

MEMORANDUM

Project No.: 030009-002-01

November 28, 2006

To: WRIA 31 Planning Unit

From: Steve Germiot, LHG, CGWP, and Timothy J. Flynn, LHG, CWGP

Re: **Evaluation of Winterizing Existing River Pump/Conveyance Systems for Use in Developing New Water Storage**
Glade-Fourmile Subbasin, WRIA 31

This memorandum is a supplement to our September 2005 preliminary assessment of water storage concepts in the Glade-Fourmile subbasin of Water Resource Inventory Area 31 (WRIA31) (Aspect Consulting 2005). That preliminary assessment concluded that it was likely not economically feasible to construct new water storage at distances away from the Columbia River, assuming small to moderate storage quantities (10 cfs/3000 acre-feet/year to 30 cfs/9000 acre-feet/year). The majority of the estimated cost was associated with construction of new river pump stations and conveyance piping from the point of diversion.

The concept of using existing Columbia River pump station/conveyance systems was identified as a potential cost-saving measure in the preliminary evaluation memorandum. Several such systems operate for irrigation supply throughout the subbasin. Operating these existing systems during the non-irrigation season (e.g., November through March) to pump river water to storage could be a means to dramatically reduce the cost for developing new sources of water storage (out of river) in the subbasin. However, most of the existing systems include above-ground components that are not designed to operate during freezing conditions that may occur during winter operation. Therefore, the Planning Unit authorized this supplemental evaluation to assess the scope and cost to retrofit existing irrigation pump/conveyance systems to allow for winter operation.

Aspect Consulting subcontracted SCM Consultants (SCM) of Kennewick, Washington, to complete the assessment. SCM has done considerable work in design, construction oversight, and maintenance of irrigation systems in the region, and has extensive knowledge of specific systems in the subbasin. Because each irrigation system is unique, SCM assumed for the assessment a conceptual representative irrigation system based on average characteristics of eight existing systems in the area.

The general findings of the assessment are as follows:

- For the conceptual system, flow rates of 10 cfs and 30 cfs can be conveyed distances of approximately 4.9 and 3.9 miles inland (north) from the river, respectively. Conveyance of these quantities further north is constrained by existing pipe diameter which is reduced as the quantity of water the farm needs to convey is reduced. Without use of a booster pump, water could be delivered to a maximum elevation of about 550 feet at a pressure of about 50 psi. Booster pumps can deliver the water to higher elevations.

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- Retrofit of an existing system would primarily involve installation of new valves to isolate parts of the irrigation system not used for conveyance to a storage location; the new valves would be installed in subsurface vaults for freeze protection. Heated enclosures would also be used around operating pumps.
- A planning-level capital cost to retrofit an existing system operating at 10 to 30 cfs would be in the range of \$500,000 to \$600,000 with an uncertainty of $\pm 40\%$. Therefore, winterization of existing systems represents a substantial cost savings relative to constructing all new systems to supply a water storage project. For example, adjusting the September 2005 planning-level cost estimates (for new construction) to use the same conveyance distances assumed by SCM (10 cfs for 4.9 miles; 30 cfs for 3.9 miles) indicates potential cost savings of greater than \$11 million for the more cost-effective diversion option (Ranney collector). Cost for development of a storage reservoir (surface or subsurface) does not change with use of existing pump /conveyance systems. In addition, additional conveyance piping would likely be needed to reach a specific storage reservoir location.
- Several of the existing irrigation pump/conveyance systems in the area can pump at higher flow rates than the 10 to 30 cfs range assumed in our preliminary assessment. Retrofit costs for the larger systems would be correspondingly higher than estimated here but, through economy of scale, costs per acre-foot of water stored can be much less.

We conclude from this supplemental assessment that retrofit of existing river pump/conveyance systems could substantially reduce the cost of developing new water storage in the Glade-Fourmile subbasin of WRIA 31. Further detailed evaluation of water storage is a key water supply strategy in the draft Watershed Management Plan for WRIA 31, which is currently in preparation. An important consideration for potentially using existing pump/conveyance systems is that many of the existing systems were designed to minimize capital (construction) costs when they were constructed and did not consider high power costs. Therefore, the existing pump/piping systems may not be hydraulically efficient, resulting in high operating costs. This will increase in importance as electric power costs increase, and may require re-engineering of existing systems.

