WASHINGTON STATE
DEPARTMENT OF
ECOLOGY

Guidelines for Developing Dam Operation and Maintenance Manuals

Revised
February 1995
92-21

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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 continued productive use of the dam and reservoir.

These guidelines were written to assist dam owners/operators in developing O & M Manuals for their projects. The need for these guidelines was prompted by the new State Dam Safety Regulations (Chapter 173-175 WAC), which take effect July 1, 1992. Under these regulations, owners of new projects are required 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 regulations also require that owners of dams constructed before July 1, 1992 develop an O & M Manual for their projects by December 31, 1997.

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 the corresponding chapter of the manual. A sample O & M Manual is provided in Appendix A, showing how the various components of an O & M Plan are typically written.

An O & M Manual should, as a minimum, contain the following chapters:

SECTION I - GENERAL INFORMATION is the introductory chapter of the O & M Manual, which discusses the purpose of the Manual, and provides general information about the project, including a Project Data Sheet.

SECTION II - PROJECT OPERATION provides details of how the reservoir and equipment at a project are to be operated.

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 dams, and instructions for monitoring and recording of data.

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

SECTION I - GENERAL INFORMATION

This section should briefly describe the purpose of the O & M Manual, and provide general information about the project. Information to be presented 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.

Location 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. Traveling directions to the dam can also be provided.

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 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 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.

Project Data Sheet

Lists all major features of dam in an easy to follow, tabular format. A blank Project Data Sheet is provided on the following pages.

Project Data Sheet

General

State I.D. #: _____
Owner and Operator: _____
Location: _____
Construction Date(s): _____
Purpose of Project: _____
Downstream Hazard Classification: _____

Reservoir

Watershed: _____
Drainage Area (Square Miles): _____
Surface Area at Spillway Crest
(Elev. ft. NVGD) _____
Active Storage at Spillway Crest: _____acre-feet
Active Storage at Dam Crest
(Elevation:_____ft): _____acre-feet

_____ Dam

Type (eg. earthfill, concrete): _____
Structural Height: _____ feet
Hydraulic Height: _____ feet
Crest Elevation: _____ feet
Crest Length: _____ feet
Crest Width: _____ feet
Upstream Slope: _____ H:_____V
Downstream Slope: _____ H:_____V

Principal Spillway

Type (eg. concrete chute): _____
Location: _____
Discharge Capacity: _____ cfs
Crest Elevation: _____feet
Dimensions of Control Section: _____
Length of Channel: _____ feet

Emergency Spillway

Type (eg. concrete chute): _____
Location: _____
Discharge Capacity: _____ cfs
Crest Elevation: _____ feet
Dimensions of Control Section: _____
Length of Channel: _____ feet

Outlet Works

Type: _____
Location: _____
Controls: _____

SECTION II - PROJECT OPERATION

This section provides details of how various elements of a project are to be operated. 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 that special operating procedures be followed. These procedures are normally contained in a separate document called an Emergency Action Plan.

Operating Instructions 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 will not likely have operating requirements 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 needed 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 instructions 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. Pages 17-19 in Appendix A provide examples of operating instructions for typical dam mechanisms.

SECTION III - MAINTENANCE

This section of the O & M Manual provides detailed information and instructions on performing periodic maintenance at a dam. Maintenance is a task which 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

Regularly Scheduled Maintenance

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 manufactures specifications.

Monitored Maintenance

Monitored maintenance involves periodic surveillance and testing of equipment and making repairs or modifications as needed. A surveillance schedule is established 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.

Maintenance Plan

Instructions for performing periodic maintenance should be given in detail, so that new personnel can understand the tasks, and experienced personnel can verify that they have performed the work properly. All regularly scheduled and monitored maintenance should be identified and listed in a maintenance plan section of the O & M Manual. A typical maintenance plan for a small dam is shown on pages 20-23 in Appendix A.

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 that is 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 an earth lined emergency spillway 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, a section should be provided in the Maintenance plan which gives instructions for dealing with unscheduled maintenance. Major repairs or improvements would necessitate review and approval by the Dam Safety Section.

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

Routine Inspections

Routine inspections are typically performed on a frequent basis (e.g. weekly, monthly). The frequency of routine inspections is tied to the need for operation and monitoring at the facility. 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 which may threaten dam safety (eg. seeps, bogs, settlement, sinkholes, debris, etc...).

