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On the Cover: Bluestone Dam, on the New River near Hinton, West Virginia.

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United States Society on Dams (USSD)

President's Message

This President's message is my last; it is hard to believe two years have passed by so quickly. Serving on the USSD Board of Directors for the last seven years has been one of the most rewarding experiences of my professional career. We've experienced much change in that time, only made possible by your efforts and commitment to the organization. There are many more exciting challenges and changes ahead of us, and I look forward to continuing my involvement in USSD to work with all of you to meet those challenges and navigate the changes ahead. Please note the items of interest below as you read through this Bulletin.

As part of our Collaborate Imperative, we continue to have strong ties with ICOLD and our fellow national committees. By now you have probably seen the registration information for the 2019 ICOLD Annual Meeting, which will take place June 8-14, in Ottawa, Canada. This offers a unique opportunity for USSD Members to participate in an ICOLD Annual Meeting right next door. As a very close partner, The Canadian Dam Association (CDA) has been very supportive of USSD, and we want to extend our appreciation for that by attending the annual meeting in Ottawa and participating in the many ICOLD committee meetings, technical sessions and social activities they have planned. In addition to the ICOLD Annual Meeting, please also look for more information on the next Dam Safety in the Americas International Workshop, to be held in Paraguay, October 29-31, 2019. This meeting is organized by the ICOLD National Committee of the Americas, of which we are members through our ICOLD membership. Some of you may be aware that we have signed MOUs in recent years with national committees from China, Canada, and South Korea. For more information, see the ICOLD update section of this Bulletin; Past President John Wolfhope provides an update on work we are doing in connection with our MOU with KNCOLD, and there is a short article on a visit to Denver by a Chinese delegation as part of our MOU with CHINCOLD.

Every year our most significant effort on the Educate Imperative is our annual meeting and conference. As I write this, final preparations are being made for the 2019 Conference and Exhibition in Chicago. Work has already begun on the 2020 Conference in Denver. Elena Sossenkina, HDR, is serving as Technical Program Chair, and Conrad Ginther, Black & Veatch, will serve as Vice Chair. They, along with others on their committee, are working on the Call for Papers, with a goal of issuing it in mid-May. I hope you'll plan to submit an abstract and attend the conference.

Please also see the article submitted by Amanda Adams in the Committee Corner section of the Bulletin (page 12). As Chair of the USSD Committee on Tailings Dams, Amanda provides an update on committee activities and initiatives during the past year. Considering the recent tailings dam failures in Brazil and Canada, it is nice to see USSD so active in the area of dam safety for tailings dams.

As part of our Advocate Imperative, Executive Director Sharon Powers, Vice President Denise Bunte-Bisnett, and I will be attending the ASCE Legislative Fly-In March 12 and 13 in Washington, DC . This intensive two-day program provides participants with an inside look at the public policy process. We will attend legislative briefing sessions and visit many Congressional offices on the Hill, advocating for issues important to water resources, and the dam and levee industry. This is an outstanding networking opportunity and we hope to bring many ideas back to the organization for future action.

Thanks again to all of you for giving me the wonderful opportunity to serve on the USSD Board of Directors. It has been an honor to represent the organization in this way and I look forward to continued involvement long into the future.

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Call for Papers will be issued in mid-May.

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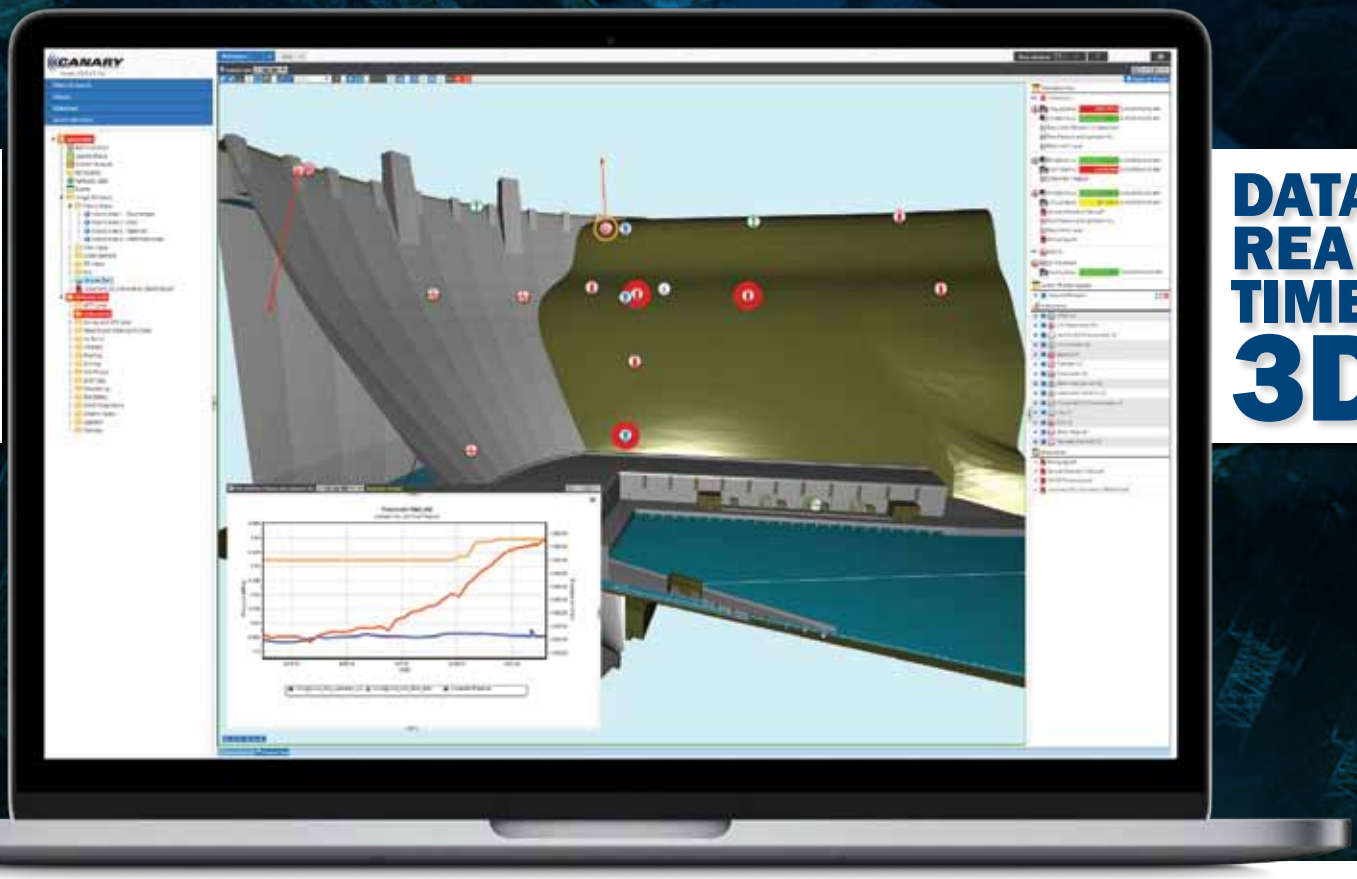

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Washington, DC, May 14-15, 2019

FEMA to Offer Workshop on DSS-WISE Lite Tool

The Federal Emergency Management Agency is offering a workshop on the **FEMA National Dam Safety Program: Rapid Dam Break, Flood and Consequence Assessment: Preparedness, Response, Recovery and Mitigation Risk Assessments.** The workshop will be held May 14-15 at the FEMA Conference Center in Washington, DC, and is being conducted with the assistance of USSD.

The workshop will focus on the FEMA's DSS-WISE Lite tool, which provides a cost-effective means of improving public awareness and safety.

Workshop Goals

Upon completion of this course, participants will understand the DSS-WISE Lite toolset and its use in dam safety preparedness, mitigation, flood response, and post-disaster planning to reduce flood losses and increase public safety.

Specifically, participants will:

- Understand the concepts associated with dam risk and consequence assessment.
- Understand the application of DSS-WISE Lite to rapid assessment of dam safety.
- Understand the data preparation needed prior to using the toolset.
- Run a successful DSS-WISE Lite dam breach model and review model results.
- Introduce the concept of flood hazard classes and lethal flood zones for evacuation planning.
- Determine the population at risk downstream of dams.
- Applications of how rapid assessment is applied by local communities as part of their emergency management and dam safety program to reduce or manage flood risk. Case studies will include California, Puerto Rico, South Carolina and other communities.

Who Should Attend

This workshop is intended for state dam safety and emergency management agency staff, community officials, emergency managers, dam safety professionals, FEMA HQ staff, FEMA insurance actuaries and FEMA contractors.

Attendees must have some basic computer skills and bring a laptop computer to the workshop. No specialized software is required.

1.6 CEUs from Colorado State University and 16 PDHs will be offered.

2018 National Inventory of Dams Available

The 2018 National Inventory of Dams has been released by the U.S. Army Corps of Engineers. All charts, queries and maps reflect the most current NID database. The NID was populated using the 116th Congressional District information. State and federal dam regulators provided their data from May to November 2018 for inclusion in the 2018 database. Inspection and EAP dates reflect 2018 data, so any inspections or updates since then will not be reflected in the current NID. Please contact the respective state or federal regulatory authority for the most up-to-date information.

Major changes to the 2018 NID allow users to download or export certain NID data and to view the hazard potential classification. State or federal agencies may restrict access to information on dams within their jurisdiction. For information not published in the NID, USACE recommends consulting the agency exercising responsibility over the dam. Also, it is important to note the hazard potential classification, as published in the NID, does not reflect the condition of a dam. That information can be found in the condition assessment, which is available to approved government users.

http://nid.usace.army.mil.

FEATURE

Aaron O. Smith, Senior Project Manager, U.S. Amy Corps of Engineers, Huntington District, Huntington, West Virginia (aaron.smith@usace.army.mil)

Dam Safety Assurance Project Update: Bluestone Dam

Introduction

Bluestone Lake, which is created by Bluestone Dam, is a flood risk management reservoir on the New River near City of Hinton, Summers County, West Virginia. Bluestone Dam is a federally owned flood risk management project, operated and maintained by the U.S. Army Corps of Engineers, Great Lakes & Ohio River Division, Huntington District. It is within the New River Basin, which is a sub-basin of the Kanawha River Basin. The dam is located approximately one and a half miles upstream of the City of Hinton and a half mile upstream of the confluence of the New and Greenbrier Rivers. The project began operation in 1949.

Bluestone Dam helps control a 4,600-square-mile drainage basin. The dam helps to reduce flood risks along the New, Kanawha and Ohio River Basins. These are the largest interior river valleys in the state of West Virginia and encompass the state capitol of Charleston, major manufacturing and chemical industries, and approximately 165,000 population at risk. Figure 1 provides the map of Bluestone Dam's geographic location, the watershed, rivers, other basin reservoirs and key cities and towns.

Bluestone Reservoir is a part of a comprehensive reservoir system for flood control on the mainstem of the Ohio River and its tributaries. It was implemented through multiple authorizations for flood control, low flow augmentation, hydropower development, recreation, and fish and wildlife conservation.

Flood risk management benefits (damages prevented) accruing from when the project began operation through fiscal year 2015 are estimated at over $2 billion in real

Figure 1. Bluestone Dam and its drainage basin.

dollars (over $5 billion indexed to FY15 dollars). Those historic damages prevented from 1949 to 2015 were brought to FY 2015 price level and averaged to yield an annual benefit of $87 million. It is expected the dam will continue to provide a similar amount of annual flood risk management benefits. The flood risk management benefits are realized in the communities of Hinton, Gauley Bridge, Montgomery, Kanawha City, Charleston, South Charleston, St. Albans, Nitro, Winfield, Point Pleasant, and many communities along the Ohio River downstream from its confluence with the Kanawha River. Many within these

communities have limited ability to recover from flood events. These communities have a higher social vulnerability than other communities. Due to the flood risk management benefits the dam still provides today (protection of lives and property) continuation of existing project purposes are warranted.

Bluestone Dam began construction in 1942 and was completed in 1948. There was an approximate two-year period of time (March 1, 1944 to January 2, 1946) where dam construction was suspended due to higher Federal priorities (World War II). Operation of Bluestone Dam began in July 1949, and minimum pool was attained in August 1949. The crest gates were installed in 1950. The original construction project was 100% federally funded in the amount of $29.5 million (1949 price level).

The dam is a straight, concrete gravity structure with a maximum height of 165 feet above the stream channel (Figure 2). The length of the dam is 2,048 feet at EL 1,535 ft and is made up of 55 independent monoliths comprising the right and left abutments, a non-overflow section, and a penstock section originally intended for hydropower (recently modified to become an auxiliary spillway), an assembly bay, and a primary spillway.

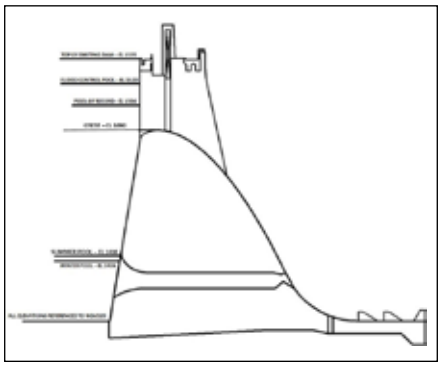

Figure 2. Section of Bluestone Dam showing key elevations.

Project Hydraulics

As originally envisioned, Bluestone Dam was to hold a permanent normal pool to EL 1,490 ft for hydropower generation with 30 feet of flood storage capacity (approximately 1 inch of runoff over the 4,600 square miles above the project) up to EL 1,520 ft. However, because hydropower was not implemented, this normal pool was reduced to EL 1,410 ft in the summer and EL 1,406 ft in the winter, giving the dam between 110-114 feet of flood storage capacity (approximately 2.43 and 2.47 inches of runoff over the 4,600 square miles above the project) and it has operated as such since (Figure 2).

