HADLOCK POND DAM FAILURE: RECONSTRUCTION OF PEAK DISCHARGE AND COMPARISON TO REGIONAL FLOOD FREQUENCY

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ABSTRACT:

On July 2, 2005 the Hadlock Pond dam breached in Fort Ann, New York and allowed approximately 2×10^6 m^3 of water to discharge through the outlet stream. Several houses were dislodged from their foundations and three bridges were washed away. Such a large discharge was unexpected below a dam that had regulated discharge for more than a century.

Our goal for this project was to reconstruct the peak discharge and compare it to flood frequency analyses of similar sized basins in New York. The Hadlock Pond watershed is 20.5 km^2 and the surficial geology is dominated by clay rich till and bedrock outcrops. We used a differential GPS unit to map the pond's bathymetry and estimated a total volume of ~3 x 10^6 m^3, of which about 2/3 discharged from the pond. Just below the dam break, data from 36 pebble counts show a rapid decrease in grain size as flood waters filled the valley and flow depth and basal shear stresses decreased. We surveyed five cross-sections of maximum depth based on high water sand deposits and reconstruction of high water lines from photographs. We estimated Manning's roughness coefficients using Arcement and Scheider (1989). Peak discharge calculations based on Manning's equation, for all five sites, range between 3000 and 9700 cfs. USGS stream gauge data from similar sized basins in eastern New York show that discharges of >3000 cfs are rare in the historic records. Flood frequency analyses suggest that the peak discharge from the Hadlock Pond dam break is equivalent to recurrence intervals that range from 50 years at the low end to more than10,000 years at the high end. Therefore, we found that the Hadlock Pond dam break discharge is an unnatural size for its basin size and likely has not experienced such a flood magnitude since the end of the last glaciation.

Aerial of Hadlock Pond post-breach Photo by Bay Ridge Fire Dept.

Pebble count site at dam break

Residents watch dam break. Fort Ann, NY Photo by Bay Ridge Fire Dept.

Flooded home, Fort Ann, NY Photo by Bay Ridge Fire Dept.

Location of Hadlock Pond, Fort Ann, and other similar sized watersheds that have long-term USGS data

Legend
- NY State
- Washington County
- Town of Fort Ann
- Allen Brook
- Bond Creek
- Mine Kill
- Platter Kill
- Bushnellsville Creek

BACKGROUND INFORMATION OF HADLOCK POND DAM:

- The Hadlock Pond Dam was originally built in 1897 to benefit a hydroelectric station at Kanes Falls, NY and has had a history of breaches.
- The first breach occurred in 1930s when a large tree growing on the dam was uprooted by a storm.
- 1976 - Pipes used to drain the lake collapsed causing a near breach.
- 1977 - US Army Corps of Engineers report stated the spillway at Hadlock Pond could only handle 13% of a probable maximum flood, and was at risk for breach.
- 1978 - Spillway was fixed and completed.
- 1984 - Dam did not pass inspection because it did not meet 500-year flood criteria and was contracted to be rebuilt.
- June, 2005- Reconstruction of the Hadlock Pond Dam, in Fort Ann, NY was completed.
- July 2, 2005- Dam breach due to internal erosion (DEC Report, 2005).
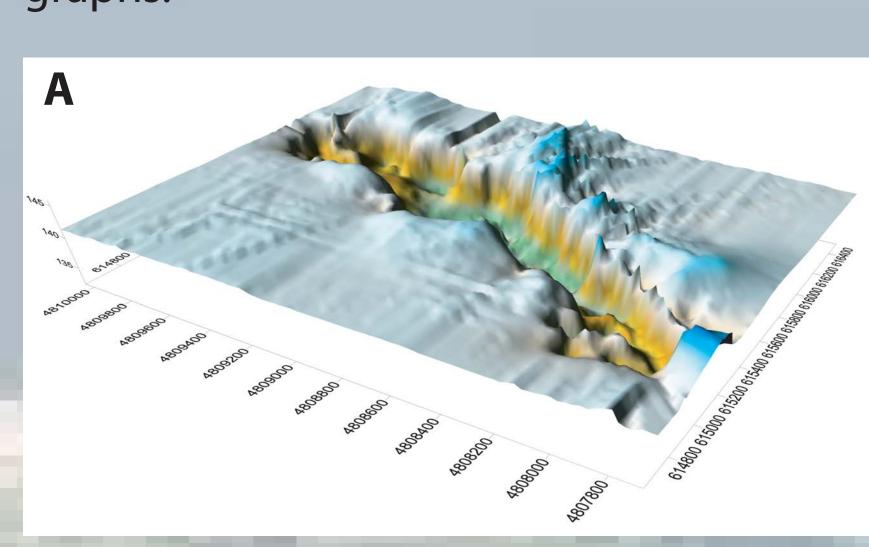- Results: Six homes were destroyed due to flooding, one was lost due to fire.

