Guidelines for Developing Dam Operation and Maintenance Manuals

Dam Safety Office
Water Resources Program

Washington State Department of Ecology
Olympia, Washington

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Guidelines for Developing Dam Operation and Maintenance Manuals

Dam Safety Office
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Olympia, WA

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Table of Contents

Introduction

An Operation and Maintenance (O&M) Manual is a detailed written description of systematic procedures for ensuring that a dam is operated and maintained properly. Adequate operation and maintenance is critical for ensuring the continued safe functioning of the dam, and ongoing productive use of the dam and reservoir.

Ecology's Dam Safety Office (DSO) created these guidelines to assist dam owners/operators in developing O&M Manuals for their projects. The need for these guidelines was prompted by State Dam Safety Regulations (Chapter 173-175 WAC[3]), which took effect February 27, 2012. These regulations require owners of new projects to submit an Operation and Maintenance Plan that summarizes how the project is to be operated, and outlines how the basic elements of monitoring, inspection, and maintenance are to be accomplished. Owners are then responsible for incorporating the details of the O&M Plan into an O&M Manual, suitable for use by dam operators.

The format of these guidelines parallels the layout of a typical O&M Manual. Each section of the guidelines provides an overview of the general purpose, intent, and contents of the corresponding section of the manual. Appendix A contains a sample O&M Manual showing how the various components of an O&M Manual are typically written.

DSO has also designed a O&M Plan template[4] to aid dam owners in creating an O&M Plan. For some simple earthen dams, completing this plan, or something equivalent, will satisfy the O&M Manual requirement under WAC 173-175-500. For other dams - like large concrete dams – DSO may require a more comprehensive, detailed manual, which incorporates this plan. DSO will make this determination on a case-by-case basis after reviewing the completed O&M plan template.

If you have been required to complete the full O&M Manual, at minimum, it should contain the following sections:

SECTION I - GENERAL INFORMATION is the introductory section of the O&M Manual, which discusses the purpose of the manual, and provides general information about the project, includes a Project Data Sheet and identifies the individual(s) responsible for implementing the plan.

SECTION II – PROJECT OPERATION provides details of how to operate the reservoir and equipment at a project.

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[3] https://apps.leg.wa.gov/WAC/default.aspx?cite=173-175

[4] https://apps.ecology.wa.gov/publications/summarypages/ecy07039.html

SECTION III – MAINTENANCE provides detailed information and instructions on performing periodic maintenance and upkeep at the dam.

SECTION IV – INSPECTION provides information on performing regular inspections of a dam by the owner/operator.

SECTION V – INSTRUMENTATION & MONITORING provides information on instrumentation at the dam, and instructions for monitoring and recording data.

SECTION VI – UPDATING provides procedures for the periodic updating of the manual.

Section 1 – General Information

This section should briefly describe the purpose of the O&M Manual, and provide general information about the project. Information in this section would include:

Purpose of O&M Manual

Briefly provides an introduction to the O&M Manual and a general statement on the overall purpose of operation and maintenance at the dam.

Land and Access to the Dam

Tells which creek/river the dam is located on (or near, for reservoirs), the county it is in, and the nearest city/town. It may also provide directions for traveling to the dam.

Purpose of Project

Explains the primary and secondary purposes of the dam and reservoir (e.g. flood control, irrigation, recreation, etc.)

General Description of the Dam and Reservoir

Identifies all major project features, including:

- Dam owner and operator.
- Type of dam (earthfill, rockfill, concrete).
- Dam height, length, and crest width.
- Location and type of spillway(s) and outlet works.
- Surface area and storage volume of reservoir.

Project History

Briefly outlines the history of dam and reservoir, including date(s) of construction, original project engineer and contractor, and any significant modifications or events that have taken place during the life of the facility.

Assignment of Responsibilities

Clearly identifies individuals for implementing the O&M manual and all areas of responsibility for operating personnel with respect to dam and reservoir operation and maintenance. Typical responsibilities would include: overall responsibility of project, equipment operation at dam, performing inspections, routine maintenance work, and recording monitoring data. Putting this information in a table format is most useful.

Project Data Sheet

Lists all major features of the dam in an easy to follow, tabular format, including the spillway(s), outlet works, and appurtenant structures and their locations at the dam site. See Appendix B.

Record Keeping

List all of the records to be kept at the dam and the location of those records. Typical types of records are maintenance records, monitoring records, gate operations, observations, pool levels, unusual weather events, drawdowns, inspections, and photos.

Facility Security

List the ways intentional damage from outside parties may be prevented at the facility. Describe any security monitoring equipment, fences, safety/warning signs, barriers, access gate, etc.

Diagrams

Include drawings in the O&M Manual showing:

- Where all hydraulic elements are located, such as:
    - Areas of surface runoff inflow to reservoir from upstream watershed
    - Inflow pipeline or channel (include gates, valves)
    - Drop inlet spillway(s) (include gates, valves)
    - Open channel or weir spillway (include gates, valves, stoplogs)
    - Culvert spillway (include gates, valves, stoplogs)
    - Storm pond flow control structure (include gates, valves, orifices)
    - Low outlet pipeline – reservoir drain (include gates, valves)
    - Low outlet pipeline – water supply (include gates, valves)
    - Diversion channel to divert runoff away from or around reservoir
- The locations of all instrumentation, such as:
    - Weirs, flumes, pipes and other means to measure seepage flow
    - Monitoring/Observation wells to measure water levels
    - Piezometers to measure pore pressures within embankment/foundation
    - Staff gauges to measure reservoir levels
    - Flumes, weirs, and/or gauges to measure reservoir inflow/outflow
    - Rain gauge to measure precipitation

Section II – Project Operations

This section provides details of how to operate various elements of a project. The extent of operation procedures depends on the complexity of the dam itself. Operation procedures for normal or "day to day" operations would include:

- Instructions for operating the reservoir.
- Instructions for operating all control mechanisms.

Operation procedures are also developed for emergency situations. Such situations require special operating procedures, normally contained in a separate document called an Emergency Action Plan. Emergency Action Plans are required for all high hazard and significant hazard dams.

Operating Instruction for Reservoir (Rule Curve)

Instructions on the general operation of the reservoir should be provided, including the regulation of inflow and outflow ditches (if applicable). The instructions should state the maximum allowable pool levels at different times of the year, maximum or minimum permissible outlet releases, operation of the outlet to limit or prevent excessive spillway flow, and the method for lowering the reservoir to permit outlet or upstream slope inspection. The instructions should describe which gates and/or valves must be operated to regulate the reservoir.

Note: Most small dams operating requirements are unlikely to be as complex (e.g. flood control, irrigation supply) as shown in the example manual in Appendix A. **However, a set of reservoir operating instructions is necessary even if the procedures are very simple.**

Operating Instructions for Control Mechanisms

The manual should provide complete, clear, step-by-step instructions for operating all mechanisms associated with a dam, including the outlet control valve(s) and spillway gates. The instruction should include a general description of the mechanism, its location, and its purpose. Proper sequences should be emphasized, and sketches, drawings, and photographs to aid in identifying specific handles, cranks, buttons, etc. should be included. The correct method of opening and closing guard gates, gate usage during low and high flows, openings at which excessive vibrations are experienced, and operating problems peculiar to a specific gate should also be listed, as necessary. For hydraulic and electric gates, a schematic diagram should be provided showing each component (including back-up equipment) and its place in the operating sequence. See Appendix A, Section II for an example. Provide examples of operating instructions for typical dam mechanisms.

Section III – Maintenance

This section of the O&M Manual provides detailed information and instruction on performing periodic maintenance at a dam. Maintenance is a task that should never be neglected. A good maintenance program will prevent deterioration of the dam, prolong its life, and maintain a safe structure. A maintenance program should consist of the following three elements:

- Regularly Scheduled Maintenance
- Monitored Maintenance
- Unscheduled Maintenance

The maintenance plan is best presented in a table format that includes the elements being maintained, frequency, and description of the maintenance activity.

