SPECIAL EDITION

KANSAS DAMS

2014

REMOVAL

Regulations, Considerations, and Design Aspects

EXACTLY HOW MANY DAMS HAVE BEEN REMOVED IN KANSAS?
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DISMANTLING KANSAS RIVER DAMS

This publication was written and designed by C. A. Higgins in compliance with the public awareness objective of the federal Dam Safety Act from funding provided by the U.S. Department of Homeland Security, Federal Emergency Management Agency.

Kansas Department of Agriculture

To update dam stakeholders in Kansas, the Dam Safety Program within the Division of Water Resources at the Kansas Department of Agriculture hosted "Dam Removal: Aging Infrastructure Option" Aug. 23, 2012, at the Wichita Area Treatment, Education and Remediation (WATER) Center, 101 E. Pawnee, Wichita, Kan. This seminar examined start-to-finish projects, engineering issues, permitting requirements, and other removal aspects. Presenters included representatives from the Watershed Institute, U.S. Corps of Engineers, Division of Water Resources, Kansas Department of Health and Environment, Kansas Department of Wildlife, Parks and Tourism, and private engineering firms. A tour of the WATER Center education area and treatment facility also was included in the symposium.

ATTENDEES

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Bruce Boettcher, BG Consultants
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Brian Clennan, City of Hutchinson
Julie Cunningham, Oklahoma Water Resources Board
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Susan Erlenwein, Sedgwick County, Environmental Resources
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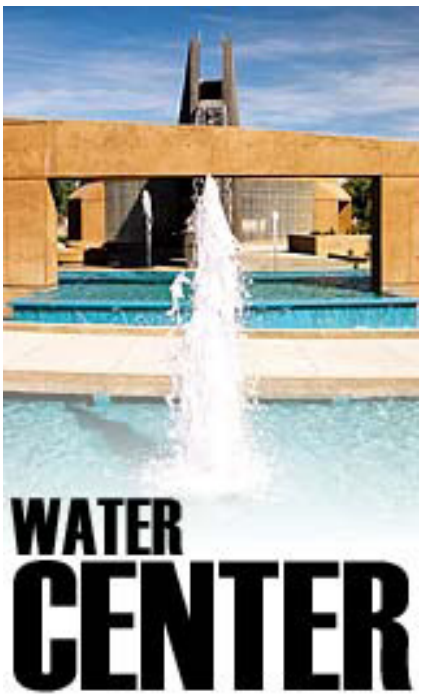


PRESENTERS

Libby Albers, environmental specialist, WATER Center, Wichita
Brock Emmert, geomorphologist, Watershed Institute, Topeka
Brett Howey, Geotechnical Services, AMEC, Tempe, AZ
Kimberly A. Hunninghake, dam safety team leader, Kansas Department of Agriculture, Division of Water Resources, Topeka
John King, water structures engineer, Division of Water Resources, Kansas Department of Agriculture, Topeka
Thomas A. McCabe, regulatory project manager/team leader, USACE-Kansas State Regulatory Office, El Dorado
Jessica Mounts, district fisheries biologist, Kansas Department of Wildlife and Parks, Wichita
Scott Satterthwaite, pollution control specialist, Kansas Department of Health and Environment, Bureau of Water, Watershed Management, Topeka

Exactly How Many Dams Have Been Removed in Kansas?

Well, that answer depends on the dam's size, when it was removed, and whether the Division of Water Resources received information for its database.

Although the state of Kansas began keeping records on permitted dams meeting certain size requirements in 1929, it wasn't until dam failures prompted Congress to authorize the US Army Corps of Engineers to inventory U.S. dams 25 feet or higher or with 50 acre-feet or more of storage capacity if more than six feet in height with the National Dam Inspection Act (Public Law 92-367) of 1972 that a physical inventory was done of Kansas' non-federal dams.

During this inventory, the Division of Water Resources created an electronic database of dams. Satellite imagery, aerial photography, topographic mapping, advanced technology, permit applications, and on-site inspections have further updated this Division of Water Resources database that is still far from complete for varied reasons.

Of the 64 breached or removed dams found in the Division of Water Resources database, 48 are of jurisdictional size. The majority of these removed dams were listed as built in the 1930s.

Many, too, were classified as "breached between 1974 to 1979" probably because these were updated in the initial National Inventory of Dams. During this inventory, inspectors often found evidence of a dam that had been breached or removed. If inspectors had access to an earlier aerial photography or topographic data, they may have recorded a best guess estimate of the dam's removal.

In terms of size, of the 16 entries reporting draining area, 12570 acres was the largest reported drainage area of a dam and belonged to a Ness County dam. The tallest (68' high) and longest (3960') dam with the largest volume (12570 acre feet) was in Butler County.

ACROSS THE NATION

A 2005 study by the American Association of State Highway and Transportation Officials found existing databases do not include all the dams removed in the United States, most removed dams were smaller than 20 feet, and deconstruction cost is about half of total removal cost. The three most common reasons for dam removals, the study found, were, in order of frequency, ecology, economics, and safety.

Dam removal appears to have been relatively uncommon before the 1980s but has escalated significantly in the 21st century. The recent acceleration of dam removals reflects problems associated with aging structures, growing interest in restoring rivers and fish passage, new funding opportunities to support dam removal, and national policies aimed at improving the safety of aging structures and mitigating the environmental impacts of these structures.

THE PROCESS

A staged process to avoid unwanted release of water and sediment that typically accumulate behind the obstruction, dam removal completely dismantles all physical barriers to stream flow. When the reservoir is emptied, a bulldozer or another earth-moving equipment excavates and removes earth.

Decommissioning is defined as the full or partial removal of an existing dam and its associated facilities or significant changes to the operations thereof.
United States Society on Dams

DWR REMOVAL PERMITTING

Construction as well as the removal of a jurisdictional dam both must comply with Kansas' Streams Obstruction Act K.S.A. 82a-301 to 328

Of the several reasons — poor maintenance, design life over, safety, illegal structure, compliance issues, cost effectiveness— why a dam owner might remove a dam, the removal is subject to the rules and regulations of Kansas' Streams Obstruction Act K.S.A. 82a-301 to 328. The first paragraph of this statute states it is unlawful to make any modifications to a stream obstruction, which a dam is, without a state permit.

