PROCEDURAL GUIDELINES
for
PREPARATION OF TECHNICAL DATA
to be included in
APPLICATIONS FOR PERMITS
for
CONSTRUCTION AND MAINTENANCE OF DAMS

STATE OF ILLINOIS
DEPARTMENT OF NATURAL RESOURCES
OFFICE OF WATER RESOURCES
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I. INTRODUCTION

The “Rules for Construction and Maintenance of Dams” require that only engineers which are registered as a structural and/or professional engineer in The State of Illinois, under the Professional Engineering Practice Act [225 ILCS 325] and the Structural Engineers Act [225 ILCS 340], and with expertise in the investigation, design, construction, and operation of dams prepare the engineering data to be submitted with an application for a permit. These guidelines have been written with the intent of providing a basic understanding of the type of information that will need to be provided with an application for a permit to construct a new dam and to modify, remove or abandon an existing dam. They have also been prepared for the engineer to understand the methods of review that will be used by the staff of the Office of Water Resources in reviewing an application for a permit. Some of the information presented herein would also be applicable to the preparation of data for an application for permit to operate and maintain an existing dam.

Section IX of these guidelines has been developed to address and provide guidance concerning the issue of the removal of dams including the abandonment of slurry disposal impoundment dams. Abandonment may differ from removal of a dam in that abandonment may leave the embankment intact. However, both removal and abandonment usually result in the dam ultimately being eliminated from the Office of Water Resources regulatory purview.

It is not the intent of these guidelines to be dictatorial as to the methods to be used to achieve the required data. Rather, the user is provided information concerning generally accepted methods of testing, analysis, and computation.

Questions regarding the preparation of the documentation noted in these guidelines may be directed to the Office of Water Resources offices in Springfield (Tel. No. 217/782-3863), Bartlett (Tel. No. 847/608-3100 ext. 2025).

II. PRELIMINARY DESIGN REPORT

It is strongly recommended that applicants submit a preliminary design report to OWR for approval of the design concept prior to initiation of detailed design studies. This report should include:

A. Ownership and Engineer Information

1. The owner of the dam (names, addresses, telephone numbers)

2. The owner's engineer (names, addresses, telephone numbers, a description of expertise in the investigation, design, construction, and operation of dams, and a listing of previously acquired permits for dams from the Office of Water Resources or its predecessors)

B. Purpose, Location and Configuration - General information regarding the dam and appurtenances. This information should include a statement of the purpose for which the dam is to be used, a legal description of the location of the dam, calculations to verify the drainage area controlled by the dam, the height of the dam and the maximum impounding capacity of the dam.

C. Downstream Hazards and Breach Analysis - In order for OWR to provisionally determine the dam classification, as described in the "Rules for Construction and Maintenance of Dams", information describing the downstream area for a distance of at least two miles is required. This information should include the number of and access to homes and buildings, roads, utilities and other property that would be endangered should failure of the dam occur. Contoured aerial photographs or recent U.S. Geological Survey topographic maps may be used for this purpose. Submittal of additional data, including a dam breach analysis, may be necessary at some sites. If a dam breach analysis is submitted, it should include failures during a range of events from normal pool through the Probable Maximum Flood. The owner should also be cognizant of the possibility for development of the downstream area which could change the dam classification and require modifications to the dam. The original design should provide for these modifications to be more easily accomplished.

D. <u>Topography</u> - Maps showing the location of the proposed structure that include the location of county and State roads, access to the site, the outline of the reservoir at normal pool elevation, the drainage area limits, and the general topography of the dam site and reservoir area. Contoured aerial photographs or recent U.S. Geological Survey topographic maps may be used for this purpose.

E. <u>Plans and Drawings</u> - Preliminary drawings that include cross-sections, plans and profiles of the dam, proposed pool levels, and types of spillways.

F. <u>Basic Design Criteria</u> - Preliminary design criteria including a description of the size, ground cover conditions, and extent of development of the watershed; the proposed geotechnical and exploration testing program, geology and geotechnical engineering assumptions for the foundation and embankment materials; the proposed hydrologic and hydraulic analyses methods; and the type of materials to be used in the dam and the spillway system(s).

III. FINAL DESIGN REPORT

In order for the Office of Water Resources to assess the safety aspects of a dam from an engineering standpoint, the final design report submitted with the Permit Application must contain the information and calculations to verify the adequacy of the design for the given size and downstream hazard potential of the dam. The safety evaluation will be based upon the capability of the project to meet the minimum performance standards established in the "Rules for Construction and Maintenance of Dams". The remaining sections of these guidelines have been written as an aid in the preparation of the data required to support the application for permit.

Computer programs which are used in the preparation of data for submittal should either be federal public domain programs or have sufficient documentation submitted with a copy of the program to allow for the review of the program. Spreadsheet applications which include equations should also be submitted to allow for the review of their equations. The data generated by all computer programs and spreadsheet applications may not be accepted as correctly representing the information required to be submitted.

IV. HYDROLOGIC AND HYDRAULIC INVESTIGATIONS

Various methods of analyzing the hydrologic and hydraulic characteristics of a watershed, reservoir, and dam are available. Some of the procedures which are generally acceptable for determination of the hydrologic and hydraulic characteristics are presented in the paragraphs that follow. In general, procedures developed by the following agencies are acceptable: U.S. Army Corps of Engineers; U.S. Department of the Interior, Bureau of Reclamation; U.S. Department of Agriculture, Natural Resources Conservation Service; and U.S. Department of Commerce, National Weather Service. The Office of Water Resources will use the Corps of Engineers and the National Weather Service computer programs as its primary review aids. The programs typically used by OWR for review include: HEC-1, HEC-HMS, HEC-2, HEC-RAS, and FLDWAV.

A. Maximum Water Surface Based on Spillway Design Flood Peak Inflow:

When the total project uncontrolled spillway discharge capability at maximum pool exceeds the peak inflow of the spillway design flood, a reservoir routing is not required. Flood volume is not controlling in this situation and surcharge storage is either absent or insignificant in relation to the spillway and outlet capacity.

When the 100-year, 50-year, or 25 year floods are applicable under the provisions of the "Rules for Construction and Maintenance of Dams", and streamflow data at or near the dam site are available, the spillway design flood peak inflow can be determined by a flood frequency analysis. The recommended method is outlined in "Guidelines for Determining Flood Flow Frequency" by the U.S. Water Resources Council, Hydrology Committee, Bulletin 17B, Revised March, 1982.

When streamflow data are not available, the recommended method is described in the latest version of documents from the U.S. Geological Survey for estimating the magnitude and frequency of floods on rural streams in Illinois. Adjustments to the computed rural discharges must be made to account for urbanization in the watershed. The U.S. Geological Survey has also published documents to assist in the determination of this adjustment. The methods described in TR55, "Urban Hydrology for Small Watersheds") may also be used if the appropriate rainfall values (see Section B1 below) are used.

B. Maximum Water Surface Based on Spillway Design Flood Inflow Hydrograph:

When either the Probable Maximum Flood (PMF) peak or a fraction thereof is required, the "unit hydrograph-infiltration loss rate technique" is considered the most expeditious method of computing the spillway design flood (SDF) peak inflow for most projects. Both the peak and the volume are required in this analysis. Where the surcharge storage is significant, or where there is insufficient discharge capability at maximum pool to pass the peak inflow of the SDF, considering all possible operational constraints, a flood hydrograph is required. Determination of the probable maximum precipitation (PMP) or the 100, 50, or 25 year precipitations, whichever is applicable, and unit hydrographs will be required, followed by the determination of the spillway design flood hydrograph.

1. Rainfall and Distribution

The PMP value used for dam safety purposes should be of at least a 24-hour duration and should be obtained from the National Weather Service Hydrometeorological Report No. 51, "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian", June, 1978. The method of applying the PMP for HMR51 is described in a companion report, Hydrometeorological Report No. 52, "Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian," August, 1982. Generalized rainfall reduction factors, such as the Hop Brook Factor, should not be used for the PMP estimates regardless of the source from which the estimates were obtained.

Rainfall values for frequency events, i.e. 100-year, 50-year and 25-year should be obtained from the Illinois State Water Survey (ISWS) Circular 172, "Frequency Distribution and Hydroclimatic Characteristics for Heavy Rainstorms in Illinois." The suggested method to distribute this rainfall is described in the ISWS publication, Circular 173, "Time Distributions of Heavy Rainstorms in Illinois".

2. Rainfall Excess

Rainfall excess is that portion of the rainfall which is not lost to infiltration, interception, and depression storage. Loss rates should be estimated for computing the rainfall excess. Consideration should be given to the seasonal variation of rainfall amounts, the associated ground cover, and the current land use. Also when applicable, snowmelt runoff rates and appropriate releases from upstream projects should be estimated.

The Natural Resources Conservation Service's weighted watershed curve number (CN) procedure is one of the most widely used methods for determining rainfall excess. If the applicant prefers, a rainfall-runoff relation for the studied basin, or one with similar characteristics, can be developed to determine the rainfall excess.

3. Unit Hydrograph

The unit hydrograph, i.e., the graph of discharge against time, is used to forecast the streamflow at a given point from one inch of direct runoff from a storm of specified duration. The duration selected should not exceed about 1/4 of the time of concentration. The time of concentration is the travel time of water from the hydraulically most distant point of the watershed to the point of interest. There are three basic approaches to the derivation of the unit hydrograph:

(A) Analysis of recorded runoff at a streamflow gaging station at or near the damsite on the same stream.

(B) Transposition of a unit hydrograph from another basin of comparable size and watershed runoff characteristics.

(C) Synthetic unit hydrographs based upon equations relating hydrograph parameters such as peak flow, time to peak, time base, etc. to the physical characteristics of the basin such as area, length, slope, etc.

Several of the more popular accepted methods of synthetic unit hydrograph derivation include:

(1) Clark's method used by the Corps of Engineers in the HEC-l and HEC-HMS computer programs.

(2) Natural Resources Conservation Service's curvilinear or triangular unit hydrograph.

(3) Snyder's method for Illinois developed by the Illinois State Water Survey.

4. Design Storm Inflow Hydrograph

Design storm refers to the intensity-duration combination of the precipitation which produces the most severe flood runoff and/or reservoir stage for the specified precipitation frequency. The time duration for a designated storm will vary depending on the hydrologic and physiographic characteristics of a specified watershed and the affect on the reservoir will depend on the storage-outflow relationship of the proposed reservoir. The design precipitation event is divided into increments of time equal to the duration of the unit hydrograph using the appropriate distribution methods. The rainfall excess is determined by subtracting the appropriate loss rates from the rainfall depths to determine the runoff values. The ordinates of the unit hydrograph at the same time increment are then multiplied by the rainfall excess, lagged accordingly, then summed to determine the direct runoff inflow hydrograph.

If a storm hydrograph for a ratio of the PMF is required, the total PMF inflow hydrograph to the reservoir must be determined. The appropriate ratio should then be applied to the ordinates of the PMF inflow hydrograph. Ratios should not be taken of the PMP. If there are other dams or flow restrictive structures, upstream of the dam being analyzed, the total PMF hydrograph to the dam and its reservoir should be determined. Ratios can then be applied to the PMF to determine the response of the dam and reservoir to this design storm inflow hydrograph. Upstream dams and restrictive structures should be included in the analysis only if they are assured of remaining in their current configuration, such as a government owned and controlled flood control or water supply dam.

The use of a partial storm hydrograph (such as is noted in TR55, "Urban Hydrology for Small Watersheds") is not appropriate for use when the design storm inflow hydrograph is needed. These methods may be used to determine the peak inflow (see Section A above) if the appropriate rainfall values (see Section B1) are used.

5. <u>Reservoir Area-Storage-Elevation Data</u>

Reservoir surface area and storage capacity versus water surface elevation (tables or curves) are required. These data are usually determined by planimetry from topographic contour maps with scales equal to USGS 7.5 minute quadrangles or better.

6. <u>Spillway Discharge-Elevation Data</u>

Rating curves or tables are required for all discharge facilities contributing to the maximum design flood outflow hydrograph. If flow capacity is developed synthetically based upon semi-empirical equations for weir, orifice, or pipe flow, assumed coefficients and how they were selected should be stated and referenced. When sufficient criteria and guidance are not available to determine the spillway flow capacity synthetically, a physical hydraulic model study should be performed with all model tests and performance results documented.

