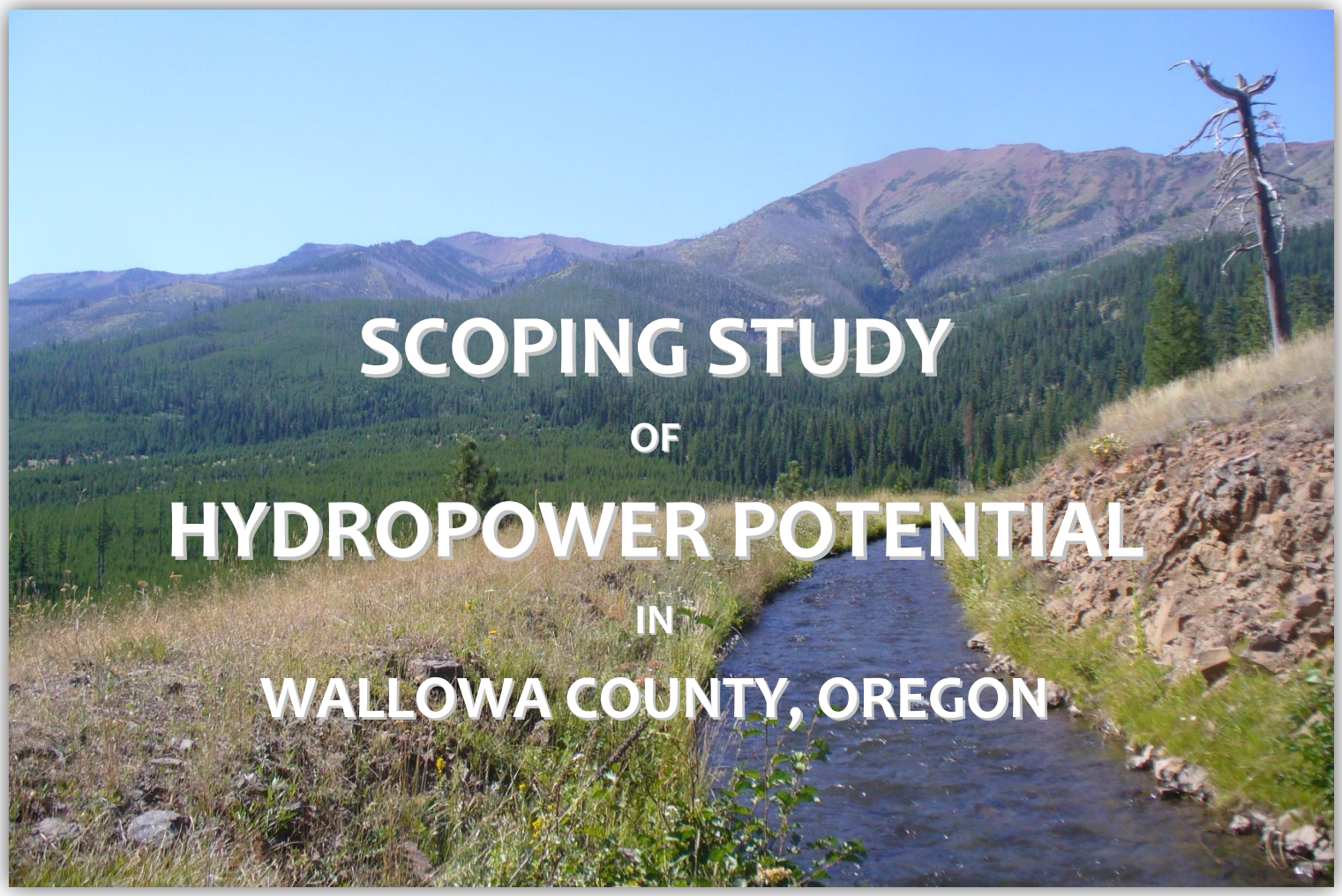

SCOPING STUDY OF HYDROPOWER POTENTIAL IN WALLOWA COUNTY, OREGON

For

Energy Trust of Oregon

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1. Table of Ditch Company Water rights
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1 Introduction

Over the course of the 2010 irrigation season, Renewable Energy Solutions (RES) has examined the hydroelectric potential and conveyance efficiency of 19 sites on irrigation conduits in Wallowa County. These site analyses, in addition to others previously completed by RES, allowed RES to document hydroelectric resources and begin building relationships with parties potentially interested in moving forward with small conduit hydroelectric project development. The project also creates a library of scoping level studies that will expedite the development of hydro projects in the county.

The sites described in this report total *1,020 kW of potential capacity on Wallowa County's irrigation conduits, capable of producing over 3.3 million kWh per year, worth $244,000 annually*.

Of the 22 sites described in this report:

- The average site head is 159 feet and the average flow is 8 cfs
- The median head is 140 feet and the median flow is 3.5 cfs
- Eight are greater than 25 kW and fourteen are less than 25 kW
- Twenty operate during the irrigation season (May – September), and 2 typically operate during additional months

Each site analysis contains pertinent information toward the goal of expanding Wallowa County's hydropower production and irrigation efficiency:

- Contact persons for future follow up
- Calculation of maximum kW capacity, annual kWh production, and dollar value based on maximum flow and existing head and seasonality of water availability
- Calculation of minimum kW capacity and annual kWh production based on minimum flow and existing head
- Designation of hydrologic information and system design: identification of the live water body from which irrigation waters are diverted, and designation of return flow into an irrigation canal and ultimately a live water body.
- Cost estimates for hydroelectric development, including capital expenditure and project development monies
- Information on energy or water efficiency as presented by the project contact

2 Conduit-Based Hydropower

Wallowa County sprawls across 3,145 square miles of the Northeastern corner of Oregon. Home to the nation's deepest natural gorge, Hells Canyon, and to the Wallowa Mountains – aptly nicknamed the *Alps of Oregon* for 26 granitic peaks higher than 8,000 feet - it is a place of rugged beauty, physical isolation, and independent people. Hundreds of streams and canals flowing from the nearby mountains sustain a rural economy dependent upon agriculture and natural resources.

Much of the County's productive valley land is irrigated. Wallowa County is the 13th largest water user in the state, with 209,000 acre feet of water allocated per year. Over 97% of these water rights holders are agricultural users.

