2011 Silver Creek Dam PFMA Capital Improvement and Maintenance Plan (PN833)

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Purpose

This memorandum has been prepared to document recommended projects and maintenance activities for the Silver Creek Dam located in Silverton, Oregon. The capital improvement and maintenance plan (CIMP) is based on a review of the US Army Corps of Engineers (USACE) 2011 potential failure modes analyses (PFMA) performed for the Silver Creek Dam and from observations made during a dam inspection performed on September 15, 2011. CH2M HILL, City of Silverton, USACE, and Oregon Department of Water Resources staff participated in the September 15, 2011 inspection activities of the Silver Creek Dam. Vince Rybel and Todd Cotten of CH2M HILL's Corvallis and Portland Oregon offices, respectively, represented CH2M HILL during the site inspection.

Background

Silver Creek Dam is located on Silver Creek in Section 12, Township 7 South and Range 1 West, about 2 miles southeast of Silverton, Oregon. Silver Creek is a tributary to Pudding River, which is approximately 6 miles downstream of the dam. The dam has a storage volume capacity of approximately 1,300 acre feet and is owned and operated by the City of Silverton, Oregon.

The dam is a zoned earthfill structure with a crest elevation of about 440 feet, which is a maximum of about 65 feet above original ground. Upstream and downstream embankment slopes are 3:1 and 2:1, respectively. The spillway, located at the right abutment, consists of a rectangular converging concrete chute with an entrance width of 120 feet and a design entrance elevation of 424 feet, where elevations are referenced to Mean Sea Level.

Based on a 1981 Phase I Inspection Report prepared by the USACE and Oregon Department of Water Resources, Silver Creek Dam is classified as a high hazard dam in the intermediate size category.

Recommended CIMP Activities

Recommended improvement projects and maintenance activities associated with the Silver Creek Dam are presented in the following sections. Recommendations are divided into projects and maintenance activities, projects being one time actions that should be taken, and maintenance activities being actions that must be taken on a regular basis.

Each recommended activity has been assigned a high, medium, or low priority. For maintenance activities, a recommended frequency is provided along with an estimate of the number of staff and duration required to accomplish the activity. Recommended projects are summarized in Table 1. Recommended maintenance activities are summarized in Table 2. Activities are grouped based on the relative priority level assigned to each. Within each priority level for projects, the activities are listed by the recommended completion period.

Discussions for each of the proposed projects not already completed, are provided following the tables.

TABLE 1
Summary of Recommended Capital Improvements Projects

Item	Project	Purpose	Priority	Completion Period	Comments
1	Remove boulders from stilling basin	Reduce additional stilling basin scour.	High	Completed	Completed in September 2011.
2	Mark and label existing embankment drains	Facilitates monitoring of seepage and record keeping.	High	Completed	Completed in September 2011
3	Purchase boat for monitoring/maintenance activities	Allows for more frequent inspection of embankment (especially left abutment) and removal of wood debris. Can be used during emergency conditions.	High	Completed	City purchased a flat-bottomed Jon Boat with 900 lb capacity.
4	Secure access to left abutment and construct access road for emergency and maintenance activities.	Access required to allow for maintenance and emergency activities.. Currently access to left abutment is by boat which makes monitoring, repair, or emergency flood fighting measures difficult.	High	As soon as possible (2012)	Efforts to secure emergency access should be completed as soon as possible
5	Fill stilling basin scour hole with concrete	Repair scour hole and prevent additional stilling basin scour.	High	2012	Late summer/fall during low flow conditions.
6	Extend right abutment training wall	Reduce risk of failure by overtopping.	High	2012	Extend wall approximately 6 feet.
7	Replace timbers on outlet structure	Project will improve safety.	High	2012	
8	Stockpile materials to allow for emergency raise of embankment.	Ensures access to supplies needed to make temporary repairs or raise embankment during large flood events. Project should include construction of staging area for stockpile of emergency materials.	High	2012 to 2013	Materials to consist of sand, sandbags, riprap, and plastic sheeting at a minimum. Stockpile materials at, or near site.
9	Hydraulic modeling/routing study to determine 100-year and probable maximum flood (PMF) pool and tailwater elevations.	Evaluate adequacy of embankment crest elevation and potential for overtopping. Use results to establish trigger thresholds for monitoring and emergency operational procedures such as outlet operation (open or closed)	High	2013	Requires that a topographical survey of the dam be performed to understand existing conditions.
10	Improve public notification system	Current system allows for notification to landlines, but does not allow for notification to cellular phone users.	High	2012	A link to update information has already been posted on the City website. Include an annual notification by letter.
11	Post “No Trespassing” signs on spillway and embankment.	Project improves public safety and limits potential for intentional interference of facilities.	High	2012	
12	Perform survey of embankment crest, spillway, and abutment training walls	Determine true height of embankment crest and walls and abutments. Identify low spots for repair. Establish baseline of vertical and horizontal deflections in walls.	Medium	2012	Establish baseline for comparison to future surveys.
13	Fill low points along embankment crest. Raise crest to	Reduce potential for concentrated or localized	Medium	2012	Complete after survey of