7. Downstream Tailwater Discharge-Elevation Data

A tailwater rating curve showing the downstream flow capacity versus elevation is required. Elevations of bankfull (at top of bank) channel capacity, principal and total spillway design floods, and 100-year flood immediately below the dam site should be noted. The method and support calculations used to determine the downstream water surface elevations (i.e., standard step backwater analysis, normal depth solution of Manning's equation, etc.) including all channel and overbank roughness, length, slope or cross section data and tailwaters due to a receiving waterway should be listed.

8. Design Storm Outflow Hydrograph

The outflow hydrograph from a dam spillway system may be estimated by either hydrologic or hydraulic routing methods. One of the simplest and most popular methods of reservoir routing is called the "Modified Puls" storage routing method. This method is described in most hydrology text books. It is also a feature of computer programs such as the Natural Resources Conservation Service's TR-48 or the Corps of Engineer's HEC-l and HEC-HMS. A hydraulic routing procedure is also acceptable and is a better method to be used for situations where a hydrograph is rapidly varying. The NWS computer program FLDWAV, the Corps of Engineers' computer programs UNET and HEC-RAS, and the USGS computer program FEQ have this capability.

C. Potential Upstream Flood Hazard Areas

Areas adjacent to the normal storage retention level that would be potentially subject to flooding should be examined to determine if a hazard to life or property could occur during sudden or frequent increases in the reservoir water surface elevation. Ownership or flood easement agreements are required from upstream property owners up to the 100-year flood elevation for new dams or for modifications to dams which include an increase in the reservoir water surface elevations.

D. Emergency and Normal Drawdown Capability

An assessment of the capability to reduce the reservoir storage within a reasonably rapid time interval to avert impending failure, or to facilitate repairs in the event of structural, embankment, or foundation problems should be made. The capability for dewatering the reservoir within a reasonable time period should be addressed with allowances for reservoir siltation and at least the typical base flow for the waterway. Gravity systems which have the capability of dewatering the entire reservoir should be provided. Other systems, such as siphons or pumps which dewater only a portion of the reservoir, will only be authorized for unique situations such as at existing dams without a current dewatering system. Factors that will be considered by OWR in determining the required drawdown time include: the purpose of the dam and reservoir; the risk and nature of a potential failure; the damage potential posed by possible failure; and the potential damage to downstream properties. Computations and assumptions used for calculating the total reservoir drawdown time and for an emergency drawdown of 50% of the normal pool storage volume, should be submitted. Recommended times for 50% drawdown are 7 days for Class I Dams, 14 days for Class II Dams, and 30 days for Class III Dams.

The capability and stability of available drainage courses to convey the waters released during a dewatering and the influence of a drawdown on the stability of the dam should be assessed. Except for emergency situations, the maximum drawdown rate should not typically exceed approximately 1.0 ft. per day.

E. Freeboard Design

Factors that should be considered in determining the minimum freeboard include the duration of high water levels in the reservoir during the design flood; the wind fetch and reservoir depth available to support wave generation; the probability of high wind speed occurring from a critical direction; the potential wave runup on the dam based on roughness and slope; and the ability of the dam to resist erosion from overtopping waves.

References for the method of analysis and the pertinent data utilized for determining the minimum freeboard should be submitted in order to verify that the dam is safe against overtopping during occurrence of the total spillway design flood and wave action using the maximum wave determination.

F. Upstream Face Protection

It is necessary to protect the upstream face of an earth embankment dam from wave erosion. The orientation, length, and purpose of the reservoir, the duration of higher reservoir stages, and the embankment material all affect the need for and the type of embankment protection. Upstream slope protection usually consists of rock riprap which should consist of a well graded, hard, durable rock. For small reservoirs with minimal change in pool elevation during flood events, a flat slope on the upstream face with a designed vegetative protection method can provide the necessary embankment protection.

The protection must also extend below the normal pool elevation a minimum of 2 ft. or 0.50 times the anticipated wave height (if greater than 2 ft.). In determining the elevation of the protection below the normal pool elevation beyond the minimum requirements, consideration should be given to the potential variation of the pool due to the purpose of the reservoir, operational factors, and the base flow of the inflow stream. The protection also serves the purpose of discouraging muskrats and other burrowing animals from burrowing a den into the embankment. The riprap and filter layer should extend at least 3 ft. below the pool elevation to offer a better deterrent to the animals.

G. Design of the Energy Dissipator Structures

Energy dissipators should be capable of sufficiently reducing the energy to insure against damage to the spillway or outlet system. Types of energy dissipators are numerous. Several of the more common type include the following: hydraulic jump stilling basin; impact-type dissipator; deflector bucket; submerged deflector bucket; plunge pool; and baffled chute. All design computations should include an assessment of the impact of a range of flows up to and including the total spillway design flood. The design should also address variations in the flows and tailwaters in the downstream channel due to flows from the principal and emergency spillways and in the receiving waterway.

A proper design should include the evaluation of the topographic features of the site, the relationship of storage capacity to flood volume, the geologic or foundation conditions, the type and height of the dam, and any other unique conditions pertaining to a particular site. In unusual situations when sufficient criteria and guidance are not available for analytical design, a physical hydraulic model study should be performed with the model tests and performance results reported.

H. Dam Breach Wave Analysis

Analyses should be made to determine the most adverse failure conditions and the resulting peak outflows and water surface elevations downstream of the dam following failure of the dam. To provide sufficient information for classification of a dam, the breach analyses should also assume nearly instantaneous total (full height) failures covering a range of events from normal pool up to and including the probable maximum flood (PMF). For Class I and II dams, computations for the dam breach wave analysis are required for a nearly instantaneous total (full height) failure of the dam during normal pool and total spillway design flood conditions. Analyses completed for flood conditions should use the maximum reservoir elevation to initiate the modeled failure of the dam. However, if the maximum reservoir elevation overtops the dam, then the lower elevation of the maximum elevation or 1 ft. above the top of the dam should be used to initiate the modeled failure of the dam. Inundation maps on 7.5 minute quadrangles or better mapping should be provided for each failure condition studied.

The term "nearly instantaneous," for the purposes of this document, is the shortest time interval for which the computer model being used will provide mathematically stable results. This time is usually about 5 minutes and typically does not exceed 15 minutes and is consistent with failure times for earth embankment dams. The failure times for concrete dams are typically quicker than those for embankment dams.

Based upon dam failures which have occurred in the past, the average breach width for an embankment dam is usually in the range of 2 to 5 multiplied by the height of the dam. The side slopes of the breach of an embankment dam are typically greater than the angle of repose of the dam materials but may vary between vertical to 1 horizontal:1 vertical.

A dam breach analysis requires several steps: developing the reservoir inflow hydrograph; routing that hydrograph through the reservoir; selecting failure conditions for the structure (i.e., mode, shape, size, and time); calculating the outflow hydrograph from the failed structure; and modeling the movement of the flood wave downstream, including downstream tributary inflows, to determine travel times, inundated areas, and maximum water surface elevations.

To determine the classification of a dam, the acquisition of additional information relative to the potentially impacted structures downstream of the dam may be necessary. Information such as the types of structures (residences, other building uses, infrastructure) within the breach inundation area, the low entry and first floor elevations of buildings, and the availability of alternate access routes to buildings if the primary access is damaged is typical. In general, the routing of the dam breach hydrograph should continue downstream to the point where the breach versus non-breach water surface profile elevation difference does not exceed 1 foot or the breach wave is contained within the channel.

Criteria, methodology, and computer programs developed by the National Weather Service, U.S. Corps of Engineers, and the U.S. Geological Survey, for simulating a hypothetical dam failure are, in general, acceptable. Simplified methods usually do not provide sufficient detail to be considered acceptable except in emergency situations where time does not allow a more detailed analysis. Documentation explaining theoretical aspects of the mathematical models, forecast ability, simulation accuracy, computer input parameter requirements, etc. are available directly from these federal agencies.

I. Hydrologic & Hydraulic Design References

The following list is provided to aid the design engineer and is not intended to be a complete listing of all available reference material.

General

"Handbook of Applied Hydrology" by Ven Te Chow, McGraw-Hill Book Company

"Handbook of Applied Hydraulics" by David & Sorensen McGraw-Hill Book Company

"Handbook of Hydraulics" by King and Brater McGraw-Hill Book Company

"Water Resources Engineering" by Linsley and Franzini, McGraw-Hill Book Company

Bureau of Reclamation

"Design of Arch Dams"

"Design of Gravity Dams"

"Design of Small Canal Structures"

"Design of Small Dams"

"Discharge Coefficients for Irregular Overfall Spillways", Engineering Monograph No. 9

"Hydraulic Design of Stilling Basin for Pipe or Channel Outlets", Research Report No. 24

"Hydraulic Design of Stilling Basins and Energy Dissipators", Engineering Monograph No. 25

"Unitgraph Procedures"

“Design Standards No. 13, Embankment Dams”

Corps of Engineers

“Shore Protection Manual,” Volumes 1-3

Engineering Manuals (EM):

1110-2-1602, Hydraulic Design of Reservoir Outlet Structures

1110-2-1603, Hydraulic Design of Spillways

1110-2-50, Low Level Discharge Facilities for Drawdown of Impoundments

1110-2-1450, Hydrologic Frequency Estimates

1110-2-2300, Earth and Rock Fill Dams, General Design and Construction Considerations

Engineering Technical Letters (ETL):

1110-2-221, Wave Runup and Wind Setup on Reservoir Embankments

1110-2-305, Determining Sheltered Water Wave Characteristics

Mine Safety and Health Administration

Engineering and Design Manual, Coal Refuse Disposal Facilities

Natural Resources Conservation Service

"SITES," Water Resource Site Analysis Program

National Engineering Handbook:

Section 4 - Hydrology

Section 5 - Hydraulic

Section ll - Drop spillways

Section 14 - Chute spillways

Technical Releases (TR):

2, Earth Spillways

16, Rainfall-Runoff Tables for Selected Runoff Curve Numbers

20, Computer Program for Project Formulation-Hydrology

25, Design of Open Channels

29, Hydraulics of Two-Way Covered Risers

39, Hydraulics of Broad-Crested Spillway

48, Computer Program for Project Formulation-Structure Site Analysis "DAMS-2"

49, Criteria for the Hydraulic Design of Impact Basins

52, A Guide for Design & Layout of Earth Emergency Spillways

55, Urban Hydrology for Small Watersheds

56, A Guide for Design and Layout of Vegetative Wave Protection for Earth Dam Embankments

59, Hydraulic Design of Riprap Gradient Control Structures

60, Earth Dams and Reservoirs

61, Computer Program for Water Surface Profiles

Design Notes (DN):

DN-6 Riprap Lined Plunge Pool for Cantilever Outlet

DN-8 Entrance Head losses in Drop-Inlet Spillways

Federal Emergency Management Agency

"Federal Guidelines for Selecting and Accommodating Inflow Design Floods for Dams".

National Weather Service

Hydrometeorological Report No. 51 - "Probable Maximum Precipitation Estimates, United States East of the 105th Meridian"

Hydrometeorological Report No. 52 - "Application of Probable Maximum Precipitation Estimates - United States East of the 105th Meridian"

"BREACH": An Erosion Model for Earthen Dams

"FLDWAV": A Generalized Flood Routing Model

Illinois State Water Survey

Bulletin 70, "Frequency Distribution and Hydroclimatic Characteristics of Heavy Rainstorms in Illinois"

Bulletin 71, "Rainfall Frequency Atlas of the Midwest"

Circular 172, "Frequency Distributions of Heavy Rainstorms in Illinois"

Circular 173, "Time Distributions of Heavy Rainstorms in Illinois"

Illinois WRC Research Report No. 107, "Criteria for Shore Protection Against Wind Generated Waves for Lakes and Ponds in Illinois"

Report of Investigation 65, “Model Test Results of Circular, Square, and Rectangular Forms of Drop-Inlet Entrance to Closed-Conduit Spillways”

Report of Investigation 67, “Hydraulic Jump Type Stilling Basins for Froude Number 2.5 to 4.5”

SWS contract Report 258, "Derivation and Regionalization of Unit Hydrograph Parameters for Illinois (Dam Safety Program)"

United States Geological Survey

“Equations for Estimating Clark Unit-Hydrograph Parameters for Small Rural Watersheds in Illinois”, WRI 00-4184, 2000

"Technique For Estimating Flood-Peak Discharges and Frequencies on Rural Streams in Illinois", WRI 87-4707, 1987.

"Effects of Urbanization on the Magnitude and Frequency of Floods in Northeastern Illinois", WRI-79-36, 1979.