This water storage project was funded under Grant number G0500011 obtained by the WRIA 31 Planning Unit from the Washington State Department of Ecology (Ecology) under the Watershed Management Act.

References

Aspect Consulting 2005. *Preliminary Water Storage Assessment, Glade-Fourmile Subbasin, WRIA 31*. September 23, 2005.

Attachment

SCM Consultants Inc. *WRIA 31 Watershed Plan, Glade-Fourmile Subbasin Water Storage,, Feasibility of Winter Operations of Existing Irrigation Equipment*. November 22, 2006.

**WRIA 31 Watershed Plan
Glade-Fourmile Subbasin Water Storage
Feasibility of Winter Operation of Existing Irrigation Equipment**

General

SCM Consultant's was contracted by Aspect Consulting to assess the feasibility of modifying an existing agricultural irrigation system pumping from the John Day pool of the Columbia River to operate during the winter (non-irrigation) season. The irrigation system would be used to pump water from the Columbia River into the Horse Heaven Hills where it would be stored in either the groundwater aquifer or in a surface reservoir(s). The stored water would be used for irrigation during the subsequent irrigation season.

Work completed earlier by Aspect Consulting had assumed a Columbia River diversion rate of between 10 and 30 cubic feet per second (cfs). These diversion rates would convey between 3,000 and 9,000 acre feet of water to the Horse Heaven Hills over the five month period beginning in November and extending through March.

Conceptual Irrigation System

There are a number of large existing irrigation systems pumping from the John Day pool. SCM has extensive knowledge and experience with these irrigation systems. No specific irrigation system was used for this evaluation. Instead a conceptual irrigation system based on the average characteristics of eight existing irrigation systems was developed. All of the existing irrigation systems used to develop a conceptual irrigation system pump water from the right bank of the John Day Dam pool and convey it north.

River Pump Station

The conceptual irrigation system has the following characteristics:

River Pump Station

Horsepower:	14,700
Pumping Head:	531 Feet
Discharge Pressure:	230 Pounds per square inch (psi)

Existing pump motor sizes range from 250 hp to 2000 hp units. The most common existing pump motor sizes are 1500 hp and 1000 hp. This suggests the majority of the conceptual irrigation systems horsepower requirement would be met using a combination of 1000 hp and 1500 hp pumps. At a pumping head of 531 feet (230 psi) and an assumed efficiency of 84% the pumps would each have the following capacities:

1500 HP	-	21 cfs (9,400 gallons per minute)
1000 HP	-	14 cfs (6,265 gallons per minute)

With a discharge head of 531 feet and an assumed efficiency of 84% withdrawal of 10 cfs would require about 700 hp and 30 cfs would require about 2200 hp.

The conceptual river pump station would have short coupled vertical turbine pumps supported above the Columbia River on a structural steel and concrete pumping deck. Discharge piping and valving would be exposed where they are located over the river and perhaps a short distance on the river bank. The discharge pipes would terminate in a common penstock pipe that conveyed the water to the farm.

In addition to the pump discharge pipes there would be an exposed pressure release /surge anticipation valve installed at the river pump station to help regulate discharge pressure.

Water Conveyance System

Piping in the conceptual irrigation system is largest at the river and gradually reduces in size as the system extends north. The conceptual conveyance system would have a 60 inch diameter steel pipe penstock leaving the river pump station. The conveyance system is more than large enough near the river to convey the 30 cfs maximum design flow rate. Moving north the pipe size gradually reduces as the quantity of water the farm needs to convey drops.

The conveyance system has the capability to convey the following quantities of water the distances shown.

30 cfs	-	20,400 feet (3.86 miles)
10 cfs	-	26,000 feet (4.92 miles)

The conveyance system extends in a northerly direction from the river pump station.

Without using a booster pump the conceptual system delivers water to areas with a maximum elevation of approximately 547 feet. At this elevation there would be sufficient pressure available to operate a circle irrigation machine. Typically about 50 psi is required to operate the circle irrigation machine.

