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January 14, 2021

MEMO

To: Gianna Petito, District Manager, Winooski Natural Resources Conservation District

From: Meghan Arpino, Gabe Bolin, PE, Stone Environmental, Inc.

Stone Project No. 20-007
Subject: Hands Mill Dam Removal – BCA Analysis Memo

Stone Environmental, Inc. (Stone) has completed a Benefit-Cost Analysis (BCA) as part of the Hands Mill Dam Removal 30% design effort. This memo provides a summary of the analysis, along with a BCA report and supporting documentation, that can be used as part of a larger grant application submission by the Winooski Natural Resources Conservation District (District) to the US Federal Emergency Management Agency (FEMA) for funding to support future project phases.

The BCA is a method developed by FEMA that compares risk reduction benefits of a hazard mitigation project to its costs. The result is a Benefit-Cost Ratio (BCR), where a project is considered cost-effective when the BCR is at or greater than 1.0. To establish cost-effectiveness of a project, those that are applying to FEMA for project funding are required to use FEMA methodologies and tools. Stone used the FEMA BCA Toolkit, Version 6.0 (https://www.fema.gov/grants/guidance-tools/benefit-cost-analysis) for this analysis. The following sections provide an explanation of details and assumptions of the analysis. Relevant supporting documents are provided as attachments to this memo.

1. Analysis Methodology and Assumptions

The overall analysis includes two mitigation actions, 1) mitigation at the dam property itself, including dam removal and 2) mitigation of impacts to the residential property at 16 Woodchuck Hollow Road, which is located at the intersection of West Corinth Road and Woodchuck Hollow Road, immediately adjacent to the dam property. Analysis of the dam property and dam removal is based on professional expected damages due the limited availability of historical damages data. Analysis of impacts to the residential property included a comparison of existing and proposed HEC-RAS model conditions and results. The following provides a summary of details, information and assumptions that were made to complete the analysis using the BCA Toolkit Version 6.0. The information is presented in the order it was input into the toolkit, for ease of understanding by FEMA reviewers. A printout of the completed BCA Toolkit Form is provided in Attachment 1.

1.1 Mitigation Actions

Mitigation Action 1 – Dam Removal at Dam Property

- Property Structure – Set to 'Other' since the dam did not fall into any of the listed categories.
- Hazard Type – 'Riverine Flood' was selected since it was most applicable to the project and provided a means to account for the 'ecosystem benefits' of the floodplain bench and open space components of the proposed project.
- Initial Project Costs – A value of $588,593 was used which is the sum of previously incurred archeological costs ($25,080, sum of Phase 1 and Phase 2 archeological costs provided in Prior Expenses table in Attachment 2) and total initial project cost ($563,513). Total initial project costs consist of construction opinion of probable cost (OPC) for the selected alternative and includes the construction costs, mobilization/demobilization and construction contingency, currently set at 20% for this 30% design project. Project costs are provided as Attachment 2 to this memo.
- Annual Maintenance Costs – A value of $244 was used to account for monitoring of planted grasses, shrubs, and/or trees following construction, with replanting and reseeding occurring as needed throughout the default project life of 30 years. The annual maintenance cost was calculated by dividing the estimated Monitoring and Stewardship costs by the project useful life. See Attachment 2 and 3 for supporting documentation, including the Dam Removal General O&M document (http://winooskinrcd.org/wp-content/uploads/Dam-Removal-OM-General-Comments-1-1.pdf) referred to for this item.
- Damage Analysis Parameters – See Attachment 4 and 5 for dam information from Dam Breach Report and historical dam documents.
- Professional Expected Damages Before Mitigation
    - Flood Recurrence Interval – The dam breach analysis performed by the VTDEC Dam Safety Program (Attachment 4) to support this analysis simulated a breach of the highest dam structure capable of impounding water, which currently is a concrete training wall along river right with a top elevation of 1280'. This elevation defined the max pool elevation in the analysis and corresponded to the 200-year recurrence interval flood event in Stone's project hydrologic and hydraulic model, simulated using the Army Corps of Engineers HEC-RAS model (https://www.hec.usace.army.mil/software/hec-ras/). Note that the model includes a 'levee' set to elevation 1280' at two cross sections that intersect the dam; levees do not exist anywhere else in the model. Starting at the 100-year recurrence interval flood event, flow from upstream of the training wall is conveyed around the levee/training wall along river right resulting in shallow flooding in a town yard located north of the concrete training wall, and along Woodchuck Hollow Road.

- Damages – A value of $256,668 was used in the BCA as the cost for dam failure based on this estimation. Damage costs for the residential structure located immediately adjacent to the dam at 16 Woodchuck Hollow Road and other downstream properties identified in the VTDEC Dam Breach Report (Attachment 4) using damage curves developed under Mitigation Action 2 of this BCA were also included. A 3 to 6-foot flood depth was assumed based on model data from the VTDEC Dam Breach Report (Attachment 4) and a finished floor elevation (FFE) of 1269.40' (relative datum). The FFE was based on a topographic survey shot located at an exterior corner of the structure. One foot was added to the elevation to obtain the best approximation of FFE based on the location of an adjacent window and other observations of the structure made in the field during the survey. See Attachment 6 for damage cost calculations.
- Loss of Life and Injury – Costs calculated based on number of residents at 16 Woodchuck Hollow Road and daytime population at risk (PAR) using values from the Benefit-Cost Analysis Sustainment and Enhancement: Standard Economic Value Methodology Report Version 9.0 (FEMA, 2020). See Attachment 7 for calculations.
- Economic Costs – This metric was estimated for interruptions to normal traffic patterns in the area. Based on the Dam Breach Report, several roads downstream of the dam, including the road accessing the local school, may be flooded in the event of a dam breach. These calculations were made using the daytime and nighttime Population at Risk (PAR) provided in the Dam Breach Report.
  - Total Cost = (Daytime PAR + Nighttime PAR)*38.15(vehicle delay time, per vehicle per hour)*24(assume 1 day, 24 hrs. of delays) =
  - Total Cost = (94+40)*38.15*24=$112,690.40
- Displacements Costs – This metric was estimated using generic damage curves and estimated flood depths for several downstream properties included in the Dam Breach Analysis (Attachment 4). See Attachment 8 for calculations.

- <u>Professional Expected Damages After Mitigation</u>
  - After Mitigation Costs –
    - Stone considered including a cost for damage to an adjacent road (i.e. West Corinth Road or Woodchuck Hollow Road), assuming that after dam removal the pilot channel could migrate/adjust during a large storm event and negatively impact adjacent infrastructure. However, a cost was ultimately not included, as the existing channel would be lowered significantly (i.e. ~10') away from the roads as part of the dam removal construction, and the potential for impacts to roads or road

embankments are further reduced. Additionally, the removal of the dam eliminates risks due to dam failure.

- Removal of the dam will lower the 100-year recurrence interval flood peak water surface elevation by approximately 14.64 feet in the vicinity of the dam, which greatly reduces the risk of flooding adjacent properties in the project area. The estimated Finished Floor Elevation (FFE) for the property adjacent to and immediately downstream of the dam (16 Woodchuck Hollow Road) is 1,269.40'. Under existing conditions, the 100- and 500-year water surface elevations (WSE) for the site are 1,265.48' and 1,266.29' respectively. Based on hydraulic modeling completed using USACE's HEC-RAS model, the water surface elevations for the 100- and 500-year recurrence interval floods are below the estimated FFE for existing and proposed conditions. Under proposed conditions (dam removal and floodplain restoration) these values become 1,264.24' for the 100-year peak WSE and 1,265.33' for the 500-year peak WSE. Given this property is closest to the dam, we can assume that there is minimal to no residual risk expected because the WSEs for proposed conditions are below those for existing conditions and all are below the existing FFE. Mitigation Action 2 accounts for before and after mitigation water surface elevations at the immediately downstream 16 Woodchuck Hollow Rd property and shown in Attachment 9.

- Standard Benefits – Ecosystem Services
  - These include benefits to the ecosystem related to floodplain, riparian, wetland and open space areas created by the project. The proposed work includes 36,000 SF or restored area, of which 52% is green open space and 48% of which is riparian area. A map showing these areas is provided as Attachment 10.

Mitigation Action 2 – Lowering of Flood Water Surface Elevations at 16 Woodchuck Hollow Road Following Dam Removal

- Project Useful Life – A project useful life (PUL) of 30 years was used for the stream and floodplain restoration project associated with dam removal.
- Initial Project Costs – This value was set to $0 since the dam removal costs are already captured in Mitigation Action 1.
- Annual Maintenance Costs – A value of $500 was used to cover annual activities similar to the annual maintenance costs for Mitigation Action 1, but covers a smaller area associated with this property.
- Lowest Floor Elevation – As stated above, a FFE of 1269.40' (relative datum) was used for the building. See Attachment 11 for survey photograph.

- Streambed Elevation at the Property Location – Thalweg elevation (in relative datum) at the property was obtained from survey data and the hydraulic model. Before and after mitigation water surface elevations were obtained from cross sections at the upstream extent of property, within the limits of disturbance of the proposed dam removal and restoration project. Differences in water surface elevations between existing and proposed conditions reduce moving from upstream to downstream. A series of graphic cross sections from the HEC-RAS model, showing thalweg and water surface elevations) are included in Attachment 9.
- Building Size – The building square foot area is based on the building outer dimensions and assumes two levels of living space.
- Standard Benefits – Ecosystem Services were captured at the residential property, similar to the Ecosystem Services discussed for Mitigation Action 1 above.

2. Results

The BCR generated for the proposed removal of Hands Mill Dam using the BCA Toolkit, and based on the assumptions as stated in this memo is 3.32. This is a composite score that includes the costs and benefits for Mitigation Actions 1 (BCR = 2.91) and 2 (BCR = 42.62).

Attachment 1: BCA Report

Project Summary

Mitigation Title	Hazard	Benefits (B)	Costs (C)	BCR (B/C)
Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"	FA - Riverine Floo	$1,719,717	$591,621	2.91
Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675	Riverine Flood	$264,486	$6,205	42.62
	Total	$1,984,203	$597,826	3.32

Property Configuration

Property Title:	Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"
Property Location:	05675, Orange, Vermont
Property Coordinates:	44.1055750, -72.4298000
Hazard Type:	Riverine Flood
Mitigation Action Type:	Floodplain and Stream Restoration
Property Type:	Other
Analysis Method Type:	Professional Expected Damages

Cost Estimation

Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"

Project Useful Life (years):	30		
Project Cost:	$588,593		
Number of Maintenance Years:	30	Use Default:	Yes
Annual Maintenance Cost:	$244		

Comments

Project Useful Life:	Used default PUL for Floodplain and Stream Restoration Projects. See Attachment 1: BCA Report for complete PDF version of BCA.
Mitigation Project Cost:	The total initial project cost entered here is the sum of initial project costs and archeological/historical costs from prior expenses. See Attachment 2 for Initial Project Costs from Project Initial and Mainte
Annual Maintenance Cost:	See Attachment 2 for Total Annual Maintenance Cost from the Project Initial and Maintenance Cost Estimation Table. Maintenance costs were divided by PUL for annual maintenance costs. Assumed monitoring of newly planted grasses, shrubs, and/or trees for 3 years, with replanting and reseeding occurring as needed. See Attachment 3 for O&M guidance.

Damage Analysis Parameters - Damage Frequency Assessment

Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"

Year of Analysis Conducted:	2020		
Year Property was Built:	1860		
Analysis Duration:	161	Use Default:	Yes

Comments

Analysis Year:	Year H&H analysis and dam failure analysis completed.
Year Built:	See Attachments 4 through 6, VTDEC Dam Breach Report, Historical Dam Documents, and Town of Washington Local Hazard Mitigation Plan for information on dam condition, age, and classification. Dam repaired or rebuilt in 1927, unclear from records.

Professional Expected Damages Before Mitigation

Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"

	Other	Optional Damages			Volunteer Costs		Total
Recurrence Interval (years)	Damages ($)	Loss of Life and Injury ($)	Economic ($)	Displacement Costs ($)	Number of Volunteers	Number of Days	Damages ($)
200	256,668	23,100,000	122,786.88	384,648.42	5	2	23,866,031

Comments	
Damages Before Mitigation:	Damages were calculated using values from the damage curve for residential properties. Loss of Life and Injury, Economic (travel delay based on daytime and nighttime PAR, assuming 1 day or 24 hours of reroute), and Displacement costs calculated using values from Benefit-Cost Analysis Sustainment and Enhancement: Standard Economic Value Methodology Report Version 9.0 (FEMA, 2020). See Attachment 4 for dam failure analysis and Attachments 7 through 9 for expected damages and optional damages. Volunteer costs estimated based on cleanup time.

Annualized Damages Before Mitigation — Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)
200	23,866,031	119,328

Professional Expected Damages After Mitigation — Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"

	Other	Optional Damages			Volunteer Costs		Total
Recurrence Interval (years)	Damages ($)	Loss of Life and Injury ($)	Economic ($)	Displacement Costs ($)	Number of Volunteers	Number of Days	Damages ($)
0	0	0	0	0	0	0	0

Comments	
Damages After Mitigation:	Since the mitigation action includes complete dam removal, there is no anticipated residual flood risk due to dam failure after mitigation. The BCA module run for mitigation action two at map marker 2 accounts for the post-mitigation WSEs for specified recurrence intervals at the property immediately downstream of the dam. All water surfaces elevations are below the first floor elevation for the property, and after mitigation WSEs are lower than before mitigation WSEs. See Attachment 10 HEC-RAS Output Figures. All elevations are in a relative datum.

Annualized Damages After Mitigation — Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"

Annualized Recurrence Interval (years)	Damages and Losses ($)	Annualized Damages and Losses ($)

Standard Benefits - Ecosystem Services — Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"

Total Project Area (sq.ft):	36,000
Percentage of Green Open Space:	52.00%
Percentage of Riparian:	48.00%
Percentage of Wetlands:	0.00%
Percentage of Forests:	0.00%
Percentage of Marine Estuary:	0.00%
Expected Annual Ecosystem Services Benefits:	$19,257.78

Comments	
Percent Green Open Space:	See Attachment 11
Percent Riparian:	See Attachment 11
Total Project Area:	Entered in square feet. Sum of riparian and green open space identified in the Ecosystems Benefit Map provided in Attachment 11.

Benefits-Costs Summary	Floodplain and Stream Restoration @ 44° 6' 20.07"; -72° -25' -47.28"
Total Standard Mitigation Benefits:	$1,719,717
Total Social Benefits:	$0
Total Mitigation Project Benefits:	$1,719,717
Total Mitigation Project Cost:	$591,621
Benefit Cost Ratio - Standard:	2.91
Benefit Cost Ratio - Standard + Social:	2.91

Property Configuration	
Property Title:	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Property Location:	05675, Orange, Vermont
Property Coordinates:	44.105675, -72.430389
Hazard Type:	Riverine Flood
Mitigation Action Type:	Floodplain and Stream Restoration
Property Type:	Residential Building
Analysis Method Type:	Modeled Damages

Cost Estimation	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675		
Project Useful Life (years):	30		
Project Cost:	$0		
Number of Maintenance Years:	30	Use Default:	Yes
Annual Maintenance Cost:	$500		

Comments	
Mitigation Project Cost:	Total initial project costs are captured in the mitigation task at map marker 1 and were not included here to avoid double counting. See Attachment 2 for those costs.
Annual Maintenance Cost:	Assumes project will require 2 to 3 years of monitoring following construction of the pilot channel. Newly planted riparian vegetation will be monitored to ensure that an 80% survival rate is establish for newly planted grasses, shrubs and/or trees. Reseeding and/or re-planting will occur as necessary.

Hazard Probabilities Parameters - Flood	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675	
Lowest Floor Elevation of the Property (ft):	1269.4	
Streambed Elevation at the Property Location (ft):	1259.94	Use Default Recurrence Intervals:
Use Default:	Yes	

Comments	
Lowest Floor Elevation:	Surveyed building corner plus 1 ft to account for foundation. Elevation recorded in relative datum. See Attachment 12 6 Woodchuck Hollow Road Topographic Survey Image.
Streambed Elevation:	Thalweg elevation at property pulled from survey data and hydraulic model. Before and After Mitigation WSEs pulled from cross section at upstream extent of property, within the limits of disturbance of the proposed dam removal and restoration project. Differences in WSE between existing and proposed conditions reduce moving from upstream to downstream. See Attachment 10 for HEC-RAS model output for before and after mitigation. And Attachment 13 for H&H Memo.

Discharge			Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Before Mitigation			
Recurrence Interval (years)	**Surface Elevation (ft)**	**Discharge (cfs)**	
10	1264.68	433	
50	1265.16	701	
100	1265.48	839	
500	1266.29	1232	
After Mitigation			
Recurrence Interval (years)	**Surface Elevation (ft)**	**Discharge (cfs)**	
10	1262.82	433	
50	1263.8	701	
100	1264.24	839	
500	1265.33	1232	

Building Information	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Building Type:	Two or More Stories
Foundation Type:	
Building Has Basement:	No
NFIP:	No

Comments	
Building Type:	See Hands Mill House SR Form in Attachment 5
Buiding has basement:	Unfinished, based on examples no basement.
Has NFIP:	Unknown

Standard Benefits - Building				Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Depth Damage Curve:	USACE Generic	Use Default:	Yes	
Building Size (sq.ft):	1,688			
Building Replacement Value ($/sq.ft):	$100	Use Default:	Yes	
Demolition Threshold (%):	50.00%	Use Default:	Yes	
Expected Annual Losses due to Building Damages before Mitigation:	$0.00			
Expected Annual Losses due to Building Damages after Mitigation :	$1.00			
Expected Annual Benefits - Building :	($1.00)			

Comments	
Building Size:	Calculated based on approximate dimensions of house. See Hands Mill House SR Form in Attachment 5.

Depth Damage Curve - Building								
	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675							
	Before Mitigation				After Mitigation			
Flood Depth (ft)	Percent (%)	Damage Value ($)	NFIP ($)	ICC Fees ($)	Percent (%)	Damage Value ($)	NFIP ($)	ICC Fees ($)
-2	0	0	0	0	0	0	0	0
-1	3	5,064	0	0	3	5,064	0	0
0	9.3	15,698.40	0	0	9.3	15,698.40	0	0
1	15.2	25,657.60	0	0	15.2	25,657.60	0	0
2	20.9	35,279.20	0	0	20.9	35,279.20	0	0
3	26.3	44,394.40	0	0	26.3	44,394.40	0	0
4	31.4	53,003.20	0	0	31.4	53,003.20	0	0
5	36.2	61,105.60	0	0	36.2	61,105.60	0	0
6	40.7	68,701.60	0	0	40.7	68,701.60	0	0
7	44.9	75,791.20	0	0	44.9	75,791.20	0	0
8	48.8	82,374.40	0	0	48.8	82,374.40	0	0
9	52.4	168,800	0	0	52.4	168,800	0	0
10	55.7	168,800	0	0	55.7	168,800	0	0
11	58.7	168,800	0	0	58.7	168,800	0	0
12	61.4	168,800	0	0	61.4	168,800	0	0
13	63.8	168,800	0	0	63.8	168,800	0	0
14	65.9	168,800	0	0	65.9	168,800	0	0
15	67.7	168,800	0	0	67.7	168,800	0	0
16	69.2	168,800	0	0	69.2	168,800	0	0

Standard Benefits - Contents	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Contents Value in Dollars:	$0 Use Default: Yes
Utilities Elevated:	No
Expected Annual Losses due to Content Damages before Mitigation:	$0.00
Expected Annual Losses due to Content Damages after Mitigation:	$1.00
Expected Annual Benefits - Content:	($1.00)

Depth Damage Curve - Contents	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675			
	Before Mitigation		**After Mitigation**	
Flood Depth (ft)	**Percent (%)**	**Damage Value ($)**	**Percent (%)**	**Damage Value ($)**
-2	0	0	0	0
-1	1	1,688	1	1,688
0	5	8,440	5	8,440
1	8.7	14,685.59	8.7	14,685.59
2	12.2	20,593.60	12.2	20,593.60
3	15.5	26,164	15.5	26,164
4	18.5	31,228	18.5	31,228
5	21.3	35,954.40	21.3	35,954.40
6	23.9	40,343.20	23.9	40,343.20
7	26.3	44,394.40	26.3	44,394.40
8	28.4	47,939.20	28.4	47,939.20
9	30.3	51,146.40	30.3	51,146.40
10	32	54,016	32	54,016
11	33.4	56,379.20	33.4	56,379.20
12	34.7	58,573.60	34.7	58,573.60
13	35.6	60,092.80	35.6	60,092.80
14	36.4	61,443.20	36.4	61,443.20
15	36.9	62,287.20	36.9	62,287.20
16	37.2	62,793.60	37.2	62,793.60

Standard Benefits - Displacement	Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675		
Lodging Per Diem:	$96	Use Default:	Yes
Meals Per Diem:	$55	Use Default:	Yes
Population Affected:	3		
Total Residential Displacement Cost:	$240		
Expected Annual Losses due to Displacement Damages before mitigation:	$0.00		
Expected Annual Losses due to Displacement Damages after Mitigation:	$0.00		
Expected Annual Losses - Displacement:	$0.00		

Comments	
Number of Building Residents:	Based on communications with property owners/residents.

Depth Damage Curve - Displacement — Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675

	Before Mitigation		After Mitigation	
Flood Depth (ft)	**Days**	**Damage Value ($)**	**Days**	**Damage Value ($)**
-2	0	0	0	0
-1	0	0	0	0
0	0	0	0	0
1	45	10,800	45	10,800
2	90	21,600	90	21,600
3	135	32,400	135	32,400
4	180	43,200	180	43,200
5	225	54,000	225	54,000
6	270	64,800	270	64,800
7	315	75,600	315	75,600
8	360	86,400	360	86,400
9	405	97,200	405	97,200
10	450	108,000	450	108,000
11	495	118,800	495	118,800
12	540	129,600	540	129,600
13	585	140,400	585	140,400
14	630	151,200	630	151,200
15	675	162,000	675	162,000
16	720	172,800	720	172,800

Additional Benefits - Street Maintenance — Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675

Total Annual Street Maintenance Budget:	$0
Total Number of Street Miles Maintained:	0
Street Miles that will not require future maintenance:	0
Expected Annual Benefits - Street Maintenance:	$0.00

Standard Benefits - Volunteer Costs — Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675

Number of Volunteers (volunteers/event):	5
Number of Days of Lodging:	1
Expected Annual Volunteer Benefits:	$1,467.60

Comments

Number of Volunteers Required:	Large amount of debris on property, assume volunteer hours will be used to help remove debris transported from property downstream during flood events.

Standard Benefits - Ecosystem Services		Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Total Project Area (sq.ft):	36,000	
Percentage of Green Open Space:	52.00%	
Percentage of Riparian:	48.00%	
Percentage of Wetlands:	0.00%	
Percentage of Forests:	0.00%	
Percentage of Marine Estuary:	0.00%	
Expected Annual Ecosystem Services Benefits:	$19,257.78	

Comments	
Total Project Area:	See Attachment 11 Ecosystem Benefits Map

Additional Benefits - Social		Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Number of Workers:	0	
Expected Annual Social Benefits:	$7,329	

Benefits-Costs Summary		Floodplain and Stream Restoration @ 16 Woodchuck Hollow Rd, Washington, Vermont, 05675
Total Standard Mitigation Benefits:	$257,157	
Total Social Benefits:	$7,329	
Total Mitigation Project Benefits:	$264,486	
Total Mitigation Project Cost:	$6,205	
Benefit Cost Ratio - Standard:	41.44	
Benefit Cost Ratio - Standard + Social:	42.62	

Attachment 2: 30% Design Opinion of Probable Cost, Initial and Maintenance Costs, Prior Expenses

Hands Mill Dam Removal
Alternative A4 - 30% Design OPC
Stone Environmental, 1/2021, V4.2

ITEM #	ITEM	AMOUNT	UNIT	UNIT COST	TOTAL
General					
1	SURVEY LAYOUT	1	LS	$4,000.00	$4,000.00
2	CONSTRUCT ACCESS	1	LS	$20,000.00	$20,000.00
3	EPSC MEASURES	1	LS	$15,000.00	$15,000.00
4	FLOW BYPASS AND DEWATER SITE	1	LS	$20,000.00	$20,000.00
Dam Removal					
5	DEMO DAM AND HAUL OUT STONE	453	CY	$220.00	$99,660.00
Channel Restoration					
6	COMMON EXCAVATION (CHANNEL AND FLOODPLAIN BENCHES)	13940	CY	$7.50	$104,550.00
7	SEDIMENT HAUL	13386	CY	$7.50	$100,395.00
8	CHANNEL REALIGNMENT	1	LS	$15,800.00	$15,800.00
9	INSTALL STONE STEPS, POOLS AND ROOTWADS	1	LS	$25,000.00	$25,000.00
10	PLACE SEED, MULCH AND FASCINES	1	LS	$10,000.00	$10,000.00
				CONSTRUCTION TOTAL	***$414,405***
				MOBILIZATION / DEMOBILIZATION (10%)	***$41,441***
				CONSTRUCTION CONTINGENCY (5%)	***$20,720***
				TOTAL (ROUNDED TO NEAREST $100)	***$476,600***

Design, Permitting and Construction Services	
FINAL DESIGN & PERMITTING (~9%)	***$36,661***
BID AND CONSTRUCTION PHASE SERVICES (~5%)	***$22,018***

Project Initial and Maintenance Cost Estimation

Category/Item	**Amount**	**Source**
Engineering		
Survey layout - Engineer	$4,000	Stone Environmental OPC
Bid and construction phase services (6%)	$22,018	Stone Environmental OPC
Archeological/Historical		
Historic Photo Documentation Package and Archeological Monitoring	$3,891	UVM Consulting Archeology Program OPC
Survey layout - Archeology	$983	UVM Consulting Archeology Program OPC
Historic Resources Mitigation	$4,800	https://www.fs.usda.gov/Internet/FSE_DOCUMENTS/stelprd3819434.pdf
Legal		
Environmental Assessment	$15,000	VHB consultation
Permit and filing expenses	$9,725.66	Stakeholder input: Dam Order (~$4726), Floodplain paperwork (~$5000)
Construction		
Construct access	$20,000.00	Stone Environmental OPC
Erosion prevention/sediment control (EPSC)	$15,000.00	Stone Environmental OPC
Flow bypass and dewater	$20,000.00	Stone Environmental OPC
Demo dam and haul out stone	$99,660.00	Stone Environmental OPC
Common excavation (Channel and Floodplain Benches)	$104,550.00	Stone Environmental OPC
sediment haul	$100,395.00	Stone Environmental OPC
Channel realignment	$15,800.00	Stone Environmental OPC

Install stone steps, pools, and rootwads	$25,000.00	Stone Environmental OPC
Place seed, mulch, fascines	$10,000.00	Stone Environmental OPC
Mobilization/demobilization (10%)	$41,440.50	Stone Environmental OPC
Contingency (20%)	$20,720.25	Stone Environmental OPC
Tree Planting Restoration		
Materials	$3,024	0.84 acres*400trees/acre*$9/tree
Labor	$672	0.84 acres*400trees/acre$2/tree
TOTAL	$536,679.41	
Management Cost - Personnel	$11,000	200 hrs * $55/hr
Management Cost - Indirect	$15,833.97	~2.8%
FEMA Request Max	$429,343.53	75% of total + 100% of management costs
Match reported to FEMA	$134,169.85	
Monitoring and Stewardship		*Note these expenses are not included in the budget request but are included in the BCA.
3 years replanting - materials	$2,268	0.84 acres*400trees/acre*0.25*$9/tree * 3 years
3 years monitoring and replanting labor	$2,016	0.84 acres*400trees/acre*$2/tree * 3 years
Invasies mgmt	$3,024	0.84 acres*400trees/acre*$3/tree * 3 years
Total Annual Maintenance Cost	$244	Sum of monitoring and stewardship costs/Default Project Useful Life

Prior Expenses (Pre-FEMA Grant)

Phase 1 - 30% Design	
Engineering	
30% plans, assistance with FEMA and CWSRF paperwork, H&H analysis, BCA, wetlands delineation	$39,400
Archeological/Historical	
Archeological assessment and historical structures report	$5,280
Project Management	$7,612
Indirect	$3,079
Phase 1 Subtotal	$55,371
Phase 2 - 100% Design	
Engineering	
100% plans - drawings and construction specifications, update cost estimates	$37,000
Archeological/Historical	
Phase 1 testing - archeological ONE SITE	$4,800
Phase 2 testing - archeological ONE SITE	$15,000
Legal	
Permit and filing expenses	$500
Project Management	$2,865
Phase 2 Subtotal	$60,165
Total Prior Expenses	***$115,536***

Attachment 3: Dam Removal General O&M

<u>Dam Removal General O&M</u>

May 20, 2019

DESIGN REVIEW

The design plans include an erosion prevention and sediment control (EPSC) plan that is different from an Operations and Maintenance (O&M) description.

