R655. Natural Resources, Water Rights.
R655-10. Dam Safety Classifications, Approval Procedures and Independent Reviews.
R655-10-1. Authority.

The following rule is established under the authority of Title 73, Chapter 5a. The procedures constitute minimum requirements for dams. Additional procedures may be required to comply with any other governing statute, federal law, federal regulation, or local ordinance.

R655-10-2. Purpose.

The purpose of this rule is to outline the procedures necessary to obtain approval to design, construct, operate, and remove a dam. This rule in no way waives the right of the State Engineer to evaluate the merits of different procedures or to require additional information before approval of any project.

R655-10-3. Applicability.

These rules apply to any dam constructed in the state with the exception of those specifically exempted by Section 73-5a-102. Some dams may have an abbreviated approval process as outlined in Section 73-5a-202.

R655-10-4. Definitions.

ABUTMENT is the part of the valley side against which the dam is constructed. Right and left abutments are those on respective sides of an observer when viewed looking downstream.

ACRE-FOOT (AC-FT) of water is the volume of water required to cover one acre, one foot deep. This is the term commonly associated with reservoir storage. It is equal to 43,560 cubic feet.

ACTIVE FAULT is a fault that has exhibited one or more of the following characteristics:

(a) movement at or near the ground surface at least once in the last 35,000 years;

(b) instrumentally determined seismicity that demonstrates a causal relationship with the fault;

(c) structural relationship to an active fault such that movement on one fault could be expected to cause movement on the other.

ACTIVE STORAGE CAPACITY is the amount of storage that can be released and utilized.

ANISOTROPY means having physical characteristics which vary in different directions.

APPURTENANT STRUCTURE means the outlet works, spillways, access structures, bridges, and other related structure to a dam.

AXIS OF DAM is the plane or curved surface, arbitrarily chosen by a designer, appearing as a line, in plan or in cross section, to which the horizontal dimensions of the dam can be referred.

BENCHMARK is a permanent physical mark of known horizontal coordinates and elevation.

BREACH is an opening or a breakthrough in a dam.

CALIBRATED WATERSHEDS are watersheds with sufficient precipitation and streamflow measuring devices and records to allow for computations of the relationships between precipitation and streamflow.

CAMBER is additional material placed on the dam crest to protect design freeboard from anticipated settlement.

CAPACITY is the maximum volume that can be stored in a reservoir below the primary spillway level.

CAVITATION is wear on a hydraulic structure where a high hydraulic gradient is present.

CHANGE ORDER is a document used to modify approved plans or make adjustments in pay quantities.

COLLECTION PIPE is a conduit used to collect seepage waters from drainage blankets and drains and convey the water to a point downstream of the dam.

CONDUIT is a closed channel to convey water through, under, or around a dam.

CONDUIT FILTER DRAIN is a pervious filter drain around a conduit for the purpose of seepage control.

CONTROL SECTION is the section where flow passes through critical depth.

CONTOUR LINE is a line of constant elevation on a map or drawing.

CREST LENGTH is the developed length of the top of a dam.

CREST WIDTH is the developed width of the top of a dam.

CUBIC FEET PER SECOND (CFS) is a unit expressing rates of discharge. One cubic foot per second is equal to the discharge through a rectangular cross-section, one foot wide and one foot deep, flowing at an average velocity of one foot per second.

CUTOFF COLLAR is a projecting collar, usually of concrete, built around the outside of a pipe, tunnel, or conduit, to lengthen the seepage path along the outer surface of the conduit.

DAM is any artificial barrier or obstruction, together with appurtenant works, if any, which impounds or diverts water.

DEAD STORAGE is the storage that lies below the invert of the lowest outlet and that cannot be withdrawn from the reservoir without pumping.

DEFORMATION ANALYSIS is a study of how a dam will permanently deform as a result of strains caused by seismic loads.

DENTAL CONCRETE is concrete used to level discontinuities in dam foundations and abutments.

DESICCATION is the process of cracking of soils due to shrinkage during drying.

DIFFERENTIAL SETTLEMENT is unequal settlement of a structure or soil mass, often leading to excessive stresses or unacceptable strains.

DISPERSIVE CLAYS are clays whose particles detach in the presence of water and may be transported by the water, leading to a piping failure.