Regularly Scheduled Maintenance

Regularly scheduled maintenance involves servicing equipment, replacing parts, or performing routine tasks according to an established schedule. Scheduled maintenance may be anything from a monthly lubrication routine on a valve, to annual replacement of component parts on a piece of equipment. Scheduled maintenance can be based on time (e.g. days, months, years, etc.) or the amount of use (e.g. hours of operation, number of cycles, etc.). Equipment maintenance schedules are normally based on the manufacturers specifications.

Monitored Maintenance

Monitored maintenance involves periodic surveillance and testing of equipment and making repairs or modifications as needed. Establish a surveillance schedule based on predictions of the wear rates of certain types of equipment or materials. For example, the oil in a hydraulic system may be changed every 100 hours of operation (scheduled maintenance), while the oil level may be checked every week and oil is added as needed (monitored maintenance). Other examples of monitored maintenance would include: inspecting trash racks weekly and clearing debris as needed, and checking gate leakage monthly and replacing seals as needed.

Unscheduled Maintenance

Despite having a proper maintenance program, unexpected deficiencies can occur at any time, prompting the need for repairs or replacement. Unscheduled maintenance is maintenance performed on an as-needed basis. The need for unscheduled maintenance may be identified during the performance of preventative maintenance, as a result of dam safety or O&M inspections, or after an unusual event such as a flood. Examples of unscheduled maintenance would include:

- Repairing and reseeding eroded areas and gullies on embankment dams.
- Repairing defective gates, valves, and other equipment discovered during inspections.
- Repairing damage to earth lined emergency spillways following a flood.

Although unscheduled maintenance cannot be planned for in a maintenance plan, an owner should anticipate the need for repair or rehabilitation of unexpected deficiencies. To this end, the Maintenance Plan should include a section that gives instructions for dealing with unscheduled maintenance. Major repairs or improvements necessitate review and approval by the Dam Safety Office.

Section IV – Inspection

An effective inspection program is essential for identifying problems and providing safe performance of a dam. Thus, the O&M Manual should contain a section on inspection. A proper inspection program should involve the following three types of inspections:

- Routine, informal inspections
- Annual safety inspections
- 5-year Periodic Inspections
- Periodic inspections
- Non-routine inspections

Routine Inspection

Routine inspections are typically performed on a frequent base (e.g. weekly, monthly) by the dam owner or operator. The frequency of routine inspections is tied to the need for operation and monitoring at the facility, as outlined in WAC 173-175-500. Important monitoring data recorded during a routine inspection would include: reservoir level, seepage flow, toe drain flow, piezometer levels, and other project-specific information. A brief, visual inspection of the major project features is performed to observe any obvious changes that may threaten dam safety (e.g. seeps, bogs, settlement, sinkholes, debris, etc.).

Annual Inspection

An annual inspection is a more detailed inspection by the dam owner or operator, during which all features and equipment at the facility are evaluated as outlined in WAC 173-175-510. The inspection may be performed by the owner, or an agent of the owner. A checklist is used to ensure that all critical features are examined.

Typical inspection items would include:

- The condition of the dam crest, upstream, and downstream slopes.
- Condition of the spillway and outlet works.
- Observation and measurement of all seepage, and any other important, project-specific items.
- Testing all operable valves, control works, and other mechanisms, to ensure they are in proper working order.
- Reviewing the monitoring information from the past year for development of any adverse conditions such as increased seepage or higher piezometer levels.
- Taking photographs of all of the dam components and any observed problems or obvious changes to the dam.

Record all information and photographs from the annual inspection on an inspection form. Dam owners can use their own annual inspection checklist or form or they are welcome to use the

inspection form templates created by the DSO - Dam Owner Annual Inspection Form – Earthen Dams[5] and Dam Owner Annual Inspection Form – Concrete Dams.[6]

Please include instructions in the O&M Manual for the inspection form that will be used when conducting the owner annual inspection.

Periodic Inspection by the DSO

Per WAC 173-175-705, the DSO is required to conduct a Periodic Inspection for dams located in areas where a dam failure poses a risk for loss of life or significant economic or environmental risk. These inspections should be performed by professional engineering specialists, registered in Washington State, and familiar with the design and construction of dams.

For High Hazard dams (1C, 1B, 1A) the frequency is every 5 years. For Significant Hazard dams (2D, 2E) the inspection frequency is also typically 5 years, but may be 10 years if necessary based upon workload and staffing limitations. If necessary, the DSO may also adjust the 5 year interval by a year longer or shorter to adjust yearly workload.

The Periodic Inspection involves:

- Review and analysis of available data on the design, construction, operation, and maintenance of the dam and its appurtenances.
- Visual inspection of the dam and its appurtenances.
- Evaluation of the safety of the dam and its appurtenances, which may include assessment of the hydrologic and hydraulic capabilities, structural stabilities, seismic stabilities, and any other condition which could constitute a hazard to the integrity of the structure.
- Evaluation of the downstream hazard classification; evaluation of the operation, maintenance, and inspection procedures employed by the owner and/or operator.
- Review of the Emergency Action Plan for the dam including review and update of dam breach inundation maps.

Afterward, the DSO prepares a comprehensive report, which includes findings from the inspection and any remedial work needed.

Non-routine Inspections by the DSO

Some inspections by the DSO may be performed for non-routine reasons (WAC 173-175-725), such as an earthquake or extreme storm event, or at public request (WAC 173-175-735). No fees are charged to the owner for these inspections.

[5] https://apps.ecology.wa.gov/publications/SummaryPages/ECY070572.html
[6] https://apps.ecology.wa.gov/publications/SummaryPages/ECY070613.html

Section V – Instrumentation & Monitoring

Instrumentation at a dam furnishes data to determine if the completed structure is functioning as intended, provides a continuing surveillance of the structure, and is an indicator of developments that may endanger its safety. The extent and complexity of instrumentation at a dam depends on the size of the structure, its intended purpose, and the potential for loss of life and property damage downstream from the facility.

Typical monitoring instrumentation at dams includes:

- Weirs, flumes, pipes, and other means to measure seepage flow.
- Monitoring wells to measure water levels, and piezometers to measure pore pressures within the embankment and/or foundation.
- Survey monuments to measure horizontal and vertical movement.
- Staff gauges to measure reservoir levels.
- Flumes, weirs, and/or gauges to measure reservoir inflow and/or outflow.
- A rain gauge to measure precipitation.

The instrumentation needed at a project could range from a simple bucket and stopwatch to measure seepage flow at a small dam with low downstream hazard, to all of the above instrumentation at a large dam with a high downstream hazard. Further information on monitoring equipment at dams can be found in Chapter 6 of Ecology Publication 92-55C, *Dam Safety Guidelines, Part III, An Owner's Guidance Manual*[7].

The O&M Manual should contain clear instructions on how to use monitoring equipment and how to take measurements at monitoring points. Provide a map identifying each instrument and monitoring point, and forms for recording the data. The monitoring points themselves, as well as any seepage or other areas needing attention should be kept clear of obscuring growth and be permanently marked. Record all data on an appropriate form. Monitoring can only be beneficial if the observations are recorded in an orderly way and form a clear performance record.

See Appendix A, Section V for an example of monitoring instructions, and Appendix C for sample monitoring forms.

[7] https://apps.ecology.wa.gov/publications/summarypages/9255c.html

Section VI – Updating

Update information in the Operation and Maintenance Manual annually, or whenever major changes have occurred. Updates can be done at any time, but It is required that the O&M Manual is updated at least every 5 years, within 180 days after a 5-year periodic inspection has been completed by the Dam Safety Office.

Things to consider when updating include:

- Update staff list of responsible individuals for the dam.
- Increase/decrease the frequency of an examination or the maintenance routine based on the performance at the time of observation.
- Add/subtract operation and maintenance information as changes are made at the dam.
- Change the operation and/or maintenance procedure(s) based on performance at the time of the observation.
- Alterations to the project data due to changes at the dam.

Keep track of all locations where the O & M Manual is distributed, so that updates can be made at all locations. Locations that might be included are:

- Dam site.
- Dam tenders/owners personal copy.
- Washington State Department of Ecology, Dam Safety Office.

