Neosho Basin High Priority Issue
Comprehensive Flood Assessment
October 2010

ISSUE:

Flooding is a reoccurring natural phenomenon in parts of Kansas, including areas in the Neosho basin. Due to the high cost of flood damage and the even more significant potential loss of life, flood management measures are necessary. Flood protection is a primary feature included in all federal reservoirs, all watershed district dams, and all state constructed multi-purpose reservoirs, and is the sole purpose of levees. While levees and reservoirs do serve the beneficial purpose of flood control, they are both subject to deterioration due to aging, and reservoirs are continuously affected by the accumulation of sediment.

Farm House Underwater Near parsons. Photo courtesy USGS.

FLOODING

In late June and early July 2007, major flooding occurred in southeast Kansas due to significant rainfall, ranging from 8 to 21 inches. Record flood peaks occurred on the Neosho, Fall, and Verdigris Rivers.

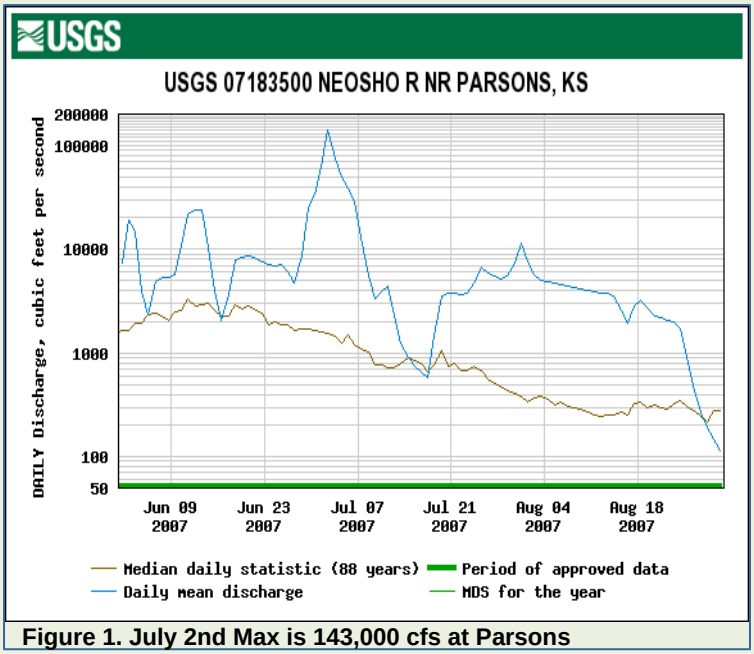


Figure 1. July 2nd Max is 143,000 cfs at Parsons

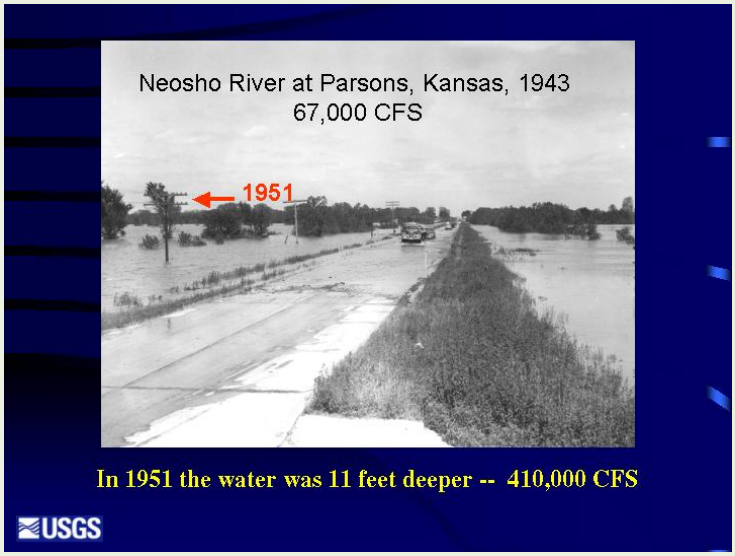
More than 3,000 homes and businesses were damaged or destroyed in just five of the counties affected by the 2007 flood. As a result of the floods, state of disaster emergency was declared by the governor in 18 counties in southeast Kansas. Nearly $40 million was approved by the FEMA and the U.S. Small Business Administration to assist those affected by the severe storms and flooding occurring from June 26 through July 25, 2007 in Kansas.