"The dams we are talking about are those that meet the definition of a jurisdictional dam," said Kimberly Hunninghake, Division of Water Resources, "and the definition is an 'or' statement. "Anything 25 feet is automatically jurisdictional--or any dam 6 feet high or greater and has the capacity of having 50 acres of feet measured at top of structure. Just because your dam's not 25 feet in height, doesn't mean your dam is exempt. If you meet the second part, then it's jurisdictional. It depends on the capacity; the capacity is the caveat.

"There isn't a specific section in the regs for breach. Breaches are under "modifications" with criteria for breach routing.

Once DWR receives an application for dam removal, it will follow Water Environmental Coordination Act 82a-325 to 327 regulations and submit that application to seven Kansas agencies for a review and commentary opportunity to be completed within 30 days. The reviewing agencies include:

Kansas State Historical Society

Kansas Department of Health and Environment

Kansas Department of Wildlife Parks and Tourism

Kansas Corporation Commission

Kansas Forest Service

U.S. Army Corps of Engineers

Agencies, too, may impose requirements on dam owners, which is why applicants may want to contact them before DWR to expedite the permit process.

Plans submitted to DWR should show all aspects of the project in three dimensions, a design report documenting assumptions and analysis for the design, and specifications for all material and work items being done.

DAM MODIFICATION PERMITS APPLICABLE TO REMOVAL

The 1% chance storm (base flood area) on the stream without a dam in place and with proposed designed breach opening for downstream impact evaluation. (Unless the dam was built specifically for flood control, the owner is not required to provide flood control for downstream landowners but potential impact and downstream landowners notification is a consideration.)

Downstream impact. A plan may need to be developed to contain and stabilize sediment within the reservoir. This could include shaping channels, side slope requirements, sediment structures, or other modifications.

Erosion control. Erosion through the breach opening is dependent on factors that include slope of the breach channel through the dam, breach opening, drainage area, and vegetation. Excavated material must be placed out of the floodplain or be addressed in the plans and hydraulics for the designed breach and will be part of the permit. "You can't put more than 1 foot of fill in floodplain in the state of Kansas without permitting," Hunninghake said. "Through all aspects of the breach, we want to make sure to reduce erosion, minimize sediment transport, protect public property, and not jeopardize public safety."

Vegetation specifications and plans. Disturbed areas need to be replanted with vegetation.

HUNNINGHAKE RECOMMENDATIONS

Consult in advance of project with permitting agencies

*

Maintain regular communication with permitting agencies

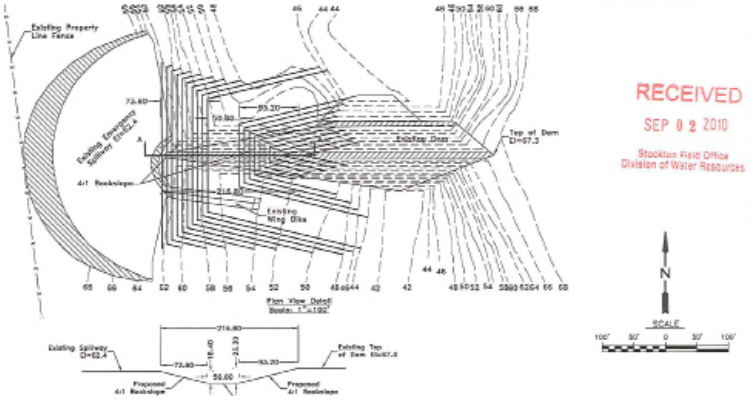
*

Incorporate sufficient time for the regulatory process

CHIEF ENGINEER BREACH ORDERS

Since 1929, a Kansas statute has prohibited stream obstructions without a permit from the Division of Water Resources' chief engineer.

The Kansas Legislature enacts written laws also known as statutes. The Kansas Department of Agriculture then develops rules and regulations to enact the statutes. The ***Obstructions in Streams K.S.A. 82a-301 through 82a-328*** statute reads: *"Dam" means any artificial barrier including appurtenant works with the ability to impound water, waste water or other liquids that has a height of 25 feet or more; or has a height of six feet or greater and also has the capacity to impound 50 or more acre feet. The height of a dam or barrier shall be determined as follows: (1) A barrier or dam that extends across the natural bed of a stream or watercourse shall be measured from the downstream toe of the barrier or dam to the top of the barrier or dam; or (2) a barrier or dam that does not extend across a stream or watercourse shall be measured from the lowest elevation of the outside limit of the barrier or dam to the top of the barrier or dam.*



The Kansas' Streams Obstruction Act statute also states that the chief engineer at the Division of Water Resources has the authority to file a breach order in District Court requiring a dam owner to remove a dam if the engineer considers a dam to be unsafe, does not meet state criteria, was built illegally, or poses a threat to public safety. Before such order is issued, the chief engineer tries to work with the landowner to resolve the issues.

If landowner chooses not to work with DWR, then DWR will start the process of issuing that breach order through the judicial process. Once a decision is made, there will be a mandate for compliance. If the owner still chooses not to obey the mandate from the court systems, then the owner is subject to civil penalties.

EXCERPT EXAMPLE FROM A BREACH ORDER

ORDER

NOW THEREFORE, pursuant to K.S.A. 82a-303c, it is the decision and order of the chief engineer that DAM OWNER shall breach the dam in the (X Quarter of ····· the X Quarter of the X Quarter of Section X, Township X South, Range X E/W, X County, Kansas. The breach shall be conducted to meet the following requirements:

1. By DATE, submit plans to breach the dam. The plans must contain provisions for reasonable precautions for the legal release of water from the impoundment in a manner to protect against erosion, release of sediment, protect property and public safety, and to ensure that the integrity of the dam is not otherwise jeopardized in such a way as to endanger public safety during the process of breaching the dam.

2. The breach material must be removed from the site or placed outside of the floodplain.

3. DAM OWNER must notify the Division of Water Resources at least 48 hours prior to beginning work on the breach of the dam.

4. A representative of the Division of Water Resources must be present at all times the breach is being conducted unless otherwise directed by the chief engineer.