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Item	Project	Purpose	Priority	Completion Period	Comments
	design elevation of 440 feet.	overtopping			embankment crest.
14	Fill joints in spillway and training walls	Original premold joint filler appears to have deteriorated. Filling joints will reduce potential for scour behind spillway walls.	Medium	2012	Low cost activity. Completion can prevent more costly future repairs.
15	Repair uppermost joint on spillway floor	Top joint exhibits signs of minor cracking and spalling. Repair damage to prevent additional cracking and more costly future repair.	Medium	2012	Low cost activity. Remove damaged/deteriorated concrete and repair.
16	Update emergency action plan (EAP)	Add action triggers for pool elevations and rain events.	Medium	2012/2013	Triggers should be re-evaluated after completion of hydraulic modeling study.
17	Upgrade hydraulic gate controls	Allows automatic verification of gate position.	Medium	2013/2014	
18	Install stream gauging upstream of reservoir.	Allows monitoring of flow into reservoir.	Medium	2013/2014	Include remote monitoring to augment early warning monitoring system.
19	Seismic assessment and design of seismic stability upgrades for existing spillway and training walls.	Evaluate potential for deformation or collapse of spillway and training walls during seismic event and develop design seismic upgrades if needed.	Medium	2013/2014	Spillway walls designed for 0.05g peak ground acceleration (PGA). Current Maximum Credible Earthquake event has PGA of approximately 0.4 g
20	Build storage and control room at dam site.	Install gate controls, power generator, emergency flood lights for night time inspection.	Medium	2014	Building to be located on flat ground north of the fish ladder. Include flood lights for night observation of the embankment.
21	Perform inspection of outlet pipe using remotely operated vehicle (ROV)	Assess condition of outlet pipe and schedule repairs if necessary	Low	2013/2014	
22	Install slope inclinometer casings in right abutment landslide mass and purchase slope inclinometer probe.	Allows monitoring of potential deformation of the landslide mass at right abutment.	Low	2014/2015	Install minimum of two inclinometer casings.
23	Replace existing reservoir Water Level Gage	Existing gage on upstream face of dam is damaged. Gage allows for visual observation of pool elevation.	Low	2013/2014	
24	Structural improvements to prevent downstream flooding (such as Silver Gardens Retirement Home).	Reduce downstream flooding.	Low	2015	Reoccurring problem that City is trying to address.
25	Reinstall log boom at entrance to spillway.	Prevent floating debris from entering and potentially clogging spillway.	Low to Not Required	See Comments	Spillway is wide and potential for clogging is very low. This option included in PFMA, but it is judged to be unnecessary if logs are removed from reservoir annually.

TABLE 1
Summary of Recommended Capital Improvements Projects

Item	Project	Purpose	Priority	Completion Period	Comments
Projects assumed to be completed as part of the Silver Creek Dam Early Warning System Improvements (USACE Contract W9127N-10-D-0001)					
1	Reservoir level gage	Monitor reservoir level with pressure transducer.	High	2012	
2	Add and automate piezometers	Install pressure transducers in existing piezometers and add new piezometers. Automated monitoring of phreatic surface.	High	2012	
3	Weirs on embankment drains	Provide measurements of flow for seepage through the dam. Automated or non-automated weirs acceptable.	High	2012	
4	Flow monitoring on outlet pipe	Provided automated measurements of discharge from reservoir.	High	2012	Completion of USACE contract projects assumed for 2012.
5	Rain Gage	Provided automated collection of rainfall rate.	High	2012	
6	Video surveillance cameras	Allow remove surveillance of spillway and upstream and downstream face, and reservoir level.	High	2012	
7	Automated alert system and response plan	Established threshold limits and an automated system to alert City's emergency response personnel and audible alarm system within Silverton City limits.	High	2012	
8	Seismic monitoring station	Record earthquake motions	Low	2012	

Note: If USACE does not fund these projects associates with Contract W9127N-10-D-0001, the City of Silverton should complete items 1 through 7 as high priority projects. They should be included as priority projects 7 through 13 in Table 1 (above) and should be completed no later than 2013. Installation of a seismic monitoring station should be considered a low priority project for the City.

TABLE 2
Summary of Recommended Maintenance or Monitoring Activities

Item	Activity	Purpose	Priority	Frequency	Estimated Effort For Each Event	Comments
1	Monitor water levels in piezometers and compare to historic levels	Identify fluctuations in phreatic surface that would signal changes or the potential for failure.	High	Monthly	4 hours assuming traditional standpipe piezometers are monitored.	Automated system will allow for easy generation of monthly report.
2	Monitor flow from embankment drains and compare to historic levels	Identify change in seepage through embankment.	High	Monthly	4 hours assuming monitoring of flow in weirs.	Automated system will allow for easy monitoring and generation of monthly report.
3	Inspect stilling basin for signs of scour	Confirm performance of concrete and basalt and make repairs as necessary	High	Every 5 years or more frequently after 100-year or PMF events	2 days for crew of 2 with 8 hours of excavator time	Requires water to be pumped out of stilling basing. Cost for 2011 inspection was $3,500.
4	Detailed City inspection of dam embankment	Visual inspection to look for signs of distress, increased seepage, and or repair needs	High	Twice annually	4 hours for crew of 2	General inspection and monitoring shall be ongoing/continuous
5	Cut vegetation on embankment and around embankment drains	Improves visual observations of seepage and/or movement. Reduces habitat for burrowing animals and potential for damage from tree roots.	Medium	Annually	1.5 days for crew of 3 laborers and 1 City supervisor using portable gas powered equipment	
6	Survey of movement monuments and spillway and abutment training walls	Compare results to baseline and historic surveys to identify horizontal or vertical movement and perform necessary repairs.	Medium	2 years after baseline survey. Every 5 years thereafter.	1 day for survey crew of 2 plus assessment to compare to previous surveys.	Performed by licensed surveyor. Estimated cost of survey and assessment is $5,000
7	Review of EAP	Update EAP if necessary based on results of observations and/or changes in embankment performance	Medium	Every 5 years.	1 to 2 days for Public Works Director with input from City Staff, ODWR, and USACE.	
8	Removed logs and debris downstream of the stilling basin	Reduce potential for downstream hazards during large flood events	Medium	Every 5 years	2 days for crew of 2. May require use of an excavator.	Perform concurrent with inspection of stilling basin.
9	Visual observation of spillway slab for damage or vertical offsets	Repair damage and/or grind down vertical offsets.	Medium	Annually	2 hours for crew of 2	Can be performed with item 4 (above).
10	Visual inspection of upstream impervious blanket for holes or erosion.	Identify holes and/or areas of erosion and make repairs.	Medium	Annually – during low pool period	2 hours for crew of 2	
11	Maintenance of access road to left abutment and embankment.	Maintain access to left abutment.	Medium	Annually	8 hours for crew of 2	Assume $2,000 cost for brushing and herbicide.
12	Turbidity monitoring	Compare turbidity of water within reservoir and water exiting embankment drains. Elevated turbidity may be a sign of piping.	Low	Twice annually	2 hours to take samples. 2 hours to measure turbidity, record data, and evaluate data.	Minimum of two samples from reservoir and one sample from each of the drains having significant flow each sampling

