Classification of Dams

Dam Safety Section

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NEBRASKA
DEPT. OF NATURAL RESOURCES

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1.0 INTRODUCTION

The design, inspection, and maintenance criteria for a dam are based on its classification. In Nebraska, dams are classified by their size and their hazard potential. The size classification is determined by the height of the dam and its storage capacity. The hazard potential classification is determined by the damage that might occur to existing or future development should the dam suddenly release large quantities of water downstream due to a breach or misoperation of the dam. The size of a dam is only one of many factors that are taken into consideration when determining a dam's hazard potential classification.

1.1 Size Classifications

In Nebraska, the three size classifications for dams are small, intermediate, and large. Table 1 provides details for determining a dam's size classification.

Table 1. Dam Size Classification.

Size	Effective Height (feet) x Effective Storage (acre-feet)	Effective Height
Small	≤ 3,000 acre-feet^2	and ≤ 35 feet
Intermediate	> 3,000 acre-feet^2 and < 30,000 acre-feet^2	or > 35 feet
Large	≥ 30,000 acre-feet^2	regardless of height

The effective height of a dam is defined as the difference in elevation in feet between the natural bed of the stream or watercourse measured at the downstream toe (or from the lowest elevation of the outside limit of the barrier if it is not across stream) to the auxiliary spillway crest. The effective storage is defined as the total storage volume in acre-feet in the reservoir below the elevation of the crest of the auxiliary spillway. If the dam does not have an auxiliary spillway, the effective height and effective storage should be measured at the top of dam elevation.

1.2 Hazard Classifications

The following hazard potential classifications have been established for dams in Nebraska:

- **Minimal Hazard Potential** - failure of the dam would likely result in no economic loss beyond the cost of the structure itself and losses principally limited to the owner's property.

- **Low Hazard Potential** - failure of the dam would result in no probable loss of human life and in low economic loss. Failure may damage storage buildings, agricultural land, and county roads.

- **Significant Hazard Potential** - failure or misoperation of the dam would result in no probable loss of human life but could result in major economic loss, environmental damage, or disruption of lifeline facilities. Failure may result in shallow flooding of homes and commercial buildings or damage to main highways, minor railroads, or important public utilities.

- **High Hazard Potential** - failure or misoperation of the dam would result in probable loss of human life. Failure may cause serious damage to homes, industrial or commercial buildings, four-lane highways, or major railroads. Failure may cause serious flooding of hospitals, nursing homes, or schools.

The minimal hazard potential classification is generally limited to small size dams (defined in section 1.1) located in predominately rural or agricultural areas.

1.3 Categories of Dams

Dams in Nebraska are divided into two main categories based on their size and hazard potential. The two categories are farm pond dams and major dams. Farm pond dams include all dams that are of the small size classification and have either a minimal or low hazard potential. All other dams in the State are categorized as major dams.

2.0 DETERMINATION OF HAZARD CLASS

The dam's location and the depth of anticipated flooding downstream of a dam following its failure are the primary basis for determining its hazard potential class. In many cases, a dam's hazard potential class is readily apparent based on the dam's location and the presence of downstream development or the lack thereof. An engineer experienced in dam hazard potential classification may be able to determine the hazard class by touring the area downstream of the dam or simply reviewing readily available information such as aerial photographs and topographic information. In other cases, when the hazard potential classification is not readily apparent, hydraulic breach routings may be required.

2.1 Future Development

The potential for future development must be taken into consideration when determining the hazard potential class for a dam. New dams constructed in close proximity to a city or village as detailed in Table 2 must be designed to meet the requirements for a high hazard potential structure. The design requirements can be adjusted if development in the downstream breach inundation area is sufficiently curtailed due to zoning restrictions, easements, deed restrictions, or other methods of restriction acceptable to the Department.

Table 2. High Hazard Potential Based on Proximity to City or Village

Incorporated class	Population	Located inside given distance from city/village limits
Metropolitan Class	≥ 300,000	3 miles
Primary Class	> 100,000 up to 300,000	3 miles
First Class	> 5,000 up to 100,000	2 miles
Second Class	> 800 up to 5,000	1 mile
Village	100 up to 800	1 mile

2.2 Dams in Series

If failure of an upper dam could contribute to the failure of a lower dam, the upper dam must have a hazard classification that is equal to or higher than the hazard classification for the lower dam.

2.3 Breach Routings

Breach routings are used to help delineate the area downstream of a dam potentially impacted by inundation should that dam fail and can be used in determining the dam's hazard potential. Breach routings used in conjunction with survey and topographic data can be used to determine the anticipated depth of flooding at specific structures or facilities. Table 3 includes guidance for determining the hazard potential classification for a dam based on specific downstream structures and facilities.