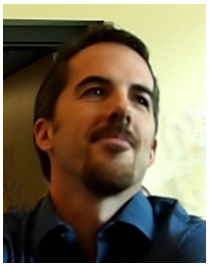
5. Due to the water level in the reservoir, a staged, controlled breach of the structure may be necessary and required, as directed by the Division of Water Resources.

6. All areas disturbed completing the breach of the dam must be reseeded to a cover of grass or other vegetation approved by the chief engineer.

7. The work listed in this Order must be completed within 60 days after the date shown on the Certificate of Service attached to this Order.

Lake Barton Dam Breach

Built by Mo-Pacific Railroad in 1922 by 100 men and 40 horse team, the dam had a 40' intake tower. Later the reservoir was used for recreation and has its own Facebook site: I Swam in Barton Lake



A geomorphologist, with the Watershed Institute, Brock Emmert, said his environmental mitigation work led to his involvement with the Lake Barton dam removal.

The story of Lake Barton began when the Missouri Pacific Railroad Company with the aid of a hundred men and 40 livestock teams constructed the 1922 dam to provide water storage for the rail shops at Hoisington. Because the 32 feet high 1630 feet long dam had a drainage area of only 358 acres, water was pumped into the reservoir from Walnut Creek to insure sufficient water for the railroad's needs. The only outlet works, a reinforced concrete intake tower, discharged into a 4 feet by 6 feet reinforced concrete box conduit through the embankment.

Gate valves controlled the three 14 -inch diameter pipes into the tower. About 307 acres drained into Lake Barton, 85-acre reservoir. Once the water left, it flowed three miles across a highway and then to a wetland west of Cheyenne Bottoms. Over time, Lake Barton became a recreational reservoir and continued to be a popular community amenity until the 1980s when the lake couldn't maintain a permanent pool because of restricted groundwater and surface water. In 1999, the dam became classified as high hazard, a classification based on downstream impact if the dam failed. This classification requires a safety inspection every three years by a licensed engineer. The owner didn't want to pay for the inspections, so faced the options of either upgrading or dam removal. Since the water source wasn't available, the owner decided to remove the dam.

DWR Water Structures Program File Notes

Barton County. . .*a review of the breach shows work is in compliance with plans approved on July 1, 2011. The bottom width of the breach is 30 feet, with 3:1 sideslopes. Rock riprap is placed at the upstream and downstream side of the channel constructed through the breach area to prevent erosion. Sideslopes have been seeded and have a matting placed to prevent erosion and to hold mulch. New grass is growing on sideslopes. Breach centerline is 166 feet to the west of the old control tower as shown on the plans. The tower has been removed and area has been graded to drain to breach area. Work in the area is complete and overall the project turned out very well and is in compliance with the approved plans.*

Barton Lake has its own Facebook site: I Swam in Barton Lake.
Also see Facebook site: Barton Lake Dam Breach.

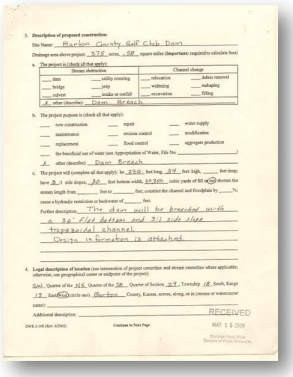
"One thing we had to work out was site protection," Emmert said. "Our instrument, conservation easement, has been a deal breaker and not always popular. We took an easement that encompasses the lake bed of Lake Barton. Before we did that, we documented existing environmental conditions to make sure of any negative impacts. Once we had easement in place, we designed the breach, filed a USACE Mitigation Plan to Corps, and also submitted designs to DWR for a dam modification permit before any construction to make sure they approved the new breach design. Since we were going to disturb more

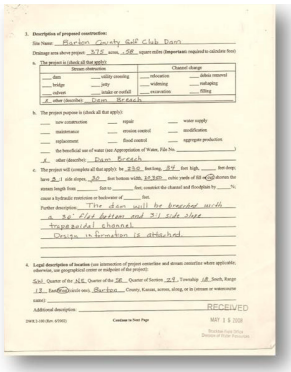
than one acre, we filed the NOI with Kansas Department of Health and Environment for sediment control during construction activities.

"The original design was changed because the golf club had mold and air flow problems on a hole north of dam. So, the breach was moved 170 feet to west to open area and open air flow. Moving the breach west, too, meant they didn't have to clear the overgrowth in the original breach by the tower. "The main thing we wanted to ensure was to get a proper flow line through the breach.

THE WATERSHED INSTITUTE AND LAND TRUST

The Watershed Institute, a non-profit organization in Topeka that conducts stream and wetland assessments, streambank stabilization, stream restoration, and wetland design, develops in-lieu fee environmentally beneficial compensatory mitigation programs for projects seeking USACE permit approval.



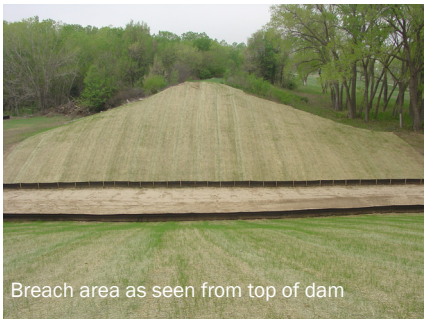


"We didn't want any excessive cutting in the streambed or laterally as well. A 30-foot wide bottom channel was constructed with 8:1 side slopes. The dam had 3:1 side slopes. Sediment had been a concern as it could be transported downstream to Cheyenne Bottoms due to the elevation difference from the reservoir bottom to the breach area of the dam.

"To mitigate sediment run off, we put in silt fences and two check dams. The concrete was removed and the tower demolished and buried on site. Fortunately, it didn't have a lot of rebar or iron. It turned out to be fairly clean.

"We gave contractor the option to take material for other purposes. He could haul it off and he did. He also was able to work with county and townships in the area that came in with scrapers and hauled off stuff for their own needs. We didn't have to stockpile dirt because half the dirt was taken off site and that helped us out considerably."

The contractor excavated 9 feet in cross sections to remove the soil. Regarding expenses, Emmert said it cost $40-50,000 for the construction part of breach with additional costs for engineering and other services.



