plant community will develop, stabilizing banks and filtering sediment and nutrients to reduce erosion and improve water quality. Healthy stream-side vegetation will also provide habitat for fish and wildlife.
  
  o On Lower Muddy Creek, SRWG is working with a landowner to replace an aging, degraded crossing. The new crossing will more adequately convey Muddy Creek's fluctuating flows, reducing erosion due to over-topping and water eddying upstream of the crossing. This project also includes fencing livestock out of the stream-side vegetation as described above.
  
  o Through US Bureau of Reclamation's WaterSmart Cooperative Watershed Management Program funding, SRWG is also developing a Master Plan for Muddy Creek that will layout a strategy for long- and short-term projects to reduce erosion, improve water quality, and manage water more effectively on Muddy Creek. The Plan will include suggestions for large-scale and small-scale projects that can only be accomplished through partnerships between SRWG and GID.

- **Channel Migration Zone Study.** SRWG commissioned a Channel Migration Zone study in 2020. Phase I of this study analyzed 51 miles of the Sun River, including surrounding lands, and was completed in July 2020. Phase II will analyze Elk Creek, starting this fall and completing in April. These studies describe historic movement of stream channels and identify areas that are at high risk for future migration or avulsion. SRWG will use these studies to identify and prioritize projects. Members of the public, agencies, municipalities, and others can also use the CMZ study to plan their efforts and spend money most effectively.

- **Next Steps.** SRWG is reviewing potential projects highlighted in the Channel Migration Zone study and a 2014 Watershed Assessment. SRWG will be applying for funds to implement many of these projects according to their potential impact on water management, water quality, and other SRWG strategic objectives.

SRWG appreciates your consideration of GID's Arnold Coulee Project. Projects like these are important to restoring and protecting the resources of the Sun River watershed and its communities.

Tracy Wendt
Sun River Watershed Group, Coordinator
tracy@sunriverwatershed.org
(406) 214-2868
June 1, 2020

To Whom It Concerns:

RE: Letter of Support

The Greenfields Irrigation District plays an enormous role in the vitality of the region in which the project serves. The availability of water in this region is crucial to the grain and hay varieties that are grown.

The system, as wonderful as it is, still requires upgrades and maintenance. The projects being pursued by the district are prudent and necessary. Offering support to this organization is an easy ask. The economic benefit that is derived from the project is huge. Funding for these projects is substantial and necessary. Please give these projects funding consideration to accomplish these upgrades.

We as the rural electric distributor in the area, benefit from the electric sales created by the irrigation pivots in the region. The pump load and pivot mover loads create approximately 20% of the annual sales for our cooperative. The continued successful operation of this entity is important to Sun River Electric Cooperative. The cooperative supports the funding requests that are being asked by Greenfields Irrigation District.

Sincerely,

Brad Bauman
Manager of Member Services/Engineering
Sun River Electric Cooperative
June 2, 2020

RE: Letter of Support - Greenfields Irrigation District Infrastructure Improvements

To Whom It May Concern:

I am in complete support of Greenfields Irrigation District (GID) upcoming infrastructure improvement projects. These projects are imperative to continue delivery of much needed Irrigation Water, Hydroelectric Power, and Safety.

The irrigation District is in need of modernizing infrastructure through repairing, replacing, and upgrading its +100 year old infrastructure while continuing uninterrupted delivery of irrigation water and sustaining irrigation for future generations. The original design of the system was intended as a flood method of irrigation. Today sprinkler irrigation accounts for nearly 68% of all irrigation and is projected to reach 80%. Sprinkler irrigation presents a unique set of challenges that the original infrastructure was not designed to support.

Modernization and upgrades will take over 30 years. State with Federal grants and low-interest loans are essential to achieving this modernization.

I am in absolute support of the following projects.

1. Spring Coulee Headworks;
2. Arnold Coulee Infrastructure and Hydropower Development;
3. SRS Main Canal; and
4. Sun River Bridge

Greenfields Irrigation District irrigates, manages and/or maintains related infrastructure in portions of Cascade, Lewis & Clark, and Teton Counties. The economic impacts, from GID, on the region is substantial resulting, in a minimum, with increased agricultural production and increased land values resulting in a larger state and local tax base. Subsequent improvements will continue the efforts in sustainable water conservation.

Again, I am in unreserved support of the projects and encourage everyone to move forward on them.

Raimund Hahn
Sunriver65@gmail.com

Retired Middle and High School Science Teacher and Geologist
A Letter in Support of Greenfields Irrigation District
P.O. Box 157, Fairfield, MT 59436

To Whom it May Concern,

This letter is being written in support of Greenfields Irrigation District’s (GID) efforts to both improve and modernize the GID +100-year-old infrastructure. The financial and economic impact that GID has on the region is considerable. I realize that the full-scale upgrade project proposed by GID would take over 30 years and cost over $50 million dollars and also realize this is well beyond GID’s ability to pay for these improvements and repairs on their own. That is why I firmly feel that there is a considerable need for all available State and Federal grants, as well as low-interest loans to achieve this crucial modernization objective.

Thank you very much for your consideration and for your support in this very worthwhile project that will both increase revenue from enhanced agricultural production, as well as bolster the state and local economies.

Respectfully,

{Signature}

Jenny Gulick
Gulick Farm Fertilizer, LLC
Co-Owner/Co-Manager
June 2, 2020

Re: Support for Greenfields Irrigation District Grant Proposals

To Whom it May Concern:

I am writing this letter in support of Greenfields Irrigation District (GID) and their four grant proposals. These proposals are crucial to the long-term health of GID and thus the Fairfield community and surrounding area. GID is considered an important part of the community and culture. We are an irrigated farm community and we are proud of it. The local agricultural economy is driven in a large part by the production of malt barley. This valuable commodity cannot be produced without the availability of plentiful and productive irrigation water.

Irrigated farm ground allows producers to make a living on fewer acres and thus provides for a stable farm culture with a robust population. Smaller farm size also provides for significant school enrollments supported by a strong tax base which is created by the steadily increasing value of the highly productive agricultural real property.

These proposed projects will address a portion of the current and continual infrastructure needs of GID and improve the health of the Sun River. Wastewater will be reduced, water management improved, hydro projects created and the longevity of the GID and the Sun River watershed will be enhanced. These projects will assist GID in their attempt to provide water in a manner that improves water application efficiency and storage as farmers migrate toward the use of pivots and away from the wasteful practice of flood irrigation.

GID is a vital organization that provides essential water to approximately 90,000 acres of productive farm ground. If the delivery of this water is allowed to deteriorate it will affect production, population, tax base and both the culture and economic well-being of the entire area in an adverse manner.

Please give these projects and GID the consideration they deserve as you move forward in the ranking of these grants. This funding is vital to the continued success of agriculture in this area and they will provide tremendous ongoing support to watershed and wildlife health and strengthen rural communities in the area.

Thank you for your time.

Sincerely,

Mitchell W. Johnson
Branch President
June 2, 2020

Re: Support for Greenfields Irrigation District’s Grant Proposals

To Whom It May Concern:

The Town of Fairfield is writing this letter of support for the four Greenfields Irrigation District’s grant proposals that are crucial projects to the long-term health of the District and our area. The Greenfields Irrigation District has always been an integral part of the Fairfield community and without the District, the local economy would be almost non-existent.

These proposed projects will address the long-standing infrastructure needs while making a substantial contribution to improving the health of Sun River. Reducing wastewater, improving water management, creating potential hydro projects, and ensuring the infrastructure will last another 100 years is very important to the entire Sun River Watershed.

Please don’t hesitate to contact me if I can be of assistance to you in the ranking of these grants to ensure they are awarded as high-value projects with benefits to agriculture, watershed health, and rural communities.

Yours truly,

Robert Swartz, Mayor
June 23, 2020

Re: Support for Greenfields Irrigation District’s Grant Proposals

To Whom It May Concern:

The Teton County Board of Commissioners are writing this letter of support for the four Greenfields Irrigation District’s grant proposals that are crucial projects to the long-term health of the District and our area. The Greenfields Irrigation District has always been an integral part of the Fairfield community and without the District, the local economy would be almost non-existent.

These proposed projects will address the long-standing infrastructure needs while making a substantial contribution to improving the health of Sun River. Reducing wastewater, improving water management, creating potential hydro projects, and ensuring the infrastructure will last another 100 years is very important to the entire Sun River Watershed.

Please don’t hesitate to contact the commissioners at 406-466-2151 if we can be of assistance to you in the ranking of these grants to ensure they are awarded as high-value projects with benefits to agriculture, watershed health, and rural communities.

Yours truly,

James E. Hodgskiss
District #1
jhodgskiss@tetoncountymt.gov

Joe Dellwo
District #2
jdellwo@tetoncountymt.gov

Richard “Dick” Snellman
District #3
rsnellman@tetoncountymt.gov
June 8, 2020

Mr. Erling Juel, Manager
Greenfields Irrigation District
105 West Central Avenue
Fairfield, Montana  59436

Sent via electronic mail:  erling@gid-mt.com

Re:  RRGL Project Funding Letter of Support

Dear Erling,

Trout Unlimited (TU) has been a member and supporter of the Sun River Watershed Group for almost twenty years, as has the Greenfields Irrigation District (GID).  This long-held collaboration among TU, GID, the Sun River Watershed Group and its other members, has worked to improve flows in the Sun River through irrigation infrastructure upgrades, reservoir operation refinements, and improving communication on the timing of water deliveries. Over this period of collaboration, the improved flows in the Sun River has resulted in a doubling of the wild trout population in the Sun River.

TU supports GID’s water delivery infrastructure improvement projects outlined below and submitted to the DNRC’s Renewable Resources Grants & Loan (RRGL) program for funding. Each of these three projects will contribute to better water management and more efficient water delivery, supporting the continuing collaboration to stretch water supplies while creating a healthier river:

- **Spring Coulee Headworks** – This is the 2nd phase of the J-Waste Way regulation project which will allow GID to better manage and conserve our limited water supply while reducing detrimental releases and subsequent environmental impacts to Spring Coulee and then Muddy Creek.

- **Arnold Coulee Hydropower Development** – This project will replace the 100-year old drop structure along the Pishkun Supply Canal which is well-beyond its
service life while also generating hydropower. Once the project is paid off, the hydropower revenue would be used to help pay for additional modernization projects.

- **SRS Main Canal Regulation** – This project includes creating in-canal regulation in the SRS Main Canal to allow for the temporary detention of water released from Pishkun (13 miles upstream), which for one reason or another cannot be delivered as intended. Such reasons could include, power outages, turn-offs resulting from rainfall events, or when a high volume of 1-day-offs exceed the 2-day-ons, thus creating excess water in the distribution system. In-canal regulation reduces operational losses and emergency releases which conserves water and preserves stored water in Pishkun and Gibson reservoirs.

TU is happy to support these projects for RRGL funding. Please don’t hesitate to contact me at laura.ziemer@tu.org or (406) 599-2606 if I can provide any additional information useful to your decision-making.

Yours truly,

Laura Ziemer
Trout Unlimited
HYDROPOWER DEVELOPMENT FOR GREENFIELDS

IRRIGATION DISTRICT

A Summary of Potential Sites & a Strategy for Implementation
HYDROPOWER DEVELOPMENT
FOR THE
GREENFIELDS IRRIGATION DISTRICT

A Summary of Potential Sites &
a Strategy for Implementation

Presented to the GID Board of Commissioners
Prepared by Erling A. Juel, P.E.
District Manager
August 2020
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. Also, 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.

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.

Starting with construction in 2009, the Upper and Lower Turnbull drop structures were reconfigured as 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 9 years of operation, GID’s annual share of the revenue distribution, after expenses, has averaged over $172,000. 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 be used to
bring additional hydropower sites on-line thus increasing and increasing the revenue stream available to GID for infrastructure replacement and modernization efforts. This report summarizes the likely potential sites along GID’s infrastructure capable of generating greater than 250 kW (0.25 MW) as well as their potential feasibility based on some governing price and cost assumptions. In addition, an implementation strategy and schedule are proposed along with several action items to initiate the process, subject to approval and adoption by the GID Board.

2.2 BACKGROUND

GID is blessed with a senior water right ensuring access to a relatively stable and ample supply of water from the Sun River watershed. The total drop in elevation from the Gibson Dam emergency spillway gates (4724) to the eastern extent of the District (3750) is approximately 1000 feet. Most of this drop occurs at Gibson Dam, Pishkun Reservoir, and numerous drop structures along the Main Canals.

Capturing this potential energy by developing hydropower has long been a consideration of the GID Board since the 1920s. The design and construction of Gibson Dam, finished in 1929, incorporated auxiliary steel penstocks through the concrete arch dam. They were intended specifically for the future development of hydropower. GID paid for the design and construction of these penstocks and anticipated their future use.

For nearly 100 years, there have been several attempts and FERC licenses obtained to develop the hydropower potential at Gibson Dam. The primary reason why hydropower development at Gibson has never been ultimately realized involves the economics of the transmission line and the corresponding easements relative to the overall market value of the electricity produced. A large hydropower facility like Gibson Dam can take several years to complete the studies, permitting and final design. The increasing time it takes to get a facility on-line from the initial inception can detrimentally influence both the capital costs as well as the market value of electricity to be produced. This is exactly what has happened with the latest venture to capture the potential energy at Gibson.

Many of GID’s drop structures have also been evaluated for potential hydropower development over the years by either GID and its partners or private developers. In 2011, Reclamation inventoried and described potential hydropower development on Reclamation-owned structures throughout the West(1). At least 8 of these sites were

---

1) – Site Inventory and Hydropower Energy Assessment of Reclamation Owned Conduits, Bureau of Reclamation, December 2011
located on the GID. As mentioned earlier, the Upper and Lower Turnbull drops were developed and brought on-line by a private developer in 2011.

2.3 ECONOMICS OF HYDROPOWER DEVELOPMENT

2.3.1 – COSTS VS. REVENUE. In simplest terms, for a potential hydropower site to be considered feasible, the projected revenue stream must exceed the estimated development costs as well as the annual operating costs within a specified period of time. The typical development costs include the following:

- Engineering and studies,
- Licenses and permits,
- Land acquisition,
- Site construction and equipment costs,
- Escalation during construction and contingencies,
- Project administration,
- Electrical gear, transmission lines and easements, and
- Interim financing and interest.

Annual operating costs include the following:

- Operator oversight,
- Repairs and maintenance,
- Power wheeling,
- Lease of Power Privilege (LOPP) fees,
- Engineering, legal & accounting costs,
- Taxes and debt service costs, and
- Lifecycle and replacement costs.

The electricity generated from the hydropower plant must be conveyed (wheeled) to a buyer and must be competitive with other forms of energy in order to be purchased. The developer of a hydropower facility cannot make someone buy their electricity; they can only make it affordable and desirable. Hydropower development on GID’s infrastructure is relatively desirable in that it is more reliable and dependable on a day-to-day basis than wind or solar generation.

On the downside, GID’s window for generation along its conveyance system is only for 4 months at best; May through August. The exceptions are Gibson Dam and Diversion Dam which have a “run-of-river” component of their hydropower potential. On the plus side, and regionally, July and August are considered high-demand months for electricity. Locally, electricity demand increases substantially when GID’s infrastructure is in use as this correlates with use of sprinkler irrigation pumps and pivot motors.
2.3.2 – RATE OF RETURN (ROR). Another component of feasibility is the time it takes for the revenue stream to reimburse the developer their original development costs or investment. The Rate of Return (ROR) is the reimbursement and profit on an investment over a desired duration of time. This is an important consideration for investors to understand and determine. For example, a potential hydropower project with a prolonged payback period would not be attractive and likely cause a developer to invest their money elsewhere. It is not uncommon for a for-profit investor to expect reimbursement plus a profit after 10 to 15 years.

The ROR, or Return on Investment (ROI), is relative depending on the purpose of the investment. Again, if the purpose is to make a conventional profit, then a short-term, payback duration is desired. If the purpose is to generate steady revenue stream well into the future, then a longer ROI maybe acceptable. A private investor, using their own money and collateral, would fall into that first category. GID or local utility company may be interested in the long haul and see themselves in the second category.

Also, if the payback period is equal to or longer than the life-cycle cost of the major equipment, a negative ROR may result. Thirty years is typically assumed to be the useful operating life for the turbine and generator equipment. This is considered conservative and the actual design life may be 40 to 50 years depending on the size of the equipment and whether used or new equipment was initially procured.

2.3.3 – OWNERSHIP STRUCTURE. Another major consideration that may impact the economics of hydropower development is how ownership of the hydropower facility is structured, i.e. whether as a private, for-profit corporation or as a public corporation. Ownership structure has a bearing on the types financing that may be available whether, grants, low-interest loans, or tax credits. Also, the impact of business taxes including property, equipment, and income will be different for a private company than a public corporation. If a private corporation structure proves to be more advantageous, GID should form a subsidiary company and/or be part of a private corporation.

A phased approach to hydropower development may allow a multi-tiered ownership structure. For example, GID could pursue funding for the 1st Phase from sources specifically set aside for government entities to construct the infrastructure upgrades and improvements necessary for eventual hydropower. These would include site development, the intake structure, penstock, and any upstream or downstream canal improvements.
The second and final phase of development could be completed by a for-profit corporation either wholly owned by GID or in part with other investors. This would allow access to other types of funding restricted to private corporations. This phase of development would include the hydro-machinery, powerhouse, and electrical transmission. Funding sources would include, in part, USDA REAP grants and SBA low interest loans as well as DOE tax credits.
3.0 FEASIBILITY

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 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 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 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 then reduced by the turbine and generator inefficiencies as well as accounting for energy losses realized along the transmission lines.
The drop in elevation can be determined from the existing facility drawings available from GID or Reclamation or measured directly in the field. For a drop structure that is part of the canal, the fall of the water is relatively constant throughout the water season. At lower canal flows, the water levels upstream and downstream of the drop are both lowered but the magnitude of the drop is essentially the same. The inlet structure to the hydropower penstock can be configured as a check structure and in theory, at lower canal flows, a larger head drop condition can be created and maintained. For a dam outlet, the potential head changes throughout the season; usually it drops as the reservoir is drawn down for irrigation.

The potential static head, or driving head, is normally corrected to account for head losses due to flow through the hydro plant. These losses include the intake entrance and tail-water exit losses and those related to flow friction, especially though the penstock. Often, the ingress (forebay) and egress (tailrace) head losses are considered small and therefore negligible compared to the flow friction realized from the penstock and turbine. Energy losses from friction are directly related to velocity and can reduce the output capacity of the hydro plant. It is therefore desirable to size the penstock such that flow velocity is minimized. A target velocity should be below 12 feet per second if feasible. Reducing the flow velocity, reduces the friction head losses and maximizes power generation.

GID is fortunate to have an extensive documented history of water flow through its canal infrastructure as well as the dams and reservoirs utilized for its operations. The flow rate of water can vary throughout the water season. It is not practical or cost-effective to size a turbine/generator based on the maximum potential flow that may be realized by a structure. To model the fluctuations of water discharge at an individual site, a flow-duration curve is normally employed. The hydro plant is normally sized for a 20 to 30 percent exceedance flow. Exceedance flow is that flow which is only exceeded 20 to 30 percent of the time each year or season.

Once the baseline parameters have been established, the formula below can be used to determine the theoretical potential capacity and is typically reduced to reflect inefficiencies of the generation plant and electrical transmission.

\[
kW := \left( \frac{Q \cdot H}{11.8152} \right) \cdot Eff
\]

where,
- \( kW = power, \ kilo\ Watts \)
- \( Q = Water\ flow\ through\ turbine,\ cf s \)
- \( H = Water\ drop\ across\ turbine,\ feet \)
- \( Eff = combined\ efficiency \)
3.2.2 – TURBINE SELECTION. The turbine is the most critical piece of equipment comprising the hydro facility and is responsible for converting the potential energy into mechanical energy that spins the electrical generator. This section provides a cursory overview of turbines to assist in the feasibility analyses, but the ultimate selection and design of the turbine will the responsibility of the site designer.

Turbines generally fall into two classifications: impulse (force) and reaction (pressure-differential). Some turbines utilize both aspects. Turbines can also be described as axial flow, radial, or mixed flow. Selection of the appropriate turbine is based on the water flow and water drop. Some turbines are better suited for high water pressure and low water discharges while other types are built specifically for a lower pressure head but with moderate to high water discharges. Some styles of turbines are better suited for varying flow conditions. Turbine efficiencies vary from style to style and depend upon the pressure-flow regime.

The figures below summarize various types of turbines that may be utilized on GID infrastructure and provide some operating regimes and characteristics of each turbine style.
3.2.3 – ANNUAL ENERGY POTENTIAL. To calculate the potential annual production of electricity at the hydro site, simply multiply the net power capacity by the number hours that electricity is produced. For seasonally operated canals, including the releases from Pishkun and Willow Creek dams, the time for potential generation is typically only 4 to 5 months. Power generation at Gibson Dam and Diversion Dam would be year-round albeit much lower once the useable storage has been depleted in late summer or early fall.

Unfortunately, power plant production is not continuous due to shutdowns from the grid, low flow limitations of the turbine, maintenance shutdowns. It is important to realistically model the energy production to realistically determine feasibility. For most hydropower plants, a load capacity/reduction factor is typically applied to the number kilowatt-hours calculated to account for this noncontinuous operation. Another method to establish the likely annual energy potential is to bracket the energy potential between the low and high year projections based on many years of data and then assign an average value.

3.2.4 – FACILITY CONSTRUCTION COSTS. The costs to construct or convert GID infrastructure into a hydropower facility can be up to 75% or higher of the overall development costs depending on the transmission construction costs (discussed below). A significant portion of these costs includes the mechanical equipment, i.e.
the turbine and generator. This equipment typically comprises between 45 and 55% of the construction costs. The costs depend upon the power output and whether it is new or used equipment.

The hydraulic conveyance structures, such as the inlet control structure, penstock, power convergence tube and the draft tube, can cost up to 35 to 45% of the total construction costs depending on the magnitude of the design discharge and length of penstock. The remainder of the costs, approximately 15% includes engineering, permitting, studies, land acquisition (if any) and general administration. The costs of interim financing would fall into this category.

3.2.5 – TRANSMISSION CAPITAL COSTS. The transmission capital costs are those expenses necessary to construct the infrastructure to convey or transmit the generated electricity to the purchaser. These costs would include the actual transmission lines, connection and switch gear, step-up transformers, and costs to obtain easements and permits. Any annual wheeling fees and interconnection costs should be included with the annual operating costs.

A transmission study was commissioned to evaluate the necessary infrastructure and potential costs to convey the electricity from Gibson Dam to the Bole Substation north of Fairfield. The primary objective of the study was to consider the combined effect of multiple hydropower sites and the level of transmission eventually warranted. Previous feasibility studies only considered their individual projects and not the big picture of an eventual and complete build-out of all the likely hydropower sites. This of course was not prudent nor practical to GID’s full hydropower potential.

Having this information and a likely implementation strategy will allow the GID Commissioners to plan and make the appropriate decisions regarding to what level of construction is appropriate for the various segments of transmission line to be built. For example, to construct or upgrade a transmission line to serve a single site only to later upgrade that line in the near future for a subsequent site may not be a proper use GID’s limited resources.

3.2.6 – ANNUAL OPERATING COSTS. Costs that are realized each year regardless of the power produced comprise the annual operating costs. These costs were summarized in Section 2.3.1 above. Some of these costs such as life cycle/replacement costs and wheeling fees would be proportional to the size of the generation equipment and output of the site. The costs related to taxes would be a function of the ownership structure, e.g. GID would not pay revenue, equipment, or property taxes.
Some annual costs such as administration, accounting, engineering and legal may be reduced on a per-site basis as incrementally more sites are developed and brought on-line.

3.2.7 – MARKETABILITY OF ELECTRICITY. All the discussions above detailed the theoretical costs to study, permit, finance, construct and operate a potential hydropower site. Collectively, these costs must be offset by the value or price for which the electricity can be sold. And, as we discussed the overall feasibility must consider the number of years it takes to reimburse the initial development costs.

If GID builds a hydropower site, it cannot make someone buy the power. Also, GID cannot control the price it is reimbursed for the electricity produced. GID has only limited control of the development costs but has some flexibility of the financing options. GID has flexibility over what constitutes an acceptable payback period. Obviously, GID would not finish out a hydropower site with a turbine or generator without a power purchase agreement and a plan to construct, finance and operate the plant.

Because GID is responsible for the operation and maintenance of the infrastructure where hydropower is proposed, GID is uniquely positioned to build much of the supporting infrastructure under the guise of an infrastructure replacement project. As such, State and Federal water resource grants and low-interest loans are available that would not necessarily be available for construction of a hydropower facility.

Making the infrastructure hydropower “ready” or hydropower “friendly”, moves the feasibility consideration in a positive direction. Also, pre-building much of the required infrastructure, shortens the time it would eventually take to bring the facility on-line. As we discussed earlier, feasibility can be a function of time. As quickly as the energy economics can change that would make GID sites feasible, they can equally change making the sites unfeasible. Lessening the time it takes to bring a site on-line, would have a tremendous advantage. Also, in this crazy world of government “stimulus funding”, having projects on-the-shelf that are predesigned and “shovel-ready”, would enable GID to be more competitive for this special funding.

Again, GID cannot force a utility to buy the electricity. However, GID can make the electricity affordable and reliable thus highly desirable to the utility. Realistically, Northwestern Energy is the local and logical buyer of this energy. Another potential buyer could be Basin Electric which sells power to the Sun River Electric Co-op.
(SREC). When a potential power purchase agreement is being pursued, it would be prudent to contact Basin Electric and ascertain their interest in the power.
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 was utilized to predict a revenue generation stream. A summary of the feasibility is provided in each write-up section below and the complete analyses is presented in the Appendix.

The following Figures show the locations of each site 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 3,000 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 outflows are generally set to match the 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.

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 in theory 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 basis of the feasibility analysis is the historic data that describes 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 3,000 cfs at full pool. There are numerous times when water is released through the gated, emergency spillway when inflows exceed 3,000 cfs and the reservoir is near full. The spillway crest elevation is 4712 and the six spillway gates allow for another 12 feet of storage: to 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 top of concrete wall is at elevation 4729.
Gibson dam has been investigated numerous times regarding the possibility of capturing the potential energy. As mentioned earlier, the design and construction of the upper penstocks during original construction demonstrate the long-standing, intention to install hydropower machinery on the dam.

In 1981, the Upper Missouri Regional Office of the U.S Bureau of Reclamation prepared an appraisal-level study to investigate the potential for hydroelectric power generation at Gibson Dam and the Sun River Diversion Dam. The report concluded that a dual-unit, 11-MW plant at Gibson and a single unit, 1.6-MW plant at Diversion were economically feasible. The Gibson site was feasible as a standalone project, but the Diversion Dam site was not. An interesting take-away from this report is that Reclamation asserted its authority to develop hydropower at these sites as well as its primary authority over the withdrawn land within the Forest Service boundaries. Reclamation obtained Congressional funding to perform a full Feasibility Study, but it is not known whether that study was ever performed.

Shortly after Reclamation’s appraisal report, a private partnership venture filed to obtain a FERC license for hydropower development at Gibson. The study and permitting process went on for about 10 years and in 1993, they surrendered their FERC license. The reason stated was due to an inability to obtain a power purchase agreement from MPC or the right to wheel the energy through MPC’s grid to an out-of-state customer. GID was to benefit from the project not as an owner or investor but as an operating partner. Throughout the decade-long process, Reclamation again asserted its authority on the withdrawn NFS lands and as the primary permitting agency. Also, Reclamation defended the project against claims from the Montana Department of State Lands which asserted that the State of Montana owned the riverbed and was requesting 10% of the gross revenue as payment in order for the project to proceed.

The latest venture to pursue hydropower development at Gibson is the Gibson Hydroelectric Company, LLC which GID is a 50% owner. The other 50% owner and managing partner is Tollhouse Energy Co. based in western Washington. A FERC license (P-12478) was issued on January 12, 2012 for a capacity of 15-MW. In general, construction failed to start due to delays obtaining transmission easements and a power purchase agreement. An extension was grant by Congress which now mandates that construction begin January 12, 2022 and be completed by January 12, 2024. Although feasible at its onset, the energy economics are currently not as favorable, and the transmission easements have still not been secured. A result of negotiation capitulation with the US Forest Service resulted in a questionable design element in that the first 9.3 miles of the transmission line (34.5kV) had to be buried.
through and beyond the Sun River canyon. The power was to be then stepped-up to 69kV and conveyed on aboveground lines for the remaining 17 miles. To date, GID has spent nearly $500,000 for studies, preliminary designs, and efforts to negotiate and obtain the FERC license. Most of this work was completed by Whitewater Engineering, which is a wholly owned, subsidiary of Tollhouse Energy. Those studies although dated provide good background information for subsequent efforts to develop hydropower generation at Gibson.

4.2.1.2 Power Potential – The power generation capacity can be easily modeled by comparing the historical daily reservoir elevation and the corresponding daily discharge through the river outlet. The driving head or turbine head is then calculated as the difference between the reservoir elevation and the appropriate tailwater elevation minus head losses due to flow. The approximate tailwater elevation of the Sun River varies from 4553.0 at 3000 cfs, to 4551.0 at 1500 cfs, to 4548.0 at minimal flows.

<table>
<thead>
<tr>
<th>Table 4.2.1 Summary of Gibson Dam Development Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Location:</strong> N47°40'34&quot;, W112°29'43&quot;</td>
</tr>
<tr>
<td><strong>Water Source:</strong> Sun River</td>
</tr>
<tr>
<td><strong>Operational Mode:</strong> Year Round</td>
</tr>
<tr>
<td><strong>Turbine Flow Range:</strong> 150 to 3,000 cfs</td>
</tr>
<tr>
<td><strong>Static Head Range:</strong> 60 to 171 feet</td>
</tr>
<tr>
<td><strong>Head Loss Range:</strong> 6 to 16 feet</td>
</tr>
<tr>
<td><strong>Turbine Head Range:</strong> 80 to 170 feet</td>
</tr>
<tr>
<td><strong>Maximum Capacity:</strong> 32.3 MW</td>
</tr>
<tr>
<td><strong>Annual Ave. Energy Production:</strong> 59,922 MW-Hrs</td>
</tr>
<tr>
<td><strong>Ave. Annual Revenue, 1st 15 years(1):</strong> $2,063,900</td>
</tr>
<tr>
<td><strong>Total Revenue, 1st 15 years(1):</strong> $30,958,600</td>
</tr>
<tr>
<td><strong>Est. Construction Costs:</strong> $33,000,000</td>
</tr>
<tr>
<td><strong>Est. Transmission Costs(2):</strong> $8,500,000</td>
</tr>
</tbody>
</table>

*Note 1: Based on Northwestern 2020 Energy Tariffs*
*Note 2: Based 2020 HDR Transmission Study*

4.2.2 – DIVERSION DAM –

4.2.2.1 Background and History – The Sun River Diversion Dam was built from 1912 to 1915 for the sole purpose of checking-up and diverting a portion of the Sun River
into the Pishkun Supply Canal (PSC) for irrigation on the Greenfields Division. Today, this structure is also necessary as a means of supplying water to the Willow Creek Feeder Canal (WCFC). The dam is a concrete arch with a structural height of 132 feet and is nestled between two massive outcrops of crystalline limestone. The dam crest consists of a 261-foot long, uncontrolled weir crest with a 10-foot width and a crest elevation of 4474.0.

Normal operation consists of all river flows passing over the dam crest except those being diverted into the PSC through the irrigation headworks situated on the right abutment of the dam. A river outlet works is located in the upstream face of the right (south) dam pier. The outlet has a limiting invert elevation of approximately 4458 and is used only to partially dewater the reservoir pond.

The river outlet works consist of a 4-foot wide by six-foot tall, slide gate. There is an unlined, horseshoe-shaped tunnel conduit upstream of the gate through limestone that measures 8 feet high and 8 feet wide. Downstream of the gate, the discharge conduit is a concrete-lined, tunnel excavation 5.33 feet high by 5.33 feet wide. The lined tunnel has reported length of 58 feet, a slope of 10 percent and discharges through a limestone cliff roughly 75 feet above the Sun River.

Photos showing the Diversion Dam outlet works tunnel interior and point of discharge into River below from cliff face below right pier.

At least two past efforts evaluated the potential for hydropower development at the Sun River Diversion Dam. In April 1981, a FERC application was prepared on behalf of the partnership of GID and Sun River Electric Co-op (SREC). The technical evaluation was performed by Tudor Engineering and concluded that a 2.3 MW plant could produce 10,500 MW-hours of electricity operating 10 months of the year. The proposed facility was to connect to the concrete-lined, river outlet works conduit downstream of the slide gate. A steel penstock approximately 500 feet long would
then convey the water to the powerhouse situated along the river. The number and configuration of the required turbines had not been evaluated. A 17-mile, 69kV transmission line was proposed to connect to SREC’s South Augusta substation. The project ultimately did not proceed as shifting energy economics yield infeasibilities.

