NATURAL RESOURCES CONSERVATION SERVICE WATERSHED REHABILITATION IN OKLAHOMA A GEOLOGICAL PERSPECTIVE

Glen B. Miller, Geologist, Natural Resources Conservation Service, 100 USDA, Suite 206, Stillwater, Oklahoma 74074, Glen.Miller@ok.usda.gov

Abstract: As floodwater control structures begin to approach the end of their functional life, Natural Resources Conservation Service (NRCS) must determine the best course of action to be taken to prevent potential damage to downstream facilities, such as mobile homes, church camps, and suburban residential areas, many of which have been built during the past few decades and since construction of the dams. NRCS continues to work with local communities to identify and rehabilitate dams that could become a threat to public health and safety. Rehabilitation will not only ensure that these flood control dams remain safe, but that they will continue to provide flood control, recreation and wildlife habitat for the next 50 to 100 years. It is the responsibility of the NRCS geologist in Oklahoma to provide the geological expertise to help ensure that these structures have adequate storage, foundations and appurtenances to function properly for the life of the structure.

Some geologic considerations that must be taken into account are:

1. Soluble geologic materials within the embankment, such as gypsum or anhydrite, which may contribute to dissolution and lead to seepage and/or structural failure.
2. Soils within secured easement areas adjacent to the existing structure or within the existing sediment pool must provide suitable borrow material and occur in adequate quantity for modification of the dam.
3. In cases where the auxiliary spillway must be widened to accommodate new discharge volumes, materials occurring there must be properly characterized to allow for a proper design.
4. Materials in the existing embankment foundation must be competent to withstand increased volumes of water should the dam height be raised to increase storage.
5. In cases where decommissioning is a viable option, effects on downstream facilities must be taken into consideration.
6. Dispersive and low plasticity soils and geologic materials, highly faulted geologic formations within the area, and karst features are just some of the geologic hazards that might have a significant impact on planning, design, and construction of dams.

A team of planning engineers, design and project engineers, surveyors, local field office and conservation district personnel must provide suitable alternatives for modification of these structures. As all parties work together, it is possible to achieve the desired effect: a safe and functional dam that will serve the local community for years to come.

INTRODUCTION

Background: The USDA Natural Resources Conservation Service (NRCS) has provided technical and financial assistance to local sponsors for the development of water resources projects since the 1940s. This assistance has been provided primarily through four programs: the

Flood Control Act of 1944 (P.L. 78-534), the Watershed Protection and Flood Prevention Act of 1954 (P.L. 83-566), the Pilot Watershed Program (transitional between P.L. 78-534 and P.L. 83-566) and the Resource Conservation and Development (RC&D) Program.

Watershed projects, which are organized and operated by local sponsors, provide flood control, municipal and irrigation water supply, recreation, erosion control, and wildlife habitat enhancement on more than 130 million acres nationwide.

Congress passed the Watershed Rehabilitation Amendments of 2000, authorizing NRCS to provide technical and financial assistance to watershed project sponsors in rehabilitating their aging dams. The purpose of rehabilitation is to extend the service life of the dams and bring them into compliance with applicable safety and performance standards or to decommission the dams so they no longer pose a threat to life and property.

DAM REHABILITATION TODAY

Needed Rehabilitation: Today, many project areas are in a far different setting than when they were originally constructed. Population has grown, residential and commercial development has occurred upstream and downstream from the dams, land use changes have taken place, sediment pools have filled with sediment, structural components have deteriorated, and many structures do not meet state dam safety regulations that have become more stringent through time.

Many of these dams lie in upstream agricultural areas and are unknown to the residents who are protected by them. Many are quietly deteriorating as time and weathering take their toll on the components. Unless something is done to rehabilitate these dams or, in some cases, to remove them, they pose a public safety concern.

As shown in Figure 1, 132 dams in Oklahoma (2005) were at or beyond design life. By the year 2015, 1090 dams in Oklahoma alone will be at or beyond design life. As of 1999, 2245 dams within 22 states were in need of rehabilitation. Many of these dams were designed to protect agricultural areas in downstream floodplains. In numerous communities, homes and businesses eventually were built downstream from the dams.