TABLE 2
Summary of Recommended Maintenance or Monitoring Activities

Item	Activity	Purpose	Priority	Frequency	Estimated Effort For Each Event	Comments
						period.
13	Remove logs and floating debris from reservoir.	Reduce potential for debris to block spillway during large flood events.	Low	Annually	2 days for crew of 2	Requires use of Jon Boat.
14	Perform slope inclinometer monitoring in newly installed slope inclinometer casings in landslide mass at right abutment.	Monitor potential deformation of the landslide mass at right abutment.	Low	Twice annually and after seismic events.	4 hours for crew of 1 to take and download measurements and compare results to previous measurements.	Requires inclinometers to be installed as CIP. Frequency may decrease if movement is not occurring. Consult with geotechnical engineer if total movement exceeds 0.5 inches.

Note: Total estimated time required for annual maintenance activities: 170 hours for City staff and 36 hours for hired support staff. Estimated annual costs are approximately $4,500 assuming labor and costs for multi-year activities are equally spread across each year.

Project Descriptions:

Capital improvement projects 1 through 3 have been completed and are therefore not described here. Capital improvement projects 4 through 24 are discussed below. An estimated cost for each activity is provided.

Item 4: Secure Access to Left Abutment

Priority: High

Recommended Completion Period: As soon as possible – to be completed in 2012

Description: Access to the embankment, low level outlet, and left abutment requires the use of a boat/barge or helicopter during periods when water is flowing over the spillway, which is the case for approximately 9 months of the year. This limitation restricts the ability to perform monitoring and maintenance activities or make emergency repairs or place material on the dam to prevent or stop dam overtopping.

The City should negotiate an agreement with adjacent property owners south of the dam embankment that would allow for regular monitoring/maintenance activities and emergency access. The agreement should allow City officials to clear trees and vegetation and establish a graveled haul road as required to bring equipment and materials to the left abutment and embankment. This will allow for more efficient monitoring and response in the event that dam failure or overtopping is a possibility. Annual maintenance of the access road will be required.

Estimated Cost: $36,000 for access agreement and initial construction of access road and $2,000 annual maintenance.

Item 5: Fill Stilling Basin Scour Hole with Concrete and Grouting of Riprap

Priority: High

Recommended Completion Period: Late Spring or Fall 2012

Description: Scour of the basalt bedrock at the bottom of the spillway channel has created a depression that is 3 to 5 feet deep across the width of the spillway. The depression extends from the bottom of the spillway downstream between 15 and 20 feet. It is believed that the majority of the scour has occurred during significant flood events and that the presence of large boulders in the stilling basin pool contributed to the development of the scour hole. The large boulders are believed to have come from the riprap armoring placed around the stilling basin after the flood events of 1996/1997. The large boulders within the stilling basin were removed in September 2011.

In order to prevent additional scour from occurring in the stilling basin, it is recommended that the existing scour hole be filled with mass concrete. Grouting of the riprap armoring stone should also be performed to prevent other boulders from falling into the stilling basin thereby leading to increased scour.

Repairs should be completed during a period of low flow and will require that standing water be pumped out of the stilling basin. Fish will need to be captured and released in Silver Creek prior to placement of concrete. Minor cleaning of the rock in the stilling basin should be performed to remove dirt and moss using a pressure washing or compressed air to improve the bond between the rock and concrete. Concrete will need to be pumped to the stilling basin from the access road and should be placed starting at lowest point in the scour hole. The end of the discharge hose should be kept at least 6 inches below the surface of the concrete to allow for seepage water to be displaced without mixing with the concrete. Concrete should be consolidated using vibratory stingers.

Concrete with a minimum 28-day unconfined compressive strength of 3,000 psi should be used.

Grouting of the riprap should be performed after the riprap has been moistened and all free water has been allowed to drain away. Grout should be injected into the riprap voids using low pressure through a maximum 2-inch diameter holes starting at the bottom of the slope and working upslope. Grout should be deposited to fill all voids. Leave the top 1/3 of riprap stones fully exposed and immediately remove all excess grout from surface of riprap stones using a stiff brush augmented with water or a cleaning agent if needed. Riprap that must be moved to allow for excavator and equipment access should not be grouted.

Estimated volume of mass concrete is 200 cubic yards (70 feet by 4 feet deep (average) by 20 feet wide). The estimated volume of concrete required for the grouted riprap is 75 cubic yards (each side is 60 feet by 25 feet by 2 feet deep x 35 percent void space).

Estimated Cost: $40,000 for concrete, concrete line pump truck, and clean up. Additional cost for labor, overhead, profit, mobilization, and bonds/insurance if work is performed by a contractor as opposed to City staff: $20,000

Item 6: Extend Right Abutment Training Wall

Priority: High

Recommended Completion Period: 2012

Description: Extend right abutment training wall or otherwise repair low point north of the right abutment training wall. Training wall needs to be extended to the north to cut off low area and reduce potential for overtopping of the right abutment. The low spot appears to be approximately 2 feet below the top of the training wall, which has a top elevation of 440 feet. Assume the wall needs to be extended approximately 8 feet to the north and the height of the wall will be approximately 6 feet, with about 4 feet buried below grade. The wall should be reinforced with layout and size of the reinforcing bar to match the design of the existing training wall (#5 @ 12” horizontal and #6 @ 12” vertical each face). The wall should have a 4-feet-wide footing to match the original design of the training wall. Dowel the new portion of the wall to the existing wall and provide water stop in the joint. Earthfill should be on both sides of the wall to improve stability and limit seepage through the joint.