Hadlock Pond Watershed: Surficial Geology

Legend MATERIAL
- k - Kame Deposit
- ld - Lacustrine Delta
- ls - Lacustrine Sand
- lsc - Lacustrine Silt and Clay
- r - Bedrock
- t - Till
- Cross-section #

Campney Lane Flood Damage (Site 4) Photo by Bay Ridge Fire Dept.

Flood damage upstream from Sites 1-3 www.hadlockpond.org.

Hadlock Pond Dam Breach, July 2, 2005 Photo by Bay Ridge Fire Department.

C

OBJECTIVES:
- Calculate volume of Hadlock Pond.
- Characterize discharge below breach using pebble counts.
- Reconstruct peak flood discharge.
- Determine return interval of peak flood discharge under natural conditions.

FIELD METHODS:
A. Bathymetric map (GPS)
B. Calculated water volume using *Surfer* .
C. Surveyed 5 channel cross sections & slopes.
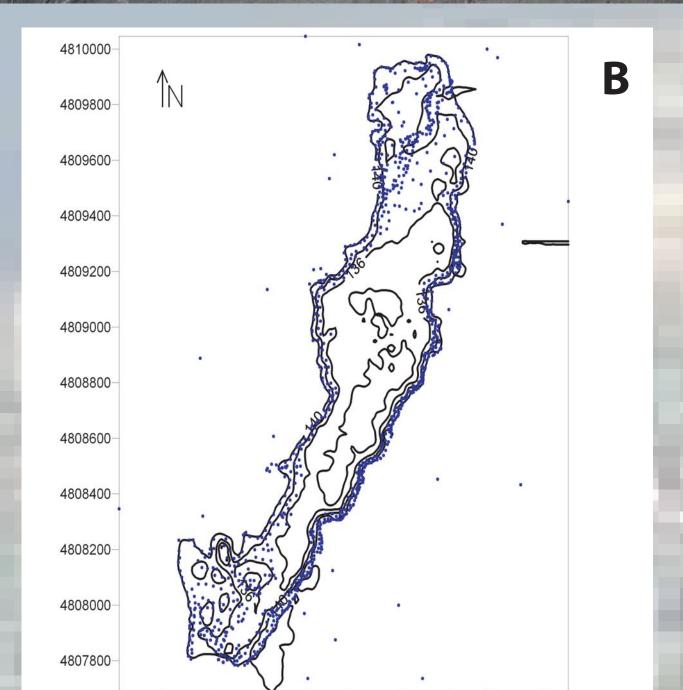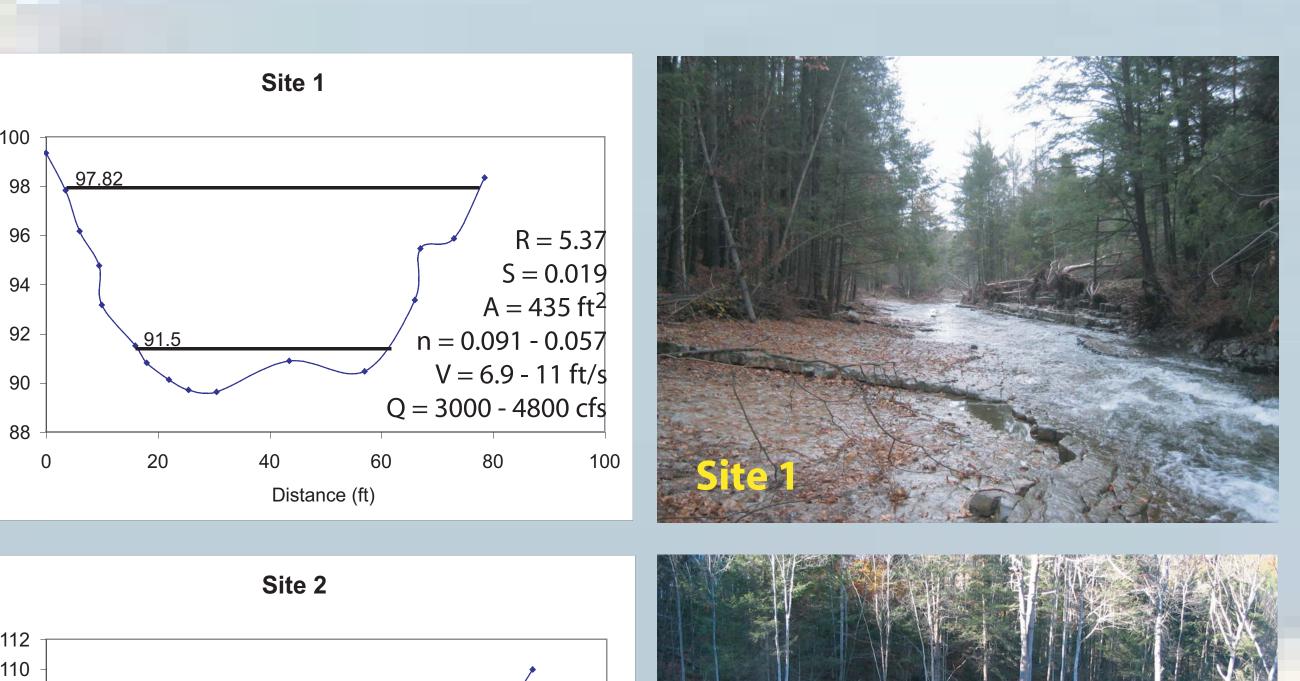D. High water marks determined by sand deposits and reconstructed from photographs.