As mentioned previously above, in August 1981, the Bureau of Reclamation finalized an appraisal-level study to investigate the potential for hydropower development at Gibson Dam and the Sun River Diversion Dam. It appears that Reclamation was discussing these projects in public meetings as early as July 1978. With respect to Diversion Dam, the study concluded that the power generation was not sufficient to offset development costs and as such was not considered feasible as a stand-alone project. However, when built in conjunction with the Gibson site, the study determined that a 1.6 MW plant was the most efficient and that it could operate year-round. It proposed the same facility development details and transmission route as the SREC-GID FERC application.

4.2.2.2 Power Potential – The power generation potential is based on the river flows not diverted for irrigation purposes and thus the flow passing over the Diversion Dam. The theoretical static head is the difference between the dam weir crest (4474) and the river below (approximately 4360) or 114 feet. The static head would increase when the river flow exceeds the capacity of the turbines.

For the purpose of my analysis, I considered two identical francis turbines with a capacity of 300 cfs each, 600 cfs total and a minimal discharge limit of 120 cfs for a single turbine. The construction cost estimate is $5.3M and involves considerable rock excavation as well as vertical support for the exposed penstock transcending down to the powerhouse situated along the Sun River. Other unique costs would include a new gate on the outlet works entrance, and bifurcation gate for the dual-use, outlet tunnel and possible a steel lining treatment for the outlet works tunnel. Transmission and related electrical costs are very low and assumes that a transmission line servicing Gibson Dam is in-place with sufficient capacity.

<table>
<thead>
<tr>
<th>Table 4.2.2 Summary of Diversion Dam Development Parameters</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location: N47°16'00&quot; W112°42'24&quot;</td>
</tr>
<tr>
<td>Water Source: Sun River</td>
</tr>
<tr>
<td>Operational Mode: Year Round</td>
</tr>
<tr>
<td>Turbine Flow Range: 120 to 600 cfs (2@300cfs)</td>
</tr>
<tr>
<td>Static Head Range: 114 to 116 feet</td>
</tr>
</tbody>
</table>
Head Loss Range: 1 to 5 feet
Turbine Head Range: 109 to 115 feet
Maximum Capacity: 4.6 MW
Annual Ave. Energy Production: 14,263 MW-Hrs
Ave. Annual Revenue, 1st 15 years(1): $567,250
Total Revenue, 1st 15 years(1): $8,508,800
Est. Construction Costs: $5,225,000
Est. Transmission Costs(2): $400,000

Note 1: Based on Northwestern 2020 Energy Tariffs
Note 2: Based 2020 HDR Transmission Study

The land comprising the Diversion Dam 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.

4.2.3 – PISHKUN REGULATING RESERVOIR –
4.2.3.1 Background and History – Pishkun is an off-stream reservoir 12 miles downstream from GID’s point of diversion, i.e. the Sun River Diversion Dam. It is supplied water by the Pishkun Supply Canal (PSC). The reservoir consists of series of interconnected prairie potholes and is geographically and topographically situated on the hydrologic divide between the Sun River and Teton River drainages. Originally, the regulating reservoir basically represented a wide spot in the supply canal delivering water to fields within the District.

The facility was initially constructed in 1914 to 1915 concurrently with the construction of the PSC. The operational capacity was increased from a series of enlargement efforts extending from the 1920’s to the 1940’s. These improvements consisted of raising the confining dikes thus incorporating additional potholes and depressions. Today, the reservoir has a reported, theoretical capacity of 46,700 acre-feet although the active or useable capacity is only 30,700 acre-feet. Nearly 16,000 acre-feet is unusable as it exists at an elevation lower than the elevation of the outlet.

The earthen embankments consist of multiple dikes surrounding and incorporating numerous naturally occurring, prairie potholes. These dikes vary in height up to 50 feet high and have a surface elevation of 4380. The operational limit of reservoir filling is restrictive to 10 feet less at elevation 4370.
Inflows are regulated and are a function of the available regulation storage, albeit temporary, and whether the reservoir level is rising or dropping. Reservoir level fluctuations are directly related to the rate of release necessary for the downstream demand for irrigation water and the PSC inflows.

The outlet works consist three slide gates each having a width of 3.3 feet and a height of 8 feet. The outlet conduit begins as a 12-foot by 12-foot rectangular concrete section and transitions to a horseshoe-shape with a 12-foot height and width. At the downstream section, this transitions back to a 12 by 12-foot rectangular section. The outlet works invert has an elevation of 4342.

A radial gate structure immediately downstream of the conduit outlet helps provide energy dissipation and back pressure against the outlet gates. Releases from Pishkun are to satisfy irrigation demands on the Greenfields District and generally commence in early to mid-May each year. Releases are terminated at the end of the irrigation season. The end of the season either corresponds to a depletion of the useable storage at Gibson and then at Pishkun or on a Board-established, shut-off day usually in October. The normal winter reservoir level is 4362 which is several feet over the concrete portal of the outlet works. Occasionally, in the past, the reservoir has been drained to a lower elevation for the winter to maximize available water for irrigation. Unfortunately, this practice exposes the 100-year old concrete to accelerated degradation from multiple freeze-thaw cycles. The maximum outlet release recorded was 1850 cfs which represented the maximum safe downstream channel capacity at that time.
Photo showing outlet releases from Pishkun Regulating Reservoir, +/-1,475 cfs. Note the back pressure radial gate is closed (submerged).

4.2.3.2 Power Potential – The power generation capacity is modelled by comparing the historical, daily reservoir level and the magnitude of the release on that day. The level of the Sun River Slope Canal is used to determine the turbine head.

The land comprising the Pishkun Dam as well as that needed for the proposed hydropower facility is on Reclamation withdrawn land.
4.3.3 – ARNOLD COULEE DROP –

4.3.3.1 Background and History – 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 static head is approximately 38 feet and would require approximately 400 lineal feet of penstock. 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. 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.

![Photo showing outlet releases from Arnold Coulee Drop, +/-1,350 cfs](image)

4.3.3.2 Power Potential – The power generation capacity of the Arnold Coulee Drop is directly related to the operation of the PSC.
### 4.3.3 Summary of Arnold Coulee Development Parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Location</td>
<td>Water Source: Willow Ck &amp; Feeder Canal</td>
</tr>
<tr>
<td>Operational Mode</td>
<td>Operational Mode: Seasonal</td>
</tr>
<tr>
<td>Turbine Flow Range</td>
<td>200 to 3,000 cfs</td>
</tr>
<tr>
<td>Static Head Range</td>
<td>60 to 171 feet</td>
</tr>
<tr>
<td>Head Loss Range</td>
<td>XX feet</td>
</tr>
<tr>
<td>Turbine Head Range</td>
<td>XX to XXX feet</td>
</tr>
<tr>
<td>Maximum Capacity</td>
<td>MW</td>
</tr>
<tr>
<td>Annual Ave. Energy Production</td>
<td>MW-Hrs</td>
</tr>
<tr>
<td>Ave. Annual Revenue, 1st 15 years(1)</td>
<td>$</td>
</tr>
<tr>
<td>Total Revenue, 1st 15 years(1)</td>
<td>$</td>
</tr>
<tr>
<td>Est. Construction Costs</td>
<td>$</td>
</tr>
<tr>
<td>Est. Transmission Costs</td>
<td>$</td>
</tr>
</tbody>
</table>

*Note 1: Based on Northwestern 2020 Energy Tariffs*

### 4.3.4 – PISHKUN INLET DROP –

#### 4.3.4.1 Background and History –

The Pishkun Inlet Drop is the terminus of the PSC where the canal drops into the Pishkun Regulation Reservoir. It is monolithic concrete construction whose inlet and pipe drop are very similar construction to the Arnold Coulee Drop described above. The outlet is a concrete bowl-shaped, submerged stilling basin having a lip elevation of 4347. This elevation is only 5 feet higher than the reservoir outlet invert (4342). The pool is hydraulically connected to Pishkun Reservoir and therefore the static head varies depending on the reservoir level. The minimum static head at full reservoir is 29 feet. This increases slightly as the reservoir level is lowered. The outlet stilling basin is shown below.
Photo showing PSC flows into Pishkun Reservoir, +/-1,350 cfs. Note red arrow shows location of inlet structure.

4.3.4.2 Power Potential – The power generation capacity of the Pishkun Inlet Drop is directly related to the operation of the PSC as well as the reservoir level.
## ARNOLD COULEE DROPPROJECTED REVENUE GENERATION

<table>
<thead>
<tr>
<th>Year</th>
<th>Off-Peak</th>
<th>On-Peak</th>
<th>Total</th>
<th>Total</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>$259,925</td>
<td>$248,741</td>
<td>$275,378</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
<tr>
<td>2021</td>
<td>$248,741</td>
<td>$275,378</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
<tr>
<td>2022</td>
<td>$275,378</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
<tr>
<td>2023</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
</tbody>
</table>

### ENERGY GEN. (MWhrs)

<table>
<thead>
<tr>
<th>Year</th>
<th>Jan</th>
<th>Feb</th>
<th>March</th>
<th>April</th>
<th>May</th>
<th>June</th>
<th>July</th>
<th>Aug</th>
<th>Sept</th>
<th>Oct</th>
<th>Nov</th>
<th>Dec</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2000</td>
<td>0</td>
<td>0</td>
<td>320</td>
<td>1712</td>
<td>1566</td>
<td>1807</td>
<td>1142</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,548</td>
</tr>
<tr>
<td>2001</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1253</td>
<td>1719</td>
<td>1807</td>
<td>626</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,409</td>
</tr>
<tr>
<td>2002</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>28</td>
<td>1352</td>
<td>1187</td>
<td>1807</td>
<td>1400</td>
<td>323</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,098</td>
</tr>
<tr>
<td>2003</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>190</td>
<td>1068</td>
<td>1749</td>
<td>1807</td>
<td>348</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,163</td>
</tr>
<tr>
<td>2004</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>426</td>
<td>1041</td>
<td>1717</td>
<td>1807</td>
<td>1090</td>
<td>195</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,276</td>
</tr>
<tr>
<td>2005</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1176</td>
<td>960</td>
<td>1807</td>
<td>830</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,775</td>
</tr>
<tr>
<td>2006</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1300</td>
<td>1538</td>
<td>1807</td>
<td>674</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,325</td>
</tr>
<tr>
<td>2007</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>294</td>
<td>518</td>
<td>1332</td>
<td>1726</td>
<td>1807</td>
<td>166</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8,842</td>
</tr>
<tr>
<td>2008</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>212</td>
<td>1387</td>
<td>1163</td>
<td>1807</td>
<td>1369</td>
<td>564</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,602</td>
</tr>
<tr>
<td>2009</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>878</td>
<td>1727</td>
<td>1799</td>
<td>943</td>
<td>1036</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,384</td>
</tr>
<tr>
<td>2010</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1004</td>
<td>1403</td>
<td>1807</td>
<td>1279</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,493</td>
</tr>
<tr>
<td>2011</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>463</td>
<td>527</td>
<td>1807</td>
<td>1723</td>
<td>1027</td>
<td>98</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8,644</td>
</tr>
<tr>
<td>2012</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>135</td>
<td>1588</td>
<td>1688</td>
<td>1807</td>
<td>1619</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>8,683</td>
</tr>
<tr>
<td>2013</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>426</td>
<td>1508</td>
<td>1558</td>
<td>1744</td>
<td>847</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,082</td>
</tr>
<tr>
<td>2014</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>725</td>
<td>579</td>
<td>1607</td>
<td>1356</td>
<td>535</td>
<td>21</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,654</td>
</tr>
<tr>
<td>2015</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>451</td>
<td>1288</td>
<td>1461</td>
<td>1800</td>
<td>279</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,277</td>
</tr>
<tr>
<td>2016</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>622</td>
<td>1339</td>
<td>1748</td>
<td>1768</td>
<td>26</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,502</td>
</tr>
<tr>
<td>2017</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>210</td>
<td>1413</td>
<td>1749</td>
<td>1807</td>
<td>1127</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>6,307</td>
</tr>
<tr>
<td>2018</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1297</td>
<td>1356</td>
<td>1807</td>
<td>1552</td>
<td>366</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>4,526</td>
</tr>
<tr>
<td>2019</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>1192</td>
<td>1636</td>
<td>1807</td>
<td>1170</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>5,825</td>
</tr>
<tr>
<td>2020</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>294</td>
<td>355</td>
<td>1,208</td>
<td>1,489</td>
<td>1,801</td>
<td>978</td>
<td>511</td>
<td>59</td>
<td>0</td>
<td>118,311</td>
</tr>
</tbody>
</table>

### Average for last 10 years

Total Ave for years shown 1,390 4,526 5,916

### Revenue Based on Ave MWhrs

<table>
<thead>
<tr>
<th>Year</th>
<th>Off-Peak</th>
<th>On-Peak</th>
<th>Total</th>
<th>Total</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>$259,925</td>
<td>$248,741</td>
<td>$275,378</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
<tr>
<td>2021</td>
<td>$248,741</td>
<td>$275,378</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
<tr>
<td>2022</td>
<td>$275,378</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
<tr>
<td>2023</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
<td>$277,121</td>
</tr>
</tbody>
</table>

### Total

$3,958,271
### Arnold Coulee Drop

#### Projected Revenue Generation

<table>
<thead>
<tr>
<th>Year</th>
<th>Off-Peak</th>
<th>On-Peak</th>
<th>Off-Peak</th>
<th>On-Peak</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>$30.63</td>
<td>$77.28</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2021</td>
<td>$28.73</td>
<td>$85.42</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2022</td>
<td>$27.99</td>
<td>$84.71</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2023</td>
<td>$28.77</td>
<td>$85.52</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2024</td>
<td>$29.54</td>
<td>$86.31</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2025</td>
<td>$30.36</td>
<td>$87.16</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2026</td>
<td>$31.28</td>
<td>$88.11</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2027</td>
<td>$31.85</td>
<td>$88.44</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2028</td>
<td>$31.90</td>
<td>$88.79</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2029</td>
<td>$32.21</td>
<td>$89.13</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2030</td>
<td>$32.54</td>
<td>$89.48</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2031</td>
<td>$32.85</td>
<td>$89.82</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2032</td>
<td>$33.16</td>
<td>$90.16</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2033</td>
<td>$33.45</td>
<td>$90.47</td>
<td>4.526</td>
<td>1.390</td>
</tr>
<tr>
<td>2034</td>
<td>$33.77</td>
<td>$90.82</td>
<td>4.526</td>
<td>1.390</td>
</tr>
</tbody>
</table>

**Total Revenue Based on $5 per MWhr (2000-2019)**

#### Estimated Annual O&M Costs

<table>
<thead>
<tr>
<th>Cost Category</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>SREC Wheeling Fees</td>
<td>$30.00</td>
</tr>
<tr>
<td>Property Taxes</td>
<td>$0</td>
</tr>
<tr>
<td>LOPP Fees</td>
<td>$0</td>
</tr>
<tr>
<td>Legal</td>
<td>$1.50</td>
</tr>
<tr>
<td>Engineering</td>
<td>$2.50</td>
</tr>
<tr>
<td>Accounting</td>
<td>$5.00</td>
</tr>
<tr>
<td>Insurance</td>
<td>$25.00</td>
</tr>
<tr>
<td>Operator Oversight</td>
<td>$2.00</td>
</tr>
<tr>
<td>Emergency Maint.</td>
<td>$2.50</td>
</tr>
<tr>
<td>Life-Cycle Costs</td>
<td>$0</td>
</tr>
</tbody>
</table>

**Total Estimated O&M Costs**

#### Funding Strategy Options

<table>
<thead>
<tr>
<th>Option</th>
<th>Cost (2020-2034)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1st Phase Infrastructure</td>
<td>$1,151,025</td>
</tr>
<tr>
<td>2nd Phase Finish Buildout</td>
<td>$2,275,500</td>
</tr>
<tr>
<td>Transmission/Electrical</td>
<td>$2,187,358</td>
</tr>
<tr>
<td>Total Construction Costs</td>
<td>$5,613,981</td>
</tr>
<tr>
<td>DNRC RRGL Grant</td>
<td>$125,000</td>
</tr>
<tr>
<td>USBR Water Smart Grant</td>
<td>$2,000,000</td>
</tr>
<tr>
<td>DNRC RDGP Grant</td>
<td>$1</td>
</tr>
<tr>
<td>USDA REAP Grant</td>
<td>$500,000</td>
</tr>
<tr>
<td>Tax Credit (30% of Equip)</td>
<td>$682,650</td>
</tr>
<tr>
<td>DOE Incentive ($0.01/kW-hr)</td>
<td>$450,010</td>
</tr>
<tr>
<td>GID In-Kind Services</td>
<td>$600,000</td>
</tr>
<tr>
<td>Unfunded Balance</td>
<td>$1,166,222</td>
</tr>
</tbody>
</table>

**SREC Wheel Rate**

$0.005 kWhr

**Loan Option**

- **Interest Rate**: 1.50%
- **Loan Length, Years**: 15
- **Annual Payment**: $87,402
- **Total Payment Over Loan**: $1,311,028
- **Total Interest Over Loan**: $144,804

<table>
<thead>
<tr>
<th>Year</th>
<th>Revenue</th>
<th>O&amp;M</th>
<th>Loan Payment</th>
<th>Net</th>
</tr>
</thead>
<tbody>
<tr>
<td>2020</td>
<td>$259,925</td>
<td>$88,501</td>
<td>$87,402</td>
<td>$84,023</td>
</tr>
<tr>
<td>2021</td>
<td>$269,741</td>
<td>$86,829</td>
<td>$87,402</td>
<td>$71,511</td>
</tr>
<tr>
<td>2022</td>
<td>$244,405</td>
<td>$91,176</td>
<td>$87,402</td>
<td>$65,828</td>
</tr>
<tr>
<td>2023</td>
<td>$249,061</td>
<td>$90,543</td>
<td>$87,402</td>
<td>$69,116</td>
</tr>
<tr>
<td>2024</td>
<td>$253,644</td>
<td>$90,931</td>
<td>$87,402</td>
<td>$72,311</td>
</tr>
<tr>
<td>2025</td>
<td>$258,536</td>
<td>$95,340</td>
<td>$87,402</td>
<td>$75,794</td>
</tr>
<tr>
<td>2026</td>
<td>$265,837</td>
<td>$96,770</td>
<td>$87,402</td>
<td>$79,484</td>
</tr>
<tr>
<td>2027</td>
<td>$269,771</td>
<td>$99,995</td>
<td>$87,402</td>
<td>$80,674</td>
</tr>
<tr>
<td>2028</td>
<td>$269,647</td>
<td>$101,191</td>
<td>$87,402</td>
<td>$81,054</td>
</tr>
<tr>
<td>2030</td>
<td>$279,227</td>
<td>$102,709</td>
<td>$87,402</td>
<td>$81,156</td>
</tr>
<tr>
<td>2031</td>
<td>$273,502</td>
<td>$104,409</td>
<td>$87,402</td>
<td>$81,156</td>
</tr>
<tr>
<td>2032</td>
<td>$275,379</td>
<td>$105,812</td>
<td>$87,402</td>
<td>$82,163</td>
</tr>
<tr>
<td>2033</td>
<td>$277,121</td>
<td>$107,400</td>
<td>$87,402</td>
<td>$82,319</td>
</tr>
<tr>
<td>2034</td>
<td>$279,036</td>
<td>$109,011</td>
<td>$87,402</td>
<td>$82,643</td>
</tr>
<tr>
<td>2035</td>
<td>$281,099</td>
<td>$110,646</td>
<td>$87,402</td>
<td>$82,804</td>
</tr>
<tr>
<td>2036</td>
<td>$282,976</td>
<td>$112,506</td>
<td>$87,402</td>
<td>$87,361</td>
</tr>
<tr>
<td>2037</td>
<td>$284,957</td>
<td>$115,301</td>
<td>$87,402</td>
<td>$87,166</td>
</tr>
<tr>
<td>2038</td>
<td>$286,952</td>
<td>$119,700</td>
<td>$87,402</td>
<td>$87,150</td>
</tr>
<tr>
<td>2039</td>
<td>$288,950</td>
<td>$121,436</td>
<td>$87,402</td>
<td>$87,150</td>
</tr>
<tr>
<td>2040</td>
<td>$290,953</td>
<td>$119,177</td>
<td>$87,402</td>
<td>$87,150</td>
</tr>
<tr>
<td>2041</td>
<td>$292,950</td>
<td>$120,985</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2042</td>
<td>$294,051</td>
<td>$122,800</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2043</td>
<td>$297,137</td>
<td>$124,642</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2044</td>
<td>$299,227</td>
<td>$126,512</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2045</td>
<td>$301,311</td>
<td>$128,410</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2046</td>
<td>$303,420</td>
<td>$130,336</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2047</td>
<td>$305,544</td>
<td>$132,291</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2049</td>
<td>$307,683</td>
<td>$134,273</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2048</td>
<td>$309,837</td>
<td>$136,298</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
<tr>
<td>2050</td>
<td>$312,006</td>
<td>$138,334</td>
<td>$87,402</td>
<td>$87,402</td>
</tr>
</tbody>
</table>
## TRANSMISSION COST ESTIMATE

Greenfields Irrigation District  
Arnold Coulee Drop Hydro  

<table>
<thead>
<tr>
<th>ITEM</th>
<th>DESCRIPTION</th>
<th>QNTY</th>
<th>UNIT</th>
<th>UNIT PRICE</th>
<th>AMOUNT</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>UTILIZE 3-PHASE DIST.</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>P1.1</td>
<td>Bypass North Augusta Substation regulators and install individual feeder regulation on platforms outside of North Augusta Substation</td>
<td>1</td>
<td>LS</td>
<td>$150,000</td>
<td>$150,000</td>
</tr>
<tr>
<td>P1.2</td>
<td>Install a new three phase 150 amp line voltage regulator bank at G1-61</td>
<td>1</td>
<td>LS</td>
<td>$45,000</td>
<td>$45,000</td>
</tr>
<tr>
<td>P1.3</td>
<td>Replace single phase regulator with a new 150 amp three phase regulator bank at G2-57</td>
<td>1</td>
<td>LS</td>
<td>$45,000</td>
<td>$45,000</td>
</tr>
<tr>
<td>P1.4</td>
<td>Install a new three phase regulator bank on new tap north of G2-132</td>
<td>1</td>
<td>LS</td>
<td>$45,000</td>
<td>$45,000</td>
</tr>
<tr>
<td>P1.5</td>
<td>Relocate single phase line voltage regulator from G2-121A to G2-142</td>
<td>1</td>
<td>LS</td>
<td>$5,000</td>
<td>$5,000</td>
</tr>
<tr>
<td>P1.6</td>
<td>Replace G2-10 recloser with a three phase electronic recloser with transfer tripping scheme</td>
<td>1</td>
<td>LS</td>
<td>$30,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>P1.7</td>
<td>Install a three phase electronic recloser with transfer tripping scheme north of G2-132</td>
<td>1</td>
<td>LS</td>
<td>$30,000</td>
<td>$30,000</td>
</tr>
<tr>
<td>P1.8</td>
<td>Construct 3.7 miles of three phase 4/0 ACSR distribution line on new transmission line framed for TP-69 and 336 ACSR. Retire existing line in shared right of way.</td>
<td>3.7</td>
<td>Miles</td>
<td>$314,546</td>
<td>$1,163,818</td>
</tr>
<tr>
<td><strong>P1.8a</strong></td>
<td>Construct 4.0 miles of 69 kV transmission line with 3 phase 4/0 ACSR underbuild.</td>
<td>4.0</td>
<td>Miles</td>
<td>$108,292</td>
<td>$433,168</td>
</tr>
<tr>
<td>P1.9</td>
<td>Construct 2.3 miles of three phase 4/0 ACSR distribution line to Arnold Coulee</td>
<td>2.3</td>
<td>Miles</td>
<td>$96,957</td>
<td>$223,000</td>
</tr>
<tr>
<td>P1.10</td>
<td>Single phase reclosers with electronic single phase reclosers (not shown)</td>
<td>1</td>
<td>LS</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
<tr>
<td>P1.11</td>
<td>Relocate three phase regulator bank from G6-90 to G6-65 (not shown)</td>
<td>1</td>
<td>LS</td>
<td>$10,000</td>
<td>$10,000</td>
</tr>
</tbody>
</table>

**TOTAL** | **$2,189,986** | **$0** |
P1.1 Install individual feeder regulation

P1.2 New three phase 150 amp line voltage regulators

P1.3 Replace with three phase 150 amp line voltage regulators

P1.4 New three phase 150 amp line voltage regulators

P1.6 Construct 7.7 miles of three phase 4/0 ACSR distribution line on new transmission line framed for TP-69 and 338 ACSR. Retire existing line in shared right of way.

P1.7 Install new three phase electronic recloser

P1.8 Replace recloser with three phase electronic recloser

P1.9 Construct 2.3 miles of three phase 4/0 ACSR distribution line to Arnold Coulee

Arnold Coulee 2,400 kW

Substation Land

3 way Transmission Switch

P1.5 Relocate single phase line voltage regulator

4/0 ACSR distribution line on new transmission line.
<table>
<thead>
<tr>
<th>Year</th>
<th>Qmax</th>
<th>Qmin</th>
<th>Area=</th>
</tr>
</thead>
<tbody>
<tr>
<td>2019</td>
<td>1,028</td>
<td>1,144</td>
<td>1 ft</td>
</tr>
<tr>
<td>2019</td>
<td>2,272</td>
<td>2,772</td>
<td>1,572</td>
</tr>
</tbody>
</table>
PRELIMINARY LEASE AND FUNDING AGREEMENT
BETWEEN THE
U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION
GREAT PLAINS REGION
and
GREENFIELDS IRRIGATION DISTRICT

This Preliminary Lease and Funding Agreement (Agreement) made this 20TH day of
August, 2020, pursuant to the Reclamation Act of June 17, 1902 (32 Stat. 388), and acts
amendatory thereof and supplementary thereto, particularly the Townsites and Power
Development Act of April 16, 1906 (43 U.S.C § 522), the Reclamation Extension Act of August
13, 1914 (38 Stat. 686), the Sundry Civil Expenses Appropriations Act for 1922 of March 4,
704), the Omnibus Adjustment Act of May 25, 1926 (44 Stat. 636), and Section 9(c) of the
Reclamation Project Act of August 4, 1939 as amended by the Bureau of Reclamation Small
485h(c)) is between the United States Department of the Interior, Bureau of Reclamation
(Reclamation), and Greenfields Irrigation District (hereinafter referred to as “GID”). The United
States and GID hereinafter are each sometimes individually called “Party,” and sometimes
collectively called the “Parties.” The purpose of this Agreement is to recognize that GID has
priority for a Lease of Power Privilege (LOPP), and to define the cost reimbursability, roles and
responsibilities of Reclamation and GID for completion of activities necessary to implement the
LOPP.

EXPLANATORY RECITALS

The following statements are made in explanation:

a. WHEREAS, the United States has constructed the Greenfields Division of the Sun River
Project, Montana, pursuant to the Reclamation Act of June 17, 1902, for the use of the waters of
Sun River from storage in Gibson Reservoir for irrigation water supply; and

b. WHEREAS, Reclamation has the authority to issue an LOPP pursuant to the Townsites
and Power Development Act of April 16, 1906 (43 U.S.C § 522), and Section 9(c) of the
Reclamation Project Act of 1939 (43 U.S.C. § 485h(c)); and

c. WHEREAS, the Bureau of Reclamation Small Conduit Hydropower Development and
Rural Jobs Act of August 9, 2013 (127 Stat. 498) established priority rights to Irrigation Districts
and Water Users Associations operating or receiving water from Reclamation conduits on small
hydropower development; and
WHEREAS, the GID is responsible for the operation and maintenance of the Greenfields Division and appurtenant facilities under Contract No. 11r-537 dated June 22, 1926; and

f. WHEREAS, the United States and the GID are joint owners of Water Right No. 41K 40869-00 for the use of Project water from the Sun River and Gibson Dam for an irrigation water supply; and

g. WHEREAS, on August 7, 2018, the GID formally requested to initiate Reclamation’s LOPP process for the Arnold Coulee Drop; and

h. WHEREAS, on June 11, 2018, the GID submitted a Feasibility Study application for development of a 2.5 Megawatt hydroelectric facility at the Arnold Coulee Drop; and

i. WHEREAS, the proposal was reviewed by Reclamation staff and was determined to be acceptable and issuance of a Preliminary Lease may proceed; and

j. WHEREAS, a Preliminary Lease is non-transferrable and does not guarantee that a LOPP will ultimately be awarded; and

k. WHEREAS, this Preliminary Lease is only granted for further development presented within the application, as modified below; and

l. WHEREAS, Reclamation has the authority for the acceptance of non-federal funds through the Sundry Civil Expenses Appropriations Act for 1922 of March 4, 1921 (43 U.S.C. § 395); and

m. WHEREAS, the electricity generated by the hydropower plant located on Arnold Coulee Drop will provide a clean, renewable energy source; and

n. WHEREAS, Reclamation shall follow previously established processes, timelines and guidelines as outlined within Reclamation Manual Directive and Standard, Lease of Power Privilege (LOPP) Processes, Responsibilities, Timelines, and Charges (FAC 04-08); and

o. WHEREAS, in accordance with the Anti-Deficiency Act of September 13, 1982 (31 U.S.C. 1341 et seq.), funds must be provided to Reclamation in advance of activities performed by Reclamation personnel.

NOW, THEREFORE, in consideration of the mutual and dependent covenants herein contained, it is hereby mutually agreed as follows:

I. BACKGROUND AND OBJECTIVES

Construction of the Pishkun Supply Canal and the Arnold Coulee Drop was completed in 1915
as part of Reclamation's Sun River Project, Greenfields Division, which was authorized by the Reclamation Act of 1902. Arnold Coulee Drop is located in Teton County, Montana, approximately 28 miles west of Fairfield, MT. The Arnold Coulee Drop is owned by the United States, while GID provides operation, maintenance, and replacement through formal contracts with Reclamation.

The proposed 2.5 MW project will modify the existing Arnold Coulee drop structure. The proposed intake will convey the Pishkun Supply Canal flows through a new diversion structure situated adjacent to the existing intake and connect to the proposed powerhouse, which will be located adjacent to the current outlet structure of the existing drop. Flow will then return to the existing canal. The proposed diversion will be a parallel bypass of water and will not affect irrigation use nor diminish the quality or quantity of water in the canal.

This Agreement will define the various responsibilities of each of the Parties, provide for the necessary coordination and access to the facilities, and establish a reimbursable account to which GID would advance funds to cover Reclamation's cost for work activities completed in support of the LOPP.

II. PURPOSE, NEED AND COORDINATION

As the Preliminary Lease activities move forward, mutual coordination of information and design data shall be required of both Parties. As such, those tasks completed by Reclamation in support of GID's pursuit of hydroelectric development at Arnold Coulee Drop need to be delineated and accounted for. Reclamation and GID recognize the need to develop mutual contact points for efficient and timely coordination and information flow.

III. ACTIVITIES COVERED AND REIMBURSABLE COSTS

A. Reclamation Activities: GID shall fund Reclamation for all costs incurred as a result of Reclamation's participation in activities associated with this Agreement. Reclamation's reimbursable activities and associated costs shall include, but not be limited to, the following activities:

1. Provide project management and coordination activities associated with Reclamation's involvement with the proposed project.
2. Be the lead agency for ensuring compliance with the National Environmental Policy Act (NEPA), Endangered Species Act (ESA) and National Historic Preservation Act (NHPA);
3. Review GID plans, reports, designs and studies necessary to ensure the following:
   a. Completion of NEPA, NHPA, ESA and other statutory requirements.
   b. Ensuring that the efficiency of water deliveries will not be impaired.
   c. Ensuring public safety and the continued safe operation and structural integrity of Reclamation facilities is maintained.
4. Conduct site visits and attend meetings as necessary and appropriate with GID and other agencies and groups regarding the development of the proposed project.
5. Provide information to GID including available copies of reports, drawings, technical data, operational data, geological data, and other data as requested.
6. Draft the final LOPP for the proposed project to establish conditions for construction and operation, maintenance, and replacement of the hydroelectric facility in order to assure that the operations, safety, integrity, and environment of the Federal facility are protected.
7. Request advancement of funds from GID with estimates for each proposed activity to be undertaken with the understanding that unexpended or unobligated funds previously advanced shall be returned to GID should they be determined unnecessary.
8. Provide an accounting of expenses and an estimate of future expenses when requesting additional funds from GID.
9. Establish a specific account (Federal Account) and receive funds advanced by GID.
10. Advise GID in writing if additional funds in excess of the initial advance and/or the cost estimate are needed. Reclamation will also advise GID of any anticipated significant expenses that may be required beyond the initial estimate. Such notification will be made in advance of such expenditures.
11. Perform any other authorized activity or activities, as mutually agreed upon by GID and Reclamation.

B. GID Activities:

1. Develop a mutually agreeable schedule of activities anticipated to be completed under this Agreement.
2. Complete and transmit to Reclamation for review any associated draft plans, reports, designs, specifications and studies necessary for the following:
   a. Ensuring that the efficiency of water operations will not be impaired.
   b. Ensuring public safety and the continued safe operation and structural integrity of the Reclamation facilities is maintained.
3. Assist Reclamation, as requested, with completion of activities required to comply with NEPA, NHPA, ESA and other statutory requirements.
4. Assist Reclamation in arranging public involvement, including meeting places and notices to the public.
5. Provide Reclamation with a final construction report including record drawings and operational procedures of the components directly related to delivery of irrigation water.
6. Pay costs pursuant to Section III (A) and V, herein.

