

## **USACE RESERVOIR SEDIMENTATION: DATA, ASSESSMENT, AND GUIDANCE**

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**Abstract** Within the United States, the Corps of Engineers (COE) maintains 609 dams of which 383 of those dams and reservoirs are maintained and operated for flood damage reduction. Thousands of other lakes are operated and maintained by various Federal, State, and local entities. In the course of normal operations, reservoirs trap sediment and eventually fill. Vanoni (1975) describes the impact of constructing a dam to form a reservoir as follows: “the velocity of the flow entering the pool thus formed will be reduced, or essentially eliminated, and the major part, or all, of the sediment transported into the reach will be deposited in the reach of backwater influence and in the reservoir.” This sediment deposition reduces the useful life of the reservoir and can severely impact authorized project purposes. Significant problems may occur when even a small percentage of volume is lost to sediment: these include sediment blockage of water intakes and recreational facilities. The impacts of reservoir sedimentation can extend considerable distances upstream and downstream, influencing channel morphology, stability, and ecological health. This underscores the need to develop ways to effectively manage sediments from a systems perspective while also seeking to extend the effective and economic lives of reservoir projects. The age of Corps reservoirs, with many projects past the mid-point of their design lives, increases the likelihood of significant sediment depletion and sediment-related impacts. The evaluation of the impacts of sedimentation on authorized purposes of Corps reservoirs has been identified as a critical need.

Research and development work has been initiated by the USACE Engineer Research and Development Center (ERDC) Coastal and Hydraulics Laboratory (CHL) under the Flood and Coastal Storm Damage Reduction Program that includes assessing the extent of reservoir sedimentation problems within the Corps; developing a standard database of reservoir sedimentation pertinent information integrated with other relevant databases; developing and demonstrating assessment methodologies for Corps reservoirs; and providing the technical basis for updating obsolete guidance related to the evaluation of sedimentation in reservoirs. An accurate understanding of the severity of existing problems in Corps reservoirs, along with improved assessment methods for ongoing data collection and analysis, will improve the Corps’ ability to manage reservoir projects. This work is being conducted in close collaboration with the USACE Committee on Channel Stabilization.

### **IDENTIFICATION OF CRITICAL ISSUES**

Key issues were identified by the Corps expert Committee on Channel Stabilization, in conjunction with the Corps Engineering Research and Development Center (ERDC). The following three issues were identified as the most critical:

1. Data needs and requirements
2. Need to complete and update guidance
3. Sedimentation impacts on project functionality, and management of reservoir sediments.

These are discussed briefly in the following paragraphs.

**Data Needs and Requirements** A complete, high-quality data base is necessary to evaluate and address the impacts of sedimentation on the authorized purposes of Corps reservoirs, which include flood control, hydropower, navigation, recreation, water supply, irrigation, fish and wildlife, and water quality. Existing data on reservoir sedimentation varies in both quality and quantity across the Corps, and is not currently available in any format that would facilitate management evaluation or decision-making. Without a relevant, quality database, it is not possible to evaluate the current project status of all Corps reservoirs or to project future sustainability. Also, the existing data has been obtained on a project-by-project basis without regard to the regional/basin/system perspective. Historic data has been collected based on the state-of-the-art at the time the projects were planned, designed, and built. Advances in technology have made it more practical to gather, store, share and process data in a global environment. A database of sedimentation information for Corps reservoirs would improve the ability to evaluate current sedimentation status, and manage for future needs.

**Need To Complete and Update Guidance** Existing guidance for the evaluation of sedimentation in reservoirs is not sufficient to either address the long-term sustainability of authorized project functions or to address the potential of reservoir sediment as a local or regional resource. Current guidance is technically obsolete in many areas and does not reflect revolutionary changes in survey techniques and other technical areas. Guidance is required to ensure that reservoir sedimentation investigations follow conventional standards of practice and address all operational and management issues. The absence of comprehensive guidance has two major impacts on the development of sediment management alternatives. First, this lack of guidance or out dated guidance undermines the importance of the monitoring process. Organizations tasked with operating these projects tend to ignore the issue, leading to a reactionary, instead of a proactive approach to problem solving. Secondly, survey and evaluation plans are not comprehensive, which often limits the utility of any data that may be collected.