Appendix A – Example O&M Manual

WASHINGTON STATE DEPARTMENT OF ECOLOGY

DAM SAFETY SECTION

OPERATION AND MAINTENANCE MANUAL

PEABODY HEIGHTS DAM

Prepared:

December 1995

Revised May 2020

Policy PW-905

Table of Contents

SECTION I - GENERAL INFORMATION

INTRODUCTION

In accordance with WAC 173-175-510, the City of Port Angeles has the responsibility to inspect the Peabody Heights Dam to reasonably assure safety to life and property. This Operation and Maintenance Manual (O&M Manual) provides the information and guidance needed to assure thorough and complete operation and maintenance of Peabody Heights Dam. It will also allow people knowledgeable in reservoir operation, but unfamiliar with the conditions at this particular dam, to operate the dam and reservoir when regular operators cannot perform their duties. Ultimately, with correct operation and maintenance, the safety of those living downslope of the dam will be maintained, and the dam will operate with maximum efficiency.

GENERAL DESCRIPTION

Background/Historical Information

The Peabody Heights Reservoir (reservoir) is a drinking water storage reservoir that was constructed in 1925. The reservoir is located within the City of Port Angeles, at Latitude 48.0980N, Longitude 123.4318W in the southeast quarter of Section 15, Township 30 North, Range 06 West. The reservoir's physical address is 601 Viewcrest Avenue, Port Angeles, Washington 98362 and can be accessed off Viewcrest Avenue east of Peabody Street.

Originally this reservoir was the terminus of the Morse Creek transmission pipeline and the controlling reservoir for the Port Angeles water system. Since 1977 the Elwha Ranney Collector has been the primary water source for the Port Angeles water system and the Morse Creek facility has been decommissioned. The Elwha Ranney collector pumps can be controlled from Peabody Heights Reservoir when the Black Diamond Reservoir is out of service.

Reservoir

The reservoir has a footprint of 250 feet by 250 feet and 25 feet deep with sloped interior walls. The reservoir's capacity is 7 million gallons. The dam crest is 950 feet long and has a maximum height of approximately 25 feet at the toe. The maximum water surface elevation is 419 feet. It is a reinforced concrete structure constructed in excavation and embankment. In September 1993 a 60 mil HDPE geomembrane liner was installed to cover the bottom and side-slopes of the reservoir, which proved effective in eliminating leakage through the concrete liner. On November 30, 1998, a break on a pressurized 12-inch pipe located along the outside edge of the northern and eastern embankments caused a significant amount of erosion of the downstream slope. As a result, in the summer of 1999, work was conducted to abandon in-place all pressurized waterlines buried within the cross-section of the impounding embankment. In September 2003, the reservoir was covered with a Hypalon floating cover to comply with Washington State Department of Health requirements. In December

2014 and again in October 2018, Layfield USA Corp., the original manufacturer and installer of the Hypalon cover, was commissioned to perform a comprehensive inspection and evaluation of the cover and associated equipment. Guided by the inspection findings, a Cover Cleaning and Repair project was performed in June 2019. A site map of the reservoir/dam can be found in Appendix C.

Embankment, Abutments, and Foundation

The dam crest and embankment extends from the northern portion of the west edge of the reservoir, around the northern edge, and along the majority of the eastern edge for a total length of slightly more than 500 feet. The crest is around 30 feet wide from the parapet wall to the downslope side, and made of well compacted material. There is a roughly 10 foot wide gravel access road along the entire crest. The downstream embankment is entirely covered in grass. The downstream side-slope is generally steeper than 2H:1V.

Outlet Works

The outlet pipe is a gravity system that also serves as a pumped inlet pipe, and receives water on a daily basis. The pipe is a 20-inch steel pipe that runs through the northern embankment and emerges in a small building referred to as the chlorination building.

Overflow Spillway

The overflow spillway is located in the southeast corner of the reservoir, and consists of a 20-inch steel pipe that exits via a 5-foot long stop log weir inside a valve house, and is then drained by another 20-inch pipe. The spillway has not been used since the Ranney Collector, which tightly controls input and output to the reservoir, was put into place. In early 2019, structural and roofing upgrades were made to the overflow building. The project also included an upgrade to the hatch inside the building that covers the weir and overflow opening.

Downstream Hazard Assessment

The hazard rating for the Reservoir Dam was identified as *High, Hazard Class 1B*. The most recent analysis was performed in 2004, and incorporated the use of digital Lidar data and the hydraulic software program "HEC-RAS" to establish the downstream flow path and depth. Detailed information can be found in the Peabody Heights Dam Emergency Action Plan.

Hydrology & Hydraulics (H&H)

There is limited information on H&H analysis for Peabody Heights Reservoir, aside from the downstream analysis performed to establish the hazard rating for the dam. Since the reservoir is contained by parapet walls, a bottom liner, and a cover system there is little or no external sources for inflow aside from what is pumped in. Thus, the reservoir is relatively insulated from extreme hydrologic events.

Analysis of the overflow spillway capacity resulted in an estimated outflow of 78 cubic feet per second, which is in excess of the potential pumping inflow. However, this may not be the ultimate capacity since the drop inlet structure is drained by a 20 inch pipe, which may alter the overall

capacity of the outlet. Currently the outlet is not part of the active reservoir system, but has the potential to be utilized as a backup outlet.

PERSONNEL & RESPONSIBILITIES

Overall Responsibility:	Deputy Director of Water and Wastewater (360) 417-4800 and City Engineer (360) 417-4803
Operations:	Water Treatment Plant Supervisor (360) 417-4860
Weekly & Monthly Inspections:	Operations Staff as assigned by Water Treatment Plant Supervisor (360) 417-4860
Annual Inspections:	Operations and Engineering Staff as assigned by Deputy Director of Water and Wastewater (360) 417-4800 and City Engineer (360) 417-4803
Routine Maintenance:	Operations Staff as assigned by Water Treatment Plant Supervisor (360) 417-4860
Monitoring:	Operations and Engineering Staff as assigned by Deputy Director of Water and Wastewater (360) 417-4800 and City Engineer (360) 417-4803

PROJECT DATA

General

State I.D. #:	CL18-1210
National I.D. #:	WA01210
Owner and Operator:	City of Port Angeles
Location:	601 Viewcrest Ave, Port Angeles, WA 98362
Construction Date:	1925
Purpose of the Project:	Water Supply
Downstream Hazard Classification:	1B

Reservoir

Water shed:	WRIA 18 – Elwha-Dungeness
Drainage Area (Square miles):	.01 square miles
Surface Area at Spillway Crest:	2.3 acre-feet
Elevation (ft. NVGD):	419 feet
Active Storage at Spillway Crest:	22 acre-feet
Active Storage at Dam Crest:	22 acre-feet

Dam

Type:	Earth Fill
Structural Height:	25 feet
Hydraulic Height:	24 feet
Crest Elevation:	419 feet
Crest Length:	960 feet
Crest Width:	30
Upstream Slope:	N/A
Downstream Slope:	≤ 2:1

Principal Spillway

Type:	Overflow Weir
Location:	Southeast Corner
Discharge Capacity:	
Crest Elevation:	
Dimensions of Control Section:	
Length of Channel:	

Emergency Spillway

Type:	Drain Line
Locations:	East Side
Discharge Capacity:	78 cfs

Outlet Works

Type:	20" Cast Iron Main
Locations:	Northwest Corner/Basement of Chlorine Building
Controls:	20" Gate Valve

SECTION II - OPERATION

The primary purpose of the Peabody Heights reservoir is to supply water to the Port Angeles municipal drinking water system. The reservoir receives water via a transmission pipeline from the Port Angeles Water Treatment Plant (PAWTP) and is maintained at a full or nearly full level with a maximum water surface elevation of 419 feet (25 feet reservoir depth). Water is released from the reservoir to meet the water system demands either directly to the water system, other storage reservoirs in the water system, or to the Mill Creek pump station which lifts water to the City's high-level service zone, as shown in Figure 1.

