

**NOTE: All of the proposed regulation text is to be added to the California Code of Regulations.**

**California Code of Regulations  
Title 23. Waters  
Division 2. Department of Water Resources  
Chapter 1. Dams and Reservoirs  
Article 6. Inundation Maps**

**§ 335. Scope of Regulations**

Inundation maps shall be prepared for dams and critical appurtenant structures regulated by the state, except dams classified by the department as low hazard as described in Section 335.4. The regulations in this article apply to inundation maps and supporting technical studies necessary to develop the maps. Owners are responsible for preparing and submitting these documents to the department.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Sections 6002, 6160, 6161, Water Code.

**§ 335.2. Definitions**

For purposes of this Article, the terms listed below shall have the meanings noted:

- (a) “Breach” refers to a sudden opening through a dam system that drains the reservoir.
- (b) “Breach elevation” refers to the elevation of the water in a reservoir at full reservoir conditions.
- (c) “Breach time” refers to the modeled time elapsed from initial dam failure to total dam failure.
- (d) “Critical appurtenant structure” refers to a man-made barrier or hydraulic control structure that impounds the same reservoir as the dam and is 25 feet or more in height, as measured from the upstream toe to the maximum water storage elevation; impounds a minimum of 5,000 acre-feet of water at full reservoir conditions; or has the potential to inundate downstream life or property, including but not limited to emergency spillways, gated spillways, and saddle dams.

## Proposed Emergency Regulations – Inundation Maps

A critical appurtenant structure may contain multiple water-barrier features, including but not limited to gates, flashboards, and concrete monoliths. Power system penstocks, lined spillway chutes, and low level outlets whose failure would not exceed the downstream channel capacity are not considered critical appurtenant structures as they pertain to inundation maps.

(e) “Critical facilities” refers to lifeline infrastructure and facilities including but not limited to schools, hospitals, skilled nursing facilities, major roads, public water and electric utilities, and communication infrastructure, as described in Section 8589.5 of the Government Code.

(f) “Cross-section” refers to a linear representation perpendicular to a watercourse and its adjacent floodplain, capturing the topography perpendicular to the flow direction.

(g) “Dam system” refers to a dam and all critical appurtenant structures that impound the same reservoir.

(h) “Deflood time” refers to the time elapsed from the flood wave arrival time until water at the measured location recedes to within one foot of its pre-flood water elevation.

(i) “Dynamic routing” refers to hydraulic flow routing based on the shallow water equations to compute changes in discharge, velocity, and stage with respect to time at various locations along a watercourse. The most common form of the equations is the Saint-Venant equations.

(j) “Failure scenario” refers to the modeled simulation of a complete or partial failure of a dam system, including a breach, which results in an uncontrolled release of water.

(k) “Flood surcharge” refers to the volume in a reservoir above the maximum certified water storage elevation resulting from a storm event.

(l) “Flood wave arrival time” refers to the elapsed time from the initiation of the failure scenario until the arrival of the leading edge of the flood wave comprising a one (1) foot rise above the ground elevation or water surface elevation before the failure scenario.

(m) “Freeboard” refers to the vertical distance between the lowest point along the top of a dam, dike, berm, levee, or other similar feature and the surface of the water contained therein.

(n) “Full reservoir conditions” refers to the maximum water storage elevation authorized in the department’s Certificate of Approval for the dam.