Annual Inspection

An annual inspection is a more detailed inspection, during which all features and equipment at the facility are evaluated. 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. During the annual inspection, all operable valves, control works and other mechanisms should be test-operated to ensure they are in proper working order. Monitoring information over the past year should be reviewed for development of any adverse conditions such as increased seepage or higher piezometer levels. All information from the annual inspection should be recorded on an inspection form similar to the one shown in Appendix B.

5-year Periodic Inspection

It is recommended that 5-year periodic inspections be performed every 5 to 6 years. These inspections should be performed by professional engineering specialists, registered in Washington State, and familiar with the design and construction of dams and should include a thorough assessment of structure safety. This type of inspection includes:

- a visual inspection of all project elements,
- detailed engineering analyses of project elements under extreme flood and earthquake loadings,
- A review of project operation and maintenance procedures,
- A comprehensive report of findings.

Page 24 in Appendix A gives an example of an inspection plan for a typical small dam.

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 which 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 include:

- 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 89-38, *Dam Safety Guidelines, Part III, An Owner's Guidance Manual*.

The O & M Manual should contain clear instructions on how to use monitoring equipment and how to take measurements at monitoring points. A map identifying each instrument and monitoring point, and forms for recording the data should be provided. 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. All data should be recorded on an appropriate form. Monitoring can only be beneficial if the observations are recorded in an orderly way and form a clear performance record.

An example of monitoring instructions is shown on pages 25-26 in Appendix A. Sample monitoring forms are provided in Appendix C.

SECTION VI - UPDATING

Updating information in the Operation and Maintenance Manual should be done annually or when major changes have occurred. Things to consider when updating include:

- Increase/Decrease the frequency of an examination or the maintenance routine based on the performance at the time of the observation;
- Add/Subtract operation and maintenance information as changes are made at the dam;
- Change the operation and/or maintenance procedure(s) based on its/their 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 Operation and Maintenance 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 Section;
- other.

APPENDIX A

EXAMPLE O & M MANUAL

EXAMPLE O & M MANUAL

LITTLE CREEK DAM

This example O & M Manual is provided to give dam owners and operators assistance in developing their own manuals. Please note that this example contains far more information than would be required for a typical small dam. This was necessary because of the great diversity of dam projects regulated by the Dam Safety Section. Our intent was to include examples of all the components that might possibly be included in an O & M Manual. In reality, most small dam owners would only need to include a few of the elements shown in the following example.

LITTLE CREEK DAM

OPERATION & MAINTENANCE MANUAL

SECTION I - LITTLE CREEK DAM - GENERAL INFORMATION

This Operation and Maintenance Manual (O&M Manual) provides the information and guidance needed to assure thorough and complete operation and maintenance of Little Creek 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 below the dam will be maintained, and the dam will operate with maximum efficiency.

GENERAL DESCRIPTION OF THE PROJECT

Little Creek Dam is located on Little Creek, tributary of the Little River, approximately 2 miles northwest of Smalltown, Washington in Chelan County. The dam is owned and operated by the Smalltown Irrigation District. The Project is used for storage of irrigation water, flood control, and recreation. The dam was constructed in 1960, and is a homogeneous embankment type dam with a rock toe drain. In 1968, the dam was raised 2 feet, and riprap was added to the upstream slope. The dam has a height of 25 feet, a crest length of 350 feet, and impounds 200 acre-feet of water. Additional project information is provided in the Project Data Sheet in the following section.

OPERATING PERSONNEL RESPONSIBILITIES

Overall Responsibility for Project	-	John Doe, President of Smalltown Irrigation District (206) 555-1122
Equipment Operation at Dam	-	Bill Smith, Watermaster for District (206) 555-2233
Setting Reservoir Levels and Irrigation Releases	-	" " "
Performing Weekly Inspections	-	" " "
Performing Annual Inspection	-	John Doe & Bill Smith
Routine Maintenance Work	-	Jim Jones, District Maintenance Foreman (206) 555-3344
Reading and Recording Monitoring Data	-	Bill Smith

SECTION II - LITTLE CREEK DAM - OPERATION PLAN

RESERVOIR OPERATION PLAN

Irrigation Supply Operation

The primary purpose of Little Creek Dam is to supply irrigation water for use by the Smalltown Irrigation District in the summer months. The reservoir receives its water supply by direct flows from Little Creek, and by a diversion from Small Creek.