IV. TERM OF AGREEMENT

A. This Agreement shall terminate upon the earliest occurrence of any of the following: (i) the date of execution of the LOPP; (ii) fifteen (15) months from the date of issuance of this Agreement unless otherwise extended by Reclamation; (iii) upon mutual agreement of the Parties; or (iv) failure by GID to advance additional funding for continuation of activities identified in Section III.A., above.
B. This Agreement may be extended or modified only in a writing signed by each Party.

V. ADVANCEMENT OF NON-FEDERAL FUNDS/PAYMENT FOR SERVICES

In accordance with Anti-Deficiency Act, funds must be provided to Reclamation in advance of activities performed by Reclamation personnel. GID shall advance to Reclamation its share of the funds necessary to accommodate Reclamation's expenditures for the work defined in Section III of this Agreement. Payment of GID's share can be in one lump sum, in partial payments prior to work being performed, or other methods as best conforms to GID's budgetary processes, provided funds are received in advance of activities performed by Reclamation personnel. Estimated costs will be provided upon receipt of work request from GID.

In the event that funds advanced to Reclamation are not required to complete the planned work, such unused funds shall be returned by Reclamation without interest, within 60 days of completion of the work defined in Section III, unless otherwise agreed upon. In the event the authorized representatives agree on additional work consistent with the commitment of this Agreement, such excess funds may be retained by Reclamation for additional work as approved by GID.

There will be no Federal funding associated with the work covered by this Agreement.

VI. INDEMNITY

GID agrees to indemnify Reclamation for, and hold Reclamation and all of its representatives harmless from, all damages resulting from suits, actions, or claims of any character brought on account of any injury to any person or property arising out of any act, omission, neglect, or misconduct in the manner or method of performing any activities relating to this Agreement.

VII. REPORTING

Reclamation will provide monthly reports to GID summarizing expenditures charged against funds advanced and to-date expenditures. GID will be entitled to challenge any expenses that it deems to be excessive or unreasonable. If a challenge is asserted, Reclamation and GID will promptly meet to resolve the concerns and agree on an appropriate adjustment, if any. Should GID determine to not advance additional funding for any expenses, this Agreement will terminate pursuant to Section IV.A., above.

VIII. REQUIRED CLAUSES

During the performance of this Agreement, the Parties agree to abide by the terms of Executive Order 11246 on non-discrimination, and will not discriminate against any person because of race, color, religion, sex, national origin, age, or disability. The Parties will take affirmative action to ensure that applicants are employed without regard to their race, color, religion, sex,
national origin, age, or disability.

No member or delegate to Congress, resident Commissioner, or official of GID shall benefit from this Agreement, other than as a water user or landowner in the same manner as other water users or landowners.

IX. POINTS OF CONTACT

The following representatives will be responsible for coordinating activities included under this Agreement:

Reclamation
Sean Keeney
Civil Engineer
Bureau of Reclamation
P.O. Box 36900
Billings, MT 59107-6900
(406) 247-7309
E-mail: dkeeney@usbr.gov

Greenfields Irrigation District
Erling Juel
District Manager
Greenfields Irrigation District
P.O. Box 157
Fairfield, MT 59436
(406) 467-2533
E-mail: erling@gid-mt.com
In witness whereof, the Parties hereto have executed this Agreement on the last date and year written below:

UNITED STATES
BUREAU OF RECLAMATION

Brent C Eshlin
Missouri Basin Regional Director

Date

GREENFIELDS IRRIGATION DISTRICT

Erling Jodel
District Manager

Date

President
Greenfields Irrigation District Board

Date
1. THE Bypass TRIPS GATES 51-W.W. be reHIsted in Model SECTIONS. SEE THE super SHUTTER DIIs PlAces FOR CONCRETE & RELATED REQUIREMENTS.

2. FOR CURBING, THE TERM "CHUTE" OR "FLUME" IS USED TO DESCRIBE THE SOUTH CHANNEL. CONCRETE CHANNELS AND NEXT TO CURB TYPE CURB STOOPLS FOR ENTIRE BANKED BARRIER. SEE CURB WITH RISERS.

3. GRADE ON PIPING AS DIRECTED BY THE ENGINEER. GRADE AT A -1% SLOPE TO THE FLUME STRUCTURE.

4. INTAKE WORK IS NOT SHOWN. WORKSHOPS ARE TO BE CONNECTED AT GRADE BY PIPE TO THE 20 BPM IN THE JACAL, SUBMARINE AND SUPPORTS ARE TO BE NO HIGHER THAN 1'-0".

NOTES:

- INSTALL BIT WALL BOLLARDS OR COVER PLATE AS INSTRUCTED BY THE ENGINEER.
- DRAIN PIPING TO SLIDE AT A -1% SLOPE AND EMPTIED INTO THE EXISTING CONCRETE FLUME.
- DRAIN PIPING TO REST ON TOP OF EXIST CHUTE ABOVE NAIL.
- DRAIN PIPING TO REST INTO THE EXISTING CONCRETE FLUME.
- DAYLIGHT EXPOSED SECTION TO BE NESTED IN CONCRETE SLIDE AT TOP OF EXIT CHUTE ABOVE NAIL.
- DAYLIGHT EXPOSED SECTION TO BE NESTED IN CMP SLIDE AT TOP OF EXIT CHUTE ABOVE NAIL.

SHAPES: 1:300 = 1'-0"

NOTE: THE DRAWING SHEET HAS BEEN REDUCED TO 1/2 SIZE FOR CONVENIENCE.
20mil PVC membrane (typ below entire intake structure)

Compact beneath penstock pipe perfor detail

20mil PVC membrane typ below entire intake structure

2. Typical construction joints are 1/2" x 1/2" unless otherwise noted.
SELECT BACKFILL OVER DRAFT TUBE ENCASEMENT CONCRETE
REMOVABLE STEEL BIRD WATCH CENTERED OVER GENERATOR

REPAIR THRUST CAGE AROUND GEN ANCHOR BOLTS SEE ITEM 25
STEEL SCROLL CASE ASSY

NOTE:
1. ALL INFILL CONCRETE SHALL HAVE #5 REBAR AT 12" OC EACH WAY AT 2"
   CLEAR AROUND ALL EDGES, TOP & BOTTOM SURFACES AND ADJACENT TO
   ALL TURBINE AND EQUIPMENT SURFACES.
2. SEE DETAIL 2 ON SHEET S-26 FOR DRAINAGE AND BACKFILL REQUIREMENTS.

REBAR THRUST CAGE AROUND GEN ANCHOR BOLTS SEE DETAIL 3
STEEL SCROLL CASE INSPECTION MANWAY

END OF SUPPLY BY TURBINE SUPPLIER

NOTE:
1. ALL INFILL CONCRETE SHALL HAVE #5 REBAR AT 12" OC EACH WAY AT 2"
   CLEAR AROUND ALL EDGES, TOP & BOTTOM SURFACES AND ADJACENT TO
   ALL TURBINE AND EQUIPMENT SURFACES.
2. SEE DETAIL 2 ON SHEET S-26 FOR DRAINAGE AND BACKFILL REQUIREMENTS.

REBAR THRUST CAGE AROUND GEN ANCHOR BOLTS SEE DETAIL 3
STEEL SCROLL CASE INSPECTION MANWAY

END OF SUPPLY BY TURBINE SUPPLIER

NOTE:
1. ALL INFILL CONCRETE SHALL HAVE #5 REBAR AT 12" OC EACH WAY AT 2"
   CLEAR AROUND ALL EDGES, TOP & BOTTOM SURFACES AND ADJACENT TO
   ALL TURBINE AND EQUIPMENT SURFACES.
2. SEE DETAIL 2 ON SHEET S-26 FOR DRAINAGE AND BACKFILL REQUIREMENTS.

REBAR THRUST CAGE AROUND GEN ANCHOR BOLTS SEE DETAIL 3
STEEL SCROLL CASE INSPECTION MANWAY

END OF SUPPLY BY TURBINE SUPPLIER

NOTE:
1. ALL INFILL CONCRETE SHALL HAVE #5 REBAR AT 12" OC EACH WAY AT 2"
   CLEAR AROUND ALL EDGES, TOP & BOTTOM SURFACES AND ADJACENT TO
   ALL TURBINE AND EQUIPMENT SURFACES.
2. SEE DETAIL 2 ON SHEET S-26 FOR DRAINAGE AND BACKFILL REQUIREMENTS.

REBAR THRUST CAGE AROUND GEN ANCHOR BOLTS SEE DETAIL 3
STEEL SCROLL CASE INSPECTION MANWAY

END OF SUPPLY BY TURBINE SUPPLIER

NOTE:
1. ALL INFILL CONCRETE SHALL HAVE #5 REBAR AT 12" OC EACH WAY AT 2"
   CLEAR AROUND ALL EDGES, TOP & BOTTOM SURFACES AND ADJACENT TO
   ALL TURBINE AND EQUIPMENT SURFACES.
2. SEE DETAIL 2 ON SHEET S-26 FOR DRAINAGE AND BACKFILL REQUIREMENTS.
12" wide x 5" deep stop log groove typ both sides of tailrace.

Floor of rock trap @ el TBD

#60 12" OC typ all around

Retaining wall typ both sides of tailrace. See sheets S-19 & S-20 for configuration of footings & wall.

12" wide x 5" deep stop log groove typ both sides of tailrace.

Floor of rock trap @ el TBD

#60 12" OC typ all around

Retaining wall typ both sides of tailrace. See sheets S-19 & S-20 for configuration of footings & wall.

18" wide by 12" deep grade beam @ (2) all long bars typ ea side of pm.

Draft tube steel liner by turbine supplier.

Sloped slab

End of draft tube steel liner

Centerline of tube & draft tube

Provide (2) #8 Dayton D101A splicer bars ± 3" long to tie to grade beam typ ea side of pm.

See item (2).

Turbine scroll case & runner

Scale: 1/4" = 1'-0"

1-17

Note:
All infill concrete shall have 8# rebar at 1" OC each way @ 2" clear around all edges, top & bottom surfaces and adjacent to all turbine and equipment surfaces.

End of supply by turbine supplier

11' 10" steel penstock pipeline

Centerline of tube & draft tube

1-6'

17'-4"'

14'-4"'

13'-11/2"'

1-1/2" CLR

1-1 1/2 CLR (Typ)

1-12" OC Typ All Around

1-18" OC Typ All Around

1-4"'

1-6"'

3'

20'

35'

1-8"'

20'

30'

1-12" OC Typ All Around

1-18" OC Typ All Around
Main Canal

January 2016
# Table of Contents

<table>
<thead>
<tr>
<th>Contents</th>
<th>Page</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Executive Summary</td>
<td>5</td>
</tr>
<tr>
<td>2. Introduction</td>
<td>6</td>
</tr>
<tr>
<td>3. Background</td>
<td>7</td>
</tr>
<tr>
<td>3.1 Greenfields Irrigation District</td>
<td>7</td>
</tr>
<tr>
<td>3.2 Rubicon Water</td>
<td>8</td>
</tr>
<tr>
<td>3.3 Rubicon’s USA Team</td>
<td>9</td>
</tr>
<tr>
<td>3.4 Rubicon’s Approach to Saving Water</td>
<td>10</td>
</tr>
<tr>
<td>3.5 Network Control</td>
<td>11</td>
</tr>
<tr>
<td>3.6 Benefits Provided by Network Control</td>
<td>13</td>
</tr>
<tr>
<td>3.7 Case Study – Coleambally Irrigation Cooperative</td>
<td>14</td>
</tr>
<tr>
<td>3.8 Case Study – Shepparton Irrigation Area</td>
<td>14</td>
</tr>
<tr>
<td>3.9 Case Study – Oakdale Irrigation District</td>
<td>15</td>
</tr>
<tr>
<td>3.10 Case Study – Northern Victoria Irrigation Renewal Project</td>
<td>16</td>
</tr>
<tr>
<td>3.11 Improving Business Processes with Confluent Management Software</td>
<td>16</td>
</tr>
<tr>
<td>4. The Opportunity to Save Water in GID</td>
<td>19</td>
</tr>
<tr>
<td>4.1 Expected System Performance Outcomes</td>
<td>20</td>
</tr>
<tr>
<td>5. Implementing Water Savings Improvements in Greenfield Irrigation District’s Main Canal</td>
<td>21</td>
</tr>
<tr>
<td>5.1 Canal Overview</td>
<td>21</td>
</tr>
<tr>
<td>5.1.1 System Operations and Flow Capacities</td>
<td>24</td>
</tr>
<tr>
<td>5.1.2 Existing Check Structure Information</td>
<td>25</td>
</tr>
<tr>
<td>6. Proposed Approach</td>
<td>26</td>
</tr>
<tr>
<td>6.1 STEP 1: Upgrade of inline check structure with water-tight precision flow control gates</td>
<td>28</td>
</tr>
<tr>
<td>6.1.1 Pishkun Headworks</td>
<td>28</td>
</tr>
<tr>
<td>6.1.2 Check 71</td>
<td>29</td>
</tr>
<tr>
<td>6.1.3 Spring Valley Headworks</td>
<td>31</td>
</tr>
<tr>
<td>6.1.4 Ring-Ring</td>
<td>32</td>
</tr>
<tr>
<td>6.1.5 Upper Turnbull Hydro and Drop</td>
<td>34</td>
</tr>
<tr>
<td>6.1.6 Lower Turnbull Hydro and Drop</td>
<td>35</td>
</tr>
<tr>
<td>6.1.7 Mary Taylor</td>
<td>37</td>
</tr>
<tr>
<td>6.2 STEP 2: The installation of a radio telemetry network and SCADA software to allow the remote operation and control of these gates</td>
<td>39</td>
</tr>
<tr>
<td>6.3 STEP 3: The tuning of controllers to allow these gates to cooperate to match supplied flow to downstream demand</td>
<td>43</td>
</tr>
<tr>
<td>6.4 STEP 4: Automation of lateral offtakes</td>
<td>44</td>
</tr>
</tbody>
</table>
6.5 STEP 5: Measurement (and Control) of Farm Turnouts

7. Pricing Summary

7.1 Assumptions and Clarifications

7.2 Exclusions

8. Implementation

9. Conclusions

10. Appendix – References

10.1 Relevant Experience

11. Supporting Documentation

11.1 Network Control Implementation Case Studies

11.2 Network Control System Component Datasheets

11.3 Network Control Solution Videos

Table of Figures

Figure 1 - Rubicon Network Control

Figure 2 - Google Earth Map showing the Main Canal

Figure 3 - Schematic Overview of the Main Canal

Figure 4 - Schematic of Main Canal – Pishkun Reservoir to Spring Valley Headworks

Figure 5 Schematic Symbols

Figure 6 - Schematic of Main Canal – Spring Valley Headworks to Ring- Ring Regulator

Figure 7 - Main Canal – Ring-Ring Regulator to Nine Feet Drop

Figure 8 - Main Canal – Nine Feet Drop to Mary Taylor

Figure 9 - Schematic Symbols

Figure 10 - Managing constant pool volumes to eliminate spill

Figure 11 - SRS 71 Check Structure

Figure 12 - Spring Valley Headworks Check Structure

Figure 13 - Ring Ring Check Structure

Figure 14 - Upper Turnbull Drop and Hydro Power Station

Figure 15 - Lower Turnbull Drop and Power Station

Figure 16 - Mary Taylor Drop and GSC Headworks

Figure 17 - Radio Path Survey From Pishkun to Mary Taylor Drop

Figure 18 - Radio Path Analysis - Pishkun Reservoir to Lower Turnbull

Figure 19 - Radio Path Analysis – Mary Taylor Drop to Spring Valley Headworks

Figure 20 - Coverage to Check 71 provided by Repeater at Spring Valley Headworks
1. Executive Summary

Greenfields Irrigation District (GID) is looking for options to modernize its infrastructure to improve overall customer service and operating efficiencies. The long travel times in the main canal can result in significant spill, despite the best efforts of the operators. This operational spill can be reduced by using precise real-time flow controllers at key structures to enable the main canal to provide in-system storage to capture water within the system when diversions are reduced from Pishkun Reservoir in response to reduced demand.

Rubicon Water supplies mature and proven technology to eliminate operational spills in open canal networks by precisely matching supplied flows to demand. Rubicon’s Network Control solutions have been in operation for more than thirteen years and are helping many districts worldwide to improve distribution efficiency by precisely matching supplied flows to demand at all points through the network.

It has been identified that Rubicon’s approach to eliminating system spills can be applied to Greenfield’s Main Canal, and this report details Rubicon’s approach and presents a proposed solution.

Rubicon’s flow control solutions will enable Greenfields Irrigation District to match the water supplied within the main canal to aggregate demand in real time and will continually regulate the reservoir headworks and main canal regulating structures to maintain a constant volume of water in the main canal independent of demand fluctuations. This will reduce the return flows to the Sun River via Muddy Creek and other tributaries and result in significant water savings and environmental benefits.

It is believed that the spills from the main canal can be greatly reduced under normal conditions, saving up to 70,000 acre-feet of water per year.

A phased implementation is proposed, with an estimated build out price of $1,549,752 for automation of the main canal. This investment in Rubicon’s solution will reduce spill from the Main Canal by precisely matching supply with demand. Operational spills will be eliminated leaving more water in storage for later availability to farmers and allowing less water to be diverted from the Sun River. The volume of water historically lost from operational spills can be retained in storage, reducing the required diversions from the Sun River and making more water available to irrigators in dry years.
2. Introduction

This report provides an analysis of the costs and benefits of installing water-tight precision automated gates and a supervisory control system to eliminate spill and surplus flow in Greenfields Irrigation District’s Main Canal, preventing surplus flows to Muddy Creek and retaining the recovered water in Pishkun Reservoir for use later in the growing season or in future dry years, and thereby allowing reduced diversions from the Sun River.

The report describes Rubicon Water’s approach to recovering water lost in irrigation canals, and how we make this water available for further beneficial use. Our Network Control water saving solution is described, and examples are presented of existing Network Control implementations and the benefits these provide to their owners.

The report then describes Rubicon’s understanding of Greenfield’s Main Canal and our proposed system implementation to eliminate spill.

A system price estimate is presented along with an implementation pathway.

The estimates of cost and benefits have been prepared on a best endeavours basis using information provided by Greenfields Irrigation District. The pricing provided is based on Rubicon’s present understanding of the Main Canal, and is considered to be a reasonable estimate for project feasibility evaluation.

Should GID decide to proceed with an implementation then Rubicon will undertake a detailed system analysis to verify the proposed system requirements and confirm project costings with formal quotes.
3.5 Network Control

Rubicon’s Network Control solution provides an upgrade of existing canal infrastructure to allow the regulation equipment to precisely match supply with demand at all points through the canal network.

All check structures along the length and breadth of a channel system are coordinated so that water levels remain stable while just the amount of water needed is supplied from the dam or river. The canal system behaves with nearly the same responsiveness and efficiency as a pipe system but without the costs of pipe systems.

The Network Control solution installs automated regulator gates, a data-radio network, canal network control software and a remote monitoring and management platform to assist irrigation district managers to achieve new levels of customer service and distribution system efficiencies.

Network Control closely integrates the following innovative technologies:

- FlumeGates are combination overshot flow measurement and control gates used in check structures to regulate the canal system. They provide accurate flow measurement and precise flow control. FlumeGates are fully integrated with water level instrumentation, motor control, solar power supply and radio telecommunications all provided in a single easy to manage device.
3.6 Benefits Provided by Network Control

Network Control implementations have been delivering benefits for more than thirteen years to irrigation districts around the world. These benefits are summarized below:

- **Water Savings**
  - Canal system spills are effectively eliminated while delivering significantly improved customer service, improved system control and flexibility.
  - The resultant “on demand” service combined with assured flow rates onto farm facilitates on-farm savings and improvements.
  - The system provides distribution efficiency increases of the order of 25-30%, with 95% distribution efficiency being realised in districts such as the Coleambally Irrigation District (described further in the solution case examples below).

- **Improved customer service**
  - Close to “on-demand” supply to customers.
  - Supply of flow at the precise rate and quantity ordered.
  - Automated opening and closing of turnouts when SlipMeters are installed.
  - Orders are confirmed at the time of placement.
  - Ability to interface to on farm automation equipment to closely coordinate on-farm activities with water deliveries.

- **Productivity Savings**
  - Network Control systems operate automatically with less involvement from water operators, allowing them to focus on more high value activities
  - The Water Operator’s role changes from routine scheduling to supervision, exception handling, preventative maintenance and emergency response

- **Occupational Safety and Health Administration (OSHA)**
  - The Network Control system eliminates the manual lifting of drop boards and operation of manual structures
5. Implementing Water Savings Improvements in Greenfield Irrigation District’s Main Canal

5.1 Canal Overview

The Greenfield Irrigation District Main Canal follows the path shown in red in Figure 2 below.

![Google Earth Map showing the Main Canal](image)

Figure 2 - Google Earth Map showing the Main Canal

The main canals are large having widths of 38-92 feet and water depths of 5-8 feet. They are relatively flat having slopes of 0.10 - 0.26 feet per 1000 feet.

The freeboard varies considerably along the main canal. In some places it is 3 feet or less. There may be an opportunity to reshape the canals to provide more freeboard where appropriate.

The vast majority of the main canal has a sandy/gravelly base through which it is believed that large amounts of water seeps. Most surface and groundwater seeps away from the canal into the numerous draws and coulees. There are no intakes of water into the canal throughout its 35 miles.

A system schematic representing the canal is presented in Figure 3 below.
This schematic is enlarged in Figure 4 through Figure 9.
Under maximum flow conditions the water surface follows a gradient that approximately matches the bed slope of the canal.

When canal inflow and outflow are reduced to zero by instantaneously closing both the upstream and the downstream regulating structures, the continued flow throughout the length of the pool causes a transfer of volume from the top end of the pool to the bottom end of the pool. This ultimately results in a horizontal water surface and zero velocity and flow throughout the pool. This transfer of volume within the pool will cause the water level at the downstream end of the pool to rise, and this rise in water level must be carefully managed to prevent over-topping of the canal.

Rubicon’s controllers are designed to safely capture water in each pool as allowed by the maximum pool elevation in front of each check structure, and safely pass any additional volume that would exceed this maximum pool elevation further downstream.
Greenfields Irrigation District
Canal Modernization

CANAL CONTROL EVALUATION AND RECOMMENDATIONS

1.0 OBJECTIVES

Irrigation water from Greenfields Irrigation District (GID) contributes undesirable flow into Muddy Creek. Water entering Muddy Creek comes from a combination of subsurface drainage, surface drainage, and canal waste flows. Improvements to canal system operations can help to reduce all of these. The most direct benefit is to reduce waste flows through J Wasteway. Although GID presently operates the system with as little waste as possible, system improvements will allow further reductions in waste flows. Improved canal operations can also reduce drainage flows, by increasing the accuracy and flexibility of deliveries to farms.

An additional benefit to improved operations is to facilitate canal system management. Canal operators’ jobs can be simplified by increasing the system’s hydraulic and control capabilities plus providing better information on system-wide conditions (monitoring) at GID headquarters. Any changes to operating philosophy or methods must be acceptable to operating personnel. To be successful, canal operators must be comfortable with methods and equipment. Therefore, simple is usually better than complex. Technical and economic feasibility must not overlook practical application considerations.

This study and report examine different methods to improve canal operations, considering technical, economic, and social feasibility.

2.0 SUMMARY OF POTENTIAL METHODS TO IMPROVE OPERATIONS

For the purpose of this study, the GID canal system consists of the Sun River Slope Canal (SRSC), Spring Valley Canal (SVC), Greenfields Main Canal (GMC), Greenfields South Canal (GSC), Big Coulee Canal, Mill Coulee Canal, and all the attached laterals and drains. Many different methods are available to upgrade the system’s operation. Possibilities are described in the sections that follow, listed in order from the simple and inexpensive to the more complex and expensive methods.

2.1 Monitoring - Supervisory monitoring of system-wide data from GID headquarters (master station) will continue to be valuable and can be expanded to include more data from more sites. Monitoring requires sensors (water level or gate position), remote terminal units (RTU), a communication system, master station equipment, and software.

2.2 Supervisory Control - Supervisory (remote) manual control allows an operator to adjust remote check gates from GID headquarters. In addition to the monitoring requirements above, supervisory control requires motorized gates, interface equipment
(interface between RTU and gate motor), and additional software at the RTU and at the master station.

2.3 Local Automatic Control - an automatic feedback controller can maintain a constant water level in the canal by adjusting the adjacent check gate(s), without human intervention. Several GID check structures were previously configured for automatic level control but are not operational. Adding local automatic control requires little additional equipment beyond that required for supervisory control, but software must be developed and added to the site, including alarms to alert operators if a problem develops.

2.4 J Lake - Additional regulatory storage in the canal system will improve operations by allowing canal flow to remain steady while deliveries to water users change. Section 3.2 below discusses this option.

2.5 Modifications at Existing Structures - Structural modifications could improve control capabilities at some existing structures. Possibilities include replacing gates and hoists, adding power, adding gate motors, and raising check structure walls. For example, the SVC headgate and SVC-35 Check would require modifications before they could be remotely or automatically controlled.

2.6 Additional Structures - Adding more check structures will improve system response and overall performance. This option was explored in the 1993 report discussed in section 3.1 below.

3.0 EVALUATION OF PREVIOUS PLANS

3.1 Multiple Check Structure Scheme - The 1993 report by Lee, Bates, and Bates addresses potential improvements to GID’s main canal. This report is a valuable piece of work that includes a good compilation of canal operation records and has many good suggestions. However, the authors missed some important considerations.

The report’s strong points include the following:

• In general, the hydraulic computations are correct. Appropriate methods were used and most of the numerical results appear to be accurate. Spot checks of numerical computation revealed some inaccuracies in backwater profiles, but these were not significant enough to change qualitative results.

• The basic premise--using additional check structures to better manage canal levels and flow--is sound. With an appropriate control system, a canal system with multiple check structures can operate efficiently with little waste while improving service to water users. This has proven successful on many modern canal systems in the U.S. and abroad.

• Site selection for additional check structures is good. Both the sites initially targeted and the final (primary) sites are logical and appropriate.
Overshot gates are an appropriate choice for this application. Overshot gates are practical and effective when routing flow changes in the downstream direction and maintaining the upstream water level at each check. (As opposed to downstream-oriented operations where gates are adjusted to maintain downstream conditions.) Overshot gates are also relatively economical in retrofit installations.

Weaknesses in the report's assumptions and conclusions include:

- The project's basic objective--"to reduce the flow down J Wasteway by 50 cfs for a period of 36 hours"--is based on the 36-hour lag time in the present system and overlooks the benefits of the new check structures. Presently, it takes 36 hours for a flow change at the Pishkun Reservoir outlet works to reach J Wasteway. This is because the entire canal must partially drain or fill, from upstream to downstream, to reach equilibrium at a new normal depth for the new flow. This 36-hour lag should have no bearing on the operation of the proposed system of check structures. In response to a downstream flow change (change in demand), the report assumes a sequential gate operating technique progressing in the upstream direction. Pool storage volumes are computed so that this sequential operation takes 36 hours to reach the headworks. Although these calculations may be correct, there is no reason to operate the canal this way. It is not necessary to wait 36 hours after a change in outflow before correcting the inflow. Whenever the outflow changes, inflow at the head end of the canal should be adjusted as soon as possible, as should the flow at checks throughout the canal system. Then, instead of draining or filling large volumes of water for 36 hours, only small volume adjustments are required (from slight shifts in water surface profiles to reach a new steady state condition).

- The magnitude of water level fluctuations proposed in the report (up to 2 ft of depth change) is probably not practical. Although this may be acceptable for emergency operations, GID is unlikely to want this much water level variation for normal operations because of problems with seepage and maintaining constant turnout deliveries. This much water level change could also increase canal maintenance costs. (For the reasons stated in the previous paragraph, much less water level fluctuation will be required anyway.)

3.2 J Lake Proposal - A GID proposal (dated 3/8/96) addresses the reasons and plans for constructing a regulatory storage reservoir at the J Wasteway site. The J Lake Proposal has considerable merit to improve canal operations while reducing waste flows into Muddy Creek. Major advantages to J Lake include:

- Regulatory storage is a simple and dependable method to reduce waste flow. Once constructed, J Lake will provide long-term benefits to the district while requiring little additional cost or effort.

- GID operations can remain essentially unchanged from present methods. Operators can continue to route flow changes downstream through the canal system with any excess water diverted towards J Lake. Releases from Pishkun Reservoir will still be based on delivery schedules and then adjusted based on the water level in J Lake.
- The planned size and location for J lake appear reasonable. It should provide enough storage to prevent most of the waste through J Wasteway. The location allows most of the canal system to pass excess flow downstream to J Lake, while releases from J Lake into GM-100 Canal can be based on downstream demand. Excess water that accumulates in J Lake can be used beneficially to supply deliveries from GM-100 downstream.

- J Lake will compliment other system enhancements. Other operation improvements, such as improved monitoring and control at intermediate structures, will be compatible with the J Lake proposal.

Disadvantages to J Lake include:

- Cost is relatively high, requiring a large initial expenditure.
- Seepage and evaporation losses will increase. The amount of seepage and evaporation depends on how much water is kept in the lake.
- Some of the control details need to be pursued further. The proposal mentions computer-controlled releases into GM-100 Canal based on downstream water level. This is a good idea, but it will require additional structures, equipment, and work.
- Once full, J Lake will not be able to prevent additional waste. An event that causes successive days of delivery flow reduction, such as several days of rain, will still cause waste. Other methods to enhance system operations will be needed, in addition to J Lake, to handle these situations.

4.0 SITE REVIEW

4.1 SRS-71 Check - The first canal check structure is in SRSC near station 715. (See photo 1.) It is in excellent condition and could easily accommodate supervisory control equipment. The existing structure, radial gates, hoists, motors, and power supply all appear to be suitable without modification. Supervisory control of this site would require the following:

a) upstream water level sensor (could be mounted on check structure);
b) gate position sensor and limit switches on each gate;
c) microprocessor-based remote terminal unit (RTU) equipment;
d) radio, antenna, and tower (or other communications equipment);
e) enclosure.

With supervisory manual control from the GID headquarters, this check structure could be used to make flow changes, control the upstream water level, and take advantage of in-channel storage in the canal pool upstream.

4.2 SVC Headgate - The second check structure is at SRSC station 1153 where the SRSC bifurcates to SVC and the pipe drop to Big Coulee Canal. (Photo 2 and 3.) This site
would need extensive modification to be suitable for remote control. Before this site could be remotely controlled, electric power would need to be brought in, gate motors added, and the gates and hoists would need to be rehabilitated or replaced. Additionally, using this check structure to vary pool storage volumes has disadvantages. Although the canal pool upstream has plenty of freeboard, fluctuating upstream water levels would interfere with the operation of canal turnouts and the Big Coulee Canal head gate.

4.3 SVC-35 Check - The third check structure, near SVC station 350, contains two overshot gates and several stoplog bays. (Photo 4 and 5.) At high flows, this structure is wide open and fully submerged and the adjacent canal has little freeboard. Therefore, the structure has little potential for control at high flows but may be useful for managing flow changes and upstream water levels at lesser canal flow rates. For remote control, this site would require power, gate motors, water level and gate position sensors, and RTU equipment.

4.4 Turnbull Drops (SVC-58) - These chutes near SVC station 581 have uncontrolled inlets, so there is no way to control the flow or upstream water levels. In order for the flow at the Turnbull Drops to change, the canal section upstream must drain or fill in response to flow changes from upstream. Attempts to change the flow downstream from the Turnbull Drops will be ineffective until water levels (and volumes) upstream from the drops have stabilized at the new flow rate. The only way to prevent this situation is to add a check structure in the canal just above the drops.

4.5 GMC-57 Check (Mary Taylor Drop) - The fourth check structure is near GMC station 576, at the bifurcation to Greenfields South Canal (GSC) and the Mary Taylor Drop. (Photo 6 and 7.) The structure has two radial gates at the inlet to Mary Taylor Drop and four slide gates that serve as the GSC headworks. The radial gates control the upstream water level in order to divert the desired flow into GSC. The remainder of the flow goes down Mary Taylor Drop into the continuation of GMC. GSC flow is measured at a rated section in the canal downstream. Control equipment at the site monitors upstream level and gate positions and telemeters these data via radio to GID headquarters. Additional control capabilities intended at this site are not operable.

4.6 GMC-95 Check (Knight Chute) - The fifth check is near GMC station 953 at the top of Knight Chute at the bifurcation to the GM extension. (Photo 8.) The structure has a single radial gate at the top of Knight Chute and four slide gates that control flow into GM extension. A constant head orifice (CHO) box has been added to control the downstream water level for two of the slide gates, but the district manager said it doesn’t work very well. (At high flows the downstream gate is submerged and level inside the CHO box will vary as downstream canal level varies.) The radial gate is used to maintain the upstream water level and it passes the remainder of the flow down Knight Chute into GM-100 lateral to the J Lake site. Control equipment at the site automatically adjusts the radial gate to maintain the upstream water level and telemeters water level and gate position data to GID headquarters via telephone lines.