D
High Water Mark
High water mark denoted by contact of recently deposited sand with forest floor at Site 2.

A

B

Bathymetry Hadlock Pond based on differential GPS data. B) Hadlock Pond bathymetry. Blue dots represent location of collected data. Volume ~3 x 10^6 m^3 before flood, 2/3 lost during dam breach.

View upstream from site 4.

ANALYTICAL/LAB METHODS:
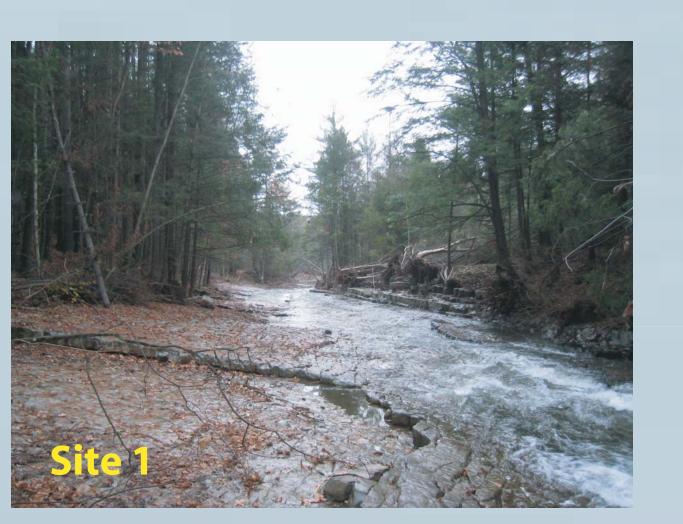- Plotted slope and cross section data from 5 sites.
- Calculated discharge of the dam break flood at 5 sites using Manning's Formula, commonly used to reconstruct paleofloods (Kochel and Baker, 1982).