1. All relevant text in plans, reports and documents should label and/or refer to the "pilot channel" in the future excavated sediments and not referenced as a "new stream channel". This use of the "pilot channel" term is intended to manage the public expectations that the newly created channel will meander over time and to establish that an underlying project goal is to manage the reach towards dynamic stream equilibrium conditions as the underlying design objective.

2. The Operations and Maintenance (O&M) component of the design plans to be implemented after project completion shall address three issues that are typical for dam removal projects:

   A. The completed project is intended to restore *dynamic stream equilibrium* to the channel as an underlying design concept and minimal channel stabilization is required and to be evaluated at this design review phase. The O & M plan shall discuss restoring *dynamic stream equilibrium* as a goal and objective for clarity for the public relative to the next two items.

   B. The completed project will likely require 2 to 3-years of monitoring of the newly planted riparian vegetation to successfully establish an 80% survival rate of the newly planted grasses, shrubs and trees and report to the US Army Corps of Engineers, VDF&W and the State Rivers Program on the status and a plan for any required re-seeding and/or re-planting of the project site.

   C. The US Army Corps of Engineers, VDF&W, State Rivers Program and Project Manager will review and approve the monitoring status and any plan for re-seeding and/or re-planting of the project site.

3. There may be various riparian buffer species encountered during the dam removal that can be discussed in the plans to be set aside for possible replanting by the selected contractor after completion of the work and at the common direction of VDF&W, state and federal staff.

Attachment 4: VTDEC Dam Breach Report

Vermont Department of Environmental Conservation *Agency of Natural Resources*
Water Investment Division
1 National Life Drive, Davis 3
Montpelier, VT 05620
Phone: 802-622-4093

MEMORANDUM

TO:	Town of Washington, Care of Carol Davis, Town Clerk, Dam Owner
FROM:	Benjamin Green, PE, Dam Safety Program (DSP), Engineer Katherine King, DSP, Assistant
DATE:	November 18, 2020
SUBJECT:	DSS-Wise Lite Dam Failure Analysis and Flood Inundation Maps Hands Mill Dam, Washington, Vermont State ID No: 225.01 | National ID No: VT00308

This memorandum summarizes the methods, assumptions, and results of dam failure and downstream flood inundation analysis using the Decision System for Water Infrastructural Security (DSS-Wise Lite) model for the Hands Mill Dam. Hands Mill Dam and its floodway are in the Town of Washington. The following attachments are included:

- ***Attachment A:*** Dam Failure Flood Inundation Map
- ***Attachment B:*** DSS-Wise Lite Simulation Results Final Report
- ***Attachment C:*** DSS-Wise Lite Human Consequences Final Report

It should be noted that ***Attachments B*** and ***C*** are automatically generated reports by the DSS-Wise Lite Program.

Purpose:
The analysis was performed to investigate the hazard potential classification of the dam and potential downstream consequences in the event of a dam failure.

Dam Overview:
Hands Mill Dam is a partially breached concrete and stone rubble gravity dam with a principal spillway and outlet works founded on bedrock and/or earth. It is our understanding that dam removal is being considered and a feasibility study is currently underway.

The dam is currently classified as a SIGNIFICANT hazard potential dam. According to our files, the dam has a total length of approximately 325 feet and a structural height of 20 feet. The principal spillway consists of an eroding concrete and stone rubble weir with a total length of about 20 feet. To the left of the principal spillway is an approximately 40-foot long training wall and an old mill foundation comprised of concrete and stone rubble with an abandoned intake and concrete sluiceway. There is no auxiliary spillway. The low-level outlet (LLO) to the right of the principal spillway is an approximately 2-foot by 2-foot square opening on the downstream face that is reportedly inoperable/plugged and abandoned. To the right of the principal spillway is an approximately 300-foot-long non-overflow concrete wall that extends to the right abutment at the valley wall.

Our records dating back to 1950 indicate that the dam was built circa 1860 and was repaired after the 1927 flood. No records exist of repairs as of the 1947 ownership transfer for use as a sawmill. The dam impounds a pond with a surface area of about 2 acres at normal pool elevation that is substantially filled with sediment. It is our understanding the dam and pond currently serve no current social or economic purpose. The upstream drainage area is approximately 4,128 acres. The normal and maximum storage of the dam were estimated as 11.2 and 18.1 acre-feet in 2020 by Stone Environmental, Inc. (STI) an engineering consultant working on the dam removal feasibility study. These storage estimates compare well with historic estimates.

Downstream Conditions:
The Hands Mill Dam flows into the Jail Branch River which flows through the Town of Washington to the East Barre Dam and northerly into the City of Barre. East Barre Dam is a large, State owned and operated flood control dam that would safely contain dam failure flood waters, preventing damage further downstream. It appears that a dam failure could potentially impact several road crossings, several homes and businesses, and a school downstream.

Methods:
The DEC DSP prepared a DSS-Wise Lite model of the Hands Mill Dam and the downstream area. DSS-Wise Lite is a publicly available flood modeling and consequence analysis tool developed by The National Center for Computational Hydroscience and Engineering at the University of Mississippi. DSS-Wise Lite is a web-based program that allows the user to setup an automated two-dimensional dam breach model with minimal inputs and provides results including inundation maps, flood arrival times, hydrographs, and other life consequence information. As noted in program literature, DSS-Wise Lite is a simplified analysis producing rough, approximate results that are not intended to replace more detailed modeling processes/programs. The following limitations of DSS-Wise Lite should be considered:

- While a flood hydrograph can be manually input into DSS-Wise Lite to simulate a storm day dam failure, the program does run most reliably under sunny day failure scenarios. For this reason, a sunny dam failure during maximum pool conditions (water level at the dam crest) was modeled. This scenario is possible assuming that the principal spillway was clogged, and the water level were to rise to the dam crest. This approach also assumes normal, base flow in the downstream channel, allowing for a more easily understood incremental impact of dam breach flooding than would be present during a storm event. The failure is assumed to occur rapidly and completely to model a worst-case scenario.
- The model defaults to the use of publicly available digital elevation models (DEMs). For the area of this project, the resolution of the DEMs used in the model is 1 meter (3.281 feet).
- The program does not allow for the modeling of culverts at downstream road crossings. Accordingly, culverts are not included in the model. This does depict a somewhat worst case but observed scenario where downstream culverts become plugged with debris during a flood flow and are ineffective. Large bridges can be input in the model but are modeled as an opening with no deck.

Model Inputs:
The model inputs are summarized in ***Attachment B***. Based on the DEMs, the following elevation and storage data was used (all elevations reference the North American Datum of 1988, NAVD88, in feet):

- Normal Pool Elevation — El. 1,287
- Normal Pool Storage — 11.2 acre-feet
- Maximum Pool Elevation — El. 1,292.5
- Maximum Pool Storage — 18.1 acre-feet
- Dam height — 20 feet

Several challenges are present when performing dam breach and flood inundation analyses/mapping at Hands Mill Dam. As noted above, the normal and maximum storage inputs are based on preliminary estimates by STI. STI also estimated the volume of impounded sediment behind the dam at 14,300 cubic yards. This estimated sediment volume is equivalent to about 386,100 cubic feet, or 8.9 acre-feet. With estimated normal and maximum storage volumes of the dam of 11.2 and 18.1 acre-feet, respectively, the impounded sediment makes up approximately 80% of the impounded volume at normal pool and 50% of the impounded volume at maximum pool. It is anticipated that in the event of a dam failure, a portion of this sediment would be mobilized downstream. It is generally recognized that saturated sediment or mud flows can result in a dam failure wave that would move slower, maintain its height and shape further downstream, but perhaps travel less distance overall when compared to its clear water equivalent. This analysis was performed assuming that all impounded liquids would perform as clear water. Accordingly, it is anticipated that in the event of a dam failure, it is possible that flood depths near the dam may be greater than predicted, but the flood wave may also dissipate more quickly.

Model Results:

The DSS-Wise Lite model results are summarized in ***Attachments A*** through ***C***. The estimated inundation limits were overlain on a ANR Atlas satellite image map. The following results are provided at select locations downstream of the dam.

Location	**Max. Estimated Flood Depth (ft)**	**Max. Estimated Flood Flow Velocity (ft/s)**	**Estimated Arrival Time of Peak Flood (hours)**
At Dam	NA[1]	NC[2]	NA
16 Woodchuck Hollow Road	3 to 6	3 to 6	Immediate
Woodchuck Hollow Road crossing	3 to 12	6 to 15	Immediate
39 Woodchuck Hollow Road	0 to 2	3 to 10	
64 West Corinth Road	<1	<1	
29 Woodchuck Hollow Road	<1	0 to 3	
31 Woodchuck Hollow Road	<1	0 to 3	
33 Woodchuck Hollow Road	<1	<1	
57 Fairgrounds Road	<1	0 to 3	
56 Fairgrounds Road	1 to 2	3 to 6	<0.25
73 Fairgrounds Road	<1	1 to 6	
2985 VT Route 110	1 to 2	1 to 3	
2973 VT Route 110 (Baptist Church)	1 to 2	1 to 3	
40 School Lane	1 to 3	3 to 6	
72 School Lane (School)	<1	0 to 3	
School Lane crossing	3 to 6	10 to 15	
Creamery Road crossing	3 to 6	10 to 15	0.25 to 0.5
Tucker Road crossing	2 to 3	3 to 6	1 to 1.5

(1) Not applicable
(2) Not calculated

Hazard Potential Classification:

As noted above, this dam is currently as a SIGNIFICANT hazard. The current hazard potential classification definitions from the Vermont Dam Safety Rule are provided below:

Classification	**General Definition**
HIGH	Dams where failure or mis-operation will probably cause loss of human life.
SIGNIFICANT	Dams where failure or mis-operation results in no probable loss of human life but can cause economic loss, environment damage, disruption of lifeline facilities, or impact other concerns. Significant hazard potential classification dams are often located in predominantly rural or agricultural areas but could be located in areas with population and significant infrastructure.
LOW	Dams where failure or mis-operation results in no probable loss of human life and low economic and environmental losses.
MINIMAL	A dam that meets the LOW hazard definition, above, but is only capable of impounding less than 500,000 cubic feet.

The Hazard Consequence Model (HCom) estimated the Population at Risk (PAR) resulting from the simulated dam failure of the Hands Mill Dam. The PAR is the estimated number of people within an inundation limits of a simulated dam failure. The HCom estimated a Nighttime PAR of 40 and a Daytime PAR of 94. The daytime and nighttime PAR vary based on the number of homes where people are typically at night, versus business, churches, or schools, where people are typically during the day.

Based on the results, the primary risk driver is the 16 Woodchuck Hollow Road property immediately downstream of the dam. While the occupancy of this property is not clear, it is noted that there was both a house and a mobile home recently observed on the lot. In the event of dam failure, the estimated depths and velocities at these structures would approach to slightly exceed accepted, survivable limits at the house and would exceed survivable limits at the mobile home. In either case, given the proximity to the dam, there would be little to no warning/evacuation time. Accordingly, there appears to be a potential for probable loss of life at the property during a dam failure.

In addition, approximately 10 buildings, including homes, a farm, and a church, would experience minor flooding that does not appear to rise to the level of probable loss of human life, but is indicative of economic loss. Also, four roadways would be overtopped, but the anticipated low daily traffic and low travel speeds suggest it is not likely this damage would result in probable loss of human life but does infer economic loss. One of the downstream roadways, School Lane, is the primary entry and exit to the Washington Village School, the failure of which could strand or limit access. According to the model results, some minor, low velocity flooding is anticipated up to and around portions of the school. This flooding is not anticipated to cause probable loss of human life but should be given extra consideration given the vulnerable population involved.

Given the results of this study, a hazard classification of HIGH or SIGNIFICANT hazard potential should be considered. A determination of the occupancy status of the 16 Woodchuck Hollow Road property is necessary to classify the dam based on this work. Also, given the close proximity of the school, a more detailed analysis may be warranted to better understand risks associated with this vulnerable population, particularly if dam removal is not pursued in the near future or if either no action or dam rehabilitation alternatives instead considered.

As the feasibility study for the dam removal project is currently underway, a prudent risk reduction measure to undertake until dam removal can be implemented would be the development of an Emergency Action Plan (EAP). The DSP would be happy to assist in the development of an EAP, which would include the flood inundation map attached here-in, pre-planned actions in the case of a dam incident or failure, and identification of key emergency personnel as well as potential evacuees.

Y:\WID_DamSafety\Dams\H\HandsMill\Hazard Classification\Hands Mill Dam (No. 225.01) – DSS Wise Lite Dam Flood Mapping

Attachment A:

Hands Mill Dam - Flood Inundation Mapping

Vermont Agency of Natural Resources

vermont.gov

Note: The dam breach flooding information and inundation areas shown on this map are approximate and should be used only as a guideline for establishing evacuation zones. Actual flooding conditions may differ from those depicted on the map. The results of the maximum pool (water level at dam crest), rapid failure breach scenario is shown.

LEGEND

- Buildings (E911)

Roads
- Interstate
- US Highway; 1
- State Highway
- Town Highway (Class 1)
- Town Highway (Class 2,3)
- Town Highway (Class 4)
- State Forest Trail
- National Forest Trail
- Legal Trail
- Private Road/Driveway
- Proposed Roads

Stream/River
- Stream
- Intermittent Stream

- Town Boundary
- Flow Direction

NOTES

Prepared by VTDEC Dam Safety Program using DSS-Wise Lite, November 2020. Represents maximum pool, rapid failure estimated flood inundation map.

NORTH

346.0 0 173.00 346.0 Feet

WGS_1984_Web_Mercator_Auxiliary_Sphere

1" = 173 Ft. 1cm = 21 Meters

THIS MAP IS NOT TO BE USED FOR NAVIGATION

Attachment B:

DSS-WISE™ Lite
Flood Simulation Report

Run #2

Hands Mill Dam

NAXXXXX

November 16, 2020

Contact Information:

DSS-WISE™ Lite modeling questions: admin@dsswiseweb.ncche.olemiss.edu

National Center for Computational Hydroscience and Engineering (NCCHE)

The University of Mississippi

For Official Use Only

Table of Contents

1.0 Overview

The Decision Support System for Water Infrastructure Security (DSS-WISE™) is an integrated software package combining 2D numerical flood modeling capabilities with a series of GIS-based decision support tools. It was developed by the National Center for Computational Hydroscience and Engineering (NCCHE) at the University of Mississippi and was initiated by the US Department of Homeland Security (DHS) Science and Technology Directorate through the Southeast Region Research Initiative (SERRI) Program.

A simplified, and fully automated, version of the DSS-WISE™ software suite (DSS-WISE™ Lite Ver 1.0) was developed on behalf of the US Army Corps of Engineers (USACE) Critical Infrastructure Protection and Resilience (CIPR) Program and the DHS Office of Infrastructure Protection. This simplified dam break flood modeling capability was available to interested parties through the Dams Sector Analysis Tool (DSAT) secure web portal until November 2014. An updated version with more features was developed on behalf of Federal Emergency Management (FEMA) and is available at dsswiseweb.ncche.olemiss.edu.

The DSS-WISE™ Lite software suite, running on NCCHE servers, automatically processes input files for dam-break modeling scenarios submitted by an user. DSS-WISE™ Lite further simplifies simulations by making several general overarching assumptions in an effort to streamline data preparation and computations.

The results produced by this simplified dam-break flood simulation tool represent a rough approximation. They are not intended to replace more detailed flood inundation modeling and mapping products or capabilities developed by hydraulic and hydrologic engineers and GIS professionals.

The user is, therefore, warned that professional engineering judgment should be used in the interpolation of the results generated by this simplified and automated dam-break flood analysis.

To learn more about DSS-WISE™ and DSS-WISE™ Lite visit us at:
`https://dsswiseweb.ncche.olemiss.edu`

Disclaimer

The National Center for Computational Hydroscience and Engineering (NCCHE), The University of Mississippi, makes no representations pertaining to the suitability of the results provided herein for any purpose whatsoever. All content contained herein is provided "as is" and is not presented with any warranty of any form. NCCHE hereby disclaims all conditions and warranties in regard to the content, including but not limited to any and all conditions of merchantability and implied warranties, suitability for a particular purpose or purposes, non-infringement and title. In no event shall NCCHE be liable for any indirect, special, consequential or exemplary damages or any damages whatsoever, including but not limited to the loss of data, use or profits, without regard to the form of any action, including but not limited to negligence or other tortious actions that arise out of or in connection with the copying, display or use of the content provided herein.

Elevation Datum

All reported elevations use the North American Vertical Datum of 1988 (NAVD 88).

2.0 Modeling Parameters and Conditions

2.1 Project Information

Project Name:	Hands Mill Dam
Scenario Name:	Run #2
NIDID:	NAXXXXX
Scenario Description:	Sudden Failure at maximum pool with 5.5 feet between normal and max pools.
User e-mail:	katherine.king@partner.vermont.gov

2.2 Simulation Parameters

Simulation distance requested (miles):	5
Simulation cell size requested (ft):	15.0
Simulation duration requested (days):	2

2.3 Impounding Structure(s) Characteristics

Number of Structures: 1

Structure Name:	Structure 1
Structure Type:	Embankment
Hydraulic Height (ft):	20.0
Crest Elevation (ft):	1292.5
Length (ft):	495.0

2.4 Bridge(s) to be Removed

Number of Bridges: 0

2.5 Reservoir Characteristics

Selected Reservoir Point (Latitude/Longitude):	44.1054194801/-72.4297714233

Pool Elevation @ Max Storage (ft):	1292.5
Maximum Storage Volume (ac-ft):	18.1
Pool Elevation @ Normal Storage (ft):	1287.0
Normal Storage Volume (ac-ft):	11.2

2.6 Failure Conditions

Structure Name:	Structure 1
Structure Type:	Embankment
Failure Mode:	Total Dam Breach
Breach Type:	Embankment
Pool Elevation @ Failure (ft):	1292.5
Storage Volume @ Failure (ac-ft):	18.1
Breach Location (Latitude/Longitude):	44.105464754/-72.4298403157

3.0 Automated Data Preparation and Job Flow Summary

3.1 Job Flow Summary

1. Prepare Digital Elevation Model (DEM) and Land Use/Land Cover (LULC) tiles for the Area of Interest (AOI) based on requested cellsize and maximum downstream distance.
2. Burn U.S. Army Corps of Engineers (USACE) levee lines into DEM for the AOI.
3. Assign Manning's coefficients based on LULC classifications.
4. Validate user provided simulation input parameters.
5. Remove user identified bridges from the DEM.
6. Estimate reservoir bathymetry.
7. Extend impounding structures if the specified reservoir level cannot be contained.
8. Fill reservoir to specified failure elevation.
9. Prepare boundary condition and all input data for simulation.

3.2 Reservoir Bathymetry and Filling

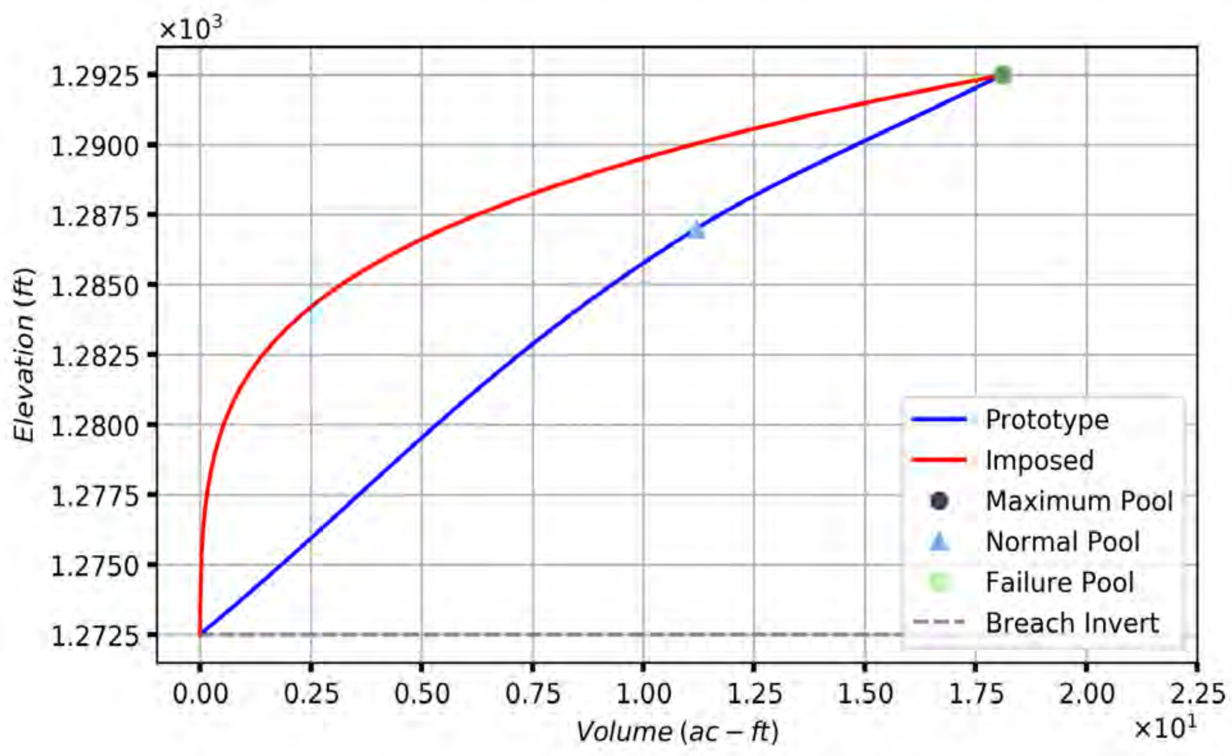

Figure 1. Stage-Volume Curve for Reservoir

Prototype: Theoretical cubic Hermite spline curve generated from user-provided reservoir elevation and volume information.
Imposed: Measured from reservoir bathymetry after filling to the failure elevation.

The reservoir water surface was detected to be in the DEM, so bathymetry estimation was performed using the prototype stage-volume curve shown above.
User-given Storage Volume at Failure (ac-ft): 18.1
Imposed Storage Volume at Failure (ac-ft): 18.1
After filling to the failure elevation, the imposed reservoir volume matched 100.0% of the prototype volume.

3.3 Data Sources

1. Digital Elevation Models

   Sources: USGS 2018 National Elevation Dataset, NOAA, DEM provided by group.

   Resolutions: 2, 1, 1/3, 1/9, 0.15 arc-seconds, 1 meter, and 10 feet based on availability

   Vertical Datum: NAVD88

   Horizontal Datum: NAD83

2. National Land Use/Land Cover Data

   Source: USGS 2016 National Land Cover Database

   Resolution: 30 m

3. National Levee Database

   Source: USACE

3.4 Digital Elevation Model

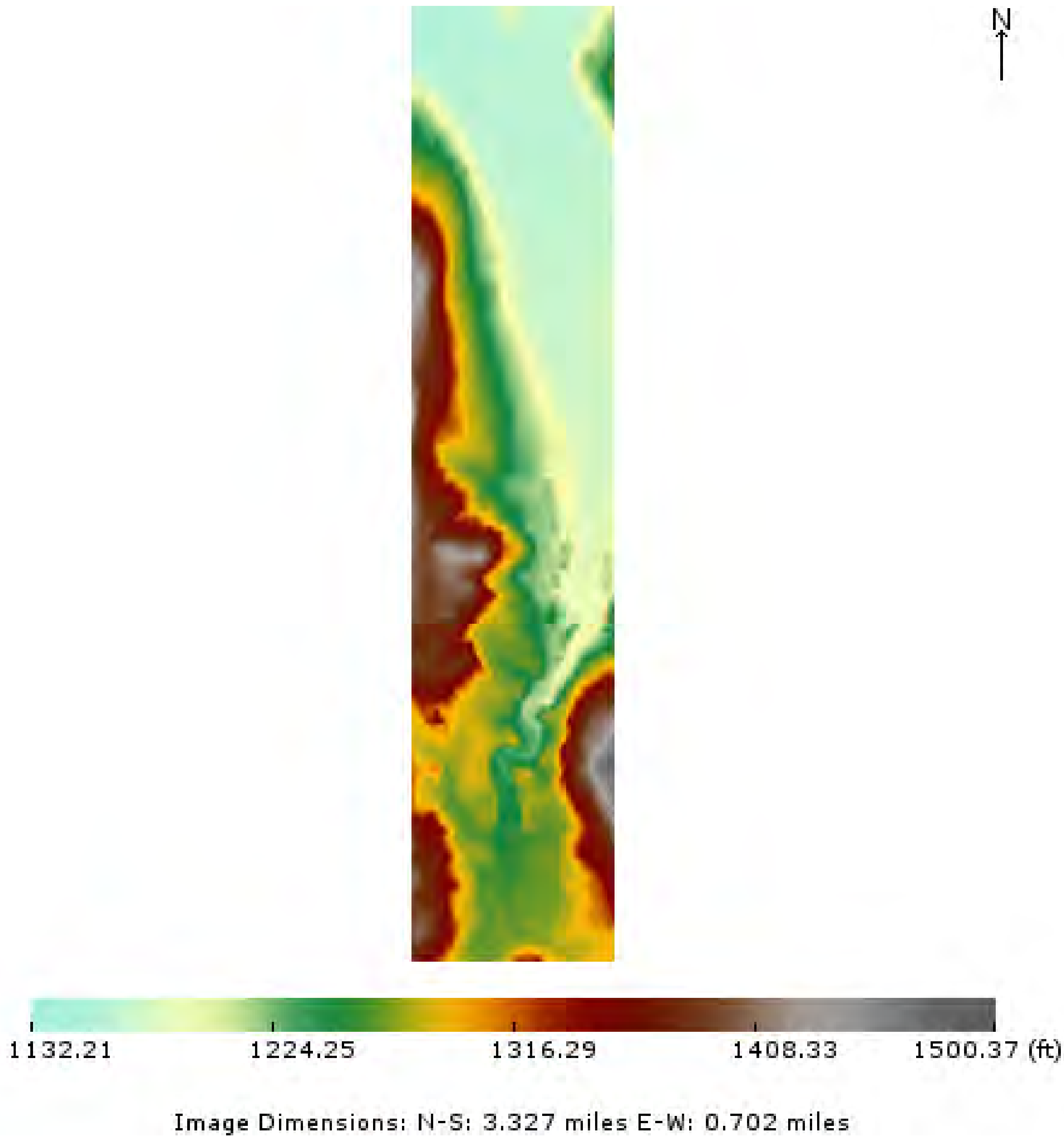

Figure 2. Map of Digital Elevation Model with Levees for AOI.