**Sedimentation Impacts on Project Functionality, and Management of Reservoir Sediments** Reservoir sedimentation impacts project benefits and functionality. Sediment deposition affects the operation and maintenance aspects of reservoir projects, including posing physical and dam safety constraints and limiting flood damage reduction. Management of reservoir sediments can extend the useful life and enhance all authorized purposes. Sediment management can also provide the opportunity for environmental enhancement. Reservoir sediment management should include evaluation and potential treatment for sources in the watershed upstream, the reservoir shoreline, and the channel downstream of the reservoir. Evaluations should include both watershed assessments and evaluation of downstream reaches.

## **DATA NEEDS AND REQUIREMENTS**

Data acquisition is the first step in evaluating the extent of sedimentation impacts on Corps reservoirs. A web-based data call was issued to all Corps districts. Members of the Channel Stabilization Committee discussed the questions and responses by teleconference with each Corps Division to improve the consistency of results, and to provide background information on the reasons for the data call. Corps districts responded to questions on multiple items, including the following:

- percent of gross storage filled due to sedimentation
- dates of sediment surveys
- impacts to authorized purposes (flood control, water supply, navigation, etc.)
- sediment management practices, and obstacles to sediment management
- survey methods
- basin hydrology and land use.

## **RESULTS OF CORPS DATA CALL**

The results from the data call indicate that fewer than five percent of Corps reservoirs are known to have sedimentation that exceeds 25% of their gross pool storage. The majority of the reservoirs with more than 25% lost storage are in three districts: Huntington, Tulsa, and Albuquerque.

Districts were queried as to sedimentation impacts on reservoir operation for authorized purposes. The results are summarized below for each authorized purpose. The five categories of sedimentation impacts were “unrestricted” (no impact to a specific purpose), “moderately restricted” (sedimentation limits operation for a specific purpose up to 10% of the time), “significantly restricted” (operations are limited up to 25% of the time), “severely restricted” (operations are limited nearly all the time and can only be wholly met during favorable hydrologic conditions), and “incapacitated” (project can no longer be operated for a specific purpose). Almost all cases of restricted operation were reported as “moderately restricted,” that is, sedimentation limits operation up to 10% of the time.

Approximately three-quarters (76%) of Corps reservoirs report no restriction on flood control operations due to sedimentation. Eleven percent of Corps reservoirs (43 reservoirs) report moderate restrictions on flood control due to sedimentation impacts on flood control operations (sedimentation limits operation up to 10% of the time). The results from the data call indicate that only one Corps reservoir has flood control operations restricted by sedimentation more than 10% of the time. Beach City Lake (Huntington District) reported severe restrictions to flood control operation due to sedimentation (operations are limited nearly all of the time). Beach City Lake is also the only Corps reservoir reporting over 90% sediment depletion.

In response to the data call, 15% of Corps reservoirs (59 reservoirs) reported recreation use is restricted by sedimentation. Five districts contain the majority of impacted reservoirs: Omaha, Tulsa, Louisville, Baltimore, and St. Paul. The remaining impacted reservoirs are distributed over the nation. Recreation impacts are one of the most widely distributed impacts of reservoir sedimentation.

Approximately 10% of Corps reservoirs report operations for fisheries are restricted by sedimentation. The majority of impacted reservoirs are located in the Omaha District and the Tulsa District.

Less than 10% of Corps reservoirs were reported as having water supply operations restricted by sedimentation. The majority of the impacted reservoirs were located in the Tulsa District.

Six percent of Corps reservoirs reported water quality operations are restricted by sedimentation, with over half of the affected reservoirs located in the Tulsa District.