DRAINAGE AREA or watershed is the area that drains naturally to a particular point on a river, stream or creek.

DRAINAGE BLANKET is a drainage layer placed directly over the foundation material.

DRAINAGE WELLS or pressure relief wells are wells or boreholes usually downstream of impervious cores, grout curtains, or cutoffs, designed to collect and control seepage through or under a dam, so as to reduce uplift pressures under or within a dam. A line of wells forms a drainage curtain.

DRAWDOWN is the lowering of a reservoir's water surface level due to releases.

DRAWINGS are graphical details of proposed construction.

DROP STRUCTURES are permanent structures used to facilitate the vertical downward movement of water without causing erosion.

DYNAMIC ANALYSIS is an analysis which predicts the stability and/or deformation of a dam due to seismic loads.

EARLY WARNING SYSTEM is an automatic device used to alert downstream interests of existing or impending high flows caused by storms or dam failures.

EMERGENCY ACTION PLAN is a predetermined plan of action to be taken to reduce the potential for loss of life and property damage in an area affected by a dam break.

EMERGENCY SPILLWAY, or secondary spillway, is the spillway designed to convey excess water generated by unusual hydrological events through, over or around a dam.

ENLARGEMENT is any change or addition to an existing dam or its appurtenant works which increases, or may increase, the maximum quantity of water which can be stored therein.

EPICENTER is the point on the earth's surface directly above the site of initial movement on the fault.

EXIT CHANNEL is an open channel, located downstream from any conduit or spillway, which conducts the flow to a point where it may be released without jeopardizing the dam.

FACE, in reference to a structure, is the external surface that limits the structure.

FILTER or filter zone is a band or zone that is incorporated in a dam and is graded, either naturally or by selection, so as to allow seepage to flow across or down the filter without allowing the migration of material from zones adjacent to the filter.

FLASHBOARDS are lengths of timber, concrete, or steel placed on the crest of a spillway to raise the water level but that may be quickly removed in the event of a flood, either by a tripping device or by a deliberately designed failure of the flashboards or their supports.

FLOOD ROUTING is a computation of the changes in the rise and fall in stream flow or reservoir levels as a flood moves downstream. The results provide hydrographs of flow or elevation versus time at given points on the stream or in a reservoir.

FLOOD STAGE is the stage or elevation in which overflow of the natural banks of a stream or body of water begins.

FLOWLINE or invert is the lowest point in a water conveyance structure where water can flow.

FOUNDATION OF DAM is the natural material on which the dam structure is placed.

GALLERY is a permanent accessible structure within the interior of a dam used for seepage collection, monitoring, and remedial work.

GEOLOGIST is a person with a degree in geology or a related field from an accredited college or university with at least three years of experience in engineering geology.

GEOMEMBRANE is a term for a geosynthetic which is designed to be an impermeable barrier.

GEOSYNTHETICS is a broad term used to describe manmade fabrics used in geotechnical applications.

GEOTEXTILE is a term for a geosynthetic which is designed to be a filter, a drain, act as reinforcement, or for separation.

GROIN is that area along the contact or intersection of the face of a dam with the abutments.

GROUT CURTAIN is a barrier to reduce seepage under a dam, produced by injecting grout into a vertical zone in the foundation.

HYDRAULIC FRACTURING is the fracturing of soil materials due to excessive fluid pressures.

HYDRAULIC HEIGHT is the vertical dimension of a dam as measured from the natural streambed at the downstream toe to the elevation of the water surface at the crest of the primary spillway.

HYDRAULICS is the science of the static and dynamic behavior of fluids.

HYDROGRAPH is a graphical representation of discharge, stage, volume, or other hydraulic property, with respect to time, for a particular point.

HYDROLOGY is the study of the properties, distribution and movement of water on the earth's surface, in the soil and underlying rocks.

INCREMENTAL DAMAGE ASSESSMENT (IDA) is an analysis showing the influence of a dam failure when superimposed upon an extreme hydrologic event.

INDEPENDENT CONSULTANT is a consultant used, in addition to the owner's engineer, to assess the design, construction, investigation or operation of a dam.

INFILTRATION RATE is the rate at which a given soil can accept surface water.