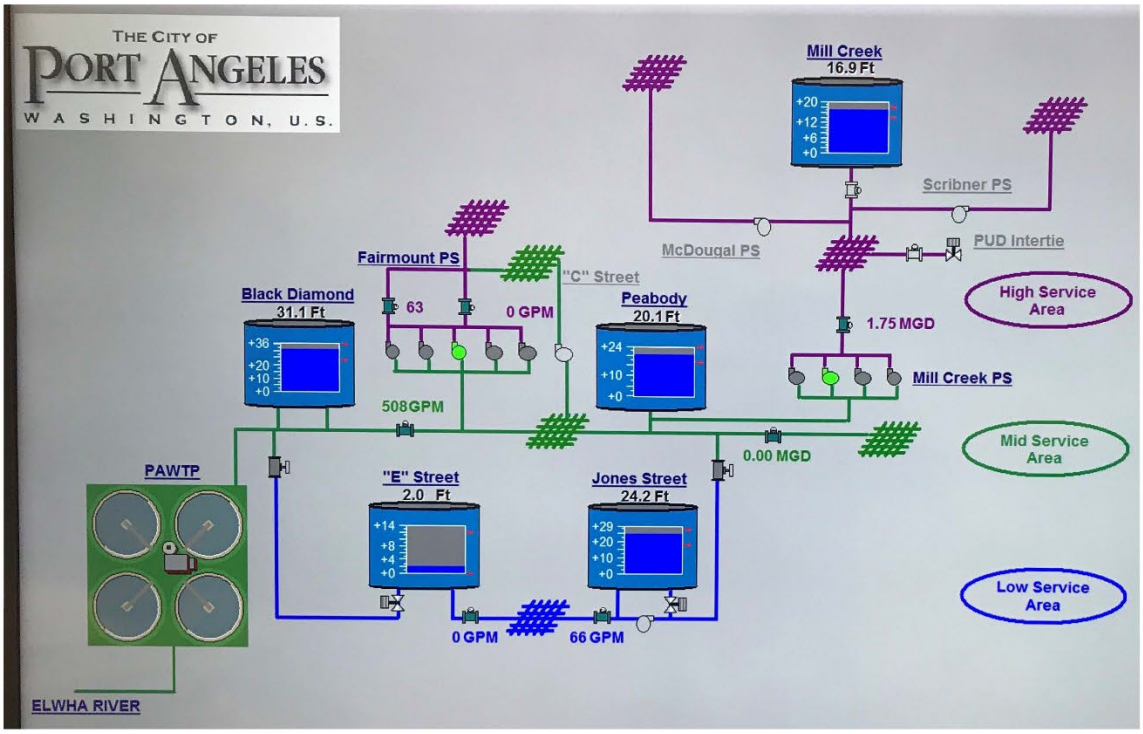


Figure 1. Port Angeles drinking water distribution system overview schematic. 2019 SCADA system.

SECTION III - MAINTENANCE

REGULARLY SCHEDULED MAINTENANCE AND MONITORING

Routine operational inspection, maintenance, and repair logs are maintained in the onsite chlorination building and are archived at the PAWTP. City operations staff may also use Cityworks®, a computerized maintenance management system (CMMS), to manage regularly scheduled maintenance activities. Maintenance activities include servicing equipment, replacing parts, performing visual inspections, and other routine tasks.

MAINTENANCE PLAN

Element	Frequency	Description
Vegetation Control	Biannually	Cut grass at least twice annually or more frequently to allow for visual surveillance of the embankment surfaces. Maximum grass height should not exceed eight inches. Remove small trees and brush. **DO NOT REMOVE TREES LARGER THAN SIX INCHES IN DIAMETER WITHOUT ADVICE FROM A PROFESSIONAL ENGINEER**.
Control of Burrowing Animals	Monthly	Repair animal burrows by compacting fill into the excavated areas. If the burrowing is extensive, seek the advice of a qualified engineer. Eliminate the burrowing animals to alleviate the problem for the long term.
Maintain Crest Roadway	Annually	Gravel Roadways: Regrade Eroded Areas. Add gravel as needed.
Maintain Crest Design Elevation	Annually Annually, or as needed	Maintain the design elevation of unimproved crest surfaces by leveling and grading the crest to design specifications. Fill any ruts or minor depressions.

Maintain Upstream Slope Protection	Annually	Repair any breaching of concrete, hypolon liner and floating cover.
Erosion Control on Downstream Face	Annually	Repair erosion gullies by removing loose materials and replacing them with compacted fill. Gravel and cobbles or planted grass should be added as appropriate.
Gates and Valves	As specified	Test gates and valves for proper operation and leakage.
Controls		Follow manufacturer's guidelines.

UNSCHEDULED MAINTENANCE

Unscheduled maintenance will be provided on an as determined basis typically resulting from observations during regularly scheduled maintenance, as a result from an annual inspection, or after an unusual event. Examples of unscheduled maintenance may include:

- Repairing and reseeding eroded areas
- Repairing defective gates, valves or other equipment
- Other deficiencies noted

Any major repairs or improvement shall be reviewed and approved by the Department of Ecology, Dam Safety Office.

SECTION IV - INSPECTION

ROUTINE INSPECTIONS

City Operations staff perform routine inspections as detailed below. Daily and Monthly inspections are recorded on log sheets maintained in the chlorination building and are later archived at the PAWTP. An inspection guidesheet is posted in the chlorination building for operator reference. Annual inspections are performed jointly between Operations and Engineering and are saved digitally on the City's server. Inspection results are utilized by Supervisory staff to influence maintenance scheduling and repair projects.

Daily

1. Visually check reservoir level and north outer embankment of dam for any irregularities.

Monthly

1. Visually Examine Condition of:
    a. Dam Crest,
    b. Upstream and Downstream Faces,
    c. All Drainage Systems, and
    d. Security and Safety Devices.
2. Check for seepage along entire length of dam base.
3. Check for animal burrows.

Annually

1. Utilize Dam Owner Annual Inspection Form (Appendix A)
2. Perform detailed annual inspection, in addition to "daily" and "monthly" inspection items.
    a. Survey settlement monuments on dam crest. (Section V, Appendix B)
    b. Check corrosion on all exposed metalwork.
    c. Visually inspect all pipes for corrosion, leakage, or other significant problems.
3. Submit form to Ecology: Dam Safety Office
4. Utilize inspection results to guide O&M adjustments and schedule upgrades/repairs.

PERIODIC INSPECTION BY ECOLOGY

City Operations staff acknowledges that the Department of Ecology Dam Safety Office has the responsibility and authority to inspect the construction of all dams pursuant to RCW 43.21A.064(2).

SECTION V – INSTRUMENTATION & MONITORING

Monitoring at the reservoir consists of measuring the horizontal and vertical position of the 2 settlement monuments installed at the lateral limits of the northern crest face. This task is performed by the City's Engineering department on an annual basis. The data collect from this task is recorded in Appendix B.

Using a survey level, transit or total station the horizontal and vertical measurements are taken at the 2 monument locations. Reference is established by a known control point at the reservoir or by using roadway monuments located in the Peabody St./Viewcrest Ave. and Regent St./Viewcrest Ave. intersections. A map showing the control and monitoring points, existing and proposed, can be found in Appendix B.

SECTION VI - UPDATING

This O & M Manual shall be reviewed and updated annually by Engineering and Operations Staff. Elements to be updated will include:

- Titles and phone numbers of responsible personnel
- Alterations to project data due to changes at the dam
- Changes in operation and/or maintenance procedures
- Increase/decrease the frequency of maintenance routines based on recent performance

Updated copies of the O & M Manual shall be distributed to and located at:

- City of Port Angeles Fire Department – Fire Chief's Office
- City of Port Angeles Public Works Department – Engineering Office
- City of Port Angeles Public Works Department – Deputy Director of Water and Wastewater's Office
- City of Port Angeles Water Treatment Plant (PAWTP)
- Peabody Heights Reservoir – Chlorination Building
- Washington State Dept. of Ecology, Dam Safety Section

APPENDIX A – DAM OWNER ANNUAL INSPECTION FORM

DEPARTMENT OF ECOLOGY
State of Washington

Dam Owner Annual Inspection Form
Earthen Dams

Project Data

Dam Name:	
County:	State Dam No. (if known)
Owner Name:	
Owner Address:	Telephone No.: E-mail address:
Inspected by:	
Inspection Date:	Weather:

Directions

- During inspection, check all boxes that apply. Fill in the overall condition of each structure and what actions will be taken to remedy any issues found. Mail or email a copy of the completed form to the Dam Safety Office.
- Mark approximate location of any problems on plan of dam footprint on page 6 and attach photos on page 7
- For concrete structures associated with your dam, check the "concrete in poor condition" box if you notice signs of settlement, misalignments, heaving, offset joints, cracks, or exposed reinforcements and make a note of what you have found in the line for overall condition.