The conceptual irrigation system penstock pipe contains branch fittings that supply water to pipes leading to other areas of the farm. On the pipe segments capable of supplying 30 cfs or more there are 5 pipe tees. There are two additional pipe tees within the segments of pipe capable of delivering a minimum of 10 cfs.

Exposed pipe clusters are located along the pipe alignment. These clusters are locations where the water supply pipes from several circle irrigation machines are brought to a common, above grade, location and various valves and other equipment installed. The conceptual conveyance system has 3 clusters located on the pipe capable of delivering 30 cfs or more and 1 additional cluster located on the pipe sizes capable of delivering a minimum of 10 cfs. There are typically air release and vacuum valves installed at the clusters.

Booster Pump Station

There are a wide range of booster pump station sizes and arrangements on farms pumping from the John Day pool. Some farms have no booster pumps, some have small booster pump stations serving one or two circle irrigation machines, some have

intermediate sized in-line booster pump stations capable of pumping 10 to 30 cfs while adding a few hundred feet of head or less and others have large in-line booster pump stations capable of pumping well over 30 cfs and adding over 300 feet of head. Because there is such a wide range of booster pump arrangements it is very difficult to determine what constitutes the average one.

The conceptual irrigation system used in this evaluation contains an intermediate size booster pump station capable adding 150 feet of head at flow rate up to 20 cfs. The pumps used in the booster pump station will be close coupled, end suction centrifugal pumps.

Winter (Non-Irrigation) Season Operation of Existing Irrigation Facilities

Normally the existing irrigation systems are not operated during the winter months. This allows the pipelines and exposed valves and fittings to be drained to prevent freezing. Operation during the winter would mean operating when temperatures may be below freezing and damage to exposed equipment could occur.

River Pump Station

Description of Modifications

The conceptual river pump station pump and piping arrangement described above exposes the pump column, pump discharge head and discharge pipe and check valve to the ambient outside temperature. The pressure release/surge anticipation valve is also installed where it is exposed to the outside air temperature.

Based on the 10 cfs to 30 cfs design flow rates only one or two of the conceptual river pump station's pumps will need to operate during the winter. The conceptual discharge manifold arrangement results in the discharge pipe of each pump, downstream from the check valve being filled with water when any pump is in operation. Cold weather operation will require the operating pump(s) be isolated from the exposed discharge pipes of pumps not operating or the discharge pipes and valves of pumps not operating be protected from below freezing temperatures. For purposes of estimating a cost associated with protecting the discharge pipe(s) of pump(s) not in operation we will reroute the discharge pipes of the pumps in operation to a location on the penstock downstream of where a new, buried 60 inch isolation valve would be installed on the penstock. During winter operation the valve would be closed so the discharge pipes of the pumps not in operation do not have standing water in them.

To cold weather protect the discharge pipe and check valve on the pump(s) in operation, in the event they need to be shutdown during freezing conditions, their check valves would be relocated into below grade vault(s) near where the pipe(s) connect to the penstock. This would eliminate exposed discharge pipe standing full of static water. The exposed discharge pipe would need to be installed to drain back through the pump in the event of pump shutdown.

The pressure release/surge anticipation valve and its associated piping would need to be protected in a heated enclosure or relocated and the valve installed in a below grade vault. Piping downstream from the valve would be installed to drain back to the river.

The pump drive shaft passes through the pump discharge head there is a shaft seal. This is accomplished using a stuffing box with packing material. The packing material is compressed around the shaft to limit the escape of water. Shaft seals using this method are generally not watertight and require regular adjustment to keep the flow of water around the shaft to the minimum required for shaft lubrication. Managing the water leaving the shaft seal will be required to avoid a build up of ice around the pump head. In order to eliminate ice build up and freeze damage to the shaft seal each pump head scheduled for winter operation would be enclosed in a heated, removable enclosure.

River Pump Station Modification Cost Estimate

The estimated pump station modification costs shown below are based on the pump station being modified to pump 10 cfs during the winter (non-irrigation) season.