Major flooding occurred again the following year in the Neosho basin from late spring to mid-summer 2008. With above-average precipitation having occurred in southeast Kansas during late 2007, the soils were already extremely wet or saturated as the 2007 – 2008 winter months approached. This, coupled with 10-14 inches of rain falling from May 21 through June 14, the area was prone to extensive flooding. Counties in the Neosho basin were again declared a federal disaster area and received federal funding. These counties included Cherokee and Crawford counties.

While flooding in 2007 and 2008 was devastating and costly, it is not a new concept, but has been a constant concern for the Neosho basin and its residents. In the 20th century, notable flooding occurred in the Neosho basin many times. One of the most memorable floods was in 1951. The flood of 1951 killed 24 people and caused thousands to abandon their homes, schools, and businesses. The unprecedented high waters affected all area river basins especially the Kansas, Neosho, Marias des Cygnes, and Verdigris. Damage costs in 1951 exceeded 760 million dollars, which today would be over 5 billion dollars.

Other notable 20th century floods occurred in 1986, 1993, and 1998. As a result of the floods in 1951, a series of flood control reservoirs and levees were built across Eastern Kansas. These systems prevented more widespread damage in many communities during the record rains and flooding of July 1993.

Neosho Basin High Priority Issue
Comprehensive Flood Assessment
October 2010



Construction of Flood Control Structures

Flood prevention and mitigation in the mid-20th century concentrated on structural controls. A total of 24 large federal reservoirs have been constructed in Kansas by the U.S. Army Corps of Engineers (Corps) and the U.S. Bureau of Reclamation (Bureau). Additional federal funding for watershed dams has been provided by the US Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS). The primary purpose of these reservoirs is flood control. Federally funded levees also provide a measure of structural flood protection.

The three of those federal reservoirs were constructed within the Neosho basin. Those three federal reservoirs have a combined contributing drainage area of over 3,400 square miles and a flood control storage capacity of nearly 650,000 acre-feet total. Table 1 provides summary information about these reservoirs.

Watershed Dam Construction Program (WDCP)

The *Kansas Watershed District Act* (WDA) was enacted in 1953 to provide a subdivision of state government with adequate powers and duties to sponsor watershed projects developed with federal assistance under PL 83-566. Figure 2 shows watershed district boundaries.

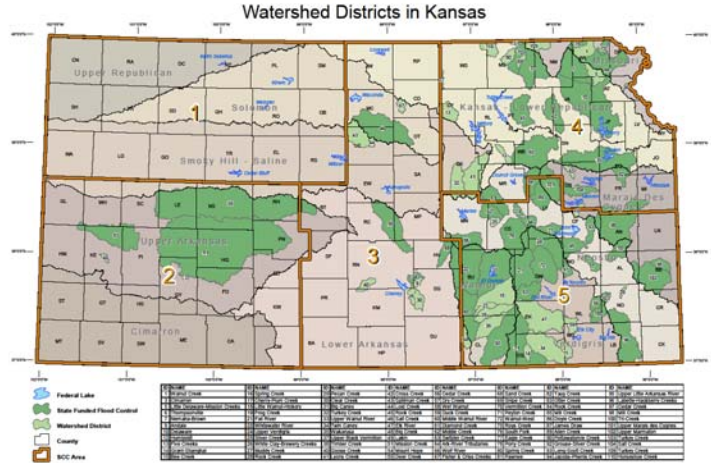


Figure 2.

In the Neosho basin there are 17 watershed districts. The State Conservation Commission (SCC) has provided cost share assistance to construct 94 of the dams within the Neosho basin. The remaining watershed dams that were constructed were financed either through private funds or the NRCS. The number of sites built per watershed district in the Neosho basin is shown below in Table 2.

