Rapid Response to Emergencies:

ASDSO – Seattle Washington
Tuesday September 21, 2010
General Session 8:30 – 10:00 AM

1 **Matt Lindon - Moderator**
Assistant State Engineer - Utah

Introduction – The Ah Ha Moment

2 **Michele Lemieux**
Montana Dam Safety

Powell Dam, MT
***Salt Fork Dam, OH* – Mia Kannik – Ohio Dam Safety**
***Lake Needwood, MD* – Hal Van Aller – Maryland Dam Safety**
***Washakie* Dam, WY – John France - URS Corp.**

3 **Mark Baker**
Bureau of Reclamation

Glen Canyon Dam, AZ
Folsom Dam, CA
Fontenelle Dam, WY
***A.V. Watkins, UT* – No Abstract**

4 **Joel Sipe**
Pennsylvania Dam Safety

Arrowhead Lake Dam, PA
Valley View Dam, PA
***Whittenton Mill Dam, PA* – No Abstract**

5 **Bill Sturdevant**
Wisconsin Dam Safety

West Fort Kickapoo – Hidden Valley Dam, WI
Hatfield Dam Millrace, WI
Park Lane (Pardeeville Lake), WI

Rapid Response to Dam Emergencies Introduction; The Ah-Ha Moment

BOOM, It hits you, out of nowhere, like a punch in the stomach. Like looking in your mirror and seeing a police car. You know what is wrong and the lesson is learned as soon as the lights go on.

The cold and stormy, midnight call from dam owner Dick Dingleberry saying “We have a problem”. “Weeeee”, you think as he explains that his nightmare dam is leaking 500 GPM of muddy water from an area somewhere in middle of his dam exactly over the outlet. It’s that Holy Crap Moment when life, as you know it, changes for ever. Time will be measured, from here on out as before or after this moment. Up to this point, you have done all of the dam engineering and owner mentoring you could do. You have handled the politics, the public posturing and the personalities involved with this structure. You have addressed all of the FEMA required emergency preparedness and mitigation but now it is time for reaction, response and hopefully recovery.

As in any emergency, the first thing you do is treat yourself for shock. If you are a bumbling basket case at this point, then the cause is already lost. Clear your mind, relax your nerves, feel your senses. Take a chill pill, a deep breath and make an accurate assessment of your abilities. Get help if you need it, right away. This is no time to be winging it or heroically go it alone. Look at this as an opportunity, the kind that makes or breaks careers, but don’t be stupid. Don’t blow it. Above all – Do no harm. As in any human endeavor, the first step is critical since it sets the pace and direction for every subsequent step. Think of Michael Jordan, Lawrence Taylor, Wayne Getzky. Not only did they have a quick first step, but they intuitively knew in which direction to take it. Go with your instincts because they are a subconscious amalgamation of everything you know. Trust your gut.

I received a call like this one-day at work, at noon on a clear Tuesday – not on a cold and stormy night. I was pissed. I was supposed to play basketball at lunchtime and this was a terrible inconvenience. ‘Maybe ill check it out after lunch’, I thought. **Wrong**. Get the file and plans, get the phone and the flashlight, get in the truck and go.

Sure enough this 100 year old nightmare dam, located just above Salt Lake City on the fault line, was full and leaking badly above the outlet. The new HDPE outlet liner and annular grouting were almost a year old and this was the first filling after repairs. This dam, that never had seepage issues, now had them in a big way. How often has this happened? The amount of damage done to this world in the name of improvements and good intentions is baffling. If it ain’t broke don’t fix it.

Seepage was pervasive on the downstream face but worse over the outlet. Small slumps and sluffs were starting to form. The first thought to my racing mind was evacuation, of the reservoir and perhaps the downstream inhabitants. The problem was obviously with the outlet or the intake well but opening the outlet would drop the head on the upstream gate and also start to draw the reservoir down. The owner wanted to fill the outlet tower with betanite pellets that we didn’t have and couldn’t find, a move that would have sealed the outlet and sealed our fate by preventing evacuation of the reservoir. Gut check time, I’ve got a better idea and I’m going for it. We opened the outlet fully to start to drain the lake, reducing the hazard and head. We sent someone downstream to warn residents of the impending high releases and possibly some very high flows.