4.7 J Wasteway and J Lake site - A small pond exists at the bifurcation to J Wasteway and the GM-100 lateral continuation, which is the intended site for J Lake. (Photo 9.) A check structure with three slide gates controls the flow to GM-100 lateral. Water enters J
Wasteway via a separate overflow structure (stoplogs) and is measured at a Parshall Flume and telemetered to GID headquarters. The two check structures at the bifurcation would be replaced by outlets from J Lake. During our site visit, the canal system was flowing at maximum capacity and the flow through J Wasteway was virtually zero.

4.8 GSC Check 1 - The first check structure in GSC is a short distance downstream from the headworks. (Photo 10.) Two Armtec overshot gates are controlled by a Modicon controller to automatically maintain the upstream water level. This site appears to be adequate as is. Because of the small pool upstream and the desire to keep a constant level for upstream turnouts, this is not a good site to vary the upstream water level in order to manage flows or water volumes.

4.9 GSC Check 2 (Johnson Drop) - The second check in GSC is at the bifurcation to Mill Coulee Canal (MCC) and Johnson Drop. (Photo 11 and 12.) The structure has a single radial gate at the top of Johnson Drop and four stop log bays as the MCC headworks. The radial gate is used to control the upstream water level in order to divert the desired flow into MCC. The remainder of the flow goes down Johnson Drop into the continuation of GSC. MCC flow is measured at a rated section about 100 ft downstream from the headworks. Control equipment at the site monitors upstream level and radial gate position and telemeters these data to GID headquarters. This equipment was intended to include local automatic control of the radial gate to maintain a constant upstream level, but that capability is not operable.

5.0 RECOMMENDED OPERATIONS

System enhancements will allow GID to improve canal operations. The status of project infrastructure will determine which operating techniques are best. Regardless of the techniques used, the primary goals of operations should be:

- Accurate and dependable deliveries to water users. Users should receive their water in the correct quantity, rate, and duration.
- Minimize waste, especially that which flows to Muddy Creek.
- Minimize operating and maintenance costs.
- Simplify the canal operators’ jobs.

5.1 Operations Without J Lake - Without J Lake, canal system operations should emphasize:

a) matching inflow (supply) to outflow (demand);
b) quick response to flow changes;
c) use of in-channel storage;
d) diverting excess flows into the Sun River drainage instead of the Muddy Creek drainage.
These items will require changes in operating philosophy as well as improved control capabilities. Check structures can be used to improve system response and recovery time and to manage in-channel storage volumes. Instead of routing each flow change from head end to tail end over a 36-hour period, flows could be changed quickly at all checks. Some of the water now wasted could be saved in the canal. Perhaps the easiest and most effective way to do this is by using a simultaneous gate operating technique. In a canal system with supervisory control capabilities, operators can adjust the flow at all check structures at the same time. A new flow rate can be established quickly without waiting for a large volume of water to drain or fill.

Another possible change in philosophy relates to the management of excess flows. Presently, excess water is directed towards J Wasteway. Surplus flows could instead be directed away from GMC and GSC by increasing diversions into Big Coulee Canal, Big Coulee Wasteway, and Mill Coulee Canal. This strategy should only be used if these diversions don't create more problems than benefits.

These changes in operating technique are more easily said than done, but they are valid considerations for long-term improvement in system performance. Similar techniques are being used successfully on many other canals.

5.2 Operations With J Lake - With J Lake, operations should emphasize:

   a) relatively steady flow in the canal from Pishkun Reservoir to J Lake using an upstream (supply-oriented) operating concept and upstream level control at check structures;
   b) periodic adjustments to canal headworks flow based on the water level in J Lake;
   c) downstream (demand-oriented) operating concept in GM-100 Canal below J Lake, with releases from J Lake into GM-100 Canal matching downstream demand;
   d) diverting excess flows towards J Lake;
   e) maintaining enough water in J Lake to avoid tailender shortages in GM-100 Canal, but saving most of the lake's capacity to accumulate excess water during rapid flow reductions.

The regulatory storage provided by J Lake will improve canal operations without significant changes in operating philosophy from the way GID has traditionally managed the system. Releases from Pishkun Reservoir can be based on delivery schedules and intermediate check structures can be operated to maintain the upstream water level while diverting excess flows to J Lake. However, if some water is kept in J Lake to supply GM-100 Canal for short periods when demand exceeds expectations, headworks flow shouldn't need to include a surplus to prevent shorting the tailenders.

J Lake will have a finite capacity to absorb and supply flow changes in the canal system. When an event occurs that exceeds this capacity, operations personnel can use the techniques discussed in section 5.1 to manage the system. Essentially, once J Lake is full during a system flow reduction or empty during a flow increase, the system will need to be operated as if J Lake did not exist. Therefore, additional control system enhancements will still be valuable after J Lake is constructed.
6.0 FEASIBILITY

6.1 Monitoring - The best benefits to cost ratio is likely to come from improved monitoring at GID headquarters of key water level and gate position data. Existing monitoring on the project appears to be quite valuable. Data collection equipment usually can be furnished for a few thousand dollars per site. If the existing communication system and master station equipment allows for easy expansion, additional monitoring sites can be added for relatively little expense. Including installation, testing, and technical support, a cost of $5000 to $10,000 per site is reasonable.

6.2 Supervisory Control - The cost to remotely control check gates is largely dependent on the existing infrastructure. For a structure that already has power and motorized gates, such as SRS-71 Check, remote control should only add a few thousand dollars over the cost of monitoring. Most of this expense is to assure safe operations. Gate limit switches, alarm software, and thorough interface with gate actuators are important when no one will be at the site to observe any problems that can develop. Costs will rise if onsite monitoring equipment (RTU) doesn’t have sufficient capacity for complete control functions. Also, additional master station software may be required. Supervisory control may add from $1000 to $10,000 per site, depending on the existing monitoring system. This cost does not include structural modifications.

Benefits can be substantial, but are difficult to quantify. Tangible benefits include reduced labor and reduced mileage on GID vehicles. The greatest benefit will be improved system operation through better management of flows and water levels, enabling some of the operating techniques discussed above. On many existing canals, damage prevented by the quick response to a single emergency event has more than paid for control system costs.

6.3 Local Automatic Control - Most of the cost for automatic feedback control is in the development, testing, and calibration of the control algorithm and associated local control software. This algorithm is the logic that determines exact gate adjustments. Automatic control opens the door for "Murphy’s Law" problems, so it pays to do the job well from the start. At least $5000 per site should be budgeted. Onsite controllers (RTU) must have enough memory and intelligence for the local control software. Benefits stem mostly from reduced labor and better water level control.

6.4 J Lake - The J Lake proposal discussed above estimates a cost of approximately one million dollars to construct the reservoir. This is an order of magnitude greater than canal automation features, but J Lake will provide long-term benefits and service. The cost of J Lake should be weighed against other long-term remediation measures. J Lake should compliment current Muddy Creek restoration activities and reduce future expenses.

7.0 SUBSURFACE DRAINAGE

It appears that a substantial portion of the water entering Muddy Creek comes from subsurface drainage rather than surface drains and wasteways. Therefore, long-term planning should address the reduction of all excess drainage, not just wasteway flows. Excess water applied to farm fields may have the same effect as waste flow into the
coulees. Requiring irrigators to wait 24 hours before shutting off their turnout may reduce flow in J Wasteway but not in Muddy Creek, as the excess water not used by crops travels via groundwater into Muddy Creek anyway.

Eliminating the bulk of the drainage flows may require substantial on-farm improvements, such as replacing flood irrigation with sprinklers. However, subsurface drainage could be reduced through more accurate and flexible deliveries to water users. If the canal system can respond more quickly to flow changes, GID will be able to provide a better water supply to irrigators. The resulting improvements in on-farm irrigation practices will reduce drainage flows entering Muddy Creek while increasing farm productivity.

8.0 CONCLUSIONS

The recommended priority of actions to improve canal operations is as follows:

1. Fix or upgrade the existing data collection system and local automatic controllers.

2. Add data collection and monitoring capabilities to key sites.

3. Add supervisory manual control to existing sites that do not require substantial infrastructure modifications.


5. Develop operating techniques that take advantage of monitoring and remote control capabilities to better manage the movement of water within the system. Start to use in-channel storage and simultaneous gate operation. Divert excess flows into branches that waste into the Sun River instead of Muddy Creek.

6. Upgrade or add check structures with monitoring and remote manual control. Use these structures to expand the operations in step 5 above.

Modernization decisions must take intangible benefits and costs into account. Intangibles are important, maybe more important than tangible benefits and costs. Technical feasibility establishes what can be done, but not what will be done with system modifications. A feature like J Lake will be used advantageously by the district, because it fits well with their existing methods of operation. More complicated schemes that require major changes in the district’s operating methods may be less successful.

Report prepared by:

David C. Rogers, Hydraulic Engineer
Bureau of Reclamation, D-8560
Technical Service Center, Denver, Colorado
August 6, 1996
Photo 1 - SRS-71 Check (check #1)

Photo 2 - SVC Headgate (check #2)
Photo 3 - Radial gate at check #2 (SVC Headgate)

Photo 4 - SVC-35 Check (check #3)
Photo 5 - Double overshot gate hoists at check #3 (SVC-35 Check)

Photo 6 - GMC-57 Check (Mary Taylor Drop), GSC headgates
Photo 7 - Radial gates at GMC-57 Check (Mary Taylor Drop)

Photo 8 - GMC-95 Check (Knight Chute)
Photo 9 - J Lake site with existing check structure and J Wasteway

Photo 10 - GSC Check 1
Photo 11 - GSC Check 2 (Johnson Drop), MCC headworks

Photo 12 - Radial gate at inlet to Johnson Drop (GSC Check 2)
SUN RIVER PROJECT

GREENFIELDS IRRIGATION DISTRICT

WATER MANAGEMENT
AND
WATER CONSERVATION PLAN

February 15, 2008

Prepared by: GID Board and Bob Hardin

Revision 1 February 15, 2008

NOTE: Plan is under major rewrite in cooperation with SRWG using a Reclamation study of preferred water savings projects.
## CONTENTS

<table>
<thead>
<tr>
<th>Section</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>I. Description of the District</td>
<td></td>
</tr>
<tr>
<td>II. Inventory of Water Resources</td>
<td></td>
</tr>
<tr>
<td>III. District Water Budget</td>
<td></td>
</tr>
<tr>
<td>IV. Existing Conservation Measures</td>
<td></td>
</tr>
<tr>
<td>V. Water Management, Opportunities and Goals</td>
<td></td>
</tr>
<tr>
<td>VI. Evaluation of Conservation Measures</td>
<td></td>
</tr>
<tr>
<td>VII. Adopted Plan Elements</td>
<td></td>
</tr>
<tr>
<td>VIII. Water Conservation Plan Summary</td>
<td></td>
</tr>
<tr>
<td>X. Appendixes</td>
<td></td>
</tr>
<tr>
<td>- District maps</td>
<td></td>
</tr>
<tr>
<td>- District Policies</td>
<td></td>
</tr>
</tbody>
</table>
I. DESCRIPTION OF THE DISTRICT

A. HISTORY - The Reclamation Act was proclaimed June 27, 1902 and appropriated receipts from the sale of public lands to construction of irrigation works for reclamation of arid lands. As part of the pursuit of irrigated lands, in 1903 the Reclamation Service made the first reconnaissance of the Sun River Project area. As the Reclamation Service moved to withdraw lands for future projects, the Sun River Project was considered a secondary project at that time. On February 26, 1906, the Secretary of Interior authorized the Sun River Project, which included Fort Shaw Irrigation District (FSID) and Greenfields Irrigation District (GID). The Fort Shaw unit was selected as the first component of the Sun River Project to be undertaken with the Greenfield unit quickly behind it. Construction on the Greenfields Division began in 1913 and the first water was delivered in 1920. The GID operates and maintains the division facilities, which is still owned by Bureau of Reclamation (Reclamation). Division headquarters are in Fairfield, Montana.

B. PHYSICAL CHARACTERISTICS - The project uses the waters of the Sun River and tributaries, stored and regulated by Gibson, Pishkun, and Willow Creek Reservoirs. Water stored in Gibson Reservoir is released into the river for diversion downstream into the Pishkun Supply Canal. The Pishkun Supply Canal, heading at Sun River Diversion Dam, conveys water to Pishkun Reservoir or Willow Creek Reservoir through the Willow Creek Feeder Canal, which stems from the Pishkun Supply Canal and empties into a natural channel to the reservoir. Water released from Pishkun Reservoir enters the Sun River Slope Canal, which branches into several main canals for distribution to approximately 83,000 acres in the Greenfields Division. Downstream water users such as Fort Shaw Irrigation District and Broken O Ranch utilize storage in Willow Creek Reservoir returned to the Sun River for direct diversion or exchange.

The main storage dam, Gibson, was constructed during 1926-1929. Gibson Reservoir is located on the Sun River above Augusta, Montana, and has a total capacity of 99,058 acre-feet. The spillway crest is at elevation 4712.00 feet and has a capacity of 30,000 cubic feet per second. Outlet structures for the dam are two 72-inch-diameter semi steel-lined conduits through the base of the dam with a capacity of 3,050 cubic feet per second.

Pishkun Reservoir is an off stream reservoir, about 154 miles northeast of Gibson Dam, and has a capacity of 46,700 acre-feet. Eight earth fill dikes form the reservoir with heights ranging from 12 to 50 feet and an overall length of 9,050 feet. The outlet for the reservoir is a 12-foot diameter, approximately semicircular, concrete conduit through Dike No.4. The outlet structure has a maximum capacity of 1,600 cubic feet per second. There is no spillway for the Reservoir.

Willow Creek Dam is an earth fill structure on Willow Creek about 15 miles southeast of Gibson Dam. In addition to storing water from Willow Creek, the reservoir is fed from the Sun River through the Willow Creek Feeder Canal. The structure is 93 feet high, has a crest length of 650 feet, and contains 275,000 cubic yards of material. An open spillway channel 700 feet wide at the ground surface has a capacity of 10,000 cubic feet per second. The outlet works tunnel runs through the right abutment. The reservoir has a capacity of 32,400 acre-feet of water.

The Sun River Diversion Dam, located 3 miles downstream from Gibson Dam, is a concrete arch structure with a structural height of 132 feet and a crest length 261 feet. The dam contains 6,500 cubic yards of concrete. It is equipped with an overflow crest for a spillway. The outlet works tunnel runs through the canal wall of the right abutment. The capacity of the outlet works feeding the Pishkun Supply Canal is 3,050 cubic feet per second.
Canal is 1,400 cubic feet per second.

The Pishkun Supply Canal extends 12 miles from the Sun River Diversion Dam to the Pishkun Reservoir. A few hundred feet below the diversion dam, the canal crosses the Sun River through 1,400 cubic feet per second capacity monolithic siphon 700 feet long. The canal flows through two tunnels, 980 feet long and 2,280 feet long, and numerous drain and control structures after it crosses the Sun River.

Stemming from Pishkun Supply Canal a short distance below the river diversion, the Willow Creek Feeder Canal has a maximum capacity of 500 cubic feet per second and is 7.5 miles long to the point where it enters a natural channel to Willow Creek Reservoir.

Sun River Slope and Spring Valley Canals combined extend 32 miles from Pishkun Reservoir to a drop at Fairfield, Montana. The diversion capacity is 1,600 cubic feet per second. Three major drops and various control structures and lateral turnouts are a part of the canals. Greenfields Main Canal heads at the end of Spring Valley Canal and extends 25.4 miles northeast. It has an initial capacity of 1,200 cubic feet per second but is gradually reduced in size to 10 cubic feet per second at its terminus. The Greenfields Main Canal at a point about 2 miles below the start of the main canal supplies Greenfields South Canal. The initial capacity is 425 cubic feet per second and the length is 16.7 miles. Mill Coulee Canal is supplied from the Greenfields South Canal. The initial capacity is 200 cubic feet per second and the length is 10.7 miles.

In total there are three reservoirs, one major diversion and about 119 miles of main canal, 384 miles of laterals, and 252 miles of drains for the project.

C. FARMING ACTIVITIES – Gravity flood irrigation with contour ditches is the most common method of irrigation used in the area. Center Pivot, wheel lines, and gated pipe are also common irrigation methods used by many farm operations.

This chart depicts the changes over time of type of irrigation:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TOAL ACRES</th>
<th>FLOOD</th>
<th>GATED PIPE</th>
<th>WHEEL LINE</th>
<th>PIVOT</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>12,177.29</td>
<td>12,177.29</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2008 estimated</td>
<td>81,352.00</td>
<td>41,352</td>
<td>0</td>
<td>5,000</td>
<td>35,000</td>
</tr>
</tbody>
</table>

This chart depicts primary crops over time:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>TOAL ACRES</th>
<th>ALFALFA</th>
<th>PASTURE</th>
<th>WHEAT</th>
<th>BARLEY</th>
<th>OTHER</th>
</tr>
</thead>
<tbody>
<tr>
<td>1920</td>
<td>12,177.29</td>
<td>12,177.29</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2008</td>
<td>81,352.00</td>
<td>22,680.00</td>
<td>9,252</td>
<td>10,318</td>
<td>38,964</td>
<td>138</td>
</tr>
</tbody>
</table>

D. PROJECT SETTING:

a. Topography – The average elevation of the GID is approximately 3,400 feet above mean sea level. Most of the land lies within as alluvial valley floor or on adjacent terraces. Some undulation exists on those lands adjacent to the valley floor and the steeper slopes.

b. Soils – The average elevation of the District is approximately 3,800 feet above mean sea level. Most of the land lies within an alluvial valley floor or on adjacent terraces. Some undulation exists on those lands adjacent to the valley floor and the steeper slopes. The Greenfields Bench is composed of about 30 feet of gravel that overlies thick shale. The Greenfields bench geological cross-section is comprised of Quaternary terrace deposits on top of Marias River Formation (Colorado Shale), which lies on top of the Blackleaf Formation (Colorado Shale). Soils throughout the irrigation District vary significantly. Those in the alluvial valley floor have medium to heavy textures and are
underlain with sands and gravels. The old river terraces adjacent to the alluvium have medium gravelly-textured profiles.

c. **Climate** - The District is located in a semi-arid climatic zone and is typical of the northern inter-mountain area. The climate is characterized by light and variable precipitation and warm and sunny days with cool nights throughout the summer months. The average annual precipitation is 11.9 inches, with an average for May through September of 8.7 inches. The Greenfields Bench receives about 30% of its water from precipitation and about 70% from irrigation supply canals. The average annual temperature is 43.4 degrees Fahrenheit and average temperature from May through September of 59.6 degrees Fahrenheit. Winter temperatures are erratic and occasionally severe.

d. **Cultural resource** - Within the GID culture resources do exist. Previous inventories by the Bureau of Reclamation have located and identified the resources that should not be disturbed.

e. **Endangered species** - There are no endangered species and species of concern within GID boundaries that require any GID actions at this time are required to protect.

**E. OPERATIONS** - GID operates in accordance with Montana Annotated Code 85 chapter 7, Reclamation requirements and GID policies. The GID board of commissioners is a five-member board elected to three-year terms. The board hires a secretary-treasurer for board activities. The GID staff also includes a district manager, water master, water management, maintenance crew of 2 full-time, eight ditches riders, part-time maintenance person and part-time weed crew of 5.

All assessed lands within the GID are taxed per acre at $14.96 for 2 acre/feet. Excess water for assessed lands may be purchased at $7.50 acre/foot. Rental waters for lands outside the district are purchased at $7.50 acre/foot.

The below chart shows incremental assessment changes:

<table>
<thead>
<tr>
<th>YEAR</th>
<th>ASSESSED COSTS 2 acre/feet</th>
<th>EXCESS WATER COSTS 1 acre/foot</th>
<th>RENTAL WATER COSTS 1 acre/foot</th>
</tr>
</thead>
<tbody>
<tr>
<td>1996</td>
<td>16.85</td>
<td>8.50</td>
<td>8.50</td>
</tr>
<tr>
<td>1997</td>
<td>16.66</td>
<td>8.50</td>
<td>8.50</td>
</tr>
<tr>
<td>1998</td>
<td>16.45</td>
<td>8.50</td>
<td>8.50</td>
</tr>
<tr>
<td>2001</td>
<td>15.93</td>
<td>7.50</td>
<td>7.50</td>
</tr>
<tr>
<td>2008</td>
<td>14.96</td>
<td>7.50</td>
<td>7.50</td>
</tr>
</tbody>
</table>
II. INVENTORY OF WATER RESOURCES

A. SURFACE WATER SUPPLY – The GID includes approximately 83,000 acres of irrigated lands receiving water from the Sun River. GID has Gibson and Pishkun storage and also Willow Creek reservoir during low water times to supplement river flows for senior water rights.

A Hydromet station at the headworks measures all inflows to the GID. Other key measurement devices tracking canal flows are at Pishkun, Willow Creek, J-Wasteway, and main canals. The below chart depicts normal Sun River flows as they relate to GID meeting their irrigation demands.

B. WATER RIGHTS – As a result of a limited water supply within the Sun River Basin due to over allocation and irregular snow pack amounts, the water rights were adjudicated in 1911. The courts awarded the United States the use of all unappropriated water with a priority date of May 25, 1905. The GID’s water supply is shared with the FSID, which encompasses 13,000 acres on land south of the Sun River. Water availability can be a problem during critically dry years. Final adjudication of the Sun River Basin by the state of Montana is under way with complications. Irrigators within the basin have filed objections for numerous reasons that are being reviewed by the Montana Water Court and Reclamation. The primary players in the Final Adjudication are GID, Broken O Ranch, FSID, and Reclamation. Final adjudication should not have any negative impact on GID’s water right.

C. Per U.S. Bureau of Reclamation contract, GID is currently irrigating approximately 83,000 acres within the boundaries.

III. GID WATER BUDGET

GID has been collecting flow data at the main diversion using Hydromet. This data is located on the Reclamation web site

IV. EXISTING WATER CONSERVATION MEASURES

A. 1982 WATER MANAGEMENT STUDY – During the summer of 1982 the GID and Reclamation entered into an agreement to initiate a Water Management and Conservation (WMC) program on the district. The objective of the program was to improve the utilization of water within the district.

B. 1986 WATER MANAGEMENT STUDY – Another review was completed in 1986 by the Reclamation. This review is the "Report on Water Management and Conservation Program, Greenfields Irrigation District, May, 1986". Both reviews give excellent ideas on how to improve the overall condition of the GID however limited actions from these plans were put into place until this plan.

C. 1986 WATER MANAGEMENT PLAN – A Water Conservation Plan was completed in June 1986 by the District and Reclamation. This review is in the report "Water Conservation Plan, Greenfields Irrigation District" by Jerry Nypen, District Manager. Another Water Conservation Plan was completed in 1998 by Ed Everhert, District Manager. Another completed in 2008 by manager Bob Hardin.

D. COMPLETED SYSTEM IMPROVEMENTS –

GID is a proactive District that has an ongoing irrigation water conservation program. The first major process started in 1978 with a Rehabilitation and Betterment (R&B) Program. The R&B Program was completed in 1988 and included lining portions of the main canals and laterals, replacement of several open laterals and buried pipe, installation of automatic and telemetric equipment for control of water regulating facilities at Gibson and Pishkun Dams and at storage points on the irrigation system; and repairing, updating, and replacing of various
structures and measuring devices.

To date, key water conservation measures the District has accomplished:

- Lining of 120 miles canal and lateral distribution system. The main canal was lined in areas of high seepage losses near Pishkun Reservoir as well as other areas of need. The major portion of the lateral system has been lined with slip-form concrete.

- Water conservation measure to save water by converting open conveyance facilities to closed pipe facilities. To date, 36 miles of open lateral system has been converted to closed concrete and PVC pipeline. The water saved is used to make up annual shortages, due to system capacity limitations during periods of high demand, or remain in storage for future use. Annual operation and maintenance costs have been drastically reduced by the conversion of the open conveyance system to the closed pipeline conveyance system.

- Approximately 20 miles of existing drains were converted from an open system to a tile or closed system to facilitate a better use of the sprinkler systems, which are used by a number of the water users in the District.

- Increased the size of the maintenance building to accommodate precasting of the concrete farm and lateral turnout structures, in-line checks and drop structures, division box structures (both open and closed system), in-line crossing structures, Parshall flumes, etc. during the winter months. These structures are then installed as time and weather conditions permit. All precast structures are standardized where possible. The lateral and farm turnout structures have been standardized to accommodate the propeller type water measurement device and to facilitate quick water turn-on, turnoffs, and delivery adjustments by the ditch rider. This has improved the system operation efficiency, therefore reducing wastewater. To date approximately 1,000 structures have been replaced which includes about 400 farm turnout structures and 80 Parshall flumes. Eventually all the farm turnouts will be replaced.

- District Manager has a highly technical background and knowledge in the engineering and irrigation field. The Manager has performed training sessions for the ditch riders to broaden their knowledge in irrigation system operation and maintenance, forecasting deliveries to water users, and maintaining accurate daily water measurements and records. As a result, the District has developed a highly trained staff that can help in developing and improving the systems efficiency. District managers and staff have all had an excellent working knowledge of water conservation and management. The District manager, in conjunction with the board, supports the ongoing review and work to improve the overall condition of District facilities for water conservation.

- Computerized water ordering and scheduling program to improve the management of water orders and scheduling the water supply for distribution to the carriage facilities. The water users are informed by farm unit as to their usage and remaining water supply balance.

- District Manager and staff in cooperation with watershed partners have held a number of public meetings each year for the water users to broaden their knowledge in methods of more efficient use of water such as land leveling, lining farm ditches, water scheduling, improving irrigation practices. This included soil moisture monitoring, application rates, potential reuse of waste waters, type of crops to grow, and on-farm maintenance programs.

- District maintains an annual schedule of canal and lateral ditching and cleaning, berm removal and terrestrial weed control. The cleaning of silt, debris
and vegetative growth from the carriage facilities in order to maintain the capacities to meet the irrigation demand. At the same time a small amount of water savings is realized by removal of the vegetation in the canal prisms. The District contracts for weed control along the canal banks at about $70,000/year. In addition, the District staff is active in weed control during the irrigation season from May through September. The ditchriders are trained to reuse drain water whenever possible to reduce spills and conserve water. The overall maintenance program includes items such as caulking and sealing concrete lined canal joints, concrete repairs of irrigation structures, and maintaining turnouts.

- Two main check and two wasteway structures were rehabilitated and automated during the R&B Program. The waste-water discharged into two main wasteways is also monitored through the automation system. The District also upgraded a main canal check structure with radial gates with electric hoists and automation equipment. The District in 2004 automated Pishkun Reservoir and Pishkun Supply Canal and the Mary Taylor site to improve overall water management.

- Water users and the Natural Resources Conservation Service worked closely in land leveling within the District as well as lining of on-farm carriage facilities. To date approximately 40,000 acres of land have been leveled with about 35 miles of on-farm carriage facilities lined. The land leveling and the lining program have improved the on-farm efficiencies.

- HYDROMET stations at the North Fork of the Sun River, Gibson Reservoir, Diversion Dam, Pishkun Reservoir and Supply Canal, Willow Creek, and various SNOTEL sites. These stations assist the District in improved water management and inflow forecasting. The District has an Agrimet station to provide valuable data for improving on-farm efficiency of water use. The basic components for the irrigation water management provided by Agrimet are a localized weather station capable of calculating evapo-transpiration rates for crops grown in a local area, information on the soil water holding capacity and crop water use information for stages of crop growth. A few water users within the District have been participating in the Agrimet Program over the last two years.

- Water measurement devices to track waste water into streams to reduce waste.

In summary, the District has calculated that about 40,000 acre-feet of water are being saved each year through the efforts of their water conservation program. An additional savings of about 15,000 acre-feet is realized from the land leveling, lining of the on-farm carriage facilities, and wastewater reuse. The overall system efficiency has increased from 45% in 1979 to about 63% in 1996. The water savings and system efficiency will continue to improve as the District continues our water conservation programs.

- Waste monitoring.

In cooperation with Reclamation and SRWG, the Montana State University was hired to accomplish special waste water monitoring evaluations into Muddy Creek, Big Coulee, and Mill Coulee. Reports are available at GID office. These studies clearly identify locations of waste and potential future project needs.
V. WATER MANAGEMENT PROBLEMS, OPPORTUNITIES, AND GOALS

A. WATER MANAGEMENT PROBLEMS and OPPORTUNITIES — Can be achieved through carefully established goals and assistance from the Reclamation, Natural Resource Conservation Service, Teton & Cascade County Conservation Districts, Sun River Watershed and other government agencies.

Some positive results of this project will be readily identified with the reduced water needs and return flows to the Sun River that will be measured with the new flow gauges and manual monitoring. Continued water quality monitoring at key points of the system will display improvements in the return flows to the Sun River. The seep reduction will take longer to accomplish and monitor as improvements are made. This project will be accomplished in support of the Reclamation’s water conservation planning process. This project will also work in harmony with the Sun River Watershed efforts to enhance the overall water quality and quantity of the Sun River.

1. Water Measurement and Accounting
   Problem: Lack of an effective tracking method of water use. These problems include limited water measurement devices on the canal, laterals, and wasteways.
   Opportunity:
   - Install more gauging stations on canals and laterals
   - Install more turnouts that can measure individual farm usage

2. Seepage
   Problem: Main canals and laterals have significant losses due to seeps that reduce efficiency of GID to deliver water to producers. Seep also causes loss of productive farmland and impacts water quality in state waters.
   Opportunity: Install pipelines and line canals and laterals that have worst seeps to improve water delivery efficiency put farmland back into production and improve water quality in state waters.

3. Water Availability
   Problem: Flow fluctuations of the Sun River due to water budgeting issues by all water users on the Sun River and limited storage capacity in the reservoirs especially later in the irrigation season.
   Opportunity: Improve monitoring on Sun River and communications between all water users to reduce flow fluctuations.

4. Deteriorating Infrastructure
   Problem: Water supply to all irrigators is a problem due to major canal seeps, delivery systems build inadequately which require water to be routed through streams to try meet the irrigation demands.
   Opportunity: As GID improve water delivers incorporate infrastructure improvements.

5. Water Quality
   Problem: Water management outside GID boundaries includes improvements of water quality and quantity in the Sun River and its tributaries. Improved water quality impacts other water uses such as fisheries, recreation and drinking water.
   Opportunity: As GID improves water management; keep water quality issues in mind to have maximum benefit. Key areas of concern include Muddy Creek, Mill Coulee and Big Coulee. GID will assist SRWG with Muddy Creek bank stabilization.

6. Facility upkeep
   Problem: GID is aging and its infrastructure shows it. Without ongoing upkeep, GID will not be able to effectively deliver water to its users
   Opportunity: In cooperation with Reclamation, GID can work on upgrading its
 infrastructure to ensure it is usable for future generations.

7. **Watershed Management** - 
   **Problem:** Lack of resources to deal with larger picture items such as flows, water quality, noxious weeds and teamwork.  
   **Opportunity:** Actively participate with SRWG to improve teamwork between all water users.

8. **Vehicle Maintenance** - 
   **Problem:** Aging vehicles and costs to maintain them take away funds for infrastructure improvements and delay projects.  
   **Opportunity:** Establish vehicle maintenance and replacement schedule to reduce down time and expenses repairs

9. **Noxious Weeds** - 
   **Problem:** Noxious weeds affect us in many ways including financial, farmland production, and stream bank erosion.  
   **Opportunity:** Partnering with producers, SRWG and others, noxious weeds can be controlled.

10. **Manpower** - 
    **Problem:** Having adequate number of well-qualified people to maintain and improve the GID infrastructure while delivering water can be difficult on a limited budget.  
    **Opportunity:** Current staff has been in place for a while now so with continued education and pay, GID should be in a good labor condition.

B. **5-YEAR GOAL** - Implementation of following goals, objectives, tasks, and quantitative results to improve irrigation efficiency while meeting full water needs to irrigators.

**Goal 1.** Improve management to address GID (Reliability in drought, system capacity, maintenance issues and costs, timeliness of deliveries, water measurement, education, and water management.  

**Objective 1.** An extensive education program for all parties involved with water within the GID, which can contribute to improved irrigation efficiency.  

**Objective 2.** Evaluate and establish an effective water delivery and improve wherever possible.  

**Objective 3.** Have an effective measurement and scheduling program to adequately monitor inflows and outflows of the system and water needs of the GID.  

**Objective 4.** Establish fiscally sound management objectives to improve short and long term funding needs.  

**Objective 5.** Reduce deficit water delivery.  

**Objective 6.** Maintain existing infrastructure in a useful condition  

**Goal 2.** Improved water management to address external issues in the Sun River Watershed (water quality, Sun River flows and return flows).  