Table 2

Watershed	# Sites Built
Allen Creek WD 89	17
Big Creek WJD 48	6
Cherry-Plum Creek WJD 17	3
Deer Creek WJD 55	6
Diamond Creek WJD 61	10
Doyle Creek WJD 86	6
Eagle Creek WD 77	5
Jacobs-Phenis Creeks WJD 94	3
Labette-Hackberry Creeks WJD 96	8
Long-Scott Creeks WD 93	5
Middle Creek WJD 62	3
Peyton Creek WD 71	3
Rock Creek WJD 84	11
South Fork WJD 76	7
Turkey Creek WJD 103	1

Table 1
Major Federal Reservoirs in Kansas

	Operating Agency[1]	Year Storage Began	Drainage Area (sq. miles)[2]	Storage Capacity (acre-feet)[3]	
				Conservation/ Multi-purpose	Exclusive Flood Control
Council Grove	**Corps**	**1964**	**246**	**43,176**	**64,217**
John Redmond	**Corps**	**1964**	**3,015**	**44,385**	**524,417**
Marion	**Corps**	**1968**	**200**	**75,133**	**61,213**

Corps – U.S. Army Corps of Engineers; Bureau – U.S. Bureau of Reclamation
Contributing drainage area
Conservation/Multipurpose pool 2004 estimate by KWO; Exclusive flood control from BOR or COE

Neosho Basin High Priority Issue
Comprehensive Flood Assessment
October 2010

State Watershed Rehabilitation Program

Since 2006 Kansas legislators have recognized that the key to the success of the WDCP is a sustained rehabilitation program. Rehabilitation was defined as any work, except work required due to inadequate operation and maintenance, to extend the service life of a dam and to meet the applicable safety and performance standards. Inundation mapping was identified as a rehabilitation component.

	Rehabilitation		Inundation Mapping	
Statewide	**Sites**	**Funding**	**Sites**	**Funding**
Statewide FY 2007-2009	**35**	**867,436**	**229**	**747,880**
Neosho Basin FY 2007-2009	**4**	**95,694**	**19**	**53,996**

Breach Inundation Zone Mapping – The SCC provides 70% cost-share assistance for dam breach inundation zone mapping. Maps produced are approved by the Chief Engineer-DWR. The maps are developed using engineering principals and represent the best estimate of where the water would flow if the dam completely failed with a full reservoir. These maps should be used in advance to develop warning and evacuation plans as well as to manage development in the inundation zones and identify downstream hazards.

On November 18, 2005 the Kansas Water Authority approved a Policy Section for the *Kansas Water Plan* concerning Small Dam Safety and Rehabilitation. The Policy Section made recommendations for expenditure of the FY 2006 SCC appropriation. Included in the recommendations were stipulations that part of the appropriation be used for breach inundation area mapping and cost-share assistance for such mapping provided that appropriate measures to control future development within the inundation area have been taken. Establishment of a state cost-share program for small dam rehabilitation and upgrades were also recommended, along with notification to owners of property within dam breach inundation areas and limitation of dam owner liability.

Resulting from the recommendations SCC as noted above, the SCC currently provides cost-share assistance to watershed districts to accomplish dam rehabilitation and inundation area mapping. However, the SCC does not currently, due to regulation, provide assistance to private dam and levee owners. Part of the Small Dam Safety and Rehabilitation Policy Section approved in 2005 addresses the need for this.

To address the private dam owners liability and funding concern, as well as to look at the hazard class changes that can occur due to regulation change and/or downstream development, the Dam Safety Technical Advisory Group (TAC) has been reconvened. The TAC is looking at ways to provide cost-share assistance for those that need help paying for dam rehabilitation, decommissioning, and inundation maps. The group is also examining different liability scenarios, as well as ways to prevent downstream development and changes in hazard classification.

Multipurpose Small Lakes Program

Administered by the SCC, the Multipurpose Small Lakes (MPSL) Program is another means for the state to assist with the provision of a public water supply and flood protection, at an affordable price, especially for smaller towns and rural water districts. Figure 3 below shows the status and location of multipurpose small lakes in Kansas.