Between the months of April and November, summer pool is maintained at EL 1410 ft to facilitate recreation on the lake when the project is not storing or releasing flood waters. Between the months of December and March, the pool is lowered to a winter pool at EL 1,406 ft to increase flood storage. During this scheduled drawdown, the surface area available for recreation on the lake is reduced. Within this operation, outflows are restricted to a minimum flow of 610 cubic feet per second, a maximum without directive (from the District's Water Management Team) being 45,000 cfs, and a maximum with directive of 90,000 cfs.

The project's discharge capacity is accomplished through 16 double-gated sluices, as well as 21 crest gates in the primary spillway and six gated penstocks of the auxiliary spillway (Figure 3). The six, 18-foot diameter penstocks were installed as part of the original construction for hydropower generation but this was never implemented. Bulkheads were originally installed near the intake side but these have been removed and replaced with gates at the downstream outlet. These gates are hinged at the bottom and are intended to be opened under reservoir load but cannot be closed until the reservoir recedes to a level at or below the intake invert. This work was completed in order to supplement discharge as an auxiliary spillway. The discharge capacity of the penstocks is 150,000 cfs with the reservoir at the top of dam (EL 1,535 ft). Normal operation of the reservoir is achieved through 16 double-gated sluices with a maximum total discharge capacity of 72,000 cfs (at pool EL 1,517 ft with no spillway crest gate flow). The original design discharge capacity of the dam is 430,000 cubic feet per second which is the same as the original estimated peak inflow.

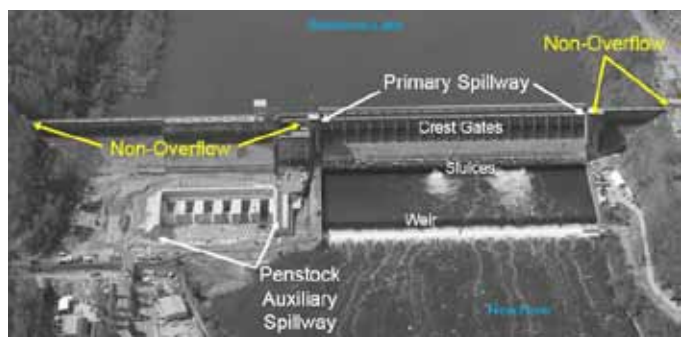

Figure 3. Oblique view of Bluestone Dam, looking upstream at key features.

Dam Safety Assurance Project

The performance of Bluestone Dam was evaluated in the mid-1990s under the Bluestone Dam Safety Assurance (DSA) Study. Since the dam was originally designed and built, advances in hydrology, rock mechanics and stability analyses of concrete gravity structures concluded the dam was hydrologically deficient and had stability issues. Specifically, it was determined that Bluestone Dam needed to pass more than double the expected outflow and the underlying orthoquartizite bedrock had interbedded layers of shale that could cause the foundation and overlying dam monoliths to slide when resisting storm waters. The DSA study recommended a plan to address these issues and was approved. The major features of the DSA have consisted of

the following:

- ~496 high-capacity, multi-strand directionally drilled anchors through the bedrock;
- Mass concrete thrust blocks against the downstream face of the dam;
- Convert existing six penstocks into an auxiliary spillway;
- Additional gravity monolith on the east abutment.

The DSA project was divided into five phases, as shown in Table 1 and Figure 4. Also, prior to the initiation of Phase 2B, a test anchor program was conducted where four stabilizing production anchors were installed in the dam.

Figure 5 highlights the work accomplished under Phases 2A, 2B and 3 to add a thrust block and convert the existing penstocks into an auxiliary spillway. Figure 6 highlights the directional drilling and steel multi-strand anchor program at Bluestone.

DSA Project	Construction Activities	Construction Contract Cost*	Construction Period
Phase 1	Construction of mass concrete thrust blocks downstream side of monoliths 15-21, extension of six penstocks, and three of the six penstock gates were installed.	~ $20M	Sep 2000 – Nov 2004
Phase 2A	Upgraded the access roadway to the stilling basin, installation of a new fishing pier, construction of a gravity wall (right abutment), relocation of primary power and telephone lines.	~ $7.5M	May 2004 - Dec 2007
Phase 2B	Installation of 216 high capacity anchors in critical monoliths, installation of gates on the three remaining penstocks, cleaning of existing drains, and installation of 32 gallery drains in the spillway area along with 16 uplift cells.	~ $60M	May 2005 - Nov 2011
Phase 3	Installation of a scour pad stilling basin downstream of the penstock extension, construction of two training walls adjacent to each side of the scour pad, and addition of five divider walls and two partial divider walls (designed to separate flow from penstock discharge), and the incorporation of a transition section and baffle blocks with an end sill into the scour pad.	~ $75M	Sep 2010 - Feb 2017
Phase 4	Installation of approximately 278 high capacity steel strand anchors in the spillway and non-overflow monoliths.	~ $95M	Under Construction (Sep 2012 - Expected completion Oct 2019)

*These are real (unindexed) contract cost to include any issued modifications and/or options.

Table 1. Summary of Bluestone Dam Safety Assurance Construction Phases and Activities.

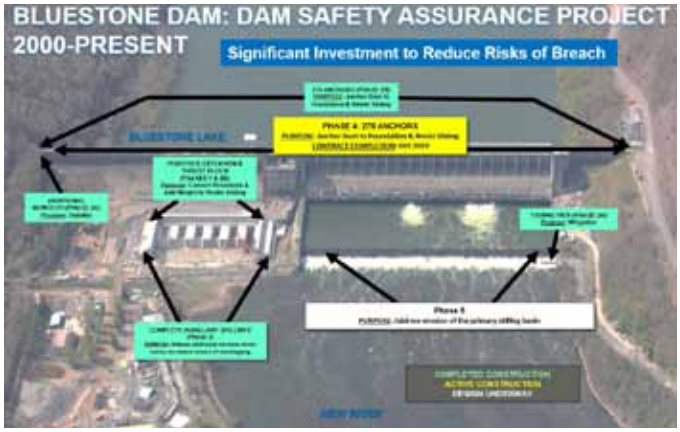

Figure 4. Overview of the Dam Safety Assurance Project phases.

Figure 5. Left, penstock tunnels extended through a thrust block. Right, complete auxiliary stilling basin.

Figure 6. Left, platform on main spillway for anchoring. Right, multi-strand anchor being pre-stressed.

In 2008, as USACE transitioned its approach to life-safety program to include risk-informed decision making, an Issue Evaluation Study indicated that new failure modes not addressed in the 1998 Dam Safety Assurance Study need to be studied. A 2013 Baseline Condition Risk Assessment confirmed that there is sufficient justification to study further modifying the project to address additional significant risks to the downstream population. A primary concern was failure from erosion of the river bed in the primary spillway, which is natural river bed and not protected with concrete. To address this concern, a Dam Safety Modification Report (DSMR) was conducted to supplement the original 1998 DSA. The DSMR was completed in 2017 and approved design and implementation of Risk Management Plan (RMP 6), also designated as Phase 5. RMP 6 consists of a combination of structural measures including modifying the primary stilling basin and constructing 42 super-cavitating baffles. The primary stilling basin and training walls will be stabilized with concrete scour protection, rock anchors, and an underdrainage system. Additional rock anchors in the dam are also included. Figure 7 provides a conceptual look at the Phase 5 investment.

Phase 5 is complicated in that the operability of the main stilling basin must be maintained as it is completely modified. While a variety of care and diversion of water alternatives were considered, ultimately bisecting the basin, first with a temporary coffer dam and then permanently with a divider wall, and constructing the required hydraulic features, drainage and scour protection in two stages was selected as the most efficient means and methods.

The design is underway and construction was originally

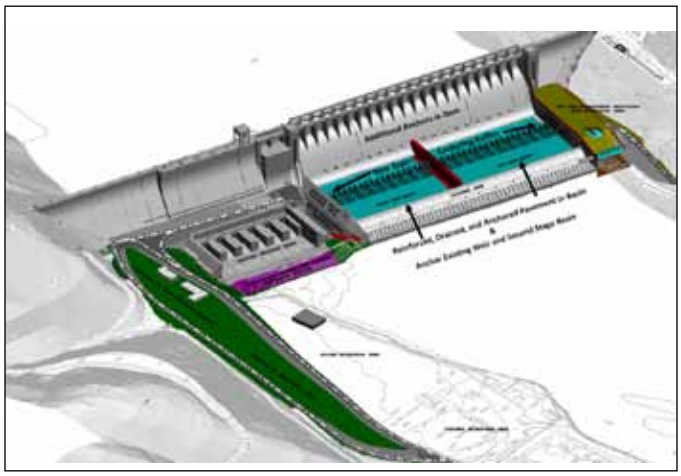

Figure 7. Conceptual look at the Phase 5 investment.

anticipated in 2022. In 2018, approximately $574M in Emergency Supplemental Funds appropriated by Public Law 115-123 were allocated to the DSA Project. Accordingly, the DSA project has taken the appropriate risk on project execution to realize this unprecedented opportunity to reduce life safety hazard and realize full benefits of the project much earlier than planned and as of this writing, the hope is to advertise Phase 5 in 2019.

To help accelerate the project, the temporary coffer dam has been advertised and is planned for construction during the summer and fall of 2019 while the stilling basin design is finalized. This allows the coffer dam to be provided to the stilling basin contractor as government furnished material to accelerate work in the basin.

For more information on the project, please visit https://www.lrh.usace.army.mil/Missions/Civil-Works/Current-Projects/Bluestone-DSA/.

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COMMITTEE CORNER

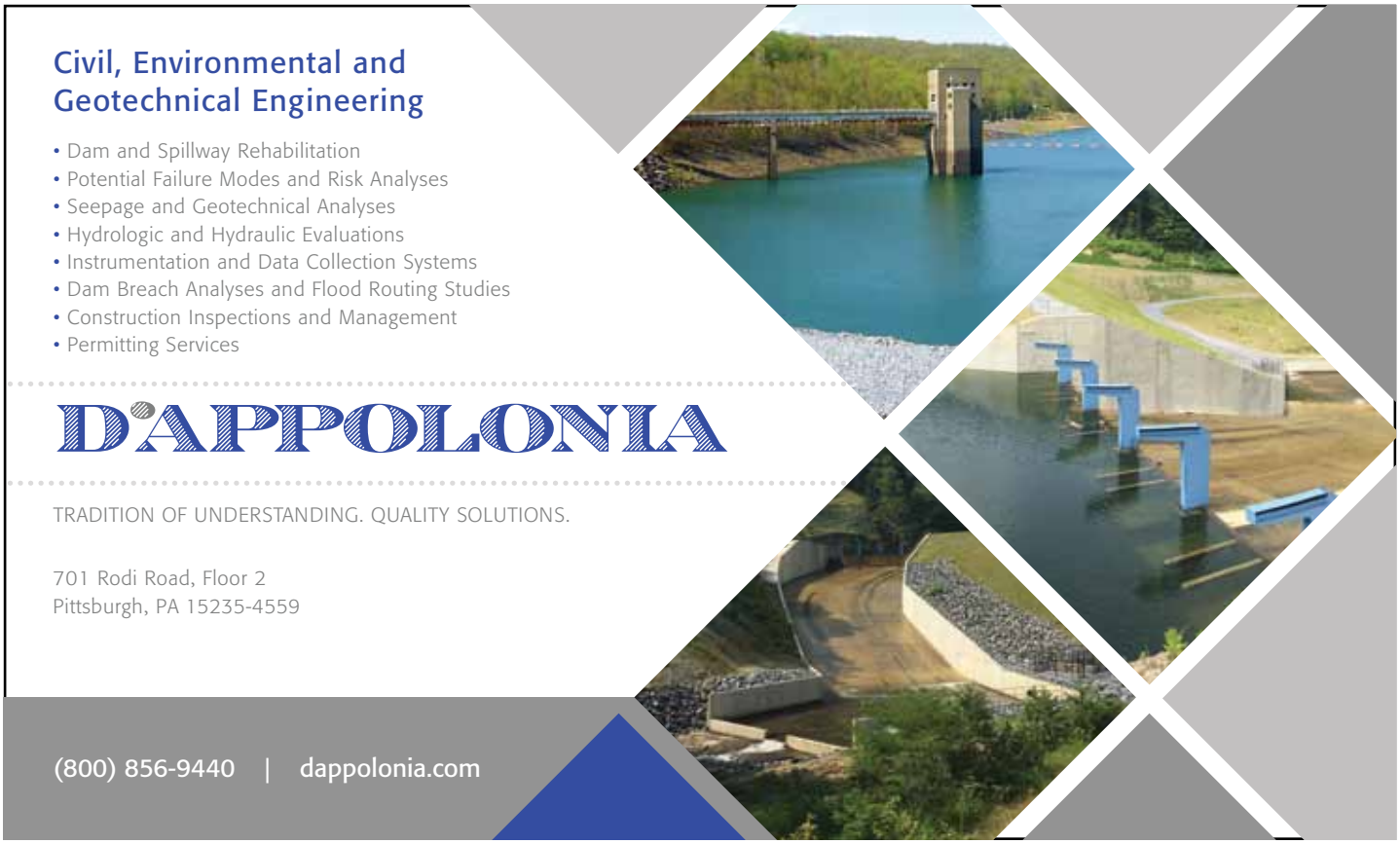
Tailings Dams

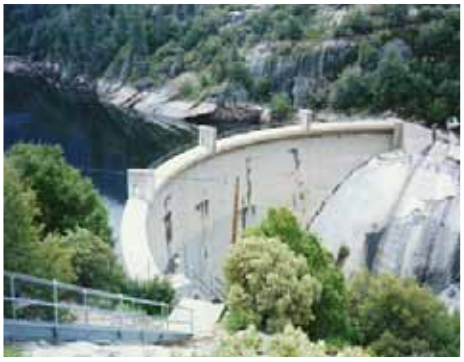
Amanda Adams, Committee Chair (amanda.adams@stantec.com)

The USSD Tailing Dams Committee has been involved in several initiatives over the past year. A major accomplishment involved collaboration with the Geoprofessional Business Association (GBA) to review and endorse the Proposed Best Practices for the Engineer of Record for Tailings Dams guidance document. During the USSD January 2019 Board Meeting, it was voted to endorse the document as follows: "USSD views this Proposed Best Practices for the Engineer of Record for Tailings Dams guidance document prepared by the Geoprofessional Business Association (GBA) as a comprehensive guidance document on the subject of the Engineer of Record for tailings storage facilities for the mining industry as a whole. The opportunity for USSD to collaborate with the GBA to review and provide input to the guidance document was appreciated. USSD endorses this document as a critical reference document for the industry." Creating, reviewing and ultimately obtaining this endorsement took significant effort by both GBA and USSD and our Committee was proud to be involved.