Filling Schedule

The outlet gates at Little Creek Dam are closed at the end of the irrigation (typically mid-October), and all available water flow is stored up to elevation 710.0 feet, which is 5 feet below the dam crest. Seepage through the dam, and flows from springs immediately below the dam provide sufficient flow for fish in Little Creek. Diversion from Small Creek into the Little Creek reservoir is started as early in the spring as ice conditions permit (typically late March), and is continued until the reservoir is filled to the spillway crest elevation of 720.0 feet.

Release Schedule

Except for flood control purposes, releases from the outlet works shall only be made as required for irrigation purposes. The capacity of the outlet works with both gates open with the reservoir at the spillway crest elevation of 720.0 feet is 1000 cfs. However, this flow would be destructive to the downstream toe area below the energy dissipator. The maximum required outlet discharge for irrigation purposes is 100 cfs. The discharge through the outlet works should not be allowed to exceed 200 cfs, unless higher discharges are required for extreme flood conditions.

Flood Control Operation

Little Lake will also be regulated for optimum flood reductions. During flood control regulation, the conduit gates are to be operated in a uniform setting with no more than one foot difference in opening among the gates. The following regulations govern releases from Little Lake:

Reservoir Stage	Reservoir Conditions	Regulation
Below 720.0	--	Releases will be made as needed to maintain elevation 720.0.
720.0 - 729.0	Rising	Make releases according to the following schedule: **Reservoir Stages** — **Maximum Allowable Release Rates (cfs)** 720.0 - 724.0 — 1,000 724.0 - 729.0 — 1,500 The combined intervening flow downstream shall <u>not</u> exceed: • 2,000 cfs on Little Creek below the dam, or • 21.0-foot stage on Little River at the Perry gauge. If flow exceeds any of the limits listed above, no release will be made until the flow recedes below flood stage.
729.0 - 732.0	Rising	If the forecasted reservoir level will crest at or below elevation 732.0, a maximum release of 4,000 cfs. will be made. If the forecasted reservoir level will crest **above** elevation 732.0, the flood control conduit gates will be opened in increments of 750 cfs each hour until both are fully opened or until the reservoir begins falling.

EQUIPMENT OPERATION

Hydraulically Controlled Slide Gate

The hydraulically controlled slide gate is located at the upstream end of the main outlet conduit at Little Creek Dam. This gate is used to release irrigation water and regulate reservoir levels.

Gate Opening Sequence

The slide gate can either be opened from the electrical cabinet in the control house or the control cabinet in the gate chamber by completing the following steps:

1. Start the hydraulic unit by depressing the "START" button. A red light will come on to confirm the operation.

2. Depress the slide gate "OPEN" button and hold in to open the gate to the desired position.

The operator should monitor the gate position indicator to determine the gate opening position. The gate position lights will indicate the position of the gates as follows:

Lights	Gate Position
Both Red and Green	Mid-position
Only Red	Full-open position
Only Green	Full-closed position

The gate will not open if the gate "full-open" limit interlock is engaged. The gate can be stopped in any intermediate position, and re-started in either the open or close direction.

4. Stop the hydraulic unit by depressing the "STOP" button. The red indicating light will go out to confirm that the hydraulic unit has stopped.

Gate Closing Sequence

The slide gate can be closed from either the electrical cabinet in the control house or the control cabinet in the gate chamber by completing the following steps:

1. Start the hydraulic unit by depressing the "START" button. A red light will come on to confirm the operation.

2. Depress the slide gate "CLOSE" push button and hold in to close the gate to the desired position.

Manually Operated Slide Gate

The manually operated slide gate at Little Lake Dam is located at the upstream end of the 36-inch auxiliary lake drain conduit. The gate is controlled via the drain gate wheel on the platform above the gate. This gate is only to be used as a backup to the main outlet conduit.

Gate Opening Sequence

The drain gate may be opened by placing the drain gate wheel on the gate and rotating the wheel clockwise. Approximately sixty turns of the wheel are required to fully open the gate.

Gate Closing Sequence

The drain gate may be closed by placing the drain gate wheel on the gate stem and rotating the wheel counter-clockwise. Approximately sixty turns of the wheel are required to fully open the gate.

Note: Should the wheel become difficult to run, particularly when the gate is near closure, do **NOT** force the wheel in the close direction. Reverse the wheel to reopen the gate approximately ten turns, then attempt to re-close the gate. In no case should the wheel be forced toward the closed position with more than normal effort. Should resistance to closure occur, stop closure of the gate when resistance begins and seek professional assistance.