Experts and officials began to materialize out of nowhere, all with their own credentials and opinions. At the worst possible moment, Deenie Wimmer, a 20 something knock out anchor woman from the local TV station dressed in a spotless white pants suit, came traipsing across the dam crest with a camera man in tow, thrusting a microphone into my face. “What’s wrong with the dam, is it going to fail, do we need to evacuate, are people going to die, …" she fired questions at me in rapid succession, never pausing to hear an answer. My mind was swimming as I looked at her white Geno GamaGucci shoes covered in mud and told her 'I didn't have a clue'. As things went from bad to worse, my Division head and Department director miraculously showed up, and with merely a nod to me, ushered the extraneous officials to one abutment and the press to the other, addressing their concerns and leaving a small group of real dam engineers and owners to figure out the problem. We have learned that with the media – if you don't give them the story, they will make up their own. Control the media, but keep them informed, and control your story.

We considered all of the cause and effects of blankets and betanite, filters and fabrics, diaphragms and drains, pumps and Piezometers, evaluation times and inundation maps. While we fiddled with the facts, I spotted the contractor from last years retrofit, off to the side, smoking nervously. 'Gary', I asked after brief pleasantries, 'how much grout did you pump into the annular space between the new HDPE outlet and the totally deteriorated CMP'. True to form, he said 'the design amount dictated in the plans and indicated on the pay request', as he looked away. 'Gary, how much grout did you really pump,' I repeated impatiently. He said 'about enough to grout half of the pipe' and he shuffled his feat. 'Gary, tell me the truth' I said almost yelling but placing my hand on his shoulder, 'this is critical.' He looked me in the eyes and spoke softly and quickly – 'the grouting went badly, and if there was 10 feet inserted at the bottom end of the pipe, that would be a lot'. This was the 'Ah-Ha' breakthrough moment we had been hoping for.

We quickly mobilized a concrete driller and drilled into the annular space above the outlet. When we drilled in about 9 feet, water exploded around the drill stem and shot mischievously over everyone. When we pulled the drill out, the 4-inch water stream shot out horizontally at least 10 feet before succumbing to the gravity of the plunge pool. Within one half hour the seepage began to abate and eventually stop. The old rotten CMP outlet had functioned as an embankment drain for years and when we fixed the outlet, we had sealed the drain. This dam was never filled again and eventually decommissioned.

We were done by sundown - tragedy narrowly averted. We went for a beer and discussed what had gone right and what had gone wrong. We had used our experience and good engineering, we trusted our gut, we kept our cool, we isolated the press and officials but kept them informed, and we counted on the people and personalities we trusted and new best. Interpersonal relationships cultivated over years of public service are critical in times of duress.

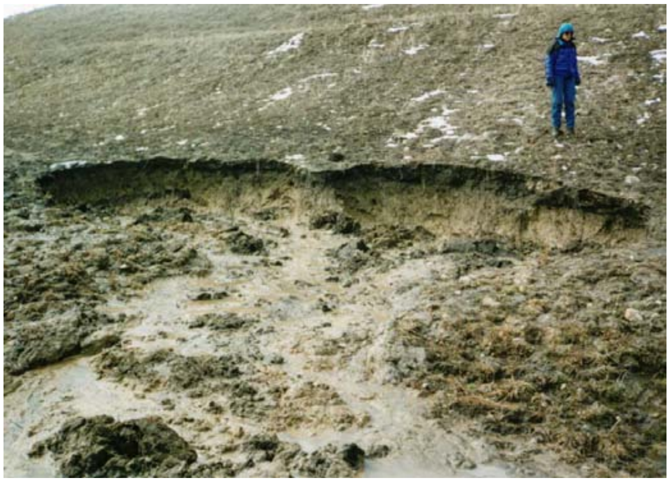
We got lucky too. This could have been at night, in a storm, with no one to help and no one to care. This could have been bad. In years to come, during other emergencies, we would have to breach a downstream dam to prevent the eminent breach of an upstream dam from causing a serial breach, compounding peak breach flows. The plan worked well but unfortunately a homeless man, attempting to cross the flooded river fell from an overhanging cable to his death. You can't fix or predict everything. On New Years Eve in 1989 during the Quail Creek dam failure we sent the sheriff, with sirens and badges and guns, downstream to evacuate residents in the flood plain. The sheriff was saluted and told 'Happy New Year to you too". Timing is everything. So we chalk it all up to experience. Live and learn. What doesn't kill you makes you stronger. We hope to share our experiences here today, not to kill anyone, but to make us all a little stronger.

Matt Lindon, Utah - Assistant State Engineer

Rapid Response to Dam Emergencies: **Powell Dam, Montana**

Problem Description

In June, 1995, the Montana Dam Safety Program received a call from the State Prison Ranch. Approximately 100 GPM of seepage was flowing from a large hole at the toe of one of the large ranch dams. The hole was increasing in size rapidly….flow was increasing as well. Unquestionably, this would lead to catastrophic failure of the dam in short order.