The results from the data call indicate that approximately 2% of Corps reservoirs report navigation operations are restricted by sedimentation. (Only one-third of Corps reservoirs have navigation as an authorized purpose.)

Only 2% of Corps reservoirs report hydropower operations are moderately restricted by sedimentation, with the remainder reporting unrestricted operation or that hydropower is not an authorized purpose.

One important observation is that moderate sedimentation impacts to flood control and other authorized purposes are seen before storage depletion of the reservoir reaches 25%. For every authorized purpose evaluated, 80% or more of the projects reporting moderate restriction of operations also reported storage depletion due to sedimentation of less than 25%.

The year of the last sedimentation survey was an important part of the data call. The percentages were reported as follows:

- 24% surveyed since 2000
- 25% last surveyed in 1995-1999 (10-14 years old)
- 30% last surveyed in the period 1980-1994 (15-29 years ago)
- 21% last surveyed prior to 1979 (thirty years or older). This category includes reservoirs with no known surveys.

There were a significant number of reservoirs where sediment surveys have not been considered necessary. (These reservoirs were not included in the percentages above.) These are projects where sedimentation rates appear to be low, and where sediment problems have not occurred and are not anticipated. One category of reservoirs where surveys are not considered necessary includes projects that are natural lakes, marshes and wetlands. Another category includes projects with a small conservation pool, where visual observations during low pool indicate no significant sediment deposition.

The numbers above give a preliminary view of the status of sedimentation surveys and sedimentation impacts for Corps reservoirs, and will be updated after more information is obtained.

## DATABASE DEVELOPMENT

A significant issue that emerged after the data call was the need for a permanent database to store information on sediment deposition rates and the status of Corps reservoirs from a sedimentation perspective. The Corps is partnering with USGS and other federal agencies to develop a national reservoir sedimentation database. The information on Corps reservoirs (obtained in the data call to Corps districts) will be combined with the federal interagency database (RESSSED) overseen by the Subcommittee on Sedimentation. The Corps is working with USGS on a national database structure that will meet the needs of the Corps while providing improved capabilities to the nation (Gray et al, 2010). The final product will provide web-based data input, error checking protocols, and data retrieval via reports and visualization tools. It is scheduled for completion in 2010.

## VISUALIZATION TOOLS

Data visualization tools are being developed by the Information Technology Laboratory (ITL) of USACE ERDC to assist in viewing and analyzing reservoir sedimentation data. Examples of data visualization are shown below in Figures 1 and 2.