3.5 Reservoir Boundary and Breaching Structure

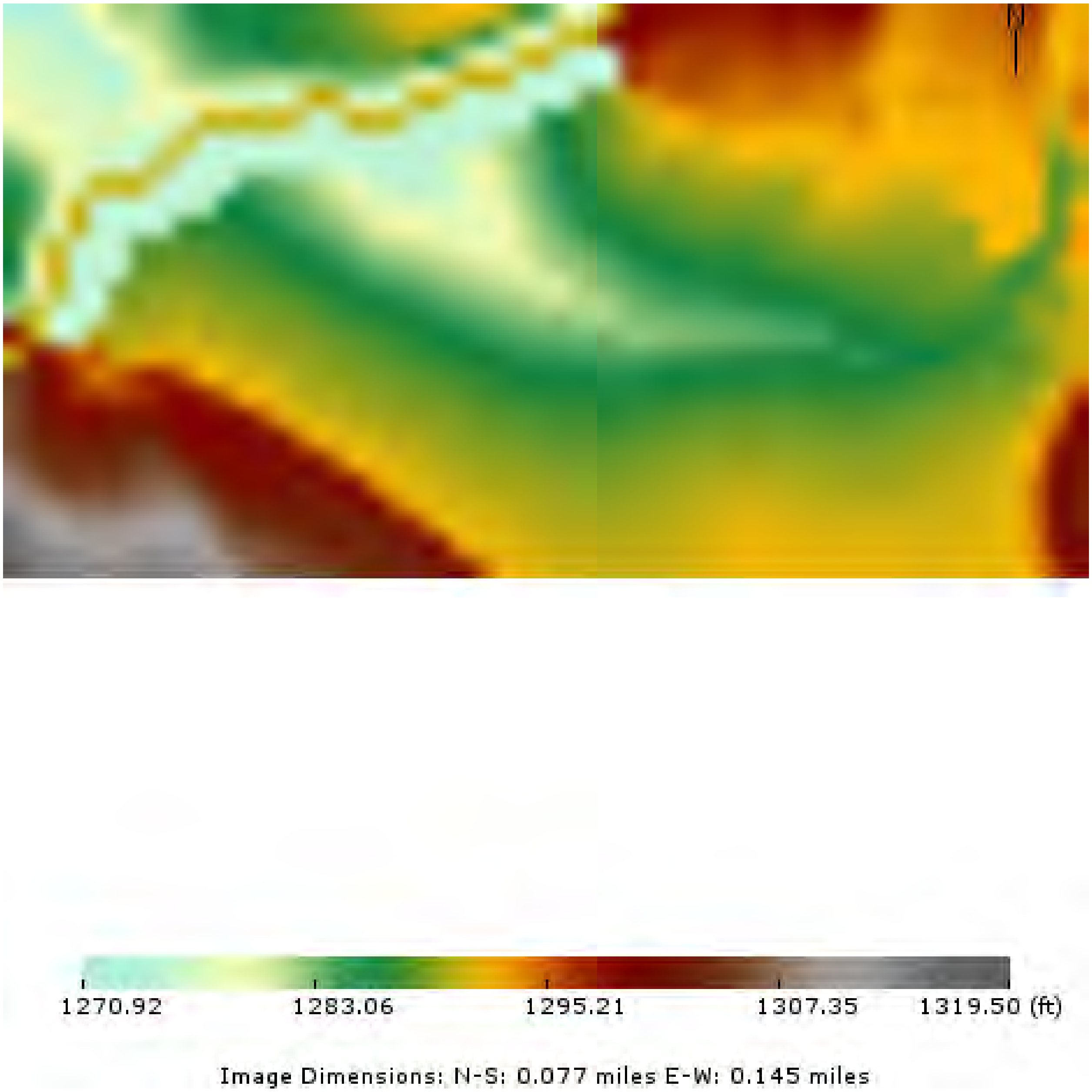

Figure 3. Map of Reservoir Boundary and Breached Structure.

3.6 Reservoir Initial Depth Profile

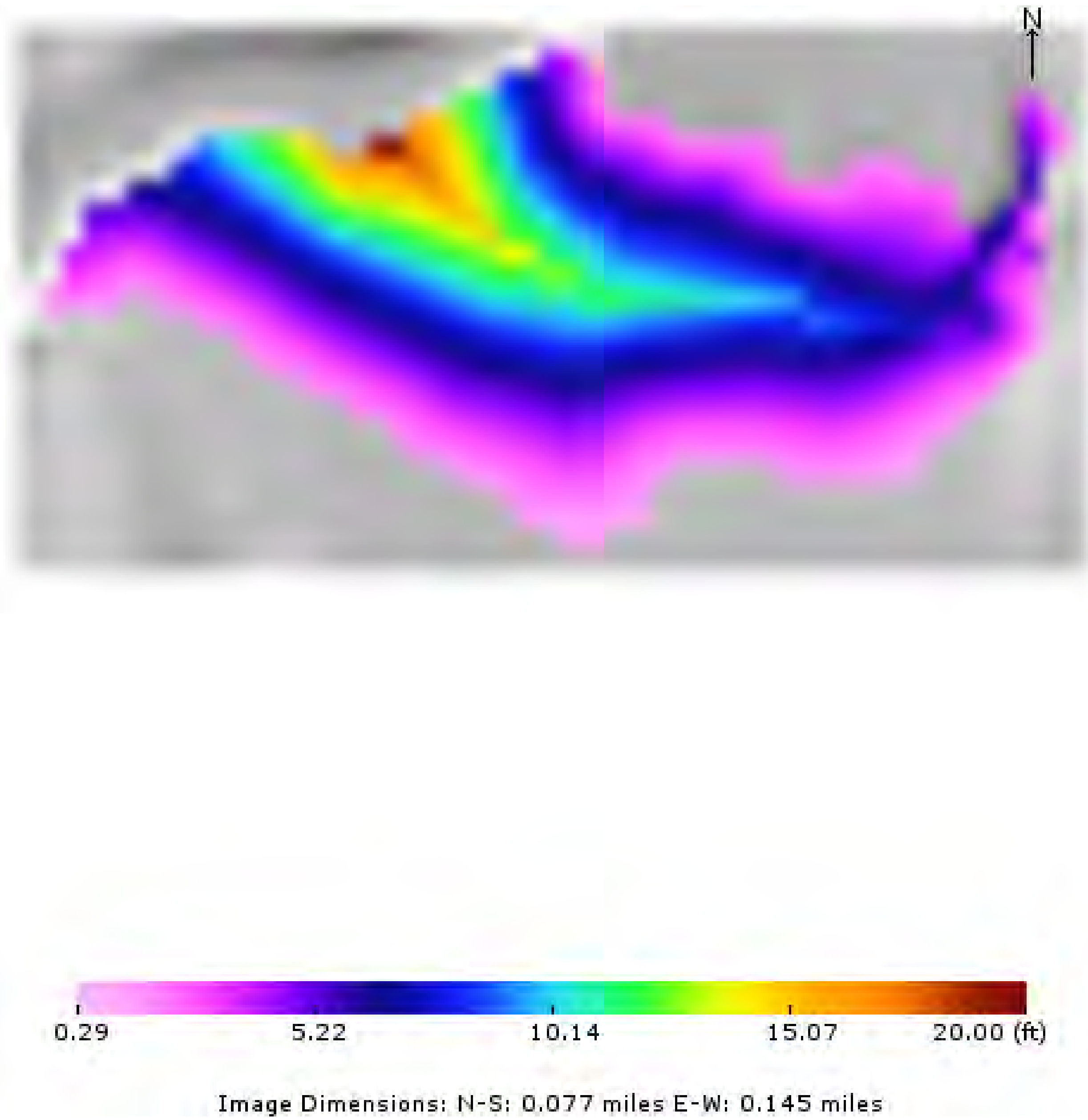

Figure 4. Map of Initial Depths in Reservoir at Failure Conditions.

3.7 Land Use/Land Cover

Figure 5. Map of Land Use for AOI.

4.0 Simulation Results

4.1 Simulation Summary

Simulation Request Received:	06:23 AM CST (11/16/2020)
Simulation Start Time:	06:24 AM CST (11/16/2020)
Simulation End Time:	06:26 AM CST (11/16/2020)
DEM resolution used for simulation (ft):	15.0
DEM resolution requested (ft):	15.0
Final distance reached downstream (miles):	3.3
Maximum downstream distance requested (miles):	5
Elapsed simulation time after breach initiation (hrs):	22.0
Remaining reservoir volume at termination (%):	1.155
Termination condition:	Water stopped spreading.

4.2 Land Use and Manning's Roughness Coefficient for Inundated Area

Land Use Description	% of Inundated Area	n-Value($m^{-1/3}s$)	Code	Color
Hay/Pasture	40.42	0.0350	81	
Woody Wetlands	18.57	0.1500	90	
Evergreen Forest *	12.41	0.1000	42	
Mixed Forest *	8.16	0.1200	43	
Developed, Low Intensity	7.12	0.0678	22	
Developed, Open Space	4.45	0.0404	21	
Developed, Medium Intensity	3.54	0.0678	23	
Deciduous Forest *	3.10	0.1000	41	
Emergent Herbaceuous Wetlands	1.91	0.1825	95	
Barren Land	0.26	0.0113	31	
Developed, High Intensity	0.03	0.0404	24	
unclassified	0.00	0.0350	0	
Open Water	0.00	0.0330	11	
Perennial Snow/Ice	0.00	0.0100	12	
Dwarf Scrub *	0.00	0.0350	51	
Shrub/Scrub	0.00	0.0400	52	
Grassland/Herbaceuous	0.00	0.0400	71	
Sedge/Herbaceous *	0.00	0.0350	72	
Lichens *	0.00	0.0350	73	
Moss *	0.00	0.0350	74	
Cultivated Crops	0.00	0.0700	82	

Note: * indicates a n-value estimated by NCCHE. Other values are taken from literature.

4.3 Coverage and Sources of DEM Raster Datasets

Figure 6. Coverage of DEM Raster Datasets in the Inundation Area.

DEM Source	Source Resolution	Source Dataset	Color
USGS	1 arc-second	usgs_1as	
USGS	1/3 arc-seconds	usgs_13as	
USGS	1 meter	usgs_utm_z18_1m	

Note: The DEM for this job was created from the source DEM raster datasets listed above. These DEM raster datasets were resampled and reprojected to the user defined cell size and UTM zone, respectively. Resampled and projected DEM raster datasets were then stacked in the order specific to the group under which this simulation was submitted.

4.4 Maximum Flood Depth

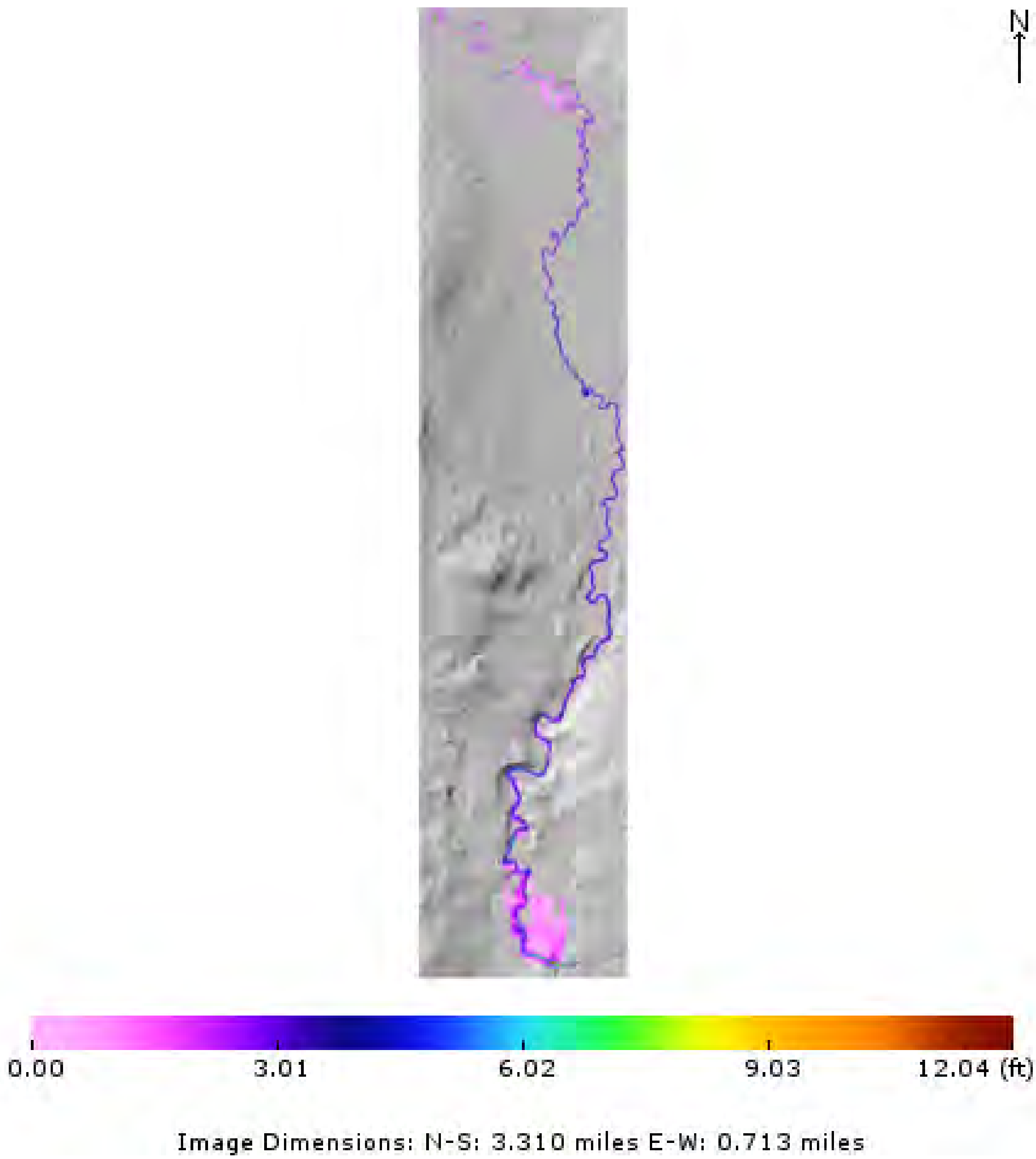

Figure 7. Maximum Flood Depth Map.

4.5 Flood Arrival Time

Flood arrival time is measured from the beginning of the simulation.

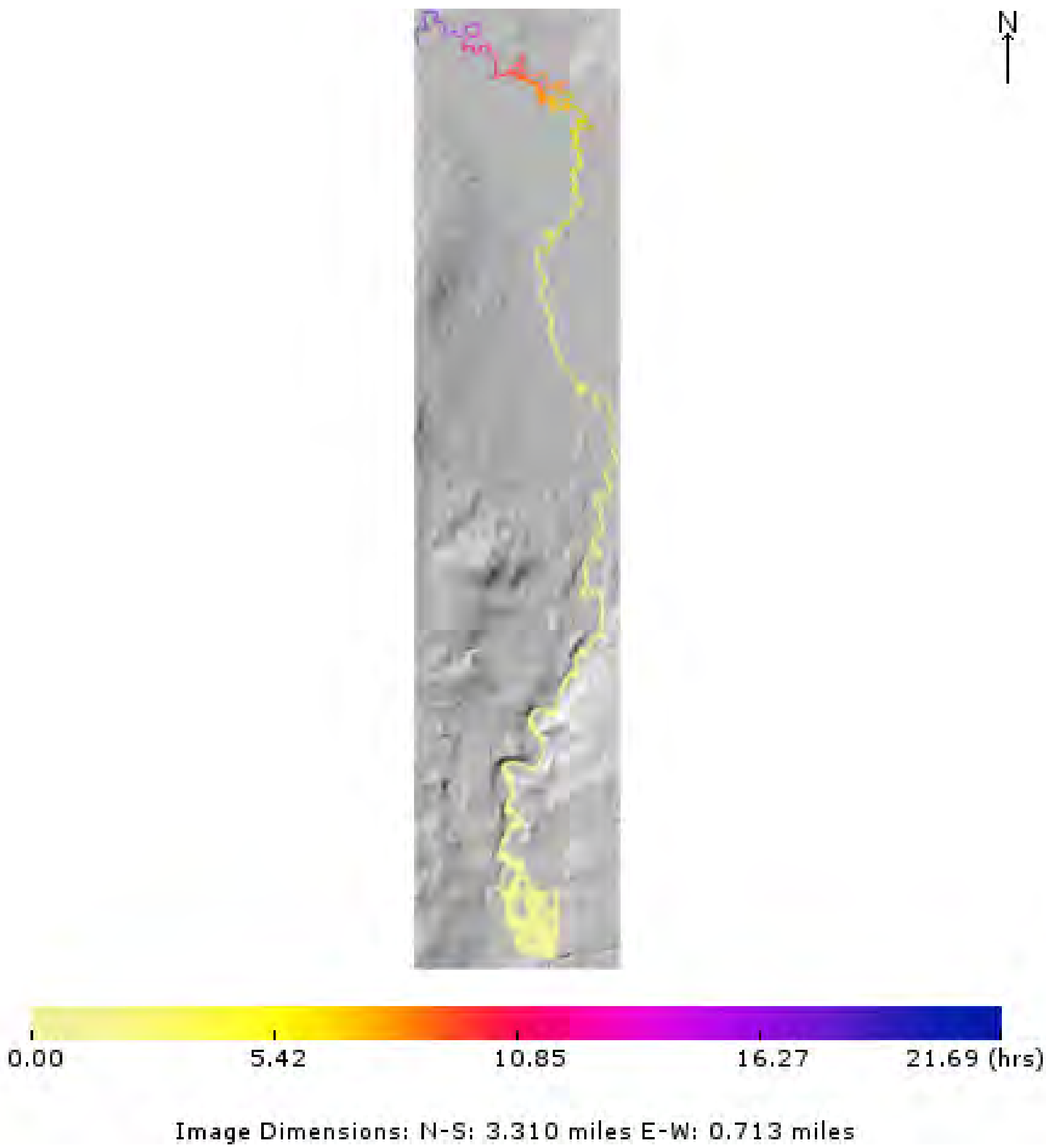

Figure 8. Flood Arrival Time Map.

4.6 Computed Breach Hydrograph through the Breaching Structure

The positive discharges (Q^+) are measured in the positive direction with respect to each observation line.

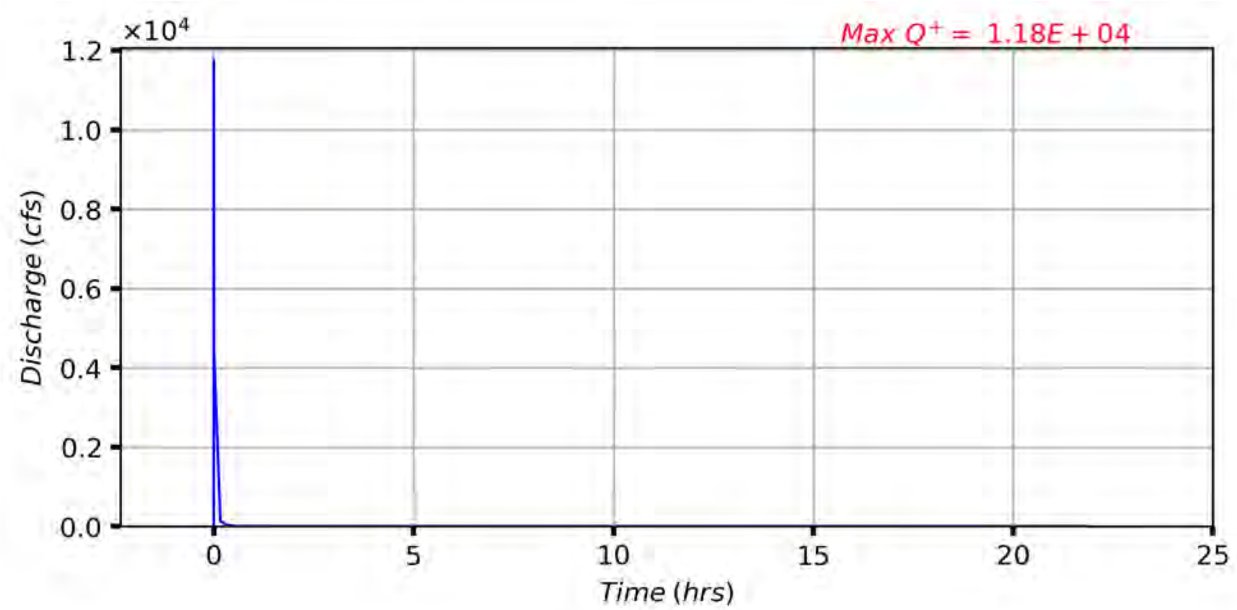

Figure 9. Breach Discharge Measured at: Structure 1.

4.7 Observation Line Hydrograph(s)

The positive discharges (Q^+) are measured in the positive direction with respect to each observation line.

No observation lines were defined.

4.8 Reservoir Time History

The reservoir water surface elevation as a function of time was computed by summing the water depth and bed elevation at a regular interval at the user-specified reservoir point.

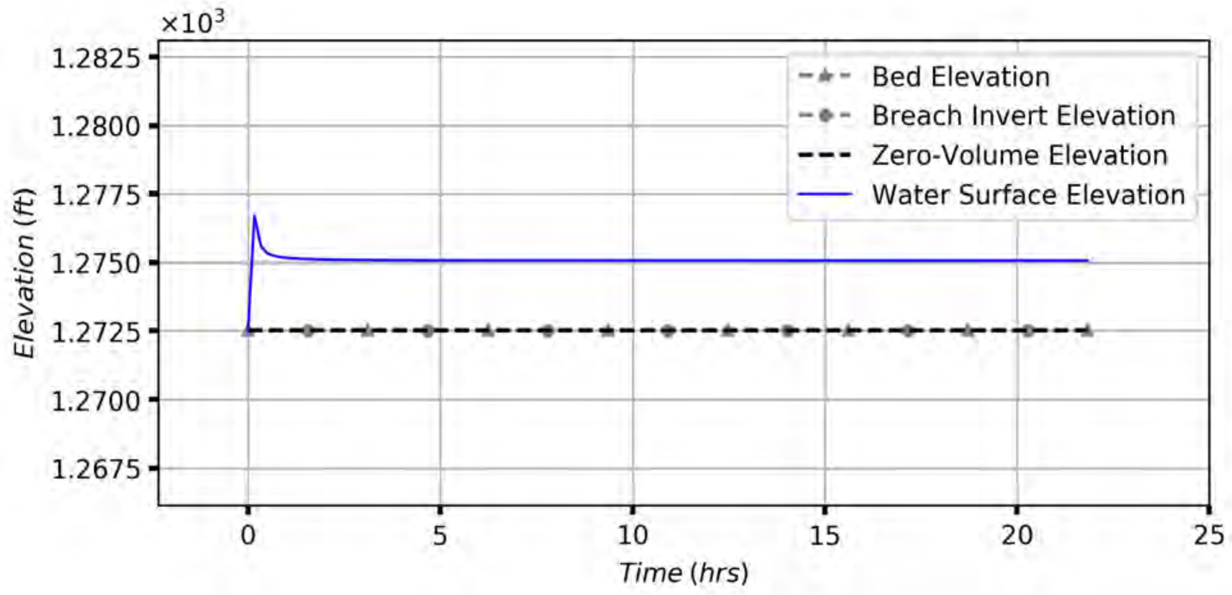

Figure 10. Reservoir Water Surface Elevation.

The reservoir volume as a function of time was computed by the following formula: $V_t = V_{init} - V_{net}$, where V_t is the reservoir volume at a given time, V_{init} is the reservoir's initial imposed volume, and V_{net} is the net volume that has crossed downstream across any part of the breaching structure's centerline up to that point. Since this only considers water which has completely exited the breach, it should be taken as an approximation.

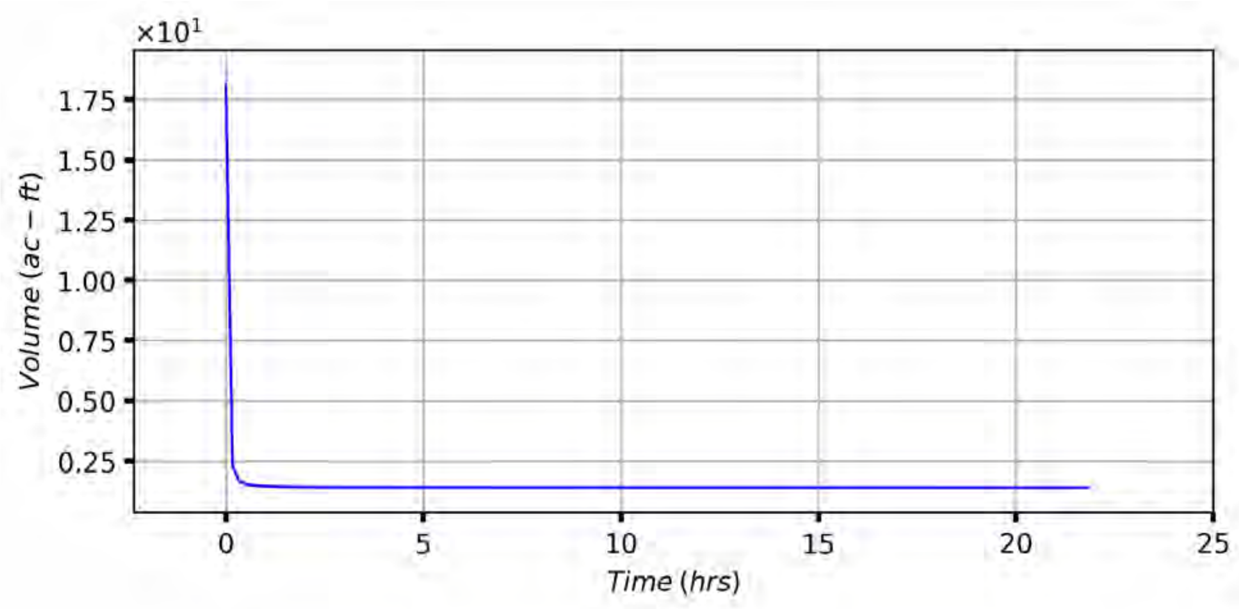

Figure 11. Reservoir Volume.

