Willamette Falls Canal and Locks

Independent Condition Assessment and Recommendations for Recommissioning

Prepared for:
Willamette Falls Locks Commission (WFLC)

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EXECUTIVE SUMMARY

In support of the Willamette Falls Locks Commission (WFLC), KPFF has completed an independent condition assessment of the Willamette Falls Canal and Locks. The assessment is based on field observations from a May 30th site visit as well as a comprehensive review of available technical documents. Critical technical documents include condition assessment reports for the facility completed in 2007 and 2011 (updated in 2013).

We found that the lock facility was in remarkably good condition for a civil works project nearing 150 years old. While the design and construction details are outdated, the facility has been very well maintained and all critical systems appear to be operable. Previous engineering assessments identified seismic safety concerns with the lock chamber walls and gate monoliths, uncertainty as to the remaining strength of the miter gate gudgeon anchors and localized erosion of backfill behind the lock wall structure. Assuming that these specific safety issues are addressed, we have concluded that the lock facility can be placed back into regular service with little additional capital improvements. Once back in service, additional capital improvements along with a well implemented continuous maintenance program will support economical and reliable operation of the facility into the foreseeable future.

Given these observations, we have developed a recommended program of capital improvements and maintenance activities for recommissioning and operating the locks. Our recommendations have been classified by priority of completion as follows:

- Critical Need: Complete prior to lock start up
- Moderate Need: Complete within the next five years
- Long Term Need : Complete within the next 10 years
- Future Capital Costs: (Gate inspection/refurbishment and other costs anticipated beyond the 10 year time frame).
- Maintenance Need: Complete on a repetitive basis (1 or 5 year cycle).

Our plan addresses the critical lock safety issues (Critical Need) prior to re-opening while making use of the existing mechanical and electrical/control systems to get the lock back into full operation.

Once the lock is operational, we have identified recommended routine maintenance (Maintenance Need) and additional capital improvements aimed at modernizing the lock system. Additional capital improvements are targeted for completion within 5 years (Moderate Need) or 10 years (Long Term Need) and are designed to improve the lock systems reliability and minimize operation and maintenance costs.

Finally we have identified significant future costs beyond the 10 year time frame (Future Capital Costs) that the new owner will need to plan for.

Future Capital Costs and 5 year cycle Maintenance Needs have been annualized to represent a recommended annual capital set aside and then added to the estimated annual maintenance costs.

Overall this plan of action is consistent with the recommendations contained in the 2007 and 2011/2013 reports. Our proposed seismic retrofit for the lock wall structures and gate monoliths is essentially identical to the solutions proposed in the earlier reports. It should be noted that the USACE Draft Disposition Study (DDS) included an additional seismic retrofit to the PGE/Ship Canal Wall that was not included in the earlier reports. Please see our discussion in the Cost Summary section titled "COMPARISON TO PREVIOUS REPORTS"for additional information. Our approach to the gudgeon anchorage is slightly different but accomplishes the same overall goal. Finally, our approach to stabilizing

the backfill erosion behind the lock wall is more substantial than proposed in the earlier reports but reflects the extensive additional damage that has occurred since the 2011 site investigation.

We estimate that our plan requires approximately $11.8M in new capital improvements over the next ten years with $8.6M to be completed prior to reopening the lock. This compares to approximately $19.03M in recommended capital improvements proposed over the same time horizon in the 2011/2013 report. Overall the seismic and structural repair costs contained in these two proposals are similar, but the control system and mechanical upgrades we are recommending are less costly.

Note that our recommended capital improvements only address functionality of the locks. Other enhancements to facility will be required to address public safety, state and local building code requirements, federal ADA requirements and recreational/historical enhancements including the historic museum on site. These enhancements will require additional capital improvement expenditures.

In addition to the estimated capital costs, we are recommending an ongoing routine maintenance program and future capital set aside program for the facility aimed at maintaining reliability and efficient operation of the facility. We estimate that this program will cost approximately $450K annually.

BACKGROUND

PURPOSE

Willamette Falls Locks is currently owned and operated by the United States Army Corps of Engineers (USACE). Willamette Falls Locks is currently not available for use to the public due to safety concerns outlined in a previous engineering evaluation. The Willamette Falls Locks Commission has been charged with determining the feasibility for potentially acquiring ownership of the Lock and envisions reopening the Willamette Falls Locks to the public to support industrial, tourism and recreational users. Summit Strategies hired KPFF Consulting Engineers to provide an independent evaluation of the facilities infrastructure needs and to advise the Commission on how best to re-open and operate the Willamette Falls Locks.

BASIS OF ASSESSMENT

This engineering assessment is based on a brief site visit and more extensive review of historic documents provided by USACE, as described in detail below.

SITE VISIT

A site visit to Willamette Falls Locks was conducted on May 30, 2018 by Bob Riley, PE, SE and Dan Hartford, PE. Both engineers spent approximately 3 hours at the locks. All gates lock chambers, and visible gate anchors were visually observed. Gates #1, #2, #3 and #4 were operated and observed. Gates #5, #6 and #7 were not operated during the site visit. A copy of our site observation report is included as Appendix B.

DOCUMENT REVIEW

Documents reviewed for this engineering evaluation are as follows:

A. *Willamette Falls Locks, Engineering Study, Large Scale Capital Costs*, July 2007. Prepared by INCA Engineers, Inc. for the Clackamas Heritage Partners.

B. *Willamette Falls Locks- Evaluation Report*, August 2011. Prepared by INCA Engineers/CH2MHill Joint Venture for USACE.
C. *Willamette Falls Locks, Interim Engineering Design Report,* March 2013, Prepared by Tetra Tech for USACE.
D. Section 216 Preliminary Draft Disposition Study with Integrated Environmental Assessment, Prepared by USACE, May of 2017.
E. *As-Built 1968.pdf*, Drawing package transferred from USACE.
F. WFL Calebs Folio.pdf, Drawing package transferred from USACE.

FACILITY ASSESSMENT

CONDITION ASSESSMENT

Based on our assessment, the facility is in remarkably good condition for a civil works project constructed in the late 19th century. While the Lock's design and construction is based on outdated practices, the facility has been very well maintained by the USACE since they took ownership in 1915.

STRUCTURAL CONDITION

The condition of the facilities' lock wall and gate monolith structures has been well documented by previous reports. Our site observations confirmed the general condition of these structures as previously reported. The size and extent of soil erosion behind the Corps side monolith and wall structure near gate 4 has significantly increased over what was reported in the 2011 evaluation report. Our review of previous structural calculations confirmed the USACE's concerns over seismic stability of the stacked ashlar masonry structure. The remediation measures recommended previously include installation of new vertically installed rock anchors drilled into the soils below the masonry walls. KPFF concurs with these recommendations and have included them in our repair recommendations.

Previous reports suggested a seismic retrofit scheme for the Chamber Walls and Gate Monolith structures assuming that the structures are classified as "normal" structures. We understand that the Commission may want to investigate the use of the Locks as a mode of transportation in an emergency situation where many of the nearby bridges may be out of service due to a large seismic event. If the Commission or another agency wishes to use the Locks in this type of emergency situation, then the structures should be classified as "critical" structures, rather than as "normal" structures. Designing a seismic retrofit with a critical classification would reduce the risk of these structures being damaged in a seismic event.

The impact of a "critical'' designation is that the required design Factor of Safety (FS) for wall or monolith sliding increases by 33% under normal loading conditions (FS of 2.0 vs 1.5), by 15% under the Operational Basis Earthquake (OBE) (FS of 1.5 vs 1.3), and stays the same under the Maximum Design Earthquake (MDE) (FS of 1.1). The Maximum Design Earthquake is the same design earthquake that would be required by local building codes and has a 950 year return period (10% chance of being exceeded in a 100 year period). The factor of safety is simply the ratio of the required structural capacity to actual demand. In this case, the actual demand is the same whether the structure is considered normal or critical; the difference is in the required structure's capacity. In order to increase the structural capacity under a "critical" designation, additional rock anchors over and above those already included in this report may be required. Given that performing this seismic stability analysis is fairly time consuming and beyond the scope of this report, KPFF has not been able to assess how many additional anchors

may be required to classify this as a critical facility. Additional analysis would be required to adequately address this question.

The condition of the Lock's miter gates is also well documented in the previous reports. These gates were removed, inspected, rehabilitated and then reinstalled in 2009. The rehabilitation addressed the primary gate structures, quoin blocks, miter blocks, gate seals and pintle bearings only. The gate gudgeon anchorage system was not refurbished. Our site observation confirmed that the primary gate structures are in good condition and consistent with what we would expect from a lightly used miter gate refurbished within the last 10 years.

The gudgeon anchorage system for the miter gates was observed to be in poor condition and to be consistent with conditions described by previous inspection reports. The gudgeon anchorage system consists of anchor rods either buried in the lock wall structure for the rods parallel with the lock or buried a significant distance below grade for the rods perpendicular to the lock. The exposed linkage components connect these anchor rods to the gudgeon pin. The true condition of the buried anchor rods cannot be assessed without substantial excavation. Based on the anchorage movements observed at gate 3 and on corrosion issues noted in previous reports, these anchor rods should be replaced to support reliable and safe operation of the miter gates in the future. Portions of the exposed linkage components appear to be in relatively good condition and can be refurbished to provide safe and reliable operation.

Mechanical and Electrical Condition

Lock mechanical equipment consists of miter gate operating cylinders, hydraulically operated lock fill/empty valves, a packaged hydraulic power unit adjacent to each miter gate, hydraulic piping/hoses, and an air bubbler system just upstream of each miter gate. With the exception of the bubbler system, all mechanical features were found to be functional and in relatively good condition. This is consistent with observations from previous inspection reports. Based on our assessment, we believe that the lock mechanical equipment can be put back into operation with minimal refurbishment and would support near term operation of the lock system.

Hydraulic power units for each gate are located adjacent to each lock gate monolith, on the Corps side (gates 1 through 5) and on the Mill side for gates 6 and 7. Hydraulic piping from the power units is routed directly to the near side gate leaf operator and to the fill/empty valves mounted on the near side gate leaf. Piping for the far side gate is routed from the HPU through a concrete encased trench down the nearside lock wall, along the sill of the lock chamber and then up the far side lock wall. Each HPU includes two solenoid operated directional control valves, one operating near side gate cylinders and the second operating far side cylinders. With only one valve operating both the miter gate and the fill/empty valve cylinders, sequencing of the various control functions is accomplished via a specialized hydraulic sequence valve. This design has a significant operational limitation in that adjustments to lock chamber water level can cause unwanted miter gate operation. Lock operators report that they routinely isolate miter gate cylinders from the HPU via manual ball valves when they are making lock chamber water level adjustments. This is time consuming and requires the significant expertise of a seasoned lock operator.

The hydraulic piping appears to be in relatively good condition, however much of it is fabricated using threaded pipe fittings and is prone to corrosion and leakage. This piping will eventually become a maintenance problem for the facility and presents a substantial risk of spilling hydraulic fluid into the river. Based on discussions with the operational staff, the hydraulic fluid in use is a biodegradable product; however any spill would trigger the need for environmental reporting and cleanup.

The bubbler system described above was non-functional during our May 30th site visit and was determined to be un-necessary for the future intended purpose of the facility. We concur with the USACE's conclusions regarding this system and recommend that it be abandoned.

The control and electrical system for the lock facility was also found to be functional and in roughly the same condition as described in the 2011 inspection report. Subsequent to the 2011 report, the elevated control house structure located at gate six (Control House 3) has been condemned and the lock gate controls located in the structure are no longer accessible. The loss of this control location has minimal impact on lock operations as lock gates 6 and 7 can still be operated from control house 2 adjacent to lock gate 4. Based on our observations and the previous reports, we believe that the lock system can be returned to operation with minimal refurbishment and repair of the electrical and control equipment.

While recognizing that the mechanical and electrical systems can be brought back to full functionality with minimal refurbishment, many of the components are nearing the end of their useful life. In addition, the existing control scheme relies almost completely on individual operator expertise to insure safe operation of the locks. This level of expertise is not likely consistent with anticipated future operations. Recognizing these issues, we are recommending significant capital improvements to the hydraulic and control systems.Generally these improvements are consistent with the measures proposed by previous evaluation reports but are tailored to the assumed future operational scenario. See the Needs Assessment section below for additional details. Note that full operation of the lock facility as assumed for this report should not begin until proposed mechanical and control systems capital improvements are completed.

Needs Assessment

Based on our site visit and review of existing documentation, we have developed a set of repairs and refurbishments that we are recommending to support future operation of the locks. Our recommendations have been classified by priority of completion as follows:

- Critical Need: Complete prior to lock start up
- Moderate Need: Complete within the next five years
- Long Term Need : Complete within the next 10 years
- Future Capital Costs: In addition to the 10 year outlook, there will be asset depreciation that will need to be planned for. The primary item being gate inspection and refurbishment.
- Maintenance Need: Complete on a repetitive basis (1 or 5 year cycle).

Our assessment is restricted to repairs and improvements required to make the lock system operable and to maintain reliable operation. Cost for capital improvements to address public safety, state and local building code requirements, federal ADA requirements and recreational/historical enhancements including the historic museum on site are not included in our estimates. Note that there may be significant financial advantages to combining these "facility enhancements" with the capital improvements and repairs recommended in this report. One typical example is the area lighting for the facility. Our recommendations restore the lighting system to support operations of the locks but do not provide area lighting that is appropriate for a public space. Combining our recommended repairs with any proposed site enhancements will result in substantial cost savings for the project. Our cost estimates also do not include costs of operation on an annual basis but do include costs of maintenance on an ongoing basis.

Needs are briefly discussed in the below sections. More detail of cost and scope are defined in Appendix A.