"River Mileages and Drainage Areas for Illinois Streams", Volumes 1 and 2, WRI 79-110, 1979.

"Time of Concentration and Storage Coefficient Values for Illinois Streams", WRI 82-13, 1982.

"A Technique for Estimating Time of Concentration and Storage Coefficient Values for Illinois Streams", WRI 82-22, 1982.

"Water Resources Data for Illinois"

"Investigation of Techniques to Estimate Rainfall-Loss Parameters for Illinois", WRI 87 4151, 1989.

Federal Highway Administration

Hydraulic Engineering Circulars:

No. 5 -"Hydraulic Charts for the Selection of Highway Culverts".

No. 10 -"Capacity Charts for the Hydraulic Design of Highway Culverts".

No. 13 -"Hydraulic Design of Improved Inlets for Culverts".

No. 14 -"Hydraulic Design of Energy Dissipators for Culverts & Channels".

No. 15 - "Design of Stable Channels with Flexible Linings".

Hydraulic Design Series No. 1 - "Hydraulics of Bridge Waterways".

Hydraulic Design Series No. 3 -"Design Charts for Open-Channel Flow".

V. STRUCTURAL AND GEOTECHNICAL INVESTIGATIONS AND DESIGN

A. Geotechnical Investigations

For all dams an investigation of the foundation and abutment soils or bedrock and the borrow materials that are to be used to construct the dam should be made. The foundation and abutments investigation should consist of borings, test pits and other subsurface exploration necessary to clearly define the existing conditions. The appropriate field and laboratory tests to be made should be based on the magnitude and type of the dam, as well as the characteristics of the foundation deposits, abutments, and materials available for use in the embankment. Some of the common tests made are Standard Penetration Tests (N-Values), unconfined compressive strength (q_u) tests, direct shear tests, triaxial tests, water content tests, Atterberg-limit tests, particle size analysis tests, Standard Proctor moisture-density relations, permeability tests, consolidation tests, and dispersion tests. Soils should be at least classified according to the Unified Soil Classification System.

In general, for embankment dams greater than 30 feet in height, the foundation and embankment soil shear strengths for the unconsolidated-undrained (Q), consolidated-undrained (R), and consolidated-drained (S or $\bar{R}$) conditions are to be based on actual test data from the dam site. One half the unconfined compressive strength ($q_u/2$) is usually adequate for the unconsolidated-undrained (Q) condition.

For embankments 30 feet or less in height, at least the unconfined compressive strengths (q_u) and the standard Penetration Test (N-Values) of the soils are to be determined from actual test data, unless unusual foundation conditions exist which require a more thorough investigation. It is recommended that the R and S or $\bar{R}$ condition soil strengths also be determined from actual test data from the dam site.

B. Earth and Rockfill Embankments -- Structural Stability.

The embankment and foundation should be analyzed for stability against failure from sliding, sloughing, or rotation along potential failure surfaces using a phi value of "0". The following loading conditions should be investigated:

Case	Loading Condition	Minimum Factor of Safety w/o Seismic Forces	w/ Seismic Forces
I	End of Construction	1.3*	N/A
II	Steady Seepage	1.5**	1.0
III	Sudden Drawdown	1.2***	N/A

* For embankments over 50 feet high on relatively weak foundations, use a minimum factor of safety of 1.4.

** The submitted design will be reviewed for an effective stress condition. A review using S or $\bar{R}$ with c=0 will also be performed. Where the analysis relies on the cohesion component to meet the minimum factor of safety, an analysis of the soil chemistry may be required.

*** The factor of safety should not be less than 1.5 when the drawdown rate and pore water pressures developed from flow nets are used in the stability analyses.

Computations of factors of safety for various loading conditions and shear strengths are readily made using computer programs. Several computer programs are available for the completion of the analysis including those developed by the federal agencies and many universities.

Seismic activity should be considered in the design of all dams in Illinois. The Peak Ground Acceleration values for 2% probability of exceedance in 50 years is shown in Appendix 1. Dams located in an area with a peak acceleration greater than 20%g must have a seismic stability analysis using equivalent static load methods included in the application submittal package. The values found in Appendix 1 should be the minimum coefficient. Dynamic analysis methods should also be considered for dams in areas of high seismic activity.

So that earth embankment side slopes can be easily maintained and/or mowed, it is recommended that the downstream slope be no steeper than 3:1. Crown vetch or similar types of ground cover should not be planted on the slopes of earth embankments because it severely restricts the ability to inspect the slopes for sloughing, erosion, seepage, animal holes or excessive settlement.

C. Earth Embankments -- Seepage.

Adequate analyses should be made of anticipated seepage rates and pressures through the embankment, foundation and abutments. The analyses should show that the seepage flow through the embankment, foundation and abutments will be controlled so that no internal erosion takes place and no sloughing takes place in the area where the seepage emerges.

D. Earth Embankments -- Conduits.

Conduits through earth embankments are to be a pressure type conduit, such as reinforced concrete pressure pipe or cast-in-place reinforced concrete. However, non-pressure type conduits properly detailed may be allowed for Class III dams, 30 feet or less in height. Reinforced concrete pipe should meet one of the following specifications:

(A) ASTM C 361
(B) AWWA C 300
(C) AWWA C 301
(D) AWWA C 302

Reinforced concrete pipe should be supported on a concrete bedding or cradle, and reinforced where spreading might be a factor. The pipe joints should incorporate a rubber gasket set in a positive groove as described in the above specifications which will prevent its displacement from either internal or external pressure under the required joint extensibility.

Conduits other than the reinforced concrete pipes listed above may be used. For those designs the application should fully document that the proposed conduit will provide performance equal or superior to reinforced concrete pressure pipe.

It is recommended that all conduits which pass through an embankment have a filter constructed at the downstream end of the conduit to control any seepage along the conduit regardless of whether anti-seep collars are used.

E. Concrete Dams and Structures.

Concrete dams and structures appurtenant to embankment dams should be capable of resisting overturning, sliding and overstressing with adequate factors of safety for normal and maximum loading conditions. Loadings to be considered in the stability analyses include the water load on the upstream face of the dam; the weight of the structure; internal hydrostatic pressures (uplift) within the body of the dam, at the base of the dam and within the foundation; earth and silt loads; ice pressure, seismic and thermal loads, and other loads as applicable. A gravity structure should be capable of resisting all overturning forces.

The analysis of concrete stresses should be based on in situ properties of the concrete and foundation. Tensile stresses in unreinforced concrete are acceptable only in locations where cracks will not adversely affect the overall performance and stability of the structure. Foundation stresses should be such as to provide adequate safety against failure of the foundation material under all loading conditions.

Sliding of concrete gravity structures and of abutment and foundation rock masses for all types of concrete dams should be evaluated by the shear-friction resistance concept. The investigation should be made along all potential sliding paths. The shear-friction safety factor is obtained by dividing the resistance, including the applicable downstream passive wedge if appropriate, by the summation of horizontal service loads. Computed sliding safety factors approximating 3 or more for all loading conditions without earthquake, and 1.5 including earthquake, should indicate satisfactory stability, depending upon the reliability of the strength parameters used in the analyses. Designs based on Corps of Engineers, Bureau of Reclamation, or Natural Resources Conservation Service criteria are generally acceptable.

F. Concrete Design.

The loadings, allowable stresses, load factors, and safety factors for the design of concrete structures should be those appropriate for hydraulic structures. Concrete design should be in accordance with the applicable sections of the latest edition of the "Building Code Requirements for

Reinforced Concrete" (ACI 318); however, because hydraulic structures are subjected to a relatively severe environment and unknown loading conditions, due consideration should be given to the allowable stresses or "Z" values used so that adequate crack control is achieved. Working stress and strength designs should be based on 28-day concrete strengths not less than 3000 psi.

The following minimum clear cover of main reinforcement should be used:

Structures exposed to weather, or backfill, or submerged and can be made accessible
Bar Size Nos. 5 and less - - - - - - - - - - - - - 1 1/2"

Structures exposed to weather, or backfill, or submerged and can be made accessible
Bar Size Nos. 6 through 18 - - - - - - - - - - - - 2"

Structures submerged and cannot be made accessible
All Bar Sizes - - - - - - - - - - - - - - - - - - 2 1/2"

Concrete cast against and permanently exposed to earth or rock
All Bar Sizes - - - - - - - - - - - - - - - - - - 3"

All concrete construction, contraction, and expansion joints subject to hydrostatic pressure should be protected by the use of waterstops or other means.

G. Steel Design.

Structural steel design should be based on the applicable sections of the latest edition of the American Institute of Steel Construction (AISC) specifications. The applicable sections of the latest edition of the Standard Specifications for Highway Bridges adopted by the American Association of State Highway and Transportation Officials (AASHTO) are acceptable, as well as designs prepared using Corps of Engineers, Natural Resources Conservation Service or Bureau of Reclamation specifications.

H. Spillways and Energy Dissipators.

The range of spillways and energy dissipator types which can be used on a dam project is very large. If a standard design is used, reference to the standard used is acceptable for the structural design documentation. If a non-standard design is proposed, the structural design computations submitted should be based on the commonly accepted principles of structural analysis and design.

Underdrains and/or anchors should be considered in the design of chute spillways.

I. Filters and Drains.

When filters and/or drainage blankets are required because of a significant difference between the gradation of the material to be protected and the material of the drain, they should be designed to provide for the controlled flow of the water while precluding the movement of embankment and filter materials. Examples of situations where filters may be required are zoned embankments, rockfill dams, pipe underdrain systems, and chimney drains and drainage blanket systems. Typical filter design criteria are shown in the Bureau of Reclamation's "Design of Small Dams" and "Earth Manual".

J. Geosynthetics.

Geosynthetics may be used in dams as filters, drains and impermeable membranes. An important aspect of the use of geosynthetics is the choice of the appropriate material and opening size. The use of geosynthetics at many construction sites are not as sensitive to this correct choice as at dams. Generalized use of geosynthetics does not assure their performance or acceptability. Detailed analysis must be completed to assure adequate constructability and functionality exists.

Geosynthetic materials are commonly used in filter and drain applications. The geosynthetic often replaces several layers of a granular design. Caution should be used in the adoption of standards developed for other engineered solutions. The assumptions and performance standards may not be consistent with those required for dam safety.

K. Riprap.

Riprap should be designed for its expected use and anticipated water velocities. All riprap should be placed on a properly designed bedding to prevent the loss of the underlying base material, unless the gradation of the underlying base material is such that it will not infiltrate through the riprap. Properly designed geosynthetic materials can be used to provide the bedding. For most riprap gradations a sand layer is required between the riprap and a geosynthetic material to prevent damage to the material during construction.

L. Geotechnical and Structural References.

The following references are a representative sample of publications available which are related to dam design, construction and safety, but are not intended to be all inclusive of dam technology.

General

“Designing with Geosynthetics”, Koerner

"Earth and Earth-Rock Dams", Sherard, Woodward, Gizienski, and Clevenger. (Wiley)

"Soil Mechanics in Engineering Practice", Terzaghi and Peck. (Wiley)

"Foundation Engineering", Peck, Hanson and Thornburn. (Wiley)

"Seepage, Drainage & Flow Nets", Cedergren. (Wiley)

"Foundation Engineering Handbook", Edited by Winterkorn and Fang. (Van Nostrand Reinhold)

"Soil Testing For Engineers", Lambe. (Wiley)

"Stability Analysis of Earth Slopes", Huang. (Van Nostrand Reinhold)

“Special Procedures for Testing Soil and Rock for Engineering Purposes”, Special Technical Publication No. 479, ASTM.

Proceedings - Research Conference on Shear Strength of Cohesive Soils, ASCE, 1960.

Proceedings - Stability and Performance of Slopes and Embankments, ASCE, 1966.

Bureau of Reclamation

"Design of Small Dams"

"Design of Gravity Dams"

"Design of Arch Dams"

"Earth Manual"

"Hydraulic Design of Stilling Basins and Energy Dissipators", Engineering Monograph No. 25.

“Stilling Basin Performance; An Aid in Determining Riprap Sizes”, Hydraulic Laboratory Report No. HYD-409.