4.9 Downloading Simulation Results

The simulation results can be accessed at the following web address:

`https://dsswiseweb.ncche.olemiss.edu/download`

Job ID: 34459

Attachment C:

National Center for Computational Hydroscience and Engineering (NCCHE)

The University of Mississippi

FEMA

DSS-WISE™ HCOM
HUMAN CONSEQUENCE REPORT

Hands Mill Dam

Run #2

NAXXXXX

November 16, 2020

DSS-WISE Lite Simulation ID: 34459

FOR OFFICIAL USE ONLY

Disclaimer

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EXECUTIVE SUMMARY

This document reports the human consequences assessment for the DSS-WISE Lite simulation ID: **34459**

INUNDATION EXTENT

Total inundated area (acres)(see figure 1): 63.44

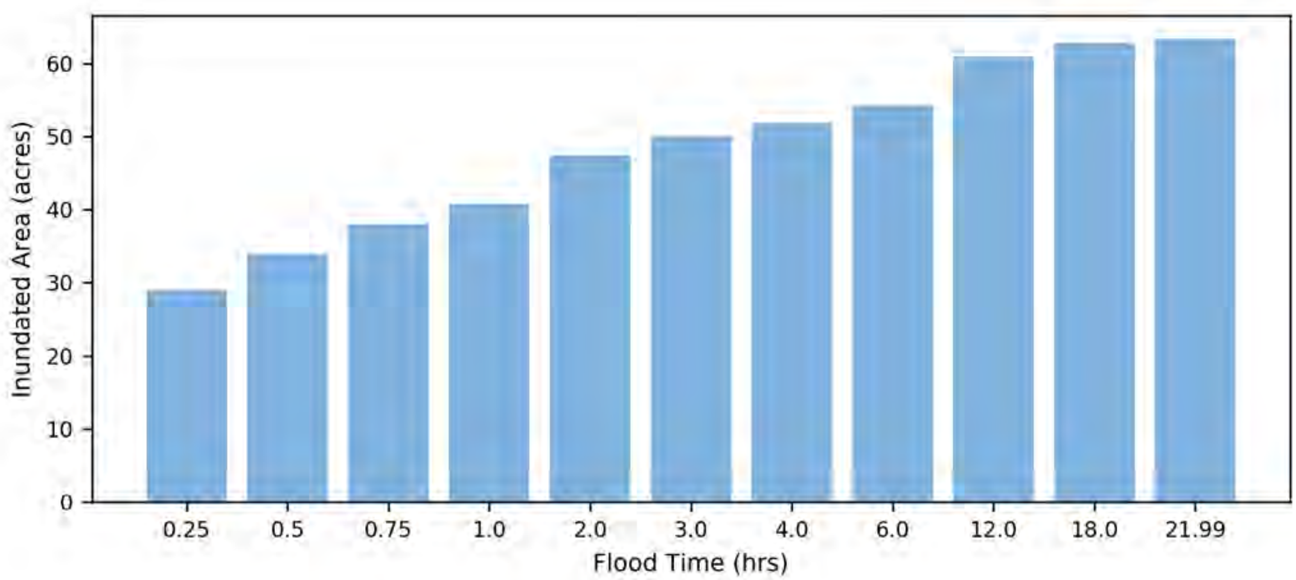


Figure 1. Evolution of total inundated area as a function of time.

ANALYSIS BASED ON CENSUS BLOCK DATA

Population in completely or partially inundated census blocks:	301
Housings in completely or partially inundated census blocks:	130
Number of states in inundated area:	1
Number of counties in inundated area:	2
Number of census blocks in inundated area:	20

ANALYSIS BASED ON GRIDDED LANDSCAN USA DATA

Total Nighttime PAR in inundated area (see figure 2):	40
Total Daytime PAR in inundated area (see figure 3):	94

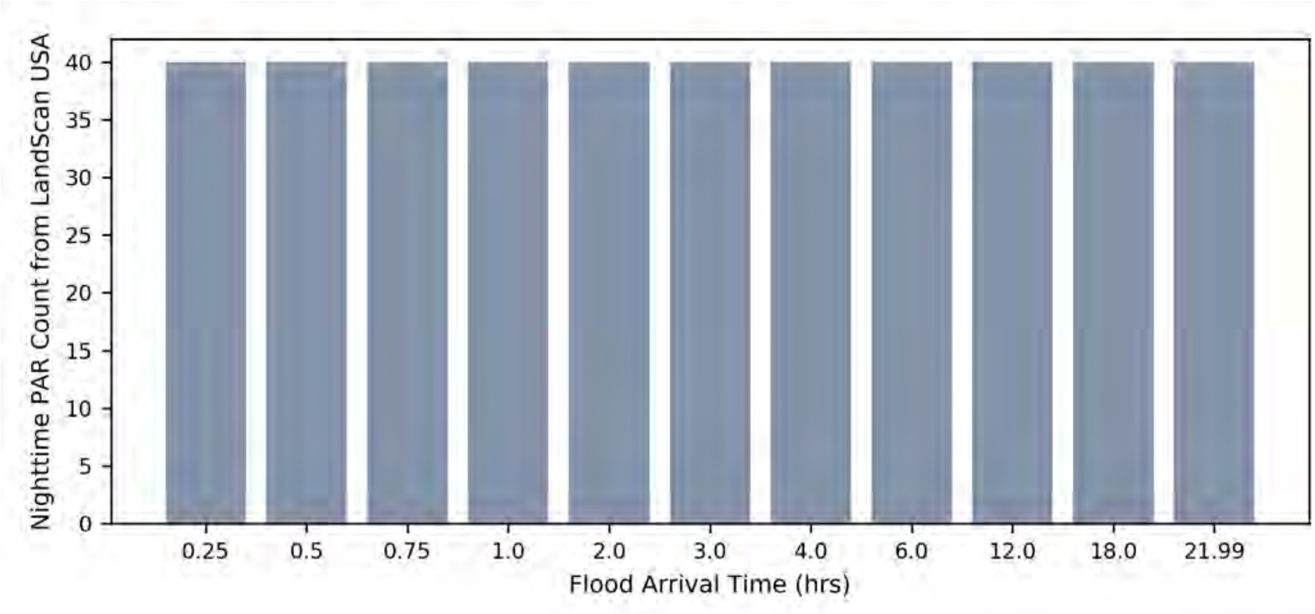


Figure 2. Evolution of nighttime PAR as a function of time.

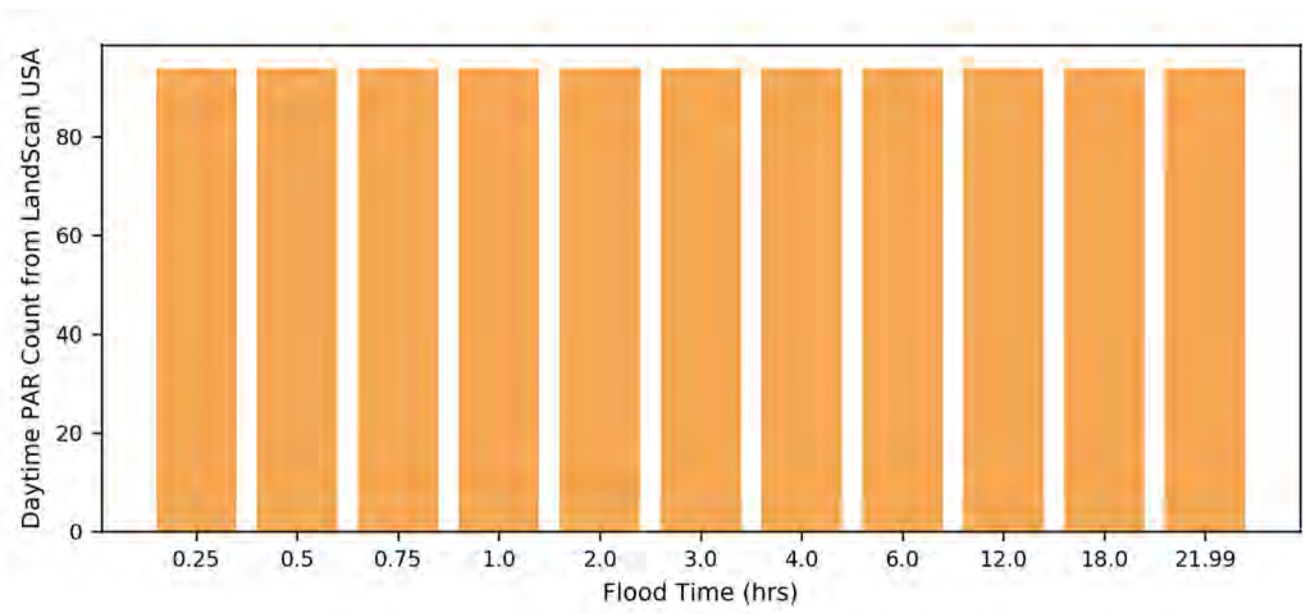


Figure 3. Evolution of daytime PAR as a function of time.

1.0 Overview

This report is produced DSS-WISE HCOM, which is part of the DSS-WISE Web system developed by the National Center for Computational Hydroscience and Engineering, at the University of Mississippi. Funding for DSS-WISE HCOM was provided by the U.S. Federal Emergency Management Agency (FEMA) through a contract with Argonne National Laboratory (ANL).

The results provided to the user by DSS-WISE HCOM include the following:

- the present report,
- a Microsoft Excel file containing data, results and plots, and
- a series of geospatial results files (in the form of polygon shapefiles).

These files can be used for further analysis and decision making for preparedness or during the response to an emergency. The files can also be used for hazard classification, risk prioritization preparing Emergency Actions Plans (EAPs).

DSS-WISE HCOM interfaces two-dimensional flood simulation results provided by DSS-WISE Lite with the population data provided by the U.S. Census Bureau and LandScan USA.

Please send any questions or suggestions to
admin@dsswiseweb.ncche.olemiss.edu

2.0 List of Abbreviations

ft	feet
hrs	hours
ft^2/s	Unit discharge, feet-squared per second
m^2/s	Unit discharge, meters squared per second
ft/s	feet per second
$ft.lb.$	foot-pounds
$m.kg.$	Meter-kilograms
D_{max}	Maximum depth
DV	Depth times velocity, unit discharge
DV_{max}	Maximum depth times velocity, maximum unit discharge
q_{max}	Maximum unit discharge, also called DV_{max}
DSS-WISE	Decision Support System for Water Infrastructural Security
DSS-WISE Web	Decision Support System for Water Infrastructural Security Web, the web-based system housing DSS-WISE Lite and other tools
DSS-WISE Lite	Decision Support System for Water Infrastructural Security Lite, the web-based version of DSS-WISE dam-break and flood modeling software
HCOM	Human Consequence Module
NCCHE	National Center for Computational Hydroscience and Engineering
PLFZ	Potentially Lethal Flood Zones
PAR	Population At Risk
EAP	Emergency Action Plan
NIDID	National Inventory of Dams (NID) Identifier
USCB	United States Census Bureau, or officially the Bureau of the Census
FEMA	Federal Emergency Management Agency
ANL	Argonne National Laboratory
ORNL	Oak Ridge National Laboratory
ESRI	Environmental Systems Research Institute
LSM	Life Safety Model

3.0 HCOM DATA SETS

3.1 DSS-WISE Lite Results Files

The human consequence analysis in this report are provided by DSS-WISE HCOM based on the raster results files for the following dam-break flood modeling simulation with DSS-WISE Lite:

DSS-WISE Lite simulation ID:	34459
Project Name:	Hands Mill Dam
Scenario Name:	Run #2
NIDID:	NAXXXXX
Scenario Description:	Sudden Failure at maximum pool with 5.5 feet between normal and max pools.
Simulation distance requested ($miles$):	5.0
Simulation cell size (ft):	15.0
Simulation duration requested ($days$):	2.0

Table 1. DSS-WISE Lite results files used by DSS-WISE HCOM.

File Name	Type	Units	Description
34459_Hmax_ft_upto_final.tif	Raster	ft	Maximum flood depth
34459_Arrival_Time_hr_upto_final.tif	Raster	hrs	Flood Arrival Time
34459_Vmax_ftps_upto_final.tif	Raster	ft/s	Maximum flood velocity
34459_DVmax_ft2ps_upto_final.tif	Raster	ft^2/s	Magnitude of the maximum specific discharge
34459_DVmax_ft2ps_upto_final.tifArrivalTime	Raster	hrs	Arrival time of the maximum value of specific discharge

3.2 Population Data Sets Used by DSS-WISE HCOM

DSS-WISE HCOM uses two different sets of population data to estimate the Population at Risk (PAR) potentially affected by the flood:

1. 2010 Census Block data provided by the United States Census Bureau (USCB), which is federal government agency in charge of producing data about the people and economy of the U.S. A census block is the smallest geographic unit for which USCB collects data from all the houses in the unit (rather than a sample of houses). Census Blocks are bounded by visible features such as streets, roads, streams and nonvisible features such as property lines and limits of city, township, school district, and counties, etc. They are defined as polygons in a shapefile covering the entire territory of the U.S. including Puerto Rico and the Island areas. The attributes of the census block polygons include 2010 Census Housing Unit Count and 2010 Census Population Count. The latter should be considered as 2010 nighttime population data.

2. LandScan USA gridded population data developed and maintained by the Oak Ridge National Laboratory (ORNL) located in Oak Ridge, TN. LandScan USA (https://landscan.ornl.gov/) is a collection of gridded nighttime and daytime population datasets developed by the Oak Ridge National Laboratory (ORNL), Department of Energy. These gridded population datasets are available as raster files with a resolution of 3 arc-second ($90m$ or $295.28ft.$). They were developed by combining satellite remote sensing data, geospatial infrastructure datasets, and demographic data from USCB. Researchers at ORNL used "Intelligent" dasymetric modeling method to assign the population counts to the grid cells (Dobson et al. 2000 and Bhaduri et al. 2007) by defining a habitability index and by maintaining the total count of cells in a census block to be equal to the total population of the census block. The LandScan USA datasets used in this report are projections for 2016 (McKee et al. 2014). Daytime data is generated using specially developed techniques for population dynamics (Bhaduri 2007).

Detailed explanations on the methodologies used by DSS-WISE HCOM are provided in the technical manual, which can be downloaded from documentation page of the DSS-WISE Web website.

4.0 FLOOD HAZARD MAPPING

Flood-hazard mapping consists of partitioning the inundation extent into zones of pre-defined potential danger classes for humans. The resulting map is an ESRI shapefile of polygon type. The polygons correspond to different levels of potential danger for humans caught outdoors and indoors.

The potential danger classes are identified based on the ranges of the value of the maximum specific discharge, DV_{max}. The ranges of $q_{max} \equiv DV_{max}$ values are different for persons caught outdoors or indoors.

4.1 Potential Flood Hazard for Humans Caught Outdoors

For humans caught outdoors, the ranges of DV_{max} corresponding to five potential hazard (or danger) levels identified by different color codes are summarized in Table 2, which is adapted from Cox et al. (2010). The potential hazard levels are:

1. "Very Low Hazard: Shallow flow or deep standing water";
2. "Low Hazard: Dangerous to children";
3. "Moderate Hazard: Dangerous to some adults";
4. "Significant Hazard: Dangerous to most adults"; and
5. "Extreme Hazard: Dangerous to all".

The three rightmost columns of Table 2 correspond to the interpretation of five potential hazard levels by Cox et al. (2010) for three population categories defined by an index value corresponding to the product of height (H) and mass (M) of the individual as listed at the bottom of Table 2.

1. "Infants and small Children",
2. "Children", and
3. "Adults";

The five polygons corresponding to the five potential flood hazard levels for people caught outdoors as listed in Table 2 are provided as an ESRI shapefile of polygon type.

Cox et al. (2010) notes that the limits of DV_{max} in Table 2 correspond loosely to the loss of stability of different population categories. However, it is important to note that the ranges of DV_{max} given in Table 2 should not be considered as strict limits. Various other factors may influence the stability of individuals caught outdoors by the flood, such as:

- Bottom conditions (uneven surface, slippery surface, visible or invisible obstacles);
- Flow conditions (floating debris, low temperature, poor visibility, unsteady flow and flow aeration);
- Human subject (standing or moving, experience and training, clothing and footwear, physical attributes, such as height, mass and muscular development, disabilities, and psychological factors); and
- Other factors (strong wind, poor lighting, feeling unsafe or complete loss of footing).

Table 2. Potential flood hazard levels for humans caught outdoors by the flood (adapted from Cox et al. 2010).

<table>
<tr><th colspan="4">DV_{max}</th><th rowspan="3">Potential Hazard Category</th><th colspan="3">Explanation</th></tr>
<tr><th colspan="2">m^2/s</th><th colspan="2">ft^2/s</th><th rowspan="2">Adults</th><th rowspan="2">Children</th><th rowspan="2">Infants, Small Children and Frail/Older Persons</th></tr>
<tr><th>from</th><th>to</th><th>from</th><th>to</th></tr>
<tr><td>0.0</td><td>0.4</td><td>0.0</td><td>4.3</td><td>HZ01
Very Low Hazard: Shallow flow or deep standing water</td><td rowspan="2">Low Hazard</td><td>Low Hazard</td><td rowspan="5">Extreme Hazard Dangerous to all Infants, small Children and Frail/Older Persons</td></tr>
<tr><td>0.4</td><td>0.6</td><td>4.3</td><td>6.5</td><td>HZ02
Low Hazard: Dangerous to Children</td><td rowspan="2">Significant Hazard; Dangerous to most Children</td></tr>
<tr><td>0.6</td><td>0.8$^{(2)}$</td><td>6.5</td><td>8.6$^{(2)}$</td><td>HZ03
Moderate Hazard: Dangerous to some adults</td><td>Moderate Hazard: Dangerous to some adults</td></tr>
<tr><td>0.8</td><td>1.2$^{(3)}$</td><td>8.6</td><td>13$^{(3)}$</td><td>HZ04
Significant Hazard: Dangerous to most adults</td><td>Significant Hazard: Dangerous to most adults</td><td rowspan="2">Extreme Hazard: Dangerous to all children</td></tr>
<tr><td>1.2$^{(3)}$</td><td></td><td>13$^{(3)}$</td><td></td><td>HZ05
Extreme Hazard: Dangerous to all</td><td>Extreme Hazard: Dangerous to all</td></tr>
<tr><td colspan="8">1) Small children, children and adult categories are defined based on $height(H) \times mass(M)$
Small children: $H \times M \leq 25l(m.kg.)$ $H \times M \leq 181(ft.lb.)$
Children: $25 < H \times M(m.kg.) \leq 50$ $181 < H \times M(m.kg.) \leq 362$
Adult: $50 < H \times M(m.kg.)$ $362 < H \times M(ft.lb.)$</td></tr>
<tr><td colspan="8">2) Recommended upper limit of tolerable working flow regime for trained safety workers or experience and well-equipped persons</td></tr>
<tr><td colspan="8">3) Above this value, the hazard is extreme according to majority of the past studies.</td></tr>
</table>

Results file package of DSS-WISE HCOM contains an ESRI shapefile of polygon type containing up to five polygons (see Table 6) corresponding to the five potential flood hazard levels for humans caught outdoors by the flood, which are listed in Table 2. For convenience, Map 09 of this report shows the inundation extent colored by the five potential flood hazard levels listed in Table 2.

4.2 Flood Hazard for Humans Caught Indoors

For people caught indoors by the flood, it is assumed that the potential danger is associated with the collapses of the building (see FEMA 2011, p.43). This implicitly assumes that the people indoors are in potential danger of loss of life if the building collapses due to inundation by floodwaters.

Table 3 list the DV_{max} values for the potential collapse of different types of buildings, which are taken from the technical report of the Life Safety Model (LSM) developed by British Columbia Hydro (BCH 2006).

Table 3. Potential flood hazard levels for humans caught indoors based on the BC Hydro LSM Building Stability Criteria.

DV_{max}		Color Code	Building Type
(m^2/s)	(ft^2/s)		
$\geq$5	$\geq$54		HZ06: Poorly constructed building
$\geq$10	$\geq$108		HZ07: Well-built timber building
$\geq$15	$\geq$161		HZ08: Well-built masonry building
$\geq$20	$\geq$215		HZ09: Concrete building
$\geq$35	$\geq$377		HZ10: Large concrete building

Results file package of DSS-WISE HCOM contains an ESRI shapefile of polygon containing up to five stacked polygons (see Table 6) corresponding to the five potential flood hazard levels for humans caught indoors by the flood, which are listed in Table 3. For convenience, Map 10 of this report shows the inundation extent colored by the five potential flood hazard levels listed in Table 3.

5.0 MAPPING POTENTIALLY LETHAL FLOOD ZONES (PLFZs) FOR CHILDREN AND ADULTS

The mapping of potentially lethal flood zones (PLFZs) for humans consists of partitioning the inundation extent into zones of predefined potential lethality classes for humans. The resulting map is an ESRI shapefile of polygon type for each category. The polygons correspond to different levels of potential lethality that are defined based on the maximum depth, D_{max}, and maximum specific discharge, DV_{max}. The PLFZs for different categories of people caught outdoors, cars, mobile homes and typical residential structures are listed in Table 4 (Feinberg, 2017).

Table 4. Definition of potentially lethal flood zones (PLFZs) for different categories (Feinberg, 2017).

Category	Color Code	D_{max} $(ft.)$		DV_{max} (ft^2/s)
Children caught outdoors (tent camping, fishing, hiking, etc.)		$\geq$2	or	$\geq$5.4
Adults caught outdoors (tent camping, fishing, hiking, etc.)		$\geq$4	or	$\geq$6.5
Motor vehicle (compact car) floating	None	$\geq$1	or	$\geq$4.3
Motor vehicle (compact car) sliding/toppling	None			$\geq$5.4
Mobile homes	None	$\geq$2	or	$\geq$30
Typical residential structures	None	$\geq$4	or	$\geq$75

Results file package of DSS-WISE HCOM contains and ESRI shapefile of polygon type containing two stacked polygons corresponding to the first two categories in Table 4. These two polygons were extracted using the maximum flow depth and maximum specific discharge files provided in the results package of DSS-WISE Lite simulation (see Table 6). For convenience, Map 11 of this report shows the extents of these two PLFZ polygons.

The polygons for the remaining PLFZ zones can also be extracted from the D_{max} and DV_{max} raster files using a suitable GIS software.

6.0 POPULATION AT RISK (PAR) ANALYSIS

The population at risk (PAR) analysis aims to provide an estimate of the number of people that will be potentially affected by the propagation of the dam-break flood. DSS-WISE HCOM provides two different types of PAR analysis based on the two different population data sets that are available (see Section 3.2).

6.1 PAR Analysis Using Census Block Population Data

The results of the PAR analysis using 2010 census block population are given in two different forms:

- The list of the census blocks that are inundated (completely or partially) by the dam-break flood is provided in the "CensusBlock_Analysis" worksheet of the MS Excel file accompanying the present report.
- The polygons of the census blocks that are inundated (completely or partially) by the dam-break flood are provided in a shapefile accompanying the present report. The attributes of the census block polygons are the same as the data columns in the MS Excel file.

The polygons of census blocks included in the inundation extent (completely or partially) are provided as an ESRI shapefile (see Table 6) in the results package of DSS-WISE HCOM. The worksheet "CensusBlock_Analysis" lists all the census blocks and their attributes, which include various data extracted by DSS-WISE HCOM. The attributes of the census-block polygons are the same as the columns in the worksheet "CensusBlock_Analysis" of the MS Excel file accompanying the present report.

These attributes of the census blocks are listed and explained in Table 5. Map 06 in this report shows the census block polygon outlines overlaid on the flood extent.

Table 5. Attributes of the census block polygons in the shapefile and the corresponding columns in the worksheet "CensusBlock_Analysis" of the MS Excel file accompanying the present report.

ExcelFile		Shapefile	Unit	Description
Col	Title	Attributes		
A	State Name	STATE_NAME		Abbreviation of the state name
B	County Name	CNTY_NAME		County Name

C	State FIPS CODE	STATEFP10		2010 Census state FIPS code
D	County FIPS CODE	COUNTYFP10		2010 Census county FIPS code
E	Tract CODE	TRACTCE10		2010 Census tract code
F	Tabulation Block Number	BLOCKCE		2010 Census tabulation block number
G	Block ID Number	BLOCKID10		Census block identifier; A concatenation of 2010 Census state FIPS code, 2010 Census county FIPS code, 2010 Census tract code , and 2010 Census block number
H	Partial Block Indicator	PARTFLG		Y = partial block N = whole block
I	Total Number of Housing	HOUSING10	*Count*	2010 Census Housing Unit Count
J	Total Number of Population	POP10	*Count*	2010 Census Population Count
K	Total Area	AREATOT	*Acres*	Total area of the census block. This information is extracted from the geometry of the census block
L	Inundated Area	AREAINUND	*Acres*	Area of the census block inundated. This information is extracted by intersecting the inundation extent with the census block.
M	Percent Area Inundated	AINUND_PCT	%	This quantity is calculated in the MS Excel spreadsheet by the dividing the AREAINUND (column L) by the AREATOT (column K).

N	Flood Arrival Time (Avg)	FLDAT_AVG	hrs	This quantity is extracted from the arrival time raster. It corresponds to the average value of the arrival times of all computational cells within the extent of the census block.
O	Flood Arrival Time (Min)	FLDAT_MIN	hrs	This quantity is extracted from the arrival time raster. It corresponds to the minimum value of the arrival times of all computational cells within the extent of the census block.
P	Flood Arrival Time (Max)	FLDAT_MAX	hrs	This quantity is extracted from the arrival time raster. It corresponds to the maximum value of the arrival times of all computational cells within the extent of the census block.
Q	Flood Maximum Depth (Avg)	HMAX_AVG	ft	This quantity is extracted from the maximum flood depth raster. It corresponds to the average value of the maximum flood depths of all computational cells within the extent of the census block.
R	Flood Maximum Depth (Min)	HMAX_MIN	ft	This quantity is extracted from the maximum flood depth raster. It corresponds to the minimum value of the maximum flood depths of all computational cells within the extent of the census block.
S	Flood Maximum Depth (Max)	HMAX_MAX	ft	This quantity is extracted from the maximum flood depth raster. It corresponds to the maximum value of the maximum flood depth of all computational cells within the extent of the census block.

T	Flood Maximum DV Arrival Time (Avg)	DVMAXATAVG	hrs	This quantity is extracted from the arrival time of maximum specific discharge raster. It corresponds to the average value of the maximum specific discharge arrival times of all computational cells within the extent of the census block.
U	Flood Maximum DV Arrival Time (Min)	DVMAXATMIN	hrs	This quantity is extracted from the arrival time of maximum specific discharge raster. It corresponds to the minimum value of the maximum specific discharge arrival times of all the computational cells within the extent of the census block.
V	Flood Maximum DV Arrival Time (Max)	DVMAXATMAX	hrs	This quantity is extracted from the arrival time of maximum specific discharge raster. It corresponds to the maximum value of the maximum specific discharge arrival times of all the computational cells within the extent of the census block.
W	Flood Maximum DV (Avg)	DVMAX_AVG	ft^2/s	This quantity is extracted from the maximum specific dishcarge raster. It corresponds to the average value of the maximum specific discharge of all the computational cells within the extent of the census block.
X	Flood Maximum DV (Min)	DVMAX_MIN	ft^2/s	This quantity is extracted from the maximum specific dishcarge raster. It corresponds to the minimum value of the maximum specfic discharge of all the computational cells within the extent of the census block.

Y	Flood Maximum DV (Max)	DVMAX_MAX	ft^2/s	This quantity is extracted from the maximum specific dishcarge raster. It corresponds to the maximum value of the maximum specific discharge of all the computational cells within the extent of the census block.

6.2 PAR Analysis Using LandScan USA Gridded Population Data

The PAR analysis using LandScan USA 3 arc-second gridded population data provides three sets of tabular results classified in up to 17 flood times and 10 flood hazard categories based on DV_{max}:

- Tabular summary of inundation areas as a function of flood time is presented in the worksheet "InundatedArea" of the MS Excel file accompanying the present report. The inundation area values are presented as a stacked column plot in the same worksheet.
- Tabular summary of nighttime PAR counts as a function of flood time is presented in the worksheet "Nighttime_PAR" of the MS Excel fle accompanying the present report. The nighttime PAR counts are plotted as a stacked column plot in the same worksheet.
- Tabular summary of daytime PAR counts as a function of flood time is presented in the worksheet "Daytime_PAR" of the MS Excel fle accompanying the present report. The tabular data is also plotted as a stacked column plot.