Blow out at toe of Powell dam

Response

The ranch had several rolls of a woven geotextile on hand (for silt fence construction). They placed the geofabric directly over the rapidly developing hole, and weighted the fabric down with drain rock that was stockpiled nearby. This successfully stopped the seepage erosion from progressing.

Repaired blow out

Cause

The blow out hole was located on the left edge of a recently constructed seepage control berm. It is suspected that construction of the seepage berm may have concentrated seepage towards the edges of the berm. Another contributing factor could have been the storage of top soil during construction. When the top soil was removed, the area may have been left with an uplift safety factor near 1. What is perplexing is the failure did not occur until the second filling after construction.

Lessons Learned:

- Maintaining stockpiles of emergency materials nearby can save the day!
- Watch extents of blanket drains – can cause a problem to move
- Neglecting the installation of monitor wells should never be part of a cost saving measure.

Status:

A toe drain was added to the dam, intercepting and draining the gravel layer believed to be the source of the high pressures to the area. No further problems have been encountered.

Rapid Response to Dam Emergencies: **Salt Fork Dam, Ohio**

Problem Description

In February, 2005, the Ohio Dam Safety Program received a call from the Salt Fork State Park. A large seepage boil had appeared at the toe of the 61 foot high dam, following record high pool levels. Staff had noted water at the toe of the dam, but the alarm was not sounded until the dam safety trained maintenance manager observed the boil. The boil was 4 feet in diameter, cloudy, with soil particles moving at the bottom.

Record high pool levels preceded incident

Four foot diameter boil at toe of dam

Response

A sandbag ring was constructed around the boil and a V notch weir installed to monitor flow. The amount of flow coming into the lake made it impossible to quickly lower the lake level. The use of large pumps to assist with the drawdown was not an option, due to high cost and availability. Excavating through an abutment to drain the lake was considered, but since both abutments are bedrock this idea was abandoned. It was decided to construct a weighted filter berm over the boil consisting of pea gravel over the boil overlain by concrete sand. Seepage flow increased from 50 GPM to 130 GPM during a short period of time

Sand bag ring

Lessons Learned:

- Train all peoples working on dam to recognize dam safety problems.
- Critical to have sand bags on hand
- Don't overlook critical inspection items (toe drain)

Cause

The boil was caused by a malfunctioning toe drain and surcharging of the toe drain by flows from the right abutment. The toe drain material consisted of a concrete sand filter material and a larger drainage material of gravel up to 8 inches in diameter that was clogged with sediment. The drain pipe also had a tear in it, and the pipe was full of sediment.

Construction of Weighted Filter Berm

Rapid Response to Dam Emergencies: **Lake Needwood Dam, Maryland**

Problem Description

In June, 2006 heavy rains caused a 23 foot rise in Lake Needwood, located in suburban Washington, D.C. Uncontrolled cloudy seepage through the dam and foundation occurred and the dam was on the verge of failure. The Dam had been judged to be in excellent condition prior to the event. No serious problems occurred when the lake rose to a similar high level in 1972. Annual inspections of the dam starting in about 1995 noted some wet areas, and by 1999 nine observation wells were installed into the dam embankments and foundation

Seep on left abutment viewed from downstream slope

Response – the Bucket Brigade

First, gravel was spread over the entire leak area. The gravel is used to collect seepage. Next filter fabric was placed over the entire seepage area and held down with gravel and sandbags. The filter fabric was intended to minimize the loss of soils due to internal erosion. The filter fabric was then held down with sand bags and gravel. Evacuation of 2400 people also took place. A simple plywood monitoring weir was constructed to monitor the change in seepage.

Spreading gravel over the leak in preparation for filter

Filter Fabric with sandbags and gravel for weight

Cause

There were insufficient funds to grout the entire foundation during construction and only the right side was grouted. The leak occurred in the ungrouted left abutment. Some finger drains of gravel were included on the left side to control foundation seepage, but the leakage rate during the flood exceeded the flow capacity of the gravel drains and flow started exiting the embankment when the head increased.