"Concrete Manual"

"Design Standards No. 3" - Canals and Related Structures

Corps of Engineers

"National Program of Inspection of Dams", Volume I, Appendix D, "Recommended Guidelines for Safety Inspection of Dams"

“Shore Protection Manual,” Volumes 1-3

Engineering Manuals (EM):

1110-2-1601, Hydraulic Design of Flood Control Channels

1110-2-1901, Soil Mechanics Design-Seepage Control

1110-2-1902, Stability of Earth and Rockfill Dams

1110-2-1906, Laboratory Soils Testing

1110-2-1908, Instrumentation of Earth and Rockfill Dams

1110-2-1911, Construction Control for Earth and Rockfill Dams

1110-1-2101, Working Stresses For Structural Design

1110-2-2200, Gravity Dam Design

1110-2-2300, Earth and Rockfill Dams General Design and Construction Considerations

1110-2-2400, Structural Design of Spillways and Outlet Works

1110-2-2702, Design of Spillway Tainter Gates

1110-2-4300, Instrumentation for Measurement of Structural Behavior of Concrete Gravity Structures

Engineering Technical Letters (ETL):

1110-2-222, Slope Protection Design for Embankments in Reservoirs

Hydraulic Design Criteria (HDC):

712-1, Stone Stability, Velocity vs. Stone Diameter

Natural Resources Conservation Service

National Engineering Handbook:

Section 6 - Structural Design

Section 11 - Drop Spillways

Section 14 - Chute Spillways

Technical Releases (TR):

18, Computation of Joint Extensibility Requirements

30, Structural Design of Standard Covered Risers

52, A Guide for the Design and Layout of Earth Emergency Spillways

54, Structural Design of SAF Stilling Basins

60, Earth Dams and Reservoirs

67, Reinforced Concrete Strength Design

69, Riprap for Slope Protection Against Wave Action

Design Note (DN)

6, Riprap Lined Plunge Pool for Cantilevered Outlet

Soil Mechanics Note (SMN)

1, Tentative Guides for Determining the Gradation of Filter Materials

Mining Safety and Health Administration

"Engineering and Design Manual, Coal Refuse Disposal Facilities", 1975.

Illinois Department of Transportation

"Soils Manual"

Illinois State Geological Survey

Bulletin 94, Pleistocene Stratigraphy of Illinois

Bulletin 95, Handbook of Illinois Stratigraphy

Circular 490, Glacial Drift in Illinois: Thickness and Character

American Society of Civil Engineers

"Current Trends in Design and Construction of Embankment Dams", Wilson and Marsal, 1979. (ASCE)

Federal Highway Administration

Hydraulic Engineering Circular

No. 14, Hydraulic Design of Energy Dissipators for Culverts and Channels

No. 15, Design of Stable Channels with Flexible Linings

VI. OPERATION PLAN

A documented plan of operation for normal conditions, flood events, and emergency conditions is required. This plan should include availability of the damtender, means of communication between the damtender and his supervising authority, method of gate operation (manual, automatic or remote control), a list of the names, addresses, and telephone numbers of people and agencies to contact during normal and emergency conditions, and a list of standing instructions for normal, flood, and emergency conditions. The actions to be taken at the dam during an emergency condition are a portion of the emergency action plan for the dam which is described in a following section.

A copy of the operation plan should be provided to the damtender and kept at the project site. An example operation and maintenance plan is included as Appendix A. This example is for the purpose of providing generalized guidance in the development of the specific plans for the dam being designed and is not a required format.

VII. MAINTENANCE PLAN

A maintenance plan must be submitted which includes a listing of the equipment and manpower necessary and a time schedule for performing routine inspections and the inspections required in the "Rules for Construction and Maintenance of Dams". This plan should, at a minimum, address the following items: prevention of the growth of trees and brush on the embankment, on the abutment, on the downstream area a minimum distance of one-half the height of the dam or 20 ft. from the toe of the embankment whichever is greater, and within the spillway system; maintenance of adequate vegetation to prevent erosion of the embankment and earth spillway and the method by which the vegetation will be maintained to allow adequate visual inspection of the embankments, spillways, and crest of the dam; removal of debris or other deleterious materials from the spillway systems; inspections as necessary to insure that all gates, orifices, dissipators and other appurtenances and all mechanical and electrical equipment that affect the operation of the dam and reservoir are kept in good repair and working order; and a time schedule for test operation of all spillway and outlet gates or other equipment that must operate to pass flood flows. The OWR document entitled "Guidelines and Forms for Inspection of Illinois Dams" also provides a generalized listing of the items to be inspected and therefore the items that need to be considered in the development of the maintenance plan. The maintenance plan should be specific to the dam.

A copy of the maintenance plan should be provided to the damtender and kept at the project site. A detailed record of all maintenance is required, including dates and results of routine inspections, and complete information on all maintenance, rehabilitation, and improvements. This record should also include data on the structural behavior of the dam embankment and spillway system for all major flood and seismic events.

An example operation and maintenance plan is included as Appendix A. This example is for the purpose of providing generalized guidance in the development of the specific plans for the dam being designed and is not a required format.

VIII. EMERGENCY ACTION PLAN

An emergency action plan is a formal document which identifies potential emergency conditions at a dam and specifies the procedures to be taken by various entities in response to the noted emergency. The plan should address: accidents at the dam which could affect the operation of the dam or present a hazard to areas downstream of the dam; impending flood conditions even though the dam may not be in danger; and the potential failure of the dam. The inundation mapping prepared as a portion of the dam breach analyses should be included in this plan.

Emergency action plans are necessary to provide early warning and notification of an emergency. Emergency action plans must be site specific. The plan for a dam must address not only the specific characteristics of the dam but also the capabilities and resources of the dam owner and the emergency responders. Due to its need to be unique, an example plan is deliberately not included in these guidelines. An appropriate format for the development of an emergency action plan is available in the document entitled "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners," prepared by the Interagency Committee on Dam Safety and the Federal Emergency Management Agency (FEMA-64).

OWR and the Illinois Emergency Management Agency offer a course on the development of emergency action plans for dams. Contact OWR's Division of Resource Management for schedule information.

IX. DAM REMOVALS AND ABANDONMENTS

This section provides guidance regarding the removal of dams and the abandonment of slurry disposal or similar material impoundment dams.   However, both removal and abandonment usually result in the dam ultimately being eliminated from the Office of Water Resources regulatory purview.

Abandonment may differ from removal of a dam in that abandonment may leave the embankment intact. Dams which are typically considered for abandonment include slurry disposal, dredge disposal and fly ash disposal impoundment dams. The principles noted for the abandonment of these dams should be applicable to the abandonment of other similar structures.

B. INVESTIGATIONS AND EVALUATIONS FOR REMOVAL OF DAMS

The removal of a dam requires careful planning and design. The size, height, reservoir impounding capacity, upstream and downstream channel conditions, existing reservoir sediment deposits, degree of hazard in case of failure, as well as any other considerations which might be peculiar to a particular dam, all have impacts on the removal process.

A method to remove or reduce the stored water prior to initiating the breach of the dam must be determined. When available, use of the dam's dewatering structures would generally be the appropriate method of drawdown. For dams without dewatering structures, the installation of siphons or pumps may be an appropriate method. Items to consider in determining the drawdown rate should normally include the capacity of the dewatering structure, the flow into the reservoir from the tributary areas, the downstream channel's bank full flow capacity, and the affects of the speed of a reservoir drawdown on the embankment and shoreline.

The method to be used for the breach of the dam can vary from typical excavation with earth moving equipment for embankment dams to controlled blasting for concrete dams. The time necessary to accomplish the breach and the flows which may enter the reservoir during that time should be considered in determining the method.

The size of the breach, width and depth, needs to be large enough that a potential failure of the remaining portion of the dam and resultant release of stored water does not cause a significant increase in downstream water surface elevations. To prevent downstream damage, an assessment of water surface elevations at the breach is used as a means to establish the necessary breach size for flows up to and including the 100-year frequency flood. For configurations where the breach opening will be to the invert elevation of the channel at the downstream toe, a backwater analysis from the downstream channel and floodplain cross section to a natural channel and floodplain cross section located upstream of the dam can be used for the assessment. If a comparison of the increase in water surface elevations for the "with the dam" condition including the breach to the "without the entire dam" condition shows the increase to be less than 1 ft. in a rural area or 0.5 ft. in an urban area, the opening is considered to have a negligible backwater effect. For configurations where the breach opening will not be to the downstream channel invert (which is typical of sites for which a drop structure at the elevation of the sediment level in the reservoir is proposed), the water surface elevation comparison should be for a cross section at the upstream toe of the dam for the "with the dam" condition including the breach to the "without the entire dam" condition.

Sediment control during and after the breach must be considered for the removal of a dam. For the configuration where the breach opening will be to the invert elevation of the channel at the downstream toe and a structure to control the headcutting of the channel through the sediment is not proposed, the re-establishment of a channel in the reservoir bed to match the channel downstream of the dam is typically proposed. For the configuration where a structure is proposed to control the headcutting or to make the bottom of the breach at the top of the sediment in the reservoir, the structure and the distance through the breach opening to the downstream channel should be designed and constructed to be stable for flow conditions up to and including the 100-year frequency flood. Erosion control and re-establishment of an appropriate vegetative cover in the reservoir bed are also items which are necessary and are usually based on the conditions at the site and the final configuration of the area. For some low head run-of-the-river concrete dams for which there is significant continual flow in the river and an accumulation of sediment upstream of the dam, the creation of sediment basins downstream of the breached dam where the sediment will be removed on a regular basis may be necessary to limit the movement of sediment further downstream.

B. INVESTIGATIONS AND EVALUATIONS FOR ABANDONMENT OF DAMS

Upon the end of the useful life of a disposal impoundment it is often necessary for the owner of such a structure to reclaim and abandon it. This reclamation and abandonment is most frequently associated with slurry disposal at mining operations, reservoir sediment disposal at lake or river dredging operations, and ash disposal at power plants. Often this process is assumed by the owner to remove the associated dam structure from the dam safety regulatory jurisdiction. This assumption is usually based on the belief that the hardened surface of the impounded refuse material is characteristic of the entire volume of impounded material. However, studies have indicated that while this material may solidify on the surface after a period of time, a portion of the material below the surface remains fluid for an extended period of time. Thus, if the dam were to fail, the remaining fluid material could escape, possibly causing loss of life and/or significant property damage. Therefore, dams used in conjunction with disposal operations cannot be removed from Illinois dam safety regulation until it has been verified that the existing impounded material is not flowable and appropriate measures have been taken to prevent it from becoming flowable by recharging or seismic activity.

The following guidelines have been written in an attempt to provide general information regarding the methods of testing, analyses and computations which must be completed and submitted with an application for permit to support an owner's request for abandonment of a disposal impoundment dam.

An evaluation regarding a request to permit abandonment of a disposal impoundment structure will be based on the documentation and data addressing four issues: 1) the classification of the existing condition of the impounded material with respect to its fluid nature; 2) the liquefaction potential of the impounded material and the related stability of the containing dam; 3) the final surface configuration for the impoundment including the potential for resaturation of the impounded material, especially from any surface water impounding characteristics and the erosion potential of the surface material; and 4) the establishment of a follow-up inspection schedule to ensure the proposed plans have been effective and the submittal of record drawings.

1. Existing Impounded Material

The existing material which has been impounded must be analyzed and classified with respect to its fluid nature. To establish the characteristics of the material, actual field samples must be obtained, tested and evaluated. Testing and analyses, as appropriate, should be completed to determine such parameters as liquid limit, water content, yield shear strength, permeability, viscosity, particle grain size distribution, confining pressure and void ratio of the material. Piezometers or other observational devices may also be used to assist in the evaluation and classification process.

If the existing impounded material is found to be of a non-fluid nature then the liquefaction potential must be evaluated as described in Section 2. If the liquefaction potential is found to be low, then a plan to prevent resaturation as discussed in Section 3 would need to be developed.

If the existing impounded material is found to be of a fluid nature and abandonment is desired then design of an appropriate method to dewater the material must be developed. Additionally, a plan to prevent future resaturation of the impounded material must also be completed. To ensure a continued non-fluid state is maintained it is suggested that observational devices such as piezometers be installed and monitored for a period of not less than one year after initial dewatering has been completed. Upon completion of dewatering procedures the existing impounded material must be evaluated with respect to liquefaction potential (as discussed in Section 2).

2. Liquefaction Potential

The impounded material within a disposal impoundment dam must be evaluated to determine if the material is susceptible to liquefaction. If necessary, a computer model capable of analyzing the dynamic effects should be used.

If the material is found to be susceptible to liquefaction then no abandonment would be permitted unless plans for modifications to eliminate the liquefaction potential were completed and approved.