Reservoir Data

Reservoir Level at time of inspection _____ feet below dam crest

Reservoir Outflow at time of inspection _____ cfs or _____ gpm

Condition of Dam (embankment, abutments, foundation)

Dam crest Check all that apply:

☐ low areas ☐ surface cracking ☐ animal burrows ☐ brush
☐ horizontal misalignment ☐ ruts ☐ trees

Overall condition: _____

Actions needed: _____

Upstream face Check all that apply:

☐ slumps ☐ sinkholes ☐ animal burrows
☐ slides ☐ slope protection ☐ trees
☐ scarps ☐ wave erosion ☐ brush

Overall condition: _____

Actions needed: _____

To request ADA accommodation including materials in a format for the visually impaired, call Ecology at 360-407-6831 or visit https://ecology.wa.gov/accessibility. People with impaired hearing may call Washington Relay Service at 711. People with speech disability may call TTY at 877-833-6341.

Condition of Dam Cont. (embankment, abutments, foundation)

Downstream face and toe Check all that apply:

☐ wet or soft areas	☐ scarps	☐ erosion	☐ water-loving vegetation
☐ slumps	☐ sinkholes	☐ unusual movement	☐ trees
☐ slides	☐ change in slope	☐ animal burrows	☐ brush

Is there seepage? ☐ Yes ☐ No If yes,

Location of seep: _____ Is the seep? ☐ clear ☐ turbid ☐ N/A

Estimated flow: _____ Is there sediment? ☐ Yes ☐ No

Overall condition: _____

Actions needed: _____

Pond liner Check all that apply:

☐ slope slumping	☐ ballooning of liner
☐ tears, punctures, abrasion, other damage	☐ gas vents obstructed
☐ seam separation	☐ safety ladders/ropes integrity issues
☐ liner attachment issues to pipes, ramps, manholes	☐ anchor trench/batten straps issues
	☐ liner subgrade support movement or displacement

Overall condition: _____

Actions needed: _____

Internal leak detection system

Check water level in sump. Is water present:	☐ Yes	☐ No
Damage to pipe boot at riser?	☐ Yes	☐ No
Odors coming from inside riser boot?	☐ Yes	☐ No

Overall condition: _____

Actions needed: _____

Drop Inlet Spillway or Culvert (Pipe) Spillway

Spillway entrance or approach channel Check all that apply:

☐ debris	☐ other obstructions	☐ trash rack in good condition
☐ vegetation	☐ erosion protection	
☐ slides	☐ other debris barrier	

Overall condition: _____

Actions needed: _____

Intake or riser structure Look at riser crest, sidewalls, floor, trash rack, air vent. Check all that apply:

☐ misalignment	☐ concrete deterioration	☐ air vent obstruction
☐ movement	☐ seepage at joints or cracks	☐ debris
☐ settlement	☐ metal corrosion	☐ vandalism
☐ cracking	☐ missing bolts	

Overall condition: _____

Actions needed: _____

Drop Inlet Spillway or Culvert (Pipe) Spillway Cont.

Gates and gate controls Check all that apply: (leave blank if not applicable)

- ☐ operable and working
- ☐ corrosion
- ☐ deterioration
- ☐ vandalism
- ☐ other damage
- ☐ annual maintenance has been done

Overall condition: _____

Actions needed: _____

Outlet pipeline Look at concrete or metal condition, protective coating, pipe joints. Check all that apply:

- ☐ debris
- ☐ other blockage or obstruction
- ☐ joint separation
- ☐ movement
- ☐ cracks
- ☐ deterioration
- ☐ settlement
- ☐ corrosion
- ☐ cavitation
- ☐ seepage from drains/pipe exterior

Overall condition: _____

Actions needed: _____

Pipeline outfall or stilling basin Check all that apply:

- ☐ debris
- ☐ vegetation
- ☐ concrete condition poor
- ☐ movement
- ☐ cracks
- ☐ deterioration
- ☐ settlement
- ☐ erosion
- ☐ undermining
- ☐ gabions in poor condition
- ☐ riprap layer in poor condition

Overall condition: _____

Actions needed: _____

Lead-out drain outfall(s)

Able to locate? ☐ Yes ☐ No Is there evidence of seepage? ☐ Yes ☐ No

Overall condition: _____

Actions needed: _____

Open Channel Spillway or Weir Drop Structure

Spillway entrance and overflow section, or weir overflow structure

Look at channel base, side slopes; concrete floor, sidewalls; weir boards. Check all that apply

- ☐ debris
- ☐ vegetation
- ☐ slides
- ☐ other obstructions
- ☐ concrete in poor condition
- ☐ movement
- ☐ cracks
- ☐ deterioration
- ☐ settlement
- ☐ cavitation
- ☐ erosion in earth or grass-lined channel
- ☐ gabions in poor condition
- ☐ riprap layer in poor condition
- ☐ weir boards in poor condition
- ☐ log boom in poor condition
- ☐ other debris barrier in poor condition

Overall condition: _____

Actions needed: _____

Open Channel Spillway or Weir Drop Structure Cont.

Gates and gate controls Check all that apply: (leave blank if not applicable)

- ☐ operable and working
- ☐ corrosion
- ☐ deterioration
- ☐ vandalism
- ☐ other damage
- ☐ annual maintenance has been done

Overall condition: _____

Actions needed: _____

Outlet channel Check: channel base, side slopes; concrete floor, sidewalls. Check all that apply:

- ☐ debris
- ☐ vegetation
- ☐ slides
- ☐ other obstructions
- ☐ concrete in poor condition
- ☐ movement
- ☐ cracks
- ☐ deterioration
- ☐ settlement
- ☐ cavitation
- ☐ erosion in earth or grass-lined channel
- ☐ gabions in poor condition
- ☐ riprap layer in poor condition
- ☐ seepage from under-drains or along concrete exterior

Overall condition: _____

Actions needed: _____

Spillway outfall or stilling basin Check all that apply:

- ☐ debris
- ☐ vegetation
- ☐ concrete in poor condition
- ☐ movement
- ☐ cracks
- ☐ deterioration
- ☐ settlement
- ☐ erosion
- ☐ undermining
- ☐ gabions in poor condition
- ☐ riprap layer in poor condition

Overall condition: _____

Actions needed: _____

Under-drain outfalls Check all that apply:

Able to locate? ☐ Yes ☐ No Is there evidence of seepage? ☐ Yes ☐ No

Overall condition: _____

Actions needed: _____

Low-Outlet Works (visible elements)

Intake structure (if visible) Check all that apply:

- ☐ debris
- ☐ other obstructions
- ☐ trash rack in poor condition
- ☐ other debris barrier in poor condition
- ☐ concrete in poor condition
- ☐ metal in poor condition

Overall condition: _____

Actions needed: _____

Gates/valves and control mechanisms Check all that apply:

- ☐ operable and working
- ☐ corrosion
- ☐ deterioration
- ☐ vandalism
- ☐ other damage
- ☐ annual maintenance has been done

Overall condition: _____

Actions needed: _____

Low-Outlet Works Cont. (visible elements)

Outlet pipeline and pipe outfall Look at concrete or metal condition, protective coating, pipe joints. Check all that apply:

- ☐ debris
- ☐ other blockage or obstruction
- ☐ joint separation
- ☐ movement
- ☐ cracks
- ☐ deterioration
- ☐ settlement
- ☐ corrosion
- ☐ cavitation
- ☐ undermining at outfall
- ☐ seepage from drains/pipe exterior
- ☐ gabions in poor condition at outfall
- ☐ riprap in poor condition at outfall