Water used for irrigation purposes has unique potential for hydroelectric development. Under Oregon Water law, hydroelectric projects may be developed under existing water rights after approval of an "Application to Develop Hydroelectric Use as Part of an Existing Certificated Water Right." These water rights designate hydroelectric as beneficial use within the existing right.

Hydroelectric projects developed on irrigation conduits also have specific designation under the Federal Energy Regulatory Commission (FERC) licensing process. Projects on conduits used for purposes other than hydroelectric development (municipal water, irrigation, livestock, household, etc.) are eligible to apply for a Conduit Exemption.

3 The Scoping Study

This report summarizes a "Scoping" level study of hydroelectric potential and water-use efficiency improvements in Wallowa County, Oregon. Sites with fatal flaws or unconfirmed resources were not included.

The investigation evaluated technical potential of both individual projects and ditch company projects.

Potential individual projects were identified by (a) highlighting zones of topographic relief in irrigated areas adjacent to water conduits; and (b) pairing those zones with water right information derived from Oregon Water Resources online water rights.

Ditch company projects were identified by (a) extracting total water rights held by each ditch company (see Table of Ditch Company Water Rights in supplemental materials); and (b) pairing those water rights with different reaches of the ditch with topographic relief. This process is described in further detail in the section, "Deriving Information from Oregon Water Resources Database."

Once areas with probable hydroelectric potential were identified, ditch company personnel (or landowners or land managers as appropriate) were contacted to arrange a site visit.

The purpose of site visits were to measure head and to mark GPS coordinates of the penstock intake and powerhouse. During the site visit, additional pertinent information was gathered, including:

- Existing irrigation infrastructure
- Distance to transmission
- Detailed water right information
- A gauge of the project proponent's level of interest, financial and technical wherewithal to develop a project
- Energy / water use efficiency information

4 Deriving Information from Oregon Water Resources Database

The following are methodologies for deriving information from Oregon Water Resources online water rights database, and ground truthing.

This study employed several different methods to derive information necessary to determine a bsae level of hydroelectric potential. Sites with hydroelectric potential greater than 20,000 kWh per year were ground-truthed.

Searching and cataloging information from the Oregon Water Resources (OWR) Database involves familiarity with the system and persistence. A close understanding of how water right information was derived from original water right certificates and cataloged, in addition to the capabilities of information filters, is essential to analyzing water right-based hydroelectric resources as accurately as possible.

Analysis was completed with the following assumptions:

- *Identifying land with significant slope adjacent to irrigation conduits is a strategic way to tie hydroelectric potential to a parcel of land.* Irrigated ground adjacent to or near the irrigation conduit likely uses that conduit to transport water from the Point of Diversion (POD). Once a tax lot parcel or area with high probability for hydroelectric potential was identified, the landowner or project proponent could be contacted using local knowledge or a tax lot database such as http://www.oregon.gov/DAS/EISPD/GEO/web_services/Wallowa/CountyMap_Wallowa.html.
- *Identifying the water right of an individual land owner can be done the following ways:*
    - Identify the parcels of ground belonging to the ditch member in the Oregon Water Resources Place of Use (POU) database. This approach is difficult in practice because the POU layer is not entirely up-to-date.
    - *Ask the land owner for a copy of his or her water right*, which is often a copy of the ditch company water right with his or her land parcel highlighted. The volume of water or cfs per acre can be calculated using information provided on that water right certificate.
    - *Calculate the water being used by existing irrigation infrastructure on the property.* This approach was recommended by staff of Oregon Water Resources.
- *Supplementary hydroelectric water rights that mirror the quantity and duration of existing irrigation water rights could be obtained to develop a hydroelectric project*. In reality, often times supplementary rights can be obtained for irrigation rights that do not exist, especially for run-off into the irrigation canals during the winter season or for the waste water off of the end of an irrigation ditch. Only two projects rely on supplementary water rights: Alder Slope D. 1 and West Side D.2. West Side Ditch has successfully been granted a supplementary right for winter run-off.

- *In-ditch hydroelectric projects have the potential of using only the flow of the ditch company water right for a hydroelectric project.* Actual flows of the ditch company differ from the maximum legally allocated flows.

4.1 Limitations to OWR Database

- Feeder canals and ditches, the water bodies with hydroelectric potential, are not mapped via Oregon Water Resources. Major canals are available via USGS surface water maps. Existing GIS information and creation of KLM line files using GoogleEarth created the hydroelectric zones which run adjacent to conduits on the project maps, and are included as aerial representations for each potential site.
- The Point of Diversion (POD) recorded in the GIS database is where control is taken from a live stream. There is no connection in the OWR database between conduits and water rights.
- Due to variations in mapping methodology and technology and shifts in natural and conduit water courses as well as diversion points, the data is only accurate to approximately 100,000-scale. Thus, POD has to be considered as a point within a region of possible locations rather than point of diversion mapped with the same mapping methodology.
- Ditch companies may have multiple "Points of Diversion" that flow into the same irrigation system at different points. Additionally, Ditch companies routinely have large areas and multiple irrigation tracts for "Places of Use." This means that the Ditch may have no points at which it carries the sum of its water rights. This makes calculating flows for in-ditch projects very difficult.
- The water rights owned by irrigation districts are not included in the combined Oregon State Water Rights data set and must be downloaded separately. This means that it is possible to be unaware of a given ditch while completing the study.
- Many Water Rights data, especially those established by Decree, do not have an entry for the field rate_cfs. Flow rates for these water rights must be researched separately by pulling out the original water right certificate, available through the Oregon Water Resources database. If an acre-foot volume is enumerated in the right, this must be converted to average cfs. (Appendix C). For water rights where cfs was stated, it was often stated in the maximum eligible flow if water were delivered according to the duty (1/40 cfs per acre or 1/80 cfs per acre in Wallowa County, generally speaking). However, the maximum eligible flow cannot be used continuously or the water user would exceed his or her water right. This complicates declaring a single flow which could be used by a hydroelectric project.

4.2 OWR Database Tasks

- Determine water rights of individual's projects (individual land owners), in terms of flow, for sites that have been ground truthed.
- Determine water rights of Ditch Companies (in ditch segments), in terms of flow, for any given point along the conduit.