$$Q = \frac{1.486}{n}(AR^{2/3}S^{1/2})$$

A= Area (ft^3)   Q= Discharge (cfs)
S= Slope   R= Hydraulic Radius
n= Manning's Coefficient

- Compared USGS stream gauge data of similar sized basins from New York and Vermont to estimate flood exceedence probability for the dam break flood.
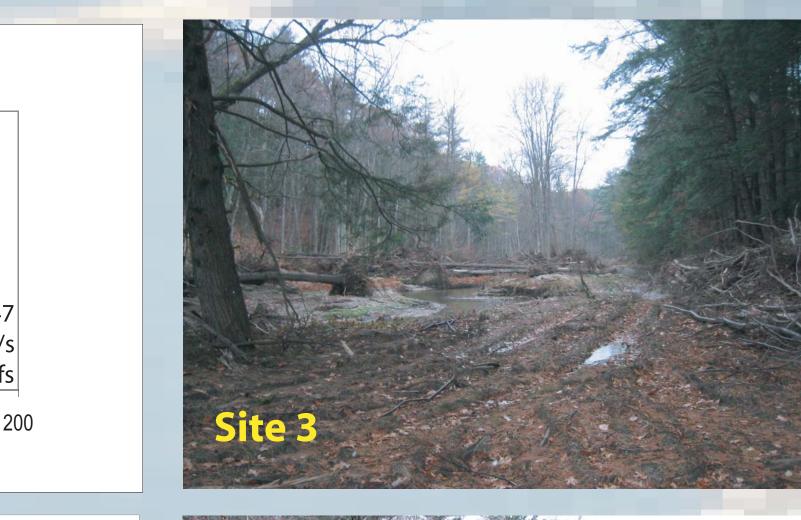
RESULTS/ DISCUSSION:
- Cross-sections for Sites 1-5 show flood elevations (and stream elevations as measured in October, 2005) that we used for discharge calculations.
- Total volume of lake is 3 x 10^6 m^3, two thirds of the volume drained after the dam breach.
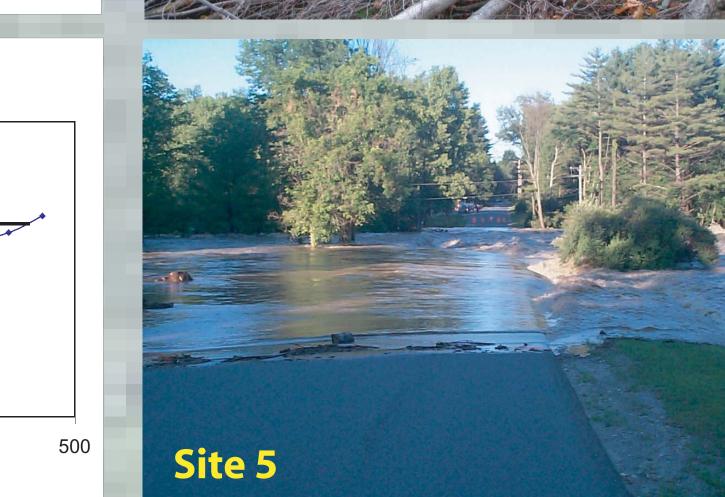- Peak discharge after the break ranged from 3000 to 9700 cfs.

Site 3
R = 8.79   S = 0.019
S = 0.0014   A = 435 ft^2
V = 2.3 - 5.0 ft/s
Q = 1503 ft^2 Q = 3400 - 7600 cfs
Site 3

Site 1
R = 5.37   S = 0.019
S = 0.007   A = 435 ft^2
n = 0.091 - 0.057
V = 6.9 - 11 ft/s
Q = 3000 - 4800 cfs
Site 1

Site 4
R = 6.99   S = 0.019
S = 0.014   A = 1425 ft^2
n = 0.2 - 0.3
V = 4.5 - 6.8 ft/s
Q = 6400 - 9600 cfs
Site 4

Site 2
R = 5.85
S = 0.007
A = 1059 ft^2
n = 0.096 - 0.044
V = 4.2 - 9.2 ft/s
Q = 4500 - 7800 cfs
Site 2