CRITICAL NEED

Critical Needs are repairs identified to be completed before startup of the locks. The following tasks are identified as needs required for the near term, **items in bold** are higher cost items and further described below:

1. Erosion Repair and Ground Improvements at Lock Chamber 3
2. **Erosion Repair and Ground Improvements at Gate 4 Monolith (Corps Side)**
3. Control Running Water via Drainage Trench at Gate 4 (Corps Side)
4. Hydrographic Survey
5. Reinstall Timber Brace for Wall Lagging, Lock 1 Mill Side
6. Replace Walkway and Walkway Framing Supports
7. **Stabilize Chamber Walls in Select Locations**
8. **Stabilize Monolith Walls in Select Locations**
9. **Replace Corroded Gudgeon Anchorages**
10. Operator Anchorage Repair
11. Replace Pedestrian Draw Bridge over Lock 4
12. Replace Gangway Float at Downstream Approach
13. Install new Piles in Concrete Foundation at Downstream Approach
14. Replace Timber Lining in Chamber 3
15. Replace all Hydraulic Hoses
16. Sample Hydraulic Fluid
17. Detailed Inspection/Documentation of All Fill/Empty Valves
18. Repairs to Valves (Projected)
19. Lubricate all Systems
20. Install New Gate & Valve Operating Cylinders at Gate #1
21. Salvage, Rebuild and Store Cylinders from Gate #1
22. Remove Debris
23. **Install Fire Protection Equipment**
24. Inspect / Repair Generator, Install Packaged Load Bank
25. Repair Broken Luminaires
26. Inspection/Documentation of Electrical Distribution System
27. Repair of Electrical Distribution System
28. Maintenance Activities

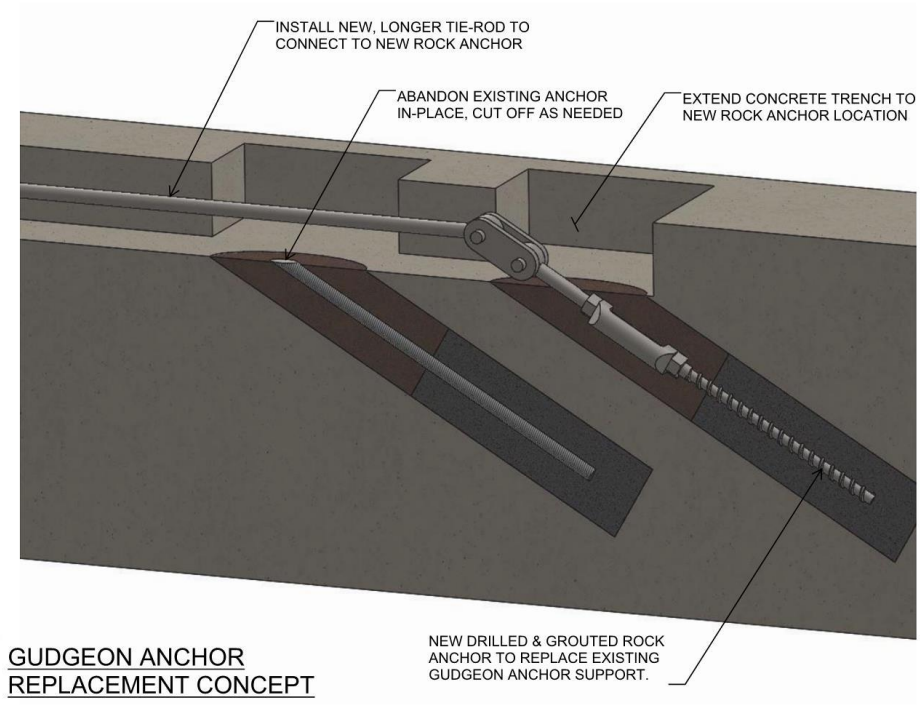
2. Erosion Repair and Ground Improvements at Gate 4 Monolith - Corps Side ($793K): It is our understanding that when Lock Chamber 4 is full, a significant amount of water seeps out of the chamber between the timber facing boards on the Corps side. This water has caused erosion behind the wall adjacent to the ashlar stone monolith that supports Gate 4. The water then travels downhill around the monolith and has caused significant erosion behind the lock chamber wall at Chamber 3 directly adjacent to the monolith. Costs for repairing this area of erosion at Lock 3 are identified in Item 1. KPFF has not been able to observe this seepage taking place in person, and is relying on video footage from 2010 provided by USACE for an understanding of this phenomenon. The 2011 INCA report identified a waterproofing repair to the Gate 4 monolith as an option for repair, which is the cost identified in this report. This repair, in conjunction with a new drainage trench identified in Item 3, will help to reduce the risk of future erosion. However, these measures do not stop the water from seeping out of lock Chamber 4 – they simply provide a means for conveying the water in a less destructive way. KPFF recommends further investigation at this area to better understand the problem and for more holistic solutions to stopping the source of the problem, if it can be accomplished for equal or less cost than proposed herein.

7. Stabilize Chamber Walls in Select Locations ($1.915M): Install vertical rock anchors at Chamber 2 (three anchors along a 20 ft long portion on Mill side), Chamber 3 (two anchors along a 10 ft long portion on both the Mill side and Corps side), Chamber 4 (the entire length with anchors spaced at 7'-6"), and the Guard Lock (the entire length with anchors spaced at 7'-6"). These anchor locations are based on the

2011 Corps Evaluation Report. Costs for this work take into account difficulty in access to the various anchor locations, as well as drilling vertically down through the center of the large masonry blocks and installing steel rod anchors that are grouted into the underlying soils (or rock) below the wall. The rock anchors will increase stability of the gate monoliths during the design level earthquake. This recommendation for repair and scope of work aligns with the 2011 USACE evaluation.

8. Stabilize Gate Monoliths in Select Locations ($1.163M): Install vertical rock anchors at Gate 4 (Corps and Mill side), Gate 5 (Corps and Mill side), Gate 6 (Mill side only), and Gate 7 (Mill side only) to address seismic stability concerns of the ashlar masonry walls. These anchor locations are based on the 2011 Corps Evaluation Report. The scope of KPFF's work did not allow sufficient time to perform an independent seismic stability analysis of these walls. However, we were able to review the original wall stability calculations and generally agreed with their approach. Costs for this work take into account difficulty in access to the various anchor locations, and the costs for drilling vertically down through the center of the large masonry blocks and installing steel rod anchors that are grouted into the underlying soils (or rock, depending upon subsurface conditions) below the wall. These rods are then post-tensioned to place a vertical load on the walls. This improves the stability of the walls by increasing the downward force on the masonry layers to increase the inter-layer friction. This recommendation for repair and scope of work aligns with the 2011 USACE evaluation.

9. Replace Corroded Gudgeon Anchorages ($540K) : This isn't one of the highest cost items, however it is heavily discussed in previous reports. This estimate assumes all gudgeon anchorages need to be replaced for gates #2, #3, #4, #5, #6, and #7 to mitigate any concerns regarding the safety of these anchorages. For the anchor rods that are parallel to the lock, these rods are assumed to be replaced in kind. For the anchor rods that are perpendicular to the lock, the approach is to abandon the existing anchor rod in place, and install new drilled in and grouted rock anchors a few feet further back from the gate and then installing longer tie rods to connect to the gate. This is true for all perpendicular gudgeon anchors except at Gates 4 & 5 Mill side, where they are replaced in kind. This recommendation for repair and scope of work is different from the 2011 USACE evaluation, which recommended abatement of existing corrosion and replacing only a handful of pieces of hardware, which did not address the potential for corroded and buried anchorages which are not accessible for inspection. See the figure below for a conceptual sketch of the replacement gudgeon anchor.



GUDGEON ANCHOR REPLACEMENT CONCEPT

23. Install Fire Protection Equipment ($760K): Currently there is no fire protection equipment along the locks to protect the lock users. There is minimal hydrant access along the lock system for fire fighters to connect to, the closest documented hydrant is up on Willamette Falls Drive, approximately 250' from the locks. Installing a firewater system with multiple hose reels along the locks would increase fire protection coverage. This recommendation aligns with the 2011 USACE evaluation.

MODERATE NEED

Moderate Needs are repairs recommended to be completed within five years of operation, but not critical for start-up of the locks. The following tasks are identified as moderate needs, items in bold are higher cost items and further described below:

29. Replace Chamber Ladders
30. Replace Damaged Guardrails
31. **Install new Hydraulic Power Units**
32. Replace Bottom Seals
33. **Replace Lighting System**
34. **Replace/Refurbish Control System**

These items could be done earlier if budget allowed for it, and some items would be less expensive to execute if completed at the same time. An example is combining tasks that require dewatering within the locks.

31. Install new Hydraulic Power Units ($616K):

As discussed above, the existing hydraulic power units, control valves and piping are operable and would support routine operation of the lock facility by personnel of equivalent expertise and training as those employed by the USACE to operate the system today. While operable, the hydraulic and controls currently installed are nearing or past their recommended service life, have significant operational

limitations and would not allow operation of the facility under a more diverse and less highly trained group of operators. For these reasons we are recommending that the existing HPU's be replaced with new package commercial units.

Our recommendation is to replace the 7 existing HPU's with 14 smaller commercial packaged HPU's, one unit for each gate leaf. With this configuration, hydraulic piping under the lock chamber can be abandoned and risks of a hydraulic oil spill are substantially reduced. We further recommend that each HPU be equipped with multiple modular directional control valves, one to control the miter gate cylinder and one for each of the four fill-empty valve cylinders. This arrangement allows for independent control of all operations and eliminates the limitations created by the sequence valves in the existing hydraulic circuit.

We further recommend that all hydraulic piping from the HPU to the gate, as well as piping on the gate leaf be replaced by high quality stainless steel tubing.

This HPU and control valve scheme is contingent upon simultaneous installation of a modern digital control system and updated power distribution system as described in the work under items 33 and 34 below. Interconnecting these HPU's and the control valves via a networked control scheme allows control valves to be mounted in a manner that minimizes the required hydraulic piping.

33. Replace Lighting System ($782K): While the existing lighting system is functional, it is obsolete and should be replaced. In addition, our proposed scheme for the hydraulic power units requires electrical power at each gate monolith (Corps. and Mill Side of the locks.). We recommend that a new power distribution and lighting system be installed simultaneous with the new HPU and control system. Our cost for this item reflects a lighting system similar in performance to the existing system but using current state of the art luminaries. We also recommend that this work be coordinated with any public access improvements to the site as the end use of the facility may dictate a lighting system better suited for a public use facility.

341. Replace / Refurbish Control System ($1,209K): Currently the control system is an older analog system. It functions, however much of the equipment is obsolete and will be difficult to maintain/repair over time and eventually should be upgraded. Upgrading the control system will allow for better overall control of the facility as well as automation of the system that will allow use by a more diverse and less highly trained group of operators.

We propose to replace the existing analog control system with a digital programmable logic controller (PLC) based control system based on distributed network controls. The PLC and key control system functions would be installed in one of the existing control houses. All lock control would be handled through touch screen human machine interfaces (HMI's) distributed throughout the lock facility. HMI's would be installed adjacent to each lock gate monolith to allow for local operator control, and in the two lock control houses.

Control devices including limit switches and hydraulic control valves would be connected to the control system via a control network, eliminating the need for individual hard wiring from the PLC to each device. To automate the system, we recommend monitoring water surface elevations in all lock chambers via redundant ultrasonic liquid level sensors. These devices would also communicate with the PLC via the control network.

With this type of a control scheme in place, the PLC can provide operational oversight of the facility, insuring that the lock is operated in a safe manner regardless of the expertise of the operator.

This system is contingent on implementation of the new HPU as well as the power distribution and lighting upgrades proposed in items 32 and 33 above.

Long Term Need

Long Term Needs are repairs identified to be completed within 10 years of operation. There were no relatively high costs identified for long term needs. The following task is identified as needs to happen within 10 years:

35. Repair Loss of Masonry at Lowest Course at the Downstream Approach, Mill Side

Estimated Maintenance + Future Capital Improvement Set-Asides

Our cost estimate accounts for annual maintenance costs as well as long term maintenance and anticipated future capital costs under a single line item. In this cost line item, all costs are annualized and are presented as total annual cost.

Future Capital Costs

Future capital needs are forecasted high cost items that will be required after 10 years and need to be anticipated and planned. The major item here is the inspection and refurbishment of gate leaves. Likely this work will be required after 2030. The following tasks are identified as future capital costs, items in bold are higher cost items and further described below:

36. Inspect / Refurbish Gate Leaves
37. Flood Repair Contingency

36. Inspect / Refurbish Gate Leaves ($1.2M): This line item was added to anticipate this large expenditure in the future. Gate Leaves typically have a 25-50 year life and need to be inspected and refurbished. All gate leaves were inspected and refurbished in 2009, thus likely the gates will need to be refurbished between 2034 - 2059. This work aligns with the line item identified in the 2011 USACE evaluation report to install new miter blocks, since that activity would require removal of the gate leaves, however KPFF does not anticipate the need to replace the miter blocks within a 10 year period. Scope of work includes removing the gates via a barge + crane and transferred to a shop, strip the planks off the gates, sand blast the structure, detailed inspection, weld repair as needed, repaint, install new bottom seals and valve seals, install new bearings, install new quoin block/miter block, transfer the gates back to the site and reinstall the gate leaves via a barge and crane, and adjust the retention diagonals so the gates hang level. Note that it is recommended to keep either Gates #6 & #7, #6 & #5 or #5 & #7 installed at the same time to maintain pool integrity for the hydroelectric plant.

37. Flood Repair Contingency ($710K): This line item was added to allow a contingency fund for repairs needed for a future flooding event.

Routine Maintenance Need

Routine Maintenance Needs are preventative maintenance items to be completed on a routine basis. The following tasks are identified as needs required annually:

1. Inspect Timber Lining and Replace Rotting Pieces as Needed
2. Inspect Lock Walls and Region behind Lock Walls for Movement
3. Inspect Masonry for Structural Integrity
4. Remove Debris as Needed
5. Hydraulic Fluid Sampling
6. Replace One Set of Gate and Valve Hydraulic Cylinder Operators
7. Lubricate Systems

8. Run Generator on Load Bank Monthly
9. Limit Switch Inspection / Repair / Replacement

The following tasks are identified as needs required every 5 years:

10. Hydrographic Survey and Dredging
11. Adjust Retention Diagonals on Miter Gate Leaf
12. Testing and Correction of Grounding System
13. Replace Hydraulic Hoses
14. Slide Gate Inspection / J seal & J clamp PM

COMPARISON WITH PREVIOUS USACE NEEDS ASSESSMENT

In general, our recommendations and needs assessments for the facility are consistent with those recommended in the 2007, 2011 and 2013 reports. All deficiencies that we have identified are discussed by the previous reports and we have been able to identify any significant additional deficiencies in the system. In some cases we have identified slightly different solutions or we are proposing to phase capital improvements differently than proposed by previous reports. Overall our estimated costs for capital improvements are less than those listed in the 2011 report, but are substantially higher than those contained in the 2007 report. The discrepancy between engineering estimates is discussed in more detail under the Cost Summary section below.