SLIDE GATE - EMERGENCY OPERATION

Emergency operation or opening of the slide gate is required when lowering of the reservoir elevation is necessary to relieve hydrostatic pressure on the dam, such as during a potential piping failure of the embankment. The gate should be fully opened and the reservoir drained as quickly as watershed inflow will allow.

Emergency operation of the gate is NOT recommended during dangerously high reservoir levels. The primary spillway pipe will already be flowing at maximum capacity and opening of the drain gate will not increase the pipe discharge.

Manually Operated Butterfly Valve

A butterfly valve is located on the outlet conduit just upstream from the main slide gate. The purpose of this valve is to maintain the slide gate in a dry condition during the winter months, and to allow for periodic draining and repair of the slide gate.

Operation

In "normal" operation this valve is to remain fully open. Only during the winter shut down of the outlet works is the gate valve to be closed and only after closing the jet-flow gate.

Only in the event of failure of the main slide gate shall the butterfly valve be closed against flowing water.

CAUTION

At no time should operation be allowed at partial opening, as operation in this manner could cause serious damage to the butterfly valve and outlet piping.

MAINTENANCE SCHEDULE FOR LITTLE CREEK DAM

Element	Frequency	Description
DAM EMBANKMENT		
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	Asphalt Roadways: Seal cracks resulting from normal wear and aging. Inform engineer of any new cracks or cracks that are increasing in size. Gravel Roadways: Regrade Eroded Areas. Add gravel as needed.
Maintain Crest Design Elevation	Annually	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 beaching of riprap by regrading the slope to original lines, and replacing the bedding material and riprap. Repair voids in the riprap by adding or moving riprap.
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

LITTLE CREEK DAM MAINTENANCE SCHEDULE (Continued)

Element	Frequency	Description
CONCRETE SPILLWAY CHANNEL		
Maintain Concrete Features	Annually	Make repairs to concrete surfaces and joints, including: • patching spalled areas with a bonding agent; • strengthening areas by applying coatings or by adding reinforcements; • repairing minor cracks with an adhesive or epoxy injection. **Note**: Get assistance from Dam Safety Section before making repairs to concrete surfaces and joints. Concrete problems may be an indication of a serious dam safety problem. Also, report any new or changing (increasing or decreasing) cracks to an engineer. Keep concrete joints and surfaces free of vegetation.
Spillway Channel	Weekly	Remove any obstructions or debris from the spillway channel.
	Monthly	Keep drains free and clear. Periodically rod and ream internal drains to keep them functioning.
Energy Dissipator (Stilling Basin)	Monthly	Remove visible and accessible and visible obstructions to outfalls (e.g., large rocks, debris, vegetation, etc.). Keep plunge pool cleaned out.
	Annually	Maintain stilling basin by removing riprap and other significant rock debris. (It may be necessary to dewater the stilling basin to remove debris.) The stilling basin may need to be dewatered and cleaned approximately every five years, depending on the previous condition of the stilling basin and the amount of use since it was last dewatered.
Return Channel	Monthly	Remove obstructions within the return channel.

LITTLE CREEK DAM MAINTENANCE SCHEDULE (Continued)

Element	Frequency	Description
EARTHEN SPILLWAY CHANNEL		
Erosion Control	Annually & After Floods	Repair erosion gullies by removing loose materials and replacing them with compacted fill. Gravel and cobbles or planted grass should be added as appropriate to the damaged area to prevent future erosion.
Maintain Spillway Channel	Weekly	Remove any obstructions or debris from the spillway channel.
	Annually	Cut grass. Remove small trees and bushes that would affect flows now or in the future if let to grow.
DROP INLET SPILLWAY		
Clean Trashrack	Weekly	Remove all floating logs and debris from trashrack and spillway opening.
Clear Air Vent(s)	Monthly	Clear debris from air vent entrance.
Inspect and Maintain Logboom	Biannually	Replace waterlogged or submerged logboom members. Repair or replace loose or missing anchors.
Inspect and Repair CMP or Concrete Riser	Annually	Concrete Risers: Make repairs to concrete surfaces and joints. (Refer to previous section on maintaining concrete features) CMP Risers: Examine metalwork for corrosion. Remove rust and apply protective coating. Check joints for leakage, apply sealant as needed.
Maintain Metal Features	Annually	Remove mineral deposits and paint metal features, as needed, check to see that the cathodic protection is performing adequately, and restore corroded metal to original condition by welding on new metal.