4.2.1 Water Rights of Individual Landowners for Ground-truthed Sites

As noted above, water rights of land owners, in terms of flow, were determined using the following strategies:

- *Identify the parcels of ground belonging to the ditch member in the Oregon Water Resources Place of Use (POU) database*
- *Ask the land owner for a copy of his or her water right*, which is often a copy of the ditch company water right with his or her land parcel highlighted. The volume of water or cfs per acre can be calculated using information provided on that water right certificate.
- *Calculate the water being used by existing irrigation infrastructure on the property.* This approach was recommended by staff of Oregon Water Resources.
- *Use online tax lot information to contact a landowner who is located on a parcel of irrigated land with sufficient head.* Perhaps due to outdated information in the online database, this strategy was not very successful. However, it may prove useful in future studies.

4.2.2 Water Rights of Ditch Companies at Ground-truthed Sites

Water rights can be downloaded by Ditch Company.

- Information Water Rights Query → Name → Company → [Ditch Co. Name]→ [SEARCH] [Download POD Data]

Simply downloading data is insufficient to determining flows with hydroelectric potential. Usually, an acre-foot water right is converted to a cfs flow rate by dividing the acre feet by the duty, where duty is the maximum cfs per acre. For hydropower potential, a more accurate representation is the average flow rate. Conversions for acre-feet to cfs are included in Appendix C.

The Master List of Ditch Company names was derived from Wallowa County personnel, online searches, and personal conversations. The Master List is included as Appendix A.

As noted above, a challenge to this task is that ditch companies with multiple points of diversion do not carry the sum of their water rights at any one place, and, as soon as that water is diverted, losses from seepage, outlets, and evaporation begins to occur, and increases from seepage, inlets, and precipitation occur. Where in-ditch sites were evaluated, a rationale for the listed cfs is justified in the project "notes" section.

Site Name	HEAD (feet)	Flow max (cfs)	Kilowatt Max	Kilowatt-hour max	Energy Value
Alder Slope D. 1	100	2.50	12.7	41,118	$ 2,961
Allen Canyon D. 1	304	7.00	108.0	349,998	$ 25,200
Arrowhead Pipeline Association 1	374	0.47	8.9	28,781	$ 2,072
Arrowhead Pipeline Association 2	462	1.15	27.1	87,696	$ 6,314
Chamberlain D. 1	36	13.11	24.0	108,674	$ 7,825
Clearwater D. 1	76	3.92	15.1	49,012	$ 3,529
Clearwater D. 3	46	3.38	7.9	25,572	$ 1,841
Creighton D. 1	40	3.00	6.1	19,737	$ 1,421
Cross Country Canal 1	16	30	24.4	78,947	$ 5,684
Kinney Lake D. 1	186	7.75	73.2	237,087	$ 17,070
Kinney Lake D. 2	49	17.5	43.5	141,035	$ 10,155
Kinney Lake D. 3	25	17.5	22.2	71,957	$ 5,181
Kinney Lake D. 4	33	17.5	29.3	94,983	$ 6,839
McCully Creek 1	128	1.98	12.9	41,684	$ 3,001
Moonshine D. 1	239	3.762	45.6	147,802	$ 10,642
Prairie Creek. 1	319	7.75	125.5	406,617	$ 29,276
Sheep Creek D. 1	220	35.00	390.9	1,266,439	$ 91,184
Sheep Ridge D. 1	222	0.45	5.0	16,270	$ 1,171
Sheep Ridge D. 2	152	0.84	6.5	21,000	$ 1,512
West Side D. 1	201	1.01	10.3	33,390	$ 2,404
West Side D. 2	92	2.00	9.3	51,447	$ 3,704
West Side D. 3	197	1.3	13.0	71,606	$ 5,156

5 Ground Truthing

5.1 Protocol

In order to standardize and create continuity of protocol between field staff conducting ground truthing, the first two site visits were completed collaboratively with follow up discussions among team members. Subsequent ground-truthing was conducted by one or two RES personnel and one or more ditch company personnel.

Please see Appendix B: Ground Truthing Methodology.

5.2 Surveys

The sites that were surveyed are summarized in the Map and Data Sets section of this report, following the Appendix materials.

6 Other Site Characteristics

During the course of the study, several sites with unique properties were identified. It is unclear how these properties will factor into hydroelectric development. These properties are noted on the project spec sheets, and are also summarized below:

- Waste water on the tail end of ditches, which could be designated "transport flows" and may or may not be readily available during the irrigation season, are distinct because:

  - They are often beyond the boundary of conduit maintained by the ditch company maintenance, presenting an interesting situation in terms of property rights
  - They are often without existing water rights, presenting an interesting situation in terms of applying for new water rights or working within the "Application to Develop Hydroelectric Use as Part of an Existing Certificated Water Right"
- Projects without existing pipelines suffer from higher capital cost but enjoy the advantage of no competing infrastructure to utilize pressure (high pressure irrigation systems).
- Existing pipelines have demonstrated pressure (psi measured by pressure gages) but development will require cooperation within a pipeline association with multiple owners and managers. These pipelines were observed to often skirt the outside of property boundaries, forming 90 degree angles which would result in longer penstocks (pipelines) with more friction loss.

7 Project Priority and Follow Up

In Wallowa County, as elsewhere, sites that have both energy potential and an enthusiastic proponent have the greatest likelihood of proceeding. A variety of energy costs, resources, incentives, and project proponent values come into play when determining whether a project will go to development. All the projects listed here could go to development. Projects which crossed a "no-go" decision threshold are not included in this report.

To assist further with the project development decision process, RES has scheduled a joint meeting for landowners and project proponents contacted during the course of the project.

The purpose of the meeting is to explain the results of the scoping study for their resource/site and to explain how project proponents can continue project assessment and development with a feasibility study. This meeting will also initiate a community wide conversation about hydropower and its potential in Wallowa County.

8 Future Studies for Hydropower Analysis

Wallowa County has more than 30 major irrigation ditches (most with numerous smaller "feeder" conduits) as well as additional irrigation ditches that are not considered "major" but may have significant hydroelectric potential. Additional sites with technical hydroelectric potential were identified in the mapping process but could not be examined in detail during this study.

Recommendations for future research include the following:

- **Associated Ditch Company (ADC) conduits.** The ADC is a water distributor located in the south end of the Wallowa Valley, maintaining five irrigation canals and transporting up

to 414 cfs during the peak irrigation season to hundreds of farmers over thousands of acres. The ADC declined to participate in this study for a variety of reasons. However, as the study reached its conclusion, they asked for RES personnel to attend a board meeting. In that meeting they reconsidered their position, and asked to be included in future work on hydro potential.