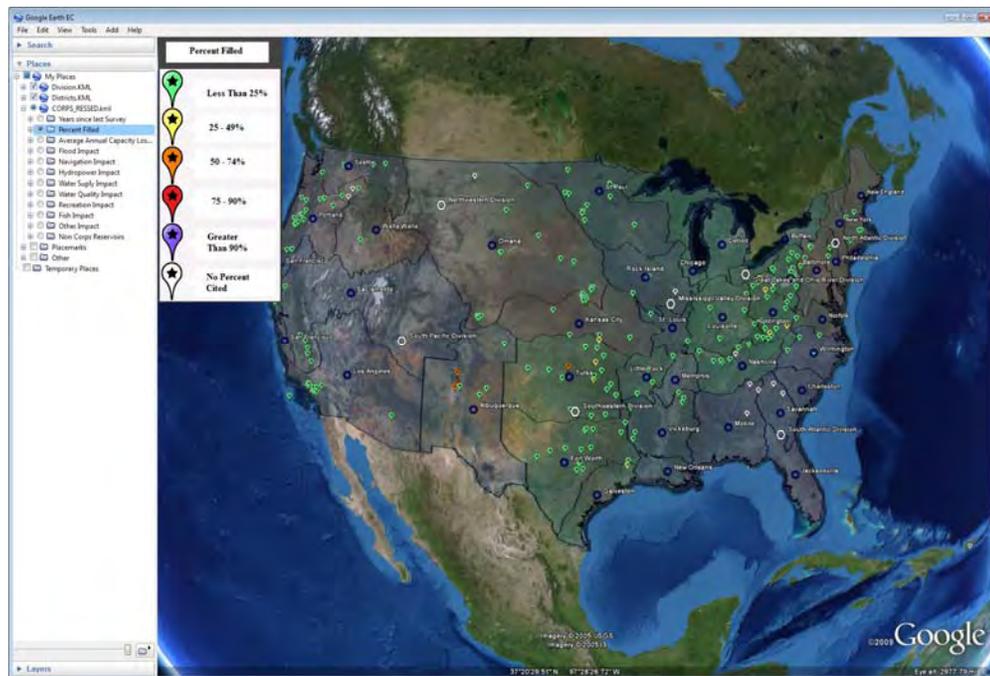


Figure 1 USACE Reservoirs – Percent Filled.

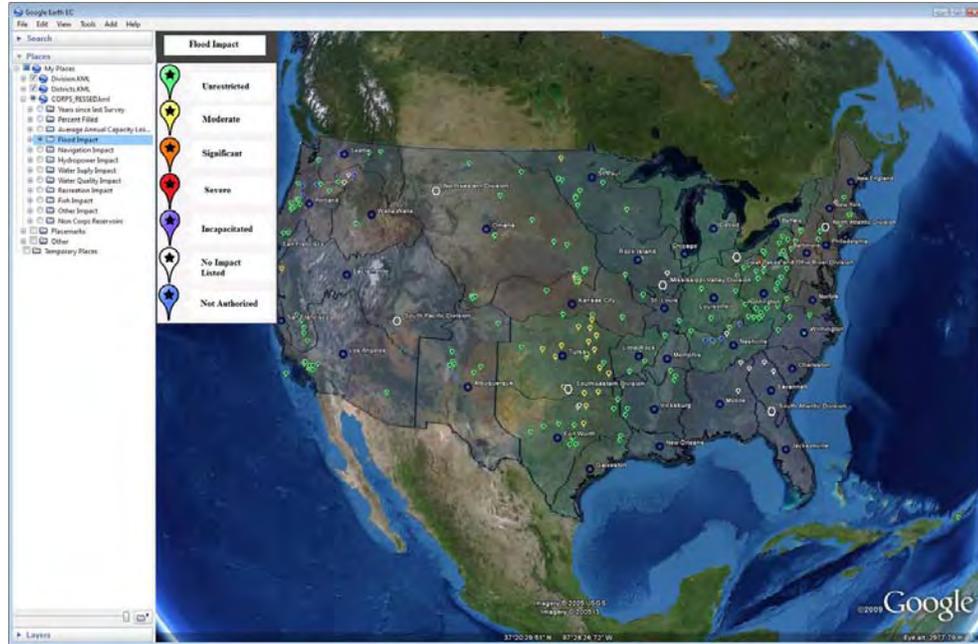


Figure 2 USACE Reservoirs – Flood Impact.

## CONCLUSIONS

The very nature of reservoirs results in the deposition of sediment. Over time, this deposition can adversely impact authorized project purposes. Currently, the sedimentation status of Corps reservoirs and the severity of sedimentation impacts on authorized reservoir purposes are not fully known. The Corps expert Committee on Channel Stabilization has identified the most critical issues associated with reservoir sedimentation: 1) data needs and requirements; 2) need to complete and update guidance, and 3) sediment impacts on project functionality. Research and development work has been initiated by the USACE ERDC under the Flood and Coastal Storm Damage Reduction Program to respond to these issues by evaluating the state of reservoir sedimentation data, the severity of existing problems in Corps reservoirs, along with improved assessment methods for ongoing data collection and analysis. The results of this work will provide a better understanding of reservoir sedimentation and provide a basis for maintaining the reservoirs as a viable resource for many years to come.

## REFERENCES

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