Estimated Cost: $6,000 to $8,000

Item 7: Replace Timbers on Outlet Structure

Priority: High

Recommended Completion Period: 2012

Description: Replace rotting timbers over top of outlet structure to improve safety. This project will involve replacing the existing timbers covering the outlet structure with new, pressure-treated timbers. Design drawings show that 10 feet of the outlet structure is covered with timbers, however only two to three feet of the timber covering is visible. The remaining timbers are buried beneath buttress fill material that was installed downstream of the dam. If all the timbers are to be replaced, excavation of buttress fill will be required and temporary slope support to keep fill material from running into the outlet structure. The temporary slope support could consist of ecology blocks or other systems.

If all existing timbers are to be replaced, consideration should be given to utilizing precast concrete planks or other materials that will last longer than treated wood. The open portion of the outlet structure that should be covered has an area of about 90 square feet.

The City may elect to replace only those timbers that are visible, or perform an inspection of the existing timbers to determine how many can remain. Depending on the amount of excavation required, the work may need to be performed during periods of low flow so that excavation equipment can be mobilized to the outlet structure and used to complete the excavation. The estimated cost is provided assuming all timbers will be replaced.

Estimated Cost: $1,000 assuming only visible timbers are replaced. $10,000 to $15,000 assuming all timbers are replaced with precast concrete planks.

Item 8: Stockpile Materials to Allow for Emergency Raise of Embankment

Priority: High

Recommended Completion Period: 2012 to 2013

Description: Emergency supplies should consist of sand, sandbags, riprap, and plastic sheeting at a minimum. The volume of sand required to raise the embankment approximately 3 feet, over a length of 600 feet and a width of6 feet is about 400 cubic yards. Assuming each sandbag will be filled with 50 to 60 pounds of sand, 25,000 sandbags

should be purchased and stockpiled. The City should also consider the purchase of a hopper to accelerate the filling of sand bags.

A minimum quantity of 100 cubic yards of riprap should also be purchased and available for use in emergency situations.

A staging area with security fence and gate should be constructed as part of this project if the materials can be stockpiled at the left abutment after an access road is constructed. An approximately 10,000 square foot area will be required and should be constructed with 7 feet tall cyclone fence with barbed perimeter and gate.

Estimated Cost: Total = $49,000 (Sandbags @ $0.38/each = $9,500. Sand @ $35/cubic yard delivered and stockpiled = $14,000. Riprap at $45/cubic yard delivered and stockpiled = $4,500. Plastic sheeting = $500, Sandbagging machine = $4,500. Cyclone fence and gate @ $40/linear foot = $16,000).

Item 9: Perform Hydraulic Modeling and Routing Study to Determine 100-Year and Probable Maximum Flood (PMF) Pool and Tailwater Elevations.

Priority: High

Recommended Completion Period: 2013

Description: A probable maximum flood (PMF) and reservoir routing study was conducted by the Oregon Department of Water Resources as part of a 1981 Phase I Inspection Report of Silver Creek Dam. The study concluded that the existing spillway has sufficient capacity to pass 90 percent of the PMF. Assuming that there was no discharge through the outlet conduit and that the pool elevation was at the spillway crest when the start of the PMF event, the study showed that the embankment would be overtopped for 7 hours with a maximum depth of 0.9 feet above the crest of the dam. It was concluded at the time that failure by overtopping is highly unlikely and that the existing spillway provides an adequate level of safety against failure by overtopping.

Overall, the approach to developing the PMF in 1981 sounds robust and appropriate for that time. However, the PMF is currently out of date and may not meet modern standards. Review and update seems warranted. The following steps are recommended.

1. Request and review the best-available documentation of the previous PMF and reconstitution studies, as well as the current dam configuration and watershed conditions. Seek to understand and summarize previous work and its technical merits. To the extent that historical efforts are inadequately documented in available files, they may not be useable at present.
2. Use HMR 57 to update the PMP local-storm and all-season general-storm conditions. Delineate the watershed from scratch in CADD or GIS to support this and subsequent tasks.
3. Develop a single-basin HEC-1 rainfall-runoff model as a starting point for sensitivity trials and model updates. This base model should duplicate the original model, if possible, to provide a basis for comparisons.
4. Modify the single-basin HEC-1 model to evaluate potential model updates and sensitivity. Update the PMP.
    - Import and evaluate available HSG, land-use, elevation, and PMP isohyetal data to evaluate potential sub-basin division and variability of loss rates and rainfall intensity.
    - Subdivide the single basin if hydrologic variability would recommend it. Develop sub-basin physical parameters needed for time of concentration, synthetic unit hydrograph calculation, loss rates, and distributed PMP rainfall.
    - Estimate uniform loss rates by sub-basin, quantitatively considering HSGs, adjusted qualitatively for other factors, such as land use, vegetation, slope, and potential for wildfire. Use an initial loss rate of zero, unless otherwise supported.
    - Develop simplified channel routing parameters, assuming sensitivity is low to hydrograph transformation, but may be higher to overlap of hydrograph peaks.
    - Assume that snowmelt can be neglected when calculating the PMF.
    - Review available gage data downstream of Silver Creek Dam to characterize baseflow.
    - Review or confirm reservoir elevation-capacity data and spillway rating data for use in the model.

- Develop a range of unit hydrographs for comparison (USBR synthetic, NRCS curve number method, current Snyder, and possibly other regional approaches that may have adequate documentation).
- Test sensitivity of peak flow rates and peak reservoir water surface elevation to key model choices (HMR, type of PMP, watershed subdivision, loss rates, choice of unit hydrograph, unit hydrograph peaking).