- **Additional funding for Feasibility Studies on the projects identified with the highest potential.** RES recommends further evaluation of the following sites via Feasibility Studies:

Alder Slope D. 1, Fairchild. Hurricane Creek > Wallowa R. Wallowa R.
Arrowhead Pipeline Association 1, Reininger . Hurricane Creek > Wallowa River. Wallowa River.
Arrowhead Pipeline Association 2, Jones. Hurricane Creek > Wallowa River. Wallowa R.
Kinney Lake D. 1, Shear **.** Big Sheep Creek. > Imnaha R. Prairie Creek.
Kinney Lake D. 4, Shear. Big Sheep Creek. > Imnaha R. Prairie Creek.
McCully Creek, 1, Shear . McCully Creek > Prairie Creek. Prairie Creek.
Moonshine 1, Hayes. Hurricane Creek > Wallowa R. Waste Ditch.
Prairie Creek. 1, 7F Ranch. Prairie Creek > Wallowa R. Prairie Creek.
Sheep Ridge D. 1, Carlsen . Lostine R. > Wallowa R. Lostine R.
Sheep Ridge D. 2, Carlsen. Lostine R. > Wallowa R. Lostine R.
West Side D. 1, Brock. Lostine R. > Wallowa R. Lostine R.

- **Funding to work with the Freshwater Trust, Natural Resource Conservation Service, Oregon Water Resources, and others as they pursue combining the Poley-Allen and Westside Ditches into a single ditch that runs where Westside Ditch currently runs.** The Westside/ Poley-Allen hillside has among the highest technical potential of any geographic area in Wallowa County. The combination of terrain and water flow could offer many users who currently draw from Poley-Allen the opportunity to develop a more efficient pressurized irrigation system along with hydroelectric power. RES would like funding to integrate renewable energy objectives into project planning with the agencies and organizations listed above.

9 Project Costs

Project costs represented in the Data Sheets are estimations of expenses based upon research, discussions with technical service providers and best available knowledge. Of note:

- **The design, capital cost, and installation of pipelines are eligible for cost share programs from NRCS.** Penstocks (pipelines) using irrigation water are also commonly irrigation conduits leading to irrigation infrastructure;

- **The powerhouse structures could be considered over engineered for the application.** Some sites may have structures which could be repurposed for this use, however engineering of the concrete work and equipment will be required.
- **Some of these project components could be completed by the project owner**. There may an opportunity for the owner to pursue the Oregon Water Resources application and working with NRCS to design and install a pipeline rather than securing the services of a professional engineering firm. This is standard procedure for NRCS.
- **Bidding.** Costs included here are usual and customary for Wallowa County. During actual project development competitive bidding would deflate some of these project costs.
- **Uncertainty**. The level of study offered by this project leaves some uncertainties when estimating costs.

10 Conclusion

This study will significantly contribute to the development of conduit-based hydropower in Wallowa County, Oregon. The survey establishes a library of the county's potential hydroelectric sites and provides a solid departure point for landowners and ditch companies interested in pursuing this potential further. Toward the end, participants and interested others have been invited to participate in ongoing discussion regarding the development of resources.

The resource maps created by this project will decrease the cost of resource evaluation. The coded zones of topographic fall (head) paired with a landowner's water right, will form the basis for initial conversations. Already, RES has used this map several times when communicating the basics of hydropower resource assessment.

This study also identifies complexities with regard to hydroelelectric development on existing pipelines, particularly with regard to shared ownership of conveyance structures. Assisting land and water owners to find congruence between individual and collective goals for water use and hydroelectric production is an example of the importance of social, as well as technical components of future project development.

Several sites were identified where pressure release valves are used by landowners to protect irrigation infrastructure. The successful development of hydroelectric resources within shared irrigation pipeline systems will depend on the protection of other people's pressure resource.

Although developing hydropower projects without existing pipelines may be more expensive than developing projects with existing pipelines, they may benefit from private ownership of the pressure resource rather than shared ownership, and can be structured to optimize the hydroelectric potential of a site.

This project has also identified the important role that hydropower development can play for rural Oregon's farms and ranches. Seeking means to hedge against rising operational costs, many production-based land owners are keen to develop hydropower projects that could

eliminate or reduce their electric utility bill. Most of these projects would offset the ranch house's electric consumption (schedule 4) rather than farm consumption (schedule 23).

Appendix A – Wallowa County Ditch Company Master List

- Wallowa Valley Improvement Association
- Silver Lake Ditch
- Estes Ditch
- Farmers Ditch
- Big Bend Ditch
- Dobbin Ditch
- Granger Ditch
- Creighton Ditch
- Cove Ditch
- Moonshine Ditch
- Hurricane Ditch
- Alder Slope Ditch
- Lower Alder Slope Ditch
- Silver Creek Ditch
- Island Ditch
- Sheep Ridge Ditch
- Cross Country Ditch
- Westside Ditch
- Poley-Alan Ditch
- Clearwater Ditch
- Fitzpatrick Ditch
- Miles Ditch
- Chamberlain Ditch
- Lower Valley Ditch

Appendix B - Ground Truthing Methodology

Data	Source	Detail
WATER PROVIDER CONTACT AND INTEREST		
Water Provider Contact • Name • Phone number • Best way to contact	Ditch Company Master List compiled from a variety of sources, including: • Wallowa County Planning Department • Oregon Water Resources • GoogleMaps • Conversations with water users	This information is offered by the water provider him or herself.
Site coordinates: powerhouse Site coordinates: penstock	GPS Device	Lat/ Long Coordinates in NAD 83 Datum (WAAS enabled) for the powerhouse and penstock. (Also refer to "Head" Data Field.)
Project Type	RES Personnel Assessment	Chosen from the following or an original description to fit the project: • Open canal • Pressurized irrigation conduit – in line of an existing pressurized irrigation conduit • Pressurized irrigation conduit – end of existing pipeline—no new penstock required • New Capacity at an existing reservoir • Re-development of an existing hydroelectric project • Other, please describe
Head	Distance between proposed penstock start and powerhouse	Viable distance for the penstock is measured as the distance where slope meets or exceeds 12 feet of fall per 100 feet. Total head from the start of the penstock to the powerhouse is the head. Head is measured with MicroTim brand altimeter. This unit has a relative accuracy of +/- 2 feet.
Range of Flows	Average flow by water right (titled by individual or by Ditch company name) is available online at the Oregon Water Resources database. However, it can be very difficult to	Minimum flow is the flow at which, using the head for a certain segment, 40,000 kWh can be generated per year. Maximum flow is the maximum flow allocated by water right at the identified project zone. This method is imperfect but