Several specific capital improvements recommended by the 2007 and 2011 reports have not been included in our recommendations. Some of these recommendations were eliminated because of the anticipated operating methodology for the lock listed below. Other specific items were eliminated because repairs were made or because site conditions had changed subsequent to the report being issued. Please see below for a discussion on why each line item was not included. Some line items included on old reports that are not directly copied onto our report or shown below are incorporated into other line items.

Analyze Lock Control Stand at Gate 6 (Mill Side): The structure of the lock control stand has been condemned. At this point, there is no need to analyze the structure since it has already been deemed unsafe structurally. If the control stand is needed, the structure would need to be replaced. This activity would have added complexity with all of the utilities routed around, underneath and into the control stand. With the recommended operational methodology, the control stand is no longer needed.

Miter Block Repair: The USACE anticipated having to replace the miter blocks within a 10 year period. KPFF recommends deferring this work until the gates are inspected and refurbished in the future. The miter block repairs were recommended after noticing a miter block had cracking towards the top on at least one gate. The 2011 USACE evaluation report suggests that these cracks occur when the gates close, due to first contact being made at the top of the gate. KPFF has added a 5 year cycle maintenance task to adjust the retention diagonals so the gates sit square, as this will reduce the likelihood of damage to the miter blocks and enable the deferral of this item.

Gate limit switches (2nd set): The USACE recommended changing the operator methodology of the locks to decrease overall wear on the system. The addition of these limit switches would allow the future control system to slow gate travel as the gate neared its open or closed limit. This would reduce impact loading on the structure and the operators and would increase the service life of the components. We have assumed that the total number of annual lockages will remain relatively low when compared to the locks' historical use, and the cost for this additional control complexity is not justified.

CCTV Repair / Upgrade: With the recommended way of operating, it was determined CCTV is not required for operation of the lock. Both the 2011 and 2013 Corps Evaluation Reports recommend CCTV repairs/upgrades for remote operation; however under new ownership we have assumed that the lock will not be operated remotely and thus these improvements would not be required in the future.

Remote monitoring / operating system: This line item was added to enable USACE to operate the Willamette locks from Bonneville dam; however under different ownership and recommended operation methodology an operator would be onsite. With an operator onsite, this line item is no longer required.

Our proposed upgrades are substantially more extensive than the final recommendations presented by the Draft Disposition Study (DDS) prepared by the USACE. That study considered 8 alternatives for transferring the facility to a new owner. Eleven (11) measures were identified that could be implemented by the Corps to facilitate the transfer of the asset. Costs for each measure were assigned based on the 2011 report. Eight (8) different alternatives were then identified, with each alternative accomplishing some subset of the eleven measures. The eight alternatives were reduced to three based on a defined screening criteria and then a preferred alternative was selected based on minimizing the associated costs to the Federal Government. The preferred alternative presented by the DDS was alternative number 3, which would transfer a non-functional Lock to a new owner after addressing only seismic safety of structures retaining the upper pool. Given the limited scope of capital improvements proposed by the USACE in the DDS, the costs presented are substantially less than those identified in this report. See the Cost Summary section for additional details of the comparative costs.

Note that the proposed capital improvements to the facility are similar in scope to the following measures identified by the DDS:

1. Seismic Partial
2. Safety Functional
3. Safety Minimal
4. Seepage

If the costs of the above measures are combined, they are similar to the capital expenditures included within this report.

COST SUMMARY

ESTIMATED ROM COSTS

The costs shown in the table below represent our ROM estimate for completing the improvements we have proposed for this facility. Costs given are Rough Order of Magnitude (ROM) costs and given in 2018 dollar values. A 30% contingency was added to each line item since this is a high level engineering evaluation. Estimated engineering & permitting costs are also included in this estimate using an additional 20% markup added to the construction and contingency costs. Table 1 gives an overall cost estimate for each Need. Note that line item 4 includes the cost of annual routine maintenance as well as annual funding set-asides to finance major system, anticipated major capital improvements and periodic emergency repairs maintenance (not accounting for earned interest or future inflation). See Appendix A for further scope detail and cost of each Need Type.

Need Type	Amount ($2018)
Critical Need (Prior to Locks Re-Opening)	$8,610,000
Moderate Need (Within 5 years)	$2,940,000
Long Term Need (Within 10 years)	$240,000
Estimated Maintenance + Future Capital Improvement Set-Asides	$450,000

TABLE 1: SUMMARY OF OVERALL COSTS

COMPARISON TO PREVIOUS REPORTS

The Table below compares our cost estimates to those developed by other consultants for the 2011 report. This table presents an apples-to-apples comparison of our estimated costs to the previous estimate based on our proposed planning horizon.

As for USACE's Disposition Study, it is difficult for us to make direct cost comparisons to this study, primarily due to the fact that this study includes costs to seismically stabilize the shared PGE/Ship Canal wall, which is currently not included in our recommendations for repair. None of the previous 2007, 2011 or 2013 reports indicate that this wall requires seismic stabilization. KPFF has heard recent anecdotal concern from the Corps regarding this wall's stability. However, we have not had the opportunity to independently evaluate the need for stabilization of this wall.

The USACE's preferred solution in the Disposition Study is Alternative 3, which transfers a non-functioning lock and limits the scope of seismic improvements at the facility to structural elements needed to maintain the upper pool at the site. USACE reports the cost for this alternative at $1.963M, which includes $1.847M in seismic retrofit costs. The scope of these retrofits include stabilization of the PGE/Ship Canal wall, the guard lock wall and guard lock gate 6 & 7 monoliths on the River side. KPFF's study presented herein includes costs for seismic retrofit of the guard lock wall and gate 6 & 7 monoliths for a cost of approximately $1.3M, but this cost does not include retrofit of the PGE/Ship Canal wall. Further study would be required for KPFF to validate the need and cost for retrofit of the Ship Canal wall.

Planning Horizon	KPFF Estimate ($2018)	2011 Report ($2011)
Critical Need (Prior to Locks Re-Opening)	$8.61M	$7.84M
Moderate Need (Within 5 years)	$2.94M	$5.63M to $4.93M
Long Term Need (Within 10 years)	$240K	$5.66M

TABLE 2: COMPARISON TO 2011 REPORT

Note that our total ROM estimated costs for the project are somewhat less than those presented in the 2011 engineering report prepared by the joint venture INCA/CH2M team. This discrepancy is primarily related to the following issues:

1. Portions of our cost estimates are based on a more detailed take-off than was used to prepare the 2011 report.
2. For some scope items we are proposing slightly different design details.
3. For many items such as the electrical/control system and the gate mechanical systems, we are proposing systems that are more appropriate for the assumed future operation of this facility. As an example, the control system that we are proposing is appropriate for a lock operated locally. The 2011 report envisioned a lock control system that allowed USACE staff to fully operate the lock remotely.

Overall we believe that our estimate ROM costs are reasonable for the Commission's planning purposes and that they are in-line with the costs that were presented in the 2011 report, once the differences in proposed scope of work are accounted for.

Potential Issues

Some additional risks were identified during this scope of work due to unknowns associated with the site, such as:

- Erosion at Gate 4: The costs included in this report are based on the solutions presented in the 2011 report. KPFF recommends further investigation be conducted to determine if there is a solution to mitigate future erosion from occurring at Lock 3 due to seepage out of Lock Chamber 4 and the Gate 4 monolith. Upon discussion with the Corps, mitigating the seepage itself may not be realistic; however there may be better options for mitigating future erosion due to this seepage.

- Dredging: Upon discussion with the Corps, it appears that minimal sediment accumulates within the lock chambers. Therefore, for the purposes of estimating a dredging maintenance cost, we have assumed 2' of sediment accumulates and needs to be dredged out from two of the standard 210' long chambers every 5 years.

- Seismic stabilization of the PGE/Ship Canal wall: Costs for stabilizing this wall are currently not included in this report. Further investigations are required to determine if this activity needs to be undertaken and to determine the costs for these improvements.

- Operations: Repairs were assessed based on an assumed method of operations, which assumed the owner will pursue an onsite/manual approach. If the owner decides to operate the Locks differently, other repairs or improvements should be considered. Examples would be the need for a remote control stand at Gate 6, CCTV requirements, etc.

- Environmental assessment - no environmental assessments were performed as part of this scope of services. The USACE has prepared a comprehensive section 216 Preliminary Draft Disposition Study with Integrated Environmental Assessment. The Locks Commission should consider having this assessment reviewed by a qualified Environmental Consultant prior to assuming Ownership of the Locks.

- The project site has been damaged by extreme flood events in the past. The new owner should be aware of the flood hazard risk and should have a plan for operating the facility under flood hazard conditions.

- The Guard Lock walls, along with miter gates 6 and 7, retain the upper pool for the dam. Since this dam facility includes generating assets, it is governed by FERC licensing requirements. These requirements dictate dam safety inspections on a routine basis. Project re-licensing is also typically contingent on capital improvements aimed at environmental mitigation. We recommend that the Commission work with PG&E to define how these potential costly items will be handled.

ADDITIONAL ITEMS TO BE CONSIDERED IN THE FUTURE:

Through wall leakage in the Mill Monolith and side walls – This was an item identified in the 2007 report. This does not appear to be a safety or operational issue. It was a concern for the Mill storage. This is primarily something to be aware of and decide if it is an issue to address prior to assuming Ownership of the Locks. Cost for mitigating this issue is not included in our proposed plan.

OPERATIONAL ASSUMPTIONS

For the purposes of this report we have assumed that the lock will be operated as a mixed commercial, tourist and recreational facility. Key assumptions include:

- Operational year-round for commercial and major tourist operations. Lockages by these users may occur while the facility is or is not staffed.
- The facility will be staffed to support light recreational use either seasonally or year round.
- When dedicated operating staff is not on site, the lock would be operated by employees of commercial/tourist operations. These independent operators would travel with the commercial/tourist vessel, would access the facility via the floating docks, and would be specifically trained in proper lock operation.

Overall we anticipate that the total number of lockages will be on the order of 1700-2500 annually.

RECOMMISSIONING APPROACH

Per our needs assessment above, we have recommended capital improvements to the facility as well as a program of ongoing routine maintenance. These recommendations are aimed at returning the facility to reliable operation as a mixed commercial and recreational facility and then improving and maintaining that operation moving forward. In general, our recommendations are consistent with those contained in the 2007, 2011 and 2013 reports compiled by the USACE, but are more extensive than the recommendations presented by the Corps in the 2017 Draft Disposition Study.

Presumably any new entity established to take over and operate the locks will negotiate the formal terms of the property transfer. This transfer will likely entail some combination of federal funds along with other state and local funding sources. Where federal funds are being contributed, the new owner may be faced with choices as to how best proceed with any capital improvements accomplished using the federal funds. The new owner can request that the USACE complete agreed-to capital improvements prior to taking full ownership of the facility. Alternately, the two parties can agree on a stipulated funding level that the Federal Government will contribute to the project at the time of the transfer, and then the new owner would take responsibility for making the capital improvements.

There are advantages and disadvantages for the new owner related to each approach. Having the USACE complete any agreed-to capital improvements to the facility prior to the transfer minimizes the owner's risk related to those projects. Any unforeseen conditions or unanticipated costs would be the responsibility of the Federal government prior to the transfer of ownership. The downside to this approach is that the ownership transfer would be delayed until the project was completed and the new owner would not be able to start other capital improvement projects until the initial federal project was complete.

The primary advantage to taking early ownership of the facility is that the new owner will have more control over the capital improvement projects and will be able to proceed with all capital improvements simultaneously regardless of funding sources. This has the potential to make more efficient use of the available capital improvement funds.

Performing construction in a facility as old as the Locks is bound to encounter unforeseen conditions, which typically lead to substantial change orders in a public bid environment. The Commission should take this fact into account when negotiating a turn over strategy with the Corps. The original bid from a Contractor will not likely be the final contract amount. Managing the unknowns can be challenging and should be planned for with contingency or escrow accounts to manage these costs.

The construction work to be performed is specialized, and should be performed by a qualified Contractor. A phased bidding approach should be considered. KPFF recommends going through a pre-qualification phase where qualified bidders are short listed and then asked to prepare pricing for the actual work in a subsequent phase of bidding. In a Design-Bid-Build type of contract, the bid could be structured so that items that are at greater risk of encountering unknown conditions could ask for additional pricing based on a per quantity basis (such as excavation, drilling of rock anchors, or removal and replacement of structure in kind to provide access to certain areas).

The Commission could investigate contracting the work using a Design-Build approach. The advantage of these types of contracts is that they typically will allow the Owner to take on less risk, but usually this is only true if the scope of the work is well defined. Given the fact that the scope of work for this facility is likely to encounter some unknowns, a Design-Build approach may not be the best contracting option for this work.

A third option that could be explored is the use of a GC/CM type of approach. In this case, qualified bidders provide high level bids for a given scope of work that is at a 15-20% level of definition. The winning Contractor is then brought on board during design to help assist the team to define the scope of work given their preferred approach to the Construction. This may be the least risky approach to the Owner in defining and pricing the work at this type of facility.