5. Prepare a draft and final PMF Report.
6. Project delivery to ensure quality, coordination and administration of the project.
7. **Optional.** If it is found that the following three conditions are met, consider updating flood reconstitution studies based on the current period of record to improve understanding of actual watershed response to rainfall:

   - Peak reservoir water surface elevation is highly sensitive to choice of unit hydrograph.
   - A conservative choice is not considered acceptable.
   - Adequately accurate, fine-scaled and distributed runoff and rainfall data are available for large floods.

   If the three conditions are not met, items 1 through 6 (above) are based on no update of flood reconstitution studies and no rainfall-runoff model calibration.

An updated hydraulic modeling and routing study will provide information needed to evaluate the adequacy of embankment crest elevation and potential for overtopping to occur during various flood conditions. Result should be used to develop recommendations for trigger thresholds for monitoring and emergency operational procedures such as outlet gate operation (open or closed). These evaluations and recommendations should be performed as part of this project effort. Establishing recommendations for trigger thresholds requires that a topographical survey of the dam be performed to establish existing conditions.

Estimated Cost: For planning purposes, the budget for steps 1 to 6 is about $40,000, with a potential range of about $30,000 to $50,000. If updated inundation maps are to be prepared (see discussion for item 15), a site visit should be added, with a supplemental budget of about $4,000.

Item 10: Improve Public Notification System.

Priority: High

Recommended Completion Period: Ongoing

Description: When the City changed public notification system providers, only the contact list for telephone landlines was made available from the previous provider. The mobile phone contact list was not provided to the current provider, therefore the notification call list is incomplete. The City should update the notification system to include cellular phone numbers of all residents and businesses that might be impacted during an emergency situation. A link to update emergency contact information has been provided on the City's website. Yearly notification of City residents and businesses in the inundation zone should continue using a minimum of one mail notification annually.

Estimated Cost: $2,000 per year.

Item 11: Post "No Trespassing" Signs on Spillway and Embankment

Priority: High

Recommended Completion Period: 2013

Description: Post additional no trespassing signs on fish ladder, spillway, and embankments to keep unauthorized parties off of the dam facilities. This will improve safety and limit the potential for terrorism or sabotage of the facilities.

Estimated Cost: $1,000

Item 12: Perform Survey of Embankment Crest, Spillway, and Abutment Training Walls

Priority: Medium

Recommended Completion Period: 2012

Description: Perform topographical survey of existing embankment, spillway, fish ladder, and training wall. Topographical survey can be compared to as-build conditions and will establish a baseline condition that can be used to compare against future surveys.

The survey should also establish offsets and inclinations in spillway, fish ladder, and training walls. The survey should be performed during a period of relatively low water level within Silver Creek Reservoir to allow for more survey of the upstream embankment.

Locations of all facilities, including movement monuments set on the embankment and on the left and right abutments, inclinometers, and drains should be captured. The survey should also establish new movement monuments that could be used to track movement of the landslide mass located north of the right abutment.

The survey shall be completed by a Professional Land Surveyor licensed and in good standing in the State of Oregon. All survey work shall be conducted using equipment, personnel, and procedures that will ensure compliance with the accuracy standards as defined below. It shall be the responsibility of the supervising Land Surveyor to ensure that all work complies with all state and local regulations. All documents submitted shall bear the surveyor's seal, signature, and a certificate that all work was done under the surveyor's supervision and that all information contained in the document is true and accurately shown.

It is recommended that Horizontal Control work be done using either standard surveying techniques or Global Positioning System (GPS) techniques meeting the specification requirements outlined herein. If standard surveying techniques are used, all horizontal control work shall comply with Third Order – Class I standard of accuracy for geodetic control as established by the **FGDC Geospatial Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Construction (A/E/C), and Facility Management.**

If GPS is used, the relative horizontal accuracy shall conform to the 2 cm accuracy standard as outlined in the FGDC **Geospatial Positioning Accuracy Standards, Part 2: National Standard for Spatial Data Accuracy.**

It is recommended that Vertical Control work shall be Third Order, as outlined in the **FGDC Geospatial Positioning Accuracy Standards, Part 4: Standards for Architecture, Engineering, Construction (A/E/C) and Facility Management.**

A minimum of two (2) new control points shall be established at the dam location. They shall be of a permanent nature to allow for future recoverability. All new control points shall be established using iron or steel pins, concrete monuments, or other permanent construction method and marked with caps or tags for identification.

The Surveyor shall provide a copy of all field notes and electronically collected notes of horizontal and vertical traverses as well as closure information on these traverses. The Surveyor shall provide a coordinate printout of all requested information, as listed in the description of work, in excel format with all X, Y, and Z coordinates listed to the nearest 0.01 foot. The collected field information shall be provided in both Excel, and ASCII format; and shall contain the station ID, the horizontal and vertical coordinate information, and feature codes. All information shall be tied to the appropriate State Plane coordinate system and a project adjustment factor shall be provided and the final coordinate system shall be converted to ground.

Additional detailed survey information for the spillway and fish ladder facilities can be obtained through use of 3-dimensioinal field scanning survey equipment. The use of this equipment would make it possible to develop a detailed 3-dimensional model of the spillway channel that could be compared to future 3-D surveys to very precisely evaluate movement of the spillway slab and walls.

It is assumed that traditional survey of the facilities can be completed by a 2-person crew in 2 ½ field days. Another day would be required, along with additional equipment fees if 3-D scanning is to be completed. Reduction of the field data and development of survey deliverables for the traditional survey will require about 3 days of office time.

An additional 3 days of office time is expected to be required to reduce field data and develop survey deliverables if 3-D scanning is performed.

Estimated Cost: $12,000 to $14,000 for traditional topographic survey with an additional $12,000 if 3-dimensional scan surveying is performed.

Item 13: Repair Embankment Crest Low Points

Priority: Medium

Recommended Completion Period: 2012

Description: Upon completion and evaluation of the topographic survey of the embankment, fill all low points on the crest to reestablish a crest elevation of 440 feet. Placement of fill to raise the crest above the design elevation of 440 feet should not be considered as it would require permits to be issued by USACE and the Oregon Department of Water Resources.