Nationally, two-thirds of the small flood control dams constructed to date are more than 30 years old. Many of the dams can function beyond the original design life with continued maintenance and rehabilitation.

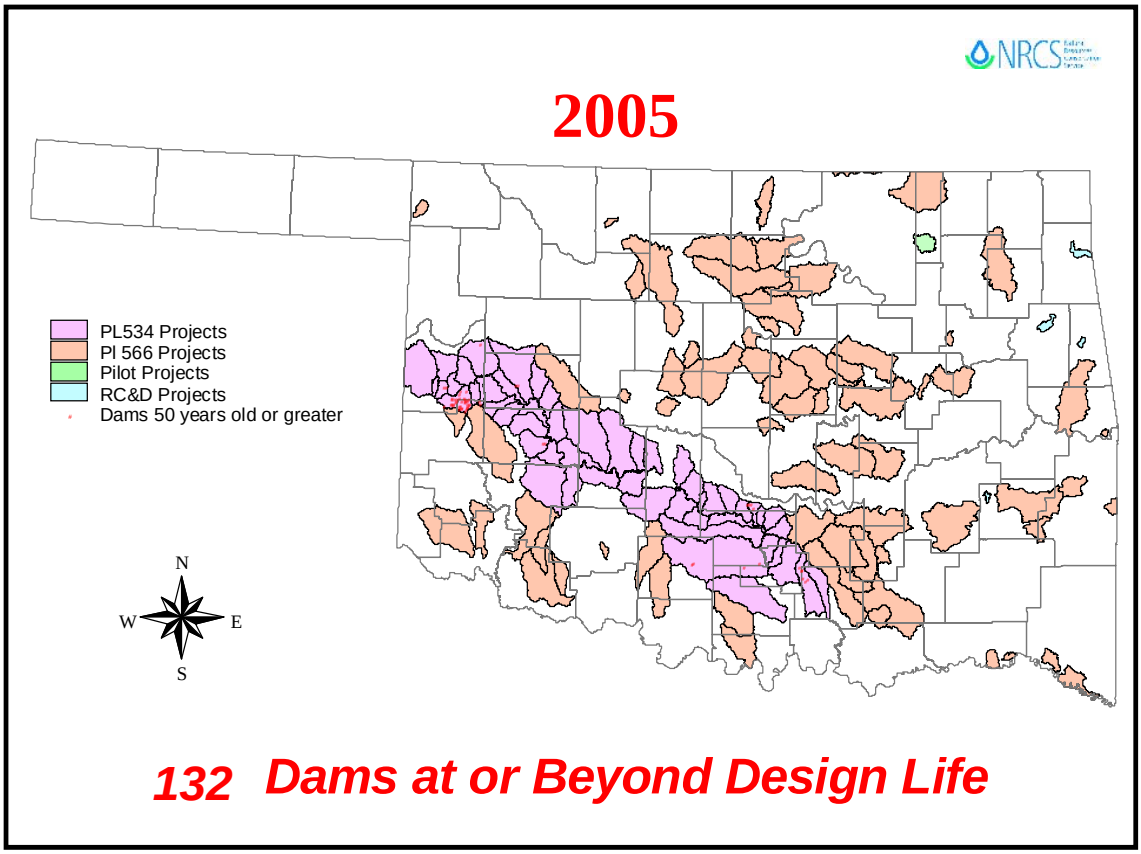

Figure 1 Status of dams needing rehabilitation in Oklahoma.

Common Rehabilitation Approaches: There are many approaches to rehabilitation of flood control dams. Any alternative considered and the final selected approach must be determined on the economic, environmental, and social merits of the site-specific project; there is no single solution for rehabilitation of all flood control dams. Common approaches to consider include the following:

- Remove sediment from the reservoir: Removing the sediment from the reservoir and disposing of it at an environmentally safe location can extend the life of a flood control dam. The sediment must be tested for potential contaminants, such as pesticides, oil field waste, and other toxins.