	ascertain which conduit carries a given water right. Ditch companies total water right volumes are readily available by company name. For a project proposed on a feeder ditch, the name of the downstream user and his or her water right/ water lease will have to be determined. Conversation with ditch company personnel will attempt to identify feeder ditches and water sources. Coordinates of the feeder ditch may be taken at various points to determine whose property is passed through, and subsequently which water rights are likely conveyed by that feeder conduit.	adequate for a scoping study of multiple sites. The method used is the following: If the project is on a feeder ditch, the potential project owner will be consulted for his or her water right and/or flow gauge information. If the project is in a pipe and is full for the duration of the season, flow data is derived using National Center for Appropriate Technology "Water Management" Handbook. If the pipe is not full for the duration of the season, uncertainty is expressed. If the project is on a main ditch, the flow rate estimate will be explained in a note on the results table.
Volume of water conveyed over the course of the irrigation season	This figure is established for main conduits only and is established by the water rights owned by those companies.	Oregon Water Resources' online database provides information on water rights. Ditch companies water rights are listed. Private water rights in the same quarter section – quarter section which are estimated to flow through the same conduit are also listed.
Proposed infrastructure capacity in KW	This will be established in a range, with a minimum KW capacity established by the requirement to generate at least 20,000 kWh per year.	Mathematics. See table of results. The upper range of kW capacity is calculated using maximum flow. See Data field "Range of Flows" for more information.
Level of Interest in water piping, gauged by their interest in hydroelectric development	Available on Contact • High • Medium • Low	High -- any of the following qualifiers • Very interested in exploring micro-hydroelectric development • Has past experience with micro-hydroelectric development. • Expresses interest in the benefits of micro hydro Medium -- any of the following qualifiers • Shows interest but is cautious about outside involvement in water project. • Wants to obtain further support from ditch company personnel • Is unsure about the implications of taking further steps to study micro hydroelectric potential Low -- any of the following qualifiers • Shows little interest of involvement with micro-hydroelectric development • Skeptical of project or further

		investigation • Unsure of liability or responsibilities
Perceived ability to develop the project, financially and technically	Final impression post-ground truthing This designation is based on: • Project financing can be undertaken on behalf of an individual, group of individuals, or the Ditch Company. Individuals will not be consulted on a site by site basis at the "scoping" level study. • On an anecdotal basis, ditch company personnel and the way he/she characterizes members and management of the ditch company will offer insight	• High – ditch company personnel gives some indication that the financial or technical resources are adequate to further investigate a project • Medium: unsure of the individual members' or ditch company's ability to investigate and develop a project • Low: Unfamiliar with basic water management principals. Expresses reluctance to invest personally (propensity to "want something for nothing")
WATER EFFICIENCY DETAILS		
Start of Irrigation Season End of Irrigation Season	Oregon Water Resources	Wallowa River Decree water rights officially commence on May 1 and end October 1. Water Rights not designated under the Wallowa River Decree have varying start / end dates and can be derived from the Oregon Water Resources Water Rights Database.
Volume of Water Right Over Course of Season	Oregon Water Resources and conversations with Ditch Company personnel.	Water Rights owned by Ditch Companies are clearly conveyed by those companies, insofar as water rights are for irrigation and not storage or other uses. Ditch companies may also convey water rights for users downstream for a fee. This information cannot be obtained by a scoping study. For in-conduit projects, the maximum cfs listed may underestimate the amount of water available for a hydropower project.
Method(s) of Water Conveyance	Visually Obtained at Site	Does site contain: • Unlined Ditch – a ditch with an earthen bottom, made of soil, clays, gravel, rocks, or other organic materials • Lined Ditch – a ditch lined with plastic, compacted clay, reinforced or unreinforced concrete, geomembranes • Pipe (type)—steel, pvc, polyethylene, other
Potential Piping Distance and	Pipe diameter taken from Figure	Potential Piping Distance is the distance

Cost	1.7: Pipe Diameter vs. Flow Nomograph in Canadian Small Hydropower Handbook (CSHH). Pipe cost taken from quotes from the following local providers: • Pioneer West, Joseph, OR • PGG, Enterprise, OR • PGG, La Grande, OR	between the penstock and powerhouse. Piping cost = $ per meter * meters of run
Powerhouse cost	Taken from LD Perry Construction.	• 5 kW – 20 kW system… $17,600 • 21 kW – 40 kW ……..$35,000 • 41kw – 100 kW…… $85,000 • 101 kW – 300 kW…….$95,000
Turbine/ Gen-set cost	One "range" of quotes for project development costs was obtained from Canyon Hydro. Eric Melander of Canyon Hydro was very helpful in quoting these turbine/ gen-set costs.	
Construction costs and any other major capital expense		See Appendix D: Project Costs
Distance to transmission and cost		Estimated distance to transmission gathered during the groundtruthing process and using GoogleEarth tools. GIS data is not available because it is considered Critical Energy Infrastructure (CEII) and protected information. Cost estimates of transmission are from Columbia River Electric Maintenance, an outfit licensed in Oregon and Washington and currently serving several hydroelectricity plants in Chelan, Co, Washington.
Estimate of range for interconnection costs		See Appendix D: Project Costs
Permitting costs		See Appendix D: Project Costs
Fatal flaws?		Fatal flaws are noted on a project by project basis and are based on RES' experience.
ENERGY EFFICIENCY		
Do members pump from open canals?	Conversation with ditch company personnel. Only applicable for in-ditch site segments.	"Open canals" are defined as water conduits that are not enclosed on the surface.
If the canals were replaced with pressurized pipe, could some of the district be gravity	If the site meets the qualifications for hydroelectric development the site would support a gravity flow pipeline for at least the amount of	YES If the psi is greater than or equal to 40. NO If the psi is less than 40