For more info: Hal Van Aller (hvanaller@mde.state.md.us)

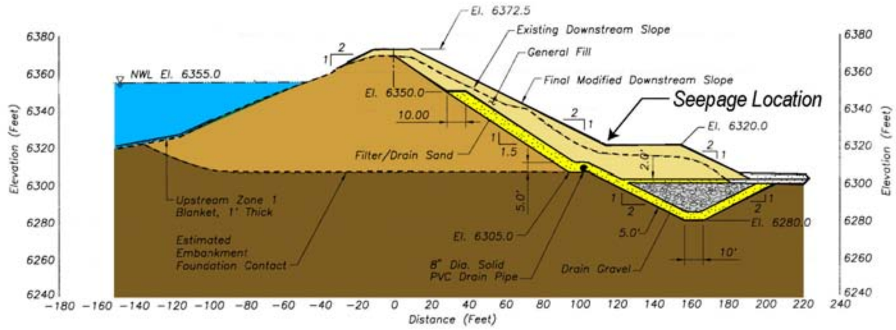
Lessons Learned:

- Observation wells installed 7 years ago at State's urging were invaluable during the incident in determining when it was safe to let evacuees return home The current policy of discouraging well installation in existing dams should be examined
- Neglecting treatment of fractured bedrock may not be an appropriate cost cutting measure
- Not all design/construction problems will be identified during first fill…may occur after years of safe operation

Rapid Response to Emergencies: Washakie Dam, Wyoming

Problem Description

Washakie Dam had undergone a major modification project to address historic seepage problems, principally through the glacial foundation soils. The modification included a single-stage chimney drain and a two-stage, deep, toe drain (Figure A). In June 2000, during first filling after the modification, a damp area was observed at the junction of the downstream slope and a toe berm. While test pits were being excavated to investigate the wet area, seepage and piping occurred suddenly in one of the pits.



A. Cross Section of Original Modification

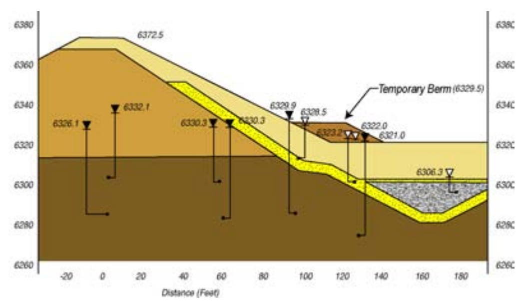
Response:

B. Temporary Berm

Outlet gates were immediately opened to begin to lower the reservoir. Sand and gravel filter materials used in the two-stage toe drain had been stockpiled on site for use if problems developed during first filling after the modifications. These materials were used to fill the test pit. It was found that the filter materials had to be placed to about 5 feet above the pre-excavation grade at the test pit to control the flow. A 24-hour per day monitoring program was put in place. A limited number of residences located a short distance downstream from the dam were evacuated overnight, as a precaution. A temporary filtered berm was constructed along the downstream face of the dam, as shown in Figure B.

Cause:

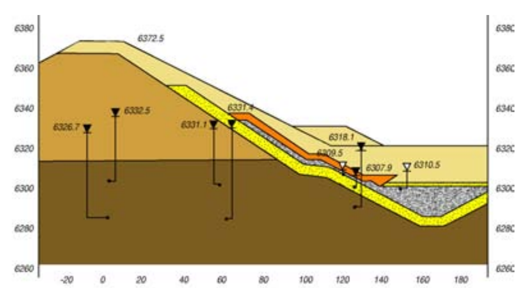
Investigations, including detailed evaluations of piezometers (Figure C) indicated that the incident was caused by large quantities of concentrated seepage flowing through highly permeable zones in the glacial foundations. This seepage was so concentrated and so large that it overwhelmed the single-stage sand chimney drain. The chimney drain could not convey the seepage to the large capacity toe drain below. The seepage bled off of the drain, raising the piezometric pressures in the downstream section of the embankment, causing the wet area and a blowout in the test pit.



C. Piezometer Readings

Lessons Learned:

- Sand and gravel on hand were very valuable in quick response.
- A functional outlet works with good discharge capacity is also very valuable.
- Careful monitoring during refilling after modifications is essential.
- Two-stage filters are highly desirable where very permeable layers are likely in the base soils.



D. Cross Section of Additional Modification With Piezometers

Status:

The embankment was further modified to include a two-stage chimney filter drain connected to the toe drain, which successfully controlled the piezometric levels (Figure D). The dam has performed well subsequent to the additional modifications.

Rapid Response to Dam Emergencies: Glen Canyon Dam Spillway Erosion

Problem Description:

A tremendous amount of snow-melt runoff occurred in the Colorado River basin in 1983. Lake Powell behind Glen Canyon Dam rose higher and higher. The rate of rise and inflows (up to 116,000 cfs) required the operators to use the dam's 41-foot diameter spillway tunnels for the first time. After operating for several days, the tunnels were inspected and significant cavitation damage was found. The spillways were used for six weeks and both tunnels were significantly damaged.