INFLOW DESIGN FLOOD (IDF) means the flood hydrograph which is used to size a dam's spillway.

INITIAL FILLING PLAN is a written procedure used during the first filling of a reservoir.

INLET CHANNEL is an open channel upstream from a spillway or conduit.

INTERNAL EROSION is piping.

INUNDATION MAPS show areas that would be subject to flooding due to storm conditions or failure of a dam.

LIQUEFACTION is the sudden loss of strength or stiffness of a soil resulting from dynamic loading as from earthquakes.

LOG BOOM is a floating device intended to prevent large floating debris from being carried into a spillway.

LOW-LEVEL OUTLET is a conduit from a reservoir, generally used for lowering the reservoir or for providing downstream releases.

MAGNITUDE of an earthquake is a quantity characteristic of the total energy released by an earthquake.

MAXIMUM CAPACITY is the maximum volume of water that can be stored in a reservoir when filled to the crest of the dam.

MAXIMUM CREDIBLE EARTHQUAKE (MCE) -- All active sources of seismicity with the potential to impact the stability of a dam should be assigned a maximum credible seismic event. The event which has the greatest potential to cause damage at the site will be defined as the Maximum Credible Earthquake.

NAPPE is the free-falling stream from a weir.

NORMAL FREEBOARD is the vertical distance between the primary spillway overflow crest and the top of the dam.

ONE HUNDRED YEAR FLOOD means the flood having a one percent probability of being equalled or exceeded in any given year.

ONE HUNDRED YEAR PRECIPITATION means the precipitation having a one percent probability of being equalled or exceeded in any given year.

OPERATING BASIS EARTHQUAKE (OBE) -- All active sources of seismicity with the potential to impact the stability of a dam should be assigned an operating basis seismic event. This event is considered to have a return interval of at least 200 years. The event which has the greatest potential to cause damage at the site will be defined as the Operating Basis Earthquake.

OWNER includes all who own, control, operate, maintain, manage, or propose to construct a dam; also, their agents, lessees, trustees, and receivers.

OWNER'S ENGINEER is a professional engineer, licensed in Utah, retained to design, construct, monitor, operate, or evaluate a dam.

PEAK FLOW is the maximum instantaneous discharge that occurs during a flood. It is coincident with the peak of a flood hydrograph.

PERVIOUS ZONE is a part of the cross section of an embankment dam comprising material of high permeability.

PHREATIC SURFACE is the free surface of ground water at atmospheric pressure.

PIEZOMETER is an instrument for measuring pore water pressure within soil, rock, or concrete.

PIPING is the progressive development of internal erosion by seepage, appearing downstream as a hole or seam, discharging water that contains soil particles.

PLANS are engineering drawings, specifications, and design reports supporting the design of a dam and detailing the construction of the dam.

POROUS INTERVAL is the portion of a piezometer where infiltrating water is allowed to act on the device.

PRINCIPAL SPILLWAY is the main spillway for normal operating conditions.

PROBABLE MAXIMUM FLOOD (PMF) is the flood that may be reasonably expected from the most severe combination of critical meteorologic and hydrologic conditions that are possible in the region.

PROBABLE MAXIMUM PRECIPITATION (PMP) is the maximum amount of precipitation that could be expected to fall on a drainage under the most severe meteorologic condition.

PSEUDO STATIC ANALYSIS is an approximate method for predicting the dynamic stability of a structure using static loads.

RESERVOIR AREA is the surface area of a reservoir when filled to a given water elevation.

RESERVOIR RIM is a term used to describe the land forms around the perimeter of a reservoir which could have an adverse impact on the dam or reservoir due to movement.

RESERVOIR STAGE is the measure of the depth or elevation of water in a reservoir relative to an established datum.

RESIDUAL FREEBOARD means the vertical distance between the maximum water surface during a given hydrologic event and the top of the dam.

RESPONSE SPECTRUM is a graphical representation of actual motions, including displacement, velocity, and acceleration, caused by seismic events.

RIPRAP is a layer of large stones, broken rock, or precast blocks placed on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel, as a protection against waves, ice, and scour.

SEDIMENT POOL is the portion of the reservoir allotted to the accumulation of submerged sediment during the design life of the dam.