APPENDIX A – COST ESTIMATE

Willamette Falls Locks

Rough Order of Magnitude Engineer's Estimate to Operate and Maintain the Locks Infrastructure

October 10, 2018

Capital Improvements (Estimated Costs in $2018)

	Item	Critical Need (Prior to Re-opening of Locks)	Moderate Need (Within Next 5 Years)	Long-Term Need (Within Next 10 Years)	Scope of Work
1	Erosion Repair and Ground Improvements at Lock Chamber 3	$ 249,000			Repair a 85' long by 6' wide by 10' deep area and a 35' long by 10' wide by 10' deep area based on KPFF's 5/30/18 site visit and 2011 Corps Evaluation Report. This includes removing steel plates and asphalt pavement at the sinkhole locations, excavating the sinkholes to expose the deteriorated timber lagging and lay back the temporary excavation slopes, removing and replacing the deteriorated timber lagging, place a non-woven drainage geotextile fabric, place new backfill, and place new asphalt pavement on the repaired areas.
2	Erosion Repair and Ground Improvements at Gate 4 Monolith (Corps Side)	$ 793,000			Repair a 20' long by 6' wide by 10' deep area based on KPFF's 5/30/18 site visit. This includes removing timber decking at the sinkhole locations, excavating the sinkholes to expose the deteriorated timber lagging and lay back the temporary excavation slopes, removing and replacing the deteriorated timber lagging, place a non-woven drainage geotextile fabric, place new backfill, and place new timber decking on the repaired areas.
3	Control Running Water Via Drainage Trench at Gate 4 (Corps Side)	$ 24,000			Construct a drainage trench from behind the Miter Gate 4 monolith to the timber faced wall downstream of the miter gate monolith per the 2011 Corps Evaluation Report
4	Hydrographic Survey	$ 94,000			Recommend a hydrographic survey be conducted to determine level of sedimentation within the locks and whether dredging may be required at this time
5	Reinstall Timber Brace for Wall Lagging, Lock 1 Mill Side	$ 4,000			Re-install the 12x12 horizontal timber brace on the Mill side of Lock 1. The work necessary is to loosen the anchor rod, lift the timber brace into place, and retighten the anchor rod per the 2011 Corps Evaluation Report
6	Replace Walkway and Walkway Framing Supports	$ 283,000			Remove and replace the walking surface, replace the missing posts, and recoating the deck at Corps side of Guard Lock and at Gate 2 per the 2011 Corps Evaluation Report.
7	Stabilize Chamber Walls in Select Locations	$ 1,915,000			Install vertical rock anchors at Gate 4 (Corps and Mill side), Gate 5 (Corps and Mill side), Gate 6 (Mill side only), and Gate 7 (Mill side only) per 2011 Corps Evaluation Report, taking into account costs for rig access.
8	Stabilize Gate Monoliths in Select Locations	$ 1,163,000			Install vertical rock anchors at Chamber 2 (three anchors along a 20 ft long portion on Mill side), Chamber 3 (two anchors along a 10 ft long portion on both the Mill side and Corps side), Chamber 4 (the entire length with anchors spaced at 7'-6"), and the Guard Lock (the entire length with anchors spaced at 7'-6"), per the 2011 Corps Evaluation Report, taking into account costs for rig access.
9	Replace Corroded Gudgeon Anchorages	$ 539,000			Replace all Gudgeon anchors from Gates 2-7. For the anchors that are parallel to the lock, replace in kind. For the anchor rods that are perpendicular to the lock, abandon the existing anchor rod in place, install new rock anchors further back from the gate and install longer tie rods.
10	Operator Anchorage Repair	$ 529,000			Replace the concrete foundation and anchor rods that hold the operating anchors down at various locations where needed. Two locations were reported in the 2011 Corps Evaluation Report.
11	Replace Pedestrian Draw Bridge over Lock 4	$ 528,000			Replace draw bridge in kind per KPFF site visit on May 30, 2018
12	Replace Gangway Float at Downstream Approach	$ 195,000			Replace in kind existing float supporting end of gangway
13	Install new Piles in Concrete Foundation at Downstream Approach	$ 78,000			Add new drilled in piles into existing concrete foundation that has been undermined by scour
14	Replace Timber Lining in Chamber #3	$ 202,000			Replace all of existing timber facing lining in lock chamber #3 as it is deteriorated and likely contributing to the erosion seen at the Corps side of this lock
15	Replace all Hydraulic Hoses	$ 57,000			Replace approximately 200 existing hydraulic hoses with new hydraulic hoses per KPFF site visit and 2011 Corps Evaluation Report. Hydraulic hoses typically have a 5 year expiration date and need to be periodically replaced.
16	Sample Hydraulic Fluid	$ 11,000			Sample existing hydraulic fluid to confirm fluid quality per KPFF site visit. Verify hydraulic fluid is environmentally safe.
17	Detailed Inspection/Documentation of all Fill/Empty Valves	$ 50,000			Inspect each gate valve for proper operation per KPFF site visit. Inspection list includes: actuator seals, actuator function, limit switch function, valve seals, control buttons, indicators, wiring, etc.
18	Repairs to Valves (Projected)	$ 553,000			Potential valve repair work includes: replace broken limit switches, replace valve actuator seals, replace/repair valve perimeter seals, replace/repair valve controllers. This cost includes installation of a coffer dam if needed. Projected repair work is based on 2011 Corps Evaluation Report. Scope includes replacing valve perimeter seals, valve limit switches, & potentially replace whole valves.
19	Lubricate all Systems	$ 29,000			Relubricate all systems per vendor recommendations per KPFF site visit.
20	Install New Gate & Valve Operating Cylinders at Gate #1	$ 59,000			Purchase and install two new gate hydraulic operators and eight hydraulic valve actuators per KPFF site visit. Salvage the existing hydraulic cylinders and have them refurbished per KPFF site visit. The design recommendation is replace in kind.
21	Salvage, Rebuild and Store Cylinders from Gate #1	$ 32,000			Send salvaged hydraulic cylinders, the gate operators as well as the valve operators, from Gate #1 to be rebuilt / refurbished per KPFF site visit. Store these cylinders on site as spares.
22	Remove Debris	$ 36,000			Clear debris from lock chambers to reduce damage on equipment per 2011 Corps Evaluation Report. Estimate is based on hiring an operator, renting a barge with a backhoe to remove debris, and transporting/disposing of debris.

23	Install Fire Protection Equipment	$ 760,000			Install a firewater system for fire protection of boaters in the locks per 2011 Corps Evaluation Report. The firewater system includes fire pumps, piping, hose stations and hydrants.
24	Inspect / Repair Generator, Install Packaged Load Bank	$ 64,000			Hire a Cummins representative to do an inspection on the generator and repair as need per 2007 report findings. Install a packaged load cell and coupler for monthly testing of generator.
25	Repair Broken Luminaires	$ 15,000			Replace two luminaires identified as broken and unrepairable in the 2011 Corps Evaluation Report. Added two luminaires and associated wiring to be replaced as contingency.
26	Inspect / Document of Electrical Distribution System	$ 117,000			As Built electrical, instrumentation and controls system to have adequate drawings for future trouble shooting of locks per 2007 report findings. Inspect electrical, instrumentation and controls equipment and document deficiencies for repair
27	Repair of Electrical Distribution System	$ 78,000			Repair/Replace broken conduit, conductors, enclosures and supports as determined during inspection. This estimate was generated based on reviews of photos of electrical equipment and repair recommendations from the 2011 Corps Evaluation Report
28	Maintenance Activities	$ 145,000			This line item is to account for the maintenance activities to be done before start up that aren't already included in other near term costs
29	Replace Chamber Ladders		$ 43,000		Remove existing ladders at lock chambers 1 through 4 and the ladder on the Mill. Furnish and install replacement ladders. Per 2011 Corps Evaluation Report
30	Replace Damaged Guardrails (Railing on Mill Side from Gate 1 to Gate 5, and Guard Lock)		$ 96,000		Replace the wood and metal guardrails near the oil storage building and the Guard Lock. Assume a majority of the railing on the Mill side from Gates 1 to 5 needs to be replaced. Per the 2011 Corps Evaluation Report
31	Install New Hydraulic Power Units		$ 616,000		Install 14 new hydraulic power units (HPU), 1 for each gate leaf. This scope of work includes demolishing the existing units, demolishing/abandoning both conduit & piping, disposing of oily waste, installing new piping to the gate leaves, installing new HPU's.
32	Replace Bottom Seals		$ 185,000		Replace in kind bottom seals as needed per 2011 Corps Evaluation Report
33	Replace Lighting System		$ 782,000		Scope of Work includes replacing all exterior luminaires, light poles, switches, junction boxes and rewiring entire lighting system per 2011 Corps Evaluation Report.
34	Replace/Refurbish Control System		$ 1,209,000		Replace control system with upgraded digital controls to allow for future automation if desired per 2011 Corps Evaluation Report.
35	Repair Loss of Masonry at Lowest Course at the Downstream Approach, Mill Side			$ 234,000	A portion of the downstream approach masonry wall is missing along the bottom length of the wall. Per the 2011 Corps Evaluation Report, mitigation would include replacing the missing portions with reinforced concrete.
	Total Cost Summary	***$ 8,610,000***	***$ 2,940,000***	***$ 240,000***	

Future Capital Costs (Estimated Costs in $2018)

36	Inspect/Refurbish Gate Leaves			$ 1,215,000	Lock Doors typically have a 25-50 year life and need to be inspected and refurbished. All of the doors were inspected and refurbished in 2009, thus likely the doors will need to be refurbished between 2034-2059. Scope of work includes removing the gates via a barge + crane and transferred to a shop, strip the planks off the gates, sand blast the structure, detailed inspection, weld repair as needed, repaint, install new bottom seals and valve seals, install new bearings, install new quoin block/miter block, transfer the gates back to the site and reinstall the gate leaves via a barge and crane, and adjust the retention diagonals so the gates hang level. Note that it is recommended to keep either Gates #6 & #7, #6 & #5 or #5 & #7 installed at the same time to maintain pool integrity for the hydroelectric plant.
37	Flood Repair Contingency			$ 710,000	After the 1996 flood, repairs were needed to the electrical system. It is referenced in the historical report that it is recommended to have a contingency fund in case another flood event occurs for potential repairs
				$ 1,930,000	

Routine Maintenance (Estimated Costs in $2018)

	Item	Annual Maint Costs	Five Year Maint Costs	Scope of Work
1	Inspect Timber Lining and Replace Rotting Pieces as Needed	$ 75,000		Physically inspect all of the timber lining for any rotten timber boards. Assume that 10% of lining will need to be replaced per year.
2	Inspect Lock Walls and Region behind Lock Walls for Movement	$ 4,000		
3	Inspect Masonry for Structural Integrity	$ 4,000		Visually inspect masonry for structural integrity. It is structurally acceptable to have 1 missing block sporadically. Repair is required if two blocks are missing adjacent to each other
4	Remove Debris as Needed	$ 17,000		As needed; it is estimated this activity will be needed post storms, approximately three times per year. This activity involves hiring a team to utilize a barge and backhoe and float through the lock system to remove debris.
5	Hydraulic Fluid Sampling	$ 16,000		Environmentally friendly Panalin hydraulic fluid is recommended to be sampled annually per vendor. This means establishing a baseline sample, and sampling each year for fluid for water content, viscosity, particulates and filtering and adding hydraulic fluid as needed. Estimate is based on a lump sum of testing and adding hydraulic fluid.
6	Replace One (1) Set of Gate and Valve Hydraulic Cylinder Operators	$ 60,000		The intent is to replace a set of hydraulic cylinder operators (Both gate and valve) for a gate each year. For year two of operation, install gate #1's refurbished hydraulic cylinders for Gate #2. Salvage Gate #2's hydraulic cylinder operators and refurbish and store as spares. For year three of operation, install gate #2's refurbished hydraulic cylinders on Gate #3, and so on. Once all of the gates have been done, start the cycle over for Gate #1.
7	Lubricate Systems	$ 29,000		Relubricate systems annually for increased equipment longevity and performance.
8	Run Generator on Load Bank Monthly	$ 5,000		This activity will reoccur monthly and run for a minimum of 30 minutes per manufacturer recommendations; Cost reflected is the projected annual cost for this activity
9	Limit Switch Inspection / Repair / Replacement	$ 57,000		Inspect / repair / and replace limit switches as need for control functionality

10	Hydrographic Survey and Dredging		$	188,000	As needed, assume removal of 2 feet of sedimentation in 2 lock chambers every 5 years.
11	Adjust Retention Diagonals on Miter Gate Leaf		$	30,000	This activity would allow the gates to level and not attempt to swing open or closed due to gravity. Over time of settling, the gates can get out of level and cause damage on other equipment such as the miter blocks
12	Testing and Correction of Grounding System		$	32,000	Test grounding system on a routine basis to verify the electrical system is grounded correctly; repair as needed.
13	Replace all Hydraulic Hoses		$	48,000	Hydraulic hoses typically have a 5 year life, replacing hoses every 5 years reduces the potential for leaks of hydraulic fluid.
14	Slide Gate Inspection / J seal & J clamp PM		$	246,000	Valve seals have a low design life and will need to be replaced as needed. This estimate assumed half of the valve seals need to be replaced every 5 years to be conservative.
	Total Cost Summary	***$ 270,000***	***$***	***550,000***	

Notes:

- A 30% contingency + a 20% engineering, design and permitting contingency is included in each value

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project: Willamette Falls Locks	by: KMB/CMK	sheet no.
location: West Linn, OR	10/10/2018	
client: Summit Strategies		job no.
Critical Need Requirements		

Opinion of Probable Construction Costs

#	Item	Quantity	Unit	Unit Cost	Cost (2018 $)
	Erosion Repair and Ground Improvements at Lock Chamber 3				
1.00	Remove Steel Plates and Asphalt Pavement at Sinkhole Locations (2 Sinkholes)	825	SF	$ 6.00	$ 4,950
1.01	Excavate Sinkholes to Timber Lagging	5	DA	$ 2,500	$ 12,500
1.02	Remove and Replace Deteriorated Timber Lagging	1,205	LF	$ 32	$ 37,960
1.03	Furnish & Install Propex Geotextile 401	4,360	SF	$ 1.00	$ 4,360
1.04	Furnish & Install Controlled Density Fill	305	CY	$ 250	$ 76,350
1.05	Furnish & Install Base Course	8	CY	$ 75	$ 580
1.06	Furnish & Install New Asphalt Paving	10	TON	$ 144	$ 1,440
1.07	Utility repair allowance	1	LS	$ 20,000	$ 20,000
	Erosion Repair and Ground Improvements at Lock Chamber 3 Subtotal				***$ 159,000***
	Erosion Repair and Ground Improvements at Gate 4 Monolith (Corps Side)				
2.00	Gate 4 Monolith Repair	1	LS	$ 500,000	$ 500,000
2.01	Utility repair allowance	1	LS	$ 7,500	$ 7,500
	Erosion Repair and Ground Improvements at Lock Chamber 4 Subtotal				***$ 508,000***
	Control Running Water Via Drainage Trench at Gate 4 (Corps Side)				
3.00	Furnish and Install drainage trench at Gate 4 (Corps side)	1	LS	$ 14,700	$ 14,700
	Control Running Water Via Drainage Trench at Gate 4 (Corps Side) Subtotal				***$ 15,000***
	Hydrographic survey				
4.00	Hydrographic survey	1	LS	$ 60,000	$ 60,000
	Hydrographic SurveySubtotal				***$ 60,000***
	Reinstall Timber Brace for Wall Lagging, Lock 1 Mill Side				
5.00	Reinstall Timber Brace for Wall Lagging (Lock 1 Mill Side)	1	LS	$ 1,750	$ 1,750
	Reinstall Timber Brace for Wall Lagging (Lock 1 Mill Side) Subtotal				***$ 2,000***

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project:	Willamette Falls Locks
location:	West Linn, OR
client:	Summit Strategies
	Critical Need Requirements
by:	KMB/CMK
	10/10/2018
sheet no.	
job no.	