Response:

As inflows increased, the decision was made to add a 4-foot flash board on top of the spillway radial gates. As the reservoir continued to rise, these flashboards were removed and an 8-foot-tall flashboard was installed. The decision was made to operate the left spillway and to keep the right spillway in reserve by limiting its use. Loud rumbling noises were heard coming from the left spillway. Large rocks and brown water were observed in the flows exiting the spillway portal. No one knew how extensive the left spillway was being damaged. The spillway operated for a total of six weeks. After it was finally closed, inspectors entered the downstream end of the tunnel on inflatable rafts. The damage was extensive. Several hundred feet of the lining were damaged or removed and a huge 35-foot-deep hole was found eroded into the soft sandstone.

Cause:

It is suspected that high flows passing over calcium deposits in the spillway elbow joints initiated the cavitation. Once cavitation damage became significant erosion became the most significant contributor to the damage. The soft sandstone was vulnerable to cavitation and erosion.

Lessons Learned:

- Changes in high velocity waterflow direction (such as at a spillway elbow) can cause cavitation. Small surface discontinuities can initiate cavitation.
- Hydraulic model testing can aid in identifying areas of potential cavitation.
- Injecting air in flow discontinuities can prevent cavitation.

Status:

In 1983 and early in 1984 the hole was filled and the tunnels were repaired. An anti-cavitation system designed to entrain air into the water was part of the project.

Rapid Response to Dam Emergencies: Folsom Dam Gate Failure, California

Problem Description:

On July 17, 1995, the gate operator stationed at Folsom Dam in California attempted to operate a spillway gate during a routine release procedure. The power plant was going through a scheduled shutdown and releases from the reservoir were required to be re-routed through the spillway. The operator began to hoist the radial gate #3 and felt an unusual vibration along with groaning noise. He turned to look at the gate a saw the radial gate swing outward away from the dam while water poured from the opening. An estimated 400,000 acre-feet of reservoir was lost.

Response:

The gate operator immediately notified dispatch and personnel located at the power plant. The operator then drove to Nimbus Dam which was located 7 miles downstream from Folsom. The gates at Nimbus were adjusted to account for the additional flow coming from Folsom. The local media from Sacramento flooded the scene with helicopter coverage and ground crews. Although the dam road was closed immediately following the accident, the Bureau worked with the local media, allowing access and proactively provided information to the public regarding the incident.

Cause:

Forensic investigation of radial gate #3 indicated that trunnion pin friction was the main cause of failure. Years of service had caused corrosion and wear on the trunnion pin which lead to additional moments induced on the struts supporting the gate. The added stress caused a failure in the lower struts. Forces then transferred to the remaining members causing failure as well. The elapsed time from the operator feeling the unusual vibration to failure is estimated to be less than a few seconds.

Lessons Learned:

- Moments and stresses caused by additional friction within the trunnion pin connection must be considered in the structural design of radial gates.
- Handling the local media in an un-evasive and proactive manor may prove beneficial. Trust and confidence was established and rumors avoided from this approach.

Status:

A replacement gate was fabricated for bay #3. The remaining 7 radial gates were refurbished to handle the additional loads caused by frictional moments. Gate repair cost $20 million.

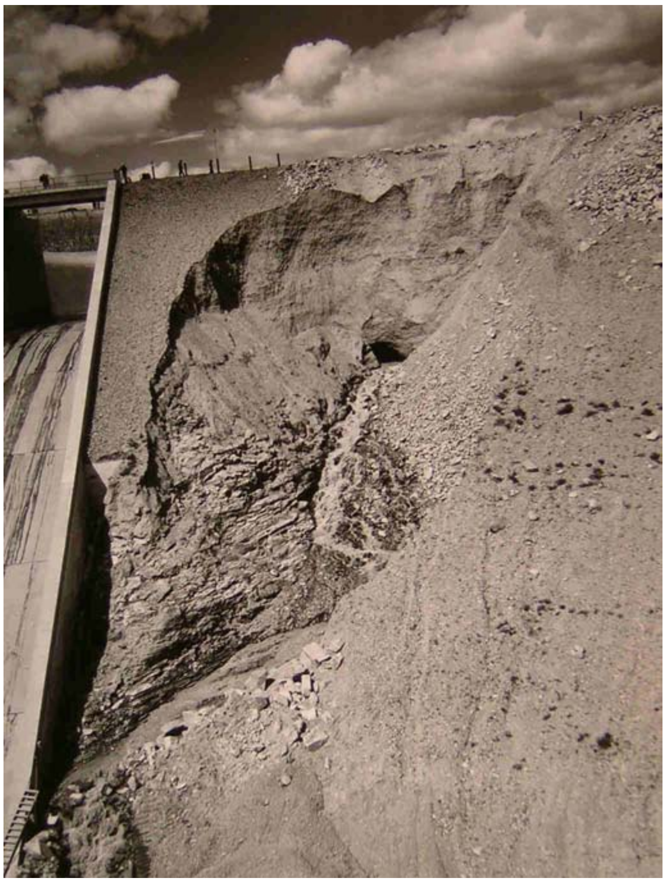
Rapid Response to Dam Emergencies: Fontenelle Dam Near-Failure, Wyoming