fed?	flow determined to be the minimum eligible for a hydroelectric project at that site, as indicated by the example analysis below: More in-depth analysis could be completed by sizing the pipe size and flow rate to the psi offered by the site. 1 foot of elevation drop = 0.433 psi of pressure head. Once the flow rate is chosen, a pipe size and its distance can be used to calculate the frictional loss of the pipeline. The psi needed to run a given wheel line or central pivot must be less than the total psi of the site minus the frictional loss associated with the pipe. This is a really complex question, because field sizes and wheel lines can be outfitted with a variety of nozzles whereby certain psi could be utilized for irrigation. One "rule of thumb" is that 40 psi (92 feet of head) will run ¼ mile of wheel line that is outfitted with 33 nozzles sized at 1 ¼" . This wheel line would have a flow rate of ½ cfs.	
Are there a small number of members who dictate system pressure requirements through their use of high-pressure irrigation?	Conversation with ditch company personnel. Only applicable for in-ditch site segments.	A non-threatening question might take the form, "so, are there quite a few guys running their wheel lines or center pivots off of this pressure?" with follow up questions to get more information
Do district owned pumps throttle or bypass flow?	Conversation from ground truthing. Only applicable for in-ditch site segments.	Throttle flow is to regulate flow using constriction through a pipe or other volume regulating flow constriction. This may limit the amount of pressure in the system. Bypass flow is excess water beyond that being diverted into the irrigation conduit.
Are pump station(s) designed for substantially greater flow than current requirements?	Conversation from ground truthing. Only applicable for in-ditch site segments.	Ask for information about the age, maintenance, and status of pumps
Does the pump station have automatic sequencing capability?	Observation and conversations from ground truthing. Only applicable for in-ditch site segments.	Ask for information about the age, maintenance, and status of pumps.
Does the pump station have	Conversation from ground truthing.	Ask for information about the age,

one or more variable speed pumps?	Only applicable for in-ditch site segments.	maintenance, and status of pumps.
How old are the pumps?	Conversation from ground truthing. Only applicable for in-ditch site segments.	Ask for information about the age, maintenance, and status of pumps.
Does the district strictly control the water used by each member? (*indirect questioning only*)	Observation from ground truthing. Only applicable for in-ditch site segments.	Observation from land owners based on overhead water distribution, or pressure in a pipeline.
District members are thought to have on average the following level of interest in switching to more efficient irrigation technology: low/ medium/ high	Observation from ground truthing. Only applicable for in-ditch site segments.	Low: No expression of interest in incentives for water or energy savings. Medium: Some interest in water or energy incentives. Potentially mixed feelings among ditch company members. High: Express interest in hydroelectric projects, energy efficiency, water-use efficiency, financial sustainability, energy independence.
Pumps used within the District: 1. Does the district own and operate pumps? 2. How many? 3. Total HP? 4. Total annual kWh for pump station, if available from billing history 5. Is the pump station served by Pacific Power, PGE, or other electric utility?	Observation from ground truthing. Only applicable for in-ditch site segments.	
Are the district pumps served by Pacific Power, PGE, or other electric utility?	PacifiCorp territory map. Online at http://energytrust.org/about/ → Service Territory Map	All sites surveyed have Pacific Power as the utility provider.
How many district members?	Conversation from ground truthing. Only applicable for in-ditch site segments.	
What is the fraction of the district acreage served by: • High pressure > 70 psi @ end use? • Low pressure < 70 psi @ end use? • Flood?	Conversation from ground truthing. Only applicable for in-ditch site segments. However, the landowner will be asked how he or she irrigates his or her land.	Estimate from conversations with Ditch Company personnel.

QUALITY OF INFORMATION QUESTIONS		
How is flow data measured and recorded? (*indirect questioning/ observation*) Automatically/ manually/ could be measured but isn't/ not practical to measure flow	Conversation from ground truthing. Landowners will be asked this question.	"Automatically" is flow that is measured by an electronic sensor or a piped conduit. "Manually" is a weir, head gate, or flow meter that is manually read and adjusted. "Could be measured but isn't" is a weir, head gate, or flow meter that is not routinely adjusted. "Not practical to measure flow" is no existing infrastructure to measure flow.
Flow measurements available on: • All major canals and pipes • Some major canals and pipes • No major canals/ pipes	Landowners will be asked this question.	RES personnel will choose from the options in the first column of this row.
Pump Data: Does the district have pump curves for district owned pumps? Has the district measured pump performance in the last 5 years? Member pumps have exclusively their own electric meters/ mostly their own electric meters/ mostly shared electric meters	Conversation from ground truthing. Only applicable for in-ditch site segments.	Ditch company personnel will interpret and answer these questions.
Water usage: Does the district have a list of individual member pumps? Does the district have annual water use: • By individual member pumps • By major district segment • For the district as a whole	Conversation from ground truthing. Only applicable for in-ditch site segments.	Ditch company personnel will interpret and answer these questions.
WATER MONITORING		
District Members are thought to have on average the following level of interest in switching to more efficient irrigation technology: very low/ low/ medium/ high/ very high	Conversation from ground truthing. Landowners will be asked this question. Landowners indicated that they talk to their neighbors and will have a sense for people's interest in more efficient irrigation technology.	RES personnel will choose from the options in the first column of this row.

WATER SAVINGS		
Points of obvious water leakage	These are points of diversion, main canals, or feeder ditches which are obviously leaking. These points are verbally verified with the ditch company personnel or landowner.	
RECHARGE		
Does the conduit recharge its source watershed? If not, which watershed does it recharge?	This is important to increasing in-stream flow.	"Source watershed" is defined as the sub-basin from which the irrigation waters were diverted. Notes are included where necessary.

Appendix C - Acre-Feet to CFS Conversions

Appendix D - Hydropower Project Cost Estimates

The following project costs are estimates of the major financial requirements of a system, including capital infrastructure, permitting, engineering, and build/equip.

The methodology of estimating these costs is included.

Cost	Method of Estimation					
Pipe	Three different regional suppliers of pipe were consulted and quoted pipe based on psi threshold, diameter, and volume. The table of costs follows.					
		PVC pipe pricing	* Gasketed pvc			
		diameter (inches)	psi		cost per linear foot	
	Quote 1-PW	12	200		$ 10.71	*in stock prices*
		8	120		$ 3.32	
	Quote 2-LG	12	200		$ 14.27	
		12	160		$ 13.44	
		8	120		$ 5.49	
		32	200		$ 85.22	
		16	235	C905	$ 31.64	
	Quote 3--WCGG	4			$ 0.95	
	Quote 4-EI	16	235	C905	$ 20.50	
		16	160		$ 14.65	
	Quote 5-NWP	16	560		$ 45.00	
		16	354		$ 29.00	

Appurtenant cost information was obtained from NRCS cost estimation tools. These appurtenant components may or may not have sufficient psi rating for the application. More details costs would have to be spelled out in a Feasibility Study.