If the material is not susceptible to liquefaction the abandonment procedures may be permitted providing that the issues of Sections 1, 3 and 4 have been appropriately addressed and the containing embankment is shown (by submitting appropriate support documentation) to be stable under static conditions.

3. Resaturation Potential

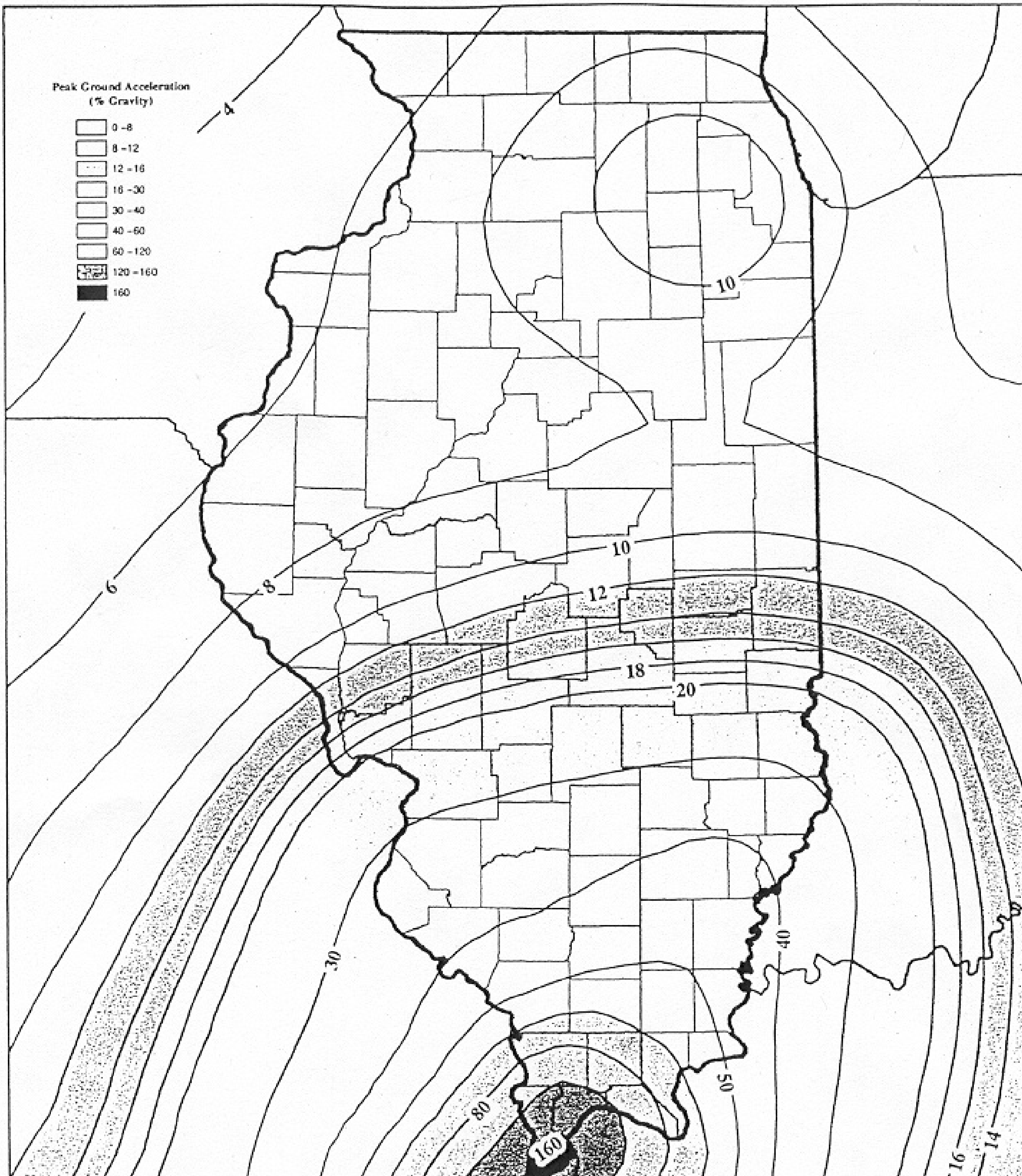
To prevent resaturation, water should not be permitted to pond on the surface of the slurry material or any cover material. Elimination of any existing surface impoundment on the slurry material will be required. Plans to prevent any future surface water impounding capability and the prevention of erosion on the final surface material should be required.

4. Final Inspection and Record Drawings

A final inspection and report by a professional engineer must be completed and submitted to the Office of Water Resources one year after the completion of the abandonment modifications to the dam. This inspection will evaluate and report the effectiveness of the abandonment designs. Record drawings should be submitted along with the final inspection report.

APPENDICES

APPENDIX NO. 1



Peak Ground Acceleration (Percent Gravity)
Two Percent Probability of Exceedance in 50 Years

Source: US Geological Survey
National Seismic Hazard Mapping Project
(Open-file Report 97-131) November, 1996

Office of
Water Resources
October 4, 2002

ILLINOIS
DEPARTMENT OF
NATURAL
RESOURCES

APPENDIX NO. 2

OPERATION AND MAINTENANCE MANUAL

UNKNOWN CREEK DAM

WHEREVER, ILLINOIS

WHICHEVER COUNTY

DATE

OPERATION AND MAINTENANCE MANUAL
UNKNOWN CREEK DAM
WHEREVER, ILLINOIS

TITLE PAGE

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SECTION 1

GENERAL

This operation and maintenance manual, (hereafter referred to as O&M manual), outlines objectives, proposed policies, responsibilities, and procedures for City of Wherever personnel who are responsible for the management of the Unknown Creek Dam.

REASONS FOR DEVELOPMENT AND DISSEMINATION OF THE O&M MANUAL

The Rivers, Lakes and Streams Act, (615 ILCS 5) Paragraph 23a includes the statement "The Department is authorized to carry out inspections of any dam within the State, and to establish standards and issue permits for the safe construction of new dams and the reconstruction, repair, operation and maintenance of all existing dams." (emphasis added).

Part 3702 of the 17 Illinois Administrative Code, Chapter I entitled the "Construction and Maintenance of Dams" details the requirements to obtain a permit for the construction, operation, and maintenance of a dam. Section 3702.40 b) includes the following statements:

> "4) An applicant for a Class I or II dam shall submit an operational plan specifying the method and schedule for the operation of the dam and the routine operating procedures to keep the dam in good working order, including an emergency warning plan." and
>
> "5) As a condition of each permit, the dam owner shall submit a maintenance plan detailing the procedures and schedules to be followed to maintain the dam and its appurtenances in a reasonable state of repair."

Thus it is a requirement of all dam owners who have dams which fall under the jurisdiction of the Illinois Department of Natural Resources to operate and maintain them safely.

As a dam owner the City of Wherever is responsible for the safety of the public and for maintaining the structures within the City's jurisdiction for both safety and economy. The overall public interest is served by providing a document to serve as a basis for the safe and economical operation and maintenance of the dam during both emergency and day-to-day conditions.

<u>GENERAL RESPONSIBILITIES CONCERNING DAMS</u>

Specific information should be included either here or throughout the O&M plan. The following comments are noted for general guidance for development of the O&M plan.

City Council

The City Council should annually provide sufficient funding to safely maintain and operate the dam. The estimated annual funding requirements as of the date of this plan is $ _________. The City Council should also provide sufficient authority to personnel within city government to assure the performance of critical functions during emergencies.

Street Department

The Street Department may have specific responsibilities which should be outlined in the O&M plan. The responsibilities might include mowing of the dam; removal of debris from the spillways; placing needed rip rap; and providing trucks and other equipment, personnel, and material during emergency actions.

Water Department

The Water Department may have specific responsibilities which should be outlined in the O&M plan. The responsibilities might include the overall responsibility for the dam such as making emergency action decisions; inspecting the dam; operating and maintaining the dam's gates, valves, and electrical system; and providing equipment, personnel, and material during emergency actions.

Emergency Services and Disaster Agency

The city's Emergency Services and Disaster Agency should review, and revise if necessary, the Emergency Action Plan for the dam prior to the plan being submitted for permit approval. The Agency should be responsible to keep the information in the Emergency Action Plan for the dam current. It should coordinate with other agencies (local, county, state, federal) the responses to an emergency at the dam.

SECTION 2

DEFINITIONS

Abutment - That part of the valley side or concrete walls against which the dam is constructed. Right and left abutments are those on respective sides of an observer when viewed looking downstream. (Illustration 1 depicts the principal parts of a "typical" earthen dam and its appurtenant works.)

Appurtenant Works - The structures or machinery auxiliary to dams which are built to operate and maintain dams; such as outlet works, spillways, gates, valves, channels, etc.

Boil - A stream of water discharging from the ground surface downstream of the dam carrying with it a volume of soil which is distributed around the hole formed by the discharging water.

Berm - A horizontal step or bench in the sloping profile of an embankment dam.

Breach - A break, gap, or opening (failure) in a dam which releases impoundment water.

Concrete Block - An erosion protection method using interlocking concrete blocks, usually with openings that are filled with soil and grass.

Core - A zone of material of low permeability in an earthen dam.

Dam - A barrier built for impounding or diverting the flow of water.

Dike (Levee) - An embankment or structure built alongside a river to prevent high water from flooding bordering land.

Drain, Layer or Blanket - A layer of pervious material in a dam to facilitate the drainage of the embankment including such items as a toe drain, a weephole, and a chimney drain.

Drawdown - The resultant lowering of water surface level due to the controlled release of water from the impoundment.

Embankment - Fill material, usually earth or rock, placed with sloping sides.

Earthen Dam - Any dam constructed of excavated natural materials.

Emergency Action Plan - A predetermined plan of action to be taken to reduce the potential for property damage and loss of lives.

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

Freeboard - The vertical distance between a stated water level and the top of a dam. (See Illustration 1.)

Gate or Valve - In general, a device in which a leaf or member is moved across the waterway to control or stop the flow.

Groin - The junction of the upstream or downstream face of the dam with the valley wall.

Maintenance - The upkeep, involving labor and materials, necessary for efficient operation of dams and their appurtenant works.

Operation - The administration, management, and performance needed to operate the dam and appurtenant works.

Operation and Maintenance Inspection - Inspections conducted by the dam operator. These inspections are frequent visual "walk-around" inspections of the dam surface and appurtenant works.

Outlet - An opening through which water can freely discharge for a particular purpose from an impoundment.

Phreatic Surface - The upper surface of saturation in an embankment.

Piping - The progressive development of internal erosion by seepage, appearing downstream as a hole or seam, discharging water that contains soil particles.

Riprap - A layer of large stones, broken rock or precast blocks placed in a random fashion usually on the upstream slope of an embankment dam, on a reservoir shore, or on the sides of a channel as a protection against current, wave and ice action.

Silt/Sediment - Soil particles and debris in an impoundment.

Slump/Slide Area - A portion of earth embankment which moves downslope, sometimes suddenly, often with cracks developing.

Spillway System - A structure or structures over or through which flows are discharged. If the flow is controlled by gates, it is considered a controlled spillway. If the elevation of the spillway crest is the only control of the flows, it is considered an uncontrolled spillway.

Emergency Spillway - A spillway designed to operate very infrequently, only during exceptionally large floods, usually constructed of materials expected to erode slowly.

Principal Spillway - The main spillway which controls both normal and flood flows and is constructed of non-erodible materials.

Auxiliary Spillway - A spillway which works in conjunction with the principal spillway to control flood flows and is constructed of non-erodible materials.

Stilling Basin - A basin constructed to dissipate the energy of fast flowing water, such as from a spillway, and to protect the stream bed from erosion.

Toe of Embankment - The junction of the face of the dam with the ground surface in the floodplain upstream or downstream of the dam.

Trash Rack - A structure of metal or concrete bars located in the waterway at an intake to prevent the entry of floating or submerged debris.

SECTION 3

INFORMATION ABOUT THE DAM

LOCATION

The Unknown Creek Dam is located in the southeast part of Wherever in the northwest part of Whichever County, Illinois. The dam is located on Unknown Creek in the southeast quarter of Section 4, Township 21 North, Range 9 East of the 4th Principal Meridian. Plate 1 shows the general vicinity of the dam within the State of Illinois, and Plate 2 is a location map.

DESCRIPTION OF DAM AND APPURTENANCES

The Unknown Creek Dam is an earth embankment structure approximately 31 feet high and 1480 feet long. The top of dam elevation is 740.8 and both faces of the dam slope at 3 horizontal to 1 vertical.