Problem Description:

Fontenelle Dam was filling for the first time following construction during the summer of 1965. High runoff and outlet works issues caused the reservoir to rise faster than planned. Significant seepage occurred through both abutments. The right abutment seepage extended to the right end of the dam causing sloughing on several occasions. On September 3, 1965, a large seep began eroding a huge cone shaped void in the downstream face of the dam. An estimated 10,300 cubic yards of material was eroded within the first 24 hours. The leak was measured as 6 cubic feet per second.

Response:

A contractor working on the outlet works was directed to relocate their equipment in an effort to slow the leak and the sloughing. This proved ineffective. The irrigation headgate was opened and the outlet works was opened to lower the reservoir and reduce the seepage flow. Large rock was dumped from the crest of the dam into the void. This rock mixing with embankment soil caused temporary blockage of the leak but then the seepage reemerged. A 20-foot by 15-feet sinkhole emerged in the crest of the dam on the 4th day of the incident. This was filled with riprap from the upstream slope. Failure was averted due to the above actions and the lowering of the reservoir. There was extensive media coverage and public interest in the event.



Cause:

To investigate the incident, the entire right end of the dam was removed. The abutment was found to be highly fractured, no dental concrete was placed, it was very steep and there were rock overhangs. The Corps of Engineers sent a team to investigate. The leak and near failure were attributed to reservoir water passing through horizontally-bedded sandstone/shale. The single line grout curtain was inadequate. Much more effort should have been undertaken at the rock/embankment interface. Filters and drains should have been incorporated in the design.

Lessons Learned:

- Not enough of the geotechnical lessons were learned as many of the causes of Fontenelle were similar to the causes of the failure of Teton Dam 11 years later.
- Multiple lines of defense should be incorporated into dam designs.

Status:

An extensive grouting program was performed on the right abutment and the dam was repaired and returned to service. A seepage cutoff wall was constructed along the entire length of the dam in the 1980's.

Rapid Response to Dam Emergencies: A.V. Watkins Piping Near-Failure, Utah

Problem Description:

A.V. Watkins Dam is a Bureau of Reclamation dam near Salt Lake City, UT. It has a maximum height of 36 feet, is 14.5 miles long and stores 215,000 acre-ft. On November 13, 2006, a local rancher notified district personnel of seepage at the downstream toe. District and Reclamation personnel immediately went out to the site and observed active piping (internal erosion). Seepage was estimated to be 1-2 cfs. Active sand boils were observed. A substantial amount of material was found deposited in the South Drain canal located just downstream of the dam toe. A slough developed on the downstream slope and cracking indicated the embankment was being compromised.

Response:

An emergency was declared. Equipment was stationed at the west dam section in case an emergency breach was needed. Reservoir drawdown was initiated. Sand and gravel sources were located and transported to the site. An excavator and other equipment were mobilized. Reclamation and the District worked through the rainy night to save the dam. Initially, filter material washed away because of high flows. A 75' x 100' filter and stability berm was constructed at the toe of the dam and up the downstream face. However, 150-200 gpm cloudy seepage continued to emerge in the South Drain. To cut off the upstream entrance seepage location, a large berm (6,000 cubic yards) was constructed on top of the upstream slope.

Cause:

A forensic study and report of findings were prepared. The presence of the South Drain canal and layers of foundation hardpan played key roles in the piping incident. The saturated, loose sands, silty sands and silts below the hardpan were highly erodible. Piping initiation could have been attributable to a number of factors including: animal burrows and high gradients due to limited effectiveness of the toe drain.

Lessons Learned:

- Many years of satisfactory performance does not guarantee future performance.
- The public can sometimes recognize a dam in distress.
- Availability of materials and equipment in an emergency can make the difference between a close call and a dam failure.

Status:

A cut off wall was constructed through a long section of the dam as a long-term solution.