SEISMIC means pertaining to an earthquake or earth vibration.

SLOPE PROTECTION is the protection of an embankment slope against wave action or erosion.

SPECIFICATIONS are written descriptions of the proposed construction.

SPILLWAY is an open or closed channel, conduit or drop structure used to convey excess water through a reservoir. It may contain gates, either manually or automatically controlled, to regulate the discharge of the water.

SPILLWAY EVALUATION FLOOD (SEF) is the flood that may be expected at the dam from applying the SEP to a given watershed.

SPILLWAY EVALUATION PRECIPITATION (SEP) is the lowest, site specific, precipitation estimate allowed by the State Engineer, used in the analysis of new, existing, high or moderate hazard dams.

STAFF GAGE is a permanent instrument or device used to read reservoir stage.

STANDARD OPERATING PLAN is a written procedure outlining the operation and maintenance of a dam and its appurtenant structures and equipment.

STATE ENGINEER is the Director of the Utah Division of Water Rights.

STILLING BASIN is a basin constructed to dissipate excess energy of waters emerging from a spillway or outlet.

STOPLOGS are beams placed on top of each other with their ends held in guides on each side of a channel or conduit.

STORAGE CAPACITY is the volume of water which can be stored at the elevation of the primary spillway, including both active and dead storage.

STRUCTURAL HEIGHT means the vertical dimension of a dam as measured from the natural streambed at the downstream toe of a dam to the top of a dam.

SURVEY MARKER is a permanent physical mark on a dam or appurtenant structure used to measure changes in horizontal and vertical movement.

TECTONICS is a study of the broader features of the earth's crust and the causes of its deformation.

TEST BORINGS are holes drilled to determine the type and physical properties of subsurface materials.

TEST PIT is an excavation used to evaluate and observe subsurface materials.

TOE OF DAM is the junction of a dam face with the foundation. For an embankment dam, the junction of the upstream face with ground surface is called the upstream toe, and the junction of the downstream face with the ground surface is referred to as the downstream toe.

TRANSITION ZONE is a zone of material used to provide filter requirements between two zones of material which do not meet filter requirements.

TRASH RACK is a screen located at an intake to prevent the entry of floating or submerged debris.

UNGATED OUTLET is an outlet that allows uncontrolled flow through or around a dam.

UNIT HYDROGRAPH is a hydrograph which shows the rates at which runoff occurs for one inch of storm runoff from a drainage area.

UPLIFT is the upward water pressure in the pores of a material or on the base of a structure.

WATER STOPS are strips of material used to prevent leakage through joints between adjacent sections of concrete.

WEIR is a device used to measure or control water.

R655-10-5. Hazard Classification.

Hazard classification of a dam places the dam into a category based upon the consequences of failure of the dam. The State Engineer is the ultimate authority on the hazard classification designation for a given dam.

R655-10-5A. Hazard Classification -- Criteria.

The hazard classification analysis should include a determination of the threat to human life and property damage in the event of the failure of a dam. In some cases the classification can be assigned by observance of the downstream development in relationship to the location of the dam. In other cases it will be necessary to prepare inundation maps to determine the downstream consequences of failure. When using maps for hazard classification determination, the inundation boundary, as well as the depth and velocity of flow, will be considered. In preparing the inundation maps, the following criteria relative to the dam should be used.

1. No concurrent flooding conditions exist.
2. The reservoir level is at the spillway crest.
3. The low level outlet is discharging at capacity.
4. The breach times and geometric parameters used to simulate the dam failure should be acceptable to the State Engineer and consistent with accepted practices.
5. The inundation study should be carried downstream to a point that the breach flows are contained within the banks of the natural channel or a downstream reservoir.

R655-10-5B. Hazard Classification--Exceptions.

It should be noted that the hazard classification as outlined in R655-10-5A may not be an absolute indicator of the hazard of the dam, since a dam failure superimposed on natural flooding conditions may cause incremental risk to life and property. Although this scenario is not normally used in the hazard classification process, it is a factor the owner should consider in determining their overall liability. Under special circumstances, as determined by the State Engineer, a hazard classification may be determined giving consideration to concurrent flooding events.

R655-10-6. Approval Processes.