Looking ahead to 2019, the Committee is working on a white paper on the state of practice for closure of tailings dams, supporting ICOLD and national efforts for development of tailings dam safety guidelines, and excited to be collaborating with other USSD committees to plan technical workshops on instrumentation and monitoring, and static liquefaction.

We would also like to express our sincere sympathy for the victims of the recent tailings dam failure in Brazil. Our committee is working with other organizations under ICOLD (such as CDA), as well as organizations like SME which focus on mining to develop better tools and guidance for tailings dams design, operation and construction. We seek to advance the state of practice for tailings dams, improve dam safety and prevent failures. We need to be excellent engineers AND excellent communicators.





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Upstream Riprap Slope Inspection by Drone

Introduction

With the advent of new and low-cost drone technology, inspection and assessment of many geotechnical and structural assets have become safer and less time intensive. For example, the ASDSO webinar *Drone Technology Integrated into Dam Safety Inspections and Evaluations*, held in October 2018 describes the cost-effective use of drones for various types of dam inspections. Although drone technology is becoming more practical for inspection applications, techniques for quantitative assessment of dam and levee infrastructure have been largely absent in both research circles and practice. Although drone photography allows inspectors to subjectively assess the state of assets, drone photos may also be post processed with Structure-from-Motion (SfM) photogrammetry algorithms to develop accurate and high-resolution three-dimensional (3D) point clouds, a collection of high resolution x,y,z survey coordinates with at least centimeter-scale precision for typical civil engineering applications. This article summarizes work accomplished to date to develop a practical method for quantitative assessment of upstream slope protection using high-resolution point clouds created from drone photos.

Upstream Slope Protection

Upstream slope protection is designed to prevent the erosion of the underlying bedding and embankment materials by the forces of rain, ice flows, and wave action. Common upstream slope protection materials include concrete pavement, hand-placed riprap, and end-dumped riprap (Design of Small Dams, 1987). This study focuses on the assessment of end-dump armored slopes because they are the most common (Design of Small Dams, 1987). In addition to the thickness of the riprap and underlying filter layers, riprap quality, shape, and weight are important material properties to provide proper protection. A key parameter controlling the performance of riprap protection is the median weight, W_{50}, which is selected so that the riprap is expected to remain stationary when subjected to wave energy caused by a design wind velocity. This design process is described by the Bureau of Reclamation in DS-13(7)-2.1 of the Design Standards and by the U.S. Army Corps of Engineers in General Design and Construction Considerations for Earth and Rock-Fill Dams. For a selected target median weight, the desired median rock diameter by weight (D_{50}) can be estimated by assuming a particle shape. The Bureau of Reclamation provides the following equation which assumes an equant, or blocky, rock shape, which has a volume between that of a sphere and cube:

$$W_{50} = 0.75\gamma_r (D_{50})^3$$

where y_r is the unit weight of the rock. Therefore, specification and inspection of riprap material may be on the basis of either an acceptable weight or diameter.

The conventional procedures for inspecting riprap involve a trained dam inspector comparing the current riprap condition to that of past inspections. Specifically, the inspector looks for changes in the riprap's condition over time due to weathering, segregation, or displacement that may inhibit the riprap's ability to protect the slope. This time-intensive process is subjective, as different inspectors/regulators may make significantly different interpretations of the riprap condition. These procedures are also strongly limited by the inspector's ability to view the rock material by boat or from the embankment crest. In

certain cases, physical measurements of a sample of in-place riprap may be taken to evaluate the D50 of a portion of the slope protection (McGuire et al., 2016); however, this is more time-intensive than visual inspection.

Drone Inspection Concept

With decreasing cost and improved performance, drones or unmanned aerial vehicles (UAVs) are becoming increasingly popular as inspection tools. In addition to taking high-quality photos or infrared images, post processing of such photos through photogrammetry algorithms provides three-dimensional (3D) data. Structure-from-Motion (SfM) photogrammetry software is used to process a set of two-dimensional (2D) digital photographs (often comprised of hundreds of images) to identify common features and evaluate the most likely camera position and orientation of each image. This information, along with the content of the images, is then processed within the same software using photogrammetric techniques to produce a 3D point cloud, or a collection of x,y,z coordinates. These coordinates may have additional information, such as the color, reflectivity, or emissivity, depending on the type of sensor used. Figure 1 shows a near photorealistic example of a high-resolution photogrammetry point cloud of upstream slope protection.

Conceptually, the variability of these 3D point coordinates orthogonal to the slope of the embankment are related to the D50 of the rock material. This point cloud variability, or roughness, increases with D50, as shown pictorially in Figure 2. For this application, roughness is defined as the standard deviation of the point cloud data perpendicular to the slope of the embankment. In this application, roughness analyses are performed over square discretized areas of the slope, called patches, which are often 10-30 feet in length (see Figure 3).

Figure 1. Example of a 3D Point Cloud of Upstream Slope Protection.

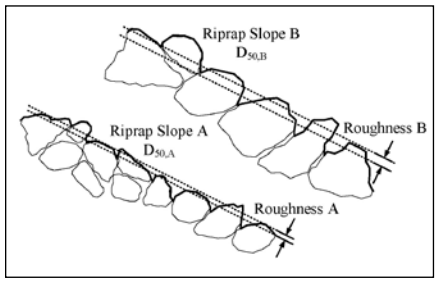

Figure 2. Pictorial example of roughness and D_{50} relationship.

Other rock properties such as void ratio, gradation, and particle shape also affect roughness; however, the findings of McGuire et al. (2016) and subsequent work presented in a forthcoming paper by the authors have shown the influence of the median riprap size on the roughness of the slope outweighs the influence of these other independent variables when the riprap is derived from the same source and is processed and placed using the same procedures. Empirical relationships between roughness and D50 have been observed using laboratory tests, numerical simulations, and field trials. An important aspect of the roughness analysis is the isolation of the point cloud variability due to the size of the riprap.

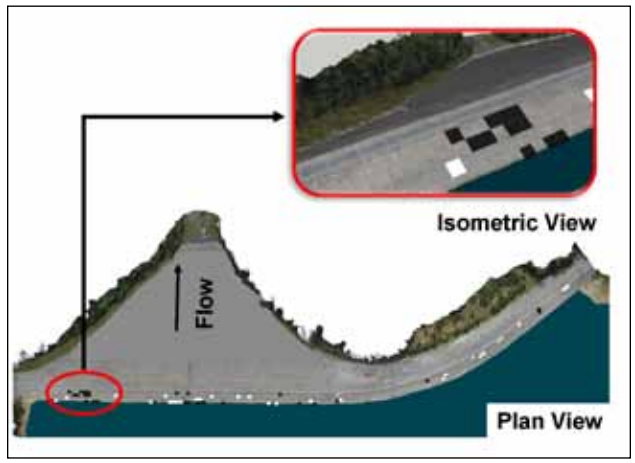

Figure 3. 3D Model of Roughness Analysis Results – white and black patches indicate lower and upper 5% of roughness, respectively.

This process, known as detrending, attempts to remove the trends in the point cloud data due to larger-scale topography such as the alignment and inclination of the slope. These studies show that the relative differences in median material size can be correctly identified provided that the riprap is poorly-graded, equant-shaped, and end-dumped on a slope that is reasonably constant and free of significant vegetation and debris. This means that locations along the slope with low roughness, as evaluated using the cumulative distribution of roughness, are likely to contain smaller riprap relative to the rest of the slope. For example, a study by the authors compared the findings of a traditional visual inspection to the drone inspection method at the same site and found that the vast majority of the areas identified by conventional procedures as having smaller riprap were also identified using roughness analysis. Furthermore, additional anomalous areas were also identified by the roughness analysis that were confirmed to have smaller riprap by inspection of photographs taken of the site. Areas of high roughness relative to the rest of the slope may also be of interest to inspections, since high roughness values may be associated with beaching or mounding caused by ice or wave action.

Step	Description	Hardware/Software
1 – Collect Drone Photographs	Fly the length of the embankment taking photographs at a set interval. Typically hundreds of photographs are taken as part of an automated drone flight plan.	Drone w/ high resolution camera
2 – Generate Point Cloud	Generate point cloud data of the riprap slopes using photographs. The point cloud data may be georeferenced to common coordinates (ex: state plane) using ground control points, or surveyed targets placed nearby.	Commercial Drone Photogrammetry Software (ex: 3DR Site Scan, Pix4D, etc.)
3 – Discretize Data	Discretize the point cloud into square segmented areas, or patches, which are often 10-30 ft in length.	Riprap Analysis Program (RAP)
4 – Calculate Roughness	Calculate the roughness of the point cloud within each patch, utilizing an appropriate detrending technique for the slope conditions.	
5 – Show Results	Graphically depict results in a GIS, CAD, or 3D model format.	Import results of RAP into CAD, GIS, or 3D modeling software
6 – Flag High/Low Data	Identify patches of low and high roughness which may indicate areas of weathered rock or eroded finer material, respectively. An example 3D model depicting roughness is provided as Figure 3.	
7 – Review Photographs	Review drone photographs (Figures 4 and 5) of flagged riprap, making special consideration for rock with signs of weathering/erosion.	Commercial Drone Photogrammetry Software
8 – Decide Next Steps	If all material appears acceptable by visual inspection of the photos or roughness, decide whether further action is needed.	
	If areas of low or high roughness appear unacceptable, progressively review photographs of riprap, working from areas of low/high roughness to areas of median roughness until acceptable material is identified. Flag all areas deemed unacceptable. Perform an on-site detailed inspection of unacceptable areas to decide if remedial action is required	

Table 1. Inspection procedure.

Inspection Procedures

With the strong relationship between median riprap size and roughness, SfM photogrammetry point cloud data collected via aerial drone may be incorporated into inspection procedures by the eight-step process shown in Table 1.

The high resolution of SfM point cloud data makes roughness calculations by hand or spreadsheet unfeasible; therefore, specialty software is required for performing these calculations. McGuire et al. (2016) describe a research software known as the Riprap Analysis Program, or RAP, which automates roughness analysis calculations.

The review of photographs described in Step 7, associated with flagged areas having anomalously low or high roughness, can be completed efficiently using tools typically built into commercial drone operation and photogrammetry software. One particularly helpful tool identifies all photos that were taken of a particular point in the point cloud. Figure 4 shows a point cloud of riprap slope protection to the left and drone photographs to the right. The red dot in the point cloud is identified in all relevant photos with a blue pin or white square to highlight the area. Therefore, the inspector can choose an area in the point cloud of low

Figure 4. Commercial srone/photogrammetry Software (3DR Site Scan) – point cloud to the left and photos relevant to the area indicated by the red dot.

Figure 5. High-resolution drone photography of upstream slope protection from a vantage point unattainable by boat..

roughness and automatically receive a list of relevant drone photographs, making review of photographs efficient. Another key advantage of this method is that photos taken from a drone may obtain vantage points that may not be accessible by boat or on foot. Figure 5 provides an example high resolution photo taken from approximately 30 feet above reservoir pool level — an impossible vantage point by boat.

Conclusions/Future Work

The proposed method of analyzing photogrammetry models obtained by inspecting riprap by drone has the potential to be more quantitative and less time intensive than the traditional visual inspection processes or simply visually evaluating photographs. Prior work has shown a strong correlation between the roughness of SfM photogrammetry point clouds created by drone photographs and the median diameter D50 of riprap material (McGuire et al., 2016). This correlation allows for objective and repeatable identification of areas of poor quality riprap, which can be more carefully evaluated by visual inspection of high resolution photographs. These drone photographs often

provide vantage points which may not be accessible by traditional visual inspection by foot or by boat. As commercial drone hardware and software develop, it may become possible to perform fully automated data collection and analysis of riprap material on board small aerial drones. Finally, multi-temporal analyses of point cloud roughness may be performed to identify change in the roughness of material over time. These quantitative analyses provide an unbiased tool for inspectors, owners, and regulators to evaluate critical breakdown of riprap over time, and characterize the areas over which loss of quality is more likely an issue and which warrant further consideration.