Appurtenant component pricing is broken down by average cost per foot of project pipeline and includes appropriately sized appurtenant pieces. Appurtenant components include:

Two Continuous Acting Combination Air/Vacuum Release Valves (CAV)

- One drain valve
- One butterfly control valve

Pipeline Appurtenances	
Diameter	NRCS quote
1-3"	$1.29/ft
4-6"	$2.56/ft
8-10"	$0.66/ft
12-15"	$0.96/ft
16-18"	$0.91/ft
21-24"	$2.08/ft
27-30"	$3.95/ft
> 30"	$3.95/ft

Powerhouse

Quote from LD Perry Construction. Simple metal building with concrete floor would likely be around $40-$50/ft.

For estimating square footage by kilowatt capacity, dimensions from the Canadian Small Hydropower Handbook: British Columbia Region. (ISBN 0-662-17178-0) were used.

- Up to 50 kW estimated at 14 feet x 14 ft
- Up to 100 kW estimated at 16 feet x 16 feet

Each of these totals were multiplied by 1.3 to account for concrete work specific to the hydro plant, fan, discharge and entry openings, etc.

Independently from this rubric, $80,000 was estimated for the Sheep

	Creek Powerhouse, because that is its current market value.
Turbine/Generator / Electrical controls	Quote from Canyon Hydro. A single quote does not take into account competitive bidding. This scoping study does not recommend a technology provider; it only offers a "ballpark" of what the turbine/gen/electrical set will cost.
Transmission	Estimated distance to transmission gathered during the groundtruthing process and using GoogleEarth tools. GIS data is not available because it is considered Critical Energy Infrastructure (CEII) and protected information. Cost estimates of transmission were obtained from Columbia River Electric Maintenance, licensed in Oregon and Washington and currently serving several hydroelectricity plants in Chelan, Co, Washington. They estimate average transmission to about $33.00 per ft. Transmission would be completed using wood poles and medium drawn #6 bare copper wire. No matter how short the run a boom lift would be required for every pole set. Their estimated for lift rental is $1200 per month, with 200-300 feet per day a reasonable expectation.
Installation	Installation includes pipeline installation, turb/gen/controls, and electrical interconnection. For pipeline install, analytical tools developed by NRCS were used to estimate cost share on irrigation infrastructure upgrades. These tools are Excel databases of information on materials, installation, labor, operation and maintenance (annual), risk, forgone revenue, etc. The information is segregated by pipeline diameter. However, these costs are based on moderate terrain with vehicle access. Ten percent was added to the NRCS costs to develop these cost estimations. Contracted installation costs, which includes labor, equipment, contractors insurance, follows:

Pipeline Installation Quotes		
Diameter	NRCS quote	Hydroelectric Estimate (NRCS + 10%)
1-3"	$1.75/ft	$1.92/ft
4-6"	$3.59/ft	$3.95/ft
8-10"	$6.24/ft	$6.86/ft
12-15"	$10.80/ft	$11.88/ft

<table>
<tr><td></td><td>
<table>
<tr><td>16-18”</td><td>$10.86/ft</td><td>$11.95/ft</td></tr>
<tr><td>21-24”</td><td>$18.79/ft</td><td>$20.64/ft</td></tr>
<tr><td>27-30”</td><td>$23.95/ft</td><td>$26.35/ft</td></tr>
<tr><td>> 30”</td><td>$23.95/ft</td><td>$26.35/ft</td></tr>
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For turb/gen/controls and electrical installation cost, an estimate from Allen Spaur of Columbia River Electric Maintenance was used. Columbia River Electric Maintenance gave a cost estimate for each project.

Columbia River Electric Maintenance submitted several estimations for designing and installing electric service:
• Single phase, less than 25 kW, lighting, general purpose outlets, utility service, and service connection point -- $14,900
• 3-phase, 25.1 – 50 kW, auto transfer switch, lighting, general purpose outlets, utility service, and service connection point. – $24,000
• For larger projects, Columbia River Electric Maintenance insisted that more detailed figures and a site visit would be necessary for a bid. This is beyond the scope of this study, therefore was estimated at $45,000 for projects larger than 50 kW.
</td></tr>
<tr><td>Interconnection costs:

Costs associated with Interconnecting to PacifiCorp’s grid via net metering contracts or power sales as a Qualifying Facility.</td><td>Projects less than 25 kW were considered to be net metered. Net metering for induction based systems less than 25 kW (the system quoted by Canyon Hydro) requires a level 2 net metering application.

PacifiCorp’s fee associated with level 2 applications of $50 plus $1/kW.

Projects 25.1-50 kW will be net metered or undertake a power purchase agreement. Interconnection and Qualifying Facilities fees associated with Power Purchase Agreements can be very expensive. These expenses cannot be known without further project analysis. As a pure estimate, RES used $45,000 for Qualifying Facilities 25.1 – 50 kW ($30,000 interconnection study plus $15,000 for system upgrades).

Projects greater than 50 kW will almost certainly use a power purchase agreement, due to remoteness of the power generation facilities. As a pure estimate, RES used $75,000 for Qualifying Facilities 50.1 kW – 250 kW.

Projects greater than 250 kW will almost certainly use a power purchase agreement. As a pure estimate, RES used $90,000 for Qualifying Facilities</td></tr>
</table>

	greater than 250 kW. • Projects >25 kW – net metered -- $50 + $1/kW • Projects 25.1 – 50 kW – power purchase -- $45,000 • Projects 50.1 kW – 250 kW – power purchase -- $75,000 • Projects 250+ kW – power purchase -- $90,000
Permitting	RES provides FERC permitting and Oregon Water Resources permitting for clients. FERC permitting is a relatively fixed cost, independent of project size. RES provided the cost estimates used in this field. FERC conduit exemption application preparation costs are estimated at $7,200. Mapping and Drawings completed by a surveyor and PE Engineer are estimated at $4,000. Drawings are not engineering design; they are simply drawings that comply with the FERC specifications set forth in 18 CFR, Part 4, Subpart D. Completing the Oregon Water Resources "Application to Develop Hydroelectric Use as Part of an Existing Certificated Water Right" is estimated to cost $1,500. Use of RES' cost estimates assume similar work could be done by other companies. It also assumes use of the Conduit Exemption application from FERC for grid-tied projects. Costs associated with interconnection, net metering application, or Power Purchase Agreement are outside the scope of "Permitting" costs and are addressed under "Feasibility and Engineering." • FERC Conduit Exemption -- $7,200 • FERC Mapping and Drawings -- $4,000 • OWR Hydroelectric application -- $1,500 TOTAL PERMITTING COSTS -- $12,700
Feasibility and Engineering	Feasibility includes scoping and feasibility studies to assess the feasibility of using hydroelectric resources. RES completes Scoping and Feasibility Studies for Hydroelectric Projects and estimates the market values as follows: • Scoping Studies: $600 -- $2,500 • Feasibility Studies: $15,000 -- $150,000. Can include interconnection study with utility company for larger scale projects.