Replace Walkway and Walkway Framing Supports

6.00	Replace Walkway Framing Supports (Corps Side of Guard Lock and one at Gate 2)	1	LS	$ 26,421	$ 26,430
6.01	Remove and Dispose of Existing Timber Waolkways on Corps Side	5,930	LF	$ 5	$ 29,650
6.02	Furnish and Install New 3x12 Treated Timber	5,930	LF	$ 21	$ 124,530
	Replace Walkway and Walkway Framing Supports (Corps Side of Guard Lock) Subtotal				***$ 181,000***

Stabilize Chamber Walls in Select Locations

7.00	Chamber 2 - Mill Side: Rock Anchors	3	EA	$ 15,000	$ 45,000
7.01	Chamber 2 - Mill Side: Access Contingency	1	LS	$ 16,500	$ 16,500
7.02	Chamber 3 - Corps and Mill Side: Rock Anchors	4	EA	$ 15,000	$ 60,000
7.03	Chamber 3 - Corps and Mill Side: Access Contingency	1	LS	$ 2,000	$ 2,000
7.04	Chamber 4 - Corps Side: Rock Anchors	25	EA	$ 15,000	$ 375,000
7.05	Chamber 4 - Corps Side: Access Contingency	1	LS	$ 40,500	$ 40,500
7.06	Guard Lock - Mill Side: Rock Anchors	25	EA	$ 15,000	$ 375,000
7.07	Guard Lock - Mill Side: Access Contingency	1	LS	$ 137,500	$ 137,500
	Stabilize Chamber Walls in Select Locations Subtotal				***$ 1,052,000***
	Additional contingency to account for potential increased quantity of anchors (assume 10 add'l anchors @ $17.5K ea)				***$ 175,000***
	Stabilize Chamber Walls in Select Locations Subtotal				***$ 1,227,000***

Stabilize Gate Monoliths in Select Locations

8.00	Gate 4 - Corps and Mill Side: Rock Anchors	10	EA	$ 15,000	$ 150,000
8.01	Gate 4 - Corps and Mill Side: Access Contingency	1	LS	$ 65,000	$ 65,000
8.02	Gate 5 - Corps and Mill Side: Rock Anchors	10	EA	$ 15,000	$ 150,000
8.03	Gate 5 - Corps and Mill Side: Access Contingency	1	LS	$ 55,000	$ 55,000
8.04	Gate 6 - Mill Side: Rock Anchors	5	EA	$ 15,000	$ 75,000
8.05	Gate 6 - Mill Side: Access Contingency	1	LS	$ 27,500	$ 27,500
8.06	Gate 7 - Mill Side: Rock Anchors	5	EA	$ 15,000	$ 75,000
8.07	Gate 7 - Mill Side: Access Contingency	1	LS	$ 27,500	$ 27,500
	Stabilize Gate Monoliths in Select Locations Subtotal				***$ 625,000***
	Additional contingency to account for potential increased quantity of anchors (assume 6 add'l anchors @ $20K ea)				***$ 120,000***
	Stabilize Gate Monoliths in Select Locations Subtotal				***$ 745,000***

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project: Willamette Falls Locks | by: KMB/CMK | sheet no.
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Critical Need Requirements

Replace Gudgeon Anchors

9.00	(12) Gudgeon Anchors Parallel to Lock: Remove Existing Gudgeon Anchors & Assoc Hardware	3,381	LB	$ 1.00	$ 3,390
9.01	Gudgeon Anchors Parallel to Lock: Furnish and Install 8'-9.5" Long 1.75" Dia. Tie Rods (2/Gate for 6 Gates)	865	LB	$ 10.00	$ 8,650
9.02	Gudgeon Anchors Parallel to Lock: Furnish and Install Link Plates (4x1x10") (4/Gate For 6 Gates)	273	LB	$ 10.00	$ 2,730
9.03	Gudgeon Anchors Parallel to Lock: Furnish & Install Support Plates (4x1.75x12") (4/Gate For 6 Gates)	573	LB	$ 10.00	$ 5,730
9.04	Gudgeon Anchors Parallel to Lock: Furnish & Install Bearing Plates (8x1.25x10") (2/Gate For 6 Gates)	341	LB	$ 10.00	$ 3,410
9.05	Gudgeon Anchors Parallel to Lock: Furnish & Install Eccen. Support Plates (7x1x9.5") (4/Gate For 6 Gates)	453	LB	$ 10.00	$ 4,540
9.06	Gudgeon Anchors Parallel to Lock: Furnish and Install 8'-9.5" Long 1.75" Dia. Anchor Rods (2/Gate for 6 Gates)	865	LB	$ 10.00	$ 8,650
9.07	Gudgeon Anchors Parallel to Lock: Furnish and Install 1.75" Dia. Turnbuckle Hex(2/Gate for 6 Gates)	12	EA	$ 150	$ 1,800
9.08	(2) Gudgeon Anchors Perpendicular to Lock: Remove Existing Gudgeon Anchors (Gate 4 & 5 on Mill Side)	421	LB	$ 1.00	$ 430
9.09	(2) Gudgeon Anchors Perpendicular to Lock: Furnish & Install 8'-9.5" Long 1.75" Dia Tie Rods (Gate 4 & 5 on Mill Side)	144	LB	$ 10.00	$ 1,440
9.10	Gudgeon Anchors Perpendicular to Lock: Furnish & Install Link Plate (4x1x10") (4 Total)	45	LB	$ 10.00	$ 450
9.11	Gudgeon Anchors Perpendicular to Lock: Furnish and Install Support Plate (4x1.75x12") (4 Total)	95	LB	$ 10.00	$ 950
9.12	Gudgeon Anchors Perpendicular to Lock: Furnish & Install Bearing Plates (8x1.25x10") (2 Total)	57	LB	$ 10.00	$ 570
9.13	Gudgeon Anchors Perpendicular to Lock: Furnish and Install Eccen. Support Plate (7x1x9.5") (4 Total)	76	LB	$ 10.00	$ 760
9.14	Gudgeon Anchors Perpendicular to Lock: Furnish and Install DWYIDAG Anchor Rod (2 Total)	2	EA	$ 15,000.00	$ 30,000
9.15	Gudgeon Anchors Perpendicular to Lock: Furnish & Install 1.75" Dia Turnbuckle Hex (2 Total)	2	EA	$ 150.00	$ 300
9.16	(10) Gudgeon Anchors Perpendicular to Lock: Abandon Existing Anchor Rods: Remove Rest of Connection	2,169	LB	$ 1.00	$ 2,170
9.17	Gudgeon Anchors Perpendicular to Lock: Furnish and Install 9'-9.5" Long 1.75" Dia. Tie Rod (2/Gate for 5 Gates)	803	LB	$ 10.00	$ 8,030
9.18	Gudgeon Anchors Perpendicular to Lock: Furnish and Install Link Plate (4x1x10") (4/Gate For 5 Gates)	227	LB	$ 10	$ 2,270
9.19	Gudgeon Anchors Perpendicular to Lock: Furnish & Install Support Plate (4x1.75x12") (4/Gate For 5 Gates)	477	LB	$ 10	$ 4,770
9.20	Gudgeon Anchors Perpendicular to Lock: Furnish & Install Bearing Plate (8x1.25x10") (2/Gate For 5 Gates)	284	LB	$ 10	$ 2,840
9.21	Gudgeon Anchors Perpendicular to Lock: Furnish & Install Eccen. Support Plate (7x1x9.5") (4/Gate For 5 Gates)	378	LB	$ 10	$ 3,780
9.22	Gudgeon Anchors Perpendicular to Lock: Furnish & Install DWYIDAG Anchor Rod (2/Gate for 5 Gates)	10	EA	$ 15,000	$ 150,000
9.23	Gudgeon Anchors Perpendicular to Lock: Funish and Install 1.75" Dia. Turnbuckle Hex(2/Gate for 5 Gates)	10	EA	$ 150	$ 1,500
9.24	Remove existg and Form and Pour new concrete trenches at (12) locations (anchors perpendicular to lock)	9	CY	$ 2,000	$ 18,000
9.25	Trench plates over new concrete trenches at (12) locations	10	EA	$ 500	$ 5,000
9.26	Access Contingency: Gate 2	1	LS	$ 13,000	$ 13,000
9.27	Access Contingency: Gate 3	1	LS	$ 6,000	$ 6,000
9.28	Access Contingency: Gate 4	1	LS	$ 13,000	$ 13,000
9.29	Access Contingency: Gate 5	1	LS	$ 11,000	$ 11,000
9.30	Access Contingency: Gate 6	1	LS	$ 18,000	$ 18,000
9.31	Access Contingency: Gate 7	1	LS	$ 11,000	$ 11,000
	Replace Gudgeon Anchors Subtotal				***$ 345,000***

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Critical Need Requirements

Operator Anchorage Repair

10.00	Demolish and Remove Existing Concrete Base (3.5'x2'x3.5' Triangular Pyramid + 3.5' Cube) for 6 Locations	13	CY	$	500	$	6,500
10.01	Remove Existing Anchors	92	LB	$	1	$	100
10.02	Pour Concrete Base (3.5'x2'x3.5' Triangular Pyramid + 3.5' Cube)	13	CY	$	1,250	$	16,250
10.03	Furnish 3/4" dia anchor rods (60' long ea)	360	LF	$	5	$	1,800
10.04	Drill (4) 13' long 4" Dia. Holes at 6 Different Locations	312	LF	$	150	$	46,800
10.05	Primary Grout	12	CY	$	1,000	$	11,560
10.06	Access Contingency	6	LS	$	12,500	$	75,000
10.07	Proof Testing of Anchor	24	EA	$	7,500	$	180,000
	Operator Anchorage Repair Subtotal					***$***	***339,000***

Replace Pedestrian Draw Bridge over Lock 4

11.00	Replace Pedestrian Draw Bridge Over Lock 4 (Assume 10' Width x 45' Length)	450	SF	$	750	$	337,500
	Pedestrian Draw Bridge Over Lock 4 Subtotal					***$***	***338,000***

Replace Gangway Float at Downstream Approach

12.00	Replace Gangway Float at Downstream Approach	250	SF	$	500	$	125,000
	Replace Gangway Float at Downstream Approach Subtotal					***$***	***125,000***

Install new Piles in Concrete Foundation at Downstream Approach

13.00	Install (2) New Piles in Existing Undermined Concrete Foundation	2	EA	$	25,000	$	50,000
	Install new Piles in Concrete Foundation at Downstream Approach Subtotal					***$***	***50,000***

Replace Timber Lining in Chamber #3

14.00	Remove and Dispose of Existing Timber Lining in Chamber #3	6,114	LF	$	5	$	30,570
14.01	Furnish and Install new 3x12 Treated Timber	6,114	LF	$	21	$	128,400
	Replace Timber Lining in Chamber #3 Subtotal					***$***	***129,000***

Replace all Hydraulic Hoses

15.00	Inspect & document hoses, collect proper size and data for ordering	40	HR	$	150	$	6,000
15.01	Replace 1/2" valve operator hoses, 1/2" ID, 3'L, 1000# rated - 3000# rated	56	EA	$	100	$	5,600
15.02	Replace 144 hoses with 3/4" ID, 3'L, 1000# rated - 3000# rated	144	EA	$	130	$	18,720
15.03	man hours to replace hoses	56	HR	$	110	$	6,160
	Replace Hydraulic Hoses Subtotal					***$***	***36,500***

Sample Hydraulic Fluid

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	Critical Need Requirements						
16.00	Sample Hydraulic Fluid / Replace Hydraulic Fluid	7	EA	$	1,000	$	7,000
	Hydraulic Fluid Subtotal					***$***	***7,000***

Detailed Inspection/Documentation of all Fill/Empty Valves

17.00	Manhours for inspection and operation of each valve	200	HR	$	110	$	22,000
17.01	Inspection of Gate 1 & Gate 7 slide gate valves	2	DY	$	5,000	$	10,000
	Detailed inspection/documentation of all fill/empty valves & valve operators Subtotal					***$***	***32,000***

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Repairs to Valves (Projected)

18.00	Valve actuator cylinder refurbish	10	EA	$	1,850	$	18,500
18.01	man hours to fix valves	640	HR	$	110	$	70,400
18.02	Total Valve Replacement	7	EA	$	10,000	$	70,000
18.03	Total Valve Replacement labor - diver	2	DY	$	5,000	$	10,000
18.04	Dewatering	2	LS	$	35,000	$	70,000
18.05	man hours to replace valves	320	HR	$	110	$	35,200
	gate 7 valve seal and perimeter seal					$	-
18.06	gate 7 perimeter seal material	8	EA	$	1,000	$	8,000
18.07	gate 7 valve seal repair - diver	4	DY	$	5,000	$	20,000
18.08	Limit switch Repair	2	LS	$	26,000	$	52,000
	Repairs to valves (estimated) Subtotal					***$***	***354,100***

Lubricate all Systems

19.00	Lubricant	1	LS	$	500	$	500
19.01	Manhours to complete lubrication	160	HR	$	110	$	17,600
	Lubricate all systems Subtotal					***$***	***18,100***

Install New Gate & Valve Operating Cylinders at Gate #1

20.00	Valve actuator cylinders	8	EA	$	2,000	$	16,000
20.01	gate operator cylinder	2	EA	$	4,000	$	8,000
20.02	Manhours to uninstall / install	120	HR	$	110	$	13,200
	Install Gate & Valve Operating Cylinders at Gate #1 Subtotal					***$***	***37,200***

Salvage, Rebuild and Store Cylinders from Gate #1

21.00	Gate operator cylinder rebuild + transportation	2	EA	$	1,850	$	3,700
21.01	Slide gate operator cylinder rebuild + transportation	8	EA	$	2,100	$	16,800
	Salvage, Rebuild and Store Cylinders from Gate #1 Subtotal					***$***	***20,500***

Remove Debris

22.00	Mobilize/Demobilize	1	LS	$	5,214	$	5,220
22.01	barge rental	10	DA	$	1,034	$	10,340
22.02	backhoe rental + operator	10	DA	$	514	$	5,140
22.03	Waste disposal/delivery	2,000	EA	$	0.95	$	1,900
	debris removal Subtotal					***$***	***22,600***

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Install Fire Protection Equipment