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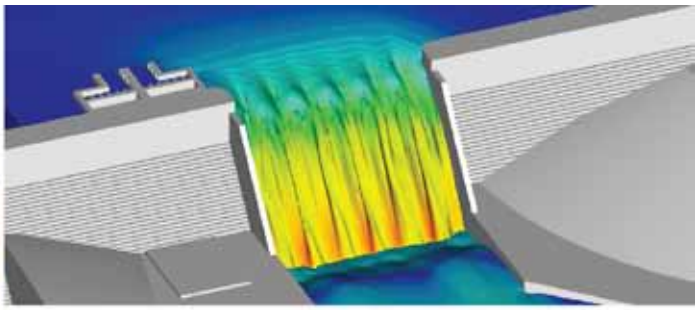

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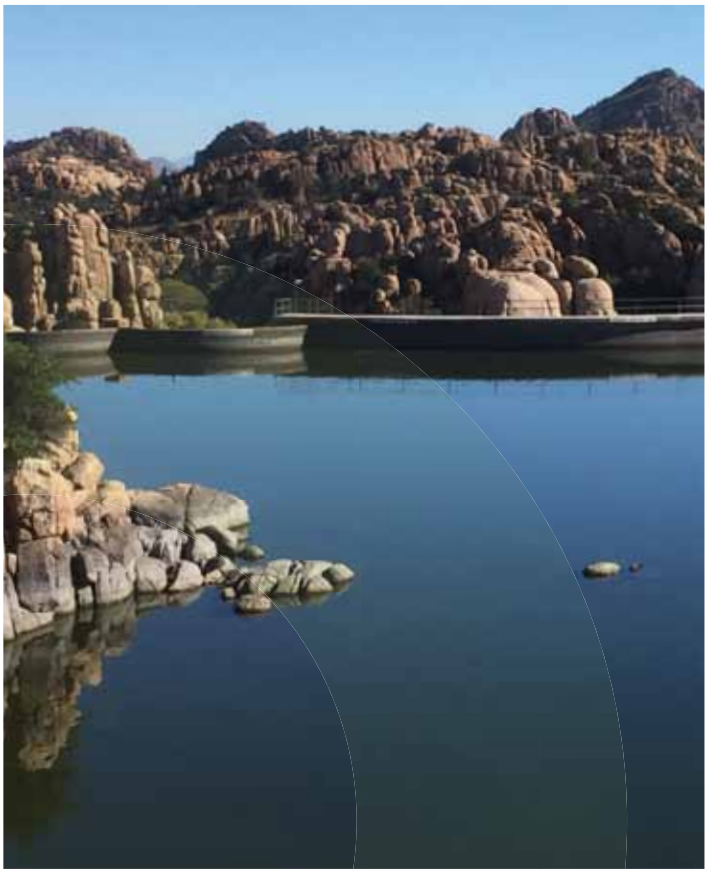

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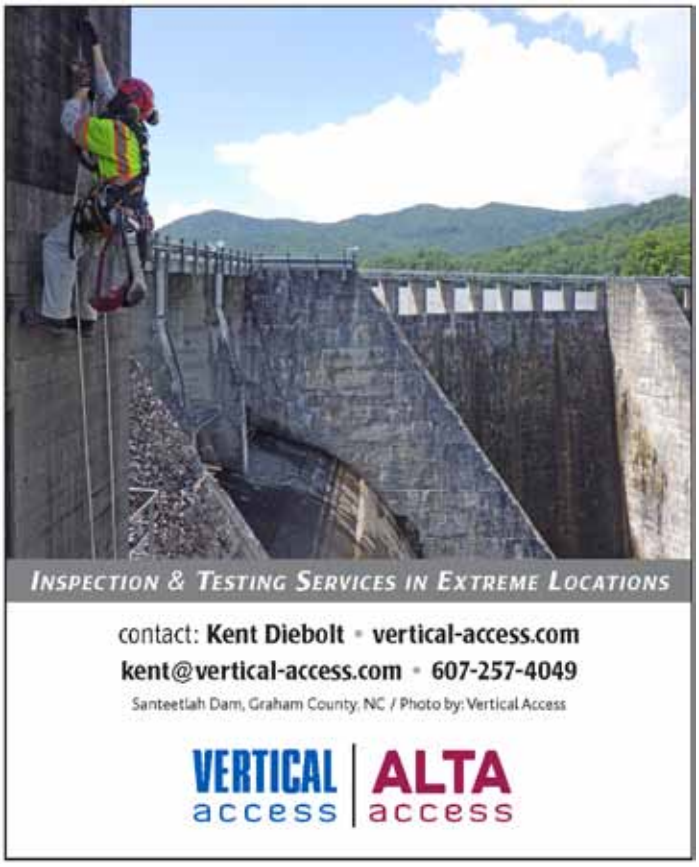
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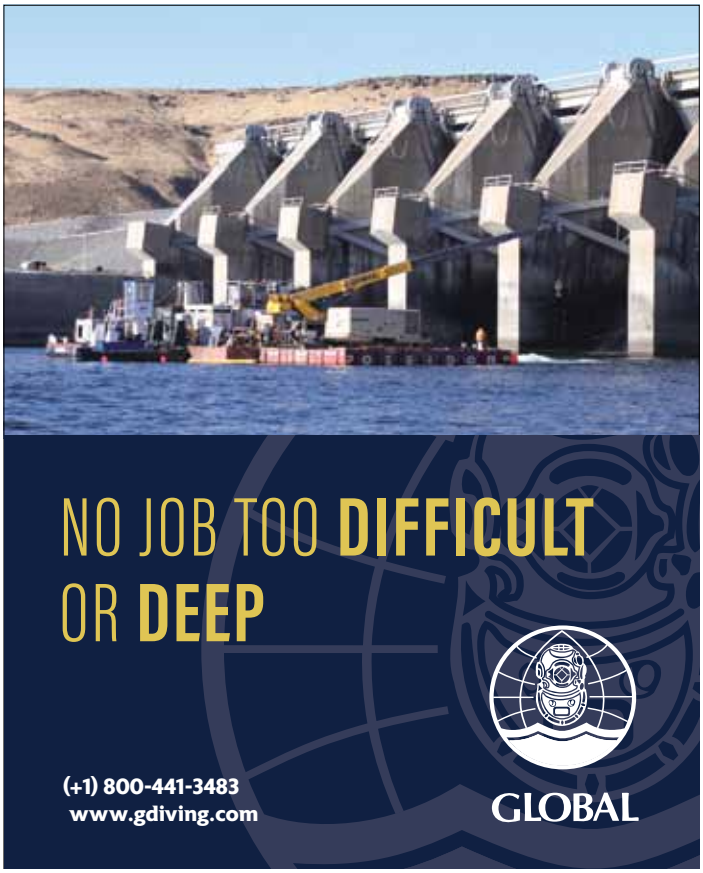
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FEATURE

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Building of Buffalo Bill Dam in 1904 — Go Figure

Introduction

This is the story of Buffalo Bill Dam in Wyoming (initially named Shoshone Dam). Who would have thought that the famous buffalo hunter and wild west show promoter, William F. (Buffalo Bill) Cody would also have a hand in the formation of the Reclamation Service and the approval of the tallest dam in the world in 1909, Shoshone Dam? And, who would have thought that Daniel Webster Cole with a high school degree (but a lot of construction experience) would be such a capable construction engineer? And, who would have thought that a newly formed Federal government agency, Reclamation Service, would attempt such a large project? Go figure!

Reclamation

John Wesley Powell, known as the Father of Irrigation and director of the U.S. Geological Survey from 1881 until 1894, believed the arid west could be irrigated. William F. Cody joined John Wesley Powell and others in imploring Congress to create an agency dedicated to developing water systems in the west. In 1894, Senator Joseph M. Carey of Wyoming sponsored the Carey Act, allocating a million acres of public lands to each state for irrigation projects and to attract settlers. In 1895, Buffalo Bill had founded Cody, Wyoming, and built the very impressive Irma Hotel (named after his daughter) downtown. The hotel still operates today and has a few "Wild West" bullet holes in the saloon bar. In 1899, under the Carey Act, Buffalo Bill and partners planned three canals to irrigate 60,000 acres around Cody, but after six years could not raise the estimated $2 million to build the project (like many Carey Act efforts, private interests could not raise the prohibitive funds).

Figure 1. Buffalo Bill Dam today.

Then in 1902, the U.S. Congress passed the Federal Irrigation Law forming the Reclamation Service (now the Bureau of Reclamation) and advanced Reclamation $50 million to build water projects. The new idea called for the Federal Government to build the projects and be repaid over time by the users of the water. The State of Wyoming along with Buffalo Bill encouraged Reclamation to take over their struggling Shoshone River Valley Project. In February 1904, Cody assigned his state water rights to Reclamation and the Secretary of the Interior Ethan A. Hitchcock allocated $2,250,000 to build Shoshone Dam.

Daniel Webster Cole

Daniel Webster (DW) Cole was born in 1863 in Marietta, Georgia to a civil engineering father in the railroad business and received his high school diploma from Marietta Academy. DW worked as an axman, chainman, rodman,

instrumentation man, assistant engineer, and finally resident engineer on various railroad projects. His first dam experience was a resident engineer in 1901 for a variety of dams for the metropolitan Water Board of Massachusetts and the city of Waterbury, Connecticut. In 1904 at the age of 41, he became the resident engineer at Buffalo Bill Dam, earning $2,700 per month. His official letter with the "Rules of the Game" from the Reclamation Service stated: 1) office hours 8 am to 5 pm except emergencies 7 am to 10 pm and 8 hours in the field, 2) pressing work will be done regardless of time, 3) hours will conform to contractor's shifts, 4) maintain warmth and ventilation for office sanitation, 5) eat, smoke and chew gum only enough to preserve life, sanity, and sociability, 6) whistle and sing only for the momentary relief of exuberant spirits, and 6) have a place for everything and keep it there." DW and his wife Carolyn lived in the Shoshone Canyon with their three daughters from 1905 to 1910, when DW became the Reclamation project engineer at Lahontan Dam in Fallon, Nevada. At his retirement in 1939, DW was considered one of the best dam builders in the world, having worked on 15 major dams.

Design of Buffalo Bill Dam

Reclamation engineers determined that a 325-foot-high dam in the Shoshone Canyon would store enough water to irrigate the planned acreage. This would be the highest dam in the world and push the state-of-the-art. Undeterred, the engineering team headed by Jeremiah Ahern, Shoshone District engineer, H.N. Savage, supervisory engineer, Charles P. Williams, project engineer, and DW Cole, resident engineer, developed designs and surveys. George Y. Wisner, renowned consulting engineer, recommended that a concrete arch dam would be better suited to the narrow canyon (recall that Pathfinder Dam was being built with masonry by Reclamation in a similar V-canyon using the identical dam shape).

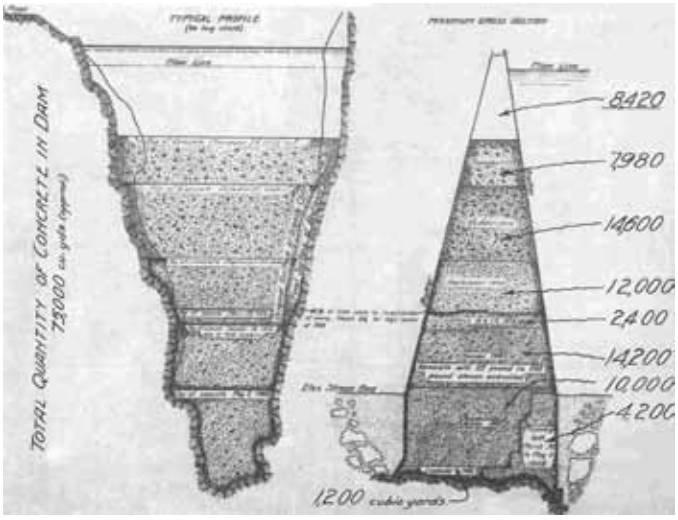

Figure 2. Profile and section of Buffalo Bill Dam.

Construction of Buffalo Bill Dam

In October 1905, the project was awarded to Prendergast and Clarkson from Chicago to build the "Great Dam" for $515,739. At the time, the Bighorn Basin, like much of the West, was sparsely populated and the terrain rugged (population of Cody was 500). As a result, the contractor had difficulty recruiting skilled workers for the project and was forced to bring in and train men.

Access road. Work at the site began the following month with the construction of an access road and worker's camp (see Figure 3). The 8-mile single-lane occasional-turnout road to the dam site was extremely difficult to build taking 1 year with picks, shovels, sledge hammers, and dynamite. It took very courageous drives to guide multi-teamed horse-drawn wagons along the road.

Figure 3. Dam, spillway, and access road.

Drilling. Drilling operations to determine the depth of rock beneath the dam were started in May 1904 and took 10 months. H.N. Savage reported that drilling carried on mostly during the winter with great difficulty through huge boulders and rocky drifts with very low temperatures. Dynamite was used to break the ice and free the drill rig barges. Pipes broke and diamond drill bits wore out overnight. But in the end, Reclamation engineers were convinced the entire dam would be founded on solid rock.

Diversion and flooding. The biggest challenge was diverting the Shoshone River. Cofferdams, flumes, and a 10-foot by 10-foot tunnel were built to provide enough capacity for redirecting normal river flows. Two men lost their lives dynamiting the tunnel. The system was completed in February 1906, but spring runoff destroyed one of the flumes. As such, the construction season in the riverbed was limited to between September and May. A new flume was built the following winter delaying construction by a year. In August 1906, the contract was suspended and awarded to Guaranty and Fidelity Co.

During the second spring runoff, a log boom in the sawmill located 1.5 miles upstream broke, sending approximately 250,000 board feet of logs destroying the cofferdam. The cofferdam was rebuilt in the fall. Excavation of 86 feet of riverbed down to granite proceeded during the winter of 1907 with hand tools and mules (see Figure 4). Overhead cables were built above the proposed height of the dam between the canyon walls. In March 1908, the contract was renegotiated and awarded to Grant, Smith, and Co. and Locher of

Figure 4. Excavating down to bedrock with hand shovels and picks.

Figure 5. Flooding though construction site in 1908.

Chicago. Concrete placements started on April 1908, but runoff flooded the foundation pit (see Figure 5). Concrete operations resumed in September after re-excavating.