Estimated Cost: Depends on volume of embankment fill required to raise grade. Estimated cost for materials compacted in place $50 to $100 per cubic yard (or more for small quantities).

Item 14: Fill Joints in Spillway and Training Walls

Priority: Medium

Recommended Completion Period: 2012

Description: The original premolded joint filler has deteriorated or disappeared from many of the spillway wall joints. Filling joints will reduce the potential for scour behind spillway walls. Remove loose or deteriorated joint filler using either hand tools or a pressure washer. It is recommended that a self-expanding cork be used to refill the wall joints. The material recommended for use is described as follows:

- Self-expanding cork formed and compressed under heat and pressure to permit expansion up to 140% of original thickness after installation. Product may be cut on jobsite to exact size required. When installed in existing concrete, it will be necessary to apply clean, hot water [>180° F (82.2° C)] to the exposed edges of the cork to facilitate expansion. A pressure washer capable of producing hot water or a steam cleaner may be used to produce the hot water.
- Product: Self-Expanding Cork meeting requirements of ASTM D1752, Type III. Manufactured by WR Meadows, Elgin, IL. http://www.wrmeadows.com/

A joint sealant should be applied over the expanded cork product. The product recommended for horizontal and vertical applications by WR Meadows is: DECK-O-SEAL GUN GRADE, a two-component, non-sag, non-flowing, polysulfide-based sealing compound. It is a non-staining sealant that cures to a firm, flexible, tear-resistant rubber.

Follow manufactures recommendations for preparing joints prior to application of joint filler and joint sealant.

In conjunction with this activity, rocks and debris should be removed from the weep holes in the spillway and fish ladder walls.

Estimated Cost: $6,000 to $8,000

Item 15: Repair Uppermost Joint on Spillway Floor

Priority: Medium

Recommended Completion Period: 2012

Description: Approximately 40 feet of the uppermost joint on the spillway floor slab shows signs of spalling and deterioration. The deterioration is primarily occurring in the downstream slab. The deteriorated concrete should be removed to a depth and width of at least 4 inches and the joint filled with high-strength concrete grout. The concrete grout on the downstream slab should be recessed approximately 0.5 inch, as shown in the original design drawings, to limit disturbance at the joint that could result in uplift forces.

Estimated Cost: $6,000

Item 16: Update Emergency Action Plan

Priority: Medium

Recommended Completion Period: 2012/2013

Description: The purpose of the emergency action plan (EAP) is to reduce the risk of human loss of life and injury and minimization of property damage during an unusual or emergency event at the Silver Creek Dam. The existing EAP should be updated based on the results of the topographic survey and updated hydraulic modeling and flood routing study. The EAP should document roles and responsibilities and include the following components:

- Event Detection
- Emergency Level Determination
- Notification and Communication Plan
- Expected Actions
- Termination and Follow-up.

Updating the EAP should be performed in cooperation with Oregon Department of Water Resources, USACE, and local law enforcement. An EAP orientation should be provided for appropriate City staff and local law enforcement officials. Drills and functional exercise/testing of the EAP should be completed.

A dam break analysis was performed by Philip Williams and Associates in January 2000. Updated inundation maps could be developed based on the results of the updated hydraulic modeling for the PMF. The complexity of developing inundation maps can vary widely, depending on the length and configuration of the downstream channel, including number and types of hydraulic structures such as bridges; level of detail needed with respect to individual structures versus generalized neighborhood impacts; need for dynamic flood routing versus simplified routing approaches; need for detailed survey or other field data; and acceptability of conservative approaches to simplify modeling.

Based on aerial images of the highly developed floodplain downstream of Silver Creek Dam, hydraulic complexity is expected to be high. Assuming use of dynamic flood routing using HEC-RAS or acceptable alternative modeling approaches, development of inundation mapping is expected to require the following tasks:

1. Develop and Evaluate Breach Parameters
2. Simplified routing to provide a context for field reconnaissance
3. Field reconnaissance (2 people for 4 days, including travel). Includes taking approximate measurements at bridges for modeling purposes.
4. Develop a basic HEC-RAS Model
5. Dynamic flood routing, stabilization and quality control. Note that numeric dynamic flood routing algorithms are mathematically unstable under many common conditions; therefore, model stabilization is typically time consuming and is not guaranteed. Although it can typically be achieved, we reserve fall-back approaches to limit unreasonable budget escalation.
6. Flood inundation mapping
7. Draft and final report
8. Project delivery to ensure quality, coordination and administration of the project.

Estimated Cost: $10,000

Updated inundation mapping: The budget for dam-failure inundation modeling and mapping is about $65,000, with a potential range of about $35,000 to $85,000. If surveying is required, a $25,000 survey allowance should be added; however, surveying should be avoidable if approximate, conservative results are considered adequate.

Item 17: Upgrade Outlet Gate Controls

Priority: Medium

Recommended Completion Period: 2013/2014

Description: Both the 18-inch and 42-inch gates to the outlet conduit are operated by hydraulic cylinders controlled by a manual hand pump and 4-way valve system. The control for the gates is located in a locked metal box bolted to the top of fish ladder. The manual controls consist of both small and large piston, hand lever-operated pumps. The small lever pump allows for more hydraulic pressure to be generated and is intended to be used to initially engage the hydraulic cylinder or dislodge a stuck gate. The large lever pump allows for the gate to be opened or closed at a faster rate than possible using the small lever pump.

Two limitations of the gate system were noted in the 2011 Silver Creek Dam PFMA:

1. It is not possible to verify the gate position from the location of the gate control unit (except in an approximate manner by counting pump strokes for a complete cycle), and
2. There is no redundancy in the gate control system.

In addition to the limitations noted in the PFMA, operation of the gate system using the hand pumps is tedious and slow. Currently, a general understanding of flow conditions can be made by counting the number of pump strokes and comparing it to the total number required to fully open or close the gate (if starting from a fully opened or closed location). Verification of the approximate position of the gate is made by visually observing the flow out of the outlet pipe. A U.S. Geological Survey (USGS) gauge station at Webb Street (downstream of the reservoir) can be monitored to more precisely determine the flow from the outlet pipe. However there is a delay of approximately 4 hours in making this determination.