The nighttime and daytime PAR counts were obtained from nighttime and daytime population densities, which were extracted from LandScan USA following the methologies described in the technical manual for DSS-WISE HCOM. Map 07 and Map 08 in this report show the nighttime and daytime population densities over the inundation area.

7.0 RESULTS FILES GENERATED BY DSS-WISE HCOM

All the results files generated by DSS-WISE HCOM are listed Table 6.

Table 6. List of results files generated by DSS-WISE HCOM.

No	Name	Type	Description
1	34459_HCOM_Final_Report.pdf	PDF	The present report.
2	34459_HCOM_Analysis.xlsx	Ms Excel	Ms Excel file accompanying this report. It contains four worksheets: 1. InundatedArea 2. Nighttime_PAR 3. Daytime_PAR 4. CensusBlock_Analysis
3	34459_HCOM_Census_Block_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains the polygons of the census blocks completely or partially included in the inundation extent. The attributes of the polygons are the same as the columns in the worksheet "CensusBlock_Analysis". They are listed in Table 5.
4	34459_HCOM_Outdoor_Hazard_Categories_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains up to five polygons corresponding to the five potential flood hazard levels for humans caught outdoors by the flood as listed in Table 2 (Section 4.1)
5	34459_HCOM_Indoor_Hazard_Categories_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains up to five polygons corresponding to the five potential flood hazard levels for humans caught indoors by the flood as listed in Table 3 (Section 4.2)

6	34459_HCOM_PLFZ_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygon type contains up to two stacked polygons corresponding to the PLFZ areas as listed in the first two rows of Table 4.
7	34459_HCOM_NT_PopDensity_persqmi_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygons type contains polygon of nighttime population density per square mile extracted from LandScan USA data. This file should be treated as **FOUO**
8	34459_HCOM_DT_PopDensity_persqmi_polygons.shp	ESRI Shapefile	This ESRI shapefile of polygons type contains polygon of daytime population density per square mile extracted from LandScan USA data. This file should be treated as **FOUO**

8.0 REFERENCES

BCH (2006). Life Safety Model System v1.0, Guidelines, Procedures, Calibration and Support Manual. Technical Report Engineering Report E310, British Columbia Hydro (BCH).

Bhaduri, B., Bright, E., Coleman, Ph., Urban, M.L. (2007). LandScan USA: a high-resolution geospatial and temporal modeling approach for population distribution and dynamics. Geojournal 69:103-117. DOI 10.1007/s10708-007-9105-9

Bhaduri, B. (2007). Workshop Presentation. https://www.csm.ornl.gov/workshops/RAMSworkshop07/presentation/bhaduri.ppt

Cox, R.J., Yee, M. and Ball, J.E. (2004). Safety of People in Flooded Streets and Floodways. 8th National Conference on Hydraulics in Water Engineering, Gold Coast. The Institution of Engineers, Australia.

Cox, R.J., Shand, T.D., and Blacka, M.J. (2010). Australian Rainfall and Runof, Revision Project 10: Appropriate Criteria for People. AR&R Report Number P10/S1/006. Engineers Australia, Water Engineering. ISBN 978-085825-9454. http://arr.ga.gov.au/revision-projects/project-list/projects/project-10

Dobson, J.E., Bright, E.A., Coleman, Ph.R., Durfee, R.C., and Worley, B.A. (2000). LandScan: A Global Population Database for Estimating Populations at Risk. Photogrammetric Engineering & Remote Sensing, Vol. 66, NO. 7, pp. 849-857. https://www.asprs.org/wp-content/uploads/pers/2000journal/july/2000_jul_849-857.pdf

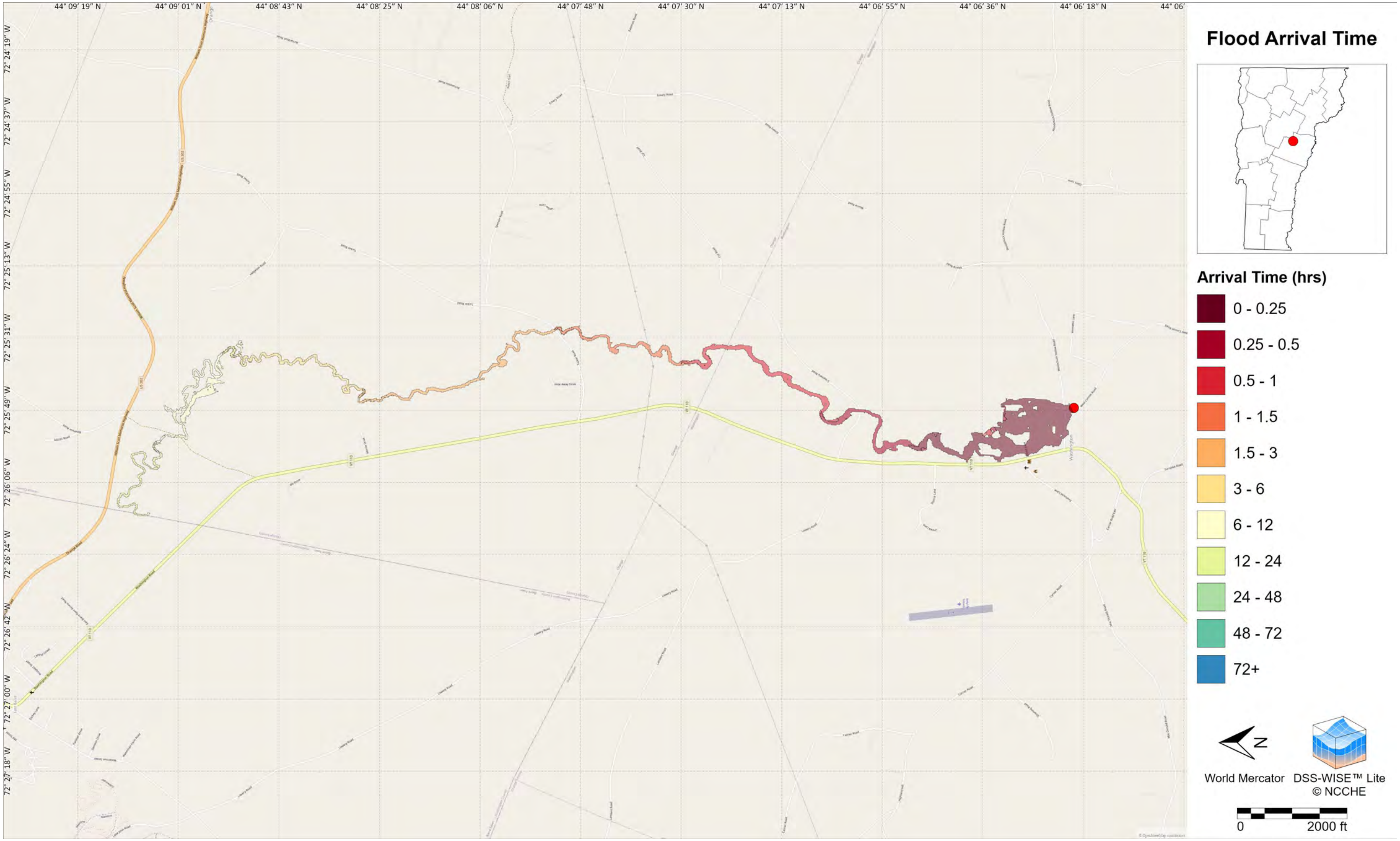
Feinberg, B. (2017). Using Potentially Lethal Flood Zones to Assess Downstream Impacts from Dam Failure. Presentation at National Dam Safety Training Seminar.

FEMA (2011). Estimating Loss of Life for Dam Failure Scenarios. Draft version.

McKee, J.J., Rose, A.N., Bright, E.A., Huynh, T., and Bhaduri, B.L. (2014). Locally adaptive, spatially explicit projection of US population for 2030 and 2050. PNAS, 112(5), 1344-1349. http://www.pnas.org/content/pnas/112/5/1344.full.pdf

Map 01: Flood Maximum Depth

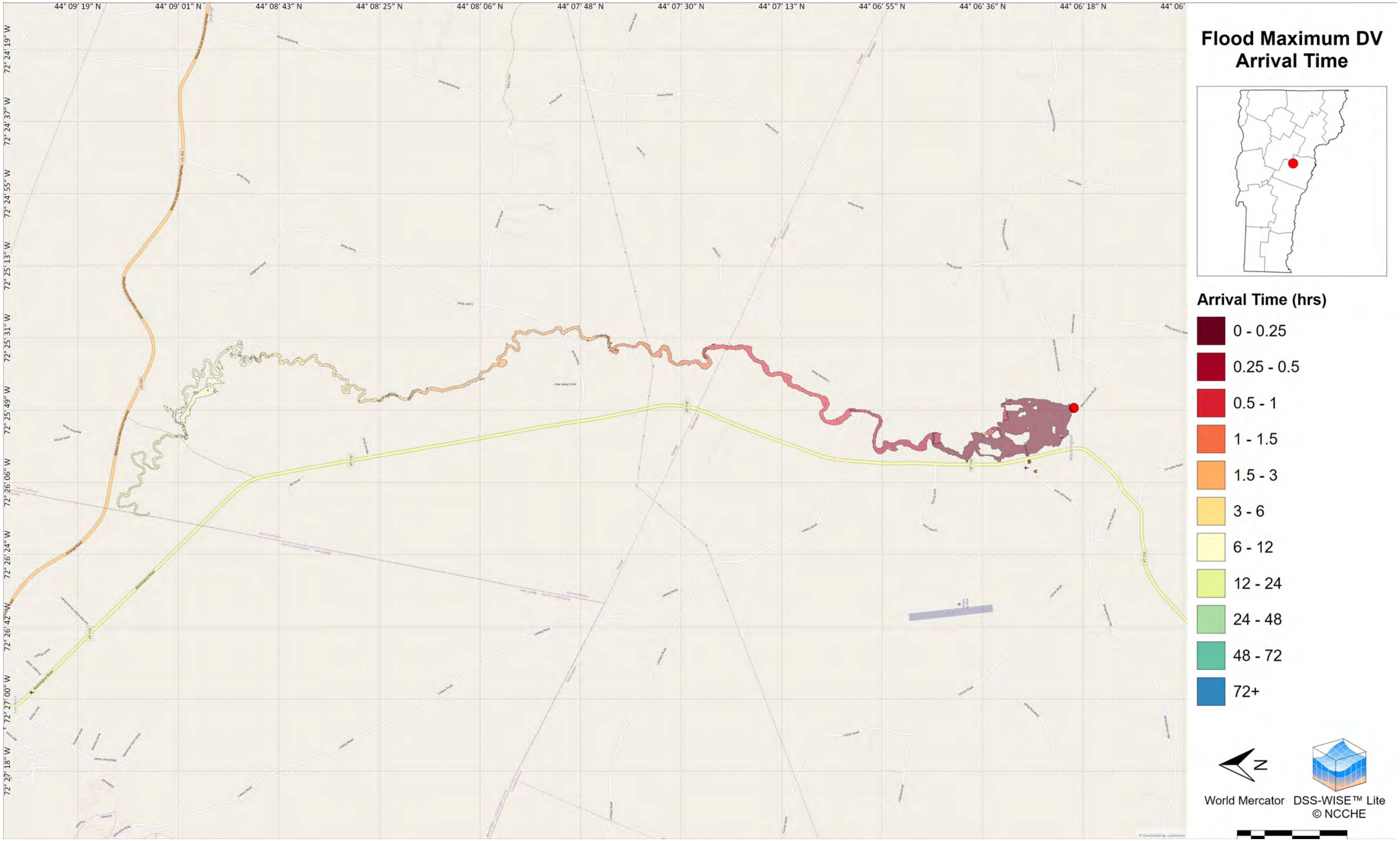
Map 02: Flood Arrival Time



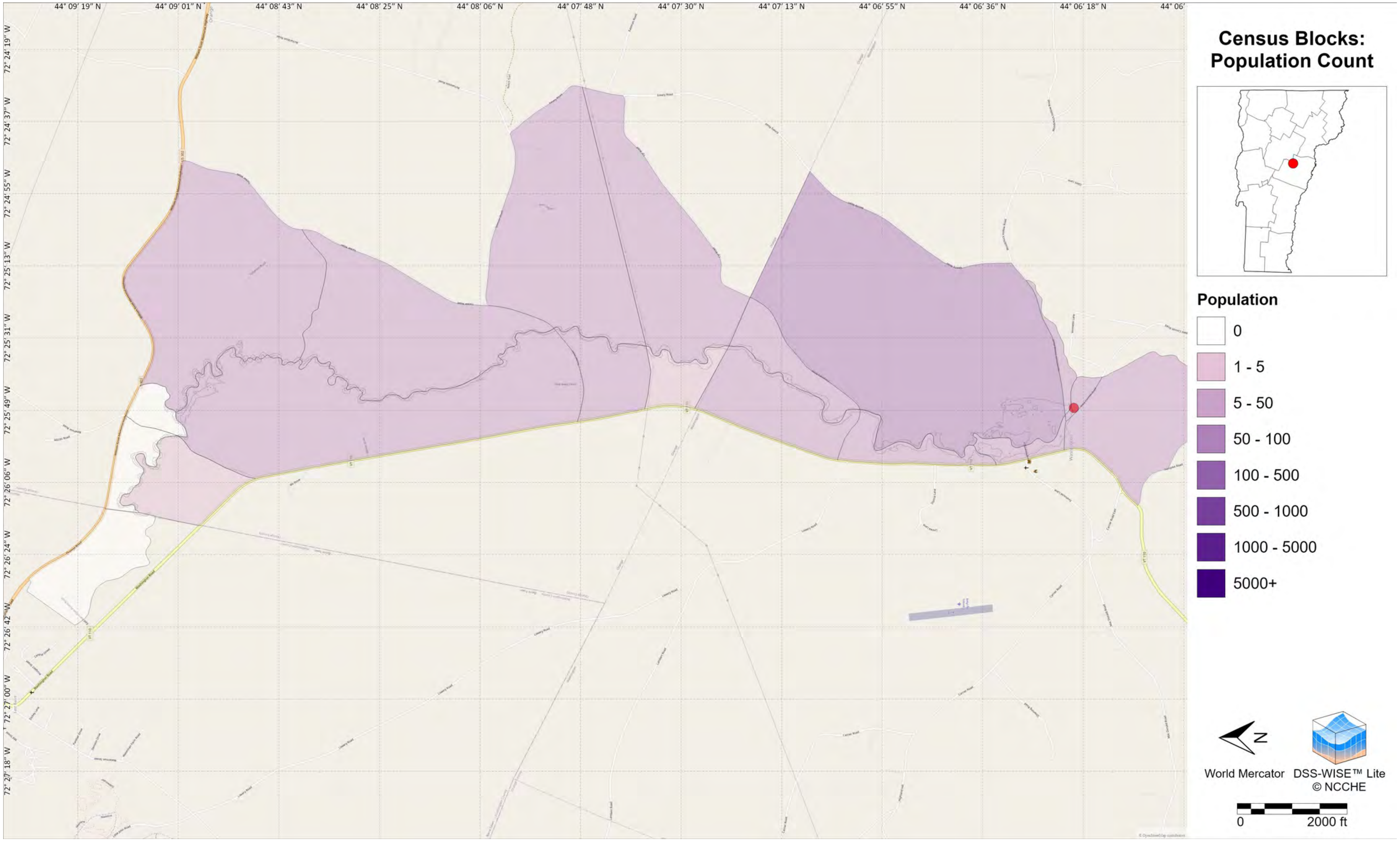
Map 03: Flood Maximum Velocity

Map 04: Flood Maximum DV

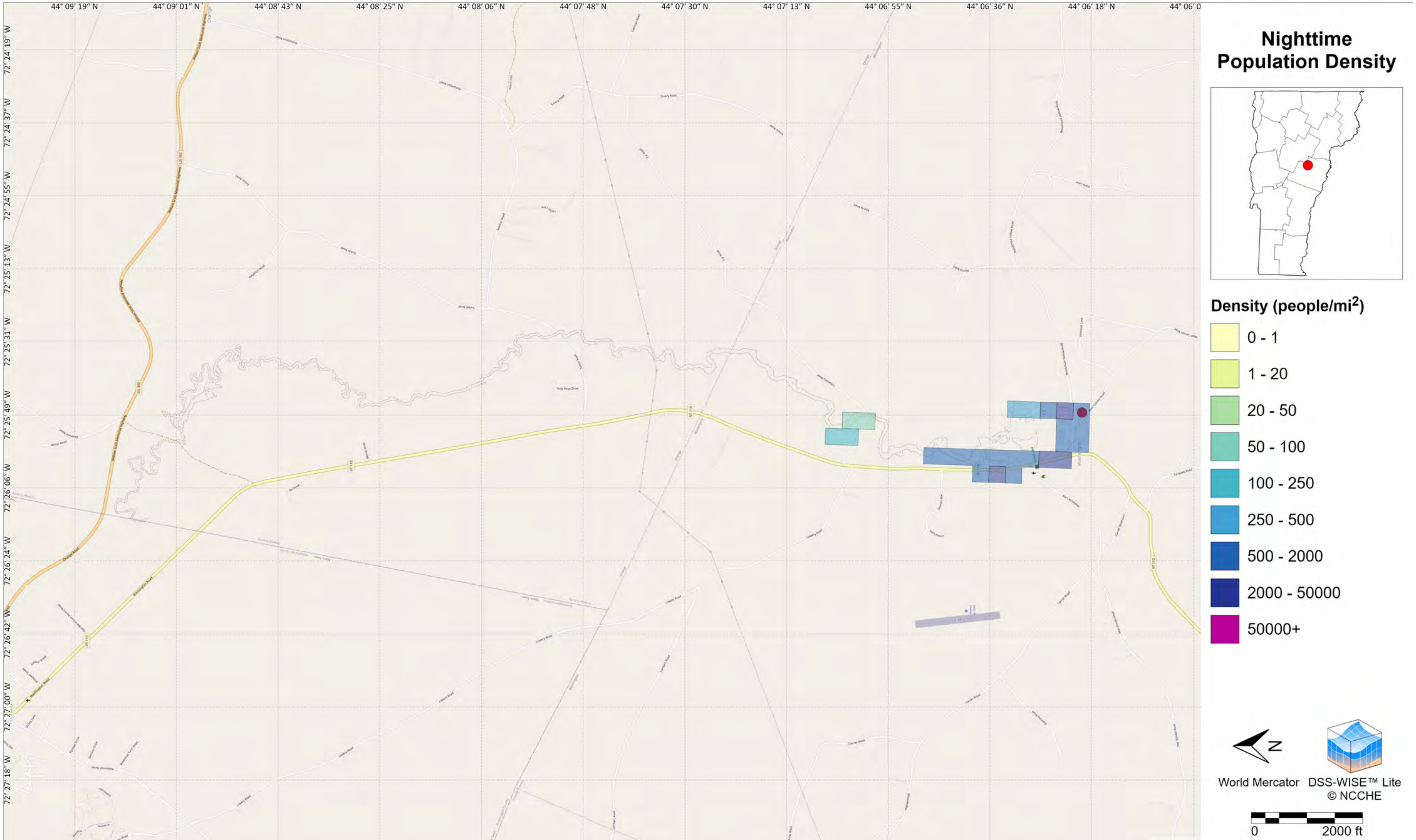
Map 05: Flood Maximum DV Arrival Time



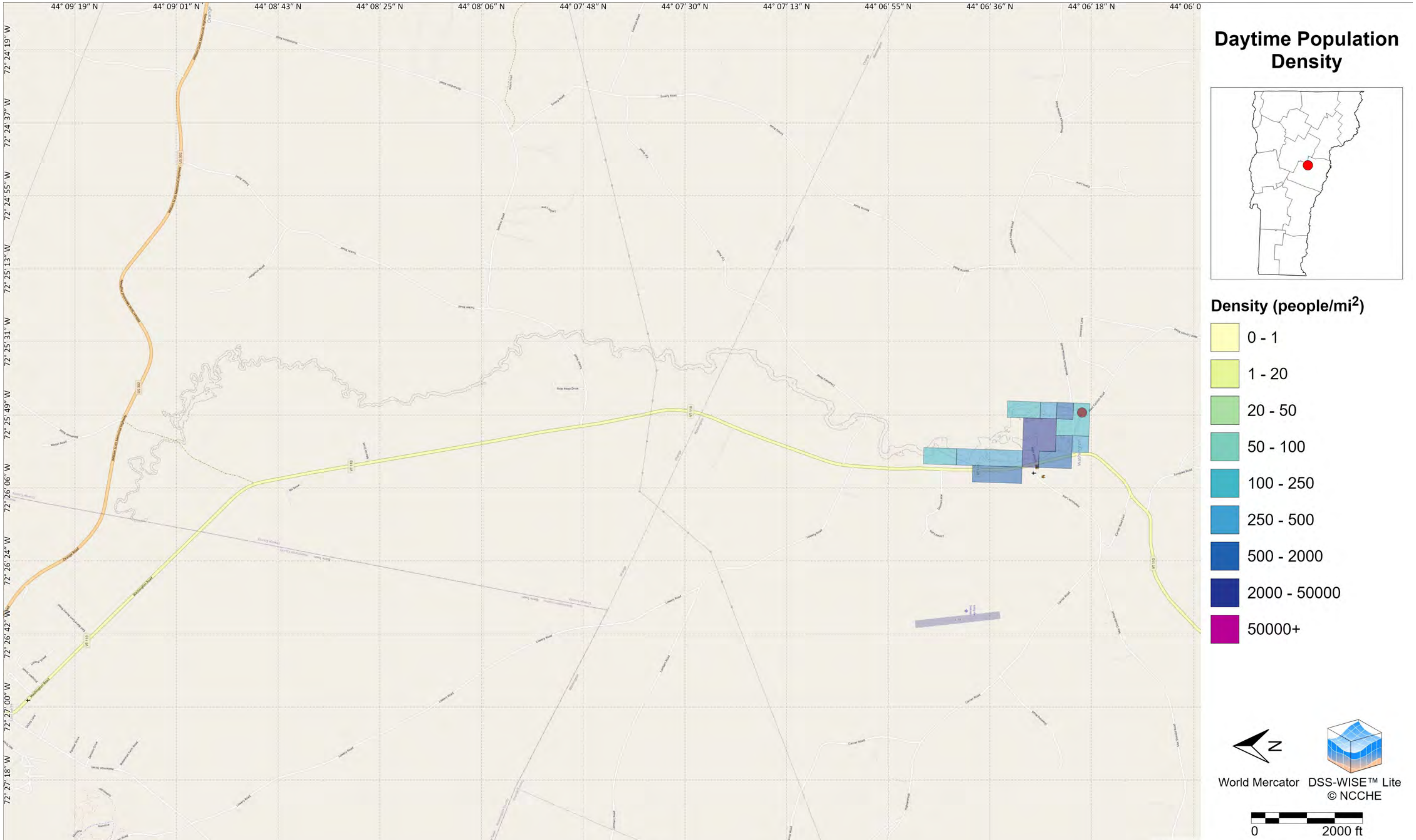
Map 06: Census Blocks: Population Count



Map 07: Nighttime Population Density

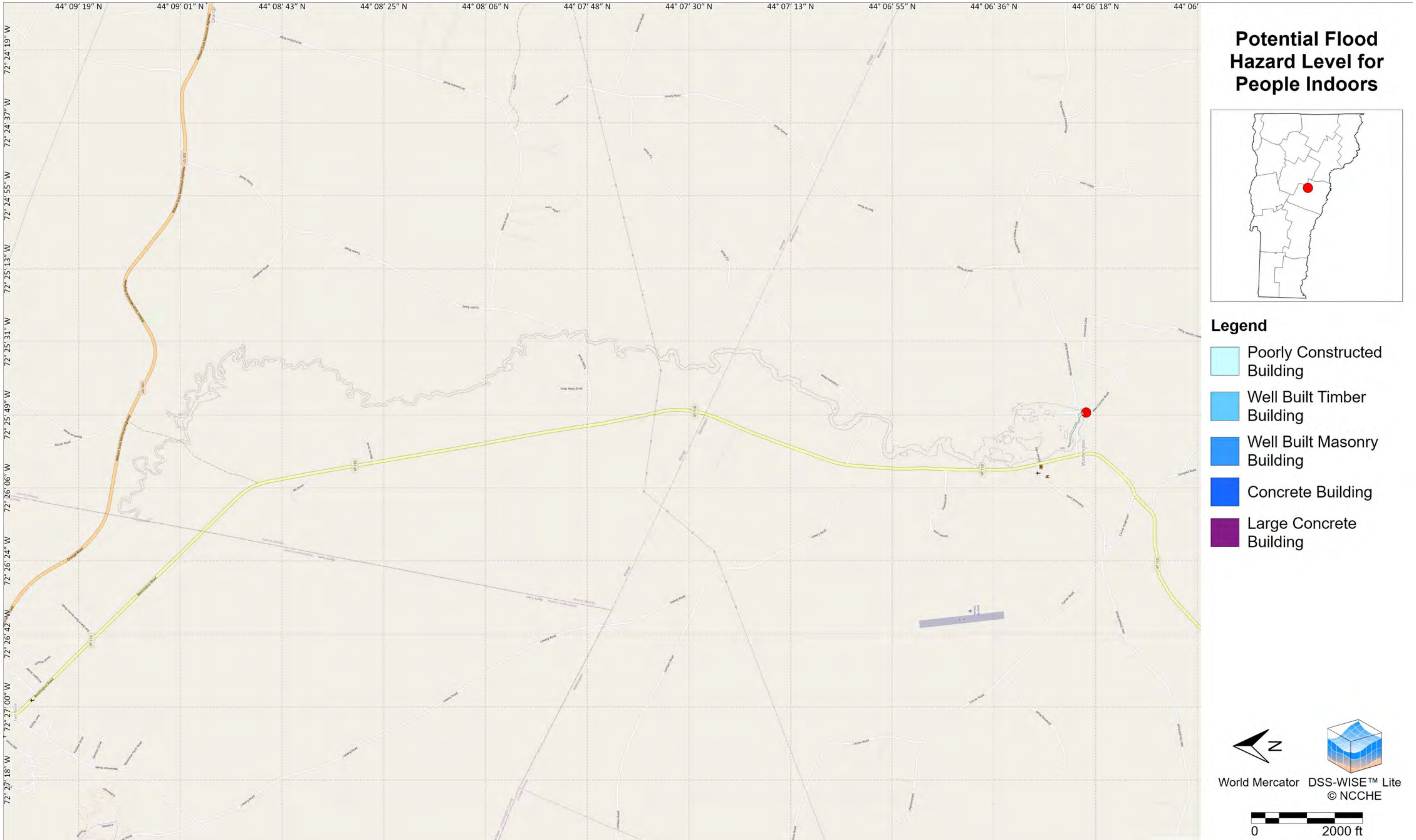


Map 08: Daytime Population Density



Map 09: Potential Flood Hazard Level for People Outdors

Map 10: Potential Flood Hazard Level for People Indoors



Map 11: Potential Lethal Flood Zones (PLFZ)

Attachment 5: Historical Documents

Listed on State Register
VT ACHP
Date: 9-14-89

STATE OF VERMONT
Division for Historic Preservation
Montpelier, VT 05602

HISTORIC SITES & STRUCTURES SURVEY
Individual Structure Survey Form

SURVEY NUMBER: 0915-26

NEGATIVE FILE NUMBER: 79-A-108-1

UTM REFERENCES: Zone/Easting/Northing
18/705660/4886580

U.S.G.S. QUAD. MAP: East Barre Quad. 15'

PRESENT FORMAL NAME: Vermette House

ORIGINAL FORMAL NAME: Rodney Clough House

PRESENT USE: Residence

ORIGINAL USE: Wagon Shop

ARCHITECT/ENGINEER: Unknown

BUILDER/CONTRACTOR: Rodney Clough (?)