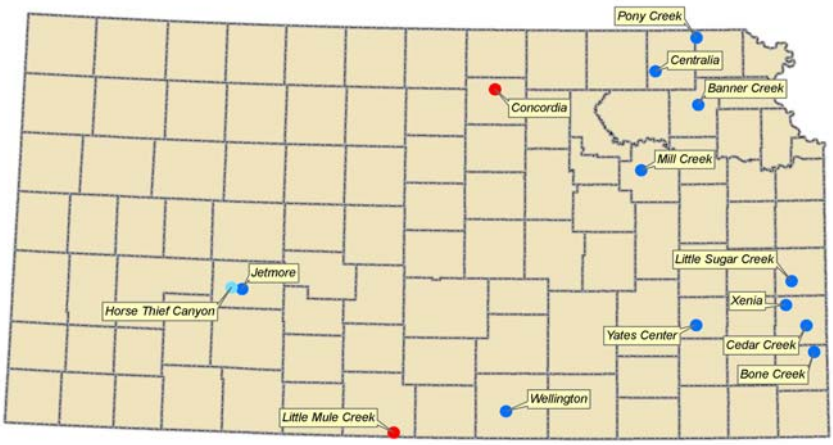


Figure 3.

Projects funded by the legislature will receive assistance in the form of a grant for flood control and, if included, recreation. Funds appropriated for the water supply component shall be on a loan to be paid back to the state. The state initially funds the construction of the dam, typically a watershed structure, but is paid back by the participating community or communities. Upon repayment of the costs, the developed water right is transferred to the community once use of water starts. While there are no MPSL located within the Neosho basin, Bone Creek does supply seven cities and four Rural Water Districts within Crawford and Cherokee counties.

Neosho Basin High Priority Issue
Comprehensive Flood Assessment
October 2010

Levees

A National Look

Of the nation's estimated 100,000 miles of levees, more than 85% are locally owned and maintained. The reliability of many of these levees is unknown and many are over 50 years old and were originally built to protect crops from flooding. With an increase in development behind these levees, the risk to public health and safety from failure has increased. Rough estimates put the cost at more than $100 billion to repair and rehabilitate the nation's levees.

In the aftermath of hurricanes Katrina and Rita in 2005, Congress passed the Water Resources Development Act (WRDA) of 2007. The Act required the establishment and maintenance of an inventory of all federal levees, as well as those non-federal levees for which information is voluntarily provided by state and local government agencies. The inventory is intended to be a comprehensive, geospatial database that is shared between the Corps, FEMA, the Department of Homeland Security (DHS), and the states.

WRDA 2007 also created a committee to develop for the first time recommendations for a national levee safety program. The National Committee on Levee Safety completed its work in January 2009 and the panel recommended that improvements in levee safety be addressed through comprehensive and consistent national leadership, new and sustained state levee safety programs, and an alignment of existing federal programs.

In 1968, Congress enacted the National Flood Insurance Program (NFIP). One of the primary purposes of the NFIP was to address the inability of the public to secure privately backed insurance for economic losses from flooding. The NFIP designated the 1% annual chance event ("100-year flood") as a special flood hazard area in which those holding federally backed mortgages would be required to purchase flood insurance. Never intended to be a safety standard, the 1% annual chance event became the target design level for many levees because it allowed development to continue while providing relief from mandatory flood insurance purchase for homeowners living behind accredited levees. Allowing levees to simply meet the minimum requirements of the NFIP has created an unintentional - and potentially dangerous - flood insurance standard that is now used as a safety standard. For more information on the NFIP visit the FEMA website at: http://www.fema.gov/business/nfip/
Finally, FEMA's Flood Map Modernization Program, which remaps floodplains using modern technologies, is resulting in a reexamination of levees throughout the United States to determine if they can still be accredited. Before accrediting a levee, FEMA is requiring many communities to certify that their levees meet the 1% criteria and are in sound condition. Flood insurance is one of the most effective ways to limit financial damages in the case of flooding and speed recovery of flood damaged communities. Currently, many people who live behind levees do not believe that they need flood insurance, believing that they are protected by a levee structure. Requiring the purchase of mandatory flood insurance is intended to increase the understanding that living behind even well-engineered levees has some risk. This may encourage communities to build levees to exceed the 1% annual-chance protection standard or limit further development behind levees. For more information on FEMA's Flood Map Modernization Program visit their website at: http://www.fema.gov/plan/prevent/fhm/mm_main.shtm

A Statewide Look

DWR has established levee hazard classes per K.A.R. 5-45-8 and has also established levee design criteria per K.A.R. 5-45-10. Levees in Kansas, as found nationally, were built solely for flood protection and were largely constructed to protect agricultural land. In many areas of Kansas, communities rely on levees for protection from flood waters even though many were not built to design standards established to protect people and property. The design level of many of these levees is listed as 1% annual-chance of occurrence, however the actual design level is often unknown and their presence can generate a false sense of security. Due to increasing risk to safety incurred from increased development behind the levees, coupled with the unknown design level of many levees and their status as aging infrastructure, a more comprehensive compilation of information about levees in Kansas should be available in 2010 according to the Kansas Hazard Mitigation Plan.

