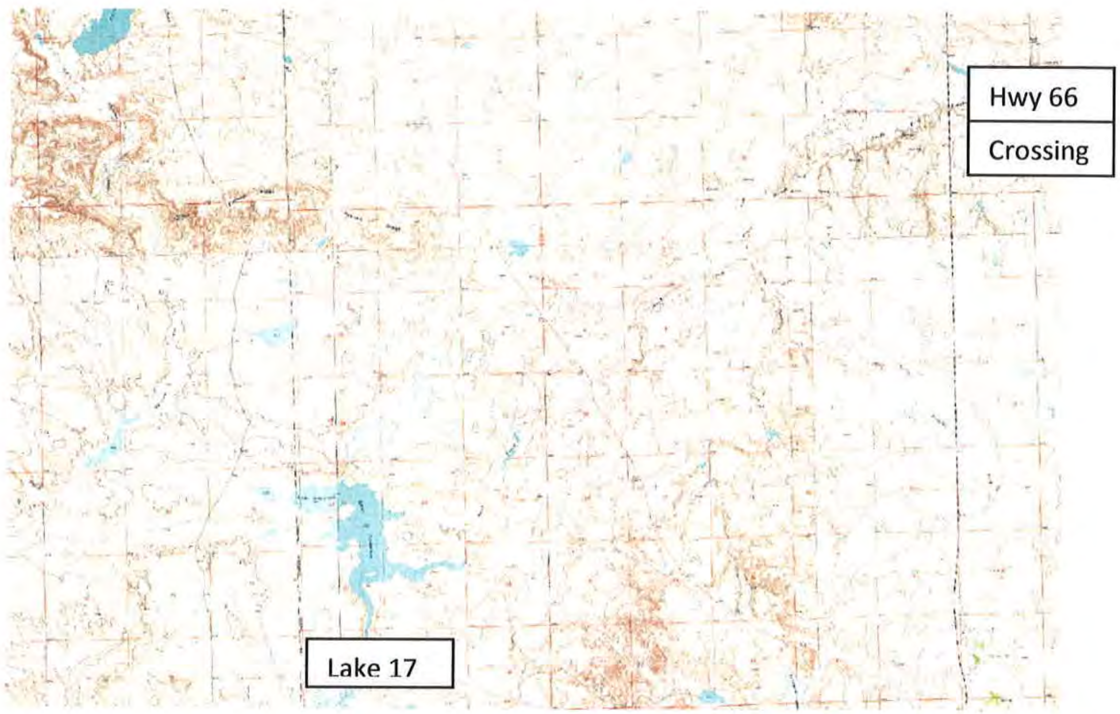
BREACH SUMMARY REPORT

Lake 17 Breach Routing Summary

Lake 17 is an artificial impoundment formed by the combination of a dam at the lake itself, and a diversion dam south of the lake. Both the diversion dam and main dam at the lake were constructed in the 1920's with the intended purpose of supplying water for a planned irrigation system. For nearly a century, the large, shallow impoundment has provided critical open water and wetland habitat for a variety of wildlife including birds, mammals, reptiles, and amphibians.

Topographic Image of Lake 17 and Highway 66



Lake 17 Stage – Storage Information

Location	Elevation	Capacity (Ac-Ft)
Principal Spillway	3020.9	4111
Auxiliary Spillway	3023.1	5773
Top of Dam	3026.5	8900

Following is a summary of the breach analysis performed on the Lake 17 dam using NRCS criteria and Corps of Engineers, HEC-RAS hydraulic model.

A breach analysis for the Lake 17 dam was performed using HEC-RAS unsteady flow procedures. A check using steady state conditions was also run and results indicated slightly higher water surface elevations using this method. The minimum peak discharge of the breach hydrograph was determined using criteria from TR-60, Earth Dams and Reservoirs, and procedures from TR-66 Breach Hydrograph.