23.00	Install 6" pipe with supports	3,105	LF	$	100	$	310,500
23.01	Install branch, valve and hose reel every 100'	20	EA	$	2,000	$	40,000
23.02	Pump Contingency - in case city water is not enough pressure	2	EA	$	68,250	$	136,500
	Fire protection equipment Subtotal					***$***	***487,000***

Inspect / Repair Generator, Install Packaged Load Bank

24.00	Generator inspection and full service	5	HR	$	150	$	950
24.01	New Generator	1	EA	$	39,910	$	39,910
	Inspect Generator, repair as needed and install a packaged load cell Subtotal					***$***	***40,900***

Repair Broken Luminaires

25.00	LED Luminaires	4	EA	$	1,723	$	6,890
25.01	Demolition Wiring - within poles only	110	LF	$	3	$	290
25.02	Installation Wiring - within poles only	110	LF	$	8	$	830
25.03	Switch Estimation	4	EA	$	286	$	1,150
25.04	Junction Box Estimation	4	EA	$	48	$	200
	Lighting System Subtotal					***$***	***9,400***

Inspect / Document of Electrical Distribution System

26.00	Inspection - electrician, electrical engineer	240	HR	$	150	$	36,000
26.01	drafting hours	320	HR	$	120	$	38,400
	Inspection/Documentation of Electrical/Power System Subtotal					***$***	***74,400***

Repair of Electrical Distribution System

27.00	Contingency Estimate	1	LS	$	50,000	$	50,000
	Electrical distribution system- conduit, conductors, enclosures, and supports Subtotal					***$***	***50,000***

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Critical Need Requirements		

Assumptions:

1.02 Assume 3x12 treated timber members
1.07 Assumes existing cabling can be reused and is pulled through new conduit
7.00 Price includes materials and installation (typical for all of task)
7.01 Access contingency costs account for how difficult it will be to get to the location and install the anchors
9.00 Remove and Replace in Kind on Gates 2 -7 (6 total), assume removing same weight as New Anchor Components
9.02 Assume 0.284 lb/ft^3 steel density to find total weight of steel (for all LB Quantities in task)
9.06 Assume length of embedded anchor rod is same as tie rod
10.00 Assumed amount of concrete based on As Builts of 1968

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	Moderate Need - 5 Year Requirements		

Opinion of Probable Construction Costs

#	Item	Quantity	Unit	Unit Cost	Cost (2018 $)
	Replace Chamber Ladders				
29.00	Replace Chamber Ladders	1	LS	$ 26,400	$ 26,400
	Replace Chamber Ladders Subtotal				***$ 27,000***
	Replace Damaged Guardrails (Railing on Mill Side from Gate 1 to Gate 5, and Guard Lock)				
30.00	Removal of Existing Guardrail (Railing on on Mill Side from Gate 1 to Gate 5, and Guard Lock)	1,051	LF	$ 8.00	$ 8,410
30.01	Chamber 1 (Chamber Length: 210' on One Side of Channel)	210	LF	$ 50	$ 10,500
30.02	Chamber 2 (Chamber Length: 210' on One Side of Channel)	210	LF	$ 50	$ 10,500
30.03	Chamber 3 (Chamber Length: 210' on One Side of Channel)	210	LF	$ 50	$ 10,500
30.04	Chamber 4 (Chamber Length: 210' on One Side of Channel)	210	LF	$ 50	$ 10,500
30.05	Guard Lock (Chamber Length: 211' on One Side of Channel)	211	LF	$ 50	$ 10,550
	Guard Rails Subtotal				***$ 61,000***
	Install New Hydraulic Power Units				
31.00	New HPU Cost	14	EA	$ 14,500	$ 203,000
31.01	Install/Demo Costs	14	LS	$ 5,000	$ 70,000
31.02	Pipe Replacement - 1"	2,646	LF	$ 26	$ 67,940
31.03	pipe demolition - 1"	2,646	LF	$ 3	$ 8,470
31.04	valves - globe- 1"	140	EA	$ 322	$ 45,050
	Install new Hydraulic Power Units Subtotal				***$ 394,500***
	Replace Bottom Seals				
32.00	Seal material cost	14	EA	$ 750	$ 10,500
32.01	Install manhour costs - Diver gate 1 & 7	4	DY	$ 5,000	$ 20,000
32.02	Dewatering - lock chamber 2, 3, 4, canal, guard lock	2	LS	$ 35,000	$ 70,000
32.03	Manhours for seal install - gate 2, 3, 4, 5, 6	160	HR	$ 110	$ 17,600
	Bottom Seals Subtotal				***$ 118,100***

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Moderate Need - 5 Year Requirements	

sheet no.

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Replace Lighting System

33.00	Replace Light Poles - 30' Aluminium	21	EA	$ 3,575	$ 75,080
33.01	Bracket Arms - 30' high	21	EA	$ 2,990	$ 62,790
33.02	LED Luminaires	19	EA	$ 1,723	$ 32,730
33.03	1000W flood lights replacement with LED's	4	EA	$ 2,795	$ 11,180
33.04	Demolition Wiring - within poles only	1,275	LF	$ 3	$ 3,290
33.05	Demolition poles	21	EA	$ 73	$ 1,550
33.06	Installation Wiring - within poles only	1,275	LF	$ 8	$ 9,620
33.07	Switch Estimation	120	EA	$ 286	$ 34,320
33.08	Junction Box Estimation	46	EA	$ 48	$ 2,220
33.09	20% Contingency for associated work & congested area work	1	LS	$ 42,736.00	$ 42,740
33.10	Guardlock wiring Replacement				$ -
33.11	Wiring installed overhead; #8 + overhead multiplier - corp side	1,236	LF	$ 11	$ 13,050
33.12	New conduit - mill side	67	LF	$ 16	$ 1,080
33.13	New wiring - mill side	379	LF	$ 6	$ 2,250
33.14	Wiring Demolition	1,615	LF	$ 3	$ 4,160
33.15	Conduit Demolition	100	LF	$ 3	$ 280
33.20	Wiring Replacement - Gate 1-5				$ -
33.21	Demolition wiring	19,815	LF	$ 3	$ 51,010
33.22	Demolition conduit	994	LF	$ 3	$ 2,690
33.23	Install 3/4" Conduit - 20% contingency for repair	419	LF	$ 13	$ 5,640
33.24	Install 1" Conduit - 20% contingency for repair	207	LF	$ 16	$ 3,330
33.25	Install 1.25" Conduit - 20% contingency for repair	368	LF	$ 19	$ 6,890
33.26	Install #8 wiring	11,845	LF	$ 8	$ 89,320
33.27	Install #10 wiring	5,680	LF	$ 6	$ 33,600
33.28	Install #12 wiring	2,290	LF	$ 5	$ 12,360
	Lighting System Subtotal				***$ 501,200***

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Replace/Refurbish Control System

34.00	Install new 2" conduit	5,500	LF	$ 26	$ 141,570
34.01	Install new 3/4" conduit	5,500	LF	$ 13	$ 74,010
34.02	Install new fiber optic cable - 4x 3/4" conduit run	22,000	LF	$ 1	$ 24,510
34.03	Install new wire #8, 3 conduit - 5x 2" run	33,000	LF	$ 8	$ 248,820
	Install of conduit through 2 lock chambers:				$ -
34.04	Dewatering	2	LS	$ 35,000	$ 70,000
34.05	Concrete - saw cut	240	LF	$ 8	$ 1,920
34.06	Waste Management - Concrete / oily waste	6	TN	$ 100	$ 610
34.07	install new concrete/re-enforced	3	CY	$ 850	$ 2,550
34.08	20x20 Enclosure NEMA 4X + install	4	EA	$ 1,000	$ 4,000
34.09	10x10 control/power Enclosure NEMA 4x + install	28	EA	$ 500	$ 14,000
34.10	HMI enclosure NEMA 4x + install	7	EA	$ 250	$ 1,750
34.11	Consoles for control houses + install	2	EA	$ 2,500	$ 5,000
34.12	Remote I/O's	15	EA	$ 400	$ 6,000
34.13	HMI screens + install	9	EA	$ 900	$ 8,100
34.14	PLC + install	1	EA	$ 10,000	$ 10,000
34.15	PLC programming	1	LS	$ 75,000	$ 75,000
34.16	Commissioning / start up	1	LS	$ 75,000	$ 75,000
34.17	Lock Chamber ultrasonic level sensors + backup, Lock chambers 1, 2, 3, 4, canal, guard lock	12	EA	$ 1,000	$ 12,000
34.18					$ -
34.19					$ -
	Control System Replacement Subtotal				***$ 774,840***

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Long Term Requirements		

Opinion of Probable Construction Costs

#	Item	Quantity	Unit	Unit Cost	Cost (2018 $)
	Repair Loss of Masonry at Lowest Course at the Downstream Approach, Mill Side				
35.00	Replace Masonry at Lowest Course with Reinforced Concrete	1	LS	$ 150,000	$ 150,000
	Loss of Masonry at Lowest Course at Downstream Approach, Mill Side Subtotal				***$ 150,000***

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Future Capital Costs		

Opinion of Probable Construction Costs

#	Item	Quantity	Unit	Unit Cost	Cost (2018 $)
	Inspect/Refurbish Gate Leaves				
36.00	Cost from 2009 Inspection and repair work in $2018	1	LS	$ 778,438	$ 778,440
	Refurbish Doors Subtotal				***$ 778,500***
	Flood Repair Contingency				
37.00	Repair contingency from 1996 flood repair work in $2018	1	LS	$ 449,960	$ 449,960
	Flood Contingency Subtotal				***$ 450,000***

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Routine Maintenance		

Opinion of Probable Construction Costs

#	Item	Quantity	Unit	Unit Cost	Cost (2018 $)
	Inspect Timber Lining and Replace Rotting Pieces as Needed				
1.00	2 Inspectors for 40 Hours (1 Week for all Chambers)	80	HR	$ 75	$ 6,000
1.01	Boat for 5 days	5	DY	$ 300	$ 1,500
1.02	Replacement of 5% of Timber Lining Per Year	1,885	LF	$ 21	$ 39,580
	Inspect Timber Lining and Replace Rotting Pieces as Needed Subtotal				***$ 48,000***
	Inspect Lock Walls and Region behind Lock Walls for Movement				
2.00	Inspect lock walls and region behind lock walls for movement	1	LS	$ 2,100	$ 2,100
	Inspection Subtotal				***$ 2,100***
	Inspect Masonry for Structural Integrity				
3.00	Inspect masonry for 2 missing rocks adjacent to each other to maintain structural integrity	1	LS	$ 2,100	$ 2,100
	Inspection Subtotal				***$ 2,100***
	Remove Debris as Needed				
4.00	barge rental	5	DA	$ 795	$ 3,980
4.01	backhoe rental + operator	5	DA	$ 395	$ 1,980
4.02	Waste disposal/delivery	1	EA	$ 2,000	$ 2,000
4.03	mobe/demobe	1	EA	$ 2,500	$ 2,500
	Remove debris as needed Subtotal				***$ 10,500***
	Hydraulic Fluid Sampling				
5.00	Fluid Sampling and Filtering	1	LS	$ 10,000	$ 10,000
	Replace Hydraulic Hoses Subtotal				***$ 10,000***

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	Routine Maintenance		

Replace One (1) Set of Gate and Valve Hydraulic Cylinder Operators

6.00	Valve actuator cylinders	8	EA	$	2,000	$	16,000
6.01	gate operator cylinder	2	EA	$	2,250	$	4,500
6.02	Manhours to uninstall / install	160	HT	$	110	$	17,600
	Replace one (1) set of gate and valve hydraulic cylinder operators					***$***	***38,100***

Lubricate Systems

7.00	Lubricant	1	LS	$	500	$	500
7.01	Manhours to complete lubrication	160	HR	$	110	$	17,600
	Lubricate all systems Subtotal					***$***	***18,100***

Run Generator on Load Bank Monthly

8.00	Operator Time	24	HR	$	110	$	2,640
8.01	Diesel fuel	24	GA	$	4	$	100
	Run generator on load cell for at least 30 minutes Subtotal					***$***	***2,800***

Limit Switch Inspection / Repair / Replacement

9.00	Limit Switch Inspection	40	HR	$	110	$	4,400
9.01	Replace gate limit switches	14	EA	$	1,000	$	14,000
9.02	Manhours to complete repairs/replacements	160	HR	$	110	$	17,600
	Limit Switch Subtotal					***$***	***36,000***

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Hydrographic Survey and Dredging

10.00	Mobilization and Demobilization for Dredging Only	1	LS	$	10,000	$	10,000
10.01	Hydrographic Survey (every 5 years)	1	LS	$	60,000	$	60,000
10.02	Downstream Approach (Chamber Size: 130' x 45', Dredge Depth: 4')	-	CY	$	30	$	-
10.03	Chamber 1 (Chamber Size: 210' x 45', Dredge Depth: 4')	700	CY	$	30	$	21,000
10.04	Chamber 2 (Chamber Size: 210' x 45', Dredge Depth: 4')	700	CY	$	30	$	21,000
10.05	Chamber 3 (Chamber Size: 210' x 45', Dredge Depth: 4')	-	CY	$	30	$	-
10.06	Chamber 4 (Chamber Size: 210' x 45', Dredge Depth: 4')	-	CY	$	30	$	-
10.07	Canal Basin (Chamber Size: 1272' x 45', Dredge Size: 4')	-	CY	$	30	$	-
10.08	Guard Lock (Chamber Size: 211' x 42'-5 7/16", Dredge Depth: 4')	-	CY	$	30	$	-
	Hydrographic Survey / Dredging Subtotal	-				***$***	***120,000***

Adjust Retention Diagonals on Miter Gate Leaf

11.00	barge rental	5	DA	$	795	$	3,980
11.01	backhoe rental + operator	5	DA	$	395	$	1,980
11.02	Manhours to complete task	120	HR	$	110	$	13,200
11.03						$	-
	Adjust retention diagonals Subtotal					***$***	***19,200***

Testing and Correction of Grounding System

12.00	Electrician time and Materials	1	LS	$	20,000	$	20,000
	Testing and Correction of grounding system Subtotal					***$***	***20,000***

Replace all Hydraulic Hoses

13.00	Replace 1/2" valve operator hoses, 1/2" ID, 3'L, 3000# rated	56	EA	$	100	$	5,600
13.01	Replace 144 hoses with 3/4" ID, 3'L, 3000# rated	144	EA	$	130	$	18,720
13.02	man hours to replace hoses	56	HR	$	110	$	6,160
	Replace all hydraulic hoses Subtotal					***$***	***30,500***