2.31 Peak Breach Discharge

The peak discharge of the breach hydrograph shall be determined using the equations detailed in *Natural Resources Conservation Service (NRCS) Technical Release 210-60 Earth Dams and Reservoirs* and repeated here for convenience:

1. For depth of water at the dam at the time of failure where $H_w \geq 103$ ft

$$Q_{max} = (65)H_w^{1.85}$$

2. For depth of water at the dam at the time of failure where $H_w < 103$ ft

$$Q_{max} = (1{,}100)B_r^{1.35} \text{ where}$$

$$B_r = \frac{(V_S)(H_w)}{A}$$

but not less than $Q_{max} = (3.2)H_w^{2.5}$ nor more than $Q_{max} = (65)H_w^{1.85}$

3. When the width of the valley, L, at the water surface elevation corresponding to the depth, H_w, is less than,

$$T = \frac{(65)H_w^{0.35}}{0.416}$$

replace the equation, $Q_{max} = (65)H_w^{1.85}$, in 1 and 2 above with,

$$Q_{max} = (0.416)(L)H_w^{1.5}$$

where:

Q_{max} = the peak breach discharge, ft^3/sec

B_r = breach factor, acre

V_s = reservoir storage at the time of failure, acre ft

H_w = depth of water at the dam, ft, calculated as the reservoir water surface elevation at the time of failure minus the elevation of the valley floor

A = cross-sectional area of embankment at the assumed location of breach, usually the template section (normal to the dam longitudinal axis) at the valley floor elevation, ft^2

T = theoretical breach width at the water surface elevation corresponding to the depth, H_w, for the equation, $Q_{max} = (65)H_w^{1.85}$, ft

L = width of the valley at the water surface elevation corresponding to the depth, H_w, ft

The elevation of the valley floor is typically taken as the average elevation of the floodplain or the elevation of the top of the channel banks along the downstream toe of the dam as illustrated in Figure 1. A lower elevation for the valley floor should be considered if the breach flow is mostly contained within the channel downstream of the dam.

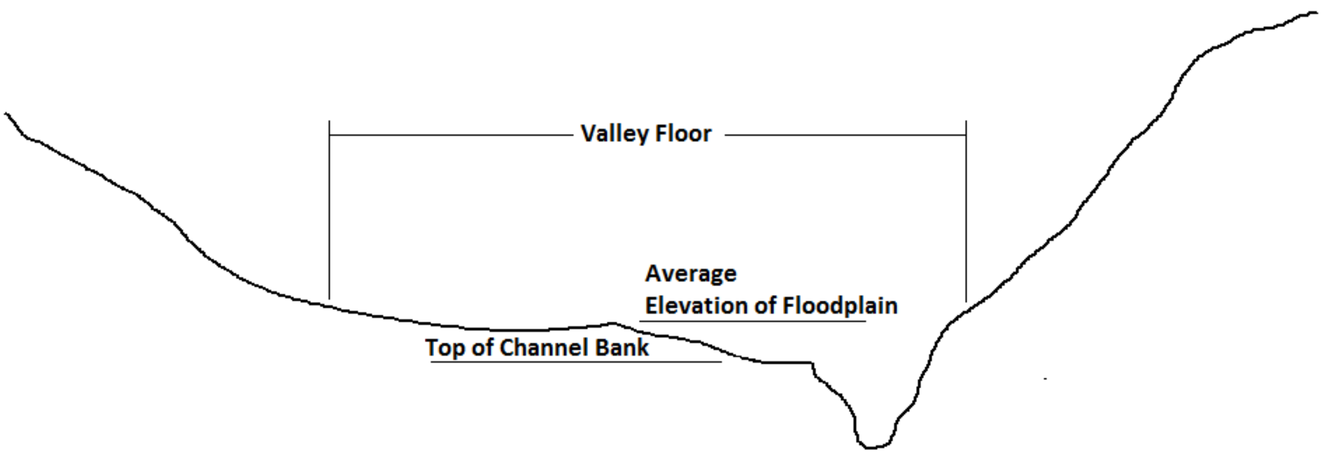

Figure 1. Typical Valley Cross Section at Downstream Toe of Dam.

2.32 Reservoir Water Surface Elevation

When determining the hazard potential class for a dam, the elevation of the reservoir water surface at the time of failure should correspond to the peak reservoir elevation during the routing of the 100-year flood; however, the water surface elevation at the time of failure should never be below the crest of the auxiliary spillway, or below the top of the dam if the dam does not have an auxiliary spillway.