PHYSICAL CONDITION OF STRUCTURE:
Excellent ☐ Good ■
Fair ☐ Poor ☐

STYLE: vernacular Queen Anne

DATE BUILT: c. 1840, remodled c. 1890

COUNTY: Orange

TOWN: Washington

LOCATION: Adjacent to Old Saw Mill site, at intersection of Woodchuck Hollow Road (T.H.#9) and Corinth Road (T.H.#1).

COMMON NAME: Armand and Edith Vermette House

FUNCTIONAL TYPE: House

OWNER: Armand and Edith Vermette
ADDRESS: Washington, VT 05675

ACCESSIBILITY TO PUBLIC:
Yes ☐ No ■ Restricted ☐

LEVEL OF SIGNIFICANCE:
Local ☐ State ■ National ☐

GENERAL DESCRIPTION:
Structural System
1. Foundation: Stone ■ Brick ☐ Concrete ■ Concrete Block ☐
2. Wall Structure
   a. Wood Frame: Post & Beam ☐ Balloon ■
   b. Load Bearing Masonry: Brick ☐ Stone ☐ Concrete ☐ Concrete Block ☐
   c. Iron ☐ d. Steel ☐ e. Other:
3. Wall Covering: Clapboard ■ Board & Batten ☐ Wood Shingle ☐ Shiplap ☐ Novelty ☐ Asbestos Shingle ☐ Sheet Metal ☐ Aluminum ☐ Asphalt Shingle ☐ Brick Veneer ☐ Stone Veneer ☐
   Bonding Pattern: Other:
4. Roof Structure
   a. Truss: Wood ■ Iron ☐ Steel ☐ Concrete ☐
   b. Other:
5. Roof Covering: Slate ☐ Wood Shingle ☐ Asphalt Shingle ☐ Sheet Metal ■ Built Up ☐ Rolled ☐ Tile ☐ Other:
6. Engineering Structure:
7. Other:

Appendages: Porches ■ Towers ☐ Cupolas ☐ Dormers ☐ Chimneys ■ Sheds ☐ Ells ☐ Wings ■ Bay Window ■ Other:

Roof Style: Gable ■ Hip ☐ Shed ☐ Flat ☐ Mansard ☐ Gambrel ☐ Jerkinhead ☐ Saw Tooth ☐ With Monitor ☐ With Bellcast ☐ With Parapet ☐ With False Front ☐ Other:

Number of Stories: $2\frac{1}{2}$

Number of Bays: 5 x 3

Entrance Location: center, front

Approximate Dimensions: 32' x 24' plus side wing

THREAT TO STRUCTURE:
No Threat ■ Zoning ☐ Roads ☐
Development ☐ Deterioration ☐
Alteration ☐ Other:

LOCAL ATTITUDES:
Positive ■ Negative ☐
Mixed ☐ Other:

ADDITIONAL ARCHITECTURAL OR STRUCTURAL DESCRIPTION:

Although this structure was originally used as a wagon shop, it was substantially remodeled c. 1890 to serve as a residence. Queen Anne Revival style is evidenced by a projecting bay having brackets under the eave. The gable is detailed with shingles, some having a heraldic pattern most freguently found in the Barre Graniteville area. The foundation includes slabs of granite that were split form local field boulders. This part of the foundation may well be part of the original wagon shop foundation. The south gable was damaged by a fire that destroyed the adjacent W. and C.W. Huntington Saw Mill in 1914. (The dam and part of the foundation remain.) A rear corner wing was added in the mid-1900's and the one bay gable-roofed garage was built c. 1950.

RELATED STRUCTURES: (Describe)

1. One bay garage 10' x 16'. Gable roof.

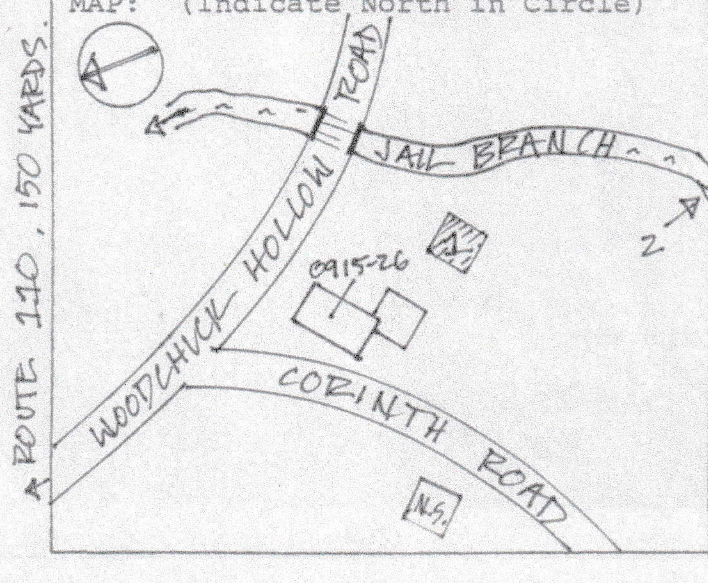
STATEMENT OF SIGNIFICANCE:

This structure was built by Rodney Clough c. 1840 and originally served as a wagon shop. Adjacent ot the shop were the Huntington saw mill and the "Washington Manufacturing Co.". Together, the buildings comprised the industrial center of Washington in the mid-19th century. Although some of the original framing of the wagon shop still exists, the structure was rebuilt as a residence, probably by a member of the Cheney family. The design of the house, especially the gable shingle work, indicates the building associations that Washington had with the Barre/ Graniteville area during the height of the granite industry in the 1890's.

REFERENCES:

1,2,3,4,7.

MAP: (Indicate North in Circle)



SURROUNDING ENVIRONMENT:
Open Land ■ Woodland ☐
Scattered Buildings ■
Moderately Built Up ☐
Densely Built Up ☐
Residential ■ Commercial ☐
Agricultural ☐ Industrial ☐
Roadside Strip Development ☐
Other:
C. 200 yards east of Route 110 and the center of Washington Village.

RECORDED BY:
Philip C. Marshall

ORGANIZATION:
Div. for Historic Preservation

DATE RECORDED: 6/3/79

0915-26

Hands Mill Dam 225.01
Washington

VERMONT

Vermont Department of Environmental Conservation
Facilities Engineering Division
1 National Life Drive, 1 Main [phone] 802-490-6229
Montpelier, VT 05620

Agency of Natural Resources

MEMORANDUM

TO: To The File

FROM: Steven Hanna, Dam Safety Engineer

DATE: December 9, 2016

SUBJECT: Inspection of Hands Mill Dam, Washington.

On August 11, 2016, Stephen Bushman, P.E., Steven Hanna and Louisa Deering made a routine inspection of the Hands Mill Pond Dam in Washington, Vermont, State Identification Number 225.01. The inspection was carried out under the provisions of Title 10 of Vermont Statutes Annotated, Section 1105. The Town of Washington owns the dam. A number of photographs and field notes were taken. The dam was last inspected by the Department on August 5, 2013, and the report of that inspection is on file. This report updates previous observations and records additional information.

OVERALL CONDITION

The overall condition of the dam is **POOR** and the dam is currently **Partially Breached.** The dam is continuing to deteriorate and progressively breach.

DOWNSTREAM HAZARD CLASSIFICATION

The dam is classified as a Class 2, "Significant Hazard" dam. Significant hazard potential category structures are those located in predominantly rural or agricultural areas where failure may damage isolated homes, secondary highways or minor railroads, or cause interruption of service of relatively important public utilities. **The potential for loss of life is few and the potential economic loss is appreciable**.

JURISDICTION

Since the dam impounds more than 500,000 cubic feet, any alteration, reconstruction or breaching would require prior approval from the Department under provisions of 10 VSA Chapter 43.

RECOMMENDATIONS FOR OWNER

1. Retain a professional engineer experienced in the design and investigation of dams to develop plans to remove the dam and restore the upstream channel. The dam is progressively breaching. **A failure of the dam could cause public and private property damage and loss of life downstream.**

2. Develop, implement and keep current an Emergency Action Plan (EAP) for use during an unusual or emergency event at the dam. The purpose of an EAP is to reduce the risk of human life loss and injury and minimize property damage. The EAP should be reviewed and tested at least annually. Submit a copy of the EAP to the Dam Safety Program.

3. Clear the dam crest, the upstream slope and the downstream slope of trees, woody vegetation, and debris extending 15 feet beyond the toe of the dam, outlet structure, and both abutments.

INSPECTION

The inspection of the dam was conducted on August 11, 2016 at 1430 hours. The weather was partly cloudy and humid with temperatures in the mid-80s. The ground conditions were dry. The following was observed:

1. Embankment Section: The earth embankment section is primarily left of the spillway tying into the left abutment that was a firm parking lot. The downstream slope of this section was covered in grass and thick brush.

2. Downstream Wall: The wall consists of cyclopean concrete (concrete with large round stones). The concrete is deteriorating and there are several areas of the wall with significant stone loss. The area to the left of the spillway had a large area of scour and several loose stones where there had been concrete loss. Several large pieces of concrete had fallen off the wall about 50 feet to the right of the spillway. This area also appeared to be impacted by overtopping events. At the extreme left end, the downstream wall consisted of large rounded stone dry-laid. The wall was irregular but appeared more stable than the rest, most likely because it has been less impacted by high flows. Most of the downstream wall had moderate to large trees growing on or adjacent to it. These are also destabilizing the wall. There were multiple areas of seepage on both sides of the spillway.

3. Upstream Wall: The right end of the dam consisted of a concrete wall. Most of the wall was covered in thick brush but the exposed section had significant cracking. The spillway and left end of the dam had significant scour. The additional large stone that has been placed appeared stable at the time of the inspection.

4. Crest: The crest was in poor condition, covered in grass, heavy brush, and trees. There were multiple locations with signs of overtopping, erosion. The dam was partially breached near its mid-section, with fallen concrete and concrete that was leaning up to 10 feet downstream.

5. Toe: Trees, woody vegetation and debris covered the toe.

6. Principal Concrete Spillway:

    a) Approach Channel: The approach channel was clear of debris. The concrete of the spillway was cracked and eroded along the whole width of the channel.

    b) Weir: The weir structure was in poor condition, the left end has been partially breached and the rest of the weir was highly eroded and in poor condition. Large rock had been placed along the contact between the spillway and left crest as protection from high flows. This erosion appears to be a continuing problem, based on previous inspections.

    c) Downstream Section: The downstream section is a cyclopean wall that has eroded. There is stone and concrete loss and water is flowing through (within) the structure.

d) Discharge Channel: The downstream channel was clear of debris.

7. Sluice: The low level sluiceway was in poor condition and is inoperable. The sluiceway channel was about 12 feet long through the dam. The sluice gate was either closed or stop logs were in place and there was seepage coming through the logs. There were multiple seepages with water flowing heavily.

HYDROLOGY AND HYDRAULICS

The drainage area at this site is about 4,130 acres (6.45 square miles). The pond area at the normal pool is 2 acres with storage of about twelve acre-feet including sediments. At the top of the crest the dam stores 16 acre-feet. The maximum spillway capacity is about 800 cubic feet per second.

Vermont Department of Environmental Conservation *Agency of Natural Resources*
Facilities Engineering Division
1 National Life Drive, 1 Main [phone] 802-490-6229
Montpelier, VT 05620

MEMORANDUM

TO:	To The File
FROM:	Stephen Bushman, P.E., Dam Safety Engineer
DATE:	August 8, 2013
SUBJECT:	Inspection of Hands Mill Dam, Washington.

On August 5, 2013, Stephen P. Bushman, P.E., and Steve Hanna, made a routine inspection of the Hands Mill Pond Dam in Washington, Vermont. A number of photographs were taken. The dam was last inspected by the Department on May 30, 2007, and the report of that inspection is on file. This report updates that report and records additional information. The inspection was carried out under the provisions of 10 VSA 1105.

OVERALL CONDITION

The overall condition of the dam is POOR. With authorization of the VT Department of Environmental Conservation, the dam should either be removed or repaired.

DOWNSTREAM HAZARD CLASSIFICATION

The dam is a Class 2, "significant hazard" dam.

JURISDICTION

Since the dam impounds more than 500,000 cubic feet, any alteration, reconstruction or breaching would require prior approval from the Department under provisions of 10 VSA Chapter 43.

RECOMMENDATIONS FOR OWNER

1. Retain a professional engineer experienced in the design and investigation of dams to develop plans to either remove or reconstruct the dam and restore the upstream channel. The dam is progressively breaching. **A sudden failure of the dam during regional high water could cause public and private property damage and loss of life downstream.**

2. Until a professional engineer is retained, monitor the condition of the dam. Report any changes to your engineer.

3. Maintenance of the dam should be improved to include clearing and brushing of the dam along the crest, the upstream slope, and the downstream slope. Brushing should be pushed 10-15 feet past the toe of the dam, 15 feet around any outlet structure, and 15 feet surrounding both abutments.

4. An emergency action plan (EAP) should be developed, implemented, and tested. The plan should indicate who would be responsible for routine and flood-time observation of the dam, the conditions

which would be cause for alarm and the way in which people possibly affected downstream would be notified.

INSPECTION

The inspection of the dam was conducted on August 5, 2013, at 1400 hours. The weather was sunny and in the 70's. The ground was dry. The following was observed:

1. Embankment Section: Most of the earth embankment section is left of the spillway (looking downstream). The left abutment was a firm parking lot, and the downstream slope of this section was covered in grass and thick brush.

2. Stone Section:

a) Downstream Wall: The downstream wall consists of cyclopean concrete for about 50 feet to the left of the spillway, in the spillway section, and for about 100 feet to the right of the spillway. There were several areas where significant stone loss had occurred: Immediately to the left of the spillway and about 50 feet to the right. The area to the left of the spillway had a large area of scour in addition to several loose stones where the concrete had been loss. This area appears to be impacted by high flows since it is on the bend of the river. Based on the photos from 2007, this section has deteriorated rapidly, probably as a result of TS Irene and recent high water. About 50 feet to the right of the spillway, several large pieces of concrete had fallen off the wall. This area appeared to be impacted by overtopping also. At the extreme left end, the downstream wall consisted of large rounded stone dry-laid. The wall was irregular but appeared more stable than the rest, most likely because it has been less impacted by high flows. Most of the downstream wall had moderate to large trees growing on or adjacent to it. These are also destabilizing the wall. There were multiple areas of seepage on both sides of the spillway.

b) Upstream Slope: The right end of the dam consisted of a concrete wall. Most of the wall was covered in thick brush but the exposed section had significant cracking. The area to the left of the spillway had significant scour that was noted in the previous inspection. However, additional large stone had been added and the area appeared stable at the time of the inspection.

c) Crest: The crest was found to be in poor condition. The crest was covered in grass, heavy brush, and trees. Structurally, there were multiple signs of overtopping, erosion, and the dam was partially breached near its mid-section. The mid-section of the dam had severe damage with fallen concrete and concrete that was leaning up to 10 feet downstream.

d) Toe: Woody vegetation covered the toe.

3. Principal Concrete Spillway:

a) Approach Channel: The approach channel was clear of debris. The concrete of the spillway was cracked and eroded along the whole width of the channel.

b) Weir: The weir structure was in poor condition. The left end of the weir has been partially breached, and the rest of the weir was highly eroded and in poor condition. Large rock, as noted above, had been placed along the contact between the spillway and left crest as protection from high flows. This appears to be a continuing problem, based on previous inspections.

c) Downstream Section: The downstream section of the spillway is a cyclopean wall. At the time of the inspection a significant amount of water was flowing over it preventing a thorough inspection. Based on the surrounding walls and weir condition, it is expected that there is some stone and concrete loss.

d) Discharge Channel: The outlet channel downstream was clear of debris.

4. Sluice: The sluiceway appeared to be in poor condition. There were multiple signs of seepage with water flowing heavily.

HYDROLOGY AND HYDRAULICS

The drainage area at this site is about 4,130 acres. The pond area at the normal pool is 2 acres with storage of about twelve acre-feet including sediments. At the top of the crest the dam stores sixteen acre-feet. The maximum spillway capacity is about 800 cfs.

VERMONT

Vermont Department of Environmental Conservation *Agency of Natural Resources*
Facilities Engineering Division, Dam Safety and Hydrology Section
103 South Main Street, [phone] 802-241-3450
Waterbury, VT 05671-0511 [fax] 802-244-4516

June 25, 2007

Carol Davis
Town Clerk
2974 VT Route 110
Washington, VT 05675

Re: Inspection of Hands Mill Dam in Washington, VT

Dear Ms. Davis,

Attached is a report of our May 30, 2007 inspection of Hands Mill Dam owned by the Town of Washington in Washington, Vermont. As was identified in 2001 the dam is in poor condition and continues to deteriorate. At that time, a recommendation to retain a professional engineer experienced in the design of dams to develop plans to either reconstruct or remove the dam and restore the upstream channel was made. That same recommendation is being made at this time. The dam is considered a significant hazard, and a sudden failure of the dam would cause probable loss of life and property damage. Consultation with your Town attorney about the liabilities of dam ownership would be prudent.

The report outlines the condition of the dam, recommendations for the owner and information about the jurisdiction of the Department under the statue on dams (10 VSA Chapter 43).

Please contact me if you have any questions on the report or recommendations.

Sincerely,

Stephen Bushman

Stephen P. Bushman, P.E.
Dam Safety Engineer

VERMONT

Vermont Department of Environmental Conservation *Agency of Natural Resources*
Facilities Engineering Division, Dam Safety and Hydrology Section
103 South Main Street, [phone] 802-241-3450
Waterbury, VT 05671-0511 [fax] 802-244-4516

MEMORANDUM

TO: For the File

FROM: Stephen Bushman, P.E., Dam Safety Engineer SB

DATE: June 25, 2007

SUBJECT: Inspection of Hands Mill Dam, Washington.

On May 30, 2007, Stephen P. Bushman, P.E., Brian Terhhune, and Henry Nyenbrink, made a routine inspection of the Hands Mill Pond Dam in Washington, Vermont. A number of photographs were taken. The dam was last inspected by the Department on June 20, 2001, and the report of that inspection is on file. This report updates that report and records additional information. The inspection was carried out under the provisions of 10 VSA 1105.

OVERALL CONDITION

The overall condition of the dam is poor.

DOWNSTREAM HAZARD CLASSIFICATION

The dam is a Class 2, "significant hazard" dam.

RECOMMENDATIONS FOR OWNER

1. The owner should retain a professional engineer experienced in the design of dams to develop plans to either reconstruct or remove the dam and restore the upstream channel. Even though the dam has withstood flood and weather for decades, it will not last forever. A sudden failure of the dam during regional high water could cause public and private property damage and loss of life downstream.

2. Maintenance of the dam should be improved to include clearing and brushing of the dam along the crest, the upstream slope, and the downstream slope to ten feet below the toe of the dam.

3. Remove the trailers and tractors from the left abutment so this area can be properly inspected and monitored for sinkholes.

4. An emergency action plan (EAP) should be developed, implemented, and tested. The plan should indicate who would be responsible for routine and flood-time observation of the dam, the conditions which would be cause for alarm and the way in which people possibly affected downstream would be notified

INSPECTION

The inspection of the dam was conducted on May 30, 2007, between 1430 and 1515 hours. The weather was partly cloudy and in the 60's. The ground was dry. The following was observed:

1. Embankment Section.

a) Upstream Slope. The upstream slope was covered in grass and thick brush. There were multiple signs of erosion. The left abutment was severely eroded while the right abutment appeared sound. There was an exposed concrete cutoff wall near the right end of the dam in a deteriorated condition.

b) Downstream Slope. The slope was covered in grass and moderate brush and trees. At the mid-point of the wall there was an eroded section that was about five-feet wide by twelve-feet high. There were multiple signs of seepage to the right of the spillway. The portion of the downstream embankment with a large rip rap wall was in fair condition.

c) Crest. The crest was found to be in poor condition. The crest was covered in grass, heavy brush, and trees. There were multiple signs of overtopping and erosion near the mid-point of the dam. There was a portion of the concrete on the crest that has failed. There were logs and woody debris along the length of the crest. In June, 2001 a sinkhole was reported on the crest to the left of the spillway. This area is now covered with trailers and tractors, presumable from the adjacent farm, so it could not be inspected.

d) Toe. The toe was wet from the multiple seeps. There was woody vegetation along the toe.

2. Principal Concrete Spillway.

a) Approach. The approach was clear of debris, but the pond is largely filled in with sediment. The concrete of the spillway was cracked and eroded along the whole width of the channel.

b) Weir. The weir structure was in poor condition. The left end of the weir appears to be failing and it is noticeably lower that the remaining structure. Excessive erosion and channel cutting was occurring around the left end of the weir structure.

c) Downstream Section. The downstream slope is a cyclopean wall that had a substantial amount of stone and concrete that was in a deteriorated state or missing. Portions of the wall were covered with seeps, moss, ferns, and small trees.

d) Outlet Channel. The outlet channel was clear of debris.

3. Sluice. The sluice was difficult to inspect but appeared to be in poor condition. There were multiple signs of seepage at the sluice.

HYDROLOGY AND HYDRAULICS

The drainage area at this site is about 4,130 acres. The pond area at the normal pool is 2 acres with storage of about twelve acre-feet including sediments. At the top of the crest the dam stores sixteen acre-feet. The maximum spillway capacity is about 800 cfs.

JURISDICTION

Since the dam impounds more than 500,000 cubic feet, any alteration, reconstruction or breaching would require prior approval from the Department under provisions of 10 VSA Chapter 43.

Please don't hesitate to call me at 241-3450 if I can be of further assistance.

State of Vermont
Department of Environmental Conservation
Dam Safety Section
103 South Main Street
Waterbury, VT 05671-0407

DAM INSPECTION CHECK LIST

Dam HANDS MILL

DEC ID. No. ____

Town WASHINGTON

NatDam ID No: VT000 ____

Owner TOWN OF

Inspection Date 5-31-07

Address ____

Time ~~1210~~ 1430-1515

Last Inspected/by ____

Telephone ____

Last D/S Haz Class ____

Right of Entry ____

PERSONS PRESENT AT TIME OF INSPECTION (Name and Organization)

Inspection Party SPB, BAT, MN

Others ____

I. Conditions at Time of Inspection

Weather: Today PT CLOUDY, 60s Previous CLEAR, 70s

Ground Conditions DRY Other ____

Water Level ____ w/r/t ____

Accessibility ____

Reservoir Area ____

Remarks POOR CONDITION, DAM SHOULD BE REMOVED & CHANNEL U/S RESTORED.

II. Condition of Main Structure

Type of Construction CYCLOPEAN CONCRETE / EARTH EMBANKMENT

A. Upstream Face or Slope

1. Vegetative Cover GRASS / THICK BRUSH

2. Erosion MODERATE ALONG EMBANKMENT SECTION

3. Slumps, Slides, Cracks

4. Animal Burrows NN

5. Slope Protection

6. Debris

7. Structural

8. Abutments LT ABUTMENT ERODED / RT ABUTMENT SOUND

9. Alignment

10. Movement

11. Remarks EXPOSED CONCRETE CUT-OFF WALL NEAR RT END. DETERIORATED CONDITION.

E. Downstream Face or Slope and Toe

1. Vegetative Cover GRASSES, MODERATE BRUSH & TREES

2. Erosion

3. Slumps, Slides, Cracks MID POINT OF DAM HAS AN ERODED SECTION ≈ 5' WIDE x 12' HIGH

4. Animal Burrows

5. Slope Protection

6. Debris

7. Seepage NOTED JUST RT OF SPILLWAY THROUGH CYCLOPEAN WALL.

8. Piping

9. Boils

10. Toe Drains NONE

11. Scour

12. Structural CYCLOPEAN WALL HAS LOST SUBSTANTIAL AMOUNT OF STONE, IN DETERIORATED STATE

13. Abutments RT SOUND, LT ERODED LT ALSO HAS TRAFFIC & TRACTOR ON THAT DURING INSPECTION.

14. Alignment

15. Movement

16. Remarks Stone wall section at right end bulges outward in several places.

C. Top of Dam

1. Vegetative Cover Grass, heavy brush & trees

2. Erosion

3. Evidence of Overtopping Yes, about at mid-point. Portion of concrete on crest has failed

4. Settlement, Cracks

5. Animal Burrows NN

6. Debris Logs, woody debris

7. Use of crest (road, trail, etc.) None

8. Structural Poor condition

9. Abutments RT: Firm, LT: Severely eroded

10. Alignment ______________________________

11. Remarks ______________________________

III. Condition of Outlet Works

A. Principal Spillway

Type CYCLOPEAN CONCRETE

Controlled or Uncontrolled UNC

1. Approach Channel CLEAN, BUT IN GENERAL POND U/S OF DAM FULL OF SEDIMENTS
2. Transition ______________________________
3. Control Section CONCRETE SEVERELY DETERIORATED
4. Discharge Channel CLEAN
5. Intake Structure ______________________________
6. Conduit ______________________________
7. Outlet Structure ______________________________
8. Trash Racks ______________________________
9. Anti-vortex Devices ______________________________

10. Stop Logs, Flash Boards ______________________

____

11. Remarks ______________________

____

____

B. Emergency Spillway

Type ______________________

____

Controlled or Uncontrolled ______________________

1. Approach Channel ______________________

____

2. Transition ______________________

____

3. Control Section ______________________

____

4. Discharge Channel ______________________

____

5. Remarks ______________________

____

____

C. Drawdown Facilities, Gates, Drains, Appurtenances, Etc.

1. Drawdown Facility ______________________

____

Condition ______________________

____

2. Other Gates, Drains, Appurtenances ____________________

____

Condition ____________________

____

3. Remarks ____________________

____

____

____

IV. Operation and Maintenance

____

____

____

____

V. Inspection Summary

A. Information Obtained

1. Photographs ____________________
2. Dimensions ____________________
3. Other ____________________

B. Additional Information Needed

____

____

____

C. Overall Condition of Dam

____

____

____

____

VI Owner Interview Yes No When/where ______

(A) Plans, inspection reports, photos, other records? ______

______

(B) History of dam ______

______

(C) Performance, floods, operation, etc. ______

______

(D) Property lines, access, water rights, etc. ______

______

(E) Other Information ______

______

VII. General Comments

______

______

______

______

Check List completed by Name ______

Title ______

Date ______

Attachments: ______

______

______

State of

AGENCY OF NATURAL RESOURCES
Department of Environmental Conservation

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
RELAY SERVICE FOR THE HEARING IMPAIRED
1-800-253-0191 TDD>Voice
1-800-253-0195 Voice>TDD

November 14, 2001

Carol Davis
Town Clerk
2974 VT Route 110
Washington, VT 05675

Re: Hands Mill Dam - Washington

Dear Ms. Davis,

Attached is a report of our June 20, 2001 inspection of the dam owned by the Town of Washington in Washington, Vermont. Some items in the recommendations of the reports should be given early attention.