**Objective 1.** Improve water quality of GID return flows to enhance Sun River water quality.  

**Objective 2.** Improve water quantity in the Sun River.
C. Long-Term Goals - Keep GID a healthy irrigation project into the foreseeable future by:
1. Improve Off-farm irrigation efficiency by 15%
2. Improve on-farm irrigation efficiency by 15%

V. EVALUATION OF CONSERVATION MEASURES

The following breaks out tasks the GID will focus on over the next five years and those that were considered and not selected:

A. Selected Conservation Measures:
1. Water Measurement
   Description
   - replace farm turnouts
   Legal and Institutional Considerations
   - None
   Environmental Considerations
   - None

2. Improve conveyance system
   Description
   - Replace open ditches with pipelines
   Legal and Institutional Considerations
   - Each project will need to be evaluated on its own merits especially impacts to return flows
   Environmental Considerations
   - Each project will need to be evaluated on its own merits especially impacts to wetlands

3. GIS Management
   Description
   - Work with local volunteers and SRWG to establish GIS layers that will help track GID improvements and needs
   Legal and Institutional Considerations
   - None
   Environmental Considerations
   - None

4. Infrastructure upkeep
   Description - Work with Reclamation on completing facility upgrades listed in Reclamation “2006 Associated Facility Review Examination Report” including:
   Legal and Institutional Considerations
   - Review with each structure
   Environmental Considerations
   - Review with each structure

5. Education
   Description
   - Educate ditch riders on effective water management and improved irrigation delivery efficiency through workshops, Bureau of Reclamation on-site assistance, and other entities knowledgeable of this issue.
   - Educate Board of Directors on the benefits of effective water management and conservation through workshops and other training opportunities.
   - Educate water users with their role on water management and how to improve on-farm irrigation efficiency.
   - Utilize training assistance from NRCS, MSU Extension Service, and Agrimet program to help find ways to improve overall irrigation efficiency.
   Legal and Institutional Considerations
   - None
Environmental Considerations
- None

B. Conservation Measures considered but dropped
1. Incentive Pricing – Due to high landowner costs to farm, this is not considered an option at this time.
2. Piping Willow Creek canal – Not cost effective at this time.

VI. ADOPTED PLAN ELEMENTS

A. Projected Results of Selected Measures

1. Water Measurement
   - Going through major evaluation to document results

2. Improve conveyance system
   - Going through major evaluation to document results

3. GIS Management
   - Work with local volunteers and SRWG to establish GIS layers that will help track GID improvements and needs. This include mapping if GID irrigated acres.

4. Infrastructure upkeep
   - Going through major evaluation to document results.
   - Assist SRWG on Muddy Creek bank stabilization.

5. Education
   - Educate ditch riders on effective water management and improved irrigation delivery efficiency through workshops, Bureau of Reclamation on-site assistance, and other entities knowledgeable of this issue.
   - Educate Board of Directors on the benefits of effective water management and conservation through workshops and other training opportunities.
   - Educate water users with their role on water management and how to improve on-farm irrigation efficiency.
   - Utilize training assistance from NRCS, MSU Extension Service, and Agrimet program to help find ways to improve overall irrigation efficiency.
EXTRA INFORMATION:

**Task** Maintain a reserve account to cover unknown expenses.
**Task** Maintain infrastructure improvement account for long-term improvements.
**Task** Implement cost saving measures through board policy.
**Task** Maintain equipment in good condition to reduce wear and tear.
**Task** Evaluate and improve overall operation of the district through field evaluations and irrigators input.
**Task** Work with Sun River Watershed Group to help remove the Sun River from the TMDL listing. This will be by reducing return flows contaminated with salts, sediments, and nutrients.
**Task** Work with other irrigation project on the Sun River to better manage flows for all water uses. Minimum flows of 130 cfs in the Sun River will be pursued

---

**GID WITHIN SUN RIVER WATERSHED**
SUN RIVER WATERSHED GROUP

Celebrating 25 years

www.sunriverwatershed.org

This report funded by a grant from:

U.S. DEPARTMENT OF THE INTERIOR
BUREAU OF RECLAMATION

SUN RIVER WATERSHED GROUP
25 years of success and 10-year STRATEGIC PLAN
A MESSAGE FROM THE SUN RIVER WATERSHED GROUP

SINCE 1994, the Sun River Watershed Group (SRWG) has been improving the health of the Sun River watershed by finding local solutions to local problems. As we celebrate our 25th anniversary, we look back on the successes of the past and look forward to continuing our work for many years to come.

This document serves not only as a report of the projects and programs SRWG has executed in the past, but also a plan for our future. On our silver anniversary, we have revisited our mission statement, goals, and objectives and have begun to identify tasks to direct us in these pursuits. This Strategic Plan is the product of months of drafting and review and has benefited from feedback contributed by many of our project partners. We'd like to thank everyone who helped develop our plan.

It would be impossible to individually thank all of the donors, funders, partners, volunteers and supporters who have helped SRWG achieve all that we have. However, we would like to acknowledge Allan Rollo who served as the heart and soul of SRWG since the beginning. We hope to build on your legacy and make you proud, Al.

ERLING JUEL, Board Chairperson
Greenfields Irrigation District

DAVID MARTIN, Lewis & Clark Conservation District

JOHN CHASE, Board Vice-Chair
Cascade Conservation District

SKIP NEUMAN, Muddy Creek Task Force

LAURA ZIEMER, Executive Committee Rep., Trout Unlimited

DEAN PEARSON, Teton Conservation District

PERK PERKINS, Conservation Community

TRACY WENDT, SRWG Coordinator

PAUL ROOS, Conservation Community

ABOUT THE SUN RIVER WATERSHED

MONTANA’S SUN RIVER watershed is east of the continental divide, south of Glacier National Park, and includes 2,200 square miles in Lewis & Clark, Teton, and Cascade counties. The Sun River starts in the Bob Marshall Wilderness, flowing out of the mountains through rolling foothills of short grasses and scattered timber, winding through rangeland and farms to its confluence with the Missouri River at Great Falls. The watershed includes the communities of Augusta, Simms, Fort Shaw, Sun River, Vaughn, Power, Fairfield, Sun Prairie, and Great Falls. The Sun River provides irrigation for 116,000 acres, served by two irrigation districts and multiple private ditch companies. Land ownership includes private, state, federal, and urban properties.

Ranching and farming sustain the rural landscape of the Sun River watershed. The Sun River Project includes a system of reservoirs and ditches to facilitate irrigation. The watershed provides habitat for wildlife and the river has a wild-reproducing trout population, making the Sun River a destination for hunting, fishing, camping, and other forms of recreation.
ABOUT THE SUN RIVER WATERSHED GROUP

THE SUN RIVER WATERSHED GROUP (SRWG) formed in 1994 as a working group to tackle water quality issues on Muddy Creek. In 1996 SRWG became a 501(c)3 nonprofit to better attract funding and enable expansion of our projects to the greater Sun River watershed. SRWG works with local stakeholders to resolve natural resource challenges affecting local resources.

Before SRWG’s inception, resource discussions in the Sun River watershed were characterized by a history of disputes over water rights, causes of erosion, water supply for fisheries and recreation, and declining water quality. Collaborative work, led by the Muddy Creek Task Force, began to change that, working together to improve one of the worst non-point-source pollution problems in Montana. The group discovered innovative ways to work together to address this issue. After successful work on Muddy Creek, the Group began to address other areas of the watershed. Along Elk Creek, a key Sun River headwater tributary, habitat and irrigation infrastructure improvement projects benefited irrigators and fish. An erosion-control project on Willow Creek reduced a major sediment contributor to Willow Creek reservoir. SRWG worked with local irrigation districts, with help from private and public partners, to improve irrigation infrastructure to help ensure the viability of agriculture across the watershed. Mill Coulee, a lower river tributary, was the target of important habitat and stream-side vegetation projects.

The SRWG is comprised of private or public stakeholders who have a vested interest in the watershed and commit to support our mission. An elected board of directors governs the organization, led by an executive committee comprised of a Chairperson, Vice-Chair, At-Large representative, and Secretary-Treasurer. The board reserves positions for representatives from Teton, Cascade, and Lewis & Clark Conservation Districts. Current federal, state, and local agency partners include the US Bureau of Reclamation, US Fish and Wildlife Service, US Bureau of Land Management, US Forest Service, Montana Department of Environmental Quality, Montana Department of Natural Resources and Conservation, Montana Fish, Wildlife and Parks, and the MSU Extension Service. Other key partners include local landowners, Greenfields and Fort Shaw Irrigation Districts, Trout Unlimited, the Front Range Weed Round Table, Missouri River Flyfishers, Broken O Ranch, and the Audubon Society.

LOCATION OF THE SUN RIVER WATERSHED

CONTACT
(406) 214 2868
info@sunriverwatershed.org
www.sunriverwatershed.org
Find us on Facebook and Instagram
OVER THE PAST 25 YEARS, SRWG has gotten to know many of the stakeholders in the Sun River watershed - landowners, land and water managers, community members, agencies, and other organizations. We have held many public meetings and convened working groups, had casual conversations, and conducted surveys. Through these interactions, SRWG has come to know what Sun River stakeholders value as resources in the watershed and threats that our community is concerned may interfere with those values. Threats include:

- Noxious weed infestations
- Sediment load contributions
- Poor water quality
- Insufficient stream flows
- Problematic land management
- Degraded and poor fisheries
- On-farm efficiencies/irrigation systems

This Strategic Plan outlines the goals and objectives that will guide our actions over the next 10 years to mitigate these threats and to protect and restore the resources of the Sun River watershed as valued by our communities. The Plan will be supported by annual workplans that identify which actions will be completed each year, including programmatic work and strategies for improving our organizational capacity. This Plan seeks to strengthen the long-term sustainability, efficiency, and effectiveness of SRWG, which are key to on-the-ground implementation of projects that promote our mission.

FOR A COPY of the appendix of this Plan, including maps, task list, and annual workplans, contact SRWG at info@sunriverwatershed.org.
**WATER QUALITY**

**STRATEGIC OBJECTIVES**
- Establish measurable targets for meeting water quality standards
- Reduce unnatural discharges, sediment, and nutrient contributions to Muddy Creek, other tributaries, reservoirs, and the Sun River
- Continue water quality monitoring to add to SRWG’s long-term database and to inform progress towards water quality targets
- Plan and promote water quality through partnerships and communication

**OVER THE PAST 25 YEARS** SRWG has lined over 85,000 feet of ditch, resulting in more efficient water conveyance. SRWG conducted two reservoir operation studies, resulting in 100% increase in winter flows without jeopardizing reservoir fill. Through water delivery infrastructure upgrades, SRWG has improved irrigation-season flows so they are now primarily at or above 100cfs - a 70% increase in similar water years over pre-project flows.

**SINCE 1994** SRWG projects have reduced sediment inputs to Muddy Creek by 80% from 200,000 tons to 27,000 tons per year. Water quality data has been collected for nearly 20 years, helping identify issues and track the progress towards water quality goals. Over 180 miles of the Sun River and tributaries have been assessed for potential improvements and those assessments help guide this plan and future projects.
**HEALTHY HABITAT**

- Improve fish habitat in key reaches
- Sustain fish habitat health and connectivity
- Protect and improve habitat for other key species of fish and wildlife
- Seek to increase public awareness and support for fish and wildlife in the watershed

**HYDROLOGIC PROCESSES**

- Identify long-term watershed-scale approaches to restoring hydrologic processes
- Identify, assess, and prioritize reach-scale projects to reestablish hydrologic processes

Hydrologic processes are healthy river behaviors such as floodplain connectivity and channel migration.

**INVASIVE WEEDS**

- Suppress or control noxious weeds in the Sun River Watershed

**COMMUNITY EDUCATION**

- Grow community knowledge, involvement, and support for watershed issues
- Promote SRWG Strategic Plan as a vehicle to address watershed issues

---

**A QUARTER CENTURY OF SRWG PROJECTS**

SRWG projects over the years have benefited fish and wildlife habitat, restored hydrologic processes, and helped manage the spread of noxious weeds. By involving volunteers, students, and community members, SRWG has helped educate the public about issues faced in the Sun River Watershed. These projects include:

- Collaborating with hundreds of people and organizations to provide local solutions to local problems
- Planting over 20,000 trees on Muddy Creek
- Removing 40 tons of trash from the lower Sun River
- Leading or supporting eight annual weed pulls or spray days in the watershed each year
- Releasing over 5 million bio-controls to help manage noxious weeds
- Pulling over 17,000 pounds of knapweed by 1,000 volunteers
- Increasing wild trout populations, particularly across similar low-water years
- Operating, managing, and/or maintaining a network of streamflow gages in key locations throughout the Sun River and tributaries
- Improving over four miles of stream banks along Mill Coulee, 10 miles on Big Coulee, and 10 miles on Elk Creek
- Replacing over 500 car bodies with native vegetation along stream banks
Only a Partial Document Due to Size

Montana State Water Plan

2015 Montana State Water Plan
THE MONTANA STATE WATER PLAN 2015
A WATERSHED APPROACH

CONTENTS

Executive Summary 2
Statutory Authority for Water Planning 9
State Water-User Profile: Promises to Keep 10
The Montana Water Supply Initiative—Process for Developing the State Water Plan 12
Institutional and Legal Framework for Water Use in Montana 16
State Water-User Profile: Bozeman Considers Water for the Future 22
Water Resources in Montana 24
State Water-User Profile: Floating Islands of Fish Fry Lake 30
Water Use in Montana 32
State Water-User Profile: Walking Fence Lines 42
Effect of Frequent Drought On the Availability of Future Water Supplies 44
State Water-User Profile: Messing about in Boats 50
Potential Future Demands for Water in Montana 52
Options for Meeting Future Water Demands 56
State Water-User Profile: Virgelle Ferry 64
Major Findings and Key Recommendations 66
Lists of Figures & Tables 77
Appendix A: Glossary of Terms 78
EXECUTIVE SUMMARY

“...all waters within Montana are the property of the state for the use of its people and are subject to appropriation for beneficial uses as provided by law.”

—Montana Constitution

Montana’s economy and quality of life rely on water for everything from agriculture, livestock, industry, fisheries, and recreation, to municipal and domestic uses. It is with this recognition of our dependence on water that the Department of Natural Resources and Conservation (DNRC) is proud to present the 2015 State Water Plan to the Montana Legislature and the citizens of Montana.

The 2015 State Water Plan is a synthesis of the vision and efforts of regional Basin Advisory Councils (BACs) established in Montana’s four main river basins: the Clark Fork/Kootenai, Upper Missouri, Lower Missouri, and the Yellowstone. The 80 members of the four BACs represent one of the most diverse groups of water users and interests ever brought together by the state of Montana.

As part of the planning process, the BACs and DNRC were assisted by the hundreds of Montanans who took the time to provide the BACs and the DNRC with comments on what they feel are the key water related issues facing Montana and how we, as a state, can address them together.

As a result, the recommendations in the State Water Plan reflect the collective work and ideas of a broad range of water users from across the state. We believe that if the state and people of Montana carry out the recommendations offered in the State Water Plan, then Montana in the next 20 years will:

- Have finalized the adjudication of all water rights in the state of Montana — an effort that began in 1973;
- Be better prepared to manage water in real-time to adjust to seasonal changes in supply and demand as well as prepare for longer term climatic changes;
- Be better able to protect existing...
and senior water right holders while continuing to improve the state’s ability to allocate water to meet new demands;

- Be better prepared to endure droughts in watersheds across the state;
- Be better able to supply water to serve the needs of a growing population and thriving economy as well as the natural systems, habitats, and species that our state is renowned for; and
- Have a public that better understands the dynamics of our water supply and the water rights system they rely upon every day.

The Montana Legislature directed DNRC to update the State Water Plan and submit the results to the 2015 Legislative Session. The State Water Plan is to include:

- An inventory of consumptive and nonconsumptive uses associated with existing water rights;
- An estimate of the amount of surface and groundwater needed to satisfy new future demands;
- Analysis of the effects of frequent drought and new or increased depletions on the availability of future water supplies;
- Proposals for the best means, such as an evaluation of opportunities for storage of water by both private and public entities, to satisfy existing water rights and new water demands;
- Possible sources of water to meet the needs of the state; and
- Any legislation necessary to address water resource concerns.

The guiding legal principles for the State Water Plan include: the Montana Constitution with its recognition of pre-1973 water rights and the fundamental principles of the prior appropriation doctrine (“first in time is first in right”); and, the Montana Water Use Act that, amongst other things, governs the adjudication of existing pre-1973 water rights, new appropriations of water, changes to existing water rights, water rights compacts, water reservations, and water planning.

During the 18-month long planning process, DNRC worked with the BACs on developing basin specific responses to each of the subject areas listed above. Results of this effort in each planning basin, along with supporting data, are contained in four individual basin planning reports. Each of the four basin plans serves as a standalone document for guiding the development and management of the basin’s water resources.

These basin plans will continue to evolve to meet the planning needs of their respective basins.

In contrast to the detail rich basin plans, the State Water Plan provides a high-level overview of the state’s water resources and lays out a path for managing those resources over the next twenty years. Although the State Water Plan represents the outgrowth of these regional plans, only the State Water Plan has been formally adopted by DNRC. In the event that guidance in one of the basin plans is at odds with the State Water Plan, the direction offered in the State Water Plan takes precedence. Similarly, the policy recommendations offered in the basin plans represent the collective work of the individual BACs and should not be interpreted as carrying the authority of official state policy. The basin plans are all available for review at www.dnrc.mt.gov/mwsi.
Water use in Montana totals approximately 84 million acre-feet annually. Hydroelectric power generation accounts for 72 million acre-feet or 86% of the water used on a state-wide basis. Approximately 3.6 million acre-feet are consumed state-wide. Agriculture diverts approximately 10.4 million acre feet and consumes approximately 2.4 million acre-feet, reservoir evaporation consumes 1 million acre-feet, and municipal, industrial, domestic, and livestock watering consume approximately 200,000 acre-feet combined.

Demand for water is a function of many factors that are inherently uncertain. Population may grow or decline and agriculture and industry may demand more water or make do with less through greater efficiency. Changing and variable climatic conditions compound this uncertainty.

To forecast the potential effects of climate trends on future water supplies in Montana, DNRC modeled a range of climate scenarios following general procedures similar to those described in the U.S. Bureau of Reclamation (2011) West-Wide Climate Risk Assessments. Virtually all model simulations project warmer temperatures and most project modest precipitation increases. Although annual stream flow volumes are expected to stay the same or increase, Montanans are likely to see a shift in the timing of runoff due to earlier snowmelt and an increase in rain as a percentage of precipitation during late winter and early spring.

The availability of water for new appropriations varies across the state and is subject to both physical water availability and existing legal demands. Many of the basins located in the western third of the state are generally closed to new surface water appropriations. Opportunities for new appropriations for surface water or hydraulically connected groundwater also may be limited outside of closed basins because of existing legal demands including irrigation claims, hydroelectric rights, or instream water rights for fisheries, wildlife, and recreational use.

Given the scarcity of legally available surface water, the reallocation of existing water rights to new uses will play a key role in meeting future demands. As part of that reallocation, water users must receive an authorization from DNRC before they change or lease their water right in order to ensure that they will not adversely affect other water rights.

In areas of Montana, the ability to put water to a beneficial use is limited as much by water quality as physical availability. Water quantity and water quality are closely intertwined and the Montana Water Use Act recognizes this relationship (§85-2-311 MCA). However, this document offers limited guidance regarding water quality issues because DNRC has no authority to regulate water quality and the state water planning statute does not explicitly address water quality. The Department of Environmental Quality has primary authority over the regulation of water quality in Montana. For more information on water quality regulation in Montana, please reference DEQ’s Montana Nonpoint Source Management Plan at http://deq.mt.gov/wqinfo/Nonpoint/NonpointSourceProgram.mcp). Another good source of information is the Clean Water Act Information Center http://deq.mt.gov/wqinfo/CWAIC/default.mcp . These sites provide information, strategies and goals and reports that address water
quality issues generally as well as water quality as it is affected by water quantity. Water storage is an important tool for meeting future demands and responding to a changing climate. The prospect of constructing storage projects in Montana is limited by the availability of suitable locations, cost, public support, the need to mitigate environmental impacts, and limited legal and physical availability of water to store. The development of new storage projects is limited to basins where the volume of annual runoff exceeds downstream legal demands. There are also opportunities to retain high spring flows through the use of natural systems such as riparian areas, floodplains and wetlands which act to slow runoff and promote groundwater recharge effectively storing water and releasing it slowly back to the surface water system. In this way, these natural systems fill a role similar to traditional reservoirs. Artificial recharge of alluvial aquifers may also provide additional opportunities to store water when the physical supply exceeds downstream legal demands.

The major findings and recommendations of the State Water Plan are found in the final section of this report and summarized below. All recommendations contained in the State Water Plan are subject to the existing institutional and legal framework for water use in Montana as provided by the Montana Constitution, prior appropriation doctrine, and Montana Water Use Act. Full implementation of some recommendations may require the Legislature to amend the Water Use Act.

WATER SUPPLY AND DEMAND

Water supply across Montana is controlled by the variability in seasonal temperature and precipitation. While the demand for water continues to grow, water availability varies from year-to-year and often changes dramatically within a given year. As a result, coping with supply and demand imbalances is a constant feature of water management in Montana. The importance of ensuring an adequate supply of water to meet current beneficial uses and future demands is a theme echoed by the four Basin Advisory Councils throughout the planning process.

- Increase water use efficiency and water conservation – As the demand for water increases, water conservation and water use efficiency to reduce the consumption of water will play a larger role in meeting the state’s future needs. Looking ahead, we must focus on innovative strategies to stretch supplies and promote water conservation while protecting against the adverse effects of increased consumption.

- Expand efforts to quantify surface water supplies and availability – While we cannot eliminate all supply and demand imbalances, Montana can improve and expand efforts to gather the best scientific information available to quantify and forecast water supplies and availability.

- Increase flexibility to manage available water supplies through storage and rehabilitation of existing infrastructure – Water storage is an important part of integrated water management. Water storage creates greater flexibility in managing available supplies to meet the multiple demands of agriculture, municipalities, industry, hydropower, fisheries, recreation and water quality. While new storage projects may be difficult to site, authorize, and finance, there may be opportunities to modify the operations of existing facilities or construct smaller off-stream storage projects.

- Explore the use of natural storage and retention to benefit water supplies and ecosystems – Existing natural systems, such as riparian areas, floodplains and wetlands act to slow runoff and promote ground-water recharge; effectively storing water and releasing it slowly back to the surface water system. In this way, these natural systems fill a role similar...
to traditional reservoirs. Artificial recharge of alluvial aquifers may also provide additional opportunities to store water when the physical supply exceeds downstream legal demands. Integrating existing natural systems into Montana’s water management practices will support late season flows, mitigate the impact of drought cycles, and provide environmental benefits.

Support and expand Montana’s existing drought preparedness and planning efforts — Drought is part of Montana’s natural hydrologic regime. Drought readiness requires proactive planning and a collaborative stakeholder approach within small- to medium-sized watersheds.

**WATER USE ADMINISTRATION**

Historic beneficial use is the basis, measure and limit of a water right. An accurate understanding of water use is critical to Montana’s ability to protect existing water rights while meeting new demands through the water right change process or new appropriations of water. Enforcement against water use without a water right or permit is also critical to the management of Montana’s water resources.

Complete an accurate and enforceable water rights adjudication — Adjudication of pre-1973 water rights is critical to Montana’s ability to develop strategies for meeting future demands while protecting existing water rights. The water rights adjudication process must be completed as accurately as possible to establish the priority of pre-1973 water rights.

Enforce against illegal water use — Montana Water users want a more efficient, less expensive, and less adversarial approach to water right enforcement. There is growing public sentiment in support of DNRC playing a more active enforcement role against illegal water use (i.e. using water without a right or permit).

Provide sufficient information, and legal and administrative capacity to minimize adverse impacts during times of water scarcity — Drought planning efforts must include legal and administrative mechanisms that let water users reduce water diversions without putting their water rights at risk of abandonment and allow for the water savings to be protected.

Analyze additional opportunities and challenges for using water marketing, mitigation, and banking tools for meeting new demands — Water marketing, mitigation, and water banking each offer distinct opportunities, and challenges. Understanding the potential positive and negative impacts of each is the first step toward taking advantage of these approaches.

Complete all outstanding tribal and federal reserved water rights compacts and work closely with federal partners to better manage federal water projects — All four Basin Advisory Councils discussed the issue of outstanding reserved water right compacts and agreed that it is in the interest of the state, federal government, and the tribes to complete this important work. The State of Montana should work with the tribes, Montana’s Congressional delegation and the federal government to complete the compacting process through congressional and tribal ratification and decree by the Water Court.

**WATER INFORMATION**

Water resource issues are multi-faceted and often highly localized. Understanding and resolving them requires ready access to up-to-date information. Multiple local, state and federal agencies generate and use water information in carrying out their responsibilities related to the protection or allocation of Montana’s water resources. Better integration of this information will support planning, policy development and decision making at local, state and federal levels. Integration of information will also support planning and decision making by individual water users. Better access to hydrologic and climatic information at the appropriate geographic scale will result in more accurate assessments of water availability. Improved measurement and monitoring of water use will support the state’s ability to determine when water is physically and legally available to meet new demands, while protecting existing water rights. Improved access to integrated water information will also support the work of water managers to distribute water by priority.

Support improvements to the Montana Water Information System — The Montana State Library’s Water Information System (WIS) is the starting point for finding water resources information in Montana. The WIS makes high quality data on surface water, groundwater, water quality, riparian areas, water rights, climate data and more available to the public from one common starting place. The State Library continues to improve the WIS through the development of new data sets, interactive applications, and maps. Efforts to improve the WIS
should be encouraged and supported.

**Inventory of consumptive and non-consumptive uses** – An accurate inventory of Montana’s water use, both consumptive and non-consumptive, is critical to the state’s ability to meet new demands while protecting existing water users from adverse effects. Accurate information on historic water use and associated water rights will support the state’s ability to determine the extent to which water is legally and physically available for new beneficial uses.

**Monitor water supply and distribution** – Effective water management and distribution depend on accurate real-time measurements of streamflow, snowpack and soil moisture. Improving Montana’s water supply and distribution monitoring network will improve the ability of water managers to adjust to seasonal supply and demand imbalances as well as plan for longer term imbalances associated with climate variability.

**Improve and expand efforts to characterize groundwater** – Montanans are increasingly looking to the state’s groundwater to meet future needs. Better groundwater information including aquifer characteristics and water monitoring data collected under the Montana Bureau of Mines and Geology Groundwater Water Assessment Program is needed statewide to identify sources of groundwater potentially available for development.

**Improve management of surface water and groundwater as a conjunctive resource** – Montana recognizes the link between surface water and groundwater and manages them as a single resource. Additional information on interactions between groundwater and surface water from site-specific investigations and long-term monitoring as well as strategies for mitigating impacts of groundwater use on surface water users is necessary to facilitate decisions on new permitting and water right change authorizations.

**ECOLOGICAL HEALTH AND THE ENVIRONMENT**

Montana’s natural aquatic systems, lakes and rivers and associated biological resources, support our quality of life and Montana’s recreation and tourism economy. The availability of water in the appropriate quantity, quality, timing and duration is necessary to ensure the health of our water-dependent ecosystems. We must pursue proactive policies and management practices to meet the needs of aquatic ecosystems within the prior appropriation system in order to sustain the health of these valuable natural systems.

**Provide sufficient protection for instream flows within the prior appropriation framework to maintain aquatic and riparian systems** – Coordinated efforts are needed to develop and implement strategies and tools for providing minimum instream flow regimes within the prior appropriation framework.
Support proactive, coordinated efforts to reduce invasive species and protect endangered species in Montana – Both aquatic and terrestrial invasive species can negatively impact water supplies and distribution. Coordinated efforts are needed to implement actions that protect Montana’s land and water resources. Experience has shown that a cooperative approach is the most effective way to address threatened and endangered species.

COLLABORATIVE WATER PLANNING AND COORDINATION
Co ordination increases communication, improves efficiencies, and leverages technical and financial resources. Effective collaboration helps to inform, engage, and connect stakeholders and supports efforts to improve water management across all watersheds. It is important to coordinate efforts and involve water managers, users, and stakeholders at the watershed, basin, and statewide scale to develop sustainable management solutions.

Expand support for basin and community-based watershed planning – Community-based watershed groups, conservation districts, and other organizations provide the structure and a forum to bring together stakeholders, build partnerships, and work collaboratively to develop local water management plans. It will be increasingly important to provide such groups with planning support, technical assistance, and access to information to develop, implement, and monitor water use plans as demand for water grows and the administration of Montana’s water becomes more complex.

Encourage collaboration, coordination, and communication across local, state and federal agencies, and tribal governments – Many local, state, federal, and tribal agencies share responsibilities for land and water management. The policies and actions of one often directly impact another. Close coordination between local, state, federal, and tribal water managers is critical for achieving outcomes that serve both economic and environmental interests.

Develop a plan to deliver water-related training, education, and outreach – Water management is complicated, not only because of water’s finite and variable nature, but also because of the complicated nature of the water right laws and rules used to administer it. Water education and outreach activities are necessary to provide a foundation for informed management of Montana’s water resources now and in the future.
EFFECT OF FREQUENT DROUGHT ON THE AVAILABILITY OF FUTURE WATER SUPPLIES

The Challenge of History, Culture, and Jurisdiction in the Jocko
EFFECTS OF DROUGHT ON FUTURE WATER SUPPLIES

The following information on Montana’s surface water resources is summarized from more detailed information provided in the individual basin reports.

The effect of drought on future surface water supplies depends on duration, geographic extent, and the mitigating effects of reservoir and groundwater storage. Droughts vary in duration from one to several years and may be continuous or interrupted by normal or high water years. They may be localized or may affect broad areas. Water supplies in basins with reservoir storage are buffered from the effects of drought, yet even in basins with significant reservoir storage capacity prolonged drought can disrupt water deliveries.

Drought also reduces the quantity of water available to recharge groundwater. This effect lowers the groundwater levels that support base flows in streams and rivers during dry years. Once depleted during an extended drought, groundwater may take years to recover to normal levels. Intact floodplains and healthy riparian areas slow runoff, promote groundwater recharge, and hasten recovery of groundwater storage following drought.

Records from droughts in the 1930s, 1980s, and 2000s provide points of reference of the potential effects of drought on water supplies. In many areas, the drought of the 1930’s exceeded the more recent droughts in magnitude and duration. For example, streamflow data from the gaging station on the Madison River near West Yellowstone in Figure 16 illustrates the differences between average monthly flows during the 1930s and 2000s droughts. Overall, the river produced about 15 percent less water,
MAJOR FINDINGS AND KEY RECOMMENDATIONS

The complete recommendations for the Montana State Water Plan are set forth below. These recommendations were developed from input provided by four regional watershed basin councils, private individuals, and local, state, tribal, and federal resource managers. These recommendations are intended to guide Montana water policy and management over the near, intermediate, and long term bases. Where appropriate, DNRC has identified the agencies with primary responsibility for plan implementation. If unidentified, the recommendation is intended to offer guidance to the many private, local, state, federal, and tribal entities involved in water management in Montana.

All recommendations contained in the State Water Plan are subject to the existing institutional and legal framework for water use in Montana as provided for by the Montana Constitution, prior appropriation doctrine, and Montana Water Use Act. Full implementation of some recommendations may require the Legislature to amend the Montana Water Use Act.
WATER SUPPLY AND DEMAND

Water supply across Montana is controlled by the variability in seasonal temperature and precipitation. While the demand for water continues to grow, water availability varies from year to year and often changes dramatically within a given year. As a result, coping with supply and demand imbalances is a constant feature of water management in Montana. Ensuring an adequate supply of water to meet current beneficial uses and future demands is a theme echoed by the four Basin Advisory Councils throughout the planning process.

Steps to address these issues include:

Support Water Use Efficiency and Water Conservation

As the demand for water increases, water conservation and water use efficiency to reduce the consumption of water will play a larger role in meeting the state’s future needs. Looking ahead, we must focus on innovative strategies to stretch supplies and promote water conservation while protecting against adverse effects to existing water users. There is a general misunderstanding that when irrigators, municipalities, or other water users improve the efficiency of their water systems so that they divert or discharge less water that they are actually “saving” or reducing water consumption. In reality, irrigation upgrades, for example, may actually increase water consumption through higher crop yields and reduced return flows relied on by other water users. Additional adverse effects may include decreased recharge of shallow groundwater. The Montana Water Use Act prohibits changes in water use that result in adverse effects to other water users on the source. Site-specific investigations, long-term monitoring and development of tools and strategies for mitigating the adverse effects from increasing efficiencies are needed to facilitate informed decisions on new permitting and water right change authorizations.

Free flowing wells are found throughout Montana and are a valuable asset, especially for stock water in remote areas, but left uncontrolled they can waste water and contribute to the decline of groundwater levels. Records from the Montana Groundwater Information Center (GWIC) indicate that there are more than 4,400 wells reported as “flowing” at the time of construction. With an average flow rate (of measured stock wells) of 20 gallons per minute, equipping a single well with a flow control valve can save approximately 32 acre feet per year. Monitoring by Montana Bureau of Mines and Geology indicate that water levels in the Lower Hell Creek – Fox Hills aquifer along the Yellowstone River corridor from Miles City to North Dakota have declined as much as 100 feet over the past 30 to 40 years partly due to uncontrolled flowing wells.

SHORT TERM RECOMMENDATIONS (0-2 YEARS)

- Support both site-specific investigations and long-term monitoring studies to quantify the effects associated with changes in irrigation methodologies and improvements to water distribution systems. These investigations will help to inform the development of water efficiency and conservation strategies that use water more effectively.
- Support state and federal programs that assist landowners with controlling discharge from uncontrolled flowing wells.