	RES applied a scoping and feasibility study cost on a case by case basis based on a variety of subjective project features. Engineering costs include civil and mechanical engineering of penstock, concrete slab and work in powerhouse, civil engineering of powerhouse, and electrical engineering of electrical interconnection. Costs of engineering penstock were derived from Anderson Perry and Associates in La Grande. Costs of engineering powerhouse were derived from previous work RES has engaged in. Costs estimated at $1,500 -- $7,500. Costs of electrical engineering derived from Columbia River Electric Maintenance, who provided estimates on electrical design and installation. • Penstock/pipeline engineering. Costs vary widely with length and other factors. Pipeline engineering is available from NRCS. • Powerhouse engineering $1,500 -- $7,500 • Electrical engineering [Please see install costs above]

Appendix E - Field Abbreviations for Conveyance Information Data Sheets

Mthd_conv	Method of conveyance: Unlined, Lined, Piped?
Proj_type	Project Type: Open Canal, Pressurized Irrigation Conduit (continuous), Pressurized Irrigation Conduit (end), Reservoir, Re-development, Other
Start_date	Start date of irrigation season
End_date	End date of irrigation season
Open_cnls	Do members pump from open canals? Y/N
Grav_fed	If canals were replaced with pressurize pipe, could some of the district be gravity fed? Y/N
Press_reqs	Are there a small number of members who dictate system pressure requirements through their use of high pressure irrigation? Y/N
Thttl/Byp	Do district owned pumps throttle or bypass flow? Throttle/ Bypass
Ineff	Are pump stations designed for substantially greater flow than current requirements? Y/N
Auto_seq	Do pump stations have automatic sequencing capability? Y/N
Vari_spd	Does the pump station have one or more variable speed pump? Y/N
Yrs_DPump	How old are district owned pumps? 0-5, 5-10, 10-20
Pac_Pwr	Is Pacific Power the utility?
Mem_pumps	Does the district have a list of individual member pumps?
Annual_use	Does the district have an annual water use by: individual member pumps/ by major district segment/ for the district as a whole/N/A.
Elec_meas	Member pumps use the following way to measure electricity: Their own meters/ mostly their own meters/ mostly shared meters.
% High press	What fraction of the district is served by high pressure > 70 psi at end use?
% Low press	What fraction of the district is served by low pressure < 70 psi at end use?
% Flood	What fraction of the district is served by flood irrigation?
Leak_lat	Latitude of point of obvious leakage
Leak_long	Longitude of point of obvious leakage
Fmrs_scrn	Is the diversion suitable for a Farmers' Screen?
Nmbr	How many district members are there?
Interest	What is their perceived level of interest in more efficient irrigation? High, Medium, Low
Dev_pot'l	What is their perceived technical and financial ability to develop a project? High, Medium, Low
Flow_meas	How is flow measured? Automatically, Manually, isn't measured
Flow_data	Flow data is available on this project: Y/N
Water_reacharge	Does the conduit recharge its source watershed? If not, which watershed does it recharge?

Map and Data Sheets 1

Chamberlain D.1

Resource Assessment

Aerial Representation

Conveyance Information

Clearwater D.1

Resource Assessment

Aerial Representation

Conveyance Information

Clearwater D.3

Resource Assessment

Aerial Representation

Conveyance Information

Map and Data Sheets 2

Allen Canyon D.1

Resource Assessment

Aerial Representation

Conveyance Information

Cross Country Canal 1

Resource Assessment

Aerial Representation

Conveyance Information

West Side D.1

Resource Assessment

Aerial Representation

Conveyance Information

West Side D.2

Resource Assessment

Aerial Representation

Conveyance Information

West Side D.3

Resource Assessment

Aerial Representation

Conveyance Information

Map and Data Sheets 3

Alder Slope D.1

Resource Assessment

Aerial Representation

Conveyance Information

Sheep Ridge D.1

Resource Assessment

Aerial Representation

Conveyance Information

Sheep Ridge D.2

Resource Assessment

Aerial Representation

Conveyance Information

Map and Data Sheets 4

Arrowhead Pipeline Association 1

Resource Assessment

Aerial Representation

Conveyance Information

Arrowhead Pipeline Association 2

Resource Assessment

Aerial Representation

Conveyance Information

Creighton D.1

Resource Assessment

Aerial Representation

Conveyance Information

Moonshine D.1

Resource Assessment

Aerial Representation

Conveyance Information

Map and Data Sheets 5

Kinney Lake D.1

Resource Assessment

Aerial Representation

Conveyance Information

Kinney Lake D.2

Resource Assessment

Aerial Representation

Conveyance Information

Kinney Lake D.3

Resource Assessment

Aerial Representation

Conveyance Information

McCully Creek 1

Resource Assessment

Aerial Representation

Conveyance Information

Prairie Creek 1

Resource Assessment

Aerial Representation

Conveyance Information

Sheep Creek D.1

Resource Assessment

Aerial Representation

Conveyance Information

Map and Data Sheets 6

Map 6 does not include data sheets.

Map 6 represents the technical potential found along the Alder Slope Ditch. The ditch in its entirety runs along the base of the Wallowa Mountains and maintains an elevation much higher than most of the farmland it supplies with water. All feeder conduits and pipes coming from this ditch have a high degree of technical potential.

Map and Data Sheets 7

Map 7 does not include data sheets.

Map 7 represents the south end of the Wallowa Valley and illustrates the many ditches that flow from Wallowa Lake. These are among the most major conduits in the county with high flow rates and good technical potential. The map shows the Moonshine Ditch, Farmers Ditch, Silver Lake Ditch, Dobbin Ditch and the headwaters of Creighton Ditch.