## Proposed Emergency Regulations – Inundation Maps

- (o) “Hydraulic model” refers to a simulation of conveyance of water through a watercourse.
- (p) “Hydrologic model” refers to a simulation of watershed processes such as precipitation, infiltration, and runoff. Hydrologic models perform simplified forms of dynamic routing.
- (q) “Inundation area” refers to the area that would experience a rise in water surface elevation of at least one (1) foot as the result of a failure scenario.
- (r) “Inundation map” refers to a map showing the area that would result in flooding from a failure scenario.
- (s) “One-dimensional model” refers to a numerical hydraulic model in which variables such as velocity and depth vary in one direction along a watercourse.
- (t) “Peak flow” refers to the maximum rate of water discharge.
- (u) “River mile” refers to the distance from a fixed point along a watercourse, measured along the thalweg.
- (v) “Sequential dam failure” refers to a failure scenario of an upstream dam system that results in the failure of one or more downstream dam systems.
- (w) “Storm-induced failure” refers to a failure scenario in which the extent of the inundation area is greater than that of a sunny day failure scenario.
- (x) “Sunny day failure” refers to a failure scenario of the dam system during full reservoir conditions with non-flood season inflow.
- (y) “Thalweg” refers to the line connecting the lowest point of a watercourse.
- (z) “Toe” refers to the junction of the slope of a dam or critical appurtenant structure with the natural ground surface.
- (aa) “Two-dimensional model” refers to a numerical hydraulic model in which variables such as velocity and depth vary in two directions along a watercourse.
- (bb) “Watercourse” refers to a stream or open conduit, including but not limited to canyons and floodplains.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 8589.5, Government Code; Sections 6002, 6002.5, 6004.5, 6005, 6008, and 6161, Water Code; FEMA

2013, *Federal Guidelines for Inundation Mapping of Flood Risks Associated with Dam Incidents and Failures* (FEMA P-946).

#### **§ 335.4. Hazard Potential Classification**

The department shall classify the public safety risk of all state jurisdictional dams, in a manner consistent with FEMA 333 (2004), as follows:

(a) Low Hazard Potential. Dams assigned the low hazard potential classification are those where failure or mis-operation of the dam system would result in no probable loss of human life and low economic and/or environmental losses. Losses are expected to be principally limited to the owner's property.

(b) Significant Hazard Potential. Dams assigned the significant hazard potential classification are those dams where failure or mis-operation of the dam system would result in no probable loss of human life but can cause economic loss, environmental damage, disruption of lifeline facilities, or other significant impacts.

(c) High Hazard Potential. Dams assigned the high hazard potential classification are those where failure or mis-operation of the dam system will probably cause loss of human life.

(d) Extremely High Hazard Potential. Dams assigned the extremely high hazard potential classification are dams that would otherwise be classified as high hazard dams, but where failure or mis-operation of the dam system would probably cause considerable loss of human life and would affect an inundation area with a population of 1,000 persons or more, or where critical facilities could be impacted.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 6002.5, 6009, 6160 and 6161, Water Code; FEMA 2004, *Federal Guidelines for Dam Safety: Hazard Potential Classification System for Dams* (FEMA 333).

#### **§ 335.6. Inundation Map Updates**

The owner of a dam shall update all inundation maps for the dam system under each of, but not limited to, the following circumstances:

(a) The department determines there is a significant change in the dam or critical appurtenant structure.

(b) There is a significant change in downstream development that involves people and property.

(c) The department changes the hazard classification of the dam.

(d) No less frequently than every 10 years.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 6006, 6007, and 6161, Water Code.

### **§ 335.8. Civil Engineering**

Inundation maps and technical studies shall be prepared by, or under the direction of, a civil engineer who is registered pursuant to California law and authenticated as provided in the Business and Professions Code, Division 3, Chapter 7 commencing with Section 6700.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 6161, Water Code; Section 6700, Business and Professions Code.

### **§ 335.10. Reporting Standards**

Inundation maps and technical studies prepared in accordance with this Article shall utilize the following standards and conventions, unless otherwise indicated:

(a) Reservoir storage and other water volumes shall be reported in acre-feet.

(b) Water discharge shall be reported in cubic feet per second.

(c) Geographic locations shall be reported in California Coordinate System or Universal Transverse Mercator coordinates relative to NAD83. Coordinates shall be specified commensurate with the precision of the analysis.

(d) Elevations shall be reported in feet above a specified vertical datum such as NAVD88 or NAVD29. Elevations may also be reported relative to an established local datum.

(e) Geospatial data shall be submitted in NAD 1983 Teale (California) Albers projection, with the units specified.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 6161, Water Code.

**§ 335.12. Technical Study**

A single technical study shall be prepared for each dam system for which inundation maps are required.

(a) Study contents. The technical study shall include the following:

(1) The name of the dam, department dam number, national dam ID number, and name or description of any critical appurtenant structures.

(2) The location of the dam and all critical appurtenant structures.