Concrete. Granite was quarried from the riverbed to create the sand, aggregate, and 25 to 200 pound boulders known as "plums." Concrete was transported by railroad to Cody, Wyoming, loaded into mule-drawn wagons, and pulled across the landscape to the dam site. Winters were brutal with temperatures well below 0 degrees. Coal fired boilers were brought in to heat tarps and tents over the concrete and workers. The dam was placed from abutment to abutment in 5-foot concrete lifts topped with a layer of hand-laid plums (see Figure 6). The plums (25 percent volume of the dam) were placed to develop additional shear strength and

Figure 6. Large rock "plums" placed in dam.

reduce the volume of concrete. Using trowels and other hand tools, the men worked concrete into all of the cavities and crevices in and between the rocks to ensure consolidation. Shoshone Dam marked the transition from masonry to concrete dam construction at Reclamation. Construction progress was slow: boilers gave out, conveyors broke down, cableways snapped, workers went on strike, and at least seven men died.

The Tallest Dam in the World

The dam reached a height of 298 feet on December 21, 1909, prompting DW to send a letter to the Reclamation Service writing, "Today I find particular happiness in announcing to you not that Shoshone Dam will be, but that it IS the highest dam on earth." The dam had surpassed the 297-foot-high Croton Dam near New York (see Figure 7).

Figure 7. Top of Buffalo Bill Dam surpassing Croton Dam as tallest dam in the world.

Dedication

Commemorated as a National Civil Engineering Landmark in September 1973, Gilbert Stamm, Commissioner of Reclamation, said, "Although as years passed greater dams across

greater rivers were built, it was at these earlier projects, such as Buffalo Bill Dam, where theories were hammered into proven science and where theorists themselves learned practical lessons from harnessing one of nature's most awesome powers. Buffalo Bill Dam stands today as a symbol of the civil engineer's contribution to our society in the past and as a reminder that difficult problems facing our society today can be solved if faced with the same degree of ingenuity, fortitude, and imagination that led to the construction of the Buffalo Bill Dam and its contribution over the years to the well-being of the people of this nation." As Beryl Churchill wrote, "It was built by real people, who experience tragedy along with the triumph. They suffered loss of life and limb, labored under natural and man-made conditions of great difficulty, and still produced a great, lasting piece of work."

Prologue

The last bucket of the 82,900 cubic yards of concrete was placed on January 15, 1910 in 15-degree-below zero weather, and concluding construction costing $1.4 million. On January 10, 1917, Buffalo Bill Cody died of kidney failure at the age of 71. In his honor, Congress passed a resolution on February 26, 1946, officially changing the name from Shoshone Dam to Buffalo Bill Dam and Reservoir.

Comprehensive Facility Review

The Bureau of Reclamation now has a Comprehensive Facility Review (CFR) process where senior engineers inspect their dams every six years. In 2002, I, the author of this article, had the privilege of performing the CFR for Buffalo Bill Dam. After reading Beryl Churchill's book and the Project History, visiting the site, standing where Daniel W. Cole stood, eating at the Irma Hotel built by Buffalo Bill Cody, and seeing the 93,000 acres of farmland irrigated by Reclamation, I felt a great sense of pride, honor, and humility and gave thanks for the privilege to have a career at an Agency with such a rich history and to learn about the incredible people that built our infrastructure with dedication, persistence, strength, and even loss of life in some of the toughest conditions around. Buffalo Bill Dam is an astonishing achievement by our predecessors!

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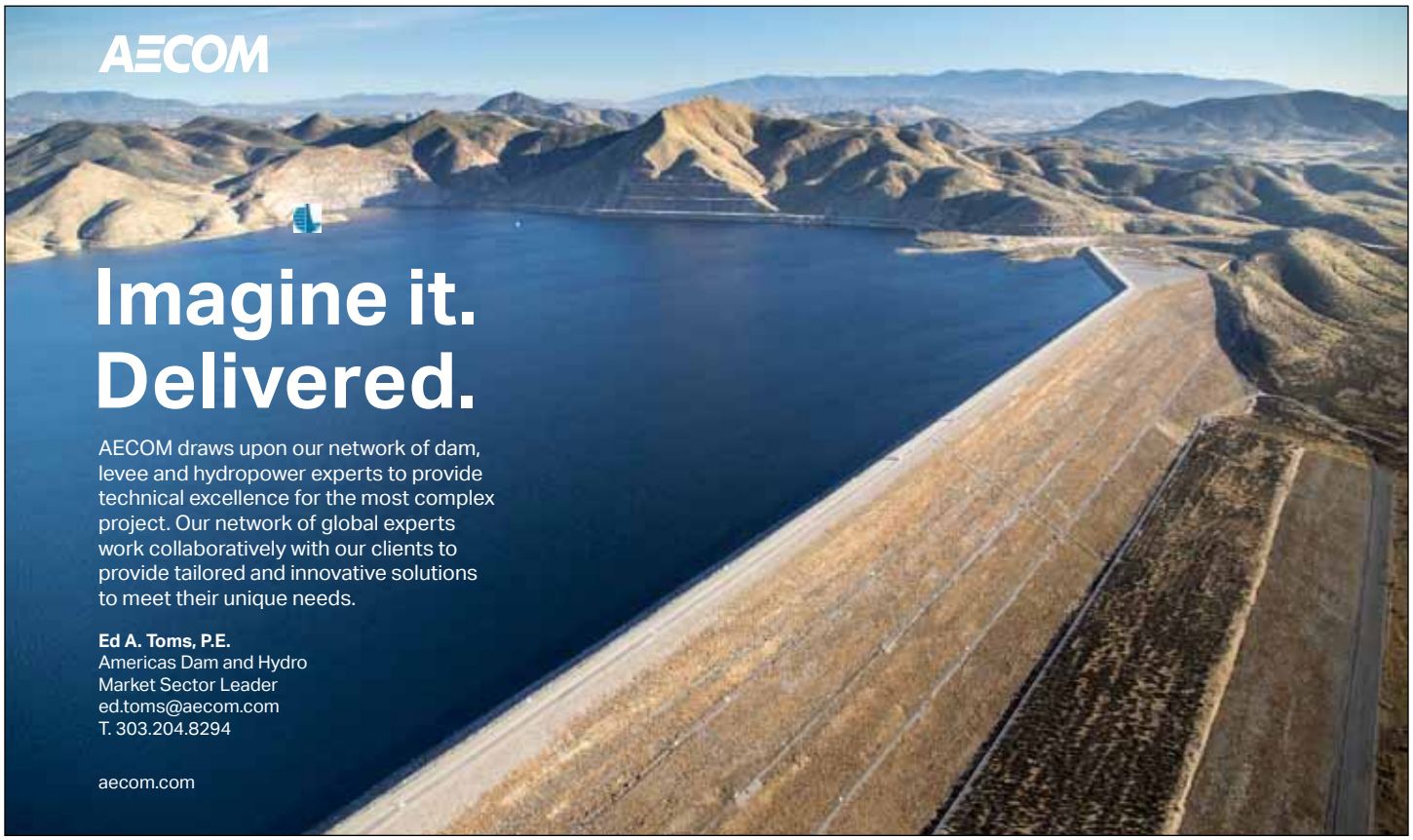

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Yakima Basin Integrated Plan

Editor's note: This is the second in a series of articles related to the Bureau of Reclamation's Yakima Basin Integrated Plan. The first article appeared in the Summer 2018 issue.

Cle Elum Pool Raise Project

The purpose of the Cle Elum Pool Raise Project is to increase the reservoir's capacity for improved aquatic resources for fish habitat, rearing, and migration in the Cle Elum and upper Yakima Rivers, thereby fulfilling the intent of the congressional authorization expressed in Title XII of Public Law 103-434. Reclamation and the Washington State Department of Ecology released a Final Environmental Impact Statement and Reclamation issued a Record of Decision in 2015. The Cle Elum Pool Raise Project would raise the pool level for about 40 days per year (generally in June and July) inundating areas around the reservoir that currently are not inundated. The raised pool level would increase erosion on some areas of shoreline, so the project includes installation of shoreline protection for public and private lands and facilities. The reservoir will not store Cle Elum Pool Raise Project water until shoreline protection has been completed.

In April 2017, Reclamation completed the modification of the existing radial gates (see photo below) at the dam spillway to raise the level of the reservoir pool 3 feet, allowing up to an additional 14,600 acre-feet of water to be stored and released from Cle Elum Reservoir. The dam will remain as is.

Modification of existing radial gates allowed for increased storage.

The first shoreline protection was completed November 2017 for the U.S. Forest Service facilities at Cle Elum River Campground. Construction for Speelyi Day Use Area, also USFS, will begin in the Fall 2018 and will be completed within a few months. The entire Cle Elum Pool Raise Project is expected to take about five years to complete.

Project map.

Completed shoreline protection at Cle Elum River Campground.

The last storage project in the Yakima Project was building the Cle Elum Dam in 1933. This will be the first additional water storage in more than 80 years.

More information about the Cle Elum Pool Raise Project can be found at Reclamation's webpage at http://www.usbr.gov/pn/programs/eis/cleelumraise/index.html.

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ICOLD UPDATE

Work Progresses on USSD, Korea MOU

John Wolfhope, USSD Past President, Freese and Nichols, Inc.

As part of USSD's Strategic Mission, the Collaborate imperative calls on USSD to build networks and relationships to strengthen the community of practice in the dam and levee industry. The first goal under this imperative is to strategically collaborate with ICOLD and targeted international professional organizations in the dam and levee industry. In 2016, USSD began a cooperative arrangement with the South Korean National Committee (KNCOLD) and the Korean Water Resources Corporation (K-water) to share best practices. In each of the past three years, invited guests of both countries have reciprocally participated in annual conferences held in the USA and South Korea. Both countries share similar challenges with dams and water resources, including management of aging infrastructure, urbanization around and downstream of dams, and responding to increasingly severe storm events. In July 2018 at the ICOLD Annual Meeting held in Vienna, Austria, a delegation representing USSD and KNCOLD held a formal signing ceremony to execute a cooperation agreement between USSD and KNCOLD to expand collaboration between both countries in dams and water resources.

The cooperation agreement identifies goals in the areas of education and training, joint-participation in symposiums, collaborative research projects, and opportunities for exchanging best practices. Three cooperative research topics have been identified for the 5-year term between July 2018 and 2023:

1. Observations of seismic performance of dams, including the sharing of seismic motion data from Korea and Japan, advancing best practices for seismic design of new dams or performance evaluation of existing dams;

2. Dam Incident Case Study Management, including root cause investigation, management of emergency situations, emergency preparedness, and lessons learned;

3. State-of-the-art subsurface investigation technologies for dam safety management of aging dams.

In November 2018, USSD Vice President Denise Bisnett joined Canada's Tony Bennett in Daejeon, Korea as invited guest speakers at the International Symposium on Present and Future of Sustainable Dam Safety Technology. Following the symposium, Denise met with representatives from KNCOLD / K-water to discuss specific collaborative research priorities for 2019. Based on the meetings in Korea and prior discussions with the USSD Earthquake Committee Chair Lelio Mejia and USSD Dam Safety Committee Chair Brian Becker, it was decided that the first collaborative research priority would be in Seismic Performance of Dams, followed by Dam Incident Case Study Management.

Martin McCann of Stanford University and Director of the National Performance of Dams Program volunteered to serve as USSD's liaison for the joint research into seismic performance of dams. Initial discussions with KNCOLD are proceeding to better define the scope of the collaborative research initiative. We welcome interested USSD members to participate in the current joint research efforts and become engaged in advancing international best practices for Seismic Performance of Dams.

Representatives of KNCOLD and USSD in Daejon, Korea.

Denise Bunte-Bisnett and Tony Bennett enjoy a roundtable discussion with Woogu Kim, Hanvara University and Jae-Young Park, K-water.

Three Gorges Delegation Visits U.S.

ICOLD President Michael F. Rogers and USSD Executive Director Sharon Powers hosted a group of senior leaders from the China Three Gorges Company earlier in January. The Chinese representatives visited Hoover Dam before arriving in Denver, where they toured the Bureau of Reclamation's Hydraulics Laboratory. Presentations about Hoover Dam were given by USSD members Larry Nuss and Tim Dolen at the downdown Denver office of Stantec. The visit ties to the objectives of the Memorandum of Understanding held between USSD and CHINCOLD (Chinese National Committee on Large Dams), and addresses the ICOLD objective of knowledge exchange.

Three Gorges delegation at the USBR Hydraulics Lab in Denver.

Upcoming ICOLD Events

87th ICOLD Annual Meeting, Ottawa, June 9-14, 2019, hosted by the Canadian Dam Association.

International Symposium on Dam Safety, Salvadore, Brazil, May 20-23, 2019, co-sponsored by the ICOLD National Committees of Brazil, China, Spain and the U.S.

15th ICOLD International Benchmark Workshop in Numerical Analysis of Dams, Milano, Italy, September 9-12, 2019.

11th ICOLD European Club Symposium, Crete, Greece, October 2-4, 2019.

Resilient Dams for Resilient Communities, Auckland, New Zealand, October 9-12, 2019. Combined conference of NZSOLD and ANCOLD.

Visit the ICOLD website for more information: https://www.icold-cigb.org/.