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p (206) 382-0600

project: Willamette Falls Locks	by: KMB/CMK	sheet no.
location: West Linn, OR	10/10/2018	
client: Summit Strategies		job no.
Routine Maintenance		

Slide Gate Inspection / J seal & J clamp PM

14.00	J seal and J clamp material costs	28	EA	$	1,000	$	28,000
14.01	Demolition / Installation costs - diver gate 1/7	4	DY	$	5,000	$	20,000
14.02	Dewatering - for repairs for valves on gates 2/3/4/5/6	2	LS	$	35,000	$	70,000
14.03	Manhours for repairs on gates 2/3/4/5/6	320	HR	$	110	$	35,200
14.04	Inspection Costs	40	HR	$	110	$	4,400
	J seal & J clamp PM Subtotal					***$***	***157,600***

Assumptions:

1.02 Total price is 3x the cost of a 3"x12" to account for installation and delivery

	Cost Accrued	Raw Estimated Costs	Annualized Costs ($2018)	Annualized Costs with Contengancy ($2018)
Annual Maintenance Costs	1	$ 168,000.00	$ 168,000.00	$ 262,080.00
Five Year Maintence Items	5	$ 348,000.00	$ 69,600.00	$ 108,576.00
Gate Inspection/Repair	25	$ 778,500.00	$ 31,140.00	$ 48,578.40
Flood Repairs	30	$ 450,000.00	$ 15,000.00	$ 23,400.00
				$ 443,000.00

APPENDIX B – KPFF DRAFT FIELD REPORT

FIELD REPORT - *DRAFT*

kpff Consulting Engineers

1601 Fifth Avenue, Suite 1300
Seattle, WA 98101
(206) 382-0600 I Fax (206) 382-0500

To:	**Michelle Giguere, Partner Summit Strategies**	Date:	**July 6, 2018**
		Job No.	**1800288**
		File No.	
		Location:	**West Linn, OR**
By:	**Dan Hartford, PE Bob Riley, PE, SE**	Weather:	**Overcast, High 50's**
Project:	**Willamette Falls Locks**	Others Present:	**Michelle Giguere & Kristine Phillips Everetz – Summit Strategies; Patrick Duyck - USACE**

The following was observed:

We met on site on May 30, 2018 at 8:30 am to perform a general condition assessment of the Willamette Falls Locks on the Willamette River in West Linn, Oregon. The lock is comprised of a series of 7 gates and 6 chambers. Gate 1 is furthest downstream and Gate 7 is furthest upstream, closest to the Falls. The uppermost chamber is the 210 foot long Guard Lock, followed by the approximately 1,275 foot Canal Basin, followed by Locks 4, 3, 2 and 1, each of which are also 210 feet long. A site overview map is provided by the USACE at the following link: Willamette Falls Locks Area Map.pdf (www.nwp.usace.army.mil/Portals/24/docs/maps/Willamette_Falls_Locks_area_map.pdf).

The Corps owns and operates the West Linn side of the lock, whereas the West Linn Paper Company and Portland General Electric (PGE) have been operating on the river side of the lock. It is our understanding that West Linn Paper Company has ceased operations at the facility within the last 6 months.

The facility was opened to operations in 1873 and has been in a non-operational status since 2011. Gates #1 & #6 are currently kept in an open position, with the remaining 5 gates kept closed. Lock chambers 1 thru 4 are currently kept empty, with the Guard Lock and Canal Basin kept full. It is our understanding that the US Army Corps of Engineers owned and maintained the facility from 1915 until present day, with much less maintenance in recent years. General observations are consistent with a facility that has been well maintained over the years, as much of the infrastructure was still in fair condition, considering the 145 year age of the facility.

It should be noted that performing a full detailed conditions assessment on a facility of this size would take several days. The results reported herein are based on spending 2 hours at the facility and are only based on our visual observations and available historic documentation. No material testing or detailed measurements were taken during our site visit.

General

All lock gates are miter style, consisting of two leaf structures supported by timber quoin blocks at the lock wall and by timber miter blocks at the lock centerline. When open, each gate leaf swings on a pintle bearing located under the quoin block and is held in place by two gudgeon anchors, one parallel to the lock to support the gate in the open position, and one lateral to the lock, in line with the gate when in the closed position. Each miter gate leaf is constructed from a steel frame with a steel face skin on the upstream surface and a timber facing on the downstream face. Each gate leaf is operated by a hydraulic cylinder located just upstream of the quoin block and anchored to the top of the lock wall. Figure 1 provides a typical plan view of the miter gates (note that the lock centerline is coincident with the miter block and only one of the two gate leaves is shown).

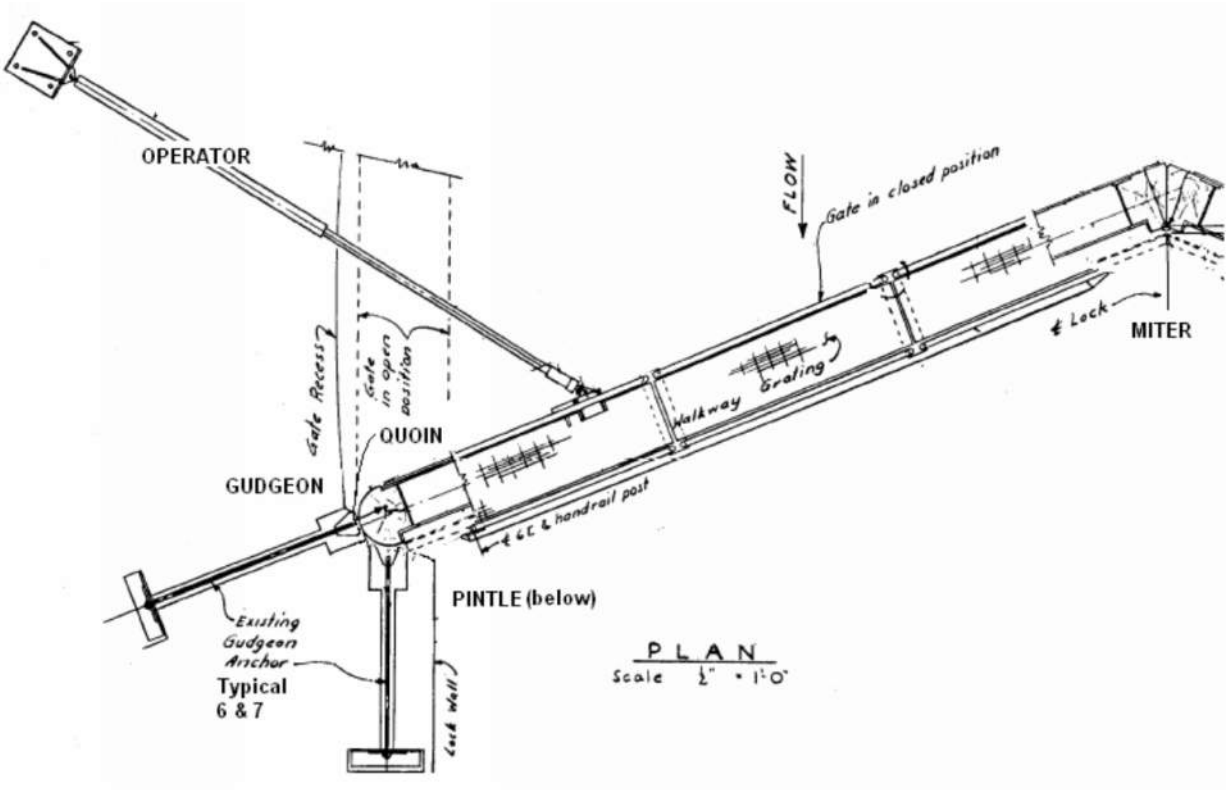

Figure 1 - Typical Miter Gate Plan

The gudgeon anchors are comprised of steel rods that are connected to a link plate that is then attached to a ground anchor rod. Gudgeon anchor configuration varies from gate to gate due to

geometric constraints at the site. The method of ground anchor rod attachment to the foundation is below grade and unknown.

The lock fill/empty system consists of hydraulic cylinder operated slide gates installed directly on the miter gate structures. Hydraulic power for both the miter gate cylinders and the fill/empty gate cylinders is provided by a small hydraulic power unit (HPU) located on top of the lock wall, just upstream of the quoin block on the West Linn side. High pressure oil from the HPU is carried by hard pipe to a location adjacent to each cylinder with the final connection being made with high pressure hydraulic hose. High pressure hydraulic hoses also connect gate mounted hard piping for the fill/empty cylinders to hard piping on the lock wall. Hydraulic fluid and controls for the opposite lock wall are routed from the HPU on the West Linn lock wall via trenches cut into the walls and across the lock chamber floor.

Gate actuation is accomplished electrically via controls mounted directly on each HPU or via remote control stations located at one of three Lock Control Stands (LCS). Lock Control Stands are numbered sequentially with LCS1 adjacent to Miter Gate 2 and LCS2 adjacent to Miter Gate 4, both on the West Linn side of the lock. LCS3 is located on the opposite side of the lock adjacent to Miter Gate 6. Miter Gates 1, 2 and 3 are remotely operated from LCS1 and Miter Gates 3, 4, 5, 6 and 7 are remotely operated from LCS2. LCS3 originally intended to remotely operate Miter Gates 6 and 7 is no longer used.

The lock electrical system consists of power distribution, lighting, controls, CCTV System and a standby generator. The majority of the power distribution, lighting, controls and the CCTV system were installed during the lock upgrades in 1966/1968. Much of the wiring, junction boxes and control components were replaced subsequent to flooding that occurred in 1996. In general, the electrical systems are functional but are in poor overall condition. The project staff at the site indicated that not all limit switches are functioning and that they cannot rely on control indicator lights to verify gate position. We noted at least one electrical junction box that was left uncovered, presumably to allow water to drain from the box. The standby generator and an automatic water balancing system was also added during the 1996 repairs.

<u>Lock 1</u>

This lock was created by cutting into the native rock, with the side walls comprised of timber facing in front of the native rock. This lock is bound by Miter Gate 1 on the downstream side and Miter Gate 2 on the upstream side. Gate 1 is kept in an open position, and Gate 2 is kept in a closed position. Total design lift on this lock is 20.5 feet. See photo #1 for an overall view of Lock 1 and photo #2 for Miter Gate 1 in the closed position. See photos #12 & #13 for close ups of Gate 1 in the open and closed positions.

At 31’- 9”, Gate 1 is the tallest of all Miter Gates used on the project. Aside from the height, the gate structure, quoin block, miter blocks, and other structural details appear to be similar to all other gates. Features unique to this gate include a roller/guide arrangement at the top of the miter block (likely intended to mechanically enforce alignment of the miter block), along with a unique gudgeon

anchorage that utilizes short anchor rods installed in keyed slots in the lock wall. See Photo #3 for the roller arrangement, Photo #4 for the quoin block and Photo #6 for the gudgeon anchorage.

The Miter gate was operated at our request by Corps personnel. The gate appeared to operate normally with no signs of malfunction or other mechanical concerns. The overall condition of the system appeared to be functional.

Shortly after gate operation, our team was able to observe a small quantity of liquid bubbling to the surface of the water and creating a small sheen on the water surface. The liquid appeared just downstream of the quoin block on the West Linn side gate. While we are not able to verify the specific fluid observed, it is possibly hydraulic fluid leaking from the hydraulic pressure pipes serving the gate operating equipment on the opposite lock wall. It may also be oils or other hydrocarbons stored in the built up sediments within the chamber that were disturbed upon gate operation.

The gate's gudgeon anchorage system functioned as designed. With the gate closed, each gate leaf was firmly seated between the miter and quoin blocks and the gudgeon anchors appeared to be unloaded. As soon as the gates started to open, a gap opened between the quoin post and the quoin block, transferring the gate's dead weight to the gudgeon anchor bars. (See Photo #5 and #6 for typical condition.)

The gate hydraulic operating cylinders appear to be National Fluid Power Association (NFPA) standard tie rod type industrial cylinders. The cylinders are connected to the gate via standard clevis and a short threaded rod with lock nuts. This arrangement allows the length of the cylinder to be adjusted to fine tune the location of the gate in the open position. Based on the cylinder's paint system and the use of threaded piping for the rod and blind end fluid connection, these cylinders were likely installed prior to 1970. Although some surface rust is apparent on the rod end connections and cylinder bodies, the cylinders are in relatively good condition and should provide reliable service if the system is put back in operation. That being said, these cylinders are well past the typical service life that would be expected and should be replaced or fully refurbished in the near future. This situation will be exacerbated by the current "care-taker" status of the facility, which dramatically limits the number of gate operations (cylinder extend/retract cycles) seen by each cylinder. (See Photos #7 and #8 for typical cylinder condition.)

On the lock wall, the miter gate cylinders are attached to steel brackets installed directly onto native stone. The steel brackets appear to be in good condition, solid and well anchored. (See Photo #9)

While we did not observe operation of the fill/empty valves, the operation staff indicated the system was operational and that there were no known issues. There is indication in the historic documents that at least 16 of the 56 total fill/empty system cylinders were replaced in 1993, however it is not clear where the 16 new cylinders were installed. Similar to the miter gate operating cylinders, these fill/empty system cylinders are well past their expected life and should be refurbished or replaced in the near future.

The hydraulic power unit (HPU) serving Miter Gate 1 appeared in relatively good condition considering its age and was fully functional. The unit consists of a rectangular reservoir and a reservoir-top mounted pump/motor group installed on a modular skid structure. Filters, solenoid operated directional control valves, motor controls and other ancillary components are all installed onto the skid structure above the reservoir. The HPU skid is enclosed by a free standing stainless steel shed and is accessible through hinged doors. (See Photo #10 for the Gate 1 HPU and Photo #11 for a typical HPU). Overall, these HPU's are well beyond their typical service life and will require more attention to maintenance and repair than a modern packaged hydraulic power unit. While individual components are relatively old technology, they are still functioning well and there is no reason that they cannot provide adequate service for future operation of the locks as long as they are carefully maintained. As components begin to fail, they can easily be replaced with their modern equivalent without needing to completely replace the entire HPU.