(3) The name and location of cities, towns, counties, and any populated area that could be affected by a failure scenario.

(4) A brief narrative of the hydrologic, meteorologic, and topographic features of the watershed, dam site, and downstream areas.

(5) An engineering description of the dam, including the type of construction (e.g., earth, rock, or concrete). Include a description of the features comprising each critical appurtenant structure (i.e., a description of all the gates and concrete structures comprising a gated spillway structure).

(6) Elevation of the crest and upstream toe for the dam and each critical appurtenant structure. Report the elevation of the downstream toe of the dam.

(7) A reservoir storage capacity curve that shows the relationship between reservoir elevation, surface area, and volume from the base of the reservoir to the dam crest.

(8) A spillway rating curve that shows the relationship between stage and discharge.

(9) The type of terrain data used, including any modifications made to the terrain.

(10) A summary of the modeled failure scenarios for the dam system.

(11) The modeling methodology, the reasons for its use, and the name, version, release date and author of the modeling software. Report all assumptions, failure parameters,

## Proposed Emergency Regulations – Inundation Maps

calibration and sensitivity analyses of the model, including the model's response to changes made to the roughness or other friction coefficients. Report modifications made to stabilize the model or accelerate its computational runtime, and the effects such modifications have on the modeled inundation results. Describe known limitations of the modeling method utilized. Provide justification for determining the downstream extent of the inundation boundary.

(12) Digital files comprising the following for each failure scenario:

(A) A vector file of the inundation area boundary.

(B) Raster files of the flood wave arrival time, maximum depth, peak velocity, and deflood time.

(13) The department may request additional information during the course of its review.

(b) Modeling Requirements.

(1) A two-dimensional, open channel, unsteady flow, hydraulic model shall be used to evaluate each failure scenario for a dam system, except as described below. The model must be capable of performing dynamic routing to approximate the temporal and spatial changes in inundation magnitude and extent.

(2) A one-dimensional hydraulic model may be used that is capable of computing spatial and temporal changes to water surface elevation, velocities, and flows at each cross section. A one-dimensional model may be used only in the following circumstances:

(A) To simulate levee overtopping as a subcomponent of the two-dimensional model of the failure scenario.

(B) Where the flood wave would be confined to a canyon or narrow watercourse in which the direction of flow is dominantly in the downstream direction.

(3) Upon approval of the department, the owner of a significant hazard dam may use a hydrologic model, rather than a hydraulic model, if the dam impounds less than 100 acre-feet of water and the flood wave produced by the failure scenario would be confined to a canyon or narrow watercourse in which the direction of flow is dominantly in the downstream direction.

(4) Each model shall utilize the best available terrain data, consisting of the finest resolution discretization available.

## Proposed Emergency Regulations – Inundation Maps

(c) Failure Scenarios. A sunny day failure condition is required for each dam and critical appurtenant structure. If a storm-induced failure condition is modeled for a dam system, that failure scenario may be submitted in lieu of a sunny day failure scenario.

Each failure scenario shall employ a complete and nearly instantaneous loss of the dam or critical appurtenant structure, and utilize breach parameters as described in FEMA P-946 (2013). The geographic extent of the model simulation shall terminate in accordance with FEMA P-946 (2013). Failure scenarios shall be modeled as follows:

(1) For gated critical appurtenant structures, such as a spillway with multiple radial gates, the failure scenario shall consist of the complete failure of all gates together with the concrete control section breached to the upstream toe.

(2) A sequential dam failure scenario is required for an upstream dam system that causes the failure of one or more downstream dam systems, as described in FEMA P-946 (2013). A sequential dam failure scenario shall employ an overtopping failure mode for all downstream dam systems impacted by the routing of the flood wave downstream. The owner of the upstream dam system is responsible for preparing the sequential failure scenario.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 6161, Water Code; FEMA P-946 (2013).

### **§ 335.14. Inundation Maps**

Inundation maps shall be prepared for each failure scenario to satisfy the FEMA P-946 (2013) and the requirements of this section.

(a) Temporal contours. Two separate inundation maps shall be prepared for each failure scenario, with contours depicting time increments appropriate for the failure scenario for flood wave arrival time and deflood time.