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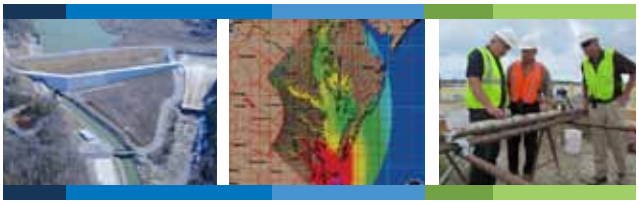

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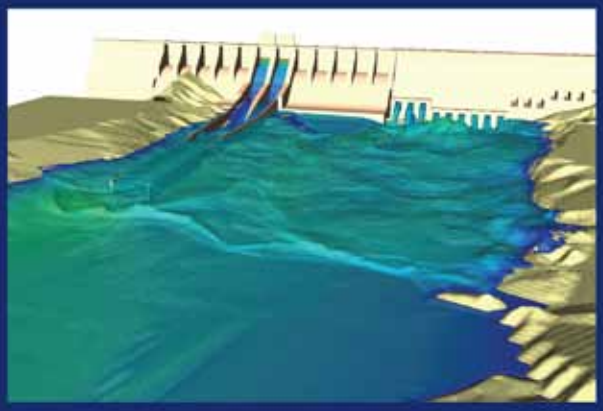

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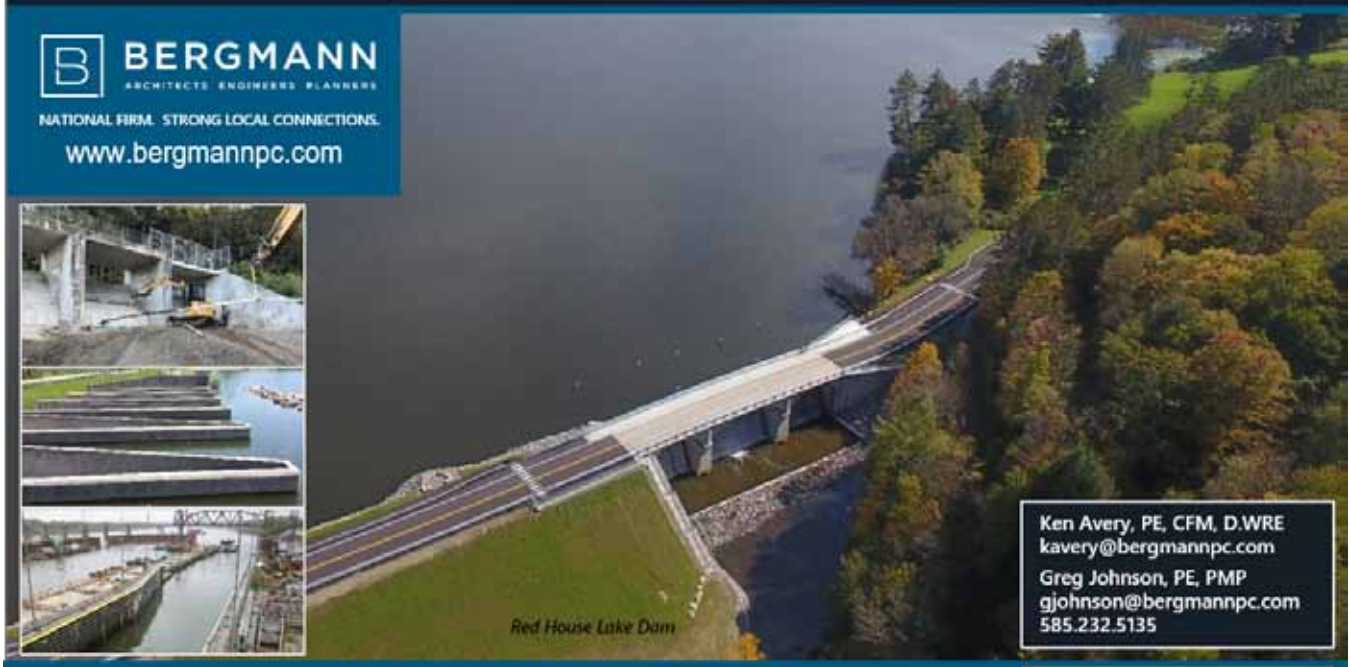

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FEATURE

Elizabeth Ouellette, P.E., Geotechnical Engineer, Bureau of Reclamation, Denver, Colorado (eouellette@usbr.gov)

Hyatt Dam — Challenges of Modifying a 96-Year-Old Embankment Dam to Address Internal Erosion Risk

Background

Hyatt Dam is a major feature of the Bureau of Reclamation's Rogue River Basin Project, and is located approximately 18 miles east of Ashland, Oregon on Keene Creek. The dam and its appurtenant structures were constructed in 1922-1923 by the Talent Irrigation District for irrigation storage. As-built drawings were not prepared, thus descriptions of the original dam and appurtenant structures are based on limited design drawings. There is little information available on construction activities; much of the information found is in a 1922 diary prepared by F.H. Walker, an engineer/inspector hired by the Talent Irrigation District for the construction of the dam. The dam consists of a homogeneous earthfill embankment, with a structural height of 53 feet and a crest length of 775 feet. A cutoff trench to bedrock was constructed beneath the upstream portion of the embankment, and was apparently extended the short depth to bedrock across the entire length of the embankment based on a design drawing, and a concrete core-wall was constructed at the base of the trench. The dam impounds a reservoir containing 16,200 acre-feet at the top of active conservation reservoir water surface elevation. Principal benefits of the reservoir include irrigation, recreation, and a source of water for the Green Springs Powerplant. Figure 1 provides an overview of the site.

The dam was constructed in a constriction that starts about 800 feet upstream of the dam axis in the broad, nearly flat-bottomed valley through which Keene Creek flows. The gradient of Keene Creek increases rapidly about 50 feet past the downstream toe of the embankment as it enters a steep valley, typical of the more mature topography of the

Figure 1. Overview of Hyatt Dam site prior to modification.

Western Cascade Volcanics province. The lava flows forming the bedrock at the dam site are likely part of the uppermost portion of the Tertiary volcanic sequence.

Seepage has been evident along the left embankment toe of Hyatt Dam since the 1970s. Estimates of the amount were not provided in earlier years, but the seepage was always reported as being clear. When these early observations of seepage were documented, the reservoir elevations were reported as around 13 to 14 feet below the dam crest elevation. Between 1979 and 1997, numerous reports disagreed both on the path and the source of the seepage evident along the left embankment toe. Some reports indicated that the seepage was probably flowing through the foundation. However, it was not apparent whether the seepage was flowing through the foundation underneath the dam, or if it was originating from higher ground located on the left side of the valley. Additionally, it was thought the seepage was probably coming through the basalt in the foundation with only minor amounts coming through the embankment. Other reports speculated that the seepage was due to plugging, collapse or some other malfunction of the left toe drain trench and collector pipe, which would cause any seepage from the reservoir to bypass the collection system. Other reports speculated the seepage source was

from the natural ground slope below the toe drain and resulted from natural runoff rather than from reservoir seepage. Still others speculated the seepage was related to the limited treatment of the fractured foundation during original construction, or the seepage was bypassing the cutoff trench altogether through the fractured foundation.

Figure 2. Seepage conditions at the toe of Hyatt Dam in May 2009.

Based on the ongoing seepage concerns and high internal erosion-related risk, an evaluation was performed in 2009. This included field investigations of the toe drains as well as drilling to characterize the embankment and foundation materials. Evaluation of the risk estimates for internal erosion after field investigations indicated that Hyatt Dam was at high risk for failure under normal operating conditions. The high risk of internal erosion of the embankment and foundation overburden materials was driven by the unfiltered seepage exiting at the downstream toe of the embankment and the underlying fractured basalt foundation that was not treated during original construction. The conclusion of the evaluation was that observations of changing seepage over the years indicated that the dam had been experiencing episodic erosion which could eventually continue to failure. Because of the consistent appearance of seepage at the same reservoir elevation, and the high risks, a reservoir restriction prior to and during construction was implemented.

Designs to Address Dam Safety Risks

Designs to address the seepage concerns through the embankment and foundation consisted of a downstream excavation to bedrock, and installation of a filter around the outlet works and up the embankment, new toe drain and a weighted berm. The original toe drain was to be grouted with pervious grout with similar permeability as ASTM C33 sand. The size of the berm required replacing the existing outlet works headwall with a new concrete headwall and retaining structure. The primary components are shown on the plan view and sections provided in Figures 3 and 4.

Construction of Modifications

The contractor began installing dewatering wells and excavating the existing embankment on June 28, 2017. Foundation excavation was started on July 22. Excavation operations continued through September, and the right foundation was exposed on July 26. The left

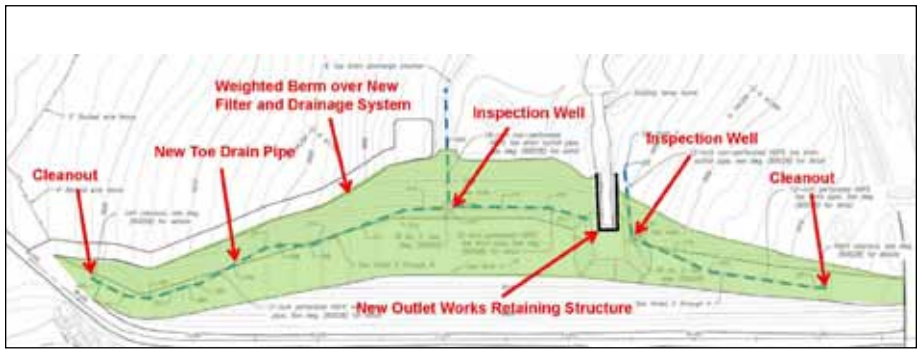

Figure 3. Plan View of Dam Safety Modifications for Hyatt Dam.

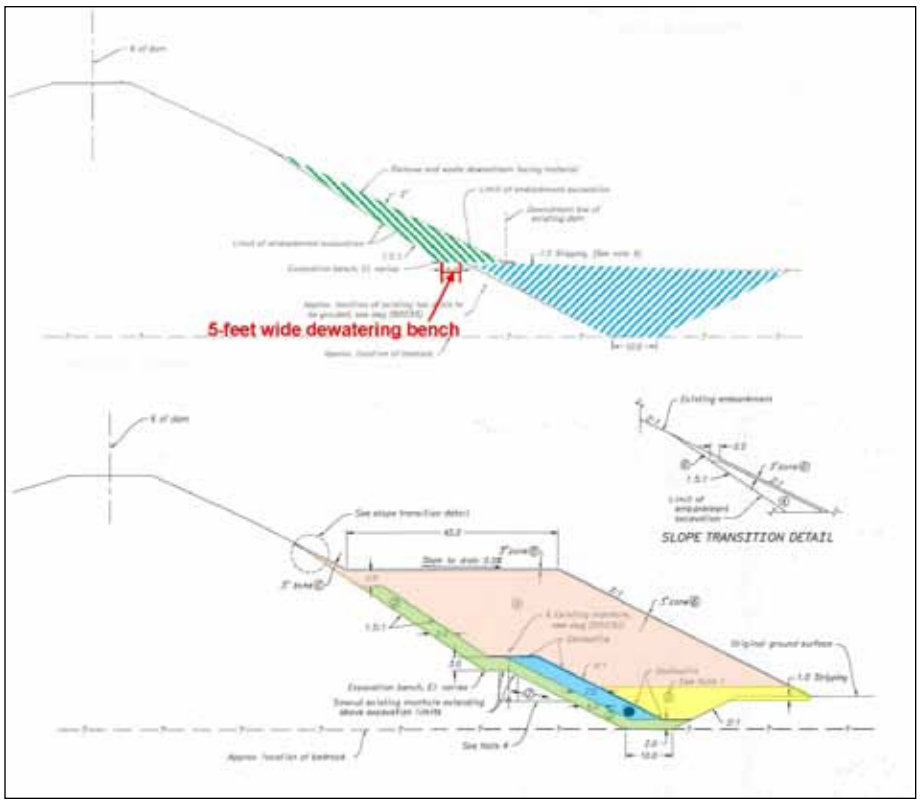

Figure 4. Typical excavation and finished cross sections for Hyatt Dam modifications.

foundation was exposed 27 days later, and excavation operations, including foundation cleaning, concluded on September 2. Installing slush grout, backfill concrete, and filter sand took approximately seven days to complete on each foundation section, with in-place densities of filter sand averaging 92 percent compaction in accordance with ASTM D7382, and dry unit weights of 107 lb/ft^3. Large-scale backfill operations commenced after the new outlet works structure was completed on October 5, 2017, and proceeded at a rate of 500 yd^3 per day (using a Caterpillar CP-563E sheepsfoot vibratory roller) until the weighted berm was topped off on October 28, 2017. The average in-place unit weight of the weighted berm material was 119 lb/ft^3 with an average of 100 percent compaction in accordance with ASTM D698.

There were significant changes to the treatment of the bedrock surface once it was exposed in the excavation. A large offset in the bedrock surface exposed in the excavation was about 10 feet high, with the bottom 4 feet comprised of fractured basalt, shown in Figure 5. Reclamation staff estimated that approximately 40 yd^3 of concrete would be needed to fill this area. However, the impermeable concrete block could inhibit seepage flows from moving into the filter and drainage system if the fractured rock was covered by backfill concrete, creating a situation where the seepage may find an unfiltered exit elsewhere. A revised detail which included placing Zone 2 filter material from the base of the excavation to the top of the fractured rock is shown

Figure 5. Large bedrock offset between dam stations 3+00 and 3+25.

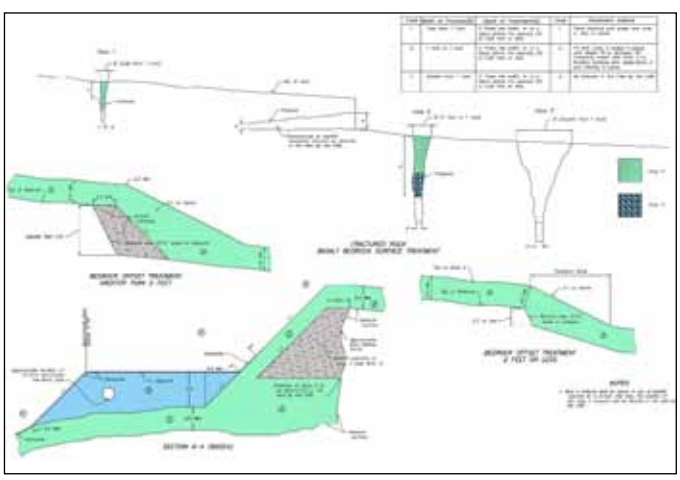

Figure 6. Foundation treatment.

in Figure 6. Backfill concrete was placed above the Zone 2 filter material to the top of the bedrock surface since there were overhangs present within the upper 5 feet of the bedrock offset. Zone 2 filter material was also placed on the downstream side of the concrete to ensure all areas were filtered. Figure 6 shows the original foundation treatment recommendations, as well as the revised detail to address the bedrock offset between Station 3+00 and Station 3+25, labeled as Section A-A.