Overall condition: _____

Actions needed: _____

Internal seepage/drainage controls (leave blank if not applicable)

Lead-out drain outfalls:

Able to locate? ☐ Yes ☐ No

Presence of fines or sediment? ☐ Yes ☐ No

Clarity of flow: _____

Estimated/measured flow(s): _____

Color or staining? ☐ Yes ☐ No

Measuring devices: _____

Overall condition: _____

Actions needed: _____

Piezometers:

Able to locate? ☐ Yes ☐ No

Readings: _____

In secure location? ☐ Yes ☐ No

Condition of casing: _____

Overall condition: _____

Actions needed: _____

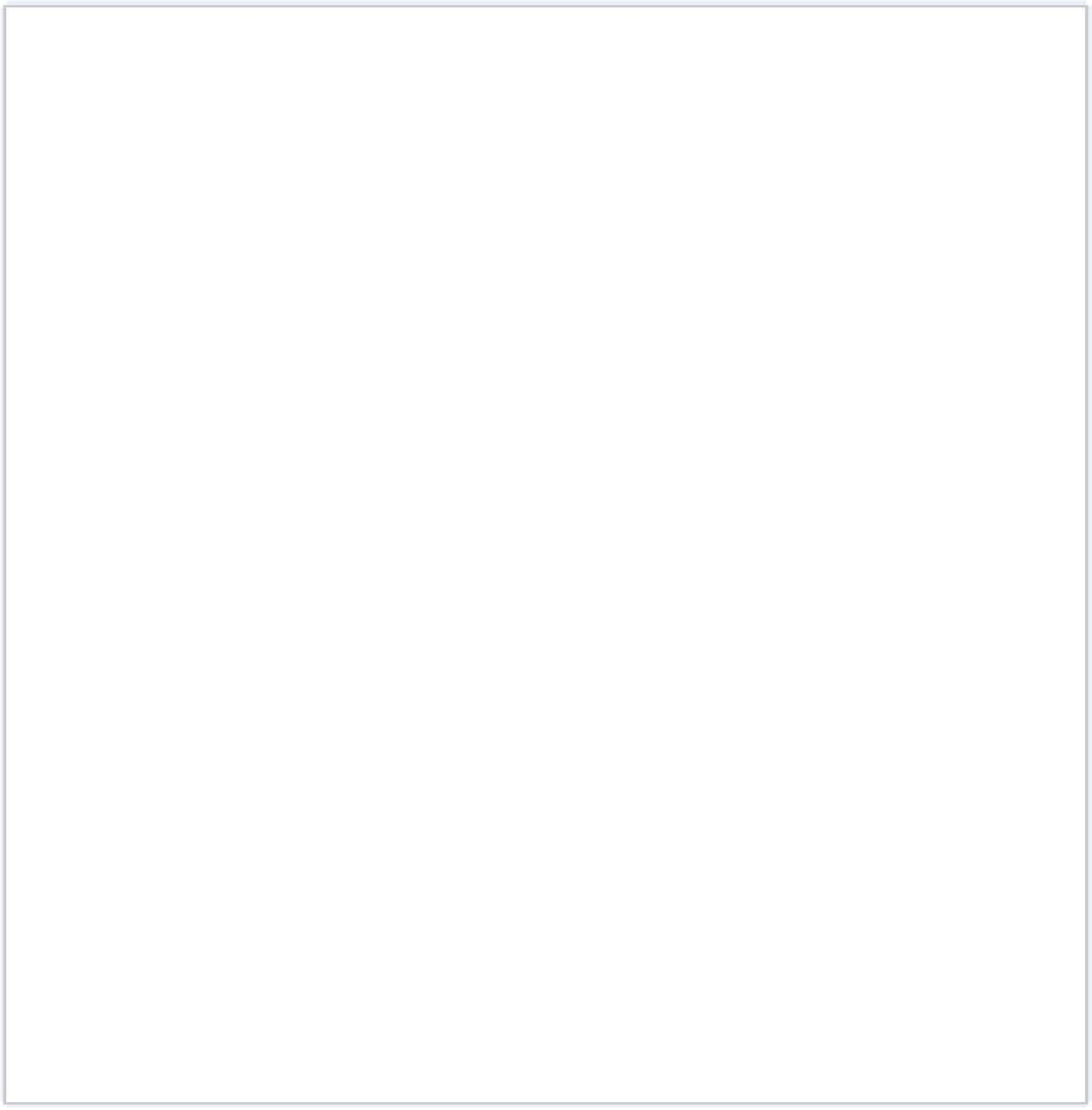
Emergency Action Plan (EAP) and Operation and Maintenance (O&M) Manual

Date of EAP or last update on file with Ecology? Date: _____

Date of O&M Manual or last update on file with Ecology? Date: _____

Additional Comments

Plan View of Dam



(Insert plan view of dam and spillways)

Photographs

(Insert photographs)

Mail or email a copy of this completed form to the attention of the Dam Compliance Technician at Ecology's Dam Safety office:

By email: damsafety@ECY.WA.GOV

By mail: Washington State Dept. of Ecology
Dam Safety Office
Attn: Dam Compliance Technician
PO Box 47600
Olympia, WA 98504-7600

Problems found during your inspection?

If a problem is observed, please call the Dam Safety Office at (360) 407-6872 during business hours for guidance and assistance.

If it is an emergency call:

1. Call **911**
2. Call State Division of Emergency Management
    a. Call the Duty Officer (available 24 hours/day) at **1-800-258-5990**
    b. Clearly state that this is a "**dam safety emergency**"

Would you like a customized inspection form?

If you have found that this form has sections that do not apply to your dam or there are aspects to your dam that are not captured in this form, contact the Dam Compliance Technician at (360) 407-6613 or damsafety@ECY.WA.GOV and we will create an Annual Inspection Form specific to your dam.

Helpful Documents and Information

Ecology's Dam safety website: https://ecology.wa.gov/Water-Shorelines/Water-supply/Dams

Documents found there:

- General information and dam ownership responsibilities
- Dam owner's guidance manual
- Impacts of animals on earthen dams
- Impacts of plants on earthen dams
- Burrowing animal guidance

APPENDIX B - DAM SETTLEMENT MONUMENT DATA

Peabody Heights Reservoir Monitor Points

Monitor Point No. 1 (Near NW Corner Earthen Berm)			
Date	Northing	Easting	Elevation
7/19/05	411,407.93	1,005,324.73	419.01
9/08/06	411,407.89	1,005,324.75	418.99
7/03/07	411,407.91	1,005,324.74	419.02
10/07/08*	411,407.96	1,005,324.71	418.99
8/19/09	411,407.96	1,005,324.71	418.99
9/02/10	411,407.95	1,005,324.71	419.02
11/01/11	411,408.01	1,005,324.73	418.99
12/21/12	411,408.02	1,005,324.72	419.00
7/26/13	411,408.01	1,005,324.73	419.00
8/01/14	411,408.02	1,005,324.74	418.99
9/10/15			418.98
6/28/18	411,408.01	1,005,324.72	418.99
4/2/20**	411,408.00	1,005,324.72	418.98

Monitor Point No. 2 (Near NE Corner Earthen Berm)			
Date	Northing	Easting	Elevation
7/19/05	411,403.52	1,005,580.62	417.63
9/08/06	411,403.50	1,005,580.63	417.60
7/03/07	411,403.53	1,005,580.62	417.61
10/07/08*	411,403.62	1,005,580.59	417.61
8/19/09	411,403.63	1,005,580.56	417.60
9/02/10	411,403.62	1,005,580.60	417.61
11/01/11	411,403.63	1,005,580.62	417.59
12/21/12	411,403.62	1,005,580.65	417.61
7/26/13	411,403.64	1,005,580.63	417.61
8/01/14	411,403.59	1,005,580.63	417.63
9/10/15			417.57
6/28/18	411,403.63	1,005,580.64	417.57
4/2/20**	411,403.63	1,005,580.64	417.58

*Control point used to measure horizontal position of monitor points in previous years destroyed by installation of new service pole. Set new control point to measure horizontal positions in 2008. Coordinates indicate greater variance than in past years, but any actual movement unlikely as indicated by measured elevations.