2.33 Breach Hydrograph

The peak breach discharge and the storage volume at the time of failure can be utilized to develop a breach hydrograph using the following equation from *NRCS Technical Release Number 66 (TR-66):*

$$Q_i = Q_{max} e^{-t^*}$$

where:

Q_i = particular discharge at any given time, cfs
Q_{max} = peak breach discharge, cfs
$t^* = t \frac{Q_{max}}{V_I}$
t = time, seconds
V_I = storage volume in reservoir at time of breach, ft^3

2.34 Breach Development and Routing Methodologies

A peak discharge value and breach hydrograph determined using principles of erosion, hydraulics, and sediment transport may be used in lieu of the peak discharge and hydrograph computed using the above equations. The criteria, methodologies, and computer programs developed by the U.S. Army Corps of Engineers, the U.S. Bureau of Reclamation, the National Weather Service, and the NRCS for simulating a hypothetical dam failure and downstream flooding are generally acceptable.

2.35 Coincidental Downstream Flooding

Coincidental flooding downstream of the dam is not taken into consideration when determining the hazard potential classification. The flow in the outlet channel prior to failure should only include the discharge from the dam corresponding to the reservoir water surface elevation at the time of failure.

TABLE 3 – POTENTIAL HAZARDS FOR DAM CLASSIFICATIONS

This table provides general guidance in evaluating potential hazards downstream of dams. These guidelines are to be used with sound engineering judgement taking into consideration conditions particular to each site.

	Minimal[1]	Low	Significant	High
LOSS OF LIFE	No	No	No	Yes
PUBLIC ROADS Interstate highways or main highways with four or more lanes.	No flow over road.	No flow over road.	Depth of flow < 2 feet over road.	Depth of flow ≥ 2 feet over road.
State and federal highways with less than four lanes.	No flow over road.	Depth of flow < 2 feet over road.	Depth of flow ≥ 2 feet over road.	
All other regularly maintained public roadways	No flow over road.	Flow over road.		
RAILROADS Main rail line – Five or more trains per day.	No flow over rail bed.	No flow over rail bed.	Depth of flow < 2 feet over rail bed.	Depth of flow ≥ 2 feet over rail bed.
Minor rail line – less than five trains per day.	No flow over rail bed.	Depth of flow < 2 feet.	Depth of flow ≥ 2 feet.	
BUILDINGS Farm/Storage/Garage Buildings that are not usually occupied.	Depth of flow below lowest foundation ground line.	Flow above lowest foundation line.		
Homes Single family residence, apartments, motel, hotel, etc.	Depth of flow below lowest foundation ground line.	Depth of flow below lowest foundation ground line.	Depth of flow < 3.5 feet above foundation ground line and DV < 20. (see note 3 below).	Depth of flow ≥ 3.5 feet above lowest foundation ground line or DV ≥ 20. (see notes 2 and 3 below)
Institutions Schools, hospitals, nursing homes, etc.	Depth of flow below lowest foundation ground line.	Depth of flow below lowest foundation ground line.	Depth of flow < 2 feet above lowest normally occupied level and DV < 15.	Depth of flow ≥ 2 feet above lowest normally occupied level or DV ≥ 15.
Industrial and Commercial Manufacturing, distribution, service, retail, office, churches, libraries, restaurants, etc.	Depth of flow below lowest foundation ground line.	Depth of flow < 1 foot above lowest foundation ground line and DV < 20.	Depth of flow ≥ 1 foot and < 3.5 feet above lowest foundation ground line and DV < 20 (see note 3 below).	Depth of flow ≥ 3.5 feet above lowest foundation groundline or DV ≥ 20. (see notes 2 and 3 below)
CAMPGOUNDS Designated public campsites that are occupied more than 25 nights per year.	Depth of flow below camper/tent pad.	Depth of flow < 1 foot above camper/ tent pad and DV < 8.	Depth of flow ≥ 1 foot and < 3.5 feet above camper/tent pad and DV < 8.	Depth of flow ≥ 3.5 feet or DV ≥ 8 at camper/tent pad.
PUBLIC UTILITIES Major power generation facilities, important interstate and intrastate power and communication lines, etc.			Damage may occur when buried lines can be exposed by erosion and when towers, poles and ground lines can be damaged by undermining or debris produced from the floodplain.	Flow above first floor of generation facilities or interruption of service for more than 1 day.
ENVIRONMENTAL LOSSES Includes damage to major archeological sites, national monuments, or state historical sites.			Major mitigation required.	Extensive mitigation cost or impossible to mitigate.

D = flow depth (ft.) V = flow velocity (ft./sec.)

1. Minimal hazard potential classification is generally limited to farm pond dams.
2. Depth may be increased to ≥ 5 feet for a walkout basement where occupants can evacuate to a higher floor.
3. If twenty or more occupied structures are flooded 2 feet or more in depth above the lowest foundation ground line, the dam should be classified as high hazard.