Rapid Response to Dam Emergencies: Arrowhead Lake Dam, Pennsylvania April 1994

Joel Sipe, Pa Department of Environmental Protection (PA-DEP)

Problem Description

In December 1993, due to severe weather the emergency spillway apron repair work was put on hold until spring. In April 1994, prior to the contractor returning to the project, a maintenance man observed a large muddy boil approximately 20 feet in diameter just below the weir with a whirlpool in the reservoir directly upstream of the weir.

Whirlpool above weir with boil flowing downstream of weir.

Response

The emergency action plan was activated immediately. A local stone quarry provided equipment and materials to plug the boil. A cofferdam was constructed upstream of the weir to dewater the area so an inspection of the weir could be conducted.

Void upstream of the weir.

Repairing the void upstream of the weir.

Cause

A trapezoidal shaped void 20-feet long, 4-feet deep had developed under the weir. The concrete cutoff wall consisted of logs and sticks surrounded by bags of concrete.

Lessons Learned

- Larger rock (2-3 feet in diameter) were the most useful in the initial response.
- Review history and records for the dam.
- Prior to completing the design investigate the entire structure.

Repaired spillway.

Status

The upstream void was repaired with concrete. A new concrete spillway apron with an under drain system was constructed. A concrete cutoff wall was placed downstream of the new apron. All repairs were completed by July 1994.

Acknowledgement given to Robert J. Cadwallader and Michael A. Sames, PA-DEP, for the use of their paper entitled "The Failure and Rehabilitation of Arrowhead Lake Dam."

Rapid Response to Dam Emergencies: Valley View Dam, Pennsylvania October 2009

Joel Sipe, Pa Department of Environmental Protection (PA-DEP)

Problem Description

This dam was owned by the Valley View Lake Association. The Association had been notified that they must address the inadequate spillway capacity, investigate seepage along the outlet conduit and develop an emergency action plan. Over time the Association dissolved due to the fact that as the properties around the lake were sold the new owners were not required to join the Association. The dam was listed as an "orphan dam" and PA-DEP needed to address the unsafe conditions at this dam.

Two siphons on the downstream face.

Water surface drawn down six feet below normal pool.

Response

In 2009, PA-DEP began preparing a removal plan. As the design progressed, it was realized that a complete removal would take longer than expected. It was decided that the hazard must be reduced as much as possible until the removal of the dam could take place. Four siphons were constructed to lower the water surface elevation to a point where the primary spillway structure could be cut where it meets the upstream embankment.

Lessons Learned

- Obtain all the tools to complete the project.
- Extend the second siphon out into the lake close to the required drawdown elevation.
- Know the capabilities of the local agencies.
- Investigate the history of the dam and all records for the dam to better understand what impacts your changes will have on the dam

Water level drawn down below primary spillway.

Current conditions at the dam.

Status

The removal of the dam is planned for the fall of 2010. Funding has been obtained to create an educational wetland system within the impoundment which will be maintained by a local environmental group.

Rapid Response to Dam Emergencies: **West Fork Kickapoo (Hidden Valley) Dam, Wisconsin**

Problem Description

In August of 2007 large rainfall events occurred over west central Wisconsin. This area of the state is home to the largest concentration of PL566 flood control dams in WI. Up to 12 inches of rain in 24 hours fell on very steep, saturated soils causing rapid runoff. The Kickapoo Valley took the blunt of the rain and reports came in quickly of the flood control dams filling and discharging through their auxiliary spillways. One remote high hazard structure, Hidden Valley Dam, was located downstream of a farm where hay was recently cut and bailed into large round bails. Those bails became floating nightmares to dam operations. The weather forecast for additional heavy rains caused concern with plugging of the principal outlet 80 bails remained in the reservoir and flowing of the already partially failed auxiliary spillway.

Aux. spillway crest with hay bail

Aux. spillway crest with hay bail

Response

We called in the Wisconsin Department of Natural Resources operations crew with a backhoe, small dozer and 6 people. Some of the six were fisheries staff and when brainstorming as to how to control the hay bails it was mentioned that they had access to two large seine nets. We devised a method to anchor the large nets to the shore using steel pipe and strung the nets across the entire impoundment upstream of the outlet structure making sure to allow for an increase in water levels. The forecasted rains came and nets held the bails from getting to the dam. Over the next two days the fisheries crews rounded up the bails using small boat, dragged them to shore and the backhoe lifted them safely out of harms way. A crew of prisoners from a low security prison was brought into to assist in the removal of woody debris that had washed down the valley to the dam.

A little help from NRCS and a Gnome

Hay bails contained by seines

Lessons Learned

- Hay bails are bad for dams
- Utilize all resources that become available
- Listen to all those involved and work together to “engineer” a solution with what you have
- MacGyver has nothing on this crew!