**Adverse weather conditions prohibited data collection during Dec. 2019 annual inspection and was therefore rescheduled to a later date.

APPENDIX C - SITE MAP AND UTILITY MAP

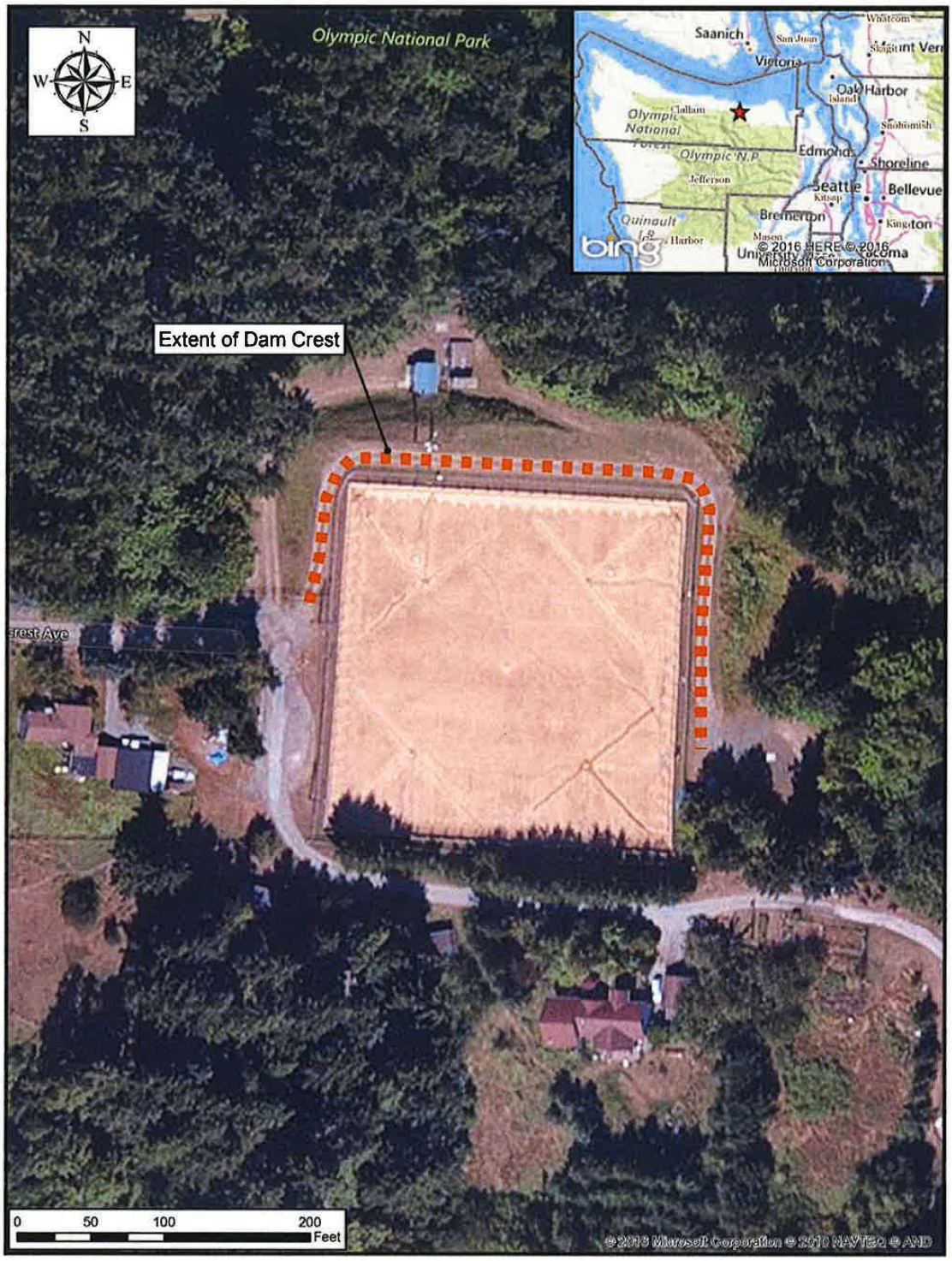
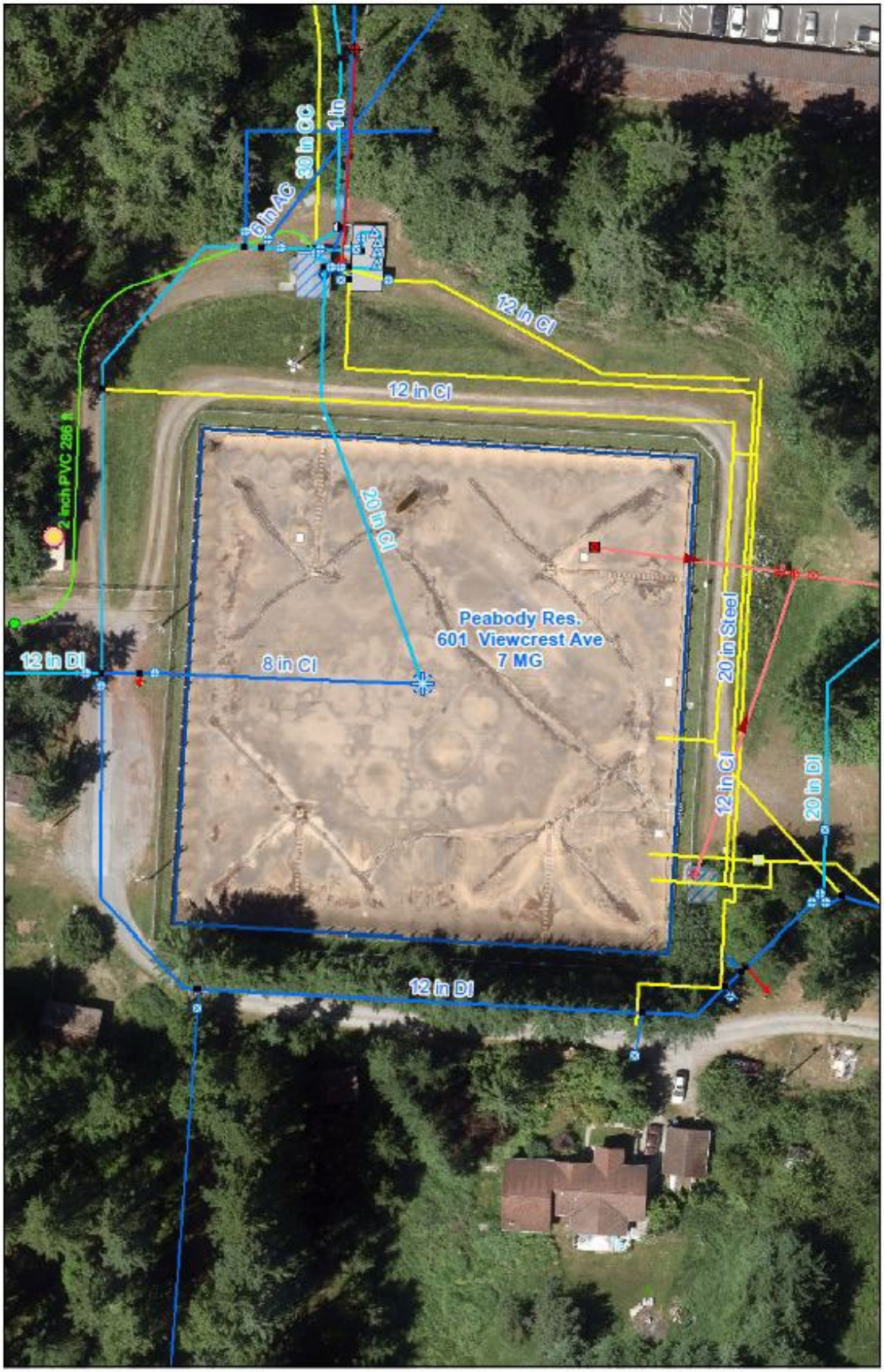


Figure 1 – Site Plan



N

Peabody Heights Reservoir

40
Feet

Printed: 5/5/2020

Legend

- DManual valve active
- DControl valve active
- DOutfall active
- DInletPoint active
- COPA, Active
- DCollector active
- DMain, Active
- WAir valve City active
- WCheck valve City active
- WGenerator
- WHyd City active
- WMeter Abandoned
- WMeter Active
- WManual valve City active
- WPump City active
- WReservoirs
- WFitting
- Dist WPress Main active
- Trans WPressMain active
- Abandoned
- WHydrantLine active
- WLateral active
- WTanks
- WPumpStation
- WBuildings
- WWSepticTank, Active
- WWCO active
- WWLateral line active

This map is not intended for use as a legal description. Locations of features are approximate only. Topographical/gis features are +-5 feet of actual locations. This map/drawing is produced by the city of Port Angeles for its own use and purposes. Any other use of this map/drawing shall not be the responsibility of the City.