There were also many areas where localized vertical/near-vertical bedrock offsets greater than two feet in height were present. In most cases, the design team believed that adequate compaction of Zone 2 filter material could be achieved in these areas, which would better meet the overall design intent of filtering seepage through the foundation rather than forcing it to exit elsewhere. Vibrating plate compactors were used in these localized areas to achieve the necessary compaction. In all areas where localized overhangs prevented proper sand installation, slush grout or backfill concrete was placed.

During construction, wet areas were observed on the downstream excavated embankment slope. The areas may have been caused either by a winter shut-down layer that was not processed properly the following spring, or a change in material type from more coarse to finer embankment material perching water on the transition. To account for the observed wet areas, the filter was extended up the slope to an elevation at least three feet above the wet areas, with the berm extended to maintain three feet of cover over the chimney filter. This modification to the design ensured that all potential seepage paths through the embankment were filtered.

The specification required the Zone 2 filter sand contain fines content of 3 percent or less (by weight, passing the No. 200 sieve). While the sand produced by the plant was within specification requirements, the material broke down during handling and placement such that in-place gradations indicated an increase in fines. The supplier incorporated additional washing of the material, which resulted in a reduction of the fines content. After performing test sections using different placement methods to evaluate the breakdown of the material, it was determined that although breakdown could be minimized, it was difficult to avoid exceeding the 3 percent fines limit. As a result, Reclamation decided to allow a maximum of 3.5 percent fines content after placement and compaction.

An error was made when modifying the outlet works and the conduit was cut two feet short of the design, which resulted in modification to the collar and headwall designs. The headwall was successfully modified; however, the

contractor did not adjust the associated conduit and slab reinforcement. To ensure that the conduit encasement would be tied to the slab, and hoop bars fully encircle the existing conduit, the encasement section was increased to four feet, and the hoop bars were dowelled five feet into the bedrock under the existing conduit.

Conclusion

Most of the issues that arose during construction were associated with the difference in the as-excavated bedrock surface as compared with the assumed surface. Although field investigations were performed, they were limited in scope and not sufficient to identify the extent of the undulating nature of the bedrock and severity of the steep bedrock offsets that were encountered in some locations. The lack of documentation during the original construction of the dam also limited the understanding of the bedrock surface, as well as the location of the existing toe drain. Nonetheless, these challenges were successfully addressed in the field by the cooperative contractor prior to the end of the construction season.

Ecosystem Responses to Dam Removal

In the United States, the removal of dams now outpaces the construction of new ones — with more than 1,400 dams decommissioned since the 1970s — and a new study suggests that the ecosystem effects of dam removal can be predicted.

Published in the journal BioScience, the study identifies a consistent set of physical and biological processes that control ecological responses to dam removal. These processes, combined with the unique environmental conditions found at each dam, ultimately determine how the ecology of the river will respond.

The study was conducted by the Dam Removal Synthesis Working Group, a team of 22 scientists from the U.S. Forest Service, U.S. Geological Survey, NOAA Fisheries, Oregon State University, University of Montana, Dartmouth College, Bowling Green State University, and American Rivers. It was sponsored by the USGS's John Wesley Powell Center for Analysis and Synthesis.

The study may be found at https://bit.ly/2BMNltT.

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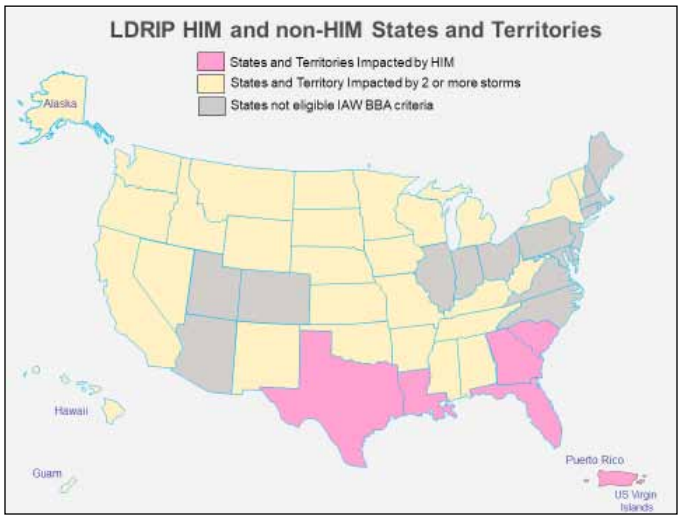
Bipartisan Budget Act of 2018 — U. S. Army Corps of Engineers Emergency Supplemental Program

Yvonne J. Prettyman-Beck, Emergency Supplemental National Program Manager, Headquarters, U.S. Army Corps of Engineers, Washington, DC (Yvonne.J.Prettyman@usace.army.mil)

On February 9, 2018, $17.398 billion in emergency supplemental funding was appropriated by Congress in the Bipartisan Budget Act (BBA) of 2018, Public Law 115-123 (Supplemental) for the U.S. Army Corps of Engineers Civil Works program. The funding includes $20 million for expenses.

More than $1.8 billion in the Supplemental is designated for short-term repairs and emergency dredging (Operation and Maintenance - $608 million; Flood Control and Coastal Emergencies - $810 million; and Mississippi River and Tributaries - $370 million). Short-term allocations for repairs will follow USACE normal procedures, whereby, emergency repair work is classified in four classes based on risks and consequences avoided, with the highest-class work being funded when funds are not sufficient for all eligible work.

$15.055 billion is provided in the construction appropriation account for long-term disaster recovery projects, $135 million in the Investigations account, and $400 million in the MR&T account. The selected studies and construction projects from these appropriations comprise what USACE refers to as the Long-term Disaster Recovery Investment Plan or LDRIP. Five states (Florida, Georgia, Louisiana, South Carolina and Texas) and two territories (Puerto Rico and the U.S. Virgin Islands) were "impacted by" Hurricanes Harvey, Irma, and Maria (HIM) and are eligible for portions of the total amount of funding identified as follows: Construction (HIM) - not less than $10.425 billion for flood and storm damage reduction,

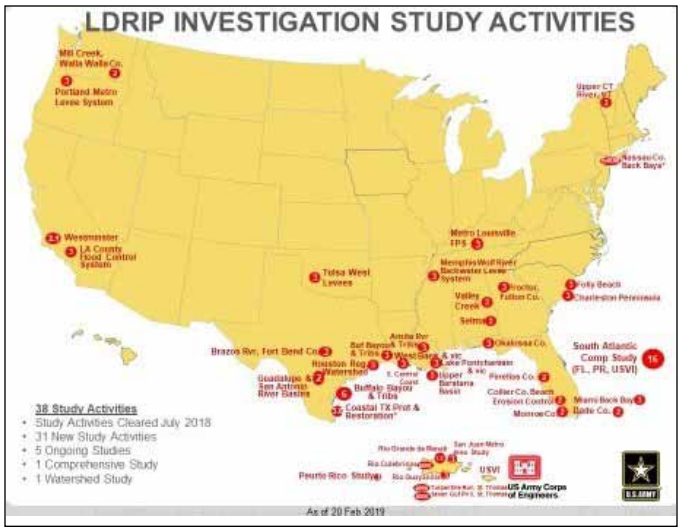


including shore protection projects, and in the Investigations (HIM) - not less than $75 million for study activities.

An additional 28 states (Alabama, Alaska, Arkansas, California, Hawaii, Idaho, Iowa, Kansas, Kentucky, Michigan, Minnesota, Mississippi, Missouri, Montana, Nebraska, New Mexico, Nevada, New York, North Dakota, Oklahoma, Oregon, South Dakota, Tennessee, Vermont, Washington, Wisconsin, West Virginia, and Wyoming) and one territory (Guam) also categorized as non-HIM states and territories, met eligibility in accordance with the Supplemental by having two or more flood-related major disaster declarations in calendar years 2014, 2015, 2016 or 2017.

Congress, through enactment of the Supplemental, did not appropriate funding to specific studies or projects. Although the universe of eligible projects and studies exceed funds allocated in the Supplemental, those selected meet the requirements stated in the Supplemental, were impacted by the qualifying disasters, and represent the highest national priorities. All eligible studies and projects are considered and those selected are based upon various performance criteria including, but not limited to, an assessment of potential damage reduction provided by the project or study, advancement of non-structural and high life-risk projects, Dam Safety Action Classification(DSAC), project Benefit-to-Cost Ratio, and more. For example, Dam Safety projects represent a significant threat to populations and infrastructure. As such, the construction list includes all DSAC 1 and 2 projects eligible in accordance with the Supplemental (includes having all required completed reports), in both the HIM and non-HIM states. The risk management/future investment reserve in the Investigations and Construction accounts are being carefully managed to both mitigate delivery risk and support subsequent allocations for implementation of additional projects where feasible. The investment plan will be reviewed and updated over time in accordance with existing policies and implementation guidance.

The Investigations Initial Investment Plan includes 38 of the USACE highest priority study activities with a current working estimate (CWE) of $111,893,000 that will complete five ongoing Feasibility Studies; initiate and complete 31 Feasibility Studies; initiate and complete



one Comprehensive Study; and initiate and complete one Watershed Study. The map (above left) depicts a snapshot of the study activity locations and the CWE.

The Construction Initial Investment Plan includes 58 construction projects with a current CWE of $13,914,580,526 that will complete 33 ongoing projects and initiate and complete construction on 25 projects not currently ongoing. The map (above right) depicts general project locations, project CWEs, and a total CWE by state/territory highlighted in blue.

The MR&T Initial Investment Plan includes $245.5 million for channel improvements and Mississippi River levee construction in multiple states, with additional levee work to be identified upon completion of environmental compliance requirements in the amount of $154.5 million. The graphic at right identifies the magnitude of the investments to be made in the MR&T account from Supplemental funds.

Projects eligible under the Continuing Authorities Program (up to $50 million) are identified and monitored separately within the LDRIP Program.

The tables listing the studies and projects receiving funding are posted at http://www.usace.army.mil/Missions/Civil-Works/Budget/ under "Supplemental Appropriations for Disasters 2018." Changes to the studies and project Investment Portfolio are periodically reviewed for approved updates and posted.

As one might imagine, "moving dirt" along with successfully executing a program of this magnitude requires USACE leadership and managers at all levels to exhibit an expeditionary mindset by focusing first on project delivery, in order to advance that delivery at every opportunity. In July 2018, USACE Civil Works published a Director's Policy Memorandum outlining key principles of delivery for executing the Emergency Supplemental. These principles

include the application of innovative ideas to enable the use of the latest technologies and Industry best practices to drive aggressive and quality project delivery; and conducting multi-engagements with industry to assess market strategies and best available construction techniques/options while consistently leveraging sponsor input and capabilities. With full available funding as an added incentive to move out aggressively, the policy also identifies Supplemental delivery targets for all studies and projects. The criteria targets overall construction completion in the year 2024, with a few projects projecting some unique challenges requiring

additional review and resolution. The policy also stresses the importance of sharing the workload (internal and external to USACE), implementing plans and schedules based upon full available funding, delivering quality, and showcasing outcomes.

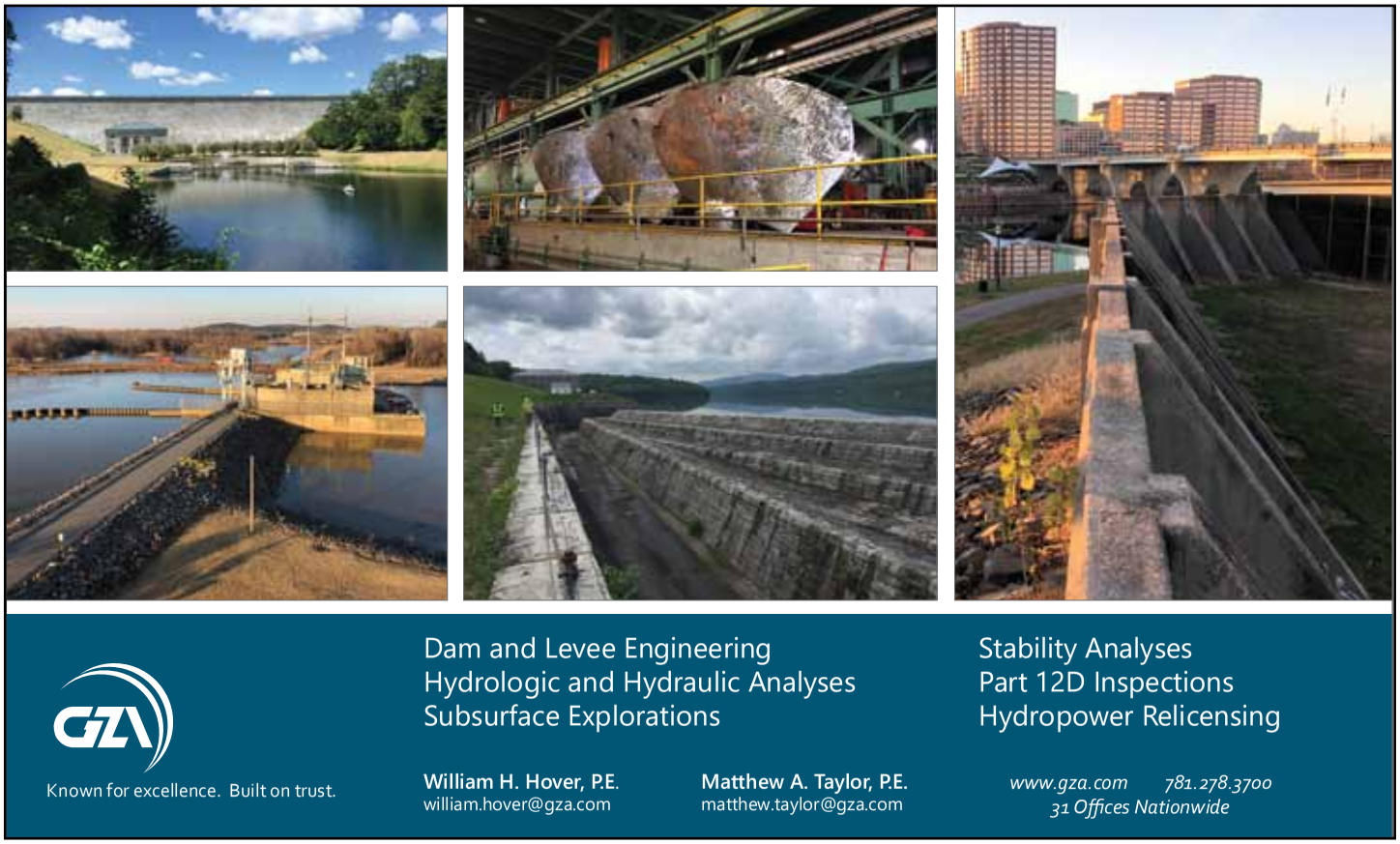
The Performance Measurement Baseline (PMB) (Earned Value Management (EVM) - Lite) System is another tool the LDRIP Program is utilizing to further enhance good project management skills and to aid in the proactive identification and quick resolution of resource challenges. The mandated use of this system for all LDRIP studies and projects helps to drive aggressive project delivery, assist in proactive management, and minimize upward reporting by reinforcing the utilization of USACE existing automation tools in the field, divisions and at the Headquarters level.