- Increase the height of the dam: Raising the embankment to provide additional storage for future sediment accumulation can extend the life of the dam and accommodate other resource needs.

- Remove the dam (decommissioning): In some projects, removal of the dam in an environmentally safe manner is an option. Obvious challenges include providing adequate grade control in the drainage way if significant sediment has been deposited in

the reservoir. Social, economic, and legal ramifications of the loss of downstream flood control must be evaluated.

- Increase the capacity of or replace the principal spillway: This approach would address greater amounts of runoff from the watershed above the dam due to residential and/or commercial development, or provide higher capacity discharge due to changed safety or design criteria. As above, social, economic, and legal ramifications of the increased flows downstream must be evaluated.

THE GEOLOGIST AND REHABILITATION

The geologist's role: The geologic investigation is crucial in determining alternatives for consideration in design of the dams targeted for rehabilitation. It forms the basis for the decisions that will be made, including soil mechanics analysis, design, construction, and operation and maintenance. The investigative procedures rely on the use of sound geomorphic, geologic, and investigative principles. With experience and conscientious effort, the geologist should be able to eliminate major surprises that can adversely affect the life and safety of the dam.

The objectives of geologic investigations are: 1) to determine and describe for other technical disciplines the geologic conditions at the specific site to be rehabilitated; 2) to interpret how these conditions will impact the design, construction, and operation of the structure; and 3) to provide representative field tests and collect samples for laboratory analysis (Fig. 2).

Figure 2 Collecting Split Tube Soil Samples, Oklahoma.

Geologic Site Considerations: Several geologic hazards or precautions have been noted within the state of Oklahoma as experience is gained through rehabilitation efforts state-wide. A few examples are provided:

- Soluble geologic materials within the embankment, pool areas, or other areas within the vicinity of the dam may cause concern. With time and continued seepage of water into the subsurface materials, gypsum or anhydrite is dissolved, and cavities or sinks form, providing avenues for water to seep through or under the embankment and eventually cause damage to the dam (Fig. 3).

- An adequate supply of usable soils must be located from within the borrow areas upstream and downstream of the dam, and quantified for use in the foundation, embankment, and auxiliary spillways. In Oklahoma, the existence of highly dispersive soils within formations of the Pennsylvanian and Permian bedrock materials and associated residual soils forming from these strata is a particular problem. It is, therefore, especially important to isolate, so far as possible, where these soils are located and in what quantity so they may be properly treated and placed in low risk zones within the embankment.

- In cases where the auxiliary spillway must be widened to accommodate potentially higher discharge velocities and volumes, materials occurring there must be properly characterized to allow for a proper design. The rock material properties are determined from examination of hand specimens, core sections, drill cuttings, outcrops, and disturbed samples.

- Many times, the existing dam must be replaced with properly compacted soil material in order to withstand increased volumes of water due to increased dam heights or greatly widened auxiliary spillways. More stringent engineering requirements due to hazard classification changes have been necessitated due to urban buildup downstream and within the watershed of many of these dams.

Figure 3 Sink Hole in Drained Sediment Pool, SW Oklahoma.

- Channel flow characteristics, changes in grade of the channel, and differing bed load will all be affected when the embankment is removed, and these impacts must also be carefully considered.

- Other considerations that may have a significant impact on planning, design, construction, and maintenance of the new dam are low plasticity soils, high shrink-swell soils (Fig. 4) and faulted geologic formations.

Figure 4 Desiccation Cracks in High Shrink-Swell Soils

CONCLUSIONS

Ultimately, it is incumbent upon the geologist to ensure that a professional geologic investigation is conducted and that the best, most cost effective tools available through training, experience and sound judgment are utilized. The geologist has the responsibility to gather not only the best tools available, but also to draw from the experience and judgment of engineers, water resource planners, contractors, local conservation district employees and NRCS field office personnel. Working as a team, these professionals are well equipped to provide a safe, economical, and socially acceptable dam that can serve the local community for years to come.

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