INTERMEDIATE TERM RECOMMENDATIONS (4-8 YEARS)

- Support the efforts of State agencies, universities and others to identify and pursue research on innovative water management and conservation strategies that are tailored to local needs and conditions.
- DNRC will analyze the water right implications and lessons learned from the land application of treated municipal wastewater.

LONG TERM RECOMMENDATIONS (6-10 YEARS)

- Support the implementation of water conservation incentives and measures that are adaptable to the needs of local conditions, individual water-sheds and municipalities.
- The State of Montana should offer incentives that encourage the development of community wells as an alternative to individual wells for domestic water supplies.

Improve and Expand Efforts to Quantify Surface Water Supplies and Availability

The importance of ensuring an adequate supply of water to meet current beneficial uses and future demands is a theme echoed by the four Basin Advisory Councils throughout the planning process. Water supply across Montana is controlled by variability in seasonal temperature and precipitation as well as long-term climatic trends. While the demand for water continues to grow, physical water availability varies from year-to-year and can often change dramatically between seasons in any given year. As a result, coping with supply and demand imbalances is a constant feature of water management in Montana. While we cannot eliminate all supply and demand imbalances, Montana can improve and expand
efforts to gather the best scientific information available to quantify water supplies and availability.

**SHORT TERM RECOMMENDATION (0–2 YEARS)**
- DNRC will work with local water users and other government agencies to conduct a basin-wide physical water availability and water management assessment in the Upper Missouri Basin. The study will assess and analyze how the basin’s existing water and power operations and infrastructure will perform under different water supply scenarios. The study will also analyze the effectiveness of adaptation and mitigation strategies for meeting the challenges of supplying adequate water in the future.

**INTERMEDIATE TERM RECOMMENDATIONS (2–6 YEARS)**
- Build upon the lessons learned from the Upper Missouri Basin water availability and water management assessment to conduct similar studies in other basins.
- Invest in the capacity to identify and evaluate the opportunities and challenges posed by large scale forces that will influence water supply and demand over the next twenty years. Examples of large scale forces include but are not limited to: energy development, demographic shifts, climate variability, the operation of federal dams and reservoirs within Montana and downstream states, treaties and compacts with neighboring states and Canada, and federal actions related to threatened and endangered species. Review and revise the assessment every 5 years.

**Increase Flexibility to Manage Available Water Supplies Through Storage and Rehabilitation of Existing Infrastructure**
Water storage is an important part of any integrated water resource management strategy. Water storage creates greater flexibility in managing available supplies to meet the multiple demands of agriculture, municipalities, industry, hydropower, fisheries, recreation and water quality. The Basin Advisory Councils and the public indicated continued support for Montana’s policy to actively pursue water storage projects if water storage is found to be the best solution for meeting growing needs and resolving water management challenges (85-1-703, MCA). However, traditional large-scale storage projects are expensive to plan, construct, operate and maintain. The prospect of constructing new large storage projects in Montana is limited by the availability of suitable locations, cost, public support, the need to mitigate environmental impacts, as well as the limited legal and physical availability of water. Smaller storage projects can improve water availability within the year, but lacking significant carry-over storage, may not be effective tools for mitigating water-supply shortages during an extended drought. Other options to explore include retro-fitting current storage infrastructure to increase the amount of water stored and modernizing outlet works to enable more efficient operation.

Another important tool for stored water management is the modification of policies and purposes governing project operations that define how and when water is stored or released, and for what purpose (e.g. irrigation, hydropower, instream flow, recreation).

**INTERMEDIATE TERM RECOMMENDATIONS (2–6 YEARS)**
- Work with state and federal reservoir operators to evaluate policies and purposes that consider multiple benefits and provide additional water to meet other beneficial uses if water is legally available and without jeopardizing the original authorized use of the reservoir.
- Explore opportunities to increase the storage capacity of existing state and federal reservoirs where feasible and modify infrastructure to enable more efficient operations.
- Explore the opportunities and challenges of securing contract water from federal projects such as Hungry Horse, Canyon Ferry, Tiber, Clark Canyon and Yellowtail Reservoirs to provide water for mitigating the effects of new appropriations.
- Work with the Legislature to make funding available to share in the cost of upgrading and rehabilitating existing water conveyance infrastructure. The state will work with willing stakeholders to develop public-private partnerships and innovative funding strategies for projects that cannot be completed within the state’s current funding programs.
- Work with willing stakeholders to identify basins where high spring flows are physically and legally available for storage.

**LONG TERM RECOMMENDATION (6 – 10 YEARS)**
- Work with the Legislature to make funding available to share in the cost of developing additional water storage infrastructure. The state will work with willing stakeholders to develop public-private partnerships and innovative funding strategies for projects that cannot be completed within the state’s current funding programs.
Integrate Natural Storage to Benefit Water Supplies and Ecosystems

Existing natural systems, such as riparian areas, floodplains and wetlands act to slow runoff and promote groundwater recharge; effectively storing water and releasing it slowly back to the surface water system. In this way, these natural systems fill a role similar to traditional reservoirs. The hydrologic characteristics of these natural systems also improve water quality. Artificial recharge of alluvial aquifers and floodplains may also provide additional opportunities to store water when the physical supply exceeds downstream legal demands. Integrating existing natural systems and promoting the protection and restoration of natural systems into Montana’s water management practices will support late season flows, help to mitigate the impact of drought cycles, and provide environmental benefits.

**SHORT TERM RECOMMENDATIONS (0-2 YEARS)**

- DNRC will explore the water right implications of integrating natural storage and artificial aquifer recharge into Montana’s water use administration.
- DNRC will work with stakeholders to identify and develop at least one pilot project to quantify the capacity and explore the water right implications of using natural storage to enhance water supplies in smaller watersheds.

**INTERMEDIATE TERM RECOMMENDATIONS (2-6 YEARS)**

- DNRC will work with stakeholders to investigate the feasibility, cost effectiveness, and water right implications of using the natural storage capacity of wetlands, riparian areas, or floodplains to enhance water management in a smaller watershed.
- DNRC will work with stakeholders and the Montana Bureau of Mines and Geology to investigate the feasibility and potential for using aquifer storage and recovery tools to meet local water needs. The investigation will include the geologic conditions required for aquifer storage and recovery, potential adverse effects to surface water flows, financial feasibility, and water right implications.

Support and Expand Existing Drought Preparedness and Planning Efforts

Drought is part of Montana’s natural hydrologic regime. Almost any part of the state can experience drought conditions in any given year. Climatologists can now forecast climate anomalies, such as El Niño, six to nine months in advance of onset. El Niño events have a consistent record of bringing warmer temperatures and below normal precipitation to Montana over the winter months resulting in below average water content of the mountain snowpack, an early spring runoff, and surface water shortages. Accurate forecasting of El Niño and other weather related events can provide up to a year of lead time to assist planning and to develop mitigation strategies.

Drought preparedness requires a collaborative approach within small- to medium-sized watersheds. Working together, water users and water management agencies can develop adaptive management strategies that can yield benefits to water supply, fisheries, and water quality. Adaptive management also requires effective coordination between state and federal agencies responsible for managing water supply, water quality, fisheries, and drought and water supply forecasting. Successful adaptive management is facilitated by ready access to information about stream flow, water rights, water quality and aquatic habitat.
SHORT TERM RECOMMENDATIONS (0–2 YEARS)

- Support the development of drought management plans in small to medium size watersheds.
- Assess potential threats to the state’s water supply and economy resulting from extended periods of drought and increased climate variability by partnering with appropriate state and federal agencies to conduct one climate risk assessment pilot study in one of the four planning basins.

INTERMEDIATE TERM RECOMMENDATIONS (2–6 YEARS)

- Support University and college programs, including the Montana Climate Office, involvement in drought monitoring and forecasting in order to increase the lead-time for Montana water users and managers to prepare for times of water scarcity.
- Build upon the lessons learned from the climate risk assessment pilot study identified above and conduct similar studies in the remaining basins.

WATER USE ADMINISTRATION

Historic beneficial use is the basis, measure and limit of a water right. An accurate understanding of water use is critical to Montana’s ability to protect existing water rights while meeting new demands through the water right change process or new appropriations of surface water and groundwater.

The existence of unused and overstated claims in the DNRC water rights database may hinder new development in some basins by making water legally unavailable for use. In some cases a water right may remain unused for a period of time due to economic forces. In other cases an appropriator may have filed a water right, but later abandoned their plans to put the water to a beneficial use. Water right administration needs to reflect actual demands and supply on specific sources.

The role of exempt wells in water allocation has created a level of uncertainty for senior water right holders, the development community and DNRC. Exempt wells are exempt for the water right permitting process and allow for the beneficial use of water without an analysis of adverse effect. DNRC has had two very different definitions of “combined appropriation” related to exempt wells. The role of exempt wells in meeting Montana’s water needs will remain unclear until the courts or the legislature provide guidance on the intent of the term “combined appropriation”. Enforcement against water use without a water right or permit, water use that exceeds the limits of a water right or permit, or water use outside of priority date is also critical to the orderly management of Montana’s water resources.

Adjudication of pre-1973 water rights is critical to Montana’s ability to develop strategies for meeting future demands while protecting existing water rights. The water rights adjudication process must be completed as accurately as possible to establish the priority of pre-1973 water rights.
SUN RIVER WATERSHED GROUP
SPECIAL STUDY REPORT

Prepared by:
Sun River Watershed Group in Cooperation with the U.S. Department of Interior Bureau of Reclamation, and Montana Department of Natural Resources and Conservation
December, 2012
# TABLE OF CONTENTS

Executive Summary .................................................................................................................. 1

Introduction ........................................................................................................................... 2
  Special Study Background .................................................................................................... 2
  The Sun River Basin ........................................................................................................... 2
  The SRWG and it Organization .......................................................................................... 3
  Sun River Water Supply and Water Use ........................................................................... 5
  Water Appropriations ......................................................................................................... 11
  Previous Investigations Leading to the Special Study ....................................................... 13

Project Identification and Evaluation .................................................................................... 15
  Potential Projects by Category ......................................................................................... 16
  Project Screening and Potential Projects to Investigate Further ....................................... 17
  Evaluation of Screened Alternatives .................................................................................. 22

Selected Projects by Group .................................................................................................. 23

Implementation Plan ............................................................................................................ 25
  Project Evaluation ............................................................................................................. 25
  Developing a Methodology for Allocating Saved Water .................................................... 25
  Operation and Maintenance of Projects .......................................................................... 26
  Obtaining Funding for Projects ....................................................................................... 27
  Example Project ................................................................................................................ 27

Conclusion ............................................................................................................................. 29

References ............................................................................................................................. 30

Appendixes A: Project Review Spreadsheet Matrix ............................................................. 32
Appendixes B: Other Options Identified .............................................................................. 35
Appendixes C: Instream Flow Option Sideboards ................................................................. 36
Appendixes D: Basis Water Sharing Agreement Outline ...................................................... 37
ACRONYMS

<table>
<thead>
<tr>
<th>Acronym</th>
<th>Full Form</th>
</tr>
</thead>
<tbody>
<tr>
<td>BLM</td>
<td>U.S. Bureau of Land Management</td>
</tr>
<tr>
<td>DEQ</td>
<td>Montana Department of Environmental Quality</td>
</tr>
<tr>
<td>DNRC</td>
<td>Montana Department of Natural Resource and Conservation</td>
</tr>
<tr>
<td>FSID</td>
<td>Fort Shaw Irrigation District</td>
</tr>
<tr>
<td>FWP</td>
<td>Montana Department of Fish, Wildlife &amp; Parks</td>
</tr>
<tr>
<td>GID</td>
<td>Greenfields Irrigation District</td>
</tr>
<tr>
<td>MSU</td>
<td>Montana State University</td>
</tr>
<tr>
<td>NRCS</td>
<td>U.S. Department of Agriculture Natural Resource Conservation Service</td>
</tr>
<tr>
<td>NRIS</td>
<td>Montana Natural Resource Information System</td>
</tr>
<tr>
<td>Project</td>
<td>The Sun River Irrigation Project</td>
</tr>
<tr>
<td>Reclamation</td>
<td>U.S. Bureau of Reclamation</td>
</tr>
<tr>
<td>SRWG</td>
<td>Sun River Watershed Group</td>
</tr>
<tr>
<td>TU</td>
<td>Trout Unlimited</td>
</tr>
<tr>
<td>USFS</td>
<td>U.S. Forest Service</td>
</tr>
<tr>
<td>USFWS</td>
<td>U.S. Fish &amp; Wildlife Service</td>
</tr>
<tr>
<td>USGS</td>
<td>U.S. Geological Survey</td>
</tr>
</tbody>
</table>
Executive Summary

In 2009, Reclamation, in consultation with the Sun River Watershed Group (SWRG), initiated the Sun River Special Study. The Special Study is an inventory and analysis of proposed measures that could be implemented to improve streamflow in the Sun River while maintaining or improving irrigated agriculture production. The study identifies a procedure by which water savings can be allocated between improved streamflow in the Sun River and irrigation needs. Although the purpose of the Special Study was not to fund projects, it does identify steps that can be taken towards implementing projects.

The Special Study identifies potential projects that might save water and provide shared benefits to agriculture and instream flow. This includes projects identified in previous studies, and those brought forth during the Special Study. The potential projects identified were placed into four categories:

1. Those that improve delivery system efficiencies
2. Reservoirs, which would include new reservoirs or improvements to existing reservoirs
3. On-farm efficiency improvements
4. Other water management measures

Information was compiled on the identified projects and the projects with the best potential were compared and ranked. The ranking did not strictly order the projects from highest to lowest, but partitioned projects into three groups based on when it might realistically be possible to implement the projects. Group 1 projects were those that ranked high and which the group could pursue now or in the near future. The second group of potential projects consisted of those which the group considered to be good projects overall, but where there was a lot more work to be done before the projects could be implemented. The third group consisted of projects that might have some potential, but were complex, possibly expensive and not workable at this time, but could still be considered in future work planning.

The last section of the report outlines a plan for further evaluating and implementing the projects. Basic procedures that might be followed, from feasibility studies through project construction, are identified. Because every project is different, this implementation plan is general rather than project specific. An important component of any project selected would be to develop a plan for sharing the saved water between irrigation and instream uses.

This Special Study has identified a number of projects that have the potential to conserve water, and provide shared benefits to irrigators and instream flow in the Sun River. Although no one project will solve all of the low-flow problems in the watershed, taken together, these projects might be enough to produce shared benefits and to increase Sun River instream flows at key locations, and during critical times. Implementing these projects will require a commitment from group members and working together as a team to obtain the necessary funding for design, authorization, and construction. Continued success of the project will require follow-through with operation and maintenance long after the projects are constructed. Developing agreements among parties that allow for sharing a project’s water-saving benefits between irrigation and instream uses will be critical to the success of these projects, and for achieving the goals of the Special Study.

The Special Study identifies projects and recommends a path for achieving the goals of improving Sun River flows and agricultural productivity. While the Special Study was in progress, the FSID and SRWG pursued an available opportunity to fund and implement a water conservation project with shared benefits. This project is presented in the report as an example of how future projects could be implemented to achieve Special Study goals.
INTRODUCTION

Special Study Background

In 2007, Reclamation, in consultation with the Sun River Watershed Group (SWRG), proposed to initiate a Special Study in Federal Fiscal Year 2009. Reclamation worked with the Sun River Watershed Group to define the specific objectives of the proposed Special Study. The study was funded by Reclamation and work began in early 2009.

Special Studies address a variety of activities that are required to make responsible resource management decisions, but not intended to lead to Federal actions requiring subsequent or additional authorizations by Congress. Special studies are usually undertaken with non-Federal entities to address specific problems or opportunities. Reclamation, as a participant, has an obligation to explore the Federal role in the study.

The expected outcomes of the Special Study were the identification of proposed measures that could be implemented to restore flows to the Sun River to address fisheries and other environmental concerns while maintaining or improving the irrigated agricultural economy of the area. The Special Study identifies measures that required appraisal level or feasibility studies to implement. The study also identifies measures that could be implemented with non-federal funds but involve Reclamation facilities, which may require an appropriate level of environmental and cultural resources compliance. An example of a potential measure that includes Reclamation facilities is a canal lining project where the appropriate share of the water savings is dedicated to in-stream flow needs.

The SRWG had been engaged for at least a decade in seeking an acceptable solution to the issue of enhancing the environmental health of the Sun River Watershed without negatively impacting irrigated agriculture, which includes the water supply available to irrigation. Part of this work includes previous studies and investigations on a broad range of topics that seek to describe the existing condition and various studies on potential projects. The SRWG had been successful in completing numerous watershed projects to date, and the Special Study would build on other ongoing efforts in the watershed.

This Special Study describes the existing state of the watershed, identifies key issues and concerns, and describes and recommends projects. Part of the initial work on the study was to assemble, review and summarize all relevant previously completed studies and projects. This was done to avoid duplicating work already completed. For potential projects where little or no existing information was available, preliminary investigations have been completed and summarized in the Special Study to identify potential costs, water savings, key issues and concerns, and to develop recommendations.

The Sun River Basin

The Sun River Watershed is located east of the continental divide and south of Glacier National Park. It covers an area of 2,200 square miles (1,408,000 acres), with approximately 356 square miles (228,096 acres) in northwest Cascade County, 1,089 square miles (696,960 acres) in east Lewis & Clark County, and 755 square miles (482,944 acres) in southern Teton County. The Sun River starts at the confluence of the North and South Forks at Gibson Reservoir. Elevations in the headwaters in the Bob Marshall Wilderness area are as high as 9,000 feet. From Gibson Reservoir, the river meanders out of the mountains through rolling grass-covered foothills and farmland for 100 miles to its confluence with the Missouri River at the City of Great Falls at an elevation of about 1,800 feet. Along the way, the river passes through the communities of Augusta, Simms, Fort Shaw, Sun River, Vaughn, and Sun Prairie Village.
Ownership and land-use patterns

The headwaters of the Sun River watershed are mostly in National Forest Lands. As the river leaves the Rocky Mountain Front, land ownership changes to primarily private. The first major irrigator is the Broken O Ranch, which has one of the largest irrigation land bases of all the ranches in Montana. The Greenfields Irrigation District (GID) is the largest single irrigation entity in the watershed, followed by the Fort Shaw Irrigation District (FSID). Other irrigation districts and private irrigators also use Sun River water. Table 1 summarizes land ownership and irrigation patterns in the watershed.

Table 1. Land ownership and irrigated acreages in the Sun River Watershed (Acres).

<table>
<thead>
<tr>
<th>Ownership/Location</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>US Forest Service</td>
<td>484,352</td>
</tr>
<tr>
<td>MT State Lands</td>
<td>98,560</td>
</tr>
<tr>
<td>Reclamation</td>
<td>17,920</td>
</tr>
<tr>
<td>US Bureau of Land Management.....</td>
<td>5,120</td>
</tr>
<tr>
<td>USFWS</td>
<td>160</td>
</tr>
<tr>
<td>Irrigated Lands (Total)</td>
<td>117,700</td>
</tr>
<tr>
<td>GID</td>
<td>87,000</td>
</tr>
<tr>
<td>Broken O Ranch</td>
<td>17,000</td>
</tr>
<tr>
<td>FSID</td>
<td>10,000</td>
</tr>
<tr>
<td>Sun River Ditch</td>
<td>3,200</td>
</tr>
<tr>
<td>Rocky Reef Ditch</td>
<td>500</td>
</tr>
<tr>
<td>Urban</td>
<td>3,000</td>
</tr>
<tr>
<td>Other Private property</td>
<td>799,048</td>
</tr>
<tr>
<td>Total Acres</td>
<td>1,525,860</td>
</tr>
</tbody>
</table>

The Sun River Watershed Group and its Organization

General Description and Mission - The Sun River Watershed Group is a nonprofit organization that was formed to help resolve natural resource problems using a consensus-based approach. The multi-stakeholder group strives to promote community-based efforts that will preserve quality of life and livelihoods, while promoting and enhancing the natural resources of the watershed. Participation in the organization is open to anyone or any group that is willing to work through collaboration. The group is funded through contributions from participating groups, business contributions, individual contributions, and government and private grants.

History and Accomplishments - Formed in 1994, the Sun River Watershed Group is the key to local involvement to resolve watershed natural resource issues, which include weeds, water quality and water quantity. In 1996 the SRWG officially formed as a 501 © (3) nonprofit organization to access additional funds to work on natural resource projects.

Historically, controversy was a way of life in the Sun River Basin, with battle lines drawn on the issues of water rights, erosion causes, water for fisheries and recreation, and water quality conditions. The tug-of-war began to change in 1994 when the Muddy Creek Task Force organized to break the status quo and to provide a team approach to resolving one of the worst non-point source pollution problems in Montana. The group discovered innovative ways to tackle this problem which had stalemated for more than 30 years. From the beginning it was agreed that, once the Task Force had a good start, it would enlarge the boundaries and participation to encompass the entire Sun River watershed. In 1996, with the demonstration of the Muddy Creek success story, leaders in the basin felt it was time to expand efforts to the bigger watershed area. Soon, other success stories...
included the following:

- Elk Creek channel work to improve stream dynamics
- Willow Creek erosion control work to reduce high sediment loads entering Willow Creek Reservoir
- Mill Coulee channel work to improve stream dynamics and riparian health
- FSID water saving projects including conversion of open ditches to pipelines, canal lining and installation of measurement devices
- GID water savings projects including canal lining, conversion of open ditches to pipelines, wastewater pump-back systems, and installation of measurement devices
- The conversion of many flood irrigation systems to more efficient sprinkler systems
- A resulting reduction to irrigation and waste-water flows entering Muddy Creek (Figure 1) where high waste-water flows were causing serious erosion on that stream.

**Figure 1. Average Monthly Flow for Muddy Creek at Vaughn for periods before and after implementation of water conservation measures.**

**Structure** - The Sun River Watershed Board is comprised of the officers of president, vice-president, secretary and treasurer, and of individuals who have a vested interest in the watershed. Formal decisions by the group and by-laws for the core organization are made by an executive committee comprised of individuals from Cascade Conservation District, Teton Conservation District, Lewis & Clark Conservation District, Muddy Creek Task Force chair, and member-at-large. The executive board makes day-today decisions and handles all financial responsibilities. The current executive committee is comprised of Fay Lesmeister (Cascade Conservation District), Brad DeZort (Teton Conservation District), Mike Cobb (Lewis and Clark Conservation District), Skip Neuman (Muddy Creek Task Force), and at large member Michael Konen.

The rest of the SRWG participants can be anyone and everyone. Federal, state, and local agencies and groups participating in the group include the U.S. Bureau of Reclamation (Reclamation), U.S. Fish & Wildlife Service (USFWS), U.S. Bureau of Land Management (BLM), U.S. Forest Service (USFS), Montana Department of
Environmental Quality (DEQ), Montana Department of Natural Resources and Conservation (DNRC), Montana Fish, Wildlife and Parks (FWP), Montana State University (MSU) Extension Service, and many individual landowners.

**Watershed Group:** From scoping meetings and subsequent work meetings the Sun River Watershed Group objectives (in no particular order) are to:

1) Maintain and/or improve a viable agriculture economy  
2) Control noxious weed infestations in the Sun River Watershed  
3) Reduce the sediment loads into the Sun and Missouri Rivers  
4) Improve the overall water quality of the Sun River  
5) Improve the flows in the Sun River  
6) Improve the fisheries of the Sun River

**Sun River Water Supply and Water Use**

Most of the flow of the Sun River originates in the higher-elevation headwaters of the watershed in the Rocky Mountains west of Great Falls, Montana. The two primary tributaries are the North and the South Forks which join to form the Sun River at the head of Gibson Reservoir on the Rocky Mountain Front. These two streams produce runoff and consistent base flow, due to the higher precipitation and snow retention that occurs at the higher elevations in the mountains.

*Photo 1: The North Fork of the Sun River above Gibson Reservoir.*

Gibson Reservoir provides storage of the combined flow of the North and the South Forks of the Sun River. It has a capacity of about 96,477 acre-feet and is operated and maintained by GID in accordance with their contract with Reclamation. Reclamation provides oversight during spring runoff, while GID operates the reservoir during the irrigation season to meet irrigation demands on GID, while passing the water needed for senior irrigation
water rights on the Sun River downstream. Water typically is stored in Gibson during two periods: following the irrigation season in the late fall and winter, and during the snowmelt-runoff period in the spring. Storage builds up slowly during the fall, winter and early spring, and quickly during snowmelt runoff in May and June. Typically the reservoir begins releasing stored water for irrigation demands starting from late May to early July, with storage releases beginning in June during most years. Releases continue until the early fall, when the reservoir typically reaches its lowest level.

Just downstream of Gibson Reservoir, the Sun River Diversion Dam diverts water through a 1,400 cfs capacity canal to Pishkun Reservoir, an off stream Reclamation Reservoir with an active storage capacity of about 30,686 acre-feet. From there, the water is reregulated and delivered to the Greenfields Irrigation District, which irrigates about 83,000 acres. Some of the water that is diverted from the Sun River at the Diversion Dam also goes to Willow Creek Reservoir, with an active storage capacity of about 31,847 acre-feet. Water from Willow Creek Reservoir is released back to the Sun River to ensure there is enough water in the river for senior users and for the Fort Shaw Irrigation District, which has some storage rights and irrigates about 10,000 acres. The main diversion dam for the FSID is located upstream of the town of Simms. The Broken O Ranch also irrigates a considerable acreage of land with Sun River water, which is diverted at several locations between the mouth of Willow Creek and the Fort Shaw Diversion Dam.

Photo 2. Gibson Dam and Reservoir near the end of the irrigation season.

The inflow to Gibson Reservoir from the North and South Forks of the Sun River is by far the largest source of water in the basin. For the period from 1930 through 2007, about the time that the Special Study began, the average annual inflow was approximately 595,000 acre-feet. On average 85% of this water was produced during the April-through-September period, but a substantial amount of the winter inflow to Gibson Reservoir is stored for release during the following irrigation season. Elk Creek, the largest higher-elevation Sun River tributary, contributes about 5-to-10 percent of the total basin flow. Nilan Reservoir, a DNRC project with a capacity of about 10,000 acre-feet, stores and releases water from the Ford and Smith Creek tributaries for irrigation in the Elk Creek drainage.
The USGS, Reclamation, DNRC, and the SRWG all collect streamflow data in the watershed. These data are used to characterize basin water supply and water use. In addition to the Sun River proper, flow data are collected for a number of tributaries including Elk Creek, Big Coulee, Adobe Creek, Mill Coulee, and Muddy Creek. Map 1 depicts the locations of the gaging stations that are operated in the Sun River watershed, as well as the various reservoirs, main irrigation supply canals, and irrigation districts.

**Water Supply for Irrigation**

Hydrologic data for a 5-year period (2003-2007) were used to characterize the limitations of the Sun River water supply in meeting irrigation demands. This 5-year period is representative of more recent drought conditions. The annual average inflow to Gibson Reservoir during 2003-2007 was 402,000 acre-feet, or approximately 190,000 acre-feet less than the long-term average. Figure 2 compares high elevation Sun River watershed inflows to Sun River outflows for the period. Total inflows include that from the North and South Forks of the Sun River, plus an additional component that flows in from around the Gibson Reservoir area. Total inflow also includes Elk Creek, which contributes to Sun River flows below the Diversion Dam. Outflows are from the Sun River at Vaughn gaging station, near where the Sun River joins the Missouri River.

![Figure 2. Sun River Basin inflow/outflow comparison.](image)

During most of the spring and summer, there is more water flowing into the basin from the higher elevations than leaves the basin at the mouth of the Sun River. This is because during the spring water is being stored in Gibson Reservoir, and because water is being used for irrigation by GID, Broken O Ranch, FSID, Elk Creek water users, Rocky Reef Ditch users, and Sun River Valley Ditch Company users. There are about 120,000 acres irrigated in the basin overall. During the fall and winter months, outflows from Gibson are reduced but the flow of the Sun River progressively increases downstream. This increase is due primarily to irrigation return flows, coming back through the groundwater, which are delayed by the time it takes the water to flow through the aquifer systems.
Sun River Basin inflow volumes for the 2003-2007 period averaged about 440,000 acre-feet per year, while outflows averaged about 320,000 acre-feet per year. Figure 3 is an approximation of an annual volumetric water budget for the watershed and depicts where the water in the basin goes. All but about 13 percent of the water in the Sun River was diverted at least once for the purpose of irrigation. Most of the 57,000 acre-feet that wasn’t diverted was flow during the fall and winter, and spring runoff that could not be captured or stored. Of the water diverted for irrigation, approximately 27 percent or about 117,000 acre-feet was consumed. This works out to almost one acre-foot of water consumed per acre of irrigated ground, assuming 120,000 acres irrigated. The rest of the flow (60 percent or 266,000 acre-feet) was water that was diverted and not consumed, and that left the basin as return flow.

It is estimated that it would take about 450,000 acre-feet of controllable flow to meet all of the irrigation needs in the basin during a typical growing season. This would assume an overall irrigation efficiency of about 40 percent. Having this volume available would allow irrigators to get sufficient water to their crops, with the plants consuming about the 1.5 acre-feet per acre irrigated (about 175,000 acre-feet total). This would provide near optimal crop production. Unfortunately, this volume of water is not available during many years.

**Figure 3. Generalized Sun River water budget: 2003-2007.**
Map 1. Sun River Watershed map including locations of irrigation districts and flow monitoring sites.
**Fisheries and Instream Flow Needs**

Montana Fish, Wildlife and Parks (FWP) manages the Sun River fisheries. FWP estimates that the main stem of the Sun River supports about 10,000 angler days per year. The primary game fish in the Sun River are rainbow and brown trout. Low-flow conditions in the river limit the trout populations to about 40-120 fish over 8 inches per mile. However, fish that do survive reach large sizes with over half of the fish being 15 inches or larger. A goal of the Sun River Watershed Group is to increase fish populations to 400 fish per mile. Doing so would require improving flow conditions in the river.

Table 2 contains FWP’s recommended minimum and absolute minimum flows for the Sun River main stem. The recommended minimums are guidelines; there is no water right to protect these flows. Flows at these rates or higher would maintain food production at or near optimum levels for the aquatic community and provide bank cover, and spawning and rearing habitat. FWP does have a water right (a water reservation) for the absolute minimum flow recommended, which identifies the flow below which there is a rapidly declining level of aquatic habitat potential that provides for only a low fish population. However, these rights have a 1985 priority date and are junior to almost all irrigation water rights in the watershed.

<table>
<thead>
<tr>
<th>Diversion Dam to Mouth of Elk Creek</th>
<th>Recommended Minimum CFS</th>
<th>Absolute Minimum CFS (Water Reservation)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elk Creek to Mouth</td>
<td>220</td>
<td>100</td>
</tr>
<tr>
<td></td>
<td>220</td>
<td>130</td>
</tr>
</tbody>
</table>

In many years it has been difficult to consistently maintain the recommended minimum or even the absolute minimum flow in all reaches in the river year round. One persistent difficulty is during the winter period when GID is storing water in Gibson Reservoir for the upcoming irrigation season. Because inflow to the reservoir typically is at its lowest during this time of the year, comparatively little water is available to store or release to begin with. The operators are going into the winter with little knowledge of what snowpack will accumulate during the winter and what the spring precipitation will be. Reliable information on mountain snowpack will not be available until the late winter or early spring. Because the winter inflow to Gibson Reservoir can be predicted based on the fall reservoir inflow (Reclamation 2007), reservoir releases can be set during the fall and winter to achieve a desired storage level prior to the beginning of spring runoff. If the reservoir ended the previous irrigation season at a very low level and the projected inflow is low, then operators typically store much of the winter inflow to reduce the risk of not filling the reservoir to full pool by the end of spring runoff.

Typically, an effort is made to maintain a minimum winter release from Gibson Reservoir of at least 100 cfs. After the February 1st water supply forecast, winter releases can be adjusted, if necessary, based on the forecast and the reservoir level at the time. However, if winter conditions are severe, the potential for ice scouring of the banks may prevent the dam operators from increasing flows. During years when reservoir storages and winter inflow is low, winter releases have been cut back to around 75 cfs. In extreme cases, the outflow has been reduced to the absolute winter minimum of 50 cfs. Because there typically is not a lot of irrigation return flow or tributary flow added to the river between the Sun River Diversion Dam and the mouth of Elk Creek, low winter releases result in less than desirable winter flows that limit fish populations in the river.

During the irrigation season, the flow that goes over the Sun River Diversion Dam for senior irrigation water rights generally keeps the river flow above recommended minimums downstream to the FSID Diversion Dam. Below the FSID Diversion Dam, low water levels and high water temperatures often are a problem during the irrigation season. River managers attempt to maintain a minimum flow of 50 CFS at the Sun River at Simms
gaging station, although flow has dropped below this level during recent years. Progressing downstream, the river flows steadily increase due to irrigation returns from GID, FSID, Broken O Ranch, and other irrigators.

**Water Appropriations**

**Reclamation’s Sun River Project**

The Sun River Project (Project) facilities, authorized under the Reclamation Act of 1902, provide the capability to store, manage and utilize federal water rights in the Sun River drainage. The major Project facilities, constructed, owned by Reclamation, and operated by GID, are managed to deliver Project water by contract to users. Two irrigation districts are served by the Project, GID and FSID. GID contains approximately 87,000 irrigated acres, and FSID contains approximately 10,000 irrigated acres. The Project is the largest water user in the basin.