LITTLE CREEK DAM MAINTENANCE SCHEDULE (Continued)

Element	Frequency	Description
OUTLET WORKS		
Gates and Valves	Annually	Test gates and valves for proper operation and leakage.
	As specified	Gates and valves are to be maintained according to the manufacturers' instructions. Follow the guidelines specified by the manufacturer.
Gate and Valve Controls	As specified	Follow guidelines specified by manufacturer.
Intake Structure	5 Years	Lower reservoir level or hire divers to inspect intake for low level outlet works. Clear debris from trashrack. Apply protective coating to metalwork. Repair concrete as needed.
Conduit	Annually	Visually inspect conduit from downstream end for corrosion, leakage, or other significant problems.
	5 Years	Inspect entire conduit interior either manually or via remote control camera. Repair or reline as needed.

Inspection Plan for Little Creek Dam

Monthly

1. Record Reservoir Level
2. Determine Reservoir Inflow
3. Check & Record Outlet Flow
4. Make Required Changes in Gates and Valves
5. Visually Examine Condition of:
   a. Dam Crest,
   b. Upstream and Downstream Faces,
   c. Spillway and Stilling Basin,
   d. Outlet Works Energy Dissipator
   e. All Drainage Systems
   f. Security and Safety Devices
6. Check and Record Piezometer Readings
7. Check and Record Toe Drain Flow
8. Check Spillway Channel For Debris
9. Check Foundation Seepage Area
10. Check Log Boom
11. Check Oil Reservoir Level in Hydraulic System
12. Check Exposed Electrical Wiring
13. Record Pertinent Information in Operating Log

Annually

1. Perform Detailed Annual Inspection of all Project Elements Using Checklist
2. Test Operate All Gates and Valves Through a Complete Cycle
3. Drain and Inspect Interior of Outlet Tower
4. Drain and Inspect Spillway Stilling Basin and Outlet Energy Dissipator
5. Test Operate all Backup Operating Equipment
6. Survey Settlement Monuments on Dam Crest
7. Check Corrosion Protection on all Exposed Metalwork
8. Review and Update Emergency Action Plan

Seasonally

Between April 1 and June 1, when reservoir is full, increase frequency of *Monthly* inspection duties to once weekly.

Between June 1 and September 1, increase frequency of *Monthly* inspection duties to once every two weeks.

SECTION V - LITTLE CREEK DAM - INSTRUMENTATION & MONITORING

Instrumentation at Little Creek Dam consists of the following:

- Two weirs along the downstream toe for measuring seepage
- A staff gauge on the outlet tower for recording reservoir levels
- Two observation wells on the dam to measure water levels within the embankment.
- Four settlement monuments along the dam crest

MONITORING INSTRUCTIONS

Seepage Measurements

Measurement Point No. 1, Toe Drain - The toe drain at Little Creek Dam is located adjacent to the energy dissipator at the downstream toe. The toe drain is a 6-inch diameter PVC pipe which is the outlet for the embankment blanket drain.

Measurement Point No. 2 - Measurement point no. 2 is a 90° V-Notch weir located near the west abutment of the dam. The weir was installed to measure seepage from a spring surfacing along the west abutment area.

Operating Instructions

For the V-Notch weir, read the value on the staff gauge attached to the weir and convert readings to gallons per minute by using the table on the back of the reporting form. For the toe drain pipe, catch water in a container of known capacity, and record the time it takes to fill. Enter Data on the Seepage Monitoring Form (Appendix B), along with the reservoir level at the time. Also note whether the seepage is clear, cloudy, or muddy.

NOTE: The presence of cloudy or muddy seepage, or an unusual increase in seepage over time, are indicators of a potential problem developing. Immediately inform the Dam Safety Section at (206) 459-6046 if any such adverse change in seepage is noted.

Interval

Weekly - March to October Monthly - November to February

Reservoir Level

Staff Gauge

The staff gauge at Little Creek Dam is located on the drop inlet riser, and can be read from the catwalk to the riser.

Operating Instructions

Read the water surface level on the gauge. Enter Data on the seepage monitoring form, and on the observation well recording log.

Observation Wells

Well No. 1 - Observation Well No. 1 is located at STA 2+75 on the dam crest. The well is a 2 inch diameter PVC tube with a slotted end. The depth of the well is 50 feet, and the bottom elevation is 685.3 feet NGVD.

Well No. 2 - Observation Well No. 2 is located at the downstream toe adjacent to the outlet works energy dissipator. This well is a 1.5 inch diameter PVC tube with a slotted end. The depth of this well is 30 feet, with a bottom elevation of 675.2 feet NGVD.