Hydraulic pressure piping between the HPU to the cylinders all appears to be carbon steel with threaded fittings. Overall the pipe appears to be in good condition with minor surface corrosion visible on portions of the pipe and pipe fittings. No obvious leaks or indication of leaks were observed, (with the exception of the possible underwater leak mentioned above), and there is no indication that the system would not support regular operation of the gate if the locks were placed back in service. While the system may be adequate to support operation, it will be more prone to developing leaks than a modern piping system due to the use of tapered pipe threads and threaded fittings. This type of fluid connection is not good practice and would not be allowed on a modern hydraulic piping system. Given the potential underwater leak, and the use of tapered pipe threads, this pipe system should be replaced by a modern welded pipe system. Ideally, this replacement would occur prior to returning the locks to full service. All hydraulic hoses on the system appear to be in good condition, but should all be replaced prior to placing the lock back in regular service as they have an expected service life of only about 5 years.

Operation of Gate 1 was accomplished using the local HPU mounted controls. The project staff member present indicated that the gate controls in LCS1 functioned properly and that there were no known issues operating the gate remotely. Based on the available documentation, we believe that remote control of the gates is accomplished through hard wired selector switches and control relays. There is an assertion in a July 27, 2007 report completed by INCA Engineers that the analog control system was replaced by a digital control system around 1996. The March 26, 2013 Interim Engineering Design Report (EDR) completed by Tetra Tech indicates that the gate controls are still analog and are still using the original 1966/1968 control devices.

Much of the lock is faced with timber to be used as fendering to protect vessels from hitting either the miter gate or the rock walls. Timber exposed to water is susceptible to decay and it should be expected to need to replace the timber facing on a fairly regular basis. Corps staff indicated that in the past they regularly replaced the timber facing due to rot and decay.

The steel gate framing was not visible due to the timber facing, so the extent of any corrosion could not be assessed. It would be reasonable to assume that the steel gates are galvanized, and in a fresh water environment, should have at least a 30 year life span before significant maintenance is required. Based on the 2007 report, all of the gates (except Gate 3) were rehabilitated between 1993 and 2001.

Further, based on the 2013 EDR , all gates were removed from the lock chamber, inspected, rehabilitated and reinstalled in 2009. At this time, the miter gate leaves, miter posts and quoin posts were judged to be sufficient to remain safe for up to 10 years without maintenance.

The gudgeon anchors are showing some signs of corrosion, but did not appear to be showing signs of significant section loss. At a time in the next 5 to 10 years, the gudgeon anchors should be replaced to reduce the risk of anchor failure due to further deterioration. Generally the anchors parallel to the lock chamber appear to be anchored to the lock wall and are readily accessible.

Lock 2

This lock was also constructed by cutting into the native rock, and has a similar timber side wall construction to Lock 1 for most of its length. Lock 2 is bound by Gate 2 on the downstream side and Gate 3 on the upstream side, both kept in a closed position. Approximately two-thirds of the downstream length of the lock has a timber facing, with the upstream one-third having an exposed ashlar masonry facing. This upper section of the lock was constructed out of large stacked masonry rock and was backfilled behind the masonry wall.

Many utilities cross under the lock within Lock 2 to feed the old Paper Mill across the chamber. These utilities appear to include water, sewer and electrical lines.

Similar to Lock 1, the timber facing is subject to decay and rot and should be expected to be maintained regularly.

Miter Gate 2 is 19'- 6 3/8" tall and is otherwise similar to the other Miter Gates on the project. Like Miter Gates 3, 4, 5 and 6, this Gate utilizes a linkage style gudgeon anchor. In this arrangement, long gudgeon bars are installed directly onto the gudgeon pin and are then connected to a small plate linkage. The plate linkage then connects to steel anchor rods installed in the lock wall. The plate linkage is intended to simultaneously allow the gudgeon bars to pull on the anchor rod while preventing them from pushing. For Gate 2, the gudgeon bars are showing some signs of corrosion, but did not appear to be showing signs of significant section loss.

Generally the anchor rods parallel to the lock chamber appear to be anchored to the lock wall and are readily accessible. The Corps has noted concern about the condition of the anchor rods used by the lateral gudgeon bars. Large portions of these anchor rods are not visible and cannot be visually assessed. To address this concern, two options may be undertaken. One would be to excavate around the anchor, where there is access, to the point at which the anchor is embedded in concrete (and should be corrosion free within the grout surrounding the anchor); or Two would be to perform a tension pull test on the anchor to verify its capacity. A third potential option would be to abandon the anchor completely and provide a new drilled in anchor with a known capacity. Note that access to the gudgeon anchors on the Corps side of the lock is difficult due to an existing framework of utilities supported by a timber boardwalk. See Photo #14.

The gate was operated by the Project staff from the remote control station in LCS1. Gate operation appeared normal with no signs of malfunction or other mechanical concerns. The overall condition of the system appeared to be functional.

Gate #3 is similar in construction to the other gates but is 19'- 5 3/8" tall. As this gate was operated, the lateral gudgeon anchor on the Corps side visibly displaced several inches upward as the gate leaf came back to the fully open position. In this position, the tension on the lateral anchor is relieved, and therefore the gudgeon anchor is free to relax. This may be indicative of the ground anchor not being fully embedded and likely requires some maintenance prior to any re-opening of the lock. The area around this anchor is free of obstructions and could easily be excavated to allow further investigation of the below ground condition. (See Photo #15)

Aside from the gudgeon anchor system and the gudgeon anchor issue noted above, the overall condition of the mechanical and electrical and systems is similar to that observed on Gates 1 and 2. The concrete pad provided to anchor the miter gate operating cylinder on the West Linn side of the lock is in poor condition and as a result, the cylinder mounting bracket moves substantially as the gate is operated. This condition is not optimal but creates no real safety issue for the gate. The gate operating cylinders are painted black and appear to have been replaced more recently than the cylinders on Gates 1 and 2.

Lock 3

This lock is bound by Gate 3 on the downstream side and Gate 4 on the upstream side, both kept in a closed position. It is our understanding that this lock was constructed with stacked ashlar masonry block and then backfilled. The lock walls are faced with timber fendering for their full height. There appears to be a several foot gap between the face of masonry and the timber facing, with the timber wall being built out several feet away from the masonry with timber cribbing and framing. On the Corps side of the lock, the downstream approximately 100 feet of ground surface adjacent to the lock wall has washed out. According to Corps staff, water got between the face of masonry and the backside face of the timber facing and washed out most of the backfill between these surfaces. There is currently orange fencing in place to keep people from walking in this area. See Photo #16.

When Lock 3 is full of water, the water leaks through the wall and continues around Gate 3 downstream to Lock 2, causing additional erosion around the base of the elevated Gate 3 control house and infrastructure just downstream of the gate house.

Gate 4 is identical to gate 2 and appears to be in similar condition to the other gates inspected. The main gate operating cylinders are painted black and appear to be installed more recently than the cylinders observed on Gates 1 and 2. Gate anchorage plates and other hardware appear to be in reasonable condition.

Lock 4

Lock 4 is similar to Lock 3 in its construction, with masonry walls and timber facing. This lock is bound by Gate 4 on the downstream side and Gate 5 on the upstream side, both kept in a closed position.

Gate 5 is holding back the Canal Basin, which is full of water. This gate appears to be leaking at the sill, the miter joint, and through a few of the slide gates within the miter gate. See Photo #17.

There is a pedestrian drawbridge in the middle of this lock that provides access from the Corps side to the Mill side of the lock. The drawbridge appears to be in moderate to poor condition.

At 12'–5 3/16" tall, Gate 5 is the smallest of the miter gates installed at the project. This gate was not operated during our site visit due to the amount of water on the Canal Basin side. A visual inspection of the structural, mechanical and electrical features of this gate confirmed that it's overall condition was similar to the other gates inspected.

Canal Basin

The Canal Basin is bound by Gate 5 on the downstream side and Gate 6 on the upstream side. Gate 5 retains the water elevation within the Basin to allow it to remain full. Gate 6 is kept open so that the Guard Lock and Canal Basin have the same water elevation.

The Corps side of the Basin appears to have a natural rock outcrop embankment, see photo #19. The Mill side of the Basin has a concrete bulkhead wall that acts as a loading dock for barges accessing the Mill facility. There also exists a hydraulically controlled loading ramp along this wall. See photo #18.

The upstream end of the Basin transitions from the Mill property to the Portland General Electrical power generation plant. At this section of the Basin, the PGE facility side has a large concrete bulkhead and intake structure for a fish ladder.

Guard Lock

The Guard Lock is bound by Gate 6 on the downstream side and Gate 7 on the upstream side. Gate 6 is kept in an open position and Gate 7 is kept closed. See photo #22 for a view of Gate 7 from upstream of the gate. The water elevation within the Guard Lock appears to be within 2 to 3 feet of the water elevation within the river, such that Gate 7 does not need to support a large head differential on one side of the gate.

The Corps side of the lock is constructed from a concrete counterfort wall, with a small section at the upstream end constructed from stacked ashlar masonry. The PGE side is constructed from stacked ashlar masonry with a 2 to 3 foot thick concrete cap on top of the masonry. See photo #20 for an overview of the Guard Lock looking downstream and photo #21 of the joint between the concrete counterfort wall and the ashlar masonry wall.

Neither gate 6 nor gate 7 were operated while we were on site. The gate and anchors appeared to be in a similar condition to the other gates further downstream. Gate machinery and electrical controls for these structures is similar to that observed on the other gates.

Note that LCS3 located on an elevated structure adjacent to Miter Gate 6 is in very poor condition. Project staff indicated that this structure has been condemned and is no longer used. Operation of

Miter Gate 6 and 7 is accomplished using the local control stations on the HPU or from LCS2 adjacent to Miter Gate 4. (See Photo #23)

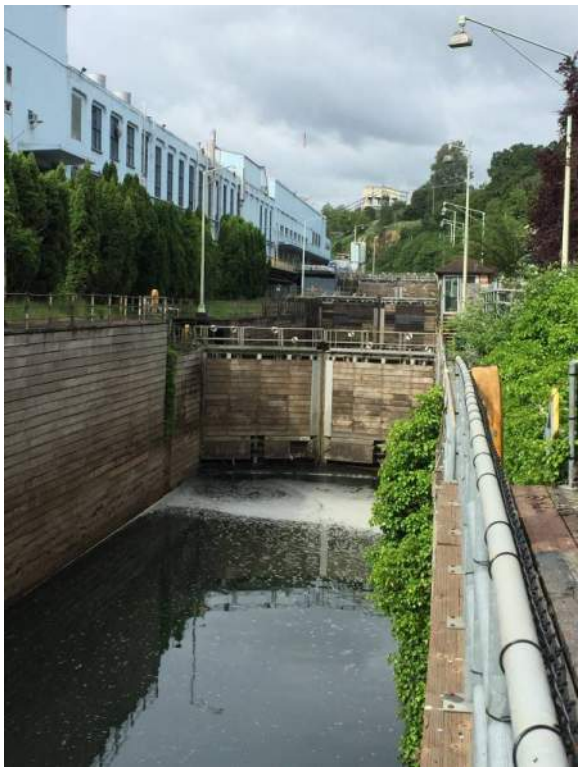

Photo #1

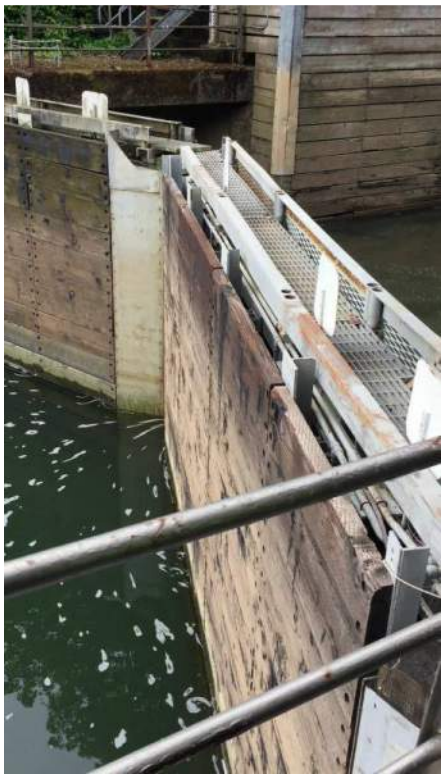

Photo #2

Photo #3

Photo #4

Photo #5

Photo #6

Photo #7

Photo #8

Photo #9

Photo #10

Photo #11

Photo #12

Photo #13

Photo #14

Photo #15

Photo #16

Photo #17

Photo #18

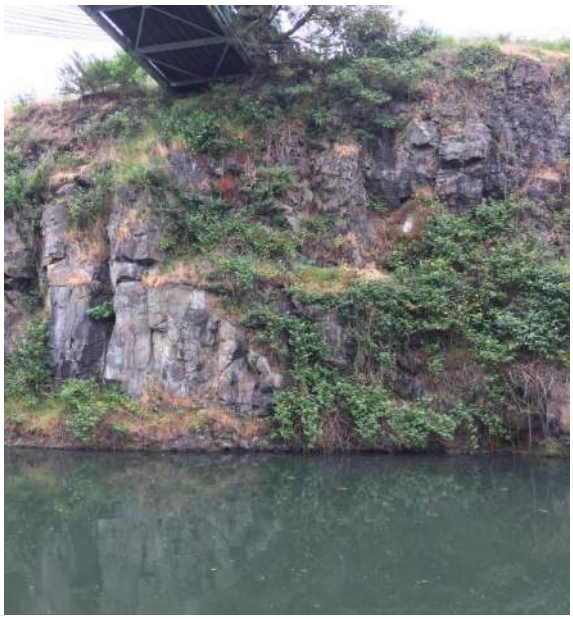

Photo #19

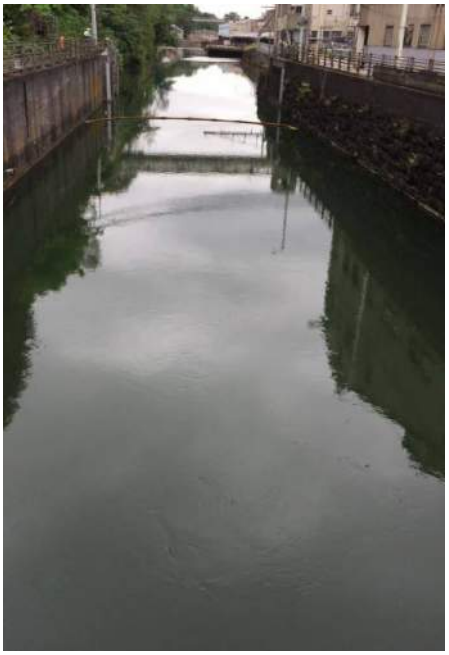

Photo #20

Photo #21

Photo #22

Photo #23