In Kansas there are countless privately owned levees and approximately 80 levees that protect communities in Kansas, including at least 19 federal levees. The Corps recently published a list of levees of concern and Kansas has one levee that was included on the list. That levee is at Ft. Leavenworth in Leavenworth County and was breached by the large flooding events in 1951 and 1993. Another levee of concern in Kansas, within the Neosho basin, is the Hartford Levee, near Hartford, Kansas, upstream of John Redmond Reservoir. The Corps has transitioned their Dam Safety Program to a risk informed

Neosho Basin High Priority Issue
Comprehensive Flood Assessment
October 2010

program. This program applies to levees, dikes, and other structures associated with Corps projects. The initial step to this program is a Screening Portfolio Risk Assessment (SPRA). This screening level assessment, completed by a Corps risk cadre, is a screening level evaluation of the possible failure modes and the consequences of that failure. The SPRA for the Hartford Levee identified two areas of concern that led to the levee being considered high risk. Although the levee height is sufficient to contain the Probable Maximum Flood (PMF), the levee has inadequate freeboard for wind/wave run-up during unusual and extreme events. Seepage beneath the levee has been a concern for years. Construction of a foundation cut-off wall, seepage berm, relief wells, and an inverted filter have addressed much of the seepage area. Seepage and piping of foundation material is considered to be a risk at higher pool levels.

As part of the Corps feasibility study that included the reallocation of John Redmond Reservoir, a two foot pool raise was suggested to compensate for lost storage in John Redmond due to its high sedimentation rate. However, as part of the Corps risk informed program, reallocations that include pool raises on structures considered to be a high risk will not be approved until the concerns leading to higher risk are adequately addressed. The complete feasibility study can be found on the KWO website at: http://www.kwo.org/Reports%20%26%20Publications/Reports%20and%20Publications.htm

SEDIMENTATION

Federal reservoirs are an important source of water supply and flood protection in Kansas, providing water in some manner to roughly two-thirds of the citizens of the state and reducing costly flood losses. The state of Kansas owns water supply storage in 13 federal reservoirs operated by the U.S. Army Corps of Engineers (Corps), but flood control is a part of every federal reservoir. Storage is being diminished over time due to sediment deposition, reducing reservoir capacity. See the Reservoir Roadmap for more details on capacity reduction due to sediment on the KWO website: http://www.kwo.org/ReservoirRoadmap.htm

While sedimentation affects all reservoirs, those in the Neosho River basin experience the highest rate of sedimentation. Sedimentation is a large factor in the decreasing quantity of storage capacity in all of the reservoirs in the Neosho basin as indicated in Table 3.

Reservoirs are planned for a design life which is the period of time during which a reservoir can provide 100% of all authorized purposes. During design, the dam is sized to accommodate the amount of sediment expected to be delivered to the lake from the watershed over that design life (typically 50 to 100 years), as well as enough storage to meet the authorized purposes. The sediment storage is apportioned among the conservation and flood pools. Theoretically, until the end of the design life, the quantity of storage for the authorized purposes is not affected by the sediment depositions, with the flood pool designed to continuously function as flood protection.

Periodic bathymetric surveys are conducted to determine the amount of sediment actually accumulating in the reservoir. This is compared to the original survey to determine the loss of storage capacity that has occurred. Bathymetric surveys of each of the public water supply lakes in the Neosho basin have been completed by the Kansas Biological Survey. Each survey was performed using an acoustic echo-sounding apparatus linked to a global positioning system. The bathymetric surveys were geo-referenced and compared with original preimpoundment maps to estimate sediment accumulation. In addition, sediment samples were extracted and analyzed at each reservoir.