Operating Instructions

Water in the embankment and/or foundation enters the PVC tube through the slotted section at the bottom, and rises to the same level in the tube as the water in the surrounding soil. The well is read by inserting a 100 foot steel tape with a weighted end into the well. When the tape goes slack, it has reached the base of the well. Retract the tape, and record the length of tape that is wetted. Record this value, along with the corresponding reservoir elevation on the Observation Well Monitoring Form (Appendix B).

Interval

Monthly - All year

Crest Settlement Monuments

Surface settlement points consisting of 3-foot lengths of reinforcing steel, driven into the surface of the completed embankment were installed at four locations parallel to the axis of the dam as follows:

Point No.	Station	Elevation
0 (Control Pt.)	0+00	745.50
1	1+00	745.00
2	2+00	745.05
3	3+25	745.06

Operating Instructions

Using a surveying level, take elevation readings of the crest monuments, using control point 0 as a reference. Record the information on the Crest Settlement Form.

LITTLE CREEK DAM - UPDATING

This O & M Manual should be reviewed and updated annually by the president of the Smalltown Irrigation District. Elements to be updated may include:

- Names and phone numbers of operating 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 information should be distributed to copies of O & M Manual located at:

- Dam Site
- Dam tender's personal copy
- Washington State Dept. of Ecology, Dam Safety Section

APPENDIX B

ANNUAL INSPECTION FORM

ANNUAL INSPECTION FORM

General

Dam Name:_____

Date of Inspection:_____

Owner's Name:_____

Address:_____

Telephone No.:_____

Inspected by:_____

Weather:_____

Reservoir Data

Reservoir Level at Time of Inspection:_____ (feet below dam crest)

Reservoir Inflow at Time of Inspection:_____ (cfs or gpm)

Reservoir Outflow at Time of Inspection:_____ (cfs or gpm)

Condition of Dam

Crest:_____

_____

_____

(Check for: surface cracking, animal burrows, low areas, horizontal alignment, ruts, trees, brush)

Upstream Face:_____

_____

_____

(Check for: slumps, slides, scarps, sinkholes, animal burrows, slope protection, wave erosion, trees, brush)

Downstream Face:_____

_____

_____

(Check for: wet areas [no flow], seepage [note location], slides, slumps, scarps, change in slope, animal burrows, erosion, unusual movement, trees, brush, water loving vegetation)

Spillway(s):

- Earthen Channel;_____

_____

_____

(Check for: slide, slump, scarp, erosion protection, vegetation, debris)

- Concrete Lined Channel;_____

_____

_____

(Examine: sidewalls, channel floor, approach area, weir, discharge area. Check for: alignment, movement, cracking, spalling, undermining, etc.)

- Drop Inlet;_____

_____

_____

(Examine: intake structure, trashrack, conduit, stilling basin)

Outlet Works:(visible elements)_____

_____

_____

(Examine: intake structure, trashrack, stilling basin, control mechanism, outlet pipe. Check for: seepage, undermining, erosion, corrosion)

Maintenance Deficiencies:_____

_____

_____

Additional Comments: _____

_____

_____

Sketch of Dam and Reservoir Site

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)

mments: _____

_____

* 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

APPENDIX D

REFERENCES

REFERENCES

1. Harp, Larry R. et al., Training Aids for Dam Safety - Module: How to Organize an Operation and Maintenance Program, U.S. Government Printing Office, Denver, Colorado, 1990.

2. State of Colorado, State Engineer's Office, Dam Safety Manual, Denver, Colorado, June 1983.

3. Washington State Department of Ecology, Dam Safety Guidelines - Part III: An Owner's Guidance Manual, Publication #89-38, Dam Safety Section, Olympia, Washington, October 1989.

4. Wenas Irrigation District, Operation and Maintenance Plan - Wenas Dam, Selah, Washington, February 1991.

5. U.S Department of the Interior, Bureau of Reclamation, Guide for Preparation of Standing Operating Procedures - for Dams and Reservoirs, U.S. Government Printing Office, Denver, Colorado, January 1986.

6. U.S. Department of the Interior, Bureau of Reclamation, Standing Operating Procedures - Conconully Dam, Pacific Northwest Region, Boise, Idaho, March 1984.

7. U.S. Department of the Interior, Bureau of Reclamation, Standing Operating Procedures - North Dam, Pacific Northwest Region, Boise, Idaho, June 1989.