Status

The hay bails are gone for now, the auxiliary spillway has been repaired. Additional investigations into the stability of the rock abutments and auxiliary spillway are being performed.

Rapid Response to Dam Emergencies: **Hatfield Dam, Wisconsin**

Problem Description

The Hatfield Dam is a large dam located in north central Wisconsin holding back Lake Arbutus. The dam consists of two gated concrete gravity sections, a 3 mile long power canal, powerhouse and earthen embankments. The dam was built in the early 1920's using mule trains to excavate the long canal. A large rain event in June of 1997 caused a portion of the canal to fail draining the canal, flooding downstream Black River Falls and threatening to drain Lake Arbutus. The headgates to the mill race were shut prior to the lake draining completely. That is when the concern was noted.

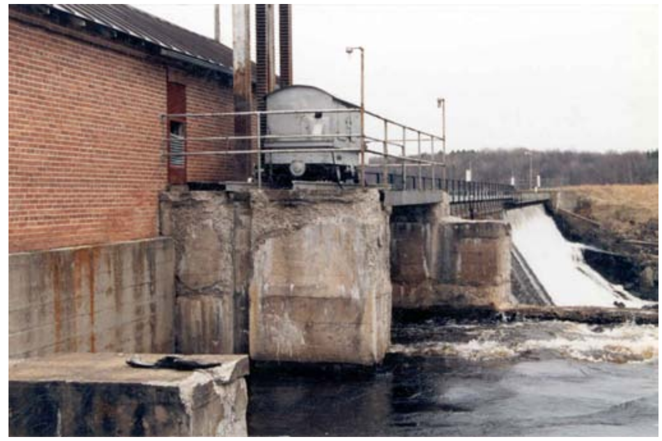
Trip gate portion of dam

Debris clogging trip gates

Response

Dam safety staff were sent to the scene to assist local law enforcement and the dam owner. Once the headgates were shut the concern became whether or not the gates were actually designed to hold the expected head once the race was drained. Emergency response had been focused on the flooding downstream of the failed structure but there could be a very dangerous situation still unfolding. A call was made back the dam safety office and calculations were made to determine if the gates would be sufficient. The onsite engineer was justified in his concern since the factor of safety for the gate structure was under 1.0 under full head.

Canal breach



Headgates

Downstream of headgates

The solution was to create another dam just downstream of the headgates to back pressure the gates and reduce the pressure. An earthen embankment was constructed using tight clay soils while the gates were temporarily closed. Construction was completed within a day and the gates were cracked open to fill the area between the gates and the new earthen plug. An engineer was on site during the “filling” to inspect the structure. There is a concrete overflow spillway between the gates and the plug that regulated the water levels during high flow. That section of spillway was intended to control the water levels in the canal.

Lessons Learned

- Make sure to look upstream as well as downstream during an emergency
- Take note of little used components of the dam and insure operability and stability

Status

The canal has been reconstructed and the dam put back into operation. The gates on the dam have been reconfigured or replaced to allow for better control of floodwaters and debris. This dam remains as one of Wisconsin's high hazard structures and is monitored closely for instabilities.

Rapid Response to Dam Emergencies: **Pardeeville Dam, Wisconsin**

Problem Description

In June 2008 Wisconsin was hit with near record rainfall falling on already saturated soils. The result was flooding over the entire southern 1/3 of the state. The Pardeeville Dam impoundment (Park Lake) was filling quickly even with the primary spillway structure completely open and unobstructed. A low area to the south of the dam was threatening to overtop State Highway 22. The highway is not designed to withstand overtopping and this high hazard dam was sure to fail unless immediate action was taken.

Main gates (just after flood)

Emergency spillway from the air

Response

The upstream portion of the roadway was sandbagged to prevent overtopping while the idea was formulated to construct a temporary emergency spillway across the crest of the road using plastic sheets and sandbags. The plastic sheets were placed and sandbags where used on upstream end and along both sides to channel the water downstream. Additional sandbags were placed in the flow way to prevent the plastic from "floating" and to assist in energy dissipation on the downstream slope. Water was allowed to enter the channel by removing a sandbag at a time from the upstream end of the channel and monitoring the conditions before removing more bags. The channel was extended 50 feet past the edge of the road to a rocky area in hopes that the water levels would recede faster than the embankment would wash out.

Downstream end of emergency spillway

Downstream end with energy dissipation

Lessons Learned

- You can never have too many sandbags
- Don’t discount what sounds like too simple of a solution
- It took 50 people about one hour to build the spillway
- This location is good location for placement of an auxiliary spillway under the roadway (plan to construct in 2010)