

A DAM (MTxxxxx)



Prepared By:

**Montana Department of Natural Resources
& Conservations**

January 2010

Operation and Maintenance Manual (O & M)

A DAM

**National Inventory of Dams (NID) No. MTxxxxx
Anywhere, MT**

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For:

**Cattle and Sheep Company
425 Any Road
Anywhere, MT. 596xx**

Version 1.0

January 2010

REVISION SHEET
Operation and Maintenance Manual
FOR
A Dam

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DISTRIBUTION LIST
Operation and Maintenance Manual
FOR
A Dam

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A DAM

Project Data Sheet

General

| | | | | |
|--------------------------|---|--|--|--|
| Dam Name: | A Dam | | | |
| NID ID #: | MTxxxxx | | | |
| Owner & Operator: | 2T | | | |
| Location: | Lat; Long | | | |
| | Sec., T, R | | | |
| Purpose of Project: | Irrigation and stock watering in Some County, MT | | | |
| Construction History: | Original construction in 1948. Repairs made to dam in 2000, included; an impermeable line placed on the upstream face of the dam, a set of water level measurement stakes installed on the upstream face of the dam, an HDPE liner placed in the existing CMP outlet conduit to control seepage from the pipe, and a sand seepage control cutoff collar installed around the downstream end of the conduit. | | | |
| Downstream Hazard Class: | High Hazard | | | |
| Project Datum: | Local Datum in feet. | | | |

Reservoir

| | | | | |
|----------------------------|---|-------------------|--------------------|---------------------|
| Watershed: | Located on Some Creek, a tributary to Another Creek | | | |
| Drainage Area: | 12.2 sqmi | | | |
| | Elevation (ft) | Surface Area (Ac) | Total Storage (AF) | Active Storage (AF) |
| Minimum Operating Pool: | | | | |
| Normal Full Pool: | | 15 | 375 | |
| Maximum Flood Pool: | | | 540 | |
| Maximum Reservoir Contour: | | | | |

Dam

| | | | |
|-------------------|--------------------|--------------------|--|
| Dam Type: | Earthen Embankment | | |
| Height: | Structural: 48 ft | Hydraulic: 48 ft | |
| Crest Elevation: | | | |
| Crest Length: | 410 ft | Crest Width: 25 ft | |
| Upstream Slope: | 3:1 | | |
| Downstream Slope: | 2:1 | | |

Outlet Works

| | |
|------------------|--|
| Conduit: | Irrigation outlet consists of an 18 inch CMP, lined with a 12 HDPE conduit. This conduit has a stainless steel slide gate. |
| Control Gate (s) | |

Spillway

| |
|---|
| The emergency spillway is approximately 6 feet below the crest of the dam and 44 feet wide. |
|---|

[Insert Project File Index Here]

[Insert any Maps Relative to Project]

1.0 GENERAL INFORMATION

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1.0 General Information

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- 1.3 Location and Access to the Dam and Facilities
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- 1.6 Public Safety and Health
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1.0 GENERAL INFORMATION

1.1 OPERATION AND MAINTENANCE MANUAL

This document is the Operation and Maintenance (O&M) Manual for A Dam. The document provides procedures, guidance and standard forms for the normal operation and maintenance of the facilities. **THE EMERGENCY ACTION PLAN (EAP) SHOULD BE UTILIZED FOR UNUSUAL AND EMERGENCY CONDITIONS.** The purpose of the O&M Manual is to ensure adherence to approved operating procedures over long periods of time and during changes in operating personnel. The instructions will permit personnel, knowledgeable in reservoir operations but unfamiliar with the conditions at a particular dam, to operate the dam and reservoir at times when regular operating personnel cannot perform their normal duties.

1.2 PURPOSE AND DESCRIPTION OF PROJECT

A Dam is used for irrigation and stock watering and is located on Some Creek, a tributary of Another Creek, in Some County, MT. The earthen embankment dam is approximately 410 feet long, 48 feet high and 25 feet wide. The Cattle and Sheep Company is the owner of A Dam, which is regulated by the Montana Department of Natural Resources and Conservation (DNRC) as a high hazard Dam. Operation shall be in conformance with the current DNRC Operating Permit which is included in Appendix E of this O&M Manual.

1.3 LOCATION AND ACCESS TO THE DAM AND FACILITIES

A Dam is in the Northeast Quarter of Section xx, Township xx North (TxxN), Range x East (RxE), and located on Some Creek, a tributary to Another Creek. The dam is located off Highway 360, twenty miles northwest of Anywhere. Access to the dam is from Highway 360 and the nearest telephone is at the home of the dam owner.

1.4 ASSIGNMENT OF RESPONSIBILITY

The Cattle and Sheep Company has final authority and responsibility for the safety, operation, and maintenance of A Dam. The Cattle and Sheep Company performs dam tender responsibilities for manually adjusting gates and valves as well as performing maintenance.