1. Penstock Isolation Valve	\$148,800
2. Pump Discharge Piping	\$31,400
3. Pressure Release Valve and Pipe Realignment	\$17,000
4. Pump Head Enclosure	<u>\$22,800</u>
	Subtotal
	\$220,000
	Contingency (25%)
	\$55,000
	Sales Tax (8.3%)
	\$22,800
	Engineering
	<u>\$33,000</u>
	Total
	\$330,800

The estimated additional cost to increase the pumping capacity to 30 cfs is shown below.

1. Pump Discharge Pipe Realignment	\$27,800
2. Pump Head Enclosure	<u>\$22,800</u>
	Subtotal
	\$50,600
	Contingency (25%)
	\$12,700
	Sales Tax (8.3%)
	\$5,300
	Engineering
	<u>\$7,600</u>
	Total
	\$76,200

The total cost to modify the conceptual river pump station to pump 30 cfs would be an estimated \$407,000.

Distribution System

Description of Modifications

The existing distribution systems contain branch fittings, tees, where lateral pipes branch off the main penstock. These pipelines need to be isolated from the penstock during winter operation or the exposed pipe and fittings the lateral pipelines serve protected from freezing. For cost estimating purposes, the preferred method for freeze protection

of lateral pipelines, and the facilities they serve, will be the installation of isolation valves at the point where the lateral pipe connects to the penstock.

The conceptual distribution system would have five pipe tees in the segments of penstock capable of conveying 30 cfs. Valves required to isolate the pipelines could range in size from 10 inch to 48 inch. For purposes of estimating the cost of installing isolation valves a valve size of 24 inches will be used for each of the five valves.

Within the pipe segments of the conceptual system capable of conveying 10 cfs there would be two pipe tees. Pipelines supplied by these segments of the penstock are generally smaller in size. For purposes of estimating a cost to isolate the lateral pipelines 16 inch valves will be used.

All of these valves would be buried butterfly valves with a gear actuator and cast iron valve box.

Distribution System Modification Cost Estimate

The estimated modification cost to isolate the lateral pipelines on penstock capable of conveying 30 cfs is shown below.

1. 24 Inch Butterfly Valve (5 Places)	<u>\$6,700</u>	Ea.
	Subtotal	\$33,500
	Contingency (25%)	\$8,400
	Sales Tax (8.3%)	\$3,500
	Engineering	<u>\$3,400</u>
	Total	\$48,800

The estimated modification costs to isolate the lateral pipelines on penstock capable of conveying a maximum of 10 cfs are shown below.

1. 16 Inch Butterfly Valve (2 Places)	<u>\$4,300</u>	Ea.
	Subtotal	\$8,600
	Contingency (25%)	\$2,200
	Sales Tax (8.3%)	\$900
	Engineering	<u>\$800</u>
	Total	\$12,500

The total combined cost required to isolate the lateral pipelines to convey 10 cfs as far north as possible is estimated to be \$61,300.

Circle Irrigation Machine Pipe Clusters

Description of Modifications

Along the penstock pipe the conceptual conveyance system would have circle cluster pipes, installed vertically, that extend above the ground surface approximately five feet.

Around the perimeter of the vertical pipe (cluster) there would be circle irrigation machine service pipes and control valves installed. The exposed pipe and valves would need to be protected from freeze damage by either isolating them from the penstock or enclosing them in a heated structure.

Our estimate assumes an isolation valve will be installed on the vertical pipe below the ground surface to isolate it and the circle irrigation machine service valves and pipe from the penstock. The vertical cluster pipes typically have an air release and vacuum valve installed on top of them which will become inoperable when the pipe is isolated from the penstock. In order to continue to provide a place for air to escape and enter the penstock a new air release and vacuum valve will be installed on the penstock in a below grade pre-cast vault. The new air release and vacuum valve assemblies would be installed adjacent to each of the clusters that was isolated from the penstock.

The conceptual irrigation system has three cluster locations on the segment of the mainline capable of delivering 30 cfs and one cluster on the segments of pipe capable of delivering a maximum of 10 cfs. A typical vertical cluster pipe would be 20 inches in diameter.

Circle Irrigation Machine Pipe Cluster Modification Cost Estimate

Estimated costs to modify the clusters associated with pipe segments adequate to convey 30 cfs are described below.