Comparison of the 2008 bathymetric survey data for Parsons Lake to a 1957 pre-impoundment map, suggests that while the surface area of the reservoir has not been markedly reduced in the 51-year period, the capacity of

Table 3
Sedimentation Estimates for Federal Reservoirs in the Neosho Basin

Reservoir	Top of Conservation Pool (Feet)	Original Storage Capacity (Acre-feet)	Capacity at most recent survey (Acre-feet)	Estimated Current Capacity (Acre-feet)	Design Sedimentation Rate (Acre-feet/Year)	Actual Sedimentation Rate (Acre-feet/Year)	Loss of Capacity to Date
Council Grove	1,274.0	54,832 (1963)	47,093 (2008)	46,935	206	172	14%
John Redmond	1,039.0.	82,231 (1963)	53,927 (2007)	52,687	404	643	36%
Marion	1,350.5	96,757 (1967)	86,711 (2008)	86,485	94	245	11%

Neosho Basin High Priority Issue
Comprehensive Flood Assessment
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the reservoir at the 927 foot elevation pool has been reduced from 10,916 acre-feet to 9,183 acre-feet.

According to a 2008 bathymetric survey, about 16% of the storage capacity has filled with sediment since construction of Council Grove City Lake. Sediment sampling conducted at the lake revealed a greater occurrence of silt in the upper end of the reservoir, while a mid-lake sample was predominantly sand. A bathymetric survey of Wolf Creek Lake was completed in October 2009. The results of the survey estimate that approximately 3% of the lake's storage capacity has been lost due to sedimentation. No sediment sampling was performed on this lake.

Of the three federal reservoirs in the Neosho basin, John Redmond has the highest sedimentation rate and greatest loss of capacity. With a conservation pool elevation of 1,039 feet, John Redmond has a current estimated capacity of 52,687 acre-feet. The reservoir's original capacity was 82,231 acre-feet in 1963. In the bathymetric survey conducted in 2007, the capacity was determined to be 53,927 acre-feet. In comparing the 2007 survey and the 2000 survey the sedimentation rate for John Redmond is calculated to be 643 acre-feet/year. The reservoir was designed for a sedimentation rate of 404 acre-feet/year. The loss of capacity from the conservation pool is 36%. The loss of capacity to the flood pool, if any, is unknown.

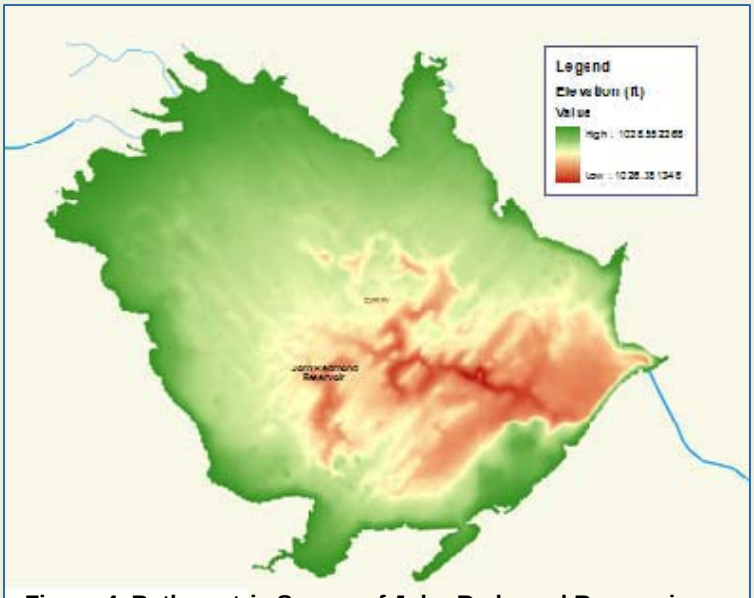

Figure 4. Bathymetric Survey of John Redmond Reservoir

Conclusions

Flooding is a reoccurring challenge in the Neosho basin that can be costly, both in property lost and more significantly in loss of lives. Due to the high cost of flood damage and the even more significant potential loss of life, flood control measures such as reservoirs, dams, and levees are necessary. Although these structures do provide flood protection, they are subject to deterioration, due to aging, and reservoirs are continuously affected by sediment.

Aging infrastructure is a national problem and increases the risk that dams and levees could fail during a flooding event. Failures could be disastrous due to development below dams and behind levees. Although national efforts are being initiated, additional state and local action is needed to ensure the safety of communities thought to be protected from flooding by dams and levees.

Reservoirs are designed to accumulate sediment, but that sediment can have impacts on all of the beneficial purposes of the reservoir, including water supply, recreational opportunities, and flood protection. A large contributor of sediment into the reservoirs is land surface and stream bank erosion. Because the rate of sedimentation is so high in the Neosho basin, it is important that actions are taken to reduce or remove sediment in the reservoirs.

The catastrophic consequences that flooding can have, as seen in the Neosho basin as recent as 2007 and 2008, is evidence that the reservoirs, dams, and levees protecting people and property, are essential. Due to the importance of this vital infrastructure, the following recommendations are proposed.

Recommended Actions

1. Design, populate, update, and maintain a statewide database on dams and levees including correct locations, hazard class, status, age, and condition that is available to all state agencies with limited public access.
2. Develop and maintain a funding source to assist dam and levee owners in permitting, maintaining, and rehabilitating dams and levees that is not limited to Watershed Districts.
3. Develop and maintain a funding source to assist dam owners in completing breach inundation maps that is not limited to Watershed Districts.
4. Develop and maintain a funding source to assist dam owners in removing residential structures from the breach inundation area of the dam. An easement prohibiting future development of the inundation area would need to be acquired that is not limited to Watershed Districts.
5. Develop and maintain a notification system for prop-

erty owners within the breach map inundation area of dam.

6. Develop and maintain voluntary incentives for proactive dam and levee maintenance for private owners.
7. Map flood pools to evaluate impacts from sediment.
8. Use LiDAR to conduct flood mapping for areas at risk.
   a. Show areas that are more prone to flooding, which will be a benefit to inundation mapping.
   b. Evaluate dams and levees more closely to improve effectiveness and reduce possible damage to the structures.
   c. Prevent or minimize construction in flood prone areas to minimize loss of life and property damage.
   d. Allow for removal of levees so areas could flood naturally so more critical areas, including inhabited rural areas and urban areas, would not flood.
9. Continue work on reduction of sediment entering the reservoirs to protect water supply storage, flood protection, and recreation. This work should include continued efforts with Best Management Practices (BMPs), stream bank stabilization and wetland creation and restoration, and continued efforts through the Watershed Restoration and Protection Strategy (WRAPS) groups.
10. Begin initial scoping process for pilot projects for reservoir dredging to determine feasibility and to locate possible dredging sites.

REFERENCES

American Society of Engineers, Report Card for America's Infrastructure, 2009, http://www.infrastructurereportcard.org/fact-sheet/levees.

Kansas Floodplain Management Newsletter, Kansas Department of Agriculture, Division of Water Resources, Floodplain Management, May 2009

Kansas Hazard Mitigation Plan, Kansas Division of Emergency Management, November 2007

Kansas Water Plan Enhanced Stream Corridor and Wetland Management to Address Reservoir Sedimentation, January 2009

Kansas Water Plan Flood Damage Mitigation and Small Dam Safety Policy and Institutional Framework, January 2009

Kansas Water Plan, Small Dam Safety and Rehabilitation Policy Section, November 18, 2005

The Northeast Kansas Flood of 1951 - 50th Anniversary, NOAA, February 07, 2006, http://www.crh.noaa.gov/top/events/flood51.php

Rehabilitating Our Nation's Aging Flood Control Dams, Larry W. Caldwell, State Conservation Engineer, USDA-NRCS November 14, 2000 http://www.landandwater.com/features/vol44no3/vol44no3_2.html

USGS Professional Paper: Flooding in the United States Midwest, 2008, Robert R. Holmes, Jr., Todd A. Koenig, and Krista A. Karstensen, 2010

USGS News release, Flood Flows and Climate Variability in the US, an Exploration of the Literature, Theory, and Long-term Flood Records, Bob Hirsch December 08, 2008

USGS Presentation, Kansas Big Water - the Flood of 1951, http://ks.water.usgs.gov/, September 17, 2008

USGS Report, Historic Floods of Kansas, (Modified from Clement, R.W., 1991, Kansas floods and droughts, *in* Paulson, R.W., Chase, E.B., Roberts, R.S., and Moody, D.W., compilers, National water summary 1988-89 -- Hydrologic events and floods and droughts: U.S. Geological Survey Water-Supply Paper 2375, p. 287-294), September 17, 2008