Installation of sensors to determine the flow rate discharging from the outlet pipe is a component of the early warning system being developed in coordination between USACE and the City (see discussion below). Installation of this flow monitoring equipment would allow the City to verify the gate position if a readout of the flow can be provided near the gate controls.

Although the existing gate control system has a history of being very reliable, City personnel have expressed concern for the outlet gate becoming stuck. Installation of an electrically operated hydraulic control system might make operation of the gate faster allowing the hydraulic cylinders to be exercised more often, thereby reducing the chance that they stick. The system would also make it easier to make gate adjustments.

Developing a redundant gate control system would require that the intake structure be accessed, which would necessitate the reservoir be emptied. Installation of a vertical stem to allow manual operation of the gate would require that a tower be constructed over the gate. The height of the tower would need to be about 65 feet. Access to the tower would be either by boat or from a catwalk between the crest of the embankment and the tower. These towers can be the target of vandalism/trespass and require additional maintenance. They can also be considered an “attractive nuisance” to the public who use the lake and there is potential for the tower to be damaged during a seismic event.

A major reconstruction of the intake structure and gate controls could allow for a gate control stem to be run up the face of the embankment to eliminate the need for a gate control tower. Both options will be very expensive to implement.

Because of the uncertainties associated with the current condition and reliability of the gate control structure, it is recommended that a separate engineering evaluation of the facility be performed. The evaluation should include an inspection of the existing gate control system using a diver or remotely operated vehicle (ROV). An assessment of each component of the gate system should be performed to evaluate the potential that the system could fail and develop recommendations for either maintenance or replacement of the components. The assessment should also consider the need to replace the gate controls or add a manual control component to the outlet gates.

A discussion and estimated cost for construction of a small control house to the north of the right abutment, is provided in item number 20, below.

Estimated Cost: $25,000

Item 18: Install Steam Gauge Station Upstream of Reservoir

Priority: Medium

Recommended Completion Period: 2013/2014

Description: There are many different types of stream flow gauge stations that can be constructed. Selection of the type of gauging station will depend on the location of the station and the accuracy of flow measurements desired. Design of a gauging station is outside the scope of work for this project. However, for the purpose of discussing the gauging station, it is assumed that the gauge station will include a permanent instrument shelter or gage house over a stilling well. The gage house will hold the stream gauging equipment, a computer for recording the height of water in the stilling basin, and a satellite or radio uplink to send the stream gauge information to the City. If power is not available at the location of the station, solar panels and batteries can be used. Flow in the stream will be estimated from pre-established stage/discharge relations, or rating curves.

If a stilling well type station is selected, the inside of the stilling well should be big enough to permit free operation of all the equipment to be installed. Normally, a pipe with a minimum 4 ft in diameter and a sealed bottom is used.

A common water-level sensor is the basic float, which consists of a float resting on the water surface in a stilling well. For automatically recording the water stage, a pulley from the float is connected to a digital shaft encoder.

The primary telemetry method used by the USGS is a satellite transmission system, however, radio and telephone-transmitting systems are also used.

The USGS establishes and monitors many gauging stations in the support of their role in flood forecasting. It is our understanding that there is currently no gauging station located on Silver Creek upstream of Silver Creek Dam. The USGS should be contacted to determine if they would provide funds and/or expertise to construct the gauge station and develop the rating curves.

Estimated Cost: Large range in cost depending on access to site, construction/monitoring requirements, and subsurface conditions. $50,000 to $300,000

Item 19: Perform Seismic Assessment of Spillway and Training Walls

Priority: Medium

Recommended Completion Period: 2013/2014

Description: The original design of the spillway and training walls was performed using a peak ground acceleration (PGA) of 0.05g, where g is the acceleration due to gravity. Based on today's design requirements, the Maximum Credible Earthquake (MCE) event has PGA of approximately 0.4 g. An assessment of the seismic stability of the walls should be conducted. The analysis may show that the walls will deform during a seismic event, but not collapse. Some amount of deformation of the walls is likely acceptable with the understanding that repairs may need to be performed after the seismic event. If excessive deformation or collapse is possible, recommendations for making upgrades to improve the seismic stability of the walls should be provided. A design for the selected seismic upgrade would then need to be developed and implemented.

The estimated cost for this activity includes the seismic stability evaluation only. The cost for developing a complete design for seismic upgrades and making the improvements would be developed as needed based on the outcome of the seismic assessment.

Estimated Cost: $15,000

Item 20: Construct Storage and Control Room at Dam Site

Priority: Medium

Recommended Completion Period: 2014

Description: A small building constructed on the relatively flat ground north of the existing fish ladder could house the gate controls, emergency lighting equipment, a back-up generator, monitoring equipment and instrumentation, and other equipment routinely used or required during an emergency event. Flood lights should be mounted on the structure to allow for nighttime observation of the downstream portion of the dam.

A simple secure building approximately 12 feet by 12 feet would provide adequate room for this type of equipment. It is assumed that the structure will not be heated.

Estimated Cost: $36,000 assuming a cost of $250/square foot for the facility complete.

Item 21: ROV Inspection of Outlet Pipe

Priority: Low

Recommended Completion Period: 2013/2014

Description: The lower level outlet pipe and control gate are critical in allowing for the reservoir level to be reduced. The 2011 PFMA recommends that inspection of the lower level outlet pipe be performed using a Remotely Operated Vehicle (ROV). A cost has been developed to inspect the intake and gate structure for the outlet pipe using an ROV and closed-circuit television (CCTV) inspection with video capture of the outlet pipe. The equipment used for the CCTV inspection should be compatible with the rough surface of a corrugated metal pipe.