Site 5
R = 4.67
S = 0.01
A = 1996 ft^2
n = 0.1 - 0.15
V = 2.8 - 4.2 ft/s
Q = 5500 - 8300 cfs
Site 5

- Pebble count analysis showing clast size distribution at dam break ~20 m below the dam (See Aerial Hadlock Pond photo).
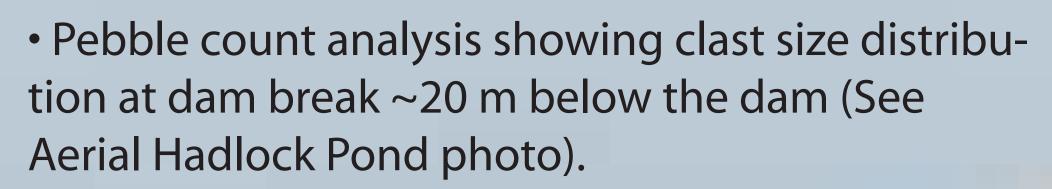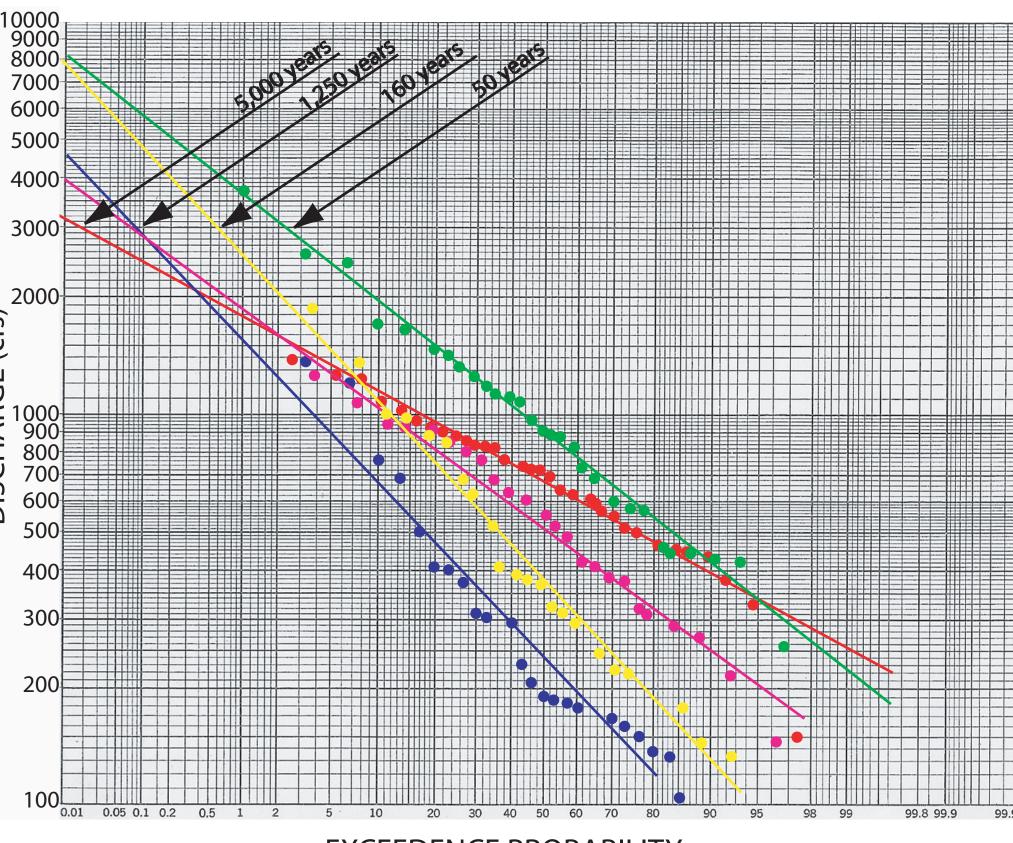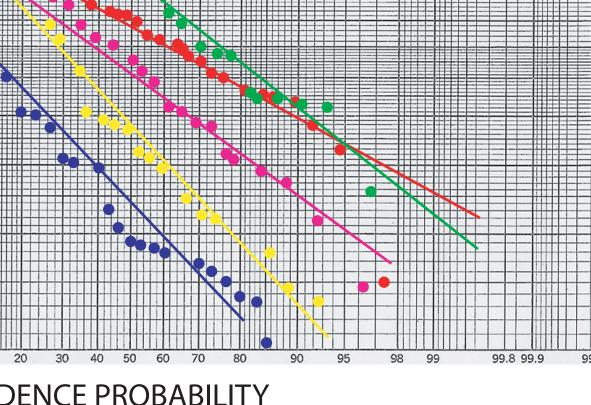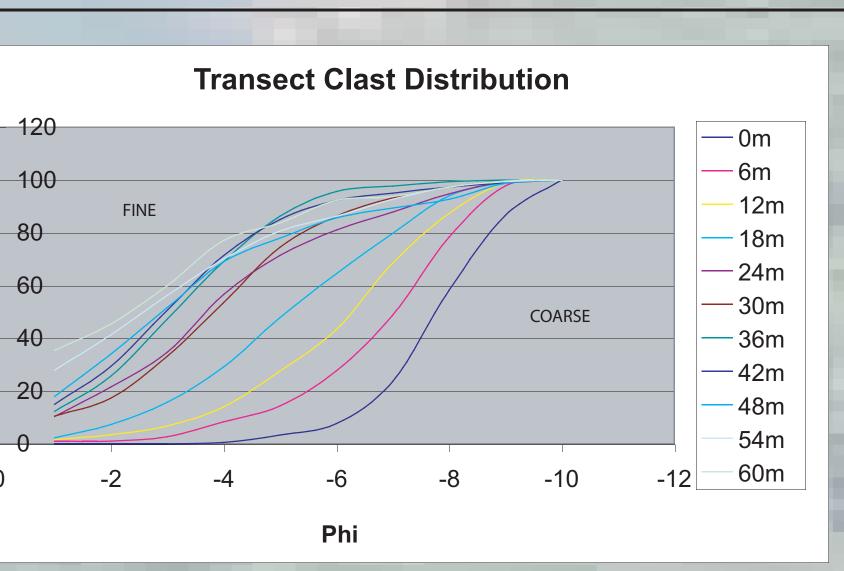- Clasts finer than 2mm were not measured in the field.
- Clast size decreased rapidly below the dam breach. Such rapid fining of clasts is consistent with decreased basal shear stress as the flow depth decreased and the water filled the valley.
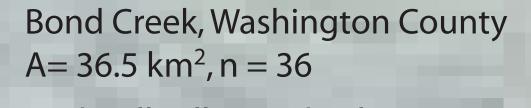