Criteria for Determination: Montana State DNRC specifies "The breach flooded area, for the purpose of classification, is the flooded area caused by a breach of the dam with the reservoir full to the crest of the emergency (auxiliary) spillway." Thus the crest elevation of the auxiliary spillway was used to determine the breach hydrograph. The TR-60 Breach Q for hazard class was determined to be 14,000 cfs. The HEC-RAS model considered to be the chosen condition was set up to simulate an 18 hour flow generated from the principal spillway when the water surface is at the crest of the auxiliary spillway (400 cfs) and an initial flow in the channel of 60 cfs. The two year flow of Little People Creek is 50 cfs. In order to keep the model stable a minimum flow of 60 cfs was used in the model. After 18 hours of flow, the breach hydrograph was inserted. Froelich dam breach equations were used to determine an estimated time to fail. A time to fail of two hours was computed, and a conservative time of one hour was used from the beginning of the breach to the peak. The breach hydrograph was then carried out another 22 hours past the start of the breach to a low flow of 200 cfs.

A point to note is that the dam is curved. The length of dam at the failure elevation of 3023.1 is approximately 750 feet. The valley width for a distance downstream at the failure elevation is approximately 450 feet. The theoretical breach width was computed to be 431 feet. If the valley width had been 25 feet narrower, the breach Q would have been 1000 cfs less, or 13,000 cfs.

Manning's n – Much discussion can be put into the selection of a roughness coefficient. The literature indicates the Manning's n needs to be increased in order to account for the additional energy losses associated with dam break flows such as those due to soil and debris that impede flows. Ralph Bergantine, retired NRCS Hydraulic Engineer, recommended using values twice those determined for steady state conditions, and referenced a paper by Trieste and Jarrett on field verified N-values at actual breach sites, however the paper could not be verified.

Computed n values without considering breach effects are in the 0.06 range. Study results from the USBR on the Glen Canyon Dam failure inundation study calibrated roughness values that varied from 0.055 to 0.12. Depths ranged from 320 to 580 feet. Lake 17 breach depths averaged in the 10 foot range and would support values on the high side of 0.06 to 0.10. For the above reasons a Manning's n value of 0.08 was used in the HEC-RAS model.

A total of three runs were used to compare with each other. The conditions and results are shown in the table below.

Summary of Breach Analysis

Condition	Base Flow	Initial Flow	n Value	WSEL
1. Unsteady***	60 cfs	400 cfs	0.08	**2749.8**
2. Unsteady	60 cfs	400 cfs	0.06	2850.7
3. Steady State	6861 cfs	--------	0.08	2850.9

*** Considered to be the run that most accurately represent the breach analysis.

Results –Unsteady flow analysis with parameters described above determined an attenuated flow immediately upstream of the bridge to be 6861 cfs. The water surface elevation of **2849.8** is approximately 0.8 feet below the top of the road at the lowest point. The chart below lists elevations of key points on the bridge:

Elevations at the Bridge

Location (Looking Downstream)	**Elevation**
Upstream Bottom Stringer (Left)	2847.7
Upstream Bottom Stringer (Right)	2848.4
Downstream Bottom Stringer (Left)	2848.5
Downstream Bottom Stringer (Right)	2849.1
Top Road (Left)	2850.6
Top Road (Right)	2851.2

Summary:

Condition 1, which represents the run that most accurately represents the breach analysis, indicates approximately 0.8 feet of freeboard at the lowest point in the road and 1.4 feet of freeboard at the highest point. The bottom of the stringers will be under water. Note that the steady state condition closely matches the unsteady run with an n value of 0.06. The steady state is not going to be the most accurate given the changing sections etc. And for the unsteady run an n value of 0.06, is considered low for a breach condition.

Bridge at Hwy 66 Crossing

Hwy 66 and Bridge

REFERENCES

- List of References
    - HEC-RAS
    - TR-60
    - TR-66
    - USGS Montana Flood Frequency and Basin Characteristic Data
    - Montana Department of Natural Resources and Conservation – Dam Safety Rules
    - National Engineering handbook Section 5, Supplement B
    - Ralph Bergantine, Retired NRCS Hydraulic Engineer, Bozeman, Montana
    - Dennis Reep, State Conservation Engineer, NRCS, Bismark, North Dakota