Appendix B – Product Data Sheet Template

Below is an example of a project data sheet. Some dams may not have all of the components below. Before including the data sheet in the O&M Manual, please alter the data sheet to match the components and pertinent features specific to your dam and reservoir.

General

State I.D. No.

Owner and Operator

Location

Construction Completed

Major Modifications

Purpose

NID Condition Assessment

Downstream Hazard Potential

Downstream Flood Path

Reservoir

Watershed	[stream name] / Offstream within _____
Drainage Area	___ acres / square miles
WQ Pool Operating Elevation	_____ feet
Surface Area at WQ Pool	____ acres
Inactive Storage at WQ Pool	____ acre-feet
Spillway Weir Overflow Elevation	_____ feet (weir within flow control riser)
Surface Area at Spillway Overflow	____ acres
Combined Storage at Spillway Overflow	____ acre-feet
Dam Crest Elevation	_____ feet
Surface Area at Dam Crest	____ acres
Combined Storage at Dam Crest	____ acre-feet

Dam Embankment

Type	[type and internal seepage/drainage controls]
Structural Height	____ feet
Hydraulic Height	____ feet
Crest Elevation (typical)	____ feet
Crest Elevation (minimum)	____ feet
Elevation Datum	Spillway / MH lid / [other] = ____ feet
Crest Length	____ feet
Crest Width	____ feet
Upstream Slope	____ H:1V
Downstream Slope	____ H:1V

Reservoir

Type	[Concrete/material] flow control structure with interior baffle wall, / [material] riser, [open at top] [Concrete drop inlet with low-level outlet]
Location	Center of dam / right/left abutment
Discharge Capacity	____ cfs at water level ____ feet ____ cfs at water level ____ feet ____ cfs at water level ____ feet ____ cfs at water level ____ feet
Riser Dimensions	____ feet x ____ feet dia. x _____ feet high
Interior Riser	____ feet diameter
Overflow Weir Length	____ feet
Weir Overflow Elevation	____ feet
Low Outlet Overflow Elevation	____ feet
Intake Conduit – section	____ inch diameter [material] pipe
Discharge Conduit – section	____ inch diameter [material] pipe
Discharge Conduit – profile	____ feet long: ____ ft at slope _____ ft/ft, then ____ feet at slope ____ ft/ft (__ H:1V)
Drawdown Capacity	____ feet/day at water level ____ feet
(max drawdown at minimal inflow)	____ feet/day at water level ____ feet

Secondary Spillway

Type	[material]-lined open channel
Location	Center of dam / right/left abut / natural grnd
Discharge Capacity	____ cfs at water level ____ feet ____ cfs at water level ____ feet ____ cfs at water level ____ feet
Overflow Elevation	____ feet
Overflow Control Section	Base ____ feet, sides ___ H:1V, ___ ft deep
Discharge Channel – section	Base ____ feet, sides ___ H:1V, ___ ft deep
Discharge Channel – profile	____ feet long: ____ ft at slope _____ ft/ft, then ____ feet at slope ____ ft/ft (__ H:1V)
Inflow Design Flood – Discharge	____ cfs
Inflow Design Flood – Storm	Step _, _% PMP; Shrt/Intm/Long, hi int/vol
Inflow Design Flood – Precipitation	2/6/24 hr = ___ inch, 6/18/72 hr = ___ inch (as calculated per Technical Note 3, 1993/2009)

Emergency/Auxiliary Spillway

Type	[material]-lined open channel
Location	Center of dam / right/left abut / natural grnd
Discharge Capacity	____ cfs at water level ____ feet ____ cfs at water level ____ feet ____ cfs at water level ____ feet
Overflow Elevation	____ feet
Overflow Control Section	Base ____ feet, sides ___ H:1V, ___ ft deep
Discharge Channel – section	Base ____ feet, sides ___ H:1V, ___ ft deep
Discharge Channel – profile	____ feet long: ____ ft at slope _____ ft/ft, then ____ feet at slope ____ ft/ft (__ H:1V)
Inflow Design Flood – Discharge	____ cfs
Inflow Design Flood – Storm	Step _, _% PMP; Shrt/Intm/Long, hi int/vol
Inflow Design Flood – Precipitation	2/6/24 hr = ___ inch, 6/18/72 hr = ___ inch (as calculated per Technical Note 3 / HMR-57)
Date of IDF Estimation	

Outlet Works

Type	____ inch diameter [material] pipe
Location	Principal spillway / center of dam / R/L abut
Discharge Capacity	____ cfs at water level ____ feet ____ cfs at flow depth ____ feet
Flow Controls	Upstream – [**req'd**: valve, gate, orifice, etc.] Downstream – [valve, gate, pump station]
Intake Elevation	____ feet (pipe invert / centroid)
Outlet Conduit – profile	____ feet long, slope _____ ft/ft
Drawdown Capacity *(max drawdown at minimal inflow)*	____ feet/day at water level ____ feet ____ feet/day at water level ____ feet
Diversion Channel	[Diversion Ditch No. _____ / other ID]
Location	N/S/E/W edge of site / ____ ft/mi u/s of dam
Diverted Drainage Area	___ acres / square miles
Discharge Capacity	____ cfs at flow depth ____ feet ____ cfs at flow depth ____ feet
Channel cross-section	Base width ___ feet, side slopes ___ H:1V, channel depth ____ feet
Channel profile	____ feet long: ____ ft at slope _____ ft/ft, then ____ feet at slope ____ ft/ft
Inflow Design Flood – Discharge	____ cfs
Inflow Design Flood – Storm	Step _, _% PMP; Short thunderstorm
Inflow Design Flood – Precipitation	2 hr = ___ inches, 6 hr = ___ inches (as calculated per Technical Note 3)

Seepage Instrumentation and Monitoring

Seepage control features	___ Clay core / Concrete core wall ___ Chimney and/or blanket drain ___ Drained buttress ___ Toe drain
Seepage measurement type	V-notch / Trapezoidal weir
Seepage measurement location	Natural ground at toe of dam Right / Left side of [feature]

Appendix C – Monitoring Recording Forms

Data Form for Seepage

Dam name: _____

Owner name: _____

Date	Location	Weir staff gauge reading (ft)	Flow rate (gpm)	Clarity (Clear,Cloudy, or Muddy)	Reservoir elevation (ft)	Observer

Observation Well Data Form

Dam name: _____

Owner name: _____

Date	Location	Elevation Top of Casing (ft)	Depth to Water* (ft)	Equivalent Water Surface Elev. (2 – 3)	Previous Elevation (ft)	Change in Elevation (4 – 5)	Reservoir Elevation (ft)
(0)	(1)	(2)	(3)	(4)	(5)	(6)	(7)

Comments: _____

*If dry, write “DRY”. If frozen, write “FROZEN”.

Settlement/Movement Monitoring Data

Dam name: _____

Owner name: _____

Monument Number	Date	Elevation (ft)	Total Settlement	Lateral Displacement and Direction
1 2 3 4 5 6 7			None As Constructed	None As Constructed