Breach area as seen from top of dam

Looking upstream to former reservoir

This Barton County dam removal project entailed seeding and matting placement to prevent erosion and to hold mulch.

No Outlet? Siphon

Slowly draining the reservoir provides more control of sediment and water release, thus preventing downstream damage.

Reservoirs have outlet structures to keep the water surface at optimum level. This is the maximum water level designed for the pond and also allows for reservoir draining to make repairs, manage fish and aquatic plants, and other reasons.

Typically any water stored behind the dam must be lowered by pumping, siphoning, or operation of a drawdown valve before the constructed breach.

Kim Hunninghake, Division of Water Resources, said: "The chief engineer does not allow a taking a back hoe out to the dam, digging a hole, and releasing water downstream. Also, other agencies may have requirements about breaching methods to prevent fish kills and sediment transport."

When extracting water from reservoirs, many types of pumps can be used. Depending on how big the pump is and other equipment used, it can take several days to remove water. For example, at one Wabaunsee County farm pond with a dam, it took a week or more to pump down the reservoir to 10 feet.

DWR Water Structures Program File Notes

Pottawatomie County. . .*was in the office October 25, to talk to us about his proposal to cut the dam down to breach it. He will use the last 10' to 15' of the primary spillway as the drawdown. Then cut the pipe to grade, put the side slopes in at 3:1 or flatter, let the water drain. As the water drains, cut the pipe again, remove more material, keeping a 3:1 front slope to allow the backhoe to get up out of the pond. Waste will be stored off to the side at this point in time to be used at a later date should they decided to be in need of material. [Note: This unrecommended removal exception resulted in an semi-uncontrolled breach.]*

DWR Water Structures Program File Notes

Nemaha County. . . *when completed, the slopes were steeper than 3:1 at the base of the breach due to excavating downward as the breach was developed. The average slope of the breach was between 2.5:1 and 3:1 and appeared to be stable. Rock riprap was placed at upstream and downstream side of channel constructed through breach area to prevent erosion. Sideslopes seeded and have a matting placed to prevent erosion and to hold mulch. New grass is growing on side slopes. Overall, project turned out well and in compliance with approved plans.*

Removal Recommendations to Protect Water Quality (and Avoid Causing a Stink)

The Kansas Department of Health and Environment may be dam removal consideration because it oversees activities that could result in the release of pollutants to waters of the state.

Scott Satterthwaite, Kansas Department of Health and Environment, discusses permitting at the dam removal symposia in Wichita.

State agencies comply with federal laws, and for the Kansas Department of Health and Environment that often involves Environmental Protection Agency laws such as Clean Water Action Section 404 and the 1974 Environmental Coordination Act and its guidelines. One example is a construction site disturbing an acre or more, which is subject to federal storm water pollution laws overseen by KDHE such as Kansas Surface Water Quality Standards K.A.R. 28-16-28b(oo).

For dam removals, KDHE staff may request a water quality protection plan that will entail project information and activity, water quality protection measures. Said Scott Satterthwaite, Kansas Department of Health and Environment, Bureau of Water, Watershed Management Section, "It is not approved and reviewed. It is simply a way for the applicant to communicate that they know what they are doing when it comes to protecting the water." Watershed field coordinators also may do a field inspection.

"Whenever I do dams," Satterthwaite said, "I also put in there about lake protection plans once the dam is filled because we've had a couple of occasions, that had a watershed dam built below a wastewater treatment plant. It became a finishing pond and caused a fish kill for a mile and a half because of the high biochemical nutrients. "Once you get the dam and impoundment filled, you need to protect that water quality so that you don't cause a discharge of some particular degradation downstream. So we had a total depletion of oxygen that caused the fish kill.

"KDHE has several water-related programs, so it's advised to check in with this agency to make sure removal planning and execution follows approved guidelines. Staff also may have useful advice.

Regarding dam removal, Satterthwaite recommends pumping in a metered fashion spread over a stable, vegetated area and dewatering a dam during cooler weather and normal flows to avoid aquatic life distress from low oxygen, excess silt, and sudden temperature change. In dam removal, he said, it's a better idea "to do this in cool weather. It's difficult in the middle of summer to take anaerobic water quality from the lower part of the lake."

This water is often low in oxygen, and at a temperature than may harm downstream organisms.

"A lot of people want to open the tube and let it flow. We have to pump the water out first on the smaller detention ponds. We want to make sure it's not opened over night that's when the depletion of oxygen hits that can cause problems.

"We've had some cut a trench and let it go and if that's an old silty pond and that goes into a registered stream there might be a problem."

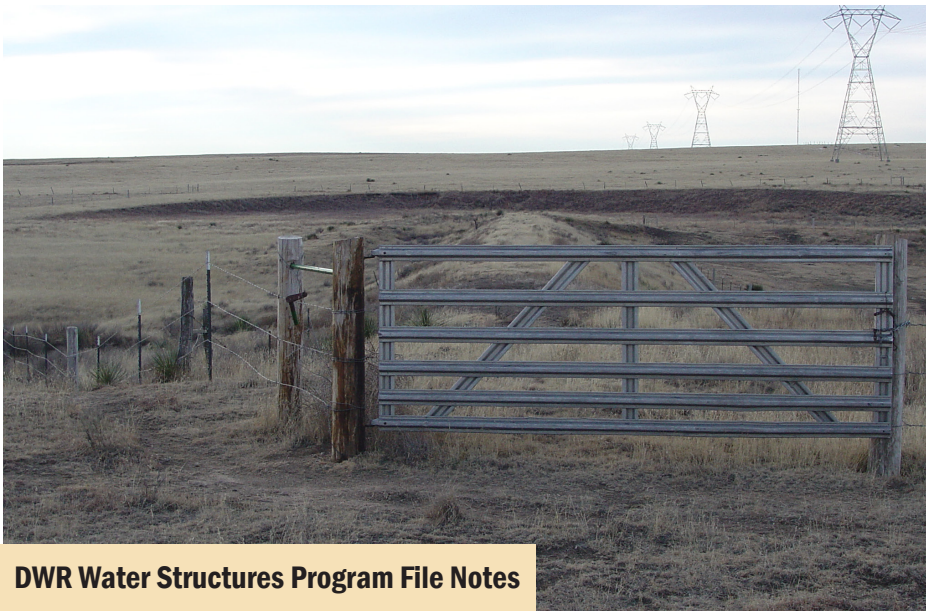
Reservoirs may have separate water layers with varying temperatures (*temperature stratification*). The top layer of warmer, water (*epilimnion*) is less dense and contains more oxygen than cooler water near the bottom (*hypolimnion*).