Transect Clast Distribution
0m, 6m, 12m, 18m, 24m, 30m, 36m, 42m, 48m, 60m
FINE / COARSE

Down stream view of pebble count area below dam..

DISCHARGE vs EXCEEDENCE PROBABILITY

- Bond Creek, Washington County A= 36.5 km^2, n = 36
- Bushnellsville Creek, Ulster County A= 29.5 km^2, n = 26
- Allen Brook, St. Lawrence County A= 41.4 km^2, n = 25
- Mine Kill, Schoharie County A= 42.0 km^2, n = 30
- Platter Kill, Schoharie County A= 28.2 km^2, n = 29

*Area of Hadlock Pond watershed at cross-section locations is ~35 km^2.

- For similar sized watersheds in eastern New York, discharges of 3000 cfs have recurrence intervals of at least 50 years and as high as 5,000 years. For higher discharges recurrence intervals are much longer, 10,000 years or more.

Part of the dam that was washed down stream

CONCLUSIONS:
- Our estimate of Hadlock Pond's volume is ~3 x 10^6 m^3 with ~2 x 10^6 m^3 of water drained after the dam breach.
- Given the cross sectional area and the Manning's n for each site, we estimated the discharge of the flood to be between 3000 and 9700 cfs.
- A flood of this magnitude has a recurrence interval between 50 years at the low end to > 10,000 years at the high end. This demonstrates that this flood is an extremely rare event for this basin size and runoff prone surficial geology.