With the approval of LDRIP studies and projects in early July 2018 and initial funding to the field by early August 2018, the Supplemental Program is well underway and making progress. Within the Investigations account, all 31 of the new Feasibility study activities have executed Feasibility Cost-Share Agreements with the non-federal sponsor, and are on schedule to reach the Alternative Meeting milestone by early March 2019.

As part of the PMB EVM-Lite System, the December 2018 initial baseline schedule for the LDRIP construction projects shows significant work ongoing in the Planning, Engineering, and Design Phase which is proceeding per project schedules. Several anticipated real estate actions and contract award actions are scheduled to intensify by the summer of 2019 into 2020, with the baseline schedule projected to peak in 2022 for the completion of numerous construction activities.

In the Construction account, key focus areas for the remainder of this fiscal year include the execution of the remaining Project Partnership Agreements, non-federal sponsor acquisition of real estate, and construction (aka "Move Dirt!").

The benefits to the nation to be achieved from executing the repairs, studies and projects as described in the BBA of 2018 cannot be understated nor taken for granted. USACE, with the nation's support, will continue to do what is required to make a positive impact in the lives of others through the successful execution of the Supplemental Program.



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Committee Chair Updates

The USSD Board of Directors has approved the following committee appointments:

Advocacy, Communication and Public Awareness — Communication subcommittee — Chair, **Tara Schenk McFarland**

Monitoring of Dams and Their Foundations — Chair, **Georgette Hlepas**

News of Members

Jeffrey B. Bradley, founder of WEST Consultants, Inc. received the 2018 Service to the Profession Award from the U.S. Committee on Irrigation and Drainage.

Canary Systems, Inc. has released a major update to its MultiLogger® Suite software platform for automated and manual data acquisition.

Brian M. Crookston is now an Assistant Professor at Utah State University, Logan, Utah.

GZA GeoEnvironmental, Inc. has announced that it has named Patrick F. Sheehan as Chief Executive Officer. He succeeds William E. Hadge, who has served in the role since 2013. GZA also announced that John C. Murphy has been promoted to the new position of Chief Operating Officer.

Eric Halpin retired from the Corps of Engineers and has established his own firm, Halpin Consultants LLC.

Korey Kadrmas is now with the Colorado Dam Safety Office.

Woogu Kim is a Professor at Hanyang University, Seoul Korea.

Nick Patch is now affiliated with Clark Bros. Inc., Missoula, Montana.

David Paul retired from the Corps of Engineers and has started his own engineering firm, Paul GeoTek Engineering, Arvada, Colorado.

Phoebe Percell has been named Chief of the Dams and Levees Branch and Deputy Dam and Levee Safety Officer, U.S. Army Corps of Engineers, Washington, DC.

Justin Phalen is now affiliated with Slate Geotechnical Consultants, Inc., Oakland, California.

Robert Pike has been selected as Chief of Dam Safety, Bureau of Reclamation.

Jeffrey S. Sanger has retired from Worthington Products, Inc. after 18 years as co-owner, and 30 years in the power industry.

Justin Stoeber is now a Senior Dams Engineer for AECOM, Greenwood Village, Colorado.

Jerry W. Webb joined the WEST Consultants, Inc. in November. He had spent more than 44 years with the U.S. Army Corps of Engineers.

WSP USA has announced that Michael Mondshine will assume leadership of the Sustainability, Energy and Climate Change national practice. David Terry has been named Director of Operations for the Water & Environment Sector. Hans Hasnay has been appointed Dams & Reservoirs Practice Lead.

Gannett Fleming Announces Innovation Challenge Winners

Gannett Fleming's Collaborative Research & Innovation Center (CRIC) Working Group selected **Jeremy Begley** and **Aimee Corn** as winners of the 2018 Gannett Fleming Innovation Challenge: The Fourth Industrial Revolution. "We chose Jeremy and Aimee from an outstanding pool of applicants," said Bob Scaer, Gannett Fleming chairman and CEO. "Their winning idea is based on the years of experience of our structural dam group combined with an innovative use of real-time data analytics and performance-based testing." Corn and Begley, who are based out of the firm's Denver office, will receive a cash prize and the support of the CRIC as they implement their validated concrete dam modeling innovation. A team composed of **Rafael Prieto** and **Cari Beenenga** was named as a runner-up.

In Memorium

Catalino B. Cecilio died March 13, 2016 at the age of 78. He had a 25 year career at Pacific Gas and Electric Company as a Senior Civil Engineer in the Hydro Engineering and Construction division. He was a life member of USSD and served on the Board of Directors from 1992 to 1997.

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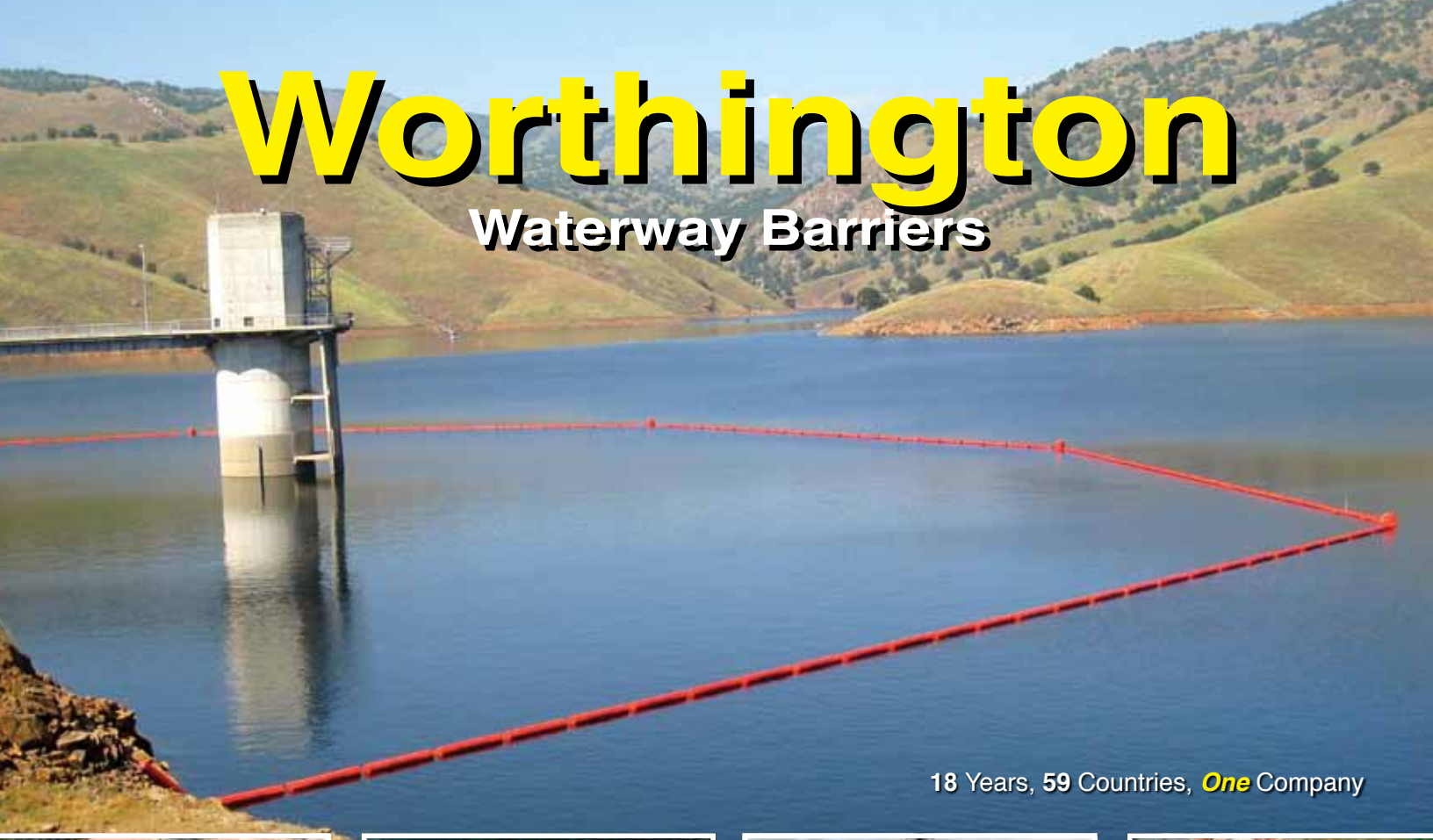

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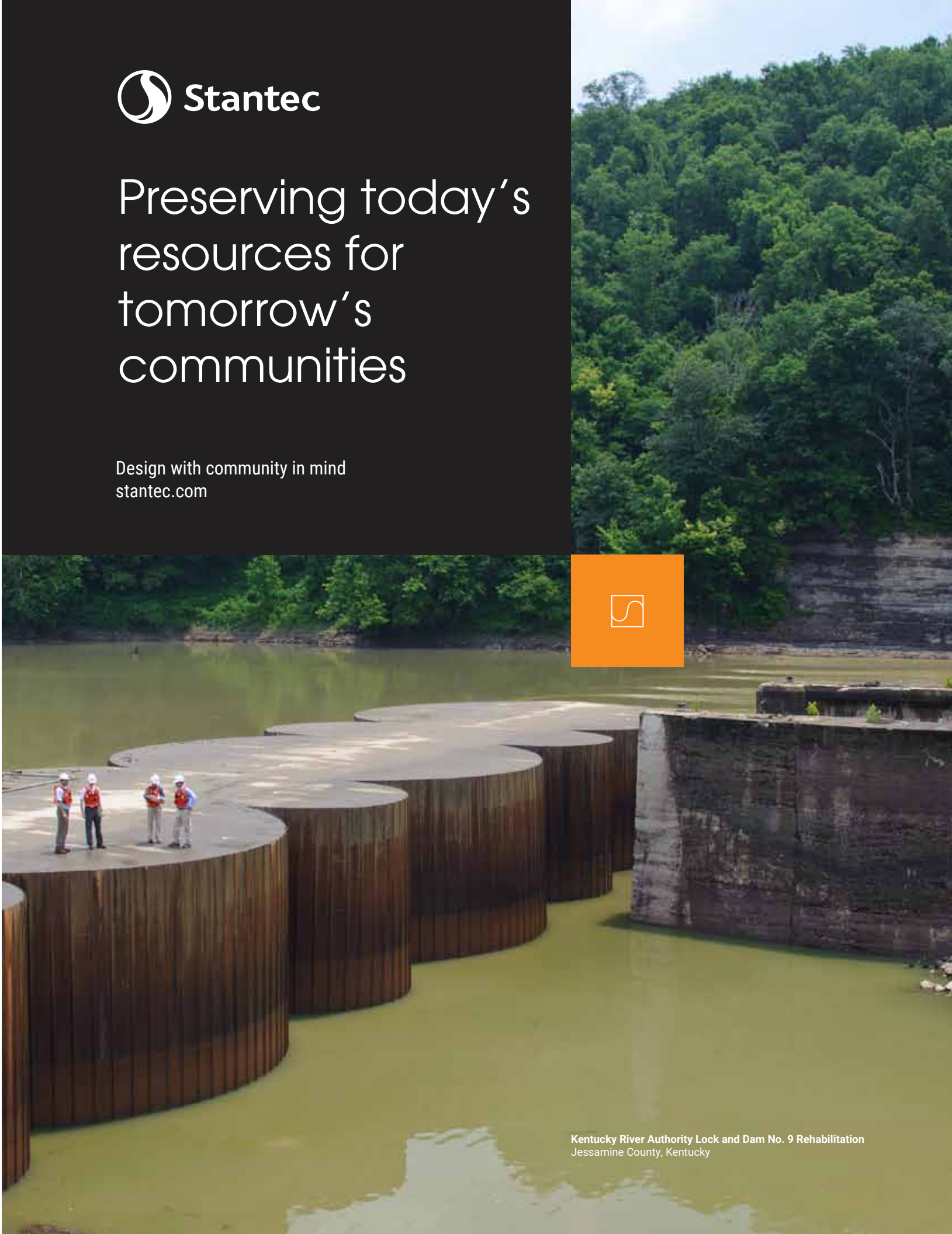

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