DWR Water Structures Program File Notes

Clark County. *During excessive rain over several weeks, a piping failure with a 25' breach width caused this 27' dam to fail. The released wastewater from the livestock lagoon overtopped a county road ½ mile downstream with 2' to 3' of water and took out 500' fences on both sides of the road. Division of Water Resources informed the owners to remove the structure or plan for its repair. The feedlot owners chose to remove the dam that had a drainage area of 10177 acres with a surface area of approximately 12.3 acres. The owners stabilized the area downstream with berms, dykes, and channelization to protect the area.*

Gray County Dry Dam Removal

Dams that outlive their purpose and require mandated inspections because of hazard classification may warrant removal consideration.



DWR Water Structures Program File Notes

DWR recently received a permit application to breach an existing class "c" high-hazard dam located on privately-owned land in Gray County. This classification does not indicate the condition of the dam -- only the potential for death, major economic loss, or interruption of public utilities or services should a dam fail.

"While the reservoir is dry most of the time, it still was able to impound water when runoff occurs. If it failed during or after a flooding event, we were confident it would put a significant amount of water over U.S. Highway 50," said the Water Structures program manager at the Division of Water Resources.

Originally issued a construction permit on August 14, 1968, the dam apparently was constructed for flood control and cattle watering.

DWR inspections in 1990, 1993, 1999 and 2006, and by a private engineering firm in 2004, noted the dry reservoir and several maintenance issues subsequently addressed by the landowner.

Inspection reports also documented findings that the dam required upgrades to meet current design criteria for its size and hazard class.

Due to some of the other issues they've had to deal with, they don't feel the dam is as necessary as it used to be" said Leonard Bristow, a water structures engineer based at DWR's Stockton field office. "It was a little more complicated than running a few around for a few days, but not a lot," said a consulting engineer. It's also high hazard now due to some changes in rules and regulations because of traffic count downstream requiring them to make upgrades. These are the basic reasons they don't want to continue maintaining it."

To start the removal process, the landowner hired an engineering firm to submit a breach plan for the Division of Water Resources' approval and to oversee the dam's removal. The plan included information regarding the breach cross section, view, profile, spoil use, reseeding disturbed areas, and controlled release of stored water (if any).

Since the structure was normally dry, a primary focus in the dam breach was to ensure it was wide enough to not cause an unreasonable increase in the 1 percent chance (100-year) flood event. Using U.S. Geological Survey regression equations, the 1 percent chance flood event is estimated to have a peak discharge of 1,490 cubic feet per second at this location.

"In reviewing dam removal, it's making sure the plans meet requirements. There isn't a specific section in the regs for breach. Breaches are under "modifications" but there is some criteria for breach routing. This is an existing dam that has a permit and now it needs a permit to modify," Bristow said.

Because of planned road improvements in the dam vicinity, the landowner planned to offer removed sediment from the dam to the construction project.

Fine Balance Lessons Learned

Every engineering project offers a learning opportunity. For Brett Howe, P.E., AMEC Environment & Infrastructure, a recent dam removal project offered several.

Brett Howe once oversaw a southeast Arizona project lasting six years and involving four dams in a high valley setting. Besides being dry, these homogenous earth dams were non-engineered dams. "The owner just went out and built them in the early 2000s -- no engineering involvement, no construction oversight. They were basically fairly large embankments blocking channels without any principal outlets. They do have some earth cut spillways because the owner knew just enough about dam design to know dams needed them.

"An ecologist, the owner dammed flowing water to improve wildlife habitat. And, then the state water office received a call from a downstream property owner, saying 'Hey, my neighbor is building all these dams and damming water that I think I got rights to.' That is what really lit the fuse to get the state water to look at these structures."

Jurisdictional in size, unpermitted, and identified by a water rights complaint, the dam drew the attention of the dam safety section of the water resources office. In its violation notice sent to the owner, the directive was clear: Either modify the dams for compliance with current regulations or safely remove from jurisdiction.

Immediately, the owner contacted his attorney and learned of the need to use an engineer in decision making. When the owner reached agreement with the state regulatory agency, that's when Howe got involved.

"I felt I was liaison between owner who knew enough about dams but not enough about regulations and the state. I spent a lot of time educating the owner and attorneys."

The geotechnical investigation consisted of 23 test pits (embankment, foundation, spillways); in-situ nuclear and sand cone densities; remolded samples for lab testing; direct shear; and seep and slope stability analysis.

Afterward when the owner said he wanted to do the construction modifications himself, Howe came up with a plan that wouldn't require contractors after the geotechnical investigation was completed.

Howe based the design on a template rather that creating one, which reduced expenses. He also simplified the design to meet the owner's expense request, hazard class, and end requirements. "We utilized an existing, off-the-shelf design to save costs," Howe said, and "He agreed to modify structures to get them below 25 feet in high and less than 50 acre feet. The design criteria was to safely pass the 100 year event with flow depth of less than 5 feet.

"Our design criteria for breaches for two was to modify the spillways for stability. We also provided for a downstream slope steady-state stability greater than 1.5 and planned to install a 12-inch diameter un-gated outlet in Crow and Gate Tanks."

Design plans also incorporated a phased approach. If each part of the project was judged sufficient, then they proceeded without further refinements. At one point, plans to modify the 19' high Gate Tank dam holding 105 acre feet changed. Ultimately, the dam was completely removed.

Lessons learned, Howe said were:

- Achieve mutual concurrence on approach between owner and regulatory agency – include dam safety engineer in process and write it down
- Appropriately scale level of engineering based on hazard class and end result requirements
- Use a phased design approach – initial phases utilizing conservative assumptions, if "ok" proceed without further refinements
- Be creative and less detailed in construction execution and design if owner doing work and won't require contractors
- Use existing design template to save costs
- Realize that owners may not always fully implement the engineer's design

Aerial photograph of one of the Arizona unpermitted dams removed by the owner with engineering oversight.

Fix It? Or?

Removal isn't the only option for an aging infrastructure. Before making a removal decision, look at the issues and options.

Many dams can function beyond the original design life with continued maintenance and rehabilitation. Issues often addressed for aging infrastructures include:

Replacement of deteriorating components, such as principal spillway pipes, slide gates, valves, and trash guards. For example, corrugated metal pipes generally are considered to have a life expectancy of less than 50 years.

Reservoirs fill with sediment. Since reservoirs are designed to store the normal sediment anticipated to accumulate during the design life of the dam, reservoirs will fill with sediment. If modifications are not performed, continued delivery of sediment to the site encroaches on the flood storage resulting in more frequent flows through the auxiliary spillway, increased maintenance needs, and increased threat of dam failure.

Dams inability to meet current state dam safety regulations. Typically, legal safety requirements have increased since the original construction as a result of federal legislation and/or state laws that have continued to be revised after dam safety and environmental concerns were raised in the 1970s. By then, more than 70 percent of the USDA-assisted project dams had been built.

Lack of adequate land rights under current easements to conduct future rehabilitation work. Water rights issues and land use control (upstream and downstream from the structure) must be addressed in a rehabilitation plan. Any rehabilitation alternative considered and final selected approach should be determined on the economic, environmental, and social merits of the site-specific project.

AGING DAM OPTIONS

Remove sediment from the reservoir to extend the life of a dam. Sediment should be tested for potential runoff contaminants, mercury methylation--the result of a bacterial process toxic to humans, and other possibly harmful substances.

Remove the dam.

Increase or replace the principal spillway. This approach provides higher capacity discharge needed due to changed safety or design criteria.

This dam located in western Kansas 350 feet upstream of highway was found to have severe erosion at the outlet of the principal spillway pipe that extended up into the downstream slope and was approaching the crest of the dam.

DWR Water Structures Program File Notes

Jackson County. Erosion and other problems caused this failing dam. The downstream embankment suffered major damage during a storm event and piping failure. The primary spillway pipe separated into multiple pieces back into the embankment area. A loss of material within the embankment created a void of a volume equal to approximately 200 cubic yards and dam in danger of complete failure.

An emergency order to begin draw-down of the lake was issued and executed the next day by removal of the cover plate on the 6-inch drawdown pipe. The order also required temporary repairs of the auxiliary spillway, evaluation of the dam and primary spillway by a licensed professional engineer and weekly monitoring of the dam until completed draw-down.

The owners preferred to breach the dam rather than repair it. Initially, they planned to use their own equipment to remove the dam but later bid out the construction work bid. The removal was halted when the local watershed decided to take over dam ownership but first had the dam cored to help them make their determination to adopt the dam or not.

Dam Removal Impact

What changes may occur after a dam removal? Knowing the answers in advance help with planning and dealing with unexpected events.

What will the newly exposed pond bottom look like? Land will be exposed when an impoundment is drawn down during dam removal. If nearby sections of the free-flowing river have rocky banks or vegetation, the restored section probably will, too. In fact, re-vegetation can occur within a matter of weeks during growing seasons because of seed accumulation in the sediment.

Will there be an odor? Depending on the time of year and make-up of exposed sediment, there may be an odor of decomposition ranging from a few days to a few weeks. However, once exposed to sunlight and oxygen, plants grow quickly, drying up the water-logged sediment in the process.

How will property values be affected? Much is dependent on the particular site and is influenced by the real estate market, location, or property characteristics. Because neighboring property values may be affected, let neighbors know in advance of removal to mitigate possible adverse consequences.

Will there be an increase in flooding? Dam removal may increase flooding frequency or alter the downstream channel course. These and other changes may change Flood Insurance Rate Maps, so it's advisable to notify local floodplain program personnel of removal plans.

Who will own the exposed land? Land ownership questions can typically be answered by referring to the deeds for the specific dam property and adjacent properties. The dam's deed might include all land that was flowed and the exposed land would revert to the dam owner. In other cases, the land currently underwater may be publicly owned, or it may simply revert to the property owners bordering the restored river. Deeds can be researched at a county's registry of deeds.

What if I don't want responsibility for the reclaimed land? Some dam owners have donated these lands to land trusts or quit-claim deeded them to adjacent land owners or municipalities.

What will public reaction be? Removal of a particular dam will be seen as a good thing to some and a not so good decision to others. One person's lost pond is another person's restored river.

How will the dam's removal affect fish and wildlife habitats in the area? Dams alter the natural physical, biological and chemical functions of streams. Research shows removal can allow fish to migrate without obstructions, restores natural seasonal flow variations, eliminates siltation above the dam, allows nutrients to pass below the dam, and promotes natural temperature variations.

How will fishing opportunities change if the dam is removed? In some cases, removing a dam will change fishing, for instance, a warm water fishery may be restored to a cool or coldwater fishery.

TEN YEARS AFTER: Land Effect and Public Relations

For one deteriorating Jefferson County dam, the city council ultimately decided on removal. Looking back, was removal the best option? Probably.

DWR Water Structures Program File Notes

"The first inspection we did was in 1979," said John King, DWR engineer. "Even back in '79, the dam was found to be in poor shape with seepage on the downstream side and lots of woody vegetation - just covered with trees, some as much as 18-24 inches in diameter throughout the embankment. "Then we inspected it again '85, '88, '90, '97, '99. Every time we looked, it was a little bit worse than last time."

Dam seepage

After years of inspection starting in 1979, the Division of Water Resources informed a public dam owner that its dam needed to be repaired or breached. Each inspection showed the dam continued to deteriorate and repeated requests to address the dam's problems didn't result in any rehabilitation.

Hydrologically inadequate, the embankment integrity was seriously in question. Besides severe deterioration undermining the primary spillway pipe, the dam had unstable embankment slopes, seepage along the downstream slope, erosion on the upstream and downstream slopes of the dam, and was covered with trees.

Originally a farm pond and partial city water supply, the dam at the time was used by a club for members' private recreation. However, the city owned the water and had maintenance responsibility for the dam from a long-ago agreement.

"When the city began to move on this project, it had to decide to fix it or breach it," said John King, DWR engineer. It looked at future dam maintenance and operations costs, costs to repair compared to cost to breach, the fact that it was a private lake not open to the public, and more stringent regulations in the future. In the end, they decided to breach the structure."

John King, seated, talked to King & Associates engineers after his presentation on this dam at the 2012 dam removal symposium in Wichita.

King said, “We want to see at minimum a breach cross section, plan view profiles, what you are going to do with the soil, reseeding the soil, controlled release of water -- the more complicated the project, the more plans we want to see.” Right, King walking the site in 100 degree plus

Cross Section 4 (1.46 mi.) - CL Elev. of County Road = 951.49

Model Description (Time of Breach Formation)	X-Sectional Area (sq. ft.)	Theoretical Flow (cfs)	Water Velocity (fps)	Maximum Elev. (ft. msl.)	Depth at CL of Road (ft.)	Time for Theo. Flow (min.)
3 min. Lower Dam Breach / 3 min. Upper Dam Breach	3502.88	24786	7.08	965.32	3.83	24.60
3 min. Lower Dam Breach / 16 min. Upper Dam Breach	2826.20	19080	6.75	964.26	2.76	25.80
16 min. Lower Dam Breach / 3 min. Upper Dam Breach	2514.09	14845	5.90	963.71	2.22	43.20
16 min. Lower Dam Breach / 16 min. Upper Dam Breach	1956.59	10707	5.47	962.65	1.16	45.00
3 min. Lower Dam Breach / No Upper Dam Failure	2279.62	15867	6.96	963.28	1.79	27.00
16 min. Lower Dam Breach / No Upper Dam Failure	1656.41	9023	5.45	962.00	0.51	46.20

Cross Section 8 (1.86 mi.) - FF Elev. of House #1 = 980.91

Model Description (Time of Breach Formation)	X-Sectional Area (sq. ft.)	Theoretical Flow (cfs)	Water Velocity (fps)	Maximum Elev. (ft. msl.)	Depth at House #1 (ft.)	Time for Theo. Flow (min.)
3 min. Lower Dam Breach / 3 min. Upper Dam Breach	2065.75	24293	11.76	981.44	0.53	24.60
3 min. Lower Dam Breach / 16 min. Upper Dam Breach	1710.67	18700	10.93	980.57	-0.34	25.40
16 min. Lower Dam Breach / 3 min. Upper Dam Breach	1437.85	14550	10.12	979.78	-1.13	44.40
16 min. Lower Dam Breach / 16 min. Upper Dam Breach	1179.12	10494	8.90	978.83	-2.08	46.20
3 min. Lower Dam Breach / No Upper Dam Failure	1501.97	15541	10.36	979.98	-0.93	27.60
16 min. Lower Dam Breach / No Upper Dam Failure	860.64	8843	10.27	976.65	-4.06	46.80

Cross Section 8 (1.84 mi.) - FF Elev. Of House #2 = 983.21, FF Elev. Of House #3 = 970.44

Model Description (Time of Breach Formation)	X-Sectional Area (sq. ft.)	Theoretical Flow (cfs)	Water Velocity (fps)	Maximum Elev. (ft. msl.)	Depth at House #2 (ft.)	Depth at House #3 (ft.)	Time for Theo. Flow (min.)
3 min. Lower Dam Breach / 3 min. Upper Dam Breach	3466.09	23810	6.87	974.92	5.65	4.48	25.20
3 min. Lower Dam Breach / 16 min. Upper Dam Breach	2819.36	18328	6.50	973.47	4.2	3.03	27.00
16 min. Lower Dam Breach / 3 min. Upper Dam Breach	2312.32	14260	6.17	972.19	2.92	1.75	45.00
16 min. Lower Dam Breach / 16 min. Upper Dam Breach	1785.80	10265	5.75	970.66	1.39	0.22	46.80
3 min. Lower Dam Breach / No Upper Dam Failure	2245.82	15232	6.78	972.01	2.74	1.57	28.20
16 min. Lower Dam Breach / No Upper Dam Failure	1519.37	8887	5.70	969.79	0.52	-0.65	48.00

Cross Section 9 (2.06 mi.) - FF Elev. Of House #4 = 967.11

Model Description (Time of Breach Formation)	X-Sectional Area (sq. ft.)	Theoretical Flow (cfs)	Water Velocity (fps)	Maximum Elev. (ft. msl.)	Depth at House #4 (ft.)	Time for Theo. Flow (min.)
3 min. Lower Dam Breach / 3 min. Upper Dam Breach	3943.13	23572	5.98	973.69	6.58	25.80
3 min. Lower Dam Breach / 16 min. Upper Dam Breach	3222.06	18145	5.63	972.43	5.32	27.00
16 min. Lower Dam Breach / 3 min. Upper Dam Breach	2653.49	14117	5.32	971.32	4.21	45.60
16 min. Lower Dam Breach / 16 min. Upper Dam Breach	2054.44	10162	4.95	969.99	2.88	47.40
3 min. Lower Dam Breach / No Upper Dam Failure	2605.85	15080	6.02	971.01	3.90	28.20
16 min. Lower Dam Breach / No Upper Dam Failure	1703.63	8581	5.04	969.10	1.99	48.60

Contractors pumped water from the dam impoundment, and then cleared the dam, leaving a section to hold sediment back while water leached out. During this phase, the public was invited to remove fish by any means before the rest were harvested with nets.

“The breach wasn’t a surprise. With the changing turnover of city councils, misinformation, added to the plain fact that it is hard to pay a lot of money for something for which you get nothing in the end, the breach of a community recreation area’s dam isn’t popular,” King noted. “As the town engineer says, “The ideal situation? If 30 years ago, there was a plan, a long-term maintenance plan.”

Design issues the engineer hired by the community looked at when developing breach plans included a controlled drawdown, sediment control, vegetation reestablishment, slope stability during drawdown, slope stability after construction, fish harvesting, and odor control.

“At a minimum, DWR wants to see the breach cross section, plan view, profile, spoil use, reseeding disturbed areas, and controlled release of stored water (if any),” King said. “The more complicated the project is, the more plans that DWR will require.”

The engineer divided the breach into three phases. The first consisted of pumping water from the two dams’ impoundment, and then contractors cleared the dam, leaving a section to hold sediment back while water leached out. During this phase, the public was invited to remove fish by any means before the rest were harvested with nets.

Next, they removed the sediment dam to draw down the water. The area was then riprapped, seeded, and mulched. Allowing the sediment to stabilize a year, they once again reseeded, fertilized, and mulched.

After a pipe siphoned the water in the breach, the former lake was essentially a large mud hole," King said.

"Water continued to flow from the sediment and out of the surrounding hillsides for several months, and beavers came in and built a dam the same height as the sedimentation dam. The surprising thing to me was that the vegetation, the greening up, began to appear very quickly.

"Within six months, the entire area was covered with cotton wood seedlings, cattails and other wetland plants. We thought that a stream channel would develop through the area after the breach. And, in fact that did happen during the first year and also a wetlands area of about two acres."

Unfortunately the city didn't do any further work on the breach resulting in significant erosion of area in last 10 years."

"We went back and re-visited the site earlier this summer. After examining the dam area and talking to numerous people in the city, we quickly determined that the public still was unhappy. With these public or semi-public structures, you need to work very hard to keep the public informed of what is going on.

'The state' has definitely been the villain in this case even though DWR had sent condition letters for decades. Looking back we and others could have worked harder to communicate the situation.

Once, the lake drained, the city didn't do anything else to the area, which now has significant erosion.

Land ownership issues took more than a decade to resolve.

Since the dam has been removed, a stream channel developed during the first year as has a wetlands area encompassing two or more acres.

Dismantling Kansas River Dams

Kansas Wildlife Parks and Tourism has started a program to remove run-of-the-river dams that no longer serve a use and can be a liability

As part of continuing efforts to preserve and enhance habitat for Kansas native species, KDWPT has been identifying in-stream barriers to aquatic organism passage. Once identified, mapped, analyzed for benefits, and prioritized, certain barriers will be removed. Initial removals are low-head dams in the Neosho River, which has been dammed at several points. The first slated for removal is the 8' Correl Dam, two miles northwest of Americus and built in the 1920s to ensure a steady stream of water to Emporia. With its gate no longer operational, a pumping station now in Council Grove, and a swimming fatality, landowners think the dam is a liability. Assisted by other organizational partners, KDWPT contracted a study done by the Watershed Institute that involved removal options, breach design, and cost estimates including monies pre- and post-monitoring.

Said Brock Emmert at the 2012 Dam Removal symposia, "They really didn't need this facility and haven't used it in years. It is sitting on bedrock, which is nice and there is some vertical stability in the stream bed with very little sediment stored behind it. In fact, just upstream there was no sediment on top of the bedrock, which makes it easier to deal with."

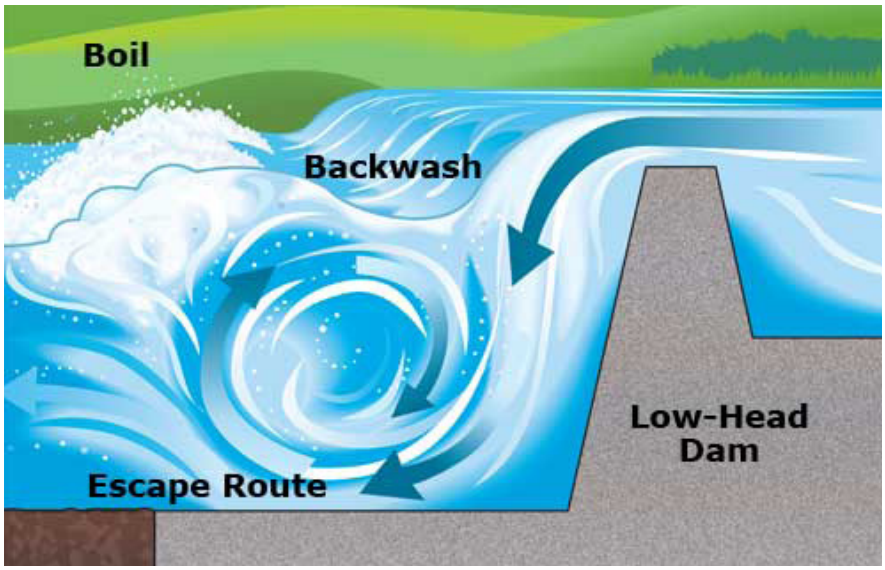
Low-Head Dam Dangers

Hazards exist not only from boating over the low-head dam (that may not be visible if below the water surface), but also from being caught in the continuous hydraulic roll where water encounters the obstruction base.

The force of the backroller water flow recirculates objects caught in it, trapping boats and individuals with such power that a personal flotation device is useless. To safeguard recreational boaters on Kansas rivers, organizations and cities have installed portage ramps and alert signage. Learn more from the Kansas online boater education course.

How well does dam removal accomplish its goal of ecosystem restoration? The evidence suggests that flow regimes and fish passage are restored to their pre-dam conditions relatively reliably and quickly.

However, the significance of these changes for ecosystem restoration depends on the impacts that may still exist, including hydrologic (e.g., water withdrawals), physical (sediment loads, channelization, water quality (pollution loading), and biotic (overfishing), as well as the presence of another dams upstream or downstream on the same river. In addition, questions remain as to how river geomophology (channel shape) readjusts to the new conditions presented by dam removal.



Low-head dams. A river-wide obstruction normally overtopped by the entire river's flow, a lowhead dam or weir increases upstream water level. In sufficient flow or high water, upstream water goes over the obstruction's face. Many in Kansas originally were built for power generation, and while not high enough to be jurisdictional dams are subject to state statutes and regulations. DWR, for example, administers K.S.A. 82a-301 - 305a with applicable regulations K.A.R. 5-40-1 through 5-43-5 for the design, construction, operation, and maintenance of the stream obstruction.