(b) Depth grid. All inundation maps shall depict the entire inundation area with discrete categories of maximum flood wave depths, with a legend showing each depth range. The opacity of the maximum flood wave depth layer shall be adjusted to display the underlying base map.

(c) General information. Each inundation map shall contain the following general information:

(1) The name of the dam, the department's dam number, the national dam ID number, and the county in which the dam is located.



## Proposed Emergency Regulations – Inundation Maps

- (2) The failure scenario. If a storm-induced failure scenario is depicted, the return period shall be reported on the inundation map.
- (3) The map background with suitable aerial imagery.
- (4) Callouts identifying the location of the dam, all critical appurtenant structures, and all critical facilities affected by the failure scenario. The downstream watercourse and flood control features, such as dams, levees, weirs, pumps, and control structures shall be labeled.
- (5) The identity of any jurisdictions, including boundary delineations or place marks identifying the city, county, or other governmental agency jurisdictional boundaries affected by the inundation area.
- (6) An arrow indicating north.
- (7) An appropriate scale bar and the stated map scale.
- (8) Vertical elevation datum.
- (9) Map collar information, including horizontal reference grid ticks.
- (10) An index showing the relationship of the map sheet to the other map sheets if the map has multiple sheets.
- (11) The date of preparation of the map.
- (12) The signature, seal, and licensed civil engineer number of the engineer responsible for preparing the map.
- (13) All features on maps shall be clearly labeled with text boxes and legends, as appropriate.
- (14) A statement that the information shown is approximate and should be used as a guideline for emergency response and preparation purposes.
- (15) A statement confirming the inundation map meets all applicable state and federal standards and has been prepared in consideration of all potential downstream hazards by a licensed civil engineer.

## Proposed Emergency Regulations – Inundation Maps

(d) Map Layout. Each of the inundation maps shall be printed on 11×17 inch or 24×36 inch paper, with a minimum resolution of 300 dots per inch. All inundation maps shall apply an appropriate map scale as described in FEMA P-946 (2013). For failure scenarios with a large inundation area, each inundation map may comprise more than one sheet.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 8589.5, Government Code; Sections 6160 and 6161, Water Code; FEMA P-946 (2013).

### **§ 335.16. Submission of Inundation Maps and Technical Study**

The owner of a dam shall submit inundation maps and the supporting technical study to the department as specified below:

(a) An electronic color copy of each new and revised inundation map in portable document format (PDF extension). If practical, two hard color copies of each inundation map should also be submitted.

(b) Technical Study: Two hard copies and an electronic copy including digital content.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 6161, Water Code.

### **§ 335.18. Department Review and Approval**

(a) The department shall evaluate each inundation map and technical study that is submitted for consistency with the requirements of this article and shall notify the dam owner in writing that the map and study have been approved, are incomplete, or are disapproved and the reasons therefor, as follows:

(1) Approved. The department has evaluated the inundation map(s) and technical study and determined that they satisfy the requirements of this article.

(2) Incomplete. The department has evaluated the inundation map(s) and technical study and determined that one or both do not satisfy the requirements of this article as a result of minor problems identified by the department. A dam owner shall have 60 calendar days from the time the department provides a notice of incompleteness to remedy any deficiencies and submit the corrected map and study. The department may extend this deadline if the map and study have been submitted more than 180 days before the deadline imposed by Section 6161 of the Water Code for submission of an emergency action plan.

## Proposed Emergency Regulations – Inundation Maps

(3) Disapproved. The department has evaluated the inundation map and technical study and determined that one or both do not satisfy the requirements of this article due to unresolved problems associated with an incomplete submittal. When an inundation map or technical study is disapproved, the dam owner shall submit a new map and technical study that satisfy this article.

b) Inundation maps submitted to the department for review by January 1, 2018, shall be evaluated for consistency with the FEMA P-946 (2013).

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 8589.5, Government Code; Sections 6161 and 6431, Water Code. FEMA P-946 (2013).

### **§ 335.20. Public Availability of Inundation Maps**

The department shall post copies of approved inundation maps on the department's website.

Note: Authority cited: Sections 6078 and 6162, Water Code. Reference: Section 6161, Water Code.