The appurtenant works consist of a 24 inch diameter concrete low flow pipe principal spillway, a reinforced concrete drop inlet auxiliary spillway with a dewatering gate, and an earth cut emergency spillway. The 24 inch diameter low flow pipe with a trash rack at its entrance and the drop inlet spillway both discharge through a 60 inch diameter concrete pipe into a reinforced concrete stilling basin at the downstream toe. The emergency spillway is located at the left abutment of the dam. (Left and right orientation is based on looking in the downstream direction.) The emergency spillway is a 150 foot wide earth cut with a concrete wall crest control section.

The principal and auxiliary spillway system is designed to pass the 100-year frequency storm with about 5.4 feet of freeboard, that is, without the emergency spillway functioning. The emergency spillway is designed to function for any storm event greater than the 100-year frequency storm. The combined spillway capacities are capable of passing 50 percent of the Probable Maximum Flood (PMF) with 2.9 feet of freeboard and 100 percent of the PMF with 1.3 feet of freeboard.

Plate 3 shows a plan view of the dam. Plate 4 shows a cross section of the dam embankment at the principal spillway. Plate 5 shows a profile of the dam.

SIZE CLASSIFICATION

With a maximum height of 31 feet and a maximum storage capacity of approximately 198 acre-feet, the dam is in the small size category.

HAZARD CLASSIFICATION

The Unknown Creek Dam is classified as a CLASS I, HIGH HAZARD POTENTIAL dam because of the high probability that, in the event of a dam failure, loss of life and/or property downstream of the dam would be substantial.

PURPOSE OF DAM

The dam serves to form a dry detention reservoir for the control of flooding on the Unknown Creek which flows through the southeastern part of Wherever.

PERTINENT DATA

Pertinent data about the dam, appurtenant works, and reservoir is presented in Table 1. Plates 3 through 5 show plans, sections and details of the dam and appurtenant works.

TABLE 1
PERTINENT DATA

DRAINAGE AREA	Square Miles	0.92
DAM		
Type	Earth Embankment	
Elevation, Top of Dam	Feet-NGVD	740.8
Height Above Streambed	Feet	31
Upstream Slope	Horiz:Vert	3:1
Downstream Slope	Horiz:Vert	3:1
Length, Crest	Feet	1480
Top Width	Feet	16
Streambed Elevation	Feet-NGVD	709.8
RESERVOIR		
Normal Pool Storage	Acre-Feet	0
Elevation, PMF Pool	Feet-NGVD	739.5
Storage, PMF Pool		Acre-Feet
177		
Length, PMF Pool	Miles	0.3
Storage, Top of Dam	Acre-Feet	198

TABLE I
(continued)

PRINCIPAL SPILLWAY		
Type	Uncontrolled flow through concrete pipe	
Size	Inch Diameter	24
Elevation, Inlet Invert	Feet-NGVD	714.0
Elevation, Outlet Invert	Feet-NGVD	713.5
Length	Feet	20
AUXILIARY SPILLWAY		
Type	Uncontrolled Drop Inlet	
Size	Feet	5' X 5'
Elevation, Crest	Feet-NGVD	733.5
Length, Crest	Feet	16.5
DEWATERING GATE		
Type	Unseating head type sluice gate with cast iron flange frame and bronze seat facings Manufacturer : Model No. :	
Size	Feet	3' X 3'
Inlet Invert Elevation	Feet-NGVD	725.0
OUTLET CONDUIT		
Type	Concrete Pipe	
Size	Inch Diameter	60
Elevation, Inlet Invert	Feet-NGVD	713.5
Elevation, Outlet Invert	Feet-NGVD	712.0
Length	Feet	124
STILLING BASIN		
Type	Impact	
Elevation, Floor		Feet-NGVD
709.75		
Elevation, End Sill	Feet-NGVD	712.
Width	Feet	13.5
EMERGENCY SPILLWAY		
Type	Earth Cut Channel (grass lined)	
Control Section	Concrete Wall	
Elevation, Crest	Feet-NGVD	735.5
Length, Crest (Bed Width)	Feet	150
Width, Crest	Feet	1
Side Slopes	Horiz:Vert	3:1

Notes: (1) NGVD is referred to as the National Geodetic Vertical Datum, 1929.

SECTION 4

OPERATION ACTIVITIES

TYPES OF DAM INSPECTIONS

The inspection program includes two types of dam inspections. The first is regularly conducted by the Dam Operator and is referred to as an Operation and Maintenance Inspection. The second type of inspection, referred to as the Engineering Inspection, is conducted by a qualified engineering consulting firm approved by the City of Wherever, (all engineering inspection reports must be signed and sealed by an Illinois Registered Professional Engineer).

Operation and Maintenance Inspection:

Occasional "walk-around" inspections of the dam and appurtenant works are to be made by the Dam Operator. During these inspections, a checklist of items to be maintained and items to be observed should be recorded. Appendix A provides an example of the Operation and Maintenance Inspection Checklist to be utilized for these inspections. Illustration 2 identifies some potential problem indicators at a "typical" earthen dam.

Frequency: Monthly and during and after unusual events such as heavy rainfall or an earthquake.

Inspection Items: During each inspection the following items should be noted in particular:

(1) Water Level - A staff gage which can be easily seen when the reservoir is full should be installed or painted on the drop inlet. Maximum reservoir levels as a result of heavy rainfall should be recorded.

(2) Earth Embankment - Walk the crest, abutments, groins, side slopes, downstream toe and upstream toe or at the waterline of the dam concentrating on surface erosion, seepage, cracks, settlements, slumps, slides, and animal burrows. These are described as follows:

Surface Erosion - Removal of vegetative cover by water action or pedestrian or vehicle usage forming deep ruts or gullies.

Seepage - The passage of water through and/or underneath the earth embankment abutment and natural groundline or at the contact between the embankment and outlet works can be indicated by cattails or other wet environmental vegetation, erosion channelization, or slumping on the embankment face.

Cracks - Deep cracks usually indicate the movement of the dam and/or the foundation and can be in either the longitudinal (along the length of the dam) or transverse (across the dam) directions. Cracking can be an indicator of the beginning of slumps. Shallow cracks may develop during the summer when the surface soils of the embankment become severely dried and are usually of no concern in regard to the safety of the dam.

Settlement - Settlement is indicated by depressions or low spots and can be signs of consolidation of the dam or foundation or the loss of material beneath the settlement area.

Slumps/Slides - Slow or sudden movements of the earth embankment slope on either face toward the toe of the dam.

> If seepage indicates the presence of soil particles, or if deep cracks, settlement, slumps, or slides are noticed, a qualified engineer should be contacted immediately for consultation.

Animal Burrows - Animal burrows result in a loss of earth embankment material and can provide seepage paths for water through the embankment.

(3) Vegetation - Grass should be a thick vigorous growth to stabilize embankment soils and prevent erosion from occurring. Note the height of the grass; if greater than 1 foot, a mowing of the area should be scheduled before the next inspection. There should be NO trees on the earth embankment and NONE within a minimum of 20 feet of the embankment toes or concrete structures. There should be NO trees in the emergency spillway.

(4) Trash Racks - Check to make sure that the trash racks are unobstructed, operating well, and allowing for the free flow of water.

(5) Drop Inlet Spillway - Check for any debris or other obstructions around the inlet crest and at the bottom of the drop inlet which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete, and seepage, cracking, breaking, or spalling of the concrete. Check the vent pipes for overall condition and alignment and to ensure that the pipes are clear and unobstructed. <u>(Do not place your hand or any tool near the inlet of the vent pipe if flows are passing over the crest of the auxiliary spillway as suction through the vent pipe may be occurring.)</u>

(6) Outlet Works - Check for any debris or other obstructions within the impact basin which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete, and seepage, cracking, breaking, or spalling of the concrete. Check to make sure weepholes are clear and operating properly. Check for any erosion occurring at the embankment/structure junction.

(7) Concrete Block and Rip Rap - Check to make sure that the blocks and rip rap are remaining in a uniform position. Freeze/thaw action or flow over the blocks or rip rap may tend to lift or fracture them, thus requiring replacement or leveling to maintain the necessary level of protection. NO trees or woody vegetation should be growing through the blocks or rip rap.

(8) Mechanical Equipment - Check for any debris or other obstructions around the dewatering gate which may block or restrict the free flow of water. Operate the gate from the fully closed to the fully open position taking note of the physical and operating conditions of the system. Lubricate the stem, stem guides, wedges and hoisting mechanism a minimum of two (2) times a year. NOTE: Except in emergencies, the drawdown of water using the dewatering gate should be limited to 0.5 foot per day to

minimize upstream slope stability problems. (Refer to Appendix D for operation and maintenance of the sluice gate.)

(9) Fences - Check for damage, accumulated debris, operation of gates and locks, and adequacy of locations (this may change with time as people access the area or development occurs in the area).

(10) Drains - The change in location or amount of flows discharging from the toe drain should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

(11) Emergency Spillway - Check for settlement or cracking of the crest control wall. Check for any logs, tree or brush growth, and other debris in the spillway, upstream and downstream areas which may restrict the flow of water.

(12) Downstream Floodplain - Check the floodplain downstream of the dam for a distance of at least 100 feet for signs of seepage or boils.

Records: A log book of activities occurring at the dam is to be kept current by the Dam Operator. The log book should be reviewed during the Engineering Inspection and may be helpful during budget preparations. This book should contain at least the following documentation:

(1) Completed operation and maintenance inspection checklists
(2) Additional visual observations
(3) A list of maintenance performed
(4) A list of any unusual occurrences at the dam
(5) A copy of the engineering inspection reports

Engineering Inspection:

The engineering inspection is to be conducted by a qualified engineering consulting firm approved by the City of Wherever. The inspection will provide a thorough evaluation of the condition of the dam and appurtenances. Appendix B is an example of the inspection report form which is to be utilized for these inspections.

Frequency: The Unknown Creek Dam is classified as a CLASS I, HIGH HAZARD POTENTIAL dam. Class I dams are to be inspected annually.

Inspection Items: The engineer will thoroughly inspect the items noted under Operation and Maintenance Inspection in addition to the following items:

(1) Principal and Auxiliary Spillways - Check for signs of seepage, structural cracking or spalling of concrete, misalignment of pipe, joint separation or differential settlement.

(2) Emergency Spillway - Check for signs of structural cracking or spalling of the concrete crest control wall. Check for signs of degradation of the embankment on the right of the emergency spillway to assure that emergency spillway flows do not attack the left downstream dam groin.

Records: The Dam Inspection Report form, Appendix B, will be completed by the inspecting engineer and will be signed and sealed by an Illinois Registered Professional Engineer. This report will document problem areas and deficiencies; recommend remedial actions for problem areas; and establish time requirements for dealing with the problems. The original report will be retained in the City of Wherever's Unknown Creek Dam file and a copy of the report will be submitted to the Illinois Department of Natural Resources, Office of Water Resources.

REVIEW OF EMERGENCY ACTION PLAN

The emergency action plan should be reviewed annually to assure that all contacts, addresses, telephone numbers, etc. are current. Changes to the plan should be made as appropriate but only with the concurrence of the Wherever office of the Emergency Services and Disaster Agency and of the Department of Natural Resources, Office of Water Resources. Copies of any revisions should also be forwarded to all personnel that have the plan.

SECTION 5

MAINTENANCE ACTIVITIES

Timely repairs are a must after problem areas have been identified. The dam operator is to perform the work required to correct items noted in the operation and maintenance and engineering inspections. Such items include mowing, seeding, tree and brush removal, painting, greasing, replacing riprap, repairing fences and locks, clearing debris, etc. Common maintenance items are pictured in Illustration 2. The maintenance activities specified in the following sections are minimum requirements. NOTE: NO alterations or repairs to structural elements should be made without the assistance of a qualified engineer and the concurrence of the Illinois Department of Natural Resources, Office of Water Resources.

Debris: Remove all trash, logs and other debris which may obstruct flow into the principal spillway pipe, drop inlet, and emergency spillway or block passage from their discharge channels.

Concrete Block and Rip Rap: Replace or level blocks and rip rap as needed to provide adequate protection against erosion.

Vegetation Control:

(1) A good grass cover on the embankment should be maintained by seeding, fertilizing and mulching areas which are refilled, barren, or thinly vegetated. Seeding mixtures used for maintenance reseeding shall result in a cover compatible with adjacent cover. The seeding mixture used at the time of the dam's construction was ____ .