The report outlines the condition of the dam, recommendations for the owner and information about the jurisdiction of the Department under the statue on dams (10 VSA Chapter 43).

Please contact me if you have any questions on the report or recommendations.

Sincerely,

Robert B. Finucane, P.E.
Dam Safety Engineer

cc: Larry R. Fitch, P.E., Director, Facilities Engineering Division.

State of Vermont

AGENCY OF NATURAL RESOURCES
Department of Environmental Conservation

Department of Fish and Wildlife
Department of Forests, Parks and Recreation
Department of Environmental Conservation
State Geologist
RELAY SERVICE FOR THE HEARING IMPAIRED
1-800-253-0191 TDD>Voice
1-800-253-0195 Voice>TDD

MEMORANDUM

TO: For the Record

FROM: Robert B. Finucane, P.E., Assistant Dam Safety Engineer

DATE: November 14, 2001

SUBJECT: Inspection of the Hands Mill Pond Dam, Washington

On June 20, 2001, Robert B. Finucane, and Jennifer Vosburgh, made a routine inspection of the Hands Mill Pond Dam in Washington, Vermont. A number of photographs were taken. A second visit to the site was made on August 3, 2001 to set a benchmark. The dam was last inspected by the Department on November 14, 1984, and the report of that inspection is on file. This report updates that report and records additional information. The inspection was carried out under the provisions of 10 VSA 1105. Permission to inspect the dam was given by Selectman Don Milne in a phone conversation on June 19.

OVERALL CONDITION

The overall condition of the dam is poor. The spillway section is partially failed at the left end and exhibits widespread concrete deterioration, spalling and erosion. The embankment section is overgrown with trees and brush.

RECOMMENDATIONS FOR OWNER

Recommendations for the owner include:

1) The owner should retain an professional engineer experienced in the design of dams to develop plans to either reconstruct or remove the dam. Even though the dam has withstood flood and weather for decades, it will not last forever. A sudden failure of the dam during regional high water could cause public and private property damage and loss of life downstream.

2) Maintenance of the dam should be improved to include clearing and brushing of the dam along the crest, the upstream slope, and the downstream slope to ten feet below the toe of the dam.

3) An emergency action plan (EAP) should be developed, implemented, and tested. The plan should indicate who would be responsible for routine and flood-time observation of the

dam, the conditions which would be cause for alarm and the way in which people possibly affected downstream would be notified

INSPECTION

The inspection of the dam was conducted on June 20, 2001, between 1300 and 1430 hours. The weather was partly cloudy and in the 80's. The pond level on August 3, 2001 was 0.2 feet below the PK nail set in a 4x4 in the crest of the dam and about the same as during the June 20 inspection. The ground was dry. Portions of the first visit to the site were observed by Ann Jennings and Brian Fitzgerald from the Water Quality Division. Washington Selectman, Don Milne was also present. The following was observed:

1. Embankment Section.

a) Upstream Slope. The upstream slope was in fair condition, and was found to be firm, dry, and irregular and heavily overgrown with brush and trees.

b) Downstream Slope. The downstream slope of the dam was also overgrown, steep, dry and irregular. Portions of the slope on the right side of the spillway are covered with riprap. At the right of the spillway, there is evidence of historic overtopping and sloughing of the embankment. On the left side of the spillway, the foundations of the old mill building form the slope.

c) Crest. The crest was found to be in poor condition. The crest to the right of the spillway is narrow, and overgrown with vegetation, including trees twelve inches in diameter breast high. The roots of these trees grow into the embankment generating pathways which allow water to enter and cause the embankment to deteriorate and eventually fail.

A 4-inch diameter, 12 inch deep hole was found in the crest to the left of the spillway, and a grade stake with flagging on it was placed in the hole. When revisited on August 3, the hole had grown to 18 inches diameter and 12 inches deep. It is believed that the hole is caused by topsoil washing into the old stone mill foundation.

d) Toe. The toe was firm, dry, and irregular and overgrown with vegetation on the right side of the spillway. Seepage was found flowing at approximately 5-10 gallons per minute from the old mill sluice that had been previously filled in at the left end of the spillway.

2. Principal Spillway.

a) Approach. The approach was in fair condition. The pond is largely silted in and with the crest of the dam lowered, the stream meanders through the sediments to form a small pool above the spillway.

b) Weir. The weir structure was in poor condition. The height of the dam appears to be the same as it was as it was at the last inspection in 1984. The weir is constructed of cyclopean concrete. Portions of the wall were covered with seepage and moss, ferns, and other small plants. Spalling was observed up to twelve inches in depth on the right side of the spillway, and seepage with various flow rates was found along the entire length of the wall to the right of the spillway. Portions of the wall have failed and debris has collected at the end of the wall on the right side of the downstream slope. Comparison with the 1979 photos documents widespread concrete deterioration.

c) Outlet Channel. The outlet channel is clear. A concrete training wall downstream of the right side of the spillway visible in the 1979 photographs has collapsed.

3. Sluice. The sluice was in fair condition. Minor seepage and efflorescence was observed.

HYDROLOGY AND HYDRAULICS

The drainage area at this site is about 4,130 acres. The pond area at the normal pool is 2 acres with storage of about twelve acre-feet including sediments. At the top of the crest the dam stores sixteen acre-feet. The maximum spillway capacity is about 800 cfs.

DOWNSTREAM HAZARD CLASSIFICATION

The dam is a Class 2, “significant hazard” dam.

JURISDICTION

Since the dam impounds more than 500,000 cubic feet, any alteration, reconstruction or breaching would require prior approval from the Department under provisions of 10 VSA Chapter 43.

Hands Mill Dam, Washington
2001

Spillway. Note vegetation, seepage, and concrete deterioration on walls and rubble in spillway crest.

Spillway from left abutment.

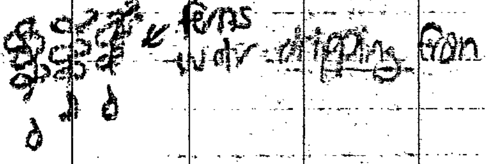
HANDS MILL 8/3/01
RBF
JMV

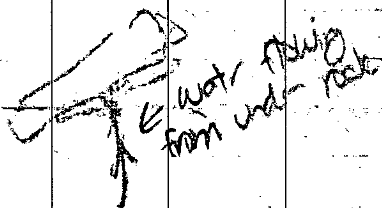
WL = 0.1" below PK nail
set in wood 4x4 in
sp wall

Sinkhole in left about now
18' dia x 12" DEEP
previously noted and
flagged at 4" dia

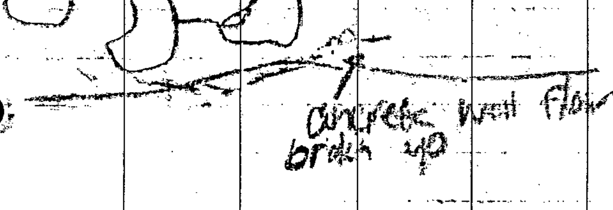
6/20/01
RBF
JMV

Hands Mill dam





right embankment completely
saturated by water (bottom ½)



[illegible]

Spoke to [illegible] Milne,
Westborough Selectman,

He will meet me at the
Town Clerk's Office Today
at 1:30 to [illegible] inspection
of dam

01-31-01

< >22+01 NNN-02AU 183

DOCUMENTS WERE FOUND STUCK TOGETHER

1-31-24

Hawls Mill 6/20 [2001]

Earthen stone RT embankment

Trees up To 12" dbh diameter breast high

heavy brush

cyclopian 1300

cyc cone main mi/me

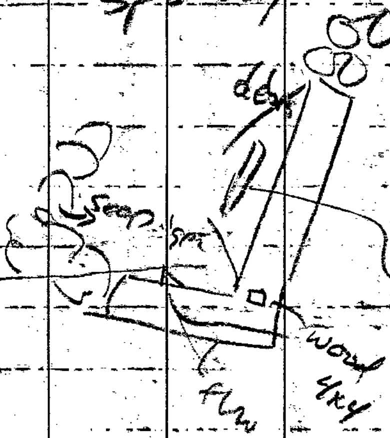
spurway bT fTz

ann jennings

RBF

JMV

PC 80's



cone spalled up To 12" deep

seepage generally

end RT side crest failed

visible d/s wall failed

hole cross hill [illegible]
sticks + flag

old mill sluice filled in
[illegible]

dam sluice 2x Planks u/s

Filename: Document4
Directory:
Template: C:\Documents and Settings\paulak\Application Data\Microsoft\Templates\Normal.dot
Title:
Subject:
Author: Staff
Keywords:
Comments:
Creation Date: 12/9/2004 10:04 AM
Change Number: 1
Last Saved On:
Last Saved By:
Total Editing Time:0 Minutes
Last Printed On: 12/9/2004 10:06 AM
As of Last Complete Printing
Number of Pages: 1
Number of Words: 0 (approx.)
Number of Characters: 4 (approx.)

State of Vermont

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AGENCY OF NATURAL RESOURCES
Department of Environmental Conservation

Dam Safety Section
Facilities Engineering Division
103 South Main Street
Waterbury, VT 05671-0407

Telephone (802) 241-3451
FAX (802) 241-3273
peter.barranco@anrmail.anr.state.vt.us

May 4, 1999

Carol Davis
Town Clerk
2974 VT. Route 110
Washington VT 05675

Re: Hands Mill Dam - Washington

Dear Ms. Davis:

This will confirm our telephone conversation this morning regarding the Department's request to make a routine safety inspection of the Hands Mill Dam this summer under provisions of 10 VSA Section 1105 (copy enclosed). The dam was last inspected by the Department in 1984 and a report sent to the Town.

It is my understanding that you will bring this to the attention of the Selectmen for their consideration. I would appreciate it if you or the Select Board could write me confirming we have the Town's permission to make the inspection. We will let you know in advance of the inspection date in the event someone from the Town would like to accompany us. A report will be prepared following the inspection and a copy will be sent to the Town.

Thank you for your assistance. Please give me a call if you have any questions or we can be of any help.

Sincerely,

A. Peter Barranco, Jr., P.E.
Dam Safety Engineer

Enclosure as noted.

c: Harry K. Roush, Fire Chief, Washington
Larry R. Fitch, P.E., Director, Facilities Engineering

5/4/99
DPD

Hancks Mill Dam — Washington

5/4/99 @ 0900 tel con Harry Rauch (Fire Chief) 241-3584

re: ~~status of dam~~ → still partially breached left side, silted in. Advised plan to inspect this ~~summer~~ — who should we contact?

→ Carol Davis TC @ 883-[illegible] 2218

@ 0920 tel con Carol Davis — OK to do inspection — she will advise Selectmen — Harry Rauch called her already — will send her letter + call again when we have it scheduled (summer sometime).

2974 VT Route 110
Washington VT 05675

7/31/97
ADB

HANDS MILL VT 00308 DEC # 225-1
~~Add to Nat Dam Inv~~
tentative Class 2 (changed from Class 3 - even though silted in until further verified).

USGS 44-B

Lat 44 05 + $\left(\frac{20.3}{37.9}\right)(2.5)$ = 44 06.34
Lon 72 25 + $\left(\frac{8.9}{27.4}\right)(2.5)$ = 72 25.81

dimensions from file - reports

L = 325' (incl. spillway) H = ? 22' SHH
Spillway 68' × 2' (min) cyclo. conc. ? 18' DHS (scale of plan)
DA = 6.45 mi² = 4128 A bot. of conc spill to stream bed?
H 2.4 C = 2.8 @ 2'
3.1 @ 3' Say H = 20' ±

pond shown of old maps
Orig dam c. 1860 SHH says (1980) at least 45 years do
conc. spill c. 1925 (timber spill washed out in 1927 flood)

1972 survey Top of embank - irregular 2'-3' above spillway crest
Call it 2.5' for no overtopping except possible 0.5' at rt. end spill. very approx
Q = (3.0)(68)(2.5)$^{1.5}$ = 806 cfs ≈ 800
(doesn't not include flow through partial breach).

DHS report uses 1025 cfs

VERMONT DAM INVENTORY

Dam name HANDS MILL		State ID	225-1
		National ID	VT00308
Other name		FERC No	0
		Basin No	8
Hydro Fac Name		Basin name WINOOSKI RIVER	
Hydro Fac Owner			
		State Reg Agency	DEC
Town WASHINGTON	County ORANGE	Fed Reg Agency	
Latitude 44- 6.34 Longitude 72-25.81			
River or Stream JAIL BRANCH		Downstream Hazard	2
Nearest City/Town WASHINGTON		Size Category	
Distance Nearest City/Town .00 MI		Hazard subclass	
Owner Name(1) TOWN OF WASHINGTON		Purposes	O
Address WASHINGTON, VT 05675		Year Completed	1860
		Status ABANDONED	
Telephone	Owner type(1) L		
Owner Name(2)		Dam type	RE
Address		Constr type EARTHFILL	
		Dam height	20 FT
Telephone	Owner type(2)	Dam length	325 FT
Non-Fed Dam on Fed Prop N		Maximum storage	16 AF
		Nor storage	12 AF
Orig const date 1860 Purpose MILL POWER			
Design	St Auth NR	Maximum discharge	800 CFS
Recon/Mod 1 date 1928 Purpose CONC SPILLWAY		Surface Area	2 A
Design UNKNOWN	St Auth NR	Drainage area(1)	4130 A
Recon/Mod 2 date 0 Purpose		Drainage Area(2)	6 SQM
Design	St Auth	Reservoir type	A
Dike Type Height 0 FT Length 0 FT		Structural height	20 FT
D/S Haz Stor:Nor 0 AF Max 0 AF		Hydraulic height	20 FT
Prin spill CYCL CONC OVERFALL 68'L X 2.5'D		Hydro fac type	
Design cap 0 CFS	Max cap 800 CFS	Hydro devel date	0
Emer spill NONE		Installed capacity	0 KW
Design cap 0 CFS	Max cap 0 CFS		
		Phase I inspection	N
Plans NO Specs NO	Des. docs NO	Phase I insp date	
Field dwg YES Photos YES	Other SURVEY	Phase I report	
USGS Quad 44-B Corps L-9	VT7420-16-155	Inspection date	11/14/84
Other AP VT-62-H-47-167	Ortho	Inspected by DEC	
Other maps		Authority 10 VSA 1105	
Remark ORIG DAM MAY DATE TO 1860'S. TIMBER SPILLWAY WASHED OUT IN 1927 FLOOD, REPLACED WITH CONCRETE C.1928. POND SILTED-IN. MAY BE CLASS 3.		Emergency action plan	NR
		Last State inspection	1984
		Next State insp due	0
		RECORD	590

7/31/91

7/19/99

Hanks Mill Dam

7/19/99 1415 Don Milne, Selectman of Washington called to say we have Town's permission to proceed. He would like to be there. The town is interested in finding out what they should do with the dam. They're concerned with the condition even though it is rebuilt in.

$\boxed{828\text{-}2241}$ work

Advised we would be glad to have him there and will call in advance. Expect it would be during the first two weeks of August.

VERMONT DEPARTMENT OF WATER RESOURCES

INFORMATION SHEET

Name of Dam Hands Mill Town Washington

Owner Town of Washington Name of Stream Jail Brook

Address Classification

Vermont

U.S.G.S. Coordinates: Lat. 44° ~~3'~~ 6' ~~21"~~ 15" Long. 72° ~~23'~~ 26' ~~54"~~ 0"

U.S.G.S. Map East Barre Aerial Photos VT-62-H 47-166 to 167

U.S.G.S. Elev. @ Spillway

Total Length of Dam 260' Crest Width of Emergency Spillway 60-70'

Width of Top 235' Maximum Height ~~20'~~ 13' check

Spillway Capacity: Principal Emergency ~~3600 cfs~~

Pond Area 2 acres Drainage Area 6.45 sq mi

Pond Volume: Normal Water Level Design High Water Level

Maximum Water Depth: Normal Water Level Design High Water Level

Storage Before Emergency Spillway is Used

Use of Reservoir N/a

Description of Dam: Earth filled with heavy concrete spillway

Description of Spillway(s): Concrete 60-70' wide, 2' below top of dam 3' in 1' downstream 1' in 1' upstream

Designed by Year Built 1928*

Hearing Date Order Date

Additional Remarks: * Concrete section; unknown for rest.

State of Vermont

AGENCY OF ENVIRONMENTAL CONSERVATION

Department of Fish and Game
Department of Forests, Parks, and Recreation
Department of Water Resources & Environmental Engineering
Natural Resources Conservation Council

Montpelier, Vermont 05602
Department of Water Resources
and
Environmental Engineering

(802) 828-2761

November 18, 1984

Ms. Patricia Woodward
Town of Washington
P.O. Box 5
Washington, Vermont 05676

Re: Hands Mill Dam - Washington

Dear Ms. Woodward:

Enclosed is a copy of the Department's 1975 report on the Hands Mill Dam which you requested by telephone on November 14.

The dam has been inspected by the Department in 1950, 1953, 1972, 1973, 1975, 1979 and most recently on November 14, 1984. The latter was a cursory inspection due to snow, ice and stream conditions. The dam is judged to be in very poor condition and deterioration has been noted over the years.

Further failure of the structure could occur duing periods of high inflows, or at other times. Since the pond has very small storage due to the sedimentation, damages due to a failure would be less severe than if the pond was at the original capacity. However, a major failure would undoubtedly damage the road and structures below the dam. Direct threat to loss of life due to discharges associated with a failure of the dam itself, i.e. not considering concurrent flooding from the watershed, is probably low in its present silted-in condition.

The Department recommends that the Town either rehabilitate the dam to an acceptable condition or remove part or all of the spillway to reduce the risk of failure and resulting damages. The latter approach would necessitate an acceptable plan to stabilize sediments behind the dam and prevent their release downstream. Since the dam is or was capable of impounding more than 500,000 cu. ft., prior approval from the Department is needed to reconstruct, alter or breach the dam under provisions of 10 VSA Chapter 43, Dams (copy enclosed).

Should you or other town officials have any questions, please get in touch,

Sincerely,

A. PETER BARRANCO, Jr., P.E.
Dam Safety Engineer

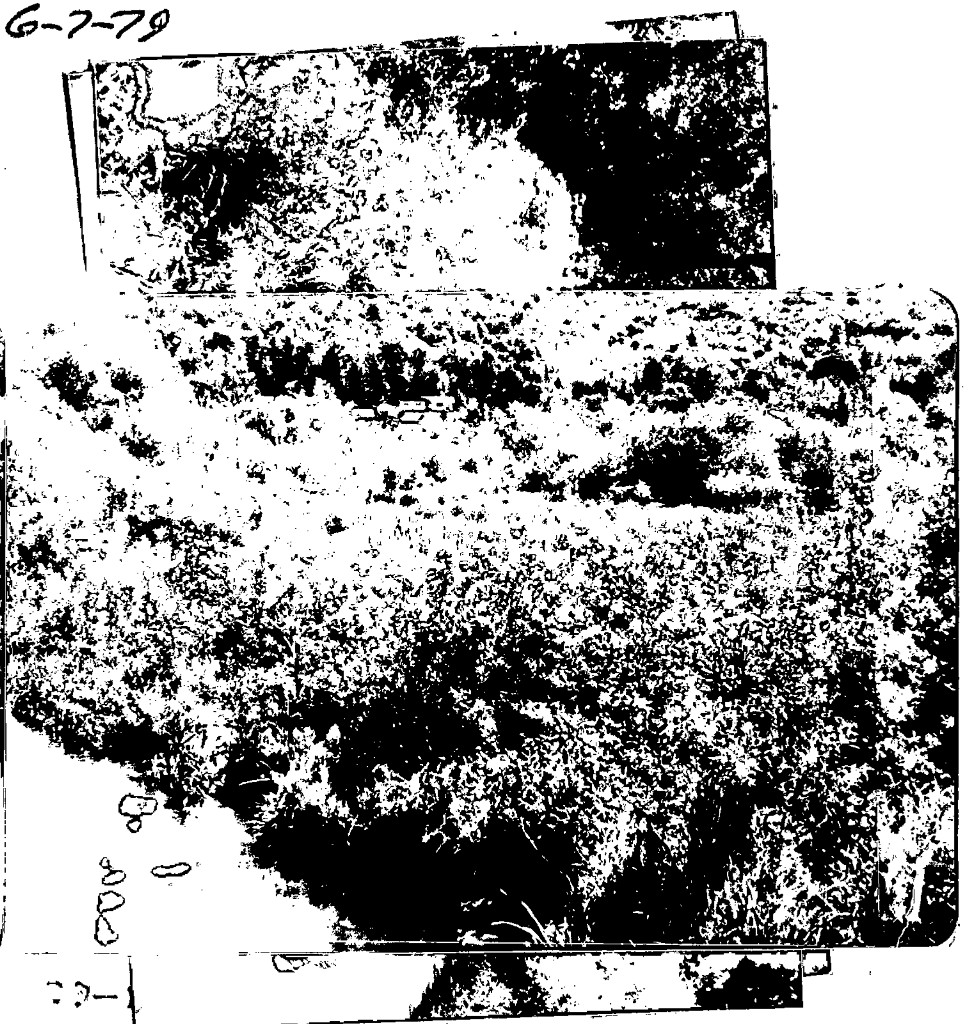
APB:j

cc: Board of Selectman, Town of Washington

encl: (1) 1975 report and transmittal letter
(2) Copy of 10 VSA Chapter 43

HANDS MILL DAM

6-7-79



79-15-21

↑

CREST OF E/F SECTION

LOOKING U/S ① [illegible]

(SILTED IN)

AGENCY OF ENVIRONMENTAL CONSERVATION

MONTPELIER, VERMONT

AGENCY MEMORANDUM

SUBJECT

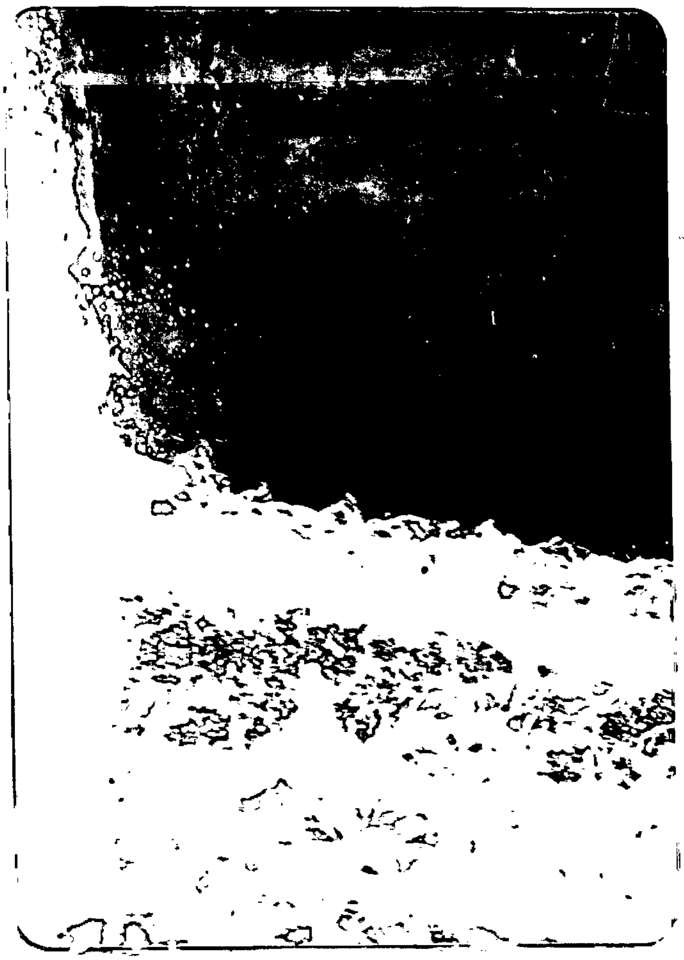
TO:

FROM:

DATE:

H[illegible]IDS MILL DAM
6-7-79

79-15-2[illegible]



79-15-28 WASTE GATE TO RIGHT OF SPILLWAY

APB

AGENCY OF ENVIRONMENTAL CONSERVATION

MONTPELIER, VERMONT

AGENCY MEMORANDUM

SUBJECT

TO:

FROM:

DATE:

HANDS MILL DAM
6-7-79

79-15-30

UNDERMINING @ RIGHT
ABUTMENT OF MAIN
SECTION

APB

AGENCY OF ENVIRONMENTAL CONSERVATION

MONTPELIER, VERMONT

AGENCY MEMORANDUM

SUBJECT

TO:

FROM:

DATE:

NDS MILL DAM

~~Washington~~

79-15-25 25

79-15-31 TAIL RACE IN BASE OF LEFT SIDE
MILL WALL SHOWN PHOTO #25

ARB

AGENCY OF ENVIRONMENTAL CONSERVATION

MONTPELIER, VERMONT

AGENCY MEMORANDUM

SUBJECT

TO:

FROM:

DATE:

[illegible]NDS MILL DAM
Washington
6-7-79

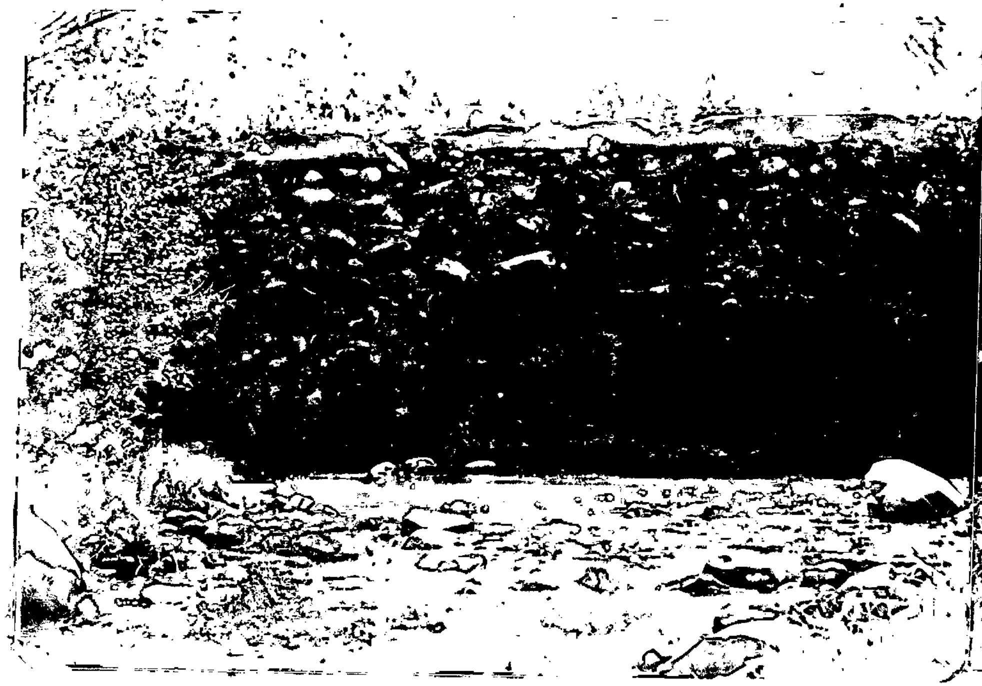
79-15-20

79-15-21 [illegible]: BREACH

[illegible]
LOOKING ALONG U/S [illegible] OF
[illegible]: BREACH TO LEFT OF SPILLWAY

ARC

HANDS MILL DAM 6-2-79



79-15-26

-27

D/S FACE

79-15-18

79-15-19

AGENCY OF ENVIRONMENTAL CONSERVATION

MONTPELIER, VERMONT

AGENCY MEMORANDUM

SUBJECT

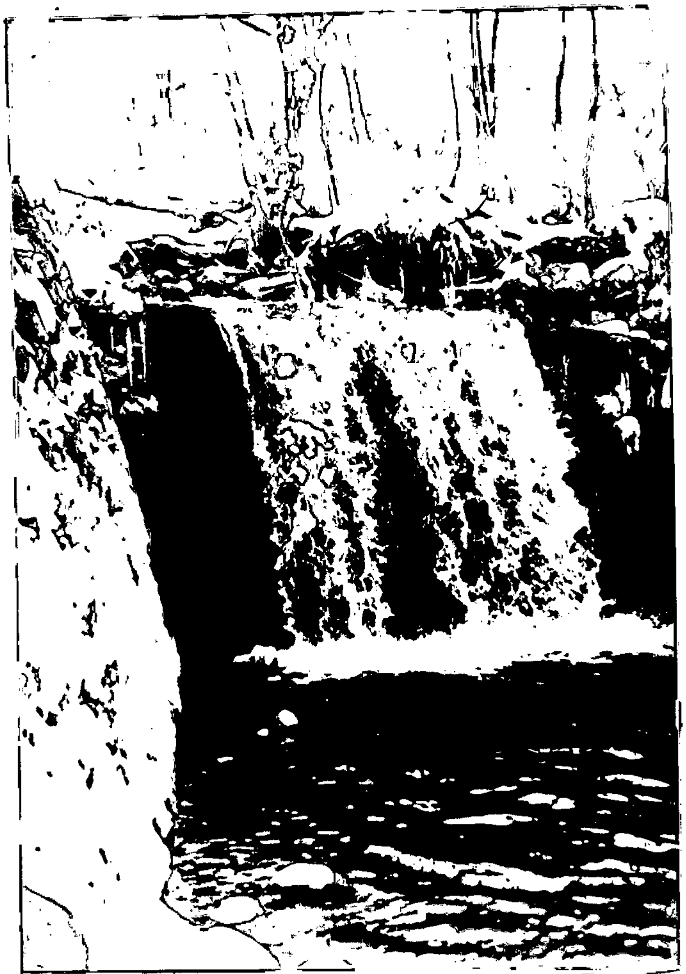
TO:

FROM:

DATE:

H[illegible]DS MILL DAM
11-14-84

84-51-25 ↖



84-51-30 ↑

D/S Face spillway adjacent to breach

84-51-32

APB

SANDS MILL DAM

11-14-84

Left end breach

84-51-23

Looking d/s along right side mill wall and wheel pit structure.