There are two procedures for obtaining approval from the State Engineer to construct or modify a dam. The first procedure requires the filing of an application, while the second procedure requires the submission of plans. No approval will be given for any dam unless the water rights are in order.

R655-10-6A. Application Procedure.

For dams not requiring submission of plans as outlined in Section 73-5a-202, an application must be submitted and approved by the State Engineer. Blank applications are available upon request. Upon reviewing the application the State Engineer may approve it, reject it, return it for correction, or approve it with conditions.

R655-10-6B. Submission of Plans.

A. All projects requiring submission of plans should include a package including the drawings, specifications, design reports, and any other information which will assist in reviewing the project. The amount of information generated becomes more involved as

the size and hazard rating of the structure increases. The following guidelines are included to alert the designer to the basic information required.

B. All drawings submitted should comply with the following:

1. The size of all drawings submitted for review, shall not be larger than 24 inches by 36 inches or smaller than 11 inches by 17 inches. All details on the drawings shall be clear and legible. Drawing sets with 10 sheets or less may be submitted electronically. Following approval of the project by the State Engineer, two sets of 11 inch by 17 inch drawings, reflecting all final approval conditions, shall be submitted, prior to the initiation of construction.

2. All drawings should include a bar scale to allow for accurate scaling of reductions.

3. All drawings shall have a title block in the lower right corner showing the project name, the owner's name, the sheet number, and the date of preparation of the plans.

4. All drawings shall have provisions for noting the dates of any modifications.

5. Each drawing shall include the signature and seal of the responsible engineer. Geological drawings should also be signed by the responsible geologist.

C. Drawings to be included in plans are:

1. Title sheet, including:

a. General location map including access roads.

b. Signature block for owner's acceptance.

c. Index of drawings.

d. Reference to the water rights for the reservoir.

e. Reservoir stage/storage curve.

f. Rating curves for outlets and spillways.

2. Plan view of reservoir, including:

a. Existing topography.

b. Borrow areas.

c. Supply canals and pipelines.

d. Suitable contour lines.

e. Clearing limits.

f. Waste areas.

3. Plan view of dam, including:

a. Location of all pertinent features.

b. A survey tie, to an outside section corner, where the longitudinal axis of the dam intersects the axis of the original stream channel or the low level outlet.

c. Clearing limits.

4. Longitudinal profile, showing:

a. Original ground line.

b. Location of core trench or other cutoff features.

c. Location of outlets and spillways.

d. Camber and anticipated settlement.

5. Typical cross-sections of dam, showing:

a. Embankment geometrics including internal zones.

b. Slope protection.

c. Cutoff.

d. Delineation of embankment on natural ground surface.

e. Freeboard.

f. Internal drainage.

g. Limits of foundation excavation.

6. Plan, profile, cross sections and details of all outlets, spillways, and other structures.

7. Structural details for reinforcing steel, metal fabrication, or waterstops.

8. Site geology map of the damsite and reservoir basin including locations of all borings and test pits.

9. Longitudinal geologic profile of both the dam and reservoir, showing:

a. Original ground line.

b. Location and orientation of borings.

c. Geological profile showing pertinent lithologic, hydrologic, and structural information.

10. Logs of borings with classifications of soil and rock, results of water pressure tests and other downhole material property tests, soil classification, standard penetration tests, core recovery, rock quality designations, and strength tests.

11. Any additional drawings such as instrumentation details necessary to construct the project.

D. Specification Requirements.

The State Engineer must review and approve all technical specifications for a proposed project. A partial list of specifications directly related to dam safety follows:

1. Site Preparation.

a. Clearing and Grubbing.

b. Soil Stripping.

c. Structure Removal.
d. Diversion and Care of Stream.
2. Foundation Preparation.
a. Foundation Dewatering.
b. Relief Wells.
c. Grouting.
d. Cutoffs.
e. Abutment Contacts.
f. Exploration.
g. Dental Concrete.
3. Earthwork.
a. Excavation.
b. Earth Fill.
c. Drain Fill.
d. Rock Fill.
e. Material Handling.
f. Testing Procedures.
4. Concrete and Reinforcement.
a. Concrete Mixing and Placement.
b. Steel Reinforcement.
c. Admixtures.
d. Curing and Curing Compounds.
e. Joint Fillers and Waterstops.
5. Outlets.
a. Water Control Gates and Valves.
b. Air Vent.
c. Operating Equipment.
d. Bedding Requirements.
6. Aggregates and Rock.
a. Drain Fill and Filters.
b. Concrete Aggregates.
c. Riprap.
7. Erosion Control.
8. Miscellaneous Structural Work.
a. Metal Fabrication and Installation.
b. Instrumentation.
9. All technical specifications should also include testing intervals to assure compliance with the specifications.