(2) Grassed areas such as the embankment, the emergency spillway, and areas beyond the embankment toes for a distance of at least 20 feet should be mowed at least twice annually and at any time the height of the grass exceeds 1 foot.

(3) All eroded areas should be filled and compacted, reseeded, fertilized and mulched to establish a thick erosion resistant cover.

(4) All trees and brush on the dam embankment should be removed to prevent development of a root system which could provide seepage paths. Herbicides utilized for tree and brush control are discussed in Appendix C.

(5) The emergency spillway area should be kept clear of weeds, brush and trees.

(6) All trees and brush should be removed from the outlet channel to a distance of approximately 100 feet downstream from the stilling basin.

(7) All brush and trees should be removed to a distance of approximately 20 feet beyond both toes of the dam.

Animal Damage: Rodent holes should be filled with compacted clayey dirt and reseeded. If rodents become a nuisance, an effective rodent control program as approved by the Illinois Department of Natural Resources District Wildlife Biologist should be implemented.

Concrete: Spalled and cracked areas on concrete structures should be patched to guard against any further deterioration of the structure. Concrete construction joints should be filled with a suitable joint filler such as a bituminous sealant to protect against weathering.

Drains: All drains and weepholes should be kept open and functional by cleaning them of silt and debris.

Painting: All metal work, fencing, railing, etc. should be properly prepared and repainted as necessary to protect against rusting.

Signs: All warning signs and staff gages should be maintained (repaired, painted, or replaced) as needed.

Vent Pipes: All obstructions should be cleared from the vent pipes.

Sedimentation: Sedimentation of this reservoir is estimated to occur at the rate of approximately 1 ac-ft per year, which is about 1.1% of the initial reservoir storage at the crest of the drop inlet. As sediment accumulates in the reservoir less storage is available for the control of flood waters from the watershed. Efforts should be made to work with the U.S. Department of Agriculture, Natural Resources Conservation Service and the upstream land owners to minimize the sediment being transported to the reservoir. A location for the placement of the sediment removed from the reservoir (if upstream of the dam, above the top of the dam) should be determined.

Mechanical Equipment: The hoisting mechanism, stem and guides, wedges, nuts and bolts should be cleaned and lubricated at least two (2) times per year. (Refer to Appendix D for operation and maintenance of the sluice gate.)

APPENDIX A

OPERATION AND MAINTENANCE INSPECTION CHECKLIST

OPERATION AND MAINTENANCE INSPECTION CHECKLIST

Dam Name :______________________________________

Date and Time of Inspection :______________________________________

Name of Inspector :______________________________________

Reservoir Elevation :______________________________________

ITEM	NO	YES	IF YES
Surface Cracks	___	___	Contact Superintendent
Slump or Slide on the upstream or downstream face	___	___	Contact Superintendent
Erosion from runoff, wave action or traffic	___	___	Repair and stabilize
Embankment, abutment or spillway seepage	___	___	Contact Superintendent
Seepage or flows of muddy water	___	___	Contact Superintendent and ESDA
Uneven settlement	___	___	Contact Superintendent
Uneven concrete blocks	__	___	Level and stabilize
Trees, brush or burrow holes on the embankment	___	___	Remove trees and brush, fill holes
Spillways or trash racks blocked	___	___	Clear immediately
Exposed metal is rusty	___	___	Clean and paint
Concrete deterioration or cracks	___	___	Contact Superintendent
Pipe joint separation	___	___	Contact Superintendent
Scour	___	___	Contact Superintendent
Vent pipe blocked	___	___	If no flow over drop inlet, clear
Height of Grass ___ inches			If more than 1 foot, schedule mowing

Comments :______________________________________

____

APPENDIX B

ENGINEERING INSPECTION FORM

(See OWR document entitled “Guidelines and Forms for Inspection of Illinois Dams”)

APPENDIX C

HERBICIDES

HERBICIDES

Site personnel should check with the Illinois Department of Natural Resources, Regional Fisheries Biologist and the Regional Wildlife Biologist before using any herbicide. Read the product label prior to use and follow the use directions and precautions accordingly.

On March 1, 1979 the U.S. Environmental Protection Agency (U.S.E.P.A.) halted the use of the herbicide 2, 4, 5-T in parks and recreation areas. The use of silvex (2, 4, 5-TP) around water has also been banned.

The Agronomy Department at the University of Illinois and the Aquatic Biology Section of the Department of Natural Resources, Office of Scientific Research and Analysis indicate that the herbicides containing the 2, 4-D or 2, 4-DP are legal for use in parks and recreation areas and effective for controlling brush and woody growth. Some examples of approved herbicides are:

1) Tordon RTU by DOW Chemical. (Can be obtained with blue dye.)

2) WEEDONE 170 by Union Carbide

3) WEEDONE, 2, 4-DP by Union Carbide

4) A 1% to 2% solution of ROUNDUP

5) Garlon by DOW Chemical

6) Banvel by Sandoz

Your distributor may carry brand name herbicides other than those listed above. Be certain that the product <u>does not</u> contain the ingredients 2, 4, 5-T or 2, 4, 5-TP. An example of an <u>unacceptable</u> product is ESTERON 2, 4, 5 by DOW Chemical.

APPENDIX D

OPERATION AND MAINTENANCE OF SLUICE GATE

MAINTENANCE

The maintenance on a sluice gate is minimal but very important. The gate, itself, requires no periodic maintenance or lubrication. It is critical that the operating stems be periodically cleaned and greased. Manufacturers recommend that stems be cleaned and greased at least once every six months. Dirty grease or lack of grease will increase the operating force necessary to open or close the gate and will accelerate the wear in the stem nut. Manufacturers of sluice gates recommend the following lubricants for this use:

Lubriplate Lithium Base No. 630AA or AAA
Texaco Multi-Fax Heavy Duty No. 2
Conoco All Purpose Superlube
Shell Alvania No. 1 or No. 2 EP
Mobilox Grease No. 2 EP
Valvoline Val-Lith No. 2 EP

At least once a year, all grease fittings on manual floor stands should be lubricated with a small amount of heavy duty grease designed to remain pliable and not dry out over long periods and wide temperature ranges. For best results the floor stand should be greased when being operated. For the first three or four turns of the crank, grease should be applied to each fitting after each turn. This will insure adequate lubrication of all parts. Over lubrication is not possible. Manufacturers recommend the following lubricants for this application:

Mobilgrease Special
Mobilplex No. 45

The exposed non-operating surfaces of the gate, stem guides, and hoisting mechanism should be cleaned and painted as conditions require or permit. All machined corrosion-resistant metal faces must be thoroughly protected during the cleaning and painting.

OPERATION

There isn't a sluice gate manufacturer who will guarantee a leak-proof gate. AWWA Specifications maintain that leakage for a seating head gate should not exceed 0.1 gpm per foot of perimeter. For unseating head gates with heads of up to 20 ft., the specifications indicate that leakage should not exceed 0.2 gpm per foot of perimeter.

As an example: a 24-inch diameter circular opening gate would have a circumference of 6.25 ft. If an unseating head gate operates under a head of 20 ft. the allowable leakage would be 1.26 gpm. That is, the gate could pass 1.26 gpm without requiring adjustment. When there is excessive leakage through the gate seating surfaces, the wedges should be re-adjusted per the manufacturer's instructions. These adjustments should not be attempted without adequate instruction, help, tools, replacement parts, and safety equipment.

Sluice gates are designed and constructed to operate satisfactorily under the design operating conditions. Care should be taken in the operation of the gate to assure that the design operating conditions are not exceeded. If, in the operation of the gate, an obstruction is met, either in the opening or closing direction, the obstruction must be removed, before continuing the operation of the gate. Excessive force must never be placed on the gate or gate stem by the operator in an effort to move the gate further. Manual operators are designed so that the maximum pull on the crank need not exceed 40 pounds when the gates are opened or closed against the specified operating head. If a problem arises in the operation of the gate, the operator should consult the Superintendent and a determination will be make as to the corrective action to be taken.

Prior to opening a sluice gate, the following checklist activities should be performed:

(1) Gate, wedges, stem, stem guides and hoist mechanism inspected.

(2) All sand, stones, and other debris cleaned from the top of the gate, wedges, and stem guides.

(3) Stem and stem guides cleaned and lubricated.

(4) Guides cleaned and lubricated.

(5) Hoisting mechanism lubricated.

When operating the gate, record the number of turns of the crank to open the gate. Repeat the number of turns to close the gate. After closure, check the gate for leakage. If leakage is "excessive" or greater than prior to opening, the wedges may need adjusting. <u>Do not force the crank to attempt to close the gate.</u> If any problems are encountered, the Superintendent should be notified immediately.

PLATES

(Specific plates or figures appropriate for the dam should be included here.)

APPENDIX NO. 3

EMERGENCY ACTION PLAN

UNKNOWN CREEK DAM

WHEREVER, ILLINOIS

WHICHEVER COUNTY

DATE

EMERGENCY ACTION PLAN
UNKNOWN CREEK DAM
WHEREVER, ILLINOIS

TITLE PAGE

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PLATES

Plates 1-5	Dam Breach Inundation Maps
Plate 6	Granular Blanket "Inverted Filter"
Plate 7	Boil Ring

EMERGENCY ACTION PLAN
UNKNOWN CREEK DAM

(The information that follows identifies the procedures to be followed in the event of a heavy rainfall or a dam failure. An example of a complete plan is specifically not included. OWR and the Illinois Emergency Management Agency offer a course on the preparation of emergency action plans for dams. Guidance on the development of a plan can be obtained in the document entitled "Federal Guidelines for Dam Safety: Emergency Action Planning for Dam Owners," prepared by the Interagency Committee on Dam Safety and the Federal Emergency Management Agency (FEMA-64). The plan should be coordinated with emergency services personnel prior to submittal to OWR for permitting of the dam construction. Some of the items which relate to actions to be taken at the dam are included for consideration and guidance.)

EMERGENCY DETECTION, EVALUATION AND ACTIONS

The following section explains some of the problems which may occur at a dam, how to make a rapid evaluation of the problem, and what action should be taken in response to the problem. This section presents only generalized information for the dam operator to aid in a first response to a problem. Any suspected problem should be reported and assistance from a qualified engineer should be obtained as soon as possible.

This section will be placed in the following format:

PROBLEM
- INDICATOR
  - HOW TO EVALUATE PROBLEM
    - ACTION TO BE TAKEN

SEEPAGE
- Wet area, on downstream embankment slope or any other area downstream of the embankment, with very little or no surface water or very minor seeps.
  - This condition may be caused by infiltration of rain water which is not serious, or may be the start of a serious seepage problem which would be indicated by a quick change to one of the conditions below.
    - No immediate action required; note location for future comparison.

- Same wet area as above with moderate seeps of clear or relatively clear water and rate of flow not increasing.
  - Measure the flow periodically and note any changes in clarity.

No immediate action required; note location, flow rate, and clarity for future comparison. During reservoir flood stages the seepage area should be watched for any changes.

Same wet area as above with moderate seeps of clear or relatively clear water and rate of flow increasing.

Measure the flow periodically and note any changes in clarity. Inspect the downstream area for any new seeps.

Contact a qualified engineer for an immediate inspection. Observe the condition constantly for any further changes in flow rate or clarity unless notified otherwise by the engineer.

Piping (seepage with the removal of material from the foundation or the embankment) with moderate to active flows of cloudy to muddy water.

If the water is cloudy to muddy and the rate of flow is increasing, this condition could lead to failure of the dam.

Immediate action is necessary. Open the dewatering gate completely. If no whirlpool is noted on the upstream side of the dam, place an "Inverted Filter" over the seepage area on the downstream side of the dam (see Plate 6). The filter should consist of a 3 to 5 ft. thick blanket of material graded from coarse sand and pea gravel at the bottom to 3-inch stone at the top. If needed, use larger stones on the top of the filter. Use filter cloth at the bottom of the filter if available. Do not try to "plug" or stop the flow of water from this location. Try to reduce the movement of material using this filter while allowing the flow to pass through it. Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5).

If, along with the piping, there is an upstream swirl (whirlpool) caused by water entering through the abutments of embankment, failure may be imminent.

Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5), open the dewatering gate completely, and attempt to construct the inverted filter over the seepage area on the downstream side of the dam as noted above. The thickness of the section will generally be greater than 5 ft. Plugging of the upstream entrance of the "pipe" should also be attempted using large rock or anything else that is available (rolls of fencing, bed springs, cars, large hay bales, etc.). If the large material placed in the hole appears to have reduced the flow, follow with progressively smaller material in an attempt to seal the entrance.

Boils (soil particles deposited around a water exit forming a cone, varying from a few inches in diameter spaced 2 to 3 ft. apart to isolated locations several feet in diameter in the floodplain downstream of the dam) may show the same types of flow as noted above.

Evaluation of the problem is the same as noted above for the various flow conditions, i.e., clear and constant, clear and increasing, and cloudy or muddy and increasing.

Actions to be taken are essentially the same as those noted above. An additional method to try to control the movement of material from a boil is the construction of a boil ring or ring dike. An example of a boil ring is shown in Plate 7. In placing the ring it must be remembered that the work is not being done to stop the flow of water but rather to stop the movement of material. When the ring reaches an elevation where the water that is discharging from the ring is flowing clear the work should stop and the flows monitored for changes.

RESERVOIR WHIRLPOOL

Water flowing in a swirling motion in an area on the upstream side of the dam.

During high reservoir stages when the drop inlet is completely submerged, debris may come together above the drop inlet and due to flows at the inlet move in a rotating motion. If there is no evident downstream exit of "piping" as noted above and the rotating debris is over the drop inlet, then it can be assumed that there is no piping failure. If the whirlpool is over a section of the embankment or abutment, the situation is critical and failure of the dam may be imminent.

Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5). Take the actions noted above under "piping".

SLIDE

Movement of a portion of the embankment, either the upstream or downstream slope, toward the toe of the dam.

Various degrees of severity of a slide require different responses. The first condition is that the slide does not pass through the crest and does not extend into the embankment more than 5 ft., measured perpendicular to the slope.

For this condition, a qualified engineer should be consulted before any repairs are initiated to determine the cause of the slide and to recommend any modifications to prevent future slides. The downstream side of the dam should be watched for the emergence of any water either through the slide or opposite the slide. If discharging water is noted, the area the slide should be treated as a seepage location and monitored as noted above.

The second condition is that the slide passes through the crest and that the reservoir elevation is more than 10 ft. below the lowered crest.

Use the same actions as noted above and notify the Emergency Services and Disaster Agency of the situation so they may be prepared to act if the condition worsens.

The third condition is that the slide passes through the crest and the reservoir elevation is less than 10 ft. below the lowered crest.

This condition is critical and failure of the dam should be considered imminent. Notify the Emergency Services and Disaster Agency Office for evacuation of the dam breach area, (see Plates 1-5). Armor the crest of the lowered portion of the embankment and try to restore the lost freeboard. If seepage is also occurring, take the appropriate actions as noted above.

CRACKS

Cracks in the embankment can occur either in the longitudinal (along the length of the dam) or transverse (across the dam from upstream to downstream) direction.

Some cracking of the surface soils may occur when they become dry. This cracking is to be expected and no further action is required.

Longitudinal cracking can indicate the beginning of a slide or be an uneven settlement of the embankment.

Monitor the crack for future changes and contact a qualified engineer for assistance in the evaluation of the crack and recommended repairs.

Transverse cracking can indicate uneven settlement or the loss of support below the crack. Such cracks usually occur over an outlet conduit, near the abutments, or in the taller portion of the embankment.

If the crack does not extend completely across the dam and the reservoir elevation is more than 10 feet below the base of the crack, monitor the crack for future changes and contact a qualified engineer for assistance in the evaluation of the crack and recommended repairs. If the crack extends across the dam and the reservoir level is less than 10 feet below the base of the crack, both the upstream and downstream sides of the dam should be protected with a plug and inverted filter (as noted above under seepage) and the Emergency Services and Disaster Agency should be notified of the situation so they may be prepared to act if the condition worsens.

BURROW HOLES

Holes in the embankment, varying in size from about 1 inch to 1 foot in diameter, caused by animals.

If the holes do not extend through the embankment the situation is usually not serious. Some animal holes will have soil pushed out around the hole in a circular fashion which may look like a boil (crayfish or crawdad). Watch for the movement of water and soil particles from these holes to determine whether they are boils.

Backfill as deeply as possible with impervious material. If rodents become a nuisance, an effective rodent control program, as approved by the Illinois Department of Natural Resources District Wildlife Biologist, should be implemented.

RESPONSIBILITIES

[This section should clearly specify responsibilities that are specific to this dam. General guidance for the positions noted for the City of Wherever are included but should be revised as appropriate for the dam and owner.]

PREPAREDNESS

Visual inspections of the dam and its appurtenances will be made on a routine basis per the schedule noted below. Items that will be monitored are those noted for the operation and maintenance inspection and are noted here again. The O&M inspection checklist should be completed for each inspection.

Inspection Items: During each inspection the following items should be noted in particular:

(1) Water Level - A staff gage which can be easily seen when the reservoir is full should be installed or painted on the drop inlet.

Maximum reservoir levels as a result of heavy rainfall should be recorded.

(2) Earth Embankment - Walk the crest, abutments, groins, side slopes, downstream toe and upstream toe or at the waterline of the dam concentrating on surface erosion, seepage, cracks, settlements, slumps, slides, and animal burrows. These are described as follows:

Surface Erosion - Removal of vegetative cover by water action or pedestrian or vehicle usage forming deep ruts or gullies.

Seepage - The passage of water through and/or underneath the earth embankment abutment and natural groundline or at the contact between the embankment and outlet works can be indicated by cattails or other wet environmental vegetation, erosion channelization, or slumping on the embankment face.

Cracks - Deep cracks usually indicate the movement of the dam and/or the foundation and can be in either the longitudinal (along the length of the dam) or transverse (across the dam) directions. Cracking can be an indicator of the beginning of slumps. Shallow cracks may develop during the summer when the surface soils of the embankment become severely dried and are usually of no concern in regard to the safety of the dam.

Settlement - Settlement is indicated by depressions or low spots and can be signs of consolidation of the dam or foundation or the loss of material beneath the settlement area.

Slumps/Slides - Slow or sudden movements of the earth embankment slope on either face toward the toe of the dam.

> If seepage indicates the presence of soil particles, or if deep cracks, settlement, slumps, or slides are noticed, a qualified engineer should be contacted immediately for consultation.

Animal Burrows - Animal burrows result in a loss of earth embankment material and can provide seepage paths for water through the embankment.

(3) Vegetation - Grass should be a thick vigorous growth to stabilize embankment soils and prevent erosion from occurring. Note the height of the grass, if greater than 1 foot, a mowing of the area should be scheduled before the next inspection. There should be NO trees on the earth embankment and NONE within a minimum of 20 feet of the embankment toes or concrete structures. There should be NO trees in the emergency spillway.

(4) Trash Racks - Check to make sure that the trash racks are unobstructed, operating well and allowing for the free flow of water.

(5) Drop Inlet Spillway - Check for any debris or other obstructions around the inlet crest and at the bottom of the drop inlet which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete and seepage, cracking, breaking, or spalling of the concrete. Check the vent pipes for overall condition and alignment and to ensure that the pipes are clear and unobstructed. (Do not place your hand or any tool near the inlet of the vent pipe if flows are passing over the crest of the auxiliary spillway as suction through the vent pipe may be occurring.)

(6) Outlet Works - Check for any debris or other obstructions within the impact basin which may block or restrict the free flow of water. Check for the development of any rusty areas on the concrete and seepage, cracking, breaking, or spalling of the concrete. Check to make sure weepholes are clear and operating properly. Check for any erosion occurring at the embankment/structure junction.

(7) Concrete Block and Rip Rap - Check to make sure that the blocks and rip rap are remaining in a uniform position. Freeze/thaw action or flow over the blocks or rip rap may tend to lift or fracture them, thus requiring replacement or leveling to maintain the necessary level of protection. NO trees or woody vegetation should be growing through the blocks or rip rap.

(8) Mechanical Equipment - Check for any debris or other obstructions around the dewatering gate which may block or restrict the free flow of water. Operate the gate from the fully closed to the fully open position taking note of the physical and operating conditions of the system. Lubricate the stem, stem guides, wedges and hoisting mechanism a minimum of two (2) times a year. NOTE: Except in emergencies, the drawdown of water using the dewatering gate should be limited to 0.5 foot per day to minimize upstream slope stability problems. (Refer to Appendix D for operation and maintenance of the sluice gate.)

(9) Fences - Check for damage, accumulated debris, operation of gates and locks, and adequacy of locations (this may change with time as people access the area or development occurs in the area).

(10) Drains - The change in location or amount of flows discharging from the toe drain should be recorded. If a significant change has occurred, a qualified engineer should be contacted for consultation.

(11) Emergency Spillway - Check for settlement or cracking of the crest control wall. Check for any logs, tree or brush growth, and other debris in the spillway, upstream and downstream areas which may restrict the flow of water.

(12) Downstream Floodplain - Check the floodplain downstream of the dam for a distance of at least 100 feet for signs of seepage or boils.

Areas downstream of the dam may experience flooding due to local runoff at times when the reservoir water level is low. However, high reservoir levels are an indicator of potential downstream flooding and are used in this plan to provide steps for various actions to be taken. The following schedule of inspections and evacuation procedures will be followed:

(1) Normal Conditions Surveillance

Under normal water level elevations (up to elevation 732.0) the embankment and appurtenant structures will be observed by the dam operator on a monthly basis.

(2) "Unusual" Storm Conditions

During and immediately following unusual storm and flood events (reservoir level equal to or greater than elevation 732.0) the dam operator will make visual inspections of the dam and its appurtenances at a minimum of every hour if it is currently raining and every 12 hours if it is not raining. Flooding in some areas downstream of the dam may occur for heavy rainfall events occurring in a short period of time. As reservoir levels increase above this elevation larger areas of flooding downstream of the dam may occur.

The dam operator is responsible to notify the Emergency Services and Disaster Agency (ESDA) in Wherever when the reservoir levels exceed elevation 732.0. The ESDA office will be responsible for notifying individuals and coordinating their evacuation and return in the event an emergency occurs.

If the reservoir level reaches elevation 734.0, the dam and appurtenances will be inspected at 1-hour intervals if it is currently raining and at 8-hour intervals if it is not raining.

If the reservoir level reaches elevation 735.5 and it is currently raining, the dam operator is responsible to notify ESDA. The dam and appurtenances will be inspected continuously if it is currently raining and at 4-hour intervals when the rain has stopped.

If the reservoir level reaches elevation 736.0 and it is currently raining, the dam operator is responsible to notify ESDA. The dam and appurtenances will be inspected continuously until the reservoir level falls to elevation 735.0 and the rain has stopped.

When the reservoir level reaches elevation 736.5 and it is currently raining, the dam operator is responsible to notify ESDA to evacuate all residents within the dam breach wave area (see Plates 1-5). The dam and appurtenances will be inspected continuously until the reservoir level falls to elevation 735.0 and the rain has stopped.

ESDA will not allow residents to return to the flood wave area until: 1) the lake level is below elevation 735.0, 2) the dam and appurtenances have been inspected by an engineer to determine if damage has occurred, and 3) all damages indicating a weakened condition of the dam have been remedied.

If there is no inflow to the reservoir the estimated time for the reservoir level to drop from the crest of the emergency spillway

(735.5) to the crest of the drop inlet (733.5) is 4.5 hours. With no inflow, the estimated time for the reservoir level to drop from the crest of the drop inlet (733.5) to the flow line of the low flow pipe (714.0) is 20 hours. If the low flow pipe or drop inlet are not allowing the reservoir level to drop due to debris accumulation or damage, the dewatering gate should be opened or portable pumps should be used to lower the reservoir level. The lower reservoir level will allow for the removal of debris, the repair of damage, and the re-establishment of storage in the reservoir.

EQUIPMENT AND MATERIALS LOCATIONS

The following equipment and materials are available at these sites:

Backhoe
Location, Contact Person, Tel. No.

Dump Truck
Location, Contact Person, Tel. No.

Grader
Location, Contact Person, Tel. No.

Crawler Tractor
Location, Contact Person, Tel. No.

Sand Bags
Location, Contact Person, Tel. No.

Sand
Location, Contact Person, Tel. No.

Gravel
Location, Contact Person, Tel. No.

Riprap
Location, Contact Person, Tel. No.

Pumps
Location, Contact Person, Tel. No.

PLATES

(Specific plates or figures appropriate for the dam should be included here.)