1. Cluster Modification (3 Required)	\$6,400	Ea.
2. Air Release/Vacuum Valves (3 Required)	<u>\$6,100</u>	Ea.
	Subtotal	\$37,500
	Contingency (25%)	\$9,400
	Sales Tax (8.3%)	\$3,900
	Engineering	<u>\$3,700</u>
	Total	\$54,500

Estimated costs to modify the clusters associated with pipe segments adequate to convey 10 cfs are described below.

1. Cluster Modification (1 Required)	\$6,400	Ea.
2. Air Release/Vacuum Valves (1 Required)	<u>\$6,100</u>	Ea.
	Subtotal	\$12,500
	Contingency (25%)	\$3,100
	Sales Tax (8.3%)	\$1,300
	Engineering	<u>\$1,200</u>
	Total	\$18,100

The total combined cost required to modify the circle irrigation machine pipe clusters to carry 10 cfs as far north as possible would be \$72,600.

Booster Pump Station

Description of Modifications

The conceptual booster pump station contains a number of close coupled end suction centrifugal pumps. The booster pump station would be located in an area of the piping where the pipe size is adequate to convey 10 cfs but not 30 cfs. Based on the 3000 gpm pump size identified earlier, two of the pumps would need to be winterized to convey 10 cfs. Winterization would include isolating the operating pumps from the pumps not scheduled for winter operation and the construction of a heated enclosure around the operating pumps.

The estimate assumes a cement masonry unit building would be constructed around two of the booster pumps.

Booster Pump Station Modification Cost Estimate

Estimated costs to modify the booster pump station to convey 10 cfs are described below.

1.	Pipe and Valving	\$33,300
2.	Building w/ Heat and Electrical	<u>\$45,600</u>
	Subtotal	\$78,900
	Contingency (25%)	\$19,700
	Sales Tax (8.3%)	\$8,200
	Engineering	<u>\$11,800</u>
	Total	\$118,600

Total Estimated Project Cost

30 CFS Pumping Option

The 30 cfs pumping option in the conceptual irrigation system would deliver 30 cfs from the river to a point in the conveyance system located 3.86 miles north of the river at an approximate elevation of 547 feet and a pressure of approximately 50 psi. The 50 psi of pressure available would raise water an additional 116 feet in elevation less any pipe pressure losses. Two pumps at the river pump station would be used and there would be no booster pump station. The total estimated cost of this option is outlined below.

1.	River Pump Station	\$407,000
2.	Lateral Pipe Isolation Valves	\$48,800
3.	Cluster Valving	<u>\$54,500</u>
	Total Estimated Cost	\$510,300

The total estimated costs shown include a 25% contingency, sales tax and engineering.

10 CFS Pumping Option

The 10 cfs pumping option in the conceptual irrigation system would deliver 10 cfs from the river to a point in the conveyance system located 4.92 miles north of the river at an elevation of 547 feet and a pressure of 115 psi. The 115 psi of pressure available at the end of the pipe would raise water an additional 266 feet in elevation less any pipe pressure losses. One pump at the river pump station would be used and two pumps at the booster pump station would be used. The total estimated cost of this option is shown below.

1.	River Pump Station	\$330,800
2.	Lateral Pipe Isolation Valves	\$61,300
3.	Cluster Valving	\$72,600
4.	Booster Pump Station	<u>\$118,600</u>
	Total Estimated Cost	\$583,300

The total estimated costs shown include a 25% contingency, sales tax and engineering.

The estimated costs shown are based on a conceptual irrigation system that is an average of many existing systems. The estimated costs associated with the conceptual irrigation system have a level of uncertainty in the range of plus or minus 15%. However, the conceptual system does not exist and which existing system might be chosen for winter operation could have a significant impact on the cost. Within the existing irrigation systems that approximate the conceptual system we believe the level of uncertainty is plus or minus 25%. This suggests a total level of uncertainty in the estimated cost of plus or minus 40%.

There are a couple existing irrigation systems that utilize multiple large booster pump stations and are capable of conveying water much further than the conceptual system's 4.92 miles (10 cfs option) from the river and to elevations well above those the conceptual system does. If one of these systems was used for the project the level of uncertainty in the estimated cost would likely be significantly more, however, these systems would be able to convey water much further from the river and to much higher elevations.