D/S

84-51-24

Collapsed and eroded area at right end and spillway at embankment (right).

APB

HANDS MILL DAM
11-14-84

84-51-21

84-51-22

View of breach to left of spillway

HANDS MILL DAM

11-14-84

8; 51-19 D/s channel

8; 51-20 "Reservoir" as viewed from crest of dam on R/s spillway near breach – looking U/s.

APB

HANDS MILL DAM

11-14-84

84-51-17

→D/s

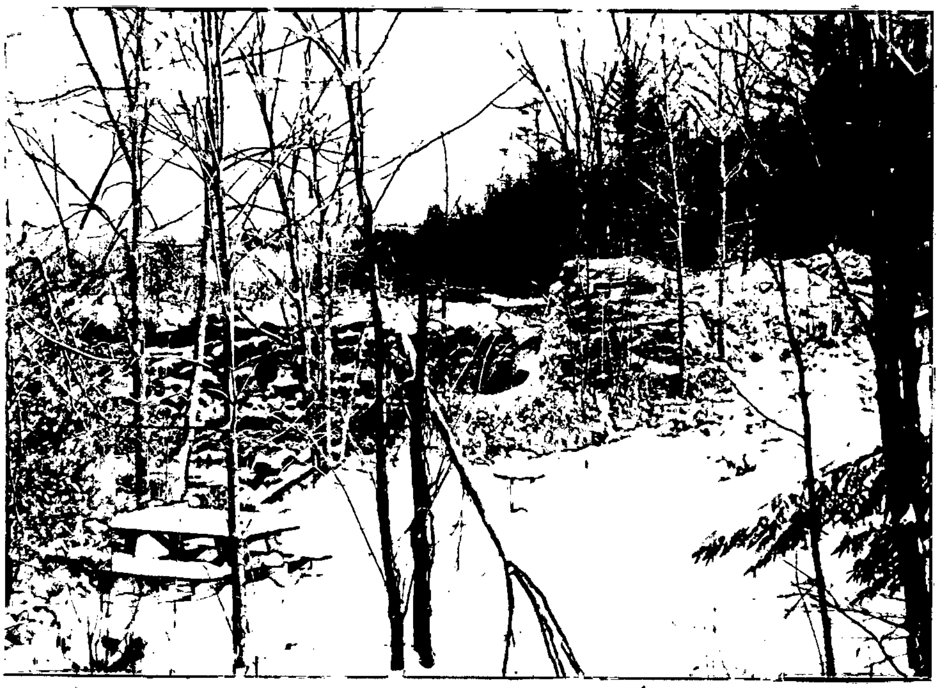
84-51-18

Crest and d/s slope near right abutment.

APB

HA[illegible]S MILL DAM

11-14-84



← left embankment

84-51-34 ↑ spillway

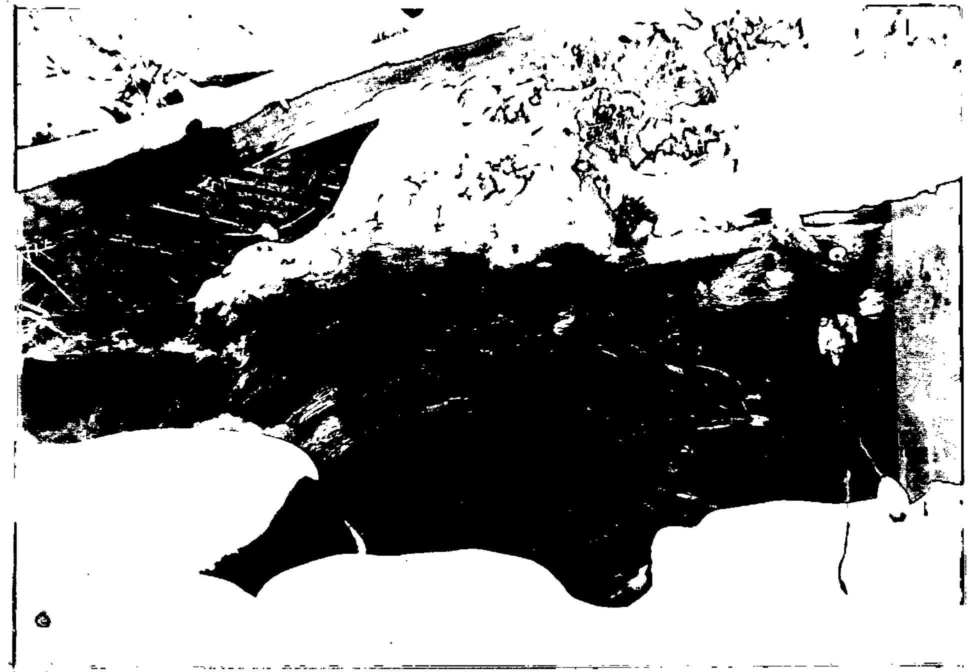
↑ Structure or chamber for wheel (?)

84-51-35 Left embankment and wheel chamber (?)

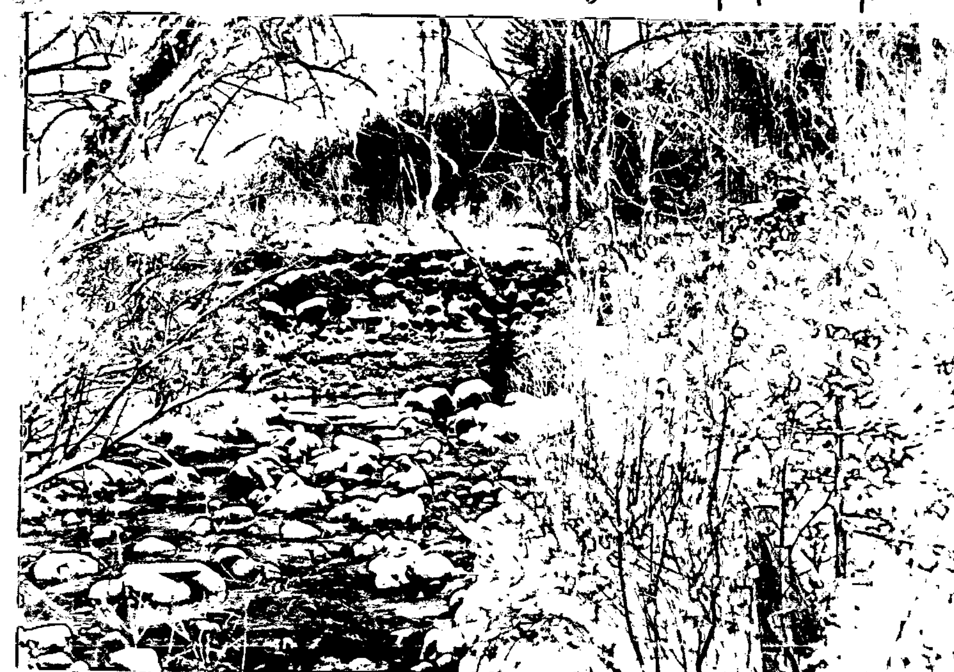
APB

HANDS MILL DAM
11-14-84

84-51-31 Remnants of wall at right end spillway and embankment



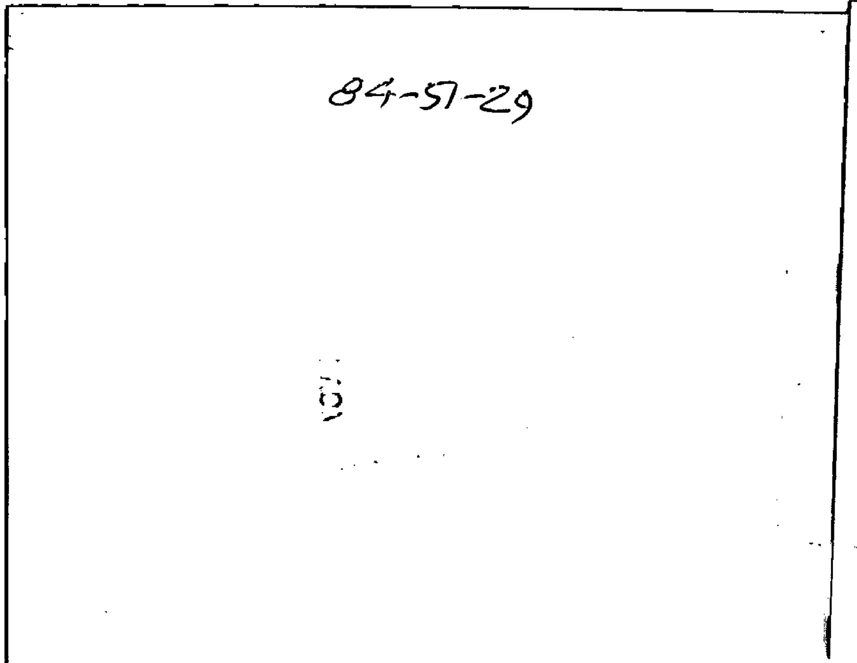
84-51-36 Breach at left end of spillway.



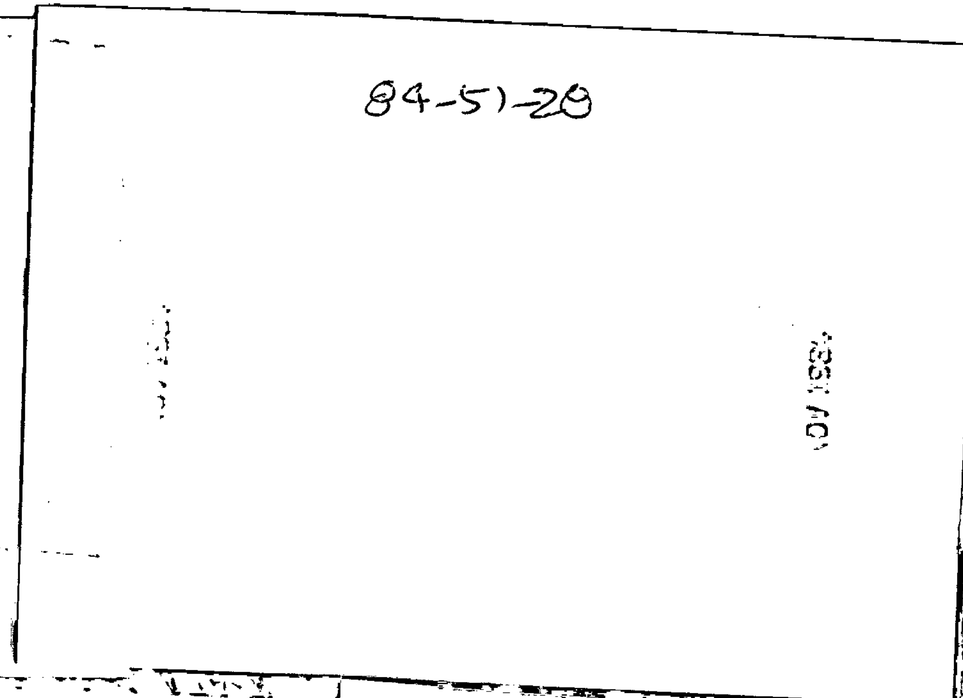
84-51-33

APB

HANDS MILL DAM
11-14-84



84-51-29



84-51-28

84-51-26

84-51-27

84-51-28 & 29

D/S Face of right embankment. Note dry boulder wall containing embankment along part of d/s face.

AFS

Wed 11-14-84 APS
35° clear, windy, 4"± snow
Hands Mill Dam on ground

1350 – 1430 inspected dam.

Cursory inspection due to snow, ice and water conditions.

Rt. Embankment: Crest & u/s slope – brush; d/s slope + toe brush, trees up to 18" including large snag; d/s wall intact but irregular and bulging (may be the way constructed – large boulders – not cut stone).

Lt. Embankment. Too much snow to inspect. Brush.

Spillway: d/s face; seepage, deeply eroded, crumbling; cyclopean concrete; crest snow covered.

(OVER)

Hands Mill Dam p. 2
11-14-84

Left spillway abut. - breach looks about the same - est. 0.5' water through breach.

Right Spillway abut.: Appear to be further erosion + movement of remnants of abut. wall. Depression in "silt" on U/S side wall in this area - probably passes water at high pond levels or is result of piping.

Overall in very poor condition. Only apparent change is further erosion / undermining at right abutment of spillway.

Photos

DIETZGEN NO. 386-5

3-10-80
[illegible]

HANDS MILL DAM

$$GP = 44\ 05 + \left(\frac{1.50}{5.82}\right)(5) = 44\ 06.29$$

$$72\ 25 + \left(\frac{0.70}{4.19}\right)(5) = 72\ 25.84$$

SA = 2 A

MAX vol = 20 X .4 X 2 = 16 AF (silted in)

NW = 16 - 4 = 12 AF (silted in)

Air photos — VT-62-H 47-167

VT 7420 16-155

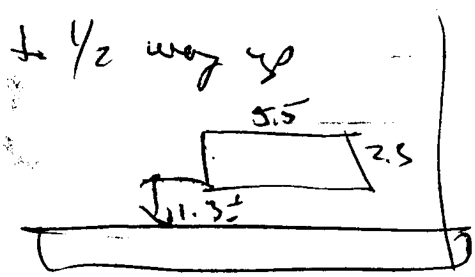
225-1 Harris Mill — Washington 6-7-79 AMB

— leakage base (gate chamber) (wheel pit?
— partially breached left end (may have been old ~~spillway~~ headworks)
— d/s face eroded — cyclopean concrete
— sand silted in
— right abut — undermined
— stable

pot. { — 3sty FH ½ up dam = ½ up 1st floor — left side before breach
2 " " — d/s below long probably old

gunite no storage

— repair entire length d/s face from toe to 1/2 way up



repair through old tail race

11-12-75

HANDS MILL DAM

"HANDS MILL DAM - WASHINGTON
(BREACH' AT LEFT END OF SPILLWAY.
W/L IS 2.3' BELOW THE CREST
OF THE SPILLWAY.
11-12-75 DON SPIES "

ROUTING

GENERAL

DES

dm 6/27/75

ae 6/27

JFC JBC

SUSPEND TO

FILE Hand's Mill Dam

MANAGEMENT & ENGINEERING DIVISION

June 25, 1975

Chairman, Board of Selectmen
Washington
Vermont 05675

Gentlemen:

The Department of Water Resources is pleased to present you with a copy of its recently completed report on Hand's Mill Dam in Washington.

Essentially, the investigation found the dam to be in a further deteriorated condition since our previous visit. Your attention is invited to the recommendations contained within the report.

We are, of course, available to meet with you and welcome any comments you may have.

Sincerely yours,

Andre J. [illegible]
Assistant Director

AJR/jcf
cc: Catherine Bothell, Water Resources Board

Agency of Environmental Conservation
Department of Water Resources
Management & Engineering Division
June, 1975

INSPECTION REPORT

on

HAND'S MILL DAM
Washington, Vermont

Owner	Town of Washington
Date Built	Prior to 1927 (original construction) 1928 (partial reconstruction)
Type of Structure	Earth fill flanking a concrete gravity spillway
Watershed Area	6.45 square miles
Probable Spillway Capacity	1,025 cfs (no freeboard)
Peak Flood Inflow Used In Analysis	715 cfs (100-year frequency)

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HAND'S MILL DAM

I. INTRODUCTION

Vermont has a long history of major floods during which loss of life and considerable property damage has occurred. The failure of dams has added materially to the peak flood flows and related losses. Basically, many of these failures are a result of either inadequate spillways; improper design and/or construction; or improper or insufficient maintenance.

Under Chapter 43, Title 10, Vermont Statutes Annotated, the Water Resources Board has jurisdiction over all dams impounding more than 500,000 cubic feet of water and not incident to the generation of electric energy for public use. The Department of Water Resources assists the Board by conducting a continuing program of inspection and investigation of existing statute-size dams. These investigations serve as a means of obtaining up-to-date information on existing dams, particularly with regards to their maintenance and their safety. As part of this program, an examination was made of the Hand's Mill Dam.

II. PURPOSE

1. To summarize the findings from the Department's investigation of the Hand's Mill Dam in the Town of Washington, Orange County, State of Vermont.

2. To report on the present condition of the structure and on the adequacy of its maintenance.

3. To determine the capacity of the spillway and evaluate its ability to pass reasonable flood flows.

(Continued)

4. To recommend appropriate action to be taken with regards to any flood hazards associated with the existing structure.

5. To recommend necessary repairs and alterations.

III. SCOPE

The scope of this investigation included a topographic survey and visual inspection of the structure on June 19 and 20, 1972. Additional inspections were made on July 17, 1973 and April 23, 1975. Office studies of the spillway capacity and the ability of the structure to pass flood flows were conducted. The summarization of the various findings have been incorporated into this report.

IV. WATERSHED DESCRIPTION

The watershed above Hand's Mill Dam has a drainage area of approximately 6.45 Square miles (see Appendix 1) and can be divided into two sub-basins—one for the Jail Branch and one for a tributary with its confluence at Hand's Mill Pond. The Jail Branch starts in the southeastern corner of the watershed and drops more than 1,050 feet before reaching the pond; this sub-basin is basically oval-shaped with its major axis oriented along an approximate northwest-to-southeast line. The other stream begins in the northeastern corner of the watershed and has a drop of about 1,075 feet before reaching the pond; this sub-basin is roughly rectangular in shape with its major axis along an approximate northeast-to southwest line. Both streams have steep gradients. The watershed terrains are predominantly hilly and about evenly divided between farm land and forest cover. There are no significant bodies of water above the site.

(Continued)

V. SITE DESCRIPTION

Hand's Mill Pond is an artificial impoundment located on the Jail Branch in the southeast corner of the Village of Washington. The pond has a surface area of approximately two acres and is roughly circular in shape. At the present, the pond is almost entirely silted in. The only apparent purpose the pond now serves is as a home to some waterfowl and beavers.

VI. STRUCTURE

A. DESCRIPTION

Hand's Mill Dam consists of a concrete gravity section, which serves as the spillway, and flanking earth embankment sections. Portions of the embankments adjacent to the spillway are backfilled against dry stone walls which form the downstream face.

Little is known about the history of this dam. It is known a mill existed at the site as early as 1866; since the mill ran on water power, it is assumed there was a mill pond and dam. The concrete section was built after 1927, its timber predecessor having been destroyed during the flood of November in that year.

B. CONDITION

The east embankment is overgrown with trees and brush and also appears to have insufficient cross-section. The west embankment has small brush on its downstream face. No seepage was noted along the embankment sections.

The concrete is badly deteriorated. The downstream face is severely spalled, and there is seepage through much of the section. The downstream

(Continued)

abutment wall at the east end of the spillway has collapsed but doesn't appear to have weakened the spillway. At the west end, a section of the abutment has collapsed allowing water to pass around the end of the spillway. This section has gradually increased in size over the years. The owner of the dam has dumped granite grout on the adjacent embankment to reduce the erosion.

The dam is in poor condition, but it does not appear to be in immediate danger of failing.

C. SPILLWAY ANALYSIS

1. Hydraulic

The existing conditions were analyzed by considering the eroded section as a spillway section. The eroded area was treated as a broad-crested spillway, and the spillway was treated as a sharp-crested weir. With the water level approximately up to the low section of the embankment, the combined flow through the spillway area is approximately 1,025 cubic feet per second (cfs).

2. Hydrologic

Flows of the Hand's Mill Dam were determined from the records of an adjoining gaged watershed. A 100-year-return flood at the dam has a peak flow of about 715 cfs. The surcharge storage in the pond is virtually negligible, resulting is little reduction of the peak in-flow; thus, the peak out-flow will be almost identical to the peak in-flow. For the 100-year flood, the peak water level will be less than six inches below the low section of the embankment.

(Continued)

D. CLASSIFICATION

Each dam under the jurisdiction of the Water Resources Board is classed into one of three categories according to the potential amount of downstream damage that particular dam could inflict should it fail. Class I dams are all structures, due to their size and/or location, a failure of which would result in major downstream damage, including the destruction of buildings, major disruption of utilities and/or transportation facilities, or the posbile loss of human life. Class II dams are those due to size and/or location whose failure would result in some downstream damage including damages to buildings and possible disruption of utilities and/or transportation facilities, but would probably not result in the loss of life. Dams in Class III are those, due to size and/or location, whose failure would result in only minor damage.

Below Hand's Mill Dam is a house, Town Highway No. 9 , and Bridge No.29 which could possibly suffer some damage from a failure of the dam. The house is likely to be limited to minor damage—such as silt and water damage—to the basement and first floor. The highway could suffer erosional damage, particularly the gravel-surface bridge approaches; a severance of the highway would not isolate anyone, but it would force them to go several miles out of their way. The bridge, which has concrete abutments and a cast-in-place concrete deck on steel beams, will probably not suffer any direct damage, but it could become plugged with debris. Therefore, Hand's Mill Dam is classified as a Class II Dam.

VII. RECOMMENDATIONS

Due to the present condition and the continuing deterioration, it is

(Continued)

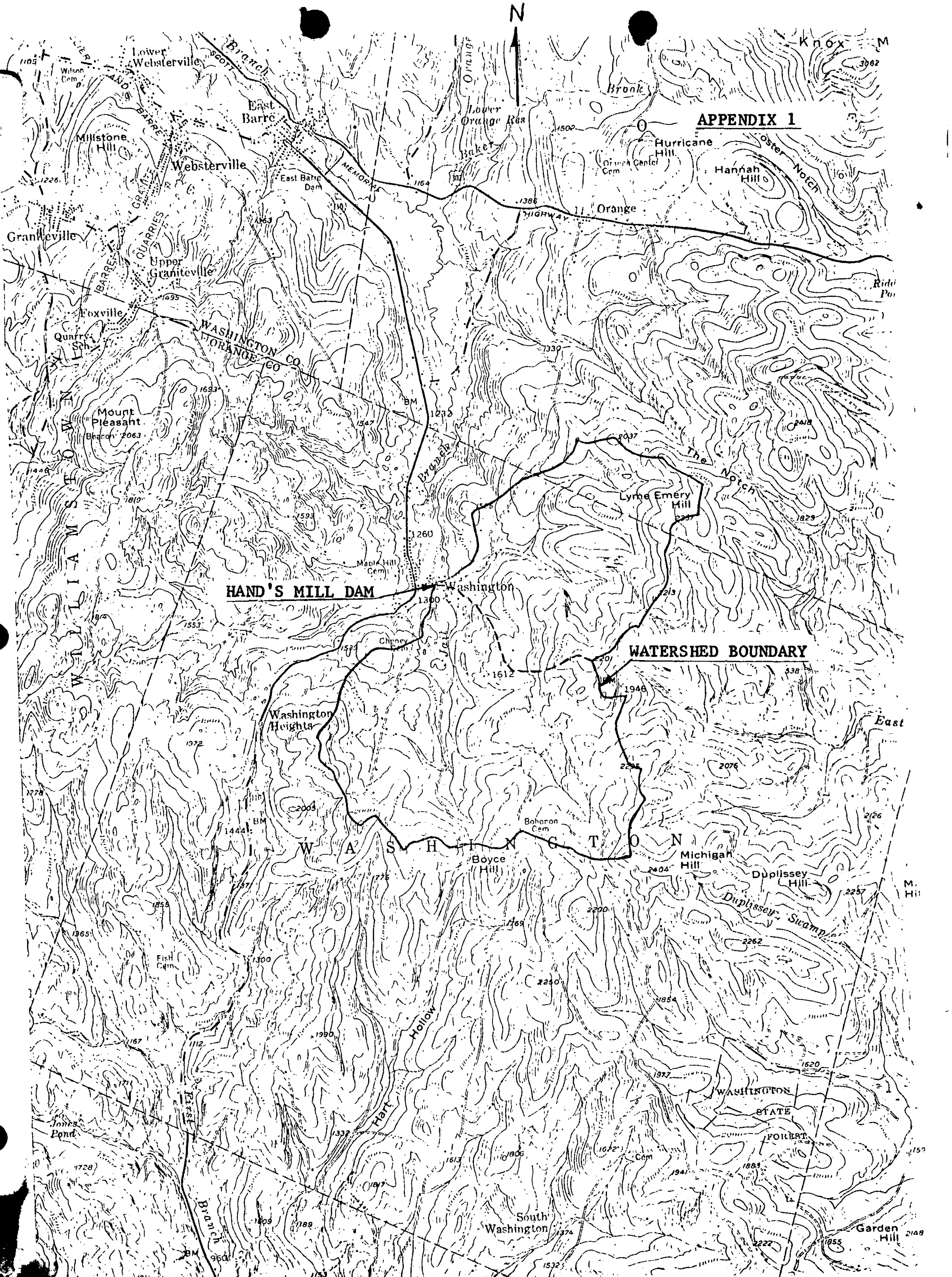
recommended that the concrete spillway be removed. The Town through its Selectmen should prepare a program suitable to the Department of Water Resources for removal of the spillway and removal and/or stabilization of the sediment in the pond.

VIII. SELECTED REFERENCES

1) "Design Of Small Dams", Bureau of Reclamation, 1973.

IX. APPENDICES

1) Watershed Map.
2) Location Map.
3) Photographs.
4) Plans.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