GID works with contract holders to set annual water allotments based on the latest water supply forecast. Because of the high demands compared to the water available in the basin and the priority of the Project, it often uses the bulk of flow of the Sun River.

**Other Irrigation Water Rights**

Major consumptive private Sun River water users include the Broken O Ranch, Rocky Reef Canal Co, and Sun River Valley Ditch Co. The Nilan Water Users Association operates Nilan Reservoir, a State of Montana water project, and irrigates approximately 10,000 acres, mostly in the Elk Creek tributary drainage. There also are numerous private water rights for irrigating relatively smaller parcels of land, and for stock and domestic use. With the exception of the Broken O Ranch, most of these rights are junior to those associated with the Sun River Project.

**Water Reservations/Reserved Water Rights**

Water reservations have been granted in the Sun River basin for current and future beneficial uses, including maintenance of minimum streamflow for fishery purposes. Water reservations were only granted to political subdivisions, the State of Montana or its agencies, or to the United States or any of its agencies. Water reservations maintain a 1985 priority date even though the water may not be put to beneficial use for decades. These rights are junior when compared to the larger irrigation water rights in the basin, and there is often insufficient flow left for them. Table 3 lists water reservations in the Sun River watershed.

**Table 3. Water Reservations in the Sun River Watershed.**

<table>
<thead>
<tr>
<th>Reservant</th>
<th>Purpose</th>
<th>Source</th>
<th>Rate CFS</th>
<th>Volume AF/yr</th>
<th>Acres</th>
</tr>
</thead>
<tbody>
<tr>
<td>City of Great Falls</td>
<td>Parks irrigation</td>
<td>Sun River</td>
<td>4.45</td>
<td>233.5</td>
<td></td>
</tr>
<tr>
<td>Montana DFWP</td>
<td>Instream flow</td>
<td>Elk Creek</td>
<td>16</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Ford Creek</td>
<td>12</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Willow Creek</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>NF Willow Creek</td>
<td>3</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sun River: Diversion Dam to Elk Creek</td>
<td>100</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sun River: Elk Creek to mouth</td>
<td>130</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cascade County CD</td>
<td>Irrigation</td>
<td>Sun River</td>
<td>7</td>
<td>991</td>
<td>388</td>
</tr>
<tr>
<td>Lewis and Clark County CD</td>
<td>Irrigation</td>
<td>Elk Creek</td>
<td>1</td>
<td>151</td>
<td>60</td>
</tr>
<tr>
<td>Teton County CD</td>
<td>Irrigation</td>
<td>Muddy Creek</td>
<td>12</td>
<td>1785</td>
<td>804</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Sun River</td>
<td>3.7</td>
<td>542</td>
<td>252</td>
</tr>
</tbody>
</table>
**Water Storage**

Water storage plays a major role in the Sun River Basin. Storage projects include Gibson, Pishkun, Nilan, and Willow Creek reservoirs. Water is stored during the winter and runoff periods, and then released to supply irrigation water to hundreds of users along the river and canal system. Water storage can also play a crucial role for recreation interests and fisheries in the basin, if releases coincide with times of need. Aside from direct recreation benefits at the reservoirs, releases for irrigation purposes can also indirectly increase stream flows when natural channels are used for conveyance or carry irrigation return flow.

Table 4 contains a summary of consumptive and non-consumptive water rights in the basin, which demonstrates the variety of uses and the volumetric extent of the various uses. More details on individual water rights can be found at the following DNRC web site: [http://dnrc.mt.gov/wrd/water_rts/default.asp](http://dnrc.mt.gov/wrd/water_rts/default.asp).

**Table 4 - Sun River Watershed water rights summary.**

<table>
<thead>
<tr>
<th>Purposes</th>
<th>Number of Rights</th>
<th>Volume (Acre-Feet)</th>
<th>Acres Irrigated</th>
<th>Percent of Total Rights</th>
<th>Percent of Total Volume</th>
<th>Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agricultural Spraying</td>
<td>2</td>
<td>1</td>
<td></td>
<td>0.04</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Commercial</td>
<td>72</td>
<td>752</td>
<td>12</td>
<td>1.5</td>
<td>0.04</td>
<td></td>
</tr>
<tr>
<td>Domestic</td>
<td>1338</td>
<td>5,550</td>
<td>1,091</td>
<td>28.7</td>
<td>0.28</td>
<td>Includes wells</td>
</tr>
<tr>
<td>Fire Protection</td>
<td>5</td>
<td>204</td>
<td></td>
<td>0.11</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Fish and Wildlife</td>
<td>37</td>
<td>14,849</td>
<td></td>
<td>0.79</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>Fishery (instream flows)</td>
<td>11</td>
<td>201,458</td>
<td></td>
<td>0.24</td>
<td>10.3</td>
<td></td>
</tr>
<tr>
<td>Industrial</td>
<td>10</td>
<td>423</td>
<td>5</td>
<td>0.21</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Institutional</td>
<td>15</td>
<td>6</td>
<td>2</td>
<td>0.32</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Irrigation</td>
<td>756</td>
<td>1,457,362</td>
<td>521,882</td>
<td>16.2</td>
<td>74.7</td>
<td>Some rights overlap</td>
</tr>
<tr>
<td>Lawn and Garden</td>
<td>262</td>
<td>1,269</td>
<td>339</td>
<td>5.61</td>
<td>0.07</td>
<td></td>
</tr>
<tr>
<td>Mining</td>
<td>1</td>
<td>1,814</td>
<td></td>
<td>0.02</td>
<td>0.09</td>
<td></td>
</tr>
<tr>
<td>Multiple Domestic</td>
<td>12</td>
<td>173</td>
<td>3</td>
<td>0.26</td>
<td>0.01</td>
<td></td>
</tr>
<tr>
<td>Municipal</td>
<td>23</td>
<td>10,991</td>
<td></td>
<td>0.49</td>
<td>0.56</td>
<td></td>
</tr>
<tr>
<td>Observation &amp; Testing</td>
<td>1</td>
<td>1</td>
<td></td>
<td>0.00</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Other Purpose</td>
<td>17</td>
<td>13</td>
<td></td>
<td>0.36</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Power Generation</td>
<td>3</td>
<td>203,674</td>
<td></td>
<td>0.06</td>
<td>10.44</td>
<td></td>
</tr>
<tr>
<td>Recreation</td>
<td>15</td>
<td>270</td>
<td></td>
<td>0.32</td>
<td>0.01</td>
<td>Some rights overlap</td>
</tr>
<tr>
<td>Stock</td>
<td>2072</td>
<td>53,028</td>
<td></td>
<td>44.4</td>
<td>2.72</td>
<td></td>
</tr>
<tr>
<td>Wildlife</td>
<td>14</td>
<td></td>
<td></td>
<td>0.30</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td>Waterfowl and Wildlife</td>
<td>3</td>
<td>98</td>
<td></td>
<td>0.06</td>
<td>0.00</td>
<td></td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>4,669</strong></td>
<td><strong>1,951,936</strong></td>
<td><strong>523,334</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td></td>
</tr>
</tbody>
</table>

**Upper Missouri River Closure**

In 1993 the Montana Legislature closed the Upper Missouri River drainage, including all tributaries, to most new appropriations of water (85-2-343, MCA). The Sun River and all water flowing into it is one of the affected tributaries. The closure was enacted due to water availability problems, over-appropriation, and a concern for protecting existing water rights, including downstream hydropower rights. Certain exemptions allow new water rights (permits) to be issued for limited non-consumptive, water storage of high spring flows, and other minimal consumptive purposes that do not adversely affect existing water rights. The closure also has an exemption for
new permits that use water from the Muddy Creek drainage, if the proposed use will help control Muddy Creek erosion. With the exception of the Muddy Creek drainage, the closure makes new permits for additional consumptive uses from the Sun River basin unlikely, other than to implement water reservations. Projects that are pursued as a result of this Special Study will need to be evaluated, during project planning, to determine if water rights changes or new water rights are needed, and if any of the projects might be subject to the Upper Missouri River Closure.

**Previous Investigations Leading to the Special Study**

The Water Management subgroup of the Sun River Watershed Group was formed in 2003. The goals of the subgroup are to: 1) improve flows in the Sun River for fisheries, and 2) while accomplishing this goal, maintain and/or improve irrigation production. The members of the subgroup represent a range of stakeholders, including GID and FSID, Reclamation, DNRC, the Broken O Ranch, Montana Fish, Wildlife and Parks, Trout Unlimited (TU), NRCS, and other private irrigators and interested citizens.

In working towards its goals, the subgroup operates, maintains, and helps fund the flow monitoring network in the watershed. This includes river and tributary stream gages, measurement of flows in irrigation canals and ditches, and the measurement of irrigation return flow. With this information, the group has developed a much better understanding of the hydrology of the Sun River system. Annual water budgets for the basin have been developed and presented to the group. Collecting, compiling, and understanding all this information is necessary for estimating what benefits various water conservation measures might provide, especially in regards to improving the flow in the Sun River.

A water management analysis was conducted by a consultant to the group during 2004 (Snowcap Hydrology 2004). This included a review and analysis of existing flow data, irrigation water management practices, and Reclamation project evaluations. Recommendations included improving irrigation efficiencies and reducing canal spillage, improving the ratio of delivered water to diverted water, using climate data to better anticipate crop needs, better use of water supply forecast information, reassessing recommended minimum outflows from Gibson Reservoir, better coordination of the release of stored water, and better education on efficient irrigation practices.

To better understand water diversions and returns to the system as a whole, the group conducted synoptic flow measurements during the 2004 (a lower quartile flow year) and 2005 (a year in the median range). Over two-day periods, when flow and diversion conditions were relatively stable, the flow of Sun River, its tributaries, and diversion were measured at various locations (up to 31 locations) throughout the watershed. The goal was to obtain snapshots of flow patterns in the watershed at the time of the synoptic measurements. The measurements were helpful in identifying where the river was gaining and losing water, and whether these gains and losses were predictable. Five synoptic measurement snapshots were made, including snapshots prior to the irrigation season, during the mid irrigation season, and near the end of the season (DNRC 2006).

In follow-up to recommendations in the Snowcap Hydrology Water analysis report, during 2006 and 2007 Reclamation used its River Operations Model, SUNAOP to investigate Gibson Reservoir winter operations and to evaluate whether instream flows could be increased in the Sun River below the Sun River and Fort Shaw Diversion Dams during the irrigation season (Reclamation 2007). The study found that it would be difficult to modify operations to increase instream flow during the irrigation season below the Sun River and Fort Shaw diversion dams without increasing irrigation shortages during drier years. In considering non-irrigation season operations, a water balancing method was developed through the study that could provide noticeable improvements in winter fishery flows during average and above average years, while protecting the irrigation water supply in low runoff years. Working from the Snowcap Hydrology report, Reclamation subsequently established a water-balance method to set minimum winter outflow rates from Gibson Reservoir. (Reclamation
Although the Reclamation studies identified these operational measures for improving winter flows during many years, the studies also found that it would be difficult to increase Sun River instream flows to desired levels during the driest years. To start identifying other potential ways of improving Sun River flows, a “brainstorming” session was held by the Water Management Subgroup during September, 2006. The intent of this session was to generate ideas on ways to improve Sun River instream flow, while maintaining current levels of agricultural productivity. The session identified a number of potential structural and nonstructural measures, and discussions moved on to how some of these measures might be implemented.

In follow-up to this meeting, tasks were assigned and preliminary investigations into some ideas were begun. Investigations into seepage from the Sun River Slope Canal were conducted in 2007, with considerable seepage losses identified (TD&H, Inc. 2008). Near that same time, Reclamation and GID initiated an appraisal study of enlarging the storage capacity of Pishkun Reservoir, to investigate the potential to store and deliver more water, with some of the savings possibly designated for improved river flow. The FSID also began investigating ways of improving the efficiency of its water delivery systems, including the K-ditch (TD&H, Inc. 2010).

Studies were also conducted by the SRWG to identify the major sources of waste-water and irrigation return flows to the major tributaries on the lower portions of the Sun River. A gaging network was established on tributaries to Muddy Creek by Montana State University Extension Water Quality to identify primary sources of flow and sediment to that stream, (MSU 2006, 2007, and 2008). Similar investigations were conducted on Big Coulee by MSU (MSU 2007b and 2008b). These studies identified which drainages were producing the most water and sediment, and are helpful in focusing water-conservation efforts. DNRC has been gaging Mill Coulee flows since 2001 in order to understand the patterns of return flow and unused water from that stream that returns to the Sun River. The Sun River Watershed Group has been monitoring tributary return flows from FSID for similar purposes.

In order to tie all this information together and develop a plan for future actions, the Watershed Group looked at incorporating all the ongoing efforts and future potential projects into a coordinated Special Study during the later part of 2008. The study was funded by Reclamation, with a 50-50 non-federal cost share. The Special Study was to be an inventory and analysis of proposed measures that could be implemented to improve streamflow in the Sun River while maintaining the irrigated agriculture economy of the area. Although the purpose of the Special Study was not to fund project implementation, it does include looking at steps that can be taken towards project implementation. A critical part of the study is the development of a procedure by which project water savings can be allocated between improved streamflow in the Sun River and irrigation needs.
PROJECT IDENTIFICATION AND EVALUATION

The first task of the Special Study was identifying all potential options that might result in saved water and shared benefits to agriculture and instream flow. This included those projects identified in previous studies, and those brought forth in the initial brain-storming session.

With the options identified, a procedure to initially screen the projects was developed. The intent was to remove projects from the analysis that had a low potential to provide shared benefits or feasibility before devoting resources to them. The initial screening asked the following questions:

- Does the project have the potential to provide additional water for irrigation and instream flow?
- Does the project have the potential to affect water users or instream flow?
- Are there any insurmountable hurdles to implementing the project?

The answer to the first two questions needed to be affirmative and the answer to the last question needed to be no. After considering these criteria, a number of the projects were dropped from further consideration. Some more general basin-wide water management efforts, such as installing and maintaining measuring devices, were not evaluated in the Special Study because these efforts are ongoing and it would be difficult to quantify actual amounts of water saved through these measures.

Following the initial screening, potential projects that remained on the list were categorized by project type and evaluated to assess potential costs, benefits, and other opportunities and constraints. For many of the projects identified, there was little if any available information to assess them appropriately. A consultant was hired to assist with the Special Study and help with a preliminary engineering assessment of potential projects. The intent of these assessments was to develop a preliminary project concept, including an estimate of project dollar costs and annualized costs, and to estimate the benefits that the project could provide in terms of saved water. Enough information needed to be compiled to describe each project’s potential and to compare projects. Other potential benefits, such as water quality, also were assessed, but in a more subjective way. The potential projects were placed into the following four categories:

1. Those that improve water delivery system efficiencies
2. Reservoirs, which would include new reservoirs or improvements to existing reservoirs
3. On-farm efficiency improvements
4. Other water management measures

Once the projects were identified and the necessary information compiled, a spreadsheet was developed to make ranking and comparing the projects easier. The spreadsheet included the initial screening criteria and other criteria to assess costs, and potential water savings. The spreadsheet can be found in Appendix A.

Developing a methodology for allocating saved water was an important part of the Special Study. An overall purpose of the Special Study is to identify and set out procedures for implementing projects that result in the joint benefits of improved agricultural productivity and enhanced streamflow in the Sun River. The methodology developed and described later in the report strives to achieve benefits that are equitably shared.

The following was the initial list of potential projects, by category.
Potential Projects by Category

Category 1 – Delivery Systems:

1. Canal lining
2. Control structure on the larger irrigation district canals
3. Automation of water delivery systems including field headgates
4. Pump-back systems to reuse waste-water that would otherwise flow to Muddy Creek and other tributaries
5. Replace some ditches with pipelines to deliver water to farm headgates or new sprinkler systems

Category 2 – Reservoirs:

1. Increase the height of Gibson Dam to increase the storage of Gibson Reservoir
2. Increase the ability to fill and release water from Willow Creek and Pishkun Reservoirs and increase efficiencies through timing of the fill
4. Build new or expand re-regulating reservoirs within irrigation districts
5. Increase the height of the Pishkun Dikes to increase the storage of Pishkun Reservoir.
6. Review the water levels that are maintained to protect reservoir-outlet fish screens at Pishkun Reservoir; see if there may be alternative ways to protect the fish screens.

Category 3 – On-Farm:

1. Improve on-farm irrigation/pivot efficiency through training and improved equipment.
2. Convert flood irrigation systems to sprinkler irrigation
3. See if improvements can be made in how farmers order water from their irrigation district; models for anticipating orders and actual ordering process.

Category 4 – Other Water Management Measures:

1. Water banking concept: allow water users to store water in Gibson for later instream flow release, especially during drought years.
2. Buy out senior water rights that would like to change their water rights or lease their rights to instream uses.
3. Look at ways to manage risk, i.e. insurance for water users to mitigate increased risk of not filling Gibson Reservoir due to higher winter release rates:
Project Screening and Potential Projects to Investigate Further

Projects that were not investigated further in this Special Study

The following potential projects were identified in the initial stages of the Special Study but were not pursued further because they did not pass the initial screening criteria. Each project is described below, with a short discussion of the reasons why the project was not pursued further.

Increase the height of Gibson Dam to increase the storage of Gibson Reservoir:

Gibson Reservoir fills and spills during most years. A larger reservoir might be able to capture and store more water for the upcoming irrigation season, or carry-over stored water from a dry year that follows a wetter year. When there are back-to-back drought years though, a larger Gibson Reservoir probably would not capture and supply more water because the reservoir might not even fill to the existing 96,477 acre-feet capacity during either year.

Gibson is a concrete-arch dam with a drop-inlet spillway. Modification to these structures to allow for a higher pool level would be very expensive. Additionally, there may be topographic limitations to increasing the full-pool elevation, and concerns about backing more water into the surrounding National Forest including the Bob Marshall Wilderness Area. Using a computer simulation model of the Sun River system to determine “firm” reservoir yield for various sizes and to model what an optimal reservoir size might be could provide more information to determine if this option should be explored in more detail in the future. Although the enlargement of Gibson might have some merit in the future, the length of time and high costs just for project evaluation precluded pursuing this option through the Special Study.

Build new off-stream water storage reservoirs:

The intent here was to investigate sites on the middle portion of the Sun River where surplus high flows from tributaries could be captured and diverted to new off-stream reservoirs and later released into the Sun River. Group members asked that the potential of two sites be investigated: one on Simms Creek, and the other in Cutting Shed Coulee. After preliminary investigation, it was determined that neither of these sites could store enough water to improve instream flows in the Sun River, and that construction costs would be prohibitive. With that determination, the group removed these potential projects from further investigation at this time.

Review the water levels that are maintained to protect fish screens at Pishkun Reservoir; see if there may be alternative ways to protect the fish screens:

There are screens at the outlet of Pishkun Reservoir to keep fish from entering the Sun River Slope Canal. During the winter, the water level above these screens needs to be high enough to prevent ice damage. It was initially thought that this was resulting in an additional volume of storage that had to be carried to the fall and was inaccessible for delivery to GID during the irrigation season. Although water levels may be important to protect the fish screens, GID can place protective berms around the screens or lower the water level enough so ice does not reach the screens. After discussions with GID, the project was not considered further because protection of the fish screens was not having an effect on reservoir storage or water deliveries.

Look at ways to manage risk, i.e. insurance for water users to mitigate increased risk of not filling Gibson Reservoir due to higher winter release rates:

Following dry years, when Gibson Reservoir storage is depleted and streamflow into the reservoir is low, winter releases from Gibson Reservoir are reduced to below 100 CFS. Most of the time, the upcoming winter and spring will produce enough snow and rain to fill the reservoir the following year. Although the low winter
release will have turned out to have been unnecessary during most years, it is implemented because, for GID irrigators, it insures that Gibson Reservoir fills in all years. Simply put, if a very dry winter and spring were to follow the previous dry year that depleted reservoir storage, Gibson Reservoir would not fill. The idea behind this option would be to allow instream interest to a guaranteed 100 cfs winter reservoir release, if they were willing to take out insurance on the reservoir filling. In years when the reservoir did not fill because of the increased winter release, GID irrigators would be compensated for the agricultural water value lost due to the higher winter release. The alternative was not pursued further due to the lack of an established procedure, lack of interest, and because both instream flow interests and GID Board did not consider it workable at this time. GID Board discussed this option and was of the opinion that it would be too difficult to manage crop-loss claims from irrigators during the years when the reservoir did not fill.

**Water banking concept: allow water users to store water in Gibson for later instream flow release, especially during drought years:**

Water banks broker voluntary transactions between people trying to sell or lease water rights and those trying to purchase rights or leases. A bank also can become a depository of water rights that are available for lease or transfer, and helps to set prices for purchase and sale. Montana does not have a water banking system, but agricultural water rights can be leased for instream uses between private parties. Although water banking is not prohibited, this option was dropped because there currently is not a water banking system in Montana. Purchasing or leasing water rights by other means is discussed under Category 4: Other Water Management Measures.

**See if improvements can be made in how farmers order water from their irrigation district; models for anticipating orders and actual ordering process:**

Within the irrigation districts, individual water users can order water with 48-hours advance notice or cancel water deliveries from the district with 24-hours advance notice. Often, the orders or cancellations come too late for the operators to balance flows in the ditch systems, which results in waste-water spills to coulees that feed drainages such as Big Coulee, Mill Coulee, and Muddy Creek result. With longer lead time for water orders and order cancellations, ditch riders might be able to reduce these operational spills. Implementing such a procedure may require incentives to encourage individual farmers to participate. Although changing the ordering system may have some merit in the future, the GID board felt the current system is working and that modifying the system would not result in substantial water savings at this time.

**Projects that Passed to Initial Screening Phase and were Analyzed Further in the Special Study**

The following section describes projects that passed the initial screening and were analyzed further in the Special Study. Each project and its potential costs and benefits are described. The projects are ordered by category. All cost figures are preliminary.

**Category 1: Delivery System Improvements**

Delivery systems include the main canals which divert water from the source to the irrigated lands, and the lateral ditches, pipelines and field ditches which distribute the water within the irrigated land base. Water is lost from canals and ditches as seepage and evaporation. Because evaporation losses are generally minor, they were not considered further. Reducing the amount of water lost at the end of canals, ditches and pipelines as operational spills presents another opportunity to conserve water through delivery system improvements. Operational spills occur when there is excess water within the system that can’t be used, such as immediately
following a rainstorm. In other cases, operational spills occur because there is a certain amount of carriage water required to get water to the very end of a system, especially on large irrigation districts. The following are potential projects that fall in the Delivery System Improvements category.

Line the Sun River Slope Canal near Augusta: The Sun River Slope Canal conveys water from Pishkun Reservoir to GID irrigated lands. The canal is 39 miles long with a capacity of 1,600 cfs. It was built between 1917 and 1919 and is thought to lose substantial amounts of water to seepage. A study by the Sun River Watershed Group investigated seepage in an 8.8 mile length of the canal from the Highway 287 Bridge near Augusta to the beginning of the Spring Valley Canal. Preliminary water loss estimates from the 2007 study estimate that 10,000 to 12,000 acre-feet is lost annually to seepage in this section of canal (TD&H, Inc. 2008). This option would line a 3-mile length of the canal which was determined to have particularly high seepage rates. A synthetic liner would be used. The overall cost of the project might be $3,000,000.

Use J-Lake Storage to reduce waste-water flows to Muddy Creek: J-Lake is a re-regulating storage reservoir on the headwater of Spring Coulee near the East Bench area of GID. Flows to Muddy Creek from Spring Coulee are estimated to be up to 20,000 acre-feet per (MSU 2006, 2007, and 2008) year, much of which is return flow and waste-water losses. An existing J-Lake dam and reservoir captures some flow and wastewater from Canal laterals and drains, and passes this water either into a GID lateral canal, where it can be used for irrigation, or into Spring Coulee, where it cannot be used and flows as waste-water into Muddy Creek. Currently, J-Lake only has about 20 acre-feet of storage capacity and it is difficult to manage the flow of waste-water into Spring Coulee with this small volume of storage and with the existing configuration of the J-Lake dam structure. This option would increase the height of the J-Lake dam and dikes, and modify the dam control structures so that storage in the lake could more effectively be used to reduce waste-water flow. Through more efficient use of delivered water, GID could save water both above and below J-Lake. Depending on the amount of storage provided, the project has the potential to save from 500 to 8,000 acre-feet of water annually at an estimated cost of up to $500,000 (Morrison-Maierle, Inc. 2011).

Construct re-regulating storage on Tank Coulee to reduce waste-water flows to Muddy Creek. Tank Coulee is another tributary to Muddy Creek on the East-Bench portion of GID. MSU (2006) has estimated that about 10,000 acre-feet of waste-water and irrigation return flow is lost down Tank Coulee during the irrigation season. This project would construct a new re-regulating reservoir on Tank Coulee to recapture flow off GID and minimize the return flow to Muddy Creek. This project would be operated in a similar manner to that described for J-Lake. It might be possible to save up to about 5,000 acre-feet of water annually with this project. The estimated cost might be $1,650,000 to $3,200,000 (Morrison-Maierle, Inc. 2011b).

Investigate Using in-canal storage on the GID Sun River Slope and Spring Valley canals: This option would use check structures and in-canal storage on the Sun River Slope and Spring Valley canals on the GID system to reduce operational spills from these canals. The project, as analyzed, was to upgrade two existing check structures, and to install two new ones. Because of the limited capacity to store water within the canal prisms, the total project only has the potential to supply benefits of about 250 acre-feet per year. Estimated construction costs are $1,600,000 (Morrison-Maierle, Inc. 2010).

Investigate the use of pump-back systems to reduce the flow of water from GID into Muddy Creek and other tributaries: There are a couple of existing systems on the eastern portion of GID that pump wastewater and return flow from drains and coulees back up into lateral ditches that are part of the GID water delivery system. These pumps capture and reuse water that otherwise would be lost from the system. Unfortunately, these pump-back systems are used infrequently because of the high power costs to operate them. This option would upgrade existing systems to more efficient variable-speed pumps, and also might include the installation of new pump-
back systems. The option would possibly include the sharing of pump-back system operational costs, along with a sharing of benefits. Preliminary analyses indicate that pump-back systems might save about 1,000 acre-feet of water annually, per site. The project cost might be $50,000 to $100,000 per site (Morrison-Maierle, Inc. 2011b).

**Install pressurized pipe to deliver water from the GID South Canal to the Simms area:** An analysis of data collected by MSU (2007b and 2008b) and DNRC indicate that total water losses from return flow and wastewater to Big Coulee might average about 10,000 acre-feet of water per year. One way to reduce some of these losses would be to increase the efficiency of water deliveries from the main GID system to the lower Simms Bench area of the District. Currently, water is diverted from the GID South Canal into Big Coulee, and then re-diverted from Big Coulee further downstream into the Beale Canal to irrigate a 1,565-acre unit of GID in the Simms area. Inefficiencies in these water transfers can result in operational spills. This project would install a pipeline to convey water directly from the GID South Canal to the lower Simms Bench area. Because of the elevation drop from the South Canal to the lower bench, the project would also provide the benefit of water under pressure, which could be used to run sprinkler irrigation systems. It is estimated that the project would cost $3,500,000 and might save about 1,600 acre-feet of water annually (Morrison-Maierle, Inc. 2010b).

**Install pressurized pipe to deliver water from the Mill Coulee Canal to the Ashuelot Bench:** An analysis of flow data collected by DNRC indicate that from 6,000 to 9,000 acre-feet of return flow and wastewater flows back to the Sun River through Mill Coulee during the irrigation season. Most of this water originates from the Ashuelot Bench area of GID. This potential project would use pipe to deliver water under pressure from the Mill Coulee Canal to about 2,700 acres of irrigation on the Ashuelot Bench portion of GID. It would also include converting a substantial amount of flood irrigation to sprinkler systems. It is estimated that this project has the potential to save about 5,400 acre-feet annually and would cost about $7,500,000 (Morrison-Maierle, Inc. 2010b).

**Replace Lateral ditches on the East Bench of GID with low-pressure pipelines:** The majority of the water delivered to farm turnouts on the East Bench of GID is through lateral ditches which are unlined, or lined to a varying degree of effectiveness. Laterals could be replaced with low-pressure pipe, which might reduce seepage losses and improve delivery efficiencies. Using pipe could reduce operational spills that result when the ditches are run relatively full to ensure that enough water is available to the users at the very end of the ditch system. The benefits of using low-pressure pipe would depend on the lateral, likely would be relatively small for individual systems, but could provide significant cumulative benefits if many laterals were upgraded. Costs might range from $100,000 to $200,000 per system, and save from 100 to 200 acre-feet annually, per system (Morrison-Maierle, Inc. 2011b). Cumulatively, there is the potential for these types of projects to add up to a significant volume of saved water.

**Rerouting and piping of the Fort Shaw Irrigation District C-K Canal:** This project would re-route an inefficient and leaky portion of the FSID C-K Canal and replace a portion of the canal with PVC pipe. The project would save about 1,200 acre-feet of water annually. It would cost about $149,000 (TD&H, Inc. 2010). This will be accomplished by abandoning nearly 7,000 linear feet of a very leaky ditch, while maintaining service to existing irrigators using a series of pipeline drops from an upslope ditch.

**Convert portions of the FSID l-4 and D-13 lateral systems to pipelines:** This project would replace 4,860 feet of FSID ditches that have high rates of seepage with PVC pipe. This will be accomplished by replacing 4,860 feet of very leaky, open ditches with PVC pipe. It is anticipated that this project will save about 4,200 acre-feet annually. The estimated cost is $222,000 (Fort Shaw Irrigation District 2011).
Category 2: Reservoirs

There is a total of about 170,000 acre-feet of reservoir storage in the Sun River basin. For comparison, the average annual inflow to Gibson Reservoir is about 590,000 acre-feet. During most years, a substantial amount of the spring runoff water leaves the basin in a relatively short period of time because there is insufficient capacity and infrastructure to capture all of it. Reservoir projects could include the construction of new reservoirs, expansion of existing reservoirs, or changes in the operations or delivery of water to reservoirs. The following is a description of the reservoir projects that passed the Special Study initial screening.

**Improve the Ability to divert water to Willow Creek Reservoir:** Water is diverted from the Sun River to the Willow Creek Feeder Canal, which then flows into Willow Creek. From there, Willow Creek flows into Willow Creek Reservoir, where the water is captured and stored for later release back to the Sun River to meet peak irrigation demands. Because of problems with erosion on Willow Creek upstream of the reservoir, diversions of Sun River water into the reservoir feeder canal are limited to a rate of about 75 cfs. This constrains how fast the reservoir can be filled and can reduce the total capture of water during the brief period that water might be available for storage. If more water could be diverted to and stored in Willow Creek Reservoir during times of higher runoff, diversions could be reduced when less water is available and other demands are higher. Additional modeling would be needed to quantify the potential water savings benefits of this project. The most recent estimated cost estimate for stabilizing the Willow Creek channel, to allow for diversion rates of up to 300 cfs to Willow Creek Reservoir, was $1,700,000 (Land and Water Consulting, Inc. 1998).

**Increase the storage capacity of Pishkun Reservoir:** Pishkun Reservoir has an active storage capacity of about 30,686 acre-feet and is formed by eight earth-fill dikes with heights ranging from 10 to 50 feet and an overall length of 9,050 feet. There is no spillway for the reservoir and water is fed into the reservoir by the Pishkun supply canal. This option would increase the capacity of Pishkun Reservoir by raising the height of the dikes. Storage increases of 10,000, 16,000, and 26,000 acre-feet were examined (Reclamation 2010). Water rights associated with the expanded storage might be obtained by: 1) transferring rights associated with Gibson Reservoir that are now ineffective due to sedimentation to Pishkun Reservoir, and (2) a new water right for the storage of high spring flows that would be within the exceptions of the upper Missouri Basin closure (§85-2-343 MCA). The additional storage would provide a more reliable water supply for GID, which might in turn free up water that could be used to improve instream flow in the Sun River. The estimated cost is $29 million for a 26,000 acre-feet storage increase (TD&H, Inc. 2008b). Reclamation is still evaluating this alternative for safety of dams concerns and is scheduled to provide a report on the evaluation in 2012. However, this should be considered a screening-level evaluation only. Additional and extensive analysis and investigations would be necessary to advance this alternative further, if this initial evaluation were favorable. It should also be anticipated that extensive efforts will be required to evaluate potential environmental and cultural related concerns with enlarging the reservoir. An increased capacity at Pishkun Reservoir might have to be accompanied by an increase in the capacity of the supply canal, in order to take advantage of excess water to fill the reservoir which sometimes is only available during short windows of time.