1.5 ATTENDANCE AND CUMMUNICATIONS

1.5.1 Attendance

A Dam is unattended. The nearest operating personnel are at the Cattle and Sheep Company ranch, which is about one and a half miles downstream of the dam.

1.5.2 Communication

There is no phone or radio at A Dam. Cattle and Sheep Company personnel may be phoned at the home of “the dam owner” at 406-xxx-xxxx

1.6 PUBLIC SAFETY AND HEALTH

Safety of the public and all personnel is a primary concern. The only access to the dam is through Cattle and Sheep Company property and needs to be coordinated with the owner. The outlet gate valves are locked.

1.7 RESTRICTED AREAS

Access to the dam is through Cattle and Sheep Company property and needs to be coordinated with the owner. The outlet gate valves are locked.

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2.0 OPERATION PROCEDURES

2.1 RESERVOIR OPERATIONS

Reservoir operating data, such as Elevation-Storage and Emergency Spillway Rating Curve, are provided in Appendix B and C respectively.

2.2 FILLING SCHEDULE

Filling will begin each spring as soon as the ice and snow have been cleared from outlets, which normally is April. Filling normally ends in June or July. Outflow occurs throughout the summer and fall, beginning in June and ending in late September.

2.3 RELEASE SCHEDULE

A decision is made to begin releasing water based on the rainfall, moisture conditions, and water demand. The outlet structure is inspected and cleaned of debris or sediment if present, and the gate is adjusted based on demand.

2.4 FLOOD OPERATION

At the earliest possible indication of abnormally heavy rainfall or runoff in the Some Creek basin, the dam tender should station himself at the dam and open the outlet to its full capacity. If it appears likely that high outflows from the emergency spillway will occur, a warning should be given to downstream residents to prepare for evacuation as outlined in the Emergency Action Plan.

2.5 CONTROL GATES

There are two control gates at the outlet of the dam. The main control gate is a stainless steel slide gate. The diversion control gate is used to divert outflow from Some Creek to a diversion canal that is used for irrigation purposes.



Main control stainless steel slide gate 18 inch CMP, lined with a 12 inch HDPE conduit.

Diversion control gate 24 inch.

Diversion Canal

2.6 SPRING STARTUP PROCEDURE

At the beginning of operations, typically late April to early May, the dam and outlet works should be inspected. The inspection should follow the procedures provided in Appendix A of this O&M Manual. Any operational deficiencies should be repaired prior to filling the reservoir.

Operation personnel should review the filling operation plan, O&M Manual and monitoring requirements. The owner and operation personnel should also review the EAP

2.7 FALL SHUTDOWN PROCEDURE

At the end of irrigation deliveries in the fall, typically September, the dam and outlet works should be inspected. The inspection should follow the procedures provided in Appendix A of the O&M Manual. The fall inspection should provide adequate time for completion of repairs prior to the following year.

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3.0 MONITORING & INSPECTION

3.1 GENERAL

Dam Instrumentation refers to a variety of devices installed within, on, or near the dam to monitor structural behavior during construction, initial filling and subsequent operation. Instruments provide a means for detecting abnormal conditions which could lead to major problems.

This section describes the instrumentation at A Dam, the methods and frequency of data collection, transmittal of data, and procedures to evaluate the data. Timely evaluation of instrumentation readings is critical if an abnormal condition is to be detected to allow for effective corrective action.

The Dam Operator is primarily responsible for collecting and reporting instrumentation readings. Periodic Owner Inspections should be performed by the Dam Operator or the Cattle and Sheep Company. The Cattle and Sheep Company is responsible to review and file the instrumentation and inspection records.

Inspection of A Dam will be scheduled and completed:

- Yearly for routine operation and maintenance inspections
- Periodically (not to exceed five years) for comprehensive inspections and engineering reviews
- After critical events including severe rain or wind storms, earthquakes, or periods of extremely high storage

3.2 MONITORING WELLS

There are no monitoring wells at A Dam.

3.3 DRAINS AND SEEPAGE

- Remove debris in and around the weirs to prevent clogging.
- Remove debris and repair the small drainage channels leading to the weirs so that water is properly directed and contained within the channels.
- Clean algae and dirt from the weir staff gauges to allow easy reading.
- Keep the weirs level to assure accurate readings

3.4 YEARLY INSPECTIONS

As the dam owner, the Cattle and Sheep Company will assign personnel to conduct the annual operation and maintenance inspections. Inspections of the embankment should occur when the reservoir is full, while inspections of the outlet works should occur while it is empty. Checklists to those in Appendix A (Forms) will be used. Inspection training will be conducted using one of the references as follows:

- Department of Natural Resources and Conservation Dam Safety Section, “Hazard Classification of Doggett Dam, Open File”, May 1990.
- Department of Natural Resources and Conservation Dam Safety Section, “Operation Permit of Doggett Dam, Open File”, May 1990 to present.
- Department of Natural Resources and Conservation Dam Safety Section, “Dam Safety Operation and Maintenance Plan Notebook.”

3.5 PERIODIC OWNER INSPECTIONS

An informal Owner Inspection should be performed twice yearly (fall shutdown and spring start-up). The inspection should include a systematic review of the conditions at each dam including the outlet works as outlined on the forms included in Appendix A. Inspection of the outlet works should be performed in compliance with OSHA confined space procedures. The forms should be completed and placed in the project record files. Digital photographic records of project features should be included with the inspection files.

3.6 PERIODIC ENGINEER INSPECTIONS

The High Hazard Dam Operation Permit issued by the Montana DNRC Dam Safety Program included in Appendix G requires a periodic inspection by a qualified engineer prior to renewal of the operation permit (typically every five years). Inspections by a qualified engineer should also be performed if unusual conditions occur or after critical events, such as earthquakes or extremely high reservoir storage levels.

3.7 CRITICAL EVENT INSPECTIONS

The dam should be inspected during or immediately following the occurrence of critical events, such as severe rain or wind, earthquakes or periods of extremely high reservoir elevation. If emergency conditions are observed, the responses outlined in the Emergency Action Plan should be implemented. Emergency conditions include erosion threatening the integrity of the dam,

seepage that is cloudy or excessive and/or extremely high water surfaces. Inspection by a qualified engineer should be performed to evaluate the impact of critical events on the dam.

Even if the water surface level is not at a high elevation at the time of an earthquake, it is possible that the dam could suffer some ill-effects from the earthquake (associated with seepage performance) that will not show up until higher reservoir elevations are subsequently reached. Therefore, heightened awareness and possible monitoring would be appropriate following an earthquake whenever the reservoir is rising to elevations that have not been previously experienced since the occurrence of the earthquake. Specific changes to monitoring schedules would need to be established on a case-by-case basis in light of the magnitude of the earthquake, reservoir elevation at the time of the earthquake, and apparent damage sustained by the dam as a result of the earthquake.

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4.0 MAINTENANCE

4.1 CRITICAL CONDITIONS

The following conditions are critical and require immediate repair or maintenance under the direction of a qualified engineer. The critical repairs or maintenance need to address the specific conditions encountered and are not covered in this O&M Manual. Critical conditions should trigger a response as outlined in the Emergency Action Plan.

- Erosion, slope failure or other conditions which are endangering the integrity of the dam.
- Piping or internal erosion as evidenced by increasingly cloudy seepage or other symptoms.
- Spillway blockage or restriction.
- Excessive or rapidly increasing seepage appearing anywhere near the dam site.

4.2 PERIODIC MAINTENANCE

The following items should be noted in the operations log and added to the work schedule whenever they are noted during Operation Inspections or Periodic Inspections. The following maintenance items should be completed as soon as possible after identification (at least annually):

- Remove bushes and trees from the embankment and abutments.
- Repair erosion gullies.
- Repair defective gates or valves.
- Repair deteriorated concrete or metal components.
- Maintain riprap or other erosion protection.

Continued maintenance should also be performed for the following items:

- Test, clean and lubricate gates and valves.
- Inspect and maintain instrumentation and gauging equipment.
- Remove debris from dam area and emergency spillway approach and exit channel.
- Remove debris from embankment face and from areas around the intake structures.
- Clean and remove debris from seepage weirs and small drainage ditches.

4.3 EMBANKMENT MAINTENANCE

1. Fill erosion gullies with properly compacted cohesive soil material. Seed or riprap repaired area to stabilize from future erosion.
2. Fill rodent burrows with slurry of soil, cement and water. Remove the rodents.
3. Maintain grass cover by spraying weeds, fertilizing and watering as needed.
4. Remove brush, bushes and trees from embankment and from within 25 feet of the groins and 50 feet of the toe of embankment. Remove tree roots, fill with compacted soil and re-seed area.
5. Add or repair riprap where displacement or other damage occurs.
6. Maintain grading of the embankment crests to prevent potholes, rutting or other potential for standing water to accumulate.
7. Maintain fences to provide site security and to exclude livestock from the embankments. Repair and revegetate damaged embankment surfaces.
8. Perform regular inspections of the embankments and abutments to identify potential maintenance items.

4.4 OUTLET MAINTENANCE

1. Test gates and valves semi-annually.
2. Lubricate gates and valves annually or as recommended by the manufacturer.
3. Repair defective gates and valves to ensure smooth operation and prevent leakage.
4. Repair deteriorated concrete or metalwork.
5. Remove debris from the outlet channels annually, inspect and repair erosion protection.
6. Repair and verify calibration of water measurement equipment.

APPENDIX A – MONITORING & INSPECTION FORMS

[I.E. OPERATION LOG, WELL FORM, PERIODIC INSPECTION
OBSERVATIONS CHECKLIST]

APPENDIX B – RESERVOIR STORAGE

[I.E. ACTIVE/INACTIVE STORAGE CAPACITIES W/ GRAPHS, RESERVOIR SURFACE ARE W/ GRAPH]

APPENDIX C – OUTLET WORKS RATING

[I.E. OUTLET WORKS RATING CURVE]

APPENDIX D – MONITOR WELLS LOGS

NONE

APPENDIX E – PROJECT DRAWINGS

[I.E. PROJECT DRAWINGS]

APPENDIX F – MANUFACTURE’S DATA

[IF APPLICABLE AND AVAILABLE]

APPENDIX G – GLOSSARY

GLOSSARY

Abutment, dam: That part of the valley wall against which the dam is constructed. Defined in terms of left and right as looking downstream from the reservoir.

Acre-foot: A term used in measuring the volume of water, or amount of water needed to cover 1 acre (43,560 square feet) 1 foot deep (325,851 gallons).

Afterbay: The body of water immediately downstream from a powerplant or pumping plant (also referred to as tailrace)

Air release valve: A valve, usually manually operated, which is used to release air from a pipe or fitting.

Alkali-aggregate reaction: A deterioration of concrete by which the alkali in cement reacts chemically with the silica present in some aggregates.

Apron: A level section of concrete or riprap constructed upstream or downstream from a control structure to prevent undercutting of the structure.

Associated facility: These facilities include most carriage, distribution, and drainage systems, small diversion works, small pumping plants and powerplants, open and closed conduits, tunnels, siphons, small regulating reservoirs, waterways, and Type 2 bridges.

Axis, dam: A plane or curved surface, appearing as a line in plan or cross section, to which horizontal dimensions can be referred.

Axis, dam (concrete): A vertical reference surface coincident with the upstream face at the top of the dam.

Baffle block: One of a series of upright obstructions designed to dissipate energy as in the case of a stilling basin or drop structure (also referred to as dentate).

Balanced head condition: The condition in which the water pressure on the upstream and downstream sides of an object are equal (such as an emergency or regulating gate).

Ball-milling: The repeated churning action of cobbles, gravel, and sand caused by the force of water in a stilling basin or other structure by which severe concrete abrasion can occur.

Bank storage: Water that has infiltrated from a reservoir into the surrounding land where it remains in storage until water level in the reservoir is lowered.

Beaching: The action of water waves by which beach materials settle into the water because of removal of finer materials.

Benchmark: A permanent or temporary monument of known elevation above sea level, used for vertical control at construction site.

Berm: A horizontal strip or shelf built into an embankment or cut to break the continuity of the slope, usually for the purpose of reducing erosion or to increase the thickness of the embankment at a point of change in slope or defined water surface elevation. Usually 10 to 15 feet in width.

Bulkhead: A one-piece fabricated steel unit which is lowered into guides and seals against a frame to close a water passage in a dam, conduit, spillway, etc.

Camber: The extra height added to the crest of embankment dams to ensure that the freeboard will not be diminished by foundation settlement or embankment consolidation. The amount of camber is different for each dam and is dependent on the amount of foundation settlement and embankment expected to occur.

Canal: A channel, usually open, that conveys water by gravity to farms, municipalities, etc.

Canal prism: The shape of the canal as seen in cross section.

Cavitation: The formation of partial vacuums in fast-flowing water caused by sub-atmospheric pressures immediately downstream from an obstruction or offset. Usually accompanied by noise and vibration.

Cavitation damage: The attack on surfaces caused by the implosion of bubbles of water vapor.

Check structure: A structure used to regulate the upstream water surface and control the downstream flow in a canal.

Chute: A conduit for conveying free-flowing materials at high velocity to lower elevations.

Clearance: A procedure used to establish a safe environment for maintenance, repair, or inspection. It includes systematically isolating pertinent equipment from all sources of hazardous energy (hydraulic, electrical, mechanical, pneumatic, and chemical) and attaching safety tags or locks to the appropriate controls. Also, it includes a written statement that documents isolation of the equipment. (also referred to as "lockout" or "tagout")

Coating: The protective material applied to the outer surface of metalwork.

Conduit: A pipe, box, or horseshoe structure, or natural channel that is constructed by means of "cut and cover". A conduit can convey water or house other conduits or pipes.

Corps of Engineers (COE): The District Engineer, located at the Omaha District, Nebraska, Corps of Engineers determines flood control and flood control regulation for reservoirs which have been allocated storage space for flood control.

Crest: The top surface of the dam. A roadway may be constructed across the crest to permit vehicular traffic or facilitate operation, maintenance, and examination of the dam. Also the high point of the spillway control section.

Crown: The highest point of the interior of a circular conduit, pipe, or tunnel.

Cubic feet per second (cfs): A unit of discharge for measurement of a flowing liquid equal to a flow of 1 cubic foot per second, 449 gallons per minute, 1.98 acre-foot per day.

Curtain grouting: The process of pressure grouting deep holes under a dam or in an abutment to form a watertight barrier and effectively seal seams, fissures, fault zones, or fill cavities in the foundation or abutment.

Cutoff (keyway) trench: An excavation in the foundation of an embankment (earth or rockfill) dam, usually located upstream of the dam axis or centerline crest which extends to bedrock or to an impervious stratum. The excavation is backfilled with impervious material to reduce percolation under the dam.

Cutoff wall: A wall of impervious material (e.g., concrete, asphaltic concrete, timber, steel sheet piling, or impervious grout curtain) located in the foundation beneath the dam which forms a water barrier and reduces seepage under a dam or spillway.

Dam: A barrier built across a watercourse to impound or divert water.

Dam Operator: The person responsible for the daily or routine operation and maintenance activities of a dam and its appurtenant structures. The dam operator commonly resides at or near the dam.

Deflection: Upstream or downstream movement of a dam or dike, or lateral movement of a wall.

Dentate: See “baffle block”.

Designated frequency flood: See “flood”.

Designers' Operating Criteria (DOC): Detailed operating criteria which stresses the designers' intended use and operation of equipment and structures in the interest of safe, proper, and efficient use of the facilities. Includes drawings, tables, etc.

Design summary: A document that summarizes the designers' development of the design that results in the specifications. It may include a section on the Designers' Operating Criteria.

Differential head condition: The condition in which the water pressure on the upstream and downstream sides of an object differ (also called unbalanced head).

Downstream face: The inclined surface of the dam away from the reservoir.

Drain, blanket: A layer of pervious material placed to facilitate drainage of the foundation and/or embankment.

Drop structure: A structure that conveys water to a lower elevation and dissipates the excess energy resulting from the drop.

Elevation-capacity table: A table giving reservoir storage capacity in terms of elevation increments.

Emergency Action Plan (EAP): A formal plan of procedures designed to minimize an emergency situation or unusual occurrence at a given dam or reservoir.

Emergency reserve fund: Money reserved or required by contract to be reserved by an operating entity for use in emergency situations involving facilities under the entity's jurisdiction.

Epicenter, earthquake: Focal point on earth's surface directly above the origin of seismic disturbance.

Erosion, concrete: Surface disturbance caused by abrasion from moving particles in water, impact of pedestrian or vehicular traffic, or impact of ice flows.

Erosion, soil: Surface displacement of soil caused by weathering, dissolution, abrasion, or other transporting.

Examination report: A written report that documents the condition of the facility during the examination, operation and maintenance activities accomplished since the last examination, and recommendations necessary for the continued safe and efficient operation of the facility.

Face, dam: Exposed surface of dam materials (earth, rockfill, or concrete), upstream and downstream.

Facility review, comprehensive: A detailed examination performed on dams with a senior dam engineer. State-of-the-art design characteristics are also evaluated.

Facility review, periodic: An examination on dams generally without the involvement of a senior dam engineer.

Failure: An incident resulting in the uncontrolled release of water from a dam.

Fault, earthquake: A fracture in rock along which the adjacent rock surfaces are differentially displaced.

Flashboard: Wooden board or structural panel anchored to the crest of a spillway used as a means of increasing the reservoir storage.

Flood, designated frequency and its probability: A 100-year flood is often considered in the design of diversion dams and for diversion-during-construction requirements. Service spillways, stilling basins, and some outlet works components may also be designed to pass certain level of floods designated by a return period. The return period should be thought as the chance that such a flood will be equaled or exceeded in any one year. For example, the 100-year flood is the flow level with a 0.01 annual exceedance probability, or there is 1 chance in 100 that this flood flow level will be equaled or exceeded in any given year.

Flood, inflow design (IDF): That flood used for design of a safe structure. It may be the PMF (probable maximum flood), but in sparsely developed areas where judgment indicates minimal property damage and no probable loss of life, the design flood may be less than the PMF.

Flood, moderate frequency: A flood of lesser magnitude than the IDF used for the service spillway design when supplemented by a separate auxiliary spillway.

Flood, probable maximum (PMF): The largest flood reasonably expected at a point on a stream because of a probable maximum storm and favorable runoff conditions.

Flume: Flumes are shaped, open-channel flow sections that force flow to accelerate. Acceleration is produced by convergence of the sidewalls, raising the bottom, or a combination of both.

Long-throated: Long-throated flumes control discharge rate in a throat that is long enough to cause nearly parallel flow lines in the region of flow control. Parallel flow allows these flumes to be accurately rated by analysis using fluid flow concepts. The energy principle, critical depth relationships, and boundary layer theory are combined to rate flumes and broad-crested weirs by Ackers et al. (1978) and Bos et al. (1991). Thus, these flumes and modified broad-crested weirs are amenable to computer calibrations. Long throated flumes can have nearly any desired cross-sectional shape and can be custom fitted into most canal-site geometries. The Ramp flumes also considered a version of broad-crested weirs is an example of this kind of flume.

Parshall Flume: A Parshall flume is a specially shaped open channel flow section that may be installed in a drainage lateral or ditch to measure the rate of flow of water.

Short-throated: Short-throated flumes are considered short because they control flow in a region that produces curvilinear flow. While they may be termed short-throated, the overall specified length of the finished structure including transitions may be relatively long. The Parshall flume is the main example of this kind of flume. These flumes would require detailed accurate and accurate knowledge of the individual streamline curvatures for calculated ratings which is usually considered impractical. Thus short-throated flumes are determined empirically by comparison with other more precise and accurate water measuring systems.

Forebay: The body of water immediately upstream from the dam.

Foundation, dam: The excavated surface upon which a dam is placed.

Foundation, drains: Tile or pipe for collecting internal seepage water of dam.

Freeboard: The difference in elevation between the maximum reservoir water surface and the dam crest.

Freeze-thaw damage: Damage to concrete caused by extreme temperature variations as noted by random pattern cracking. Damage is accelerated by the presence of water and commonly more severe on the south-facing side of structures.

Gallery: A passageway within the body of a dam, its foundation, or abutments.

Gate: A device that controls the flow in a conduit, pipe, or tunnel without obstructing any portion of the passageway when in the fully open position.

Gate chamber: A chamber in which a guard gate in a pressurized outlet works or both the guard and regulating gates in a free-flow outlet works is located.

Gate, emergency (guard): The first gate in a series of flow controls, remaining open while downstream gates or valves are operative.

Gate, high-pressure: A gate consisting of a rectangular leaf encased in a body and bonnet and equipped with a hydraulic hoist for moving the gate leaf.

Gate, operating (or regulating): A gate used to regulate the rate of flow through an outlet works.

Gate, slide: A steel gate that upon opening or closing slides on its bearings in edge guide slots.

Gate hanger: A device used to maintain a set gate opening.

Groin: The contact between the upstream or downstream face of the dam and abutments.

Grout: A fluid mixture of cement and water or sand, cement, and water used to seal joints and cracks in rock foundation.

Hazard classification: The rating for a dam based on the potential consequences of failure. The rating is based on potential loss of life and damage to property that failure of the dam cause. Such classification is related to the amount of development downstream of a dam.

Head: The difference in number of feet between two water surface elevations.

Head loss: The energy per unit weight of water lost due to transitions, bends, etc.

Heave: The upward movement of land surfaces or structures due to subsurface expansion of soil or rock, or vertical faulting of rock.

Hydraulic height: Height to which water rises behind the dam and is the difference between the lowest point in the original stream bed at the axis or the centerline crest of the dam and the maximum controllable water surface.

Hydrograph: A graph showing for a given point on a stream or conduit, the discharge, stage, velocity, available power, or other property of water with respect to time.

Hydromet: A network of automated remote-monitoring stations which collect hydrologic and meteorologic field data, and transmit the data via satellite to a computer for processing and storage. Hydromet makes near real-time data available for easy access by computer.

Hydrology: The science that treats the occurrence, circulation properties, and distribution of the waters of the earth and their reaction to the environment.

Inflow, reservoir: The amount of water entering a reservoir expressed in acre-feet per day or cubic feet per second.

Instrumentation: Any device used to monitor the performance of the structure during its construction and/or throughout its useful life.

Inundation map: A map of the ground surfaces downstream of a dam showing the probable encroachment by water released because of failure of the dam or from abnormal flood flows released through a dam's spillway.

Invert: The lowest point of the interior of a circular conduit, pipe, or tunnel.

Job hazard analysis: A study of a job or activity to identify hazards or potential accidents associated with each step or task, and develop solutions that will eliminate, nullify, or prevent such hazards or accidents.

Joint, contraction: Contraction joints are placed in concrete to provide for volumetric shrinkage of a monolithic unit or movement between monolithic units.

Joint, construction: Construction joints are purposely placed in concrete to facilitate construction; to reduce initial shrinkage stresses and cracks; to allow time for the installation of embedded metalwork; or to allow for the subsequent placing of other concrete.

Joint, expansion: A separation between adjoining parts of a concrete structure which is provided to allow small relative movements, such as those caused by temperature changes, to occur independently.

Lateral: A channel that conveys water from a canal to a farm, municipality, etc.

Lift line: Horizontal construction joint created when new concrete is placed on previously placed concrete.

Lining: Any protective material used to line the interior surface of a conduit, pipe, or tunnel.

Lockout: Clearance procedure in which physical locks replace Safety Tags (see “clearance”).

Log boom: A device used to prevent floating debris from obstructing spillways and intakes.

Logbook: A dated, written record of performed operation and maintenance items or observations pertinent to a structure.

Maintenance management system: Any organized system used to ensure that all preventive maintenance at a facility is accomplished and documented

Major facility: Major facilities include storage dams and reservoirs, diversion dams with significant storage or where major equipment and operation are complex, large pumping plants and powerplants, large canal systems, large complex closed conduit systems, and Type 1 bridges.

Maximum credible earthquake (MCE): The severest earthquake that is believed to be possible at the site on the basis of geologic and seismological evidence. It is determined by regional and local studies that include a complete review of all historic earthquake data of events sufficiently nearby to influence the project, all faults in the area, and attenuations from causative faults to the site.

Multipurpose project: A project designed for irrigation, power, flood control, municipal and industrial, recreation, and fish and wildlife benefits, in any combinations of two or more. Contrasted to single-purpose projects serving only one need.

O&M: Acronym for operation and maintenance.

Ogee crest: The shape of the concrete spillway crest that represents the lower profile of the under-nappe of a jet of water flowing over a sharp-crested weir at a design depth.

Outflow: The amount of water passing a given point downstream of a structure, expressed in acre-feet per day or cubic feet per second.

Outlet works: A series of components located in a dam through which normal releases from the reservoir are made.

Piezometer: An instrument which measures pressure head or hydraulic pressures in a conduit or hydraulic pressures within the fill of an earth dam or the abutment; at the foundation because of seepage or soil compression; or on a flow surface of a spillway, gate, or valve.

Pattern cracking: Fine cracks in the form of a pattern on a concrete surface.

Pipe: A circular conduit constructed of any one of a number of materials that conveys water by gravity or under pressure.

Piping: The action of water passing through or under an embankment dam and carrying with it to the surface at the downstream face some of the finer material.

Pore-water pressure: Internal hydrostatic pressure in an embankment caused by the level of water in the reservoir acting through pressure-transmitting paths between soil particles in the fill.

Posted operating instructions: The O&M instructions taken from the Standing Operating Procedures that pertain to the mechanical/electrical features in the immediate area.

Pound per square inch (psi): A pressure designation for pounds per square inch.

Reach: The area of a canal or lateral between check structures.

Remote operation: Operation of mechanical features from an on-site location other than at the feature.

Reservoir: The body of water (pool) impounded by a dam.

Reservoir Capacity Allocations (RCA): Shows a summary of acre-feet allocations of water, to such purposes as surcharge, exclusive flood control, joint use, active conservation, inactive storage, and dead storage.

Richter scale: A scale of numerical values of earthquake magnitude ranging from 1 to 9.

Riprap: The broken rock or boulders placed on upstream and downstream faces of embankment dams to provide protection from erosion caused by wind or wave action.

RO&M: The Review of Operation and Maintenance program; a periodic evaluation of O&M activities at a particular facility. Also see “facility review”.

Sand Boil: Seepage characterized by a boiling action at the surface surrounded by a cone of material from deposition of foundation and embankment material carried by the seepage.

Seepage: The slow movement or percolation of water through small cracks, pores, interstices, etc., from an embankment, abutment, or foundation.

Seismic: Of or related to movement in the earth's crust caused by natural relief of rock stresses.

Settlement: The sinking of land surfaces because of subsurface compaction, usually occurring when moisture added deliberately or by nature, causes a reduction in void volumes.

Sinkhole: A steep-sided depression formed when removal of subsurface embankment or foundation material causes overlying material to collapse into the resulting void.

Slough: Movement of a soil mass downward along a slope because of a slope angle too great to support the soil, wetness reducing internal friction among particles, or seismic activity. It is also called a slope failure, usually a rather shallow failure.

SOD: Acronym for Safety of Dams program.

Soil Cement: A mixture of Portland cement and pulverized soil placed in layers on the upstream face of a dam to provide slope protection.

Spalling: The loss of surface concrete usually caused by impact, abrasion, or compression.

SPCC: Acronym for spill prevention control and countermeasure plan.

Spillway: A structure that passes normal and/or flood flows in a manner that protects the structural integrity of the dam.

Splitter wall: A wall or pier parallel to the direction of flow in a channel that separates flows released from different sources as a means of energy dissipation.

Springline: An imaginary reference line located at mid-height of a circular conduit, pipe, or tunnel. Also the maximum horizontal dimension of a circular conduit, pipe, or tunnel.

Standing Operating Procedures (SOP): A comprehensive single-source document covering all aspects of dam and reservoir operation and maintenance and emergency procedures. Its purpose is to ensure adherence to approved operating procedures.

Stilling basin: A pool, usually lined with reinforced concrete, located below a spillway, gate, or valve into which the discharge dissipates energy to avoid downstream channel degradation.

Stilling pool: A pool located below a spillway, gate, or valve into which the discharge dissipates energy to avoid downstream channel degradation.

Stoplogs: A set of interchangeable fabricated steel or wood units lowered between walls or piers to close a water passage in a dam, conduit, spillway, etc. The logs are inserted in slots one at a time. A lifting beam may be used for their installation.

Structural height: Distance between the lowest point in the excavated foundation (excluding narrow fault zones) and the top of dam.

-The structural height of an embankment (earth or rockfill) dam is the vertical distance between the top of the embankment and the lowest point in the excavated foundation area, including the main cutoff trench, if any, but excluding small trenches or narrow backfilled areas. The top elevation does not include the camber, crown, or roadway surfacing.

-The structural height of a concrete dam is the vertical distance between the top of the dam and lowest point of the excavated foundation area, excluding narrow fault zones.

Sulfate attack: Damage to concrete caused by the effects of a chemical reaction between sulfates in soils or ground water and hydrated lime and hydrated calcium aluminate in cement paste. The attack results in considerable expansion and disruption of paste.

Supervisory control: A system used to monitor conditions and operate mechanical/electrical features associated with a facility from a location other than at the site.

Tailwater: The water in the natural stream immediately downstream from a dam. The elevation of water varies with discharge from the reservoir.

Toe: The contact between the upstream or downstream face of the dam and natural ground.

Toe drain(s): Open-jointed tile or perforated pipe located at the toe of the dam used in conjunction with horizontal drainage blankets to collect seepage from the embankment and foundation and conveys the seepage to a location downstream from the dam.

Trash rake: A device that is used to remove debris which has collected on a trashrack to prevent blocking the associated intake.

Trashrack: A metal or reinforced concrete structure placed at the intake of a conduit, pipe, or tunnel that prevents entrance of debris over a certain size.

Tunnel: An enclosed channel that is constructed by excavating through natural ground. A tunnel can convey water or house conduits or pipes.

Turnout: A structure used to divert water from a supply channel to a smaller channel.

USGS: An acronym used for U.S. Geological Survey, the agency that monitors stream flows, river hydrology, and seismic activity.

Unbalanced head condition: See “differential head condition”.

Uplift pressure: See “pore-water pressure”.

Upstream face: The inclined surface of the dam that is in contact with the reservoir.

Valve: A device used to control the flow in a conduit, pipe, or tunnel that permanently obstructs a portion of the waterway.

Vortex: A revolving mass of water in which the streamlines are concentric circles and in which the total head is the same.

Water conveyance structure: Any structure that conveys water from one location to another.

Water stage recorder: A motor-driven (spring wound or electric) instrument for monitoring water surface elevation.

Waterstop: A continuous strip of waterproof material placed at concrete joints designed to control cracking and limit moisture penetration.

Weep hole: A drain embedded in a concrete or masonry structure intended to relieve pressure caused by seepage behind the structure.

Weir: An overflow structure built across an open channel to measure the flow of water and is calibrated for depth of flow over the crest.

Cipolletti: A contracted weir of trapezoidal shape in which the sides of the notch are given a slope of 1 horizontal to 4 vertical.

Rectangular: A contracted or suppressed weir with horizontal crest, rectangular in shape, having vertical sides.

V-notch: A weir that is V-shaped, with its apex downward, used to accurately measure small rates of flow.

LIST OF ACRONYMS

| | |
|------------|---|
| AC | Alternating Current |
| AOP | Annual Operating Plan |
| CFS or cfs | Cubic feet per second |
| COE | United States Army Corps of Engineers |
| DC | Direct Current |
| DCP | Data Collection Platform |
| DES | Disaster and Emergency Services |
| EAP | Emergency Action Plan |
| EPA | Environmental Protection Agency |
| g | acceleration due to gravity (32 ft/s ²) |
| GOES | Geostationary Operational Environmental Satellites |
| gpm | Gallons per minute |
| IDF | Inflow Design Flood |
| JHA | Job Hazard Analysis |
| M&I | Municipal and Industrial |
| MT | Montana |
| NRCS | Natural Resource Conservation Service |
| NWS | National Weather Service |
| PMF | Probable Maximum Flood |
| PFR | Periodic Facility Review |
| SOD | Safety of Dams |
| SOP | Standing Operating Procedures |
| USGS | United States Geological Survey |

APPENDIX H – DNRC OPERATION PERMIT

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