Estimated Cost: $6,000

Item 22: Install Slope Inclinometers to Monitor Movement of Landslide Mass

Priority: Low

Recommended Completion Period: 2014/2015

Description: Slope inclinometer casings should be installed in at least two locations within the landslide mass located to the north of the right abutment to monitor for the potential that the old landslide material is moving. The casings would be installed by a licensed well driller familiar with the critical nature of installing and grouting inclinometer casing. The casing is typically installed in a near vertical borehole that passes through suspected zones of movement and extends a minimum of five feet into stable ground or competent bedrock. The inclinometer probe, control cable, pulley assembly, and readout are used to survey the casing.

Although movement of the landslide mass at the right abutment was not a failure mode identified in the USACE PFMA, the presence of the landslide material is known. Movement of the slide material could result in damage to the fish ladder and spillway. Left unchecked, excessive movement could threaten the integrity of the dam.

Based on a review of boring logs available for the dam construction, it is expected that the depth of the inclinometer casings would be about 40 to 50 feet.

An inclinometer probe should be purchased to allow for periodic readings of the inclinometer casings. The inclinometer probe records deflections in the casings as a function of depth in two directions offset by 180 degrees. By comparing deflections over time, an assessment of the rate and depth of slope movement can be made. Movement of the landslide mass would result in deflection of the inclinometer casing which would be observed through periodic readings.

Estimated Cost: Total cost = $20,000 ($11,000 for digital inclinometer probe, control box, and pulley system. $9,000 for drilling and installation of inclinometer casings).

Item 23: Replace Existing Water Level Gage.

Priority: Low

Recommended Completion Period: 2013/2014

Description: The existing reservoir staff gage is damaged and cannot be used to determine the reservoir stage. An automated reservoir level gage is to be installed as part of the Silver Creek Dam Early Warning System Improvements (USACE Contract **W9127N-10-D-0001)**. However, a standard staff gage should be installed in the reservoir to provide reduncancy in the ability to determine the reservoir level and allow for verification of the automated reservoir level gage.

The new staff gage should be installed when the water level in the reservoir is very low. A survey will be required to establish the correct elevation to set the staff gage.

Estimated Cost: $5,000 to $10,000

Item 24: Structural Improvements to Prevent Downstream Flooding

Priority: Low

Recommended Completion Period: 2015

Description: Flooding of property near the James Street Bridge downstream of the Silver Creek Dam is a reoccurring problem that the City would like to resolve. Flooding typically occurs when the water level in Silver Creek reaches a MSL elevation of about 228.2 feet. The primary location of the flooding is at the Silver Gardens Retirement Home.

In order to solve the flooding problem for normal stream flow conditions, it is expected that a survey of the property and engineering assessment will be required. If is also anticipated that permits will need to be submitted to the USACE and Oregon Division of State Lands (DSL). Following design and permitting, construction of the flood control wall can be completed.

Estimated Cost: $67,000

Item 25: Reinstall Log Boom Across Spillway Entrance

Priority: Low to Not Required

Recommended Completion Period: - NA-

Description: The original design of the dam included a floating log boom across the upper end of the reservoir to prevent floating debris from entering the spillway and potentially clogging and reducing the capacity of the spillway. The location of the boom (so far upstream) made it difficult to service and eventually the City removed it and allowed the debris to go over the spillway. Past operation of the facility has shown that debris buildup at the entrance of the spillway has not been a problem, primarily because the entrance to the spillway is wide (120 feet). Additionally, there are not large quantities of floating debris that enter the reservoir.

The City anticipates performing annual maintenance activities at the reservoir to remove woody debris from the shoreline of the reservoir. Provided this activity is occurring on an annual basis, it is CH2M HILL's recommendation that the floating log boom is not required, unless unacceptable build-up of debris in the spillway entrance is observed. If annual removal of woody debris from the reservoir is not performed, the log boom should be reinstalled.

Estimated Cost: $5,000 to $8,000

Early Warning System:

The City of Silverton and the Portland District USACE have agreed to partner on the design and installation of data collection and warning systems as part of the Continuing Authorities Program (CAP). As part of this project USACE has developed a detailed scope of work for design of an early warning system for the City of Silverton.

The system design shall include an assessment of the number, type and location of instruments required to monitor the development of issues of concern related to the identified potential failure modes. Types of instruments that are expected to be included in the early warning system are:

(1) Reservoir Level Gage: Monitor reservoir level with pressure transducer.
(2) Piezometers: Existing standpipe piezometers shall be modified by installing pressure transducers in them. New piezometers may be required; the system design report shall include details of the proposed design for any new piezometers.

(3) Weir flows: Sensors shall provide automated measurements of flow for seepage through the dam.
(4) Flow in outlet pipe: Sensors shall provide measurements of flow through the outlet pipe.
(5) Seismic recorders: Recorders shall record earthquake motions that exceed a predetermined threshold.
(6) Rain Gage: Sensor shall provided automated collection of rainfall rate.
(7) Video surveillance cameras: Cameras to allow for remote surveillance of the spillway and downstream face, and the reservoir level and upstream face.
(8) Visual observation procedure and checklist.

In addition to the detection system, a notification system, including notification components of the warning system will be designed and is anticipated to include the following components:

(1) Automated alert to City of Silverton via the City's computer network.
(2) Automated telephone contact to the City's emergency response personnel.
(3) Alarm system audible within Silverton City limits.

Upon completion of the design for the early warning detection and notification systems, the USACE is to issue a new task order to implement the design.

It is understood that the USACE is currently considering pulling funding for these projects. If the USACE contract does not move forward, the City will need to complete most of these projects independently. With the exception of the installation of the seismic recorders, the other components should be considered high priority items. Each of these high priority projects should be scheduled for completion in 2012 and no later than 2013. Installation of a seismic monitoring station should be considered a low priority task that should be funded by a state or federal agency.

Because of the complexity of the early warning system components and notification system, it is not practical for CH2M HILL to develop a cost estimate for this work.