**Improve the Ability to divert water to Pishkun Reservoir:** Although the capacity of the supply canal to Pishkun Reservoir generally is adequate, there are times when it may be advantageous to move water to Pishkun more quickly. This option would investigate that possibility. The canal has an existing capacity of approximately 1,400 cfs, and this capacity would need to be increased for the 12.1 miles of canal above Pishkun Reservoir. This project would need to be modeled through computer simulations of the system before an optimal canal size could be determined and before potential water savings benefits could be estimated. Potential costs for increasing the capacity of the supply canal have not been estimated.
**Category 3: On-Farm Irrigation Efficiency Improvements**

Possible on-farm efficiency improvements include conversion from flood to center-pivot sprinkler irrigation, better managing irrigation water by applying no more water than the crop needs, and converting on-farm open ditches to PVC pipe to reduce water loss. Although these types of projects could be undertaken by individual operators, larger, coordinated projects would be needed to accumulate measurable savings where a portion might be used to improve stream flows. The Ashuelot Bench and Simms area projects, described in the Delivery System Improvements section, include improved on-farm efficiency components. No other project blocks have been identified at this time.

**Category 4: Other Water Management Measures**

**Investigate the costs and benefits of purchasing or leasing senior water rights and changing them to instream flow use:** This option would investigate potential benefits and opportunities for purchasing existing irrigation water rights and changing the use to instream flow. Instead of being diverted for irrigation use, the water for these transferred rights would be left in the Sun River to provide instream-flow benefits. This type of transfer would need to be negotiated by willing sellers and buyers. The option most likely would involve leasing water rights for instream flow, rather than a permanent water rights change. The costs of water would need to be determined between buyer and seller and would vary based on market conditions. For Montana instream flow leases that TU was involved with, costs were $21 to $25 per acre-foot (Ziemer, 2011). Although the Sun River Watershed Group would not actively pursue such purchases and changes, it might be able to offer assistance to willing buyers and sellers to ensure that transfer goals are realized without impact to other water users.

**Evaluation of Screened Alternatives**

The potential projects that passed the initial screening were incorporated into an evaluation spreadsheet. The spreadsheet included the initial screening criteria and other criteria to assess costs, and potential water savings. The spreadsheet can be found in Appendix A.

The first set of screening criteria in the spreadsheet, beyond the preliminary screening criteria, is an estimate of the amount of water that the alternative might save. These savings are tabulated as an annual volume in acre-feet. The next criteria addressed was where in the river system might some of the saved water provide instream-flow benefits. Projects also were examined as to whether or not they might provide benefits both to irrigation and instream flow purposes. Estimates of project costs also were developed. This included total costs to build or implement the project, annual cost, and cost per unit of water saved in acre-feet. For some projects, where costs were very uncertain due to limited information for analysis, a max-min cost range was used. Alternatives also were assessed for their potential complexity, from an administrative, legal and permitting standpoint. Additional studies that would be required before a project could be constructed or implemented were identified and listed too. And an estimate was made of the time it might take to implement the project. Agencies and groups that might be involved in development of the alternative were identified. Finally, a judgement was made on what the potential was to obtain funding for the project, from grants and other sources.

After considering all of this information, the final selected projects were compared and ranked. This ranking did not strictly order the projects from highest to lowest, but partitioned projects which were considered to have the most potential into three groups based on when it might realistically be possible to implement the projects. Group 1 projects were those that ranked high and which the group could pursue now or in the near future. The second group of potential projects consisted of those which the group considered to be good projects overall, but where there was a lot more work to be done before the projects could be implemented. The third group consisted of projects that might have some potential, but were complex, possibly expensive for the benefits that could be realized, and not workable at this time . . . . . . . but to still consider during future planning. A final fourth group contains projects that were dropped from further consideration at this point in the project screening.
Selected Projects by Group

Table 5 lists projects that the group believes have potential, and that it would like to pursue further. The exception is the Group 4 project, which was found to have a low potential to provide substantial water-savings benefits. The project groups are ordered by the amount of time it might actually take to implement the projects. Map 2 shows the location of the projects within the Sun River watershed. All of the costs listed in Table 5 are preliminary.

Table 5. Selected Projects by Group.

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Estimated Time to Implementation</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSID C-K pipeline</td>
<td>Project construction completed</td>
<td>$149,000</td>
</tr>
<tr>
<td>FSID L4 and D13 pipelines</td>
<td>Ongoing: 1 year to completion</td>
<td>$222,000</td>
</tr>
<tr>
<td>GID pump-back systems</td>
<td>May involve multiple projects over a period of 1-to-5 years</td>
<td>$50,000 to $100,000 per system</td>
</tr>
</tbody>
</table>

Group 2: Projects for the SRWG to work towards in the medium term where more detailed analysis is needed and which would require more substantial funding

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Estimated Time to Implementation</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sunny Slope canal lining</td>
<td>5-to-10 years</td>
<td>$3,000,000</td>
</tr>
<tr>
<td>J-Lake re-regulating storage</td>
<td>5-to-10 years</td>
<td>$500,000</td>
</tr>
<tr>
<td>Ashuelot Bench pressurized pipe and improved efficiencies</td>
<td>5-to-10 years</td>
<td>$7,500,000</td>
</tr>
</tbody>
</table>

Group 3: Projects for SRWG to continue to investigate for long-term planning; these projects may be expensive or require substantial coordination and funding

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Estimated Time to Implementation</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tank Coulee re-regulating storage</td>
<td>10-to-20 years</td>
<td>$1,650,000 - $3,200,000</td>
</tr>
<tr>
<td>Pressurized pipe to Simms area with improved efficiencies</td>
<td>10-to-20 years</td>
<td>$3,500,000</td>
</tr>
<tr>
<td>GID low pressure pipe delivery system projects</td>
<td>10-to-20 years</td>
<td>$100,000 - $200,000 per system</td>
</tr>
<tr>
<td>Willow Creek Reservoir flow delivery rate increase</td>
<td>10-to-20 years</td>
<td>$1,700,000</td>
</tr>
<tr>
<td>Pishkun Reservoir Enlargement</td>
<td>5-to-10 years</td>
<td>$29,000,000</td>
</tr>
<tr>
<td>Pishkun Reservoir flow delivery increase</td>
<td>10-to-20 years</td>
<td>Not available</td>
</tr>
<tr>
<td>Water rights changes to instream flow purposes</td>
<td>10-to-20 years</td>
<td>$20 per acre-foot or more</td>
</tr>
</tbody>
</table>

Group 4: Project that are currently considered to have a low potential for providing benefits

<table>
<thead>
<tr>
<th>Project Description</th>
<th>Estimated Time to Implementation</th>
<th>Estimated Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>In-canal check structures</td>
<td>None</td>
<td>$1,600,000</td>
</tr>
</tbody>
</table>
Map 2. Special Study Potential Projects Location Map.

- **Group 1**
  - 1a. FSID C-K Pipeline
  - 1b. FSID L4 & D13 Pipelines
  - 1c. GID Pump-back Systems

- **Group 2**
  - 2a. GID Canal Lining
  - 2b. GID J-Lake
  - 2c. GID Ashuelot Bench

- **Group 3**
  - 3a. GID Tank Coulee
  - 3b. GID Simms Area
  - 3c. GID Low Pressure Pipe
  - 3d. GID Willow Creek
  - 3e. GID Pishkun Enlargement
  - 3f. GID Pishkun Delivery
  - 3g. Watershed Water Rights

- **Group 4**
  - 4a. GID In-Canal Checks
IMPLEMENTATION PLAN

This section outlines a plan for further evaluating and implementing the projects that have potential to save water and provide shared benefits to agriculture and instream flow. Basic procedures that might be followed, from feasibility studies through project construction, are discussed. Because every project is different, this implementation plan is general rather than project specific. An important component of any project selected would be to develop a plan for sharing the saved water between irrigation and instream uses. Following the general implementation plan discussions is a specific example of an ongoing project that is being implemented under the Special Study framework.

Project Evaluation

Many of the projects discussed in this report have been evaluated at the conceptual level because only enough information has been assembled on the project to determine if it might be workable, and to develop a rough estimate of project costs and water-saving potential. Costs estimates in this report might be, at best, within about 25 percent of actual 2012 costs.

Projects that the Watershed Group intends to proceed with would need to be brought from the conceptual design level to the feasibility level. This would include a more detailed engineering evaluation of project components, and a more detailed estimate of project capital costs, as well as operation and maintenance costs. A more thorough evaluation of the water-savings potential of the project also would be required. This might include on-site evaluations during the irrigation season to determine flow conditions at the project site and to evaluate water-savings potential under a variety of conditions. The details collected during this stage of the project evaluation could be used to make a final decision on whether it would be worth pursuing the project.

Projects that the group chooses to proceed with, and which there is funding for, would continue to final design and through all appropriate environmental compliance and permitting activities. This would be the level of design required before construction could proceed. The final design will contain a much more refined estimate of project costs.

Developing a Methodology for Allocating Saved Water

The overall purpose of the Special Study is to identify water conservation projects that have the potential to improve agricultural productivity and enhance streamflow in the Sun River. In the past, a number of water conservation projects have been implemented in the watershed. Many of these projects have been successful in improving crop production and in decreasing return-flow water to lower Sun River tributaries, such as Muddy Creek, Mill Coulee (photo 3), and Big Coulee, but they haven’t necessarily resulted in improvements in flow to the reaches of the Sun River where flow is most critically needed. The reason for this is that, during most years, there are irrigation water shortages and the water that is conserved is simply re-distributed and used by irrigators to decrease crop-water shortages.
Part of the plan for the Special Study was to develop methodologies for sharing the benefits of saved water between instream and agricultural uses. An underlying principle to this sharing of benefits is the sharing in the responsibility to procure funds to implement the projects that result in water savings. Although the specifics of how benefits are to be shared would vary from project to project, a general agreement among participants is that water savings will be shared equitably between irrigation and instream uses. Agreements also likely will have adaptive management stipulations for sharing the pain when unusual conditions occur, for instance, during extremely dry years. Water-sharing agreements could be entered into between irrigation districts and other irrigation water rights holders, and entities that represent instream flow interests, such as FWP and TU.

Binding agreements as well as cooperative relationships would need to be established between project partners to ensure that the benefits of water conservation projects are shared as intended. Agreements might need to specify how the project is to be paid for and by whom, who will be responsible for operating and maintaining the projects and associated costs, how water savings will be tallied, and how the water savings allocated to instream flow will be realized in the river, and when and where. Because there is not a lot of precedent in Montana for these types of agreements, parties will need to be creative and flexible. After an initial agreement is made for one project identified in the Special Study, it could be useful as a template on which subsequent projects can build. A potential outline of what this type of agreement might look like is attached in Appendix D.

**Operation and Maintenance of Projects**

Most projects, once they are constructed, will need to be operated and require periodic maintenance. There also will be annual costs for operating some projects, such as the power costs to operate pump-back systems. During project planning these costs will need to be recognized and factored into funding. Water-sharing agreements might contain stipulations as to which parties are responsible for operation and maintenance costs.
Obtaining Project Funding

It is likely that the costs of most projects will be beyond the capacity of what any single user will be able to pay for. Because the projects will provide shared benefits, the Sun River Watershed Group will work with the project beneficiaries to obtain project funding. Funding might come from a combination of government and private sources. For feasibility level studies, project planning grants might be obtained through the DNRC Renewable Resource Project Planning Grants program. DNRC Renewable Resource Grants and Renewable Resource Loans might be a source for funds for implementation of small to mid-sized projects. Other potential grant sources include Reclamation’s WaterSMART, FWP Future Fisheries, and NRCS programs such as EQIP (environmental quality incentive program), and AWEP (agricultural water enhancement program).

Irrigation Districts might be able to provide in-kind construction and other services to match the funds provided by grants and other sources. GID, for example, has substantial construction capabilities and has demonstrated its expertise by completing a number of large infrastructure projects. Using these resources could result in substantial savings on project construction costs.

Example Project: Convert Portions of the FSID L-4 and D-13 Lateral Systems to Pipelines

Project History and Evaluation

The Fort Shaw Irrigation District had been working with the Sun River Watershed Group for 15 years to conserve water for the benefit of all users while at the same time improving their ability to deliver water to District producers. Over the years, FSID had implemented a variety of infrastructure improvements but was finding, through experience, that projects which converted open ditch delivery systems to pipelines were producing the most benefit. These types of projects are logical choices for the District to pursue because estimated conveyance efficiencies of the open ditches on FSID were found to be only about 46 percent (Reclamation, 1982). After assessing the system as a whole, FSID and the SRWG targeted the L and the D system ditches as a top priority for future improvement. While the Special Study was in progress, the FSID and SRWG pursued an available opportunity to fund and implement this project.

Obtaining Project Funding

With the assistance of the SRWG, FSID submitted an application to Reclamation under the WaterSMART program. The District requested funding to replace 4,860 feet of very leaky open ditches with PVC pipe. It was estimated that improvements to these delivery systems would result in water savings of 4,158 acre-feet per year. The estimated total project costs were $222,367, of which a grant from Reclamation of $103,717 was requested with the balance to be contributed through labor, equipment and in-kind services by FSID and SRWG. An important component of the grant application was a commitment to improve Sun River flows below the FSID Diversion Dam during the summer irrigation season. Reclamation funded the project for the amount requested.

Project Implementation

Upon receiving project funding, FSID and SRWG worked with Reclamation on National Environmental Policy Act (NEPA) and National Historic Preservation Act (NHPA) compliance, and on obtaining the permits needed before construction could proceed. This included the Corps 404, Cascade Conservation District 310 and DEQ 3A Turbidity permits, and a permit for access across County roads. FSID used a portion of the funds to hire an engineering firm for assistance with project design and construction oversight. Work on the project began during the fall of 2011 and construction work proceeded on schedule, with the project mostly complete by the early
spring, 2012. This included replacement of the leaky ditches with PVC pipe, and improvements to headgates and farm turn-outs.

**Project Follow-Through and Performance Measures**

With the assistance of SRWG, FSID has committed to measuring water delivered to the farms on the ditch system, and to measure return flows in Adobe Creek and flows in the Sun River at Simms for two years following project completion. These flows will be compared to corresponding flow data prior to the system improvements in order to document water savings due to the project. Flow monitoring efforts might continue following the 2-year period, if resources are available.

**Developing and Implementing a Plan for Sharing Water Savings**

FSID has committed to sharing water savings resulting from this project by increasing Sun River flows by 10 CFS at the USGS gaging station near Simms during the summer irrigation season. FSID is working with TU on this plan, with assistance from the SRWG. An important consideration towards the success of this plan will be adequate communication with other water users on the river to ensure that the targeted flows remain in the river. Although the 10 CFS may not seem huge, it represents a significant improvement to this reach of the river, where irrigation-season flows drop to as low as 30 CFS.
CONCLUSIONS

The Sun River Watershed Group and others have been working to improve flows in the Sun River while maintaining or improving the production of irrigated agriculture. Because water is not always available in the amounts required to meet all uses, improving Sun River flows has been a persistent challenge. The Watershed Group has found that no one project by itself will solve all of the low-flow problems in the Sun River. This Special Study has identified a number of projects that have the potential to conserve water, and provide shared benefits to irrigators and instream flow in the Sun River. Taken together, these projects might be enough to produce shared benefits and to increase Sun River instream flows at key locations, and during critical times.

Implementing these projects will require a commitment from group members and working together as a team to obtain the necessary funding for design, authorization, and construction. Continued success of the project will require follow-through with operation and maintenance long after the projects are constructed. Developing agreements among parties that allow for sharing a project’s water-saving benefits between irrigation and instream uses is critical to the success of these projects, and for achieving the goals of the Special Study.

The Special Study maps out a path for achieving these goals. The process that the group sets out should be flexible too, so that other water-conservation projects that might be identified can be incorporated in the future into the framework set forth in the Special Study.
REFERENCES


Morrison-Maierle, Inc. 2010b. Greenfields Irrigation District Main Canal Storage. Technical Memorandum No. 1 to Sun River Watershed Group for Sun River Special Study. Helena, MT.


Reclamation. 2007b. Sun River In-stream Flow Study. United States Department of the Interior, Bureau of Reclamation, Great Plains Region, Billings, MT.


Snowcap Hydrology, 2009. Supplement to Sun River Water Management Analysis, Phase 2. For Sun River Watershed Group, Great Falls, MT.

Snowcap Hydrology, 2005. Sun River Water Management Analysis, Phase 2. For Sun River Watershed Group, Great Falls, MT.

Snowcap Hydrology, 2004. Sun River Water Management Analysis. For Sun River Watershed Group, Great Falls, MT.


Appendix A: Project Review Spreadsheet Matrix
Appendix A: Project Review Spreadsheet Matrix View 1.

<table>
<thead>
<tr>
<th>Potential projects were screened for the following initial criteria</th>
<th>Any project passes the initial screening if yes, continue. If no, remove from consideration in the Special Study</th>
<th>Water Saved (Acre-ft)</th>
<th>Winter</th>
<th>Summer</th>
<th>Over Reach / Canal Location where water can be reduced</th>
</tr>
</thead>
<tbody>
<tr>
<td>Does the project have the potential to provide water for irrigation and/or instream flows?</td>
<td>Does the project have the potential to adversely affect water users and/or instream flows?</td>
<td>Are there irreconcilable trade-offs?</td>
<td>No</td>
<td>Yes</td>
<td>Project passes the initial screening</td>
</tr>
<tr>
<td>Investigates the potential for water savings of lining up to 3 miles of the Sunny Slope canal near Augusta.</td>
<td>Yes</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
<td>Potential of 500,000 acre-feet depending on size of storage</td>
</tr>
<tr>
<td>Investigates using Lake-channelling storage to help reduce waste water flow to Muddy Creek.</td>
<td>Yes</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
<td>Up to 3,000 acre-feet dependent on reservoir size</td>
</tr>
<tr>
<td>Investigates using Tense Corr-channelling storage to help reduce waste water flow to Muddy Creek.</td>
<td>Yes</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
<td>244 acre-feet</td>
</tr>
<tr>
<td>Investigates using check structures and automation to provide in canal storage to help reduce waste water flows into Big Coulee, Muddy Creek and other drains.</td>
<td>No</td>
<td>No</td>
<td>No due to low water-saving potential</td>
<td>0</td>
<td>2,000 acre-feet per site</td>
</tr>
<tr>
<td>Investigate the potential for water savings of lining up to 3 miles of the Sunny Slope canal near Augusta.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
</tr>
<tr>
<td>Investigate installing pressurized pipe to deliver water from the GID South Canal to the Simms area and converting some flood irrigated acres to sprinkler irrigation.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
</tr>
<tr>
<td>Investigate installing pressurized pipe to deliver water from the M12 Canal and converting some flood irrigated acres to sprinkler irrigation.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
</tr>
<tr>
<td>Increasing the rate at which water can be delivered to Willow Creek Reservoir.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
</tr>
<tr>
<td>Increasing the height of the Phillips Dikes to increase the storage of Phillips Reservoir.</td>
<td>Yes</td>
<td>No</td>
<td>No</td>
<td>Project passes the initial screening</td>
<td>0</td>
</tr>
</tbody>
</table>

Note: For purposes of the Sun River Special Study, the term ‘water saved’ refers to the recovery of water intended for a specific use that leaves the system (reservoir, canal, lateral, etc.) without fulfilling the intended function of that use. Examples of loss include but are not limited by leakage, evaporation, evapotranspiration, and unaccounted water that enters an irrigation system’s waste system.

* Water savings for these projects could decrease the amount of water that needed to be diverted from the Sun River at the Diversion Dam during times of low flow.
### Appendix A: Project Review Spreadsheet View 2

| Investigate the potential for water savings of lining up to 3 miles of the Sunny Slope canal near Augusta | $2,000,000 | $50 to $1,000 | Moderate High Moderate Would require engineering design work | GIS may be able to store future data | 3 to 5 years |
| Investigate using check structures and automation to provide in-field storage to help reduce waste water flows into Big Coulee, Muddy Creek and other drains | $3,000,000 | $250 to $2,000 | Moderate Moderate Moderate Higher | GIS could do much of the construction work | 5 to 10 years |
| Investigate installing pressurized piping to deliver water from the Stolof Island South Canal to the Simms area and converting some flood irrigated acres to center pivot irrigation | $1,650,000 | $50,000 | Moderate Moderate Moderate Higher | GIS could do much of the installation work | 5 to 10 years |
| Investigate installing pressurized piping to deliver water from the Muddy Creek canal to the Ashuelot Bench area and converting some flood irrigated acres to center pivot irrigation | $3,000,000 | $6,500 | Moderate Moderate Moderate Higher | GIS could do much of the installation work | 5 to 10 years |
| Investigate reducing waste from FSID L-4 and D-10 system through piping | $149,000 | $950 | Moderate Moderate Moderate Higher | Project is Complete GIS will provide construction assistance | 1 to 2 years |
| Investigate using Lake regulating storage to help reduce waste water flows to Muddy Creek | $1,000,000 | $2,132 | Moderate Moderate Moderate Higher | GIS could do much of the construction work | 5 to 10 years |
| Investigate using Tank Coulee regulating storage ta help reduce waste water flows to Muddy Creek | $470,000 | $6,500 | Moderate Moderate Moderate Higher | GIS could do much of the construction work | 5 to 10 years |
| Investigate using C-K canal to reduce waste from FSID C-K canal through a combination of planning and routeing the system | $1,600,000 | $149,218 | Moderate Moderate Moderate Higher | GIS could do much of the construction work | 5 to 10 years |
| Investigate installing pressure piping to deliver water from the Willow Creek reservoir to Willow Creek | $29,000,000 | $1,000 | Moderate Moderate Moderate Higher | GIS could do much of the construction work | 5 to 10 years |
| Note: For purposes of the Sun River Special Study, the term ‘water saved’ refers to the recovery of water intended for a specific use that leaves the system (reservoir, canal, lateral, etc.) without fulfilling the intended function of that use.

Examples of loss include that are not limited to seepage, evaporation, evapotranspiration, and uncontrolled water that enters an irrigation system’s ‘waste’ system.

* Water savings for these projects could decrease the amount of water that needed to be diverted from the Sun River at the Diversion Dam during times of low flow.
Appendix B: Options Identified During Brainstorming that did not fit in the Special Study

These options were dropped from further consideration in the Special Study. There may be opportunity to improve water management in the watershed with these options, but they are outside of the scope of what is needed or could be analyzed in the Special Study at this time.

1. **Review natural Willow Creek inflows to determine if they are declining and why.**
   It would be interesting to find out if Willow Creek natural flows are declining, but it is unlikely there is anything that could be done if they are.

2. **Investigate minimum flows and flow gains in the Sun River below the Fort Shaw diversion.**
   We already compiled a lot of information on this with the stream gaging and synoptic measurements. This seems to be more a question of how other alternatives might affect gains and losses, rather than an option in itself.

3. **Review winter release rates.**
   This already has been done.

4. **Use the internet to track all water diverted to help manage water better.**
   This is an ongoing effort. It seems that with the Hydromet system, USGS gages, and the District’s resources water is being tracked pretty well.

5. **Look at impacts of changing water use from Ag to other uses, such as pond or yards.**
   This really is not an option for improving instream flows in the Sun River. These sorts of changes are occurring, but our intuitions are that they are only a small part of the total water use.

6. **Improve the accuracy of the measurement of water over the Diversion Dam.**
   This is an ongoing task; it probably doesn’t need to be explicitly addressed as an option in the Special Study.

7. **Add more SNOTEL sites in the watershed.**
   This would be helpful, but it would be difficult to quantify the potential water savings.

8. **Cleanup streamflow data to make it more accurate and usable.**
   This is a long-term goal, but not a Special Study Alternative.

9. **Trans-basin transfer.**
   Not lots of possibilities here because all the surrounding watersheds on the east-side of the Divide are water short too, and any water transfers from the west-side would have to occur through a remote wilderness area.

10. **Investigate cloud seeding.**
    It doesn’t seem to have a lot of potential because of state and federal laws and policies.

11. **Review the work done by other watershed groups for other ideas on water conservation: Specifically mentioned the review of work done by the Jefferson Watershed Group.**
    Work and projects done by other groups was taken into consideration in developing potential projects.
Appendix C
Instream Flow Pursuit Sideboards

Finalized at December 10, 2008 meeting

<table>
<thead>
<tr>
<th>CONDITION</th>
</tr>
</thead>
<tbody>
<tr>
<td>Be above board on all acceptable solutions</td>
</tr>
<tr>
<td>Projects and solutions should provide true “win-win” results</td>
</tr>
<tr>
<td>Realize there is a risk factor with any changes</td>
</tr>
<tr>
<td>Projects shall provide Transparency and accountability to all project partners</td>
</tr>
<tr>
<td>Projects shall provide benefits to as many watershed group members as possible and will not adversely affect the interest of any member</td>
</tr>
<tr>
<td>Projects shall conform to Reclamation and state water laws, including evaluation of return flow issues and adverse impacts to third-party water right holders (ie. PPL)</td>
</tr>
<tr>
<td>Need to look at &quot;big picture&quot; with all projects</td>
</tr>
<tr>
<td>Water savings from projects should be shared fairly and equitably</td>
</tr>
<tr>
<td>With any water savings, need to decide if will be divided up by percentage or at a variable rate</td>
</tr>
<tr>
<td>Projects will strive to find and provide 100 cfs out of Gibson to meet the 130 cfs FWP instream flow right from Elk Creek to confluence with Missouri River</td>
</tr>
<tr>
<td>Need to seriously evaluate all risks when swapping water for money</td>
</tr>
<tr>
<td>Trying to meet agriculture needs at the headgate while looking at opportunities to use saved waste-water to help increase river flows</td>
</tr>
<tr>
<td>Need to consider impacts to return flows with any project</td>
</tr>
<tr>
<td>Mechanism to deal with individual farmers risk when pursuing Gibson storage issues</td>
</tr>
<tr>
<td>If increase storage is pursued, need to look at adverse effects to other water needs</td>
</tr>
<tr>
<td>Allow capture for filling reservoirs during runoff periods</td>
</tr>
<tr>
<td>Full reservoirs does not guarantee full water season</td>
</tr>
<tr>
<td>Need operations review for water savings improvements then rank projects</td>
</tr>
</tbody>
</table>

First criteria established were:

- Project will help irrigation
- Project will benefit the river
- Project will make up for lost reservoir capacity at Gibson
- Project cost will be considered
- Project feasibility to be considered
- Does the project have an adverse impact on other water users
- Project needs to consider actual water saved
- Does the project fit legal and permitting requirements
- How complex is the project
- Location on where the water savings benefits will occur
- Water savings timing and return flow impacts
- Include life-span of the potential projects and the average annual costs for the life of each project
Appendix D: Basic Water-Sharing Agreement Outline
MEMORANDUM OF UNDERSTANDING

AMONG

_____ (entity saving water)_____
SUN RIVER WATERSHED GROUP
TROUT UNLIMITED
MONTANA DEPARTMENT OF FISH, WILDLIFE, AND PARKS
and the
U.S. DEPARTMENT OF INTERIOR, BUREAU OF RECLAMATION, GREAT PLAINS REGION, MONTANA AREA OFFICE.

DATED THIS _____ DAY OF ________________, 2012.

This Memorandum of Understanding (MOU) is among the ___________________, the Sun River Watershed Group, Trout Unlimited, and the Montana Department of Fish, Wildlife, and Parks, and the United States Bureau of Reclamation. The purpose of this MOU is to allocate the conserved water from a collaborative water conservation project between irrigation and instream purposes.

I. Background.

The signatories to this MOU have all, through lengthy involvement, discussion, fundraising, and work, participated in the collaborative water conservation project to _________________________________(project name).

The objective of this project is to ______________________(description of the project).

______ (project information)

II. Objectives.

The signatories to this MOU agree that the following principles are guiding their allocation of conserved water from the collaborative water savings project:

- **Proportional Investment.** Conserved water is allocated in roughly equal measure between irrigation and instream flows because each interest has, and will, invested time, involvement, and has made contributions to the overall success of the project.

- **Fairness.** Conserved water is allocated between irrigation and instream flows to meet the needs of each interest, to the greatest possible extent.
• **Adaptive Management.** While the signatories to this MOU have worked for several years to quantify the water loss, we acknowledge that these are still estimates. The signatories to this MOU acknowledge that as additional data is collected over time after the project is completed, the signatories will re-evaluate the implementation of the water savings agreement according to the two principles articulated above, fairness and proportional investment.

III. Allocation of Water Savings.

The signatories to this MOU agree to allocate the water savings from the collaborative ___(project name)____ fairly between irrigation and instream flow needs, based on: on-going monitoring of conserved water; adaptive management and learning from successive years of implementation; wet-year management; and, dry-year management. This MOU addresses utilization and allocation of water conserved through ___(project activity)___ and assumes all other water management operations remain similar to historic methods of operation.

IV. Implementation of Water Savings Agreement.

The signatories to this MOU propose to administer the water conserved from the ___(project name)____ as described herein, as follows:

1. For the life of the project, at least one-half of the estimated annual conserved volume of water will be administered by the _____(entity saving water)_______, to deliver to its share-holders as needed to meet the District’s water delivery obligations for an irrigation purpose. More than one-half of the annual conserved volume of water will be administered for an irrigation purpose under drought conditions, pursuant to the “Dry-Year Administration” paragraph, below.

2. For the life of the project, one-half of the estimated annual conserved volume of water will be administered by the _____(entity saving water)_______, in collaboration with Trout Unlimited and the Sun River Watershed Group, for an instream purpose, subject to reduction pursuant to the “Dry-Year Administration” paragraph, below.

3. Allocation of the conserved water for an instream purpose will take place when the Sun River Watershed Group and Trout Unlimited request that the _____(entity saving water)_______, deliver water over Diversion Dam. The period of delivery will be restricted to between July 15 and September 30 annually, and requests for an instream delivery will be triggered by Sun River flows between 130 cfs and 40 cfs as measured at the Simms USGS gauge. _____(entity saving water)_______, will deliver water over Diversion Dam for an instream purpose up to the volume cap identified below, in the Wet-Year and Dry-Year Administration paragraphs, in consultation with the Sun River Watershed Group and Trout Unlimited. Delivery of the conserved water for an instream purpose down to the Simms USGS gauge will be accomplished pursuant to a water administration agreement, separate from and involving parties not included in this MOU. That separate water administration agreement will conform to Mont. Code Ann. § 85-2-411 (“Water turned into natural channels”).
4. Upon reaching the end of the life of the project, or its earlier termination, Trout Unlimited and the Sun River Watershed Group shall terminate and surrender to _____ (entity saving water)_______, and the _____ (entity saving water)_______, the conserved water dedicated to instream flows, unless otherwise agreed to by the parties.

5. The parties acknowledge that there is no intent to abandon any portion of the conserved water, nor does this MOU imply any relinquishment of the ownership rights of the _____ (entity saving water)_______, or the _____ (entity saving water)_______, over any of the conserved water, whether it is put to an instream or irrigation purpose.

V. Monitoring and Administration of Conserved Water.

1. Monitoring of Loss. Describe monitoring

2. Wet-Year Administration. The parties to this MOU agree to a protocol for administration of conserved water in an average to wet-year, based on one-half of the estimated volume of conserved water delivered over Diversion Dam. The determination of an average to wet-year will be made in the spring of each year, based on whether Gibson Reservoir fills. If Gibson Reservoir fills, defined for purposes of this MOU as reaching a minimum of 96,500 acre-feet of storage, then the Sun River Watershed Group and Trout Unlimited may request delivery over Diversion Dam of flows between July 15 and September 30 of each year hereunder, not to exceed one-half of the estimated volume of conserved water.

3. Dry-Year Administration. The parties to this MOU agree to a protocol for administration of conserved water in dry years and drought years. The determination of a dry or drought year will be made in the spring of each year based on whether Gibson Reservoir fills, reaching 96,500 acre-feet of storage. If Gibson Reservoir does not fill in a dry or drought year, then the percentage by which Gibson Reservoir fails to fill (the percentage less than 96,500 acre-feet of storage reached as measured on the date of the first releases of stored water) will be the percentage reduction in the volume of water that the Sun River Watershed Group and Trout Unlimited may request for delivery over Diversion Dam.

4. On-Going Monitoring. The parties to this MOU agree that on-going monitoring of canal loss, water deliveries, and implementation of this MOU is necessary for its long-term success. Pursuant to the adaptive management principle set out in Section II of this agreement, the data collected from on-going monitoring will provide the basis for any future revision to the estimated volume of conserved water, or other amendment to this agreement, based on the written consent of all parties hereto.

VI. Agreement in Good Faith.

The parties to this MOU have worked in good faith to come to an agreement, and will continue to work in good faith to implement this water allocation agreement. No party to this MOU shall unreasonably withhold consent to alter its terms in the future, based on the results of the on-going monitoring and the shared learning during its implementation.
Signed this ________ day of __________________, 2012.

_____________________________  ________________________________
_____ (entity saving water)_____,  Sun River Watershed Group

_____________________________  ________________________________
Trout Unlimited  Montana Dep't of Fish, Wildlife and Parks

_____________________________
Bureau of Reclamation
United States Department of Interior
USGS flow data in Sun River at Simms used to track lower Sun River flow conditions
(130 desired minimum flow)

10 cfs from this District project will make significant progress to meeting 130 cfs desired flow target.
Muddy Creek Flow data

Tail Water from 50,000 acres of Greenfields Irrigation District

Desired flow is less than 150 cfs when erosion is almost none

and

Extra water can be used to reduce impacts of drought and more instream flows in Sun River

--- Provisional Data Subject to Revision ---

- Discharge
- Value is affected by ice at the measurement site.