E. Design Report Requirements. The design report should include all information used to design the dam, including assumptions made and methodology used with sufficient documentation. Any building codes or design manuals used in the design should be referenced, including the year of publication of the source. If the design report is a product of a team effort, the names of all persons producing the report should be included along with the sections they prepared. Examples of items to be included in the design report are as follows:

1. Hydrology calculations for determining the spillway requirements.
2. Hydraulic characteristics of the outlets and spillways.
3. Subsurface investigation including logs of test borings and geologic cross-sections.
4. Material testing results and the location and logs of test pits.
5. Foundation treatment and abutment contact design.
6. Calculations for the reinforced concrete design and the loading conditions utilized.
7. Stability analysis of the dam, abutments, and reservoir rim, including appropriate seismic loading, safety factors and embankment zone characteristics.
8. Geological investigations including:
a. Regional perspective of the site's geologic and seismic setting at a scale appropriate to the geologic complexity of the area.
b. Seismic evaluation establishing the relationship of the site to all seismic features of concern and the potential for reservoir induced seismicity.
c. Site geology of areas affected by construction activities and appropriate adjacent areas.
d. Plans to compensate for any geological weakness in the dam foundation, abutment areas, and reservoir rim.
9. Subsurface seepage considerations including the cutoff trench design and internal drainage design and filtering.
10. Post-construction monitoring or alarm systems.

R655-10-7. Independent Consultant Review.

The State Engineer may require an independent consultant review to assess the adequacy of the design, construction, or operation of a dam. For purposes of these rules, an independent consultant review is a review of the owner's engineers' work in addition to the review provided by the State Engineer.

R655-10-7A. Review of Design.

The following situations will require an independent consultant review of the design of a new dam or significant enlargement of an existing dam.

1. Any dam that in the opinion of the State Engineer warrants additional review due to the large size or complexity of the dam and/or reservoir, or to supplement the technical expertise of the design engineer.
2. Any high or moderate hazard dam which, in the opinion of the State Engineer, has a unique problem requiring additional review.
3. Any high or moderate hazard dam whose design is not typical of dams normally built in the state and is thus beyond the technical abilities of the State Engineer's dam safety staff.
4. If the owner's engineer and the State Engineer cannot reach an agreement on the design of a dam.
5. If the owner specifically requests an independent consultant review.

R655-10-7B. Review of Construction.

The State Engineer may require an independent consultant review when unusual problems are noted during construction, the dam is not being constructed as per approved plans and specifications, or to supplement the technical expertise of the project engineer.

R655-10-7C. Operation.

The State Engineer may require an independent consultant review of the operation of a dam including initial filling plans, standard operating plans, emergency action plans, and performance of the dam if, in his opinion, conditions require a review.

R655-10-7D. Selection of Independent Consultants.

Upon notification to the owner, the owner will select independent consultants to conduct the required review. Prior to contracting with the proposed consultants, they must be approved by the State Engineer.

R655-10-7E. Qualifications of Independent Consultants.

All independent consultants must have a minimum of ten years' experience related to dams. In the case of engineers, they need to be licensed in the state where they reside, unless exempted by the State Engineer. All proposed consultants must demonstrate that they have the expertise to investigate problems identified and that they have insignificant past association with the dam in question.

R655-10-7F. Scope of Work.

In requiring the owner to obtain the services of an independent consultant, the State Engineer will include specific items needing investigation, the format for the reports submitted by the independent consultant, and a timetable for completion of the investigations.

R655-10-7G. Purpose of Independent Consultants Investigations.

The purpose of an independent consultant is to provide additional technical expertise and to insure safety issues are addressed. Conclusions generated by the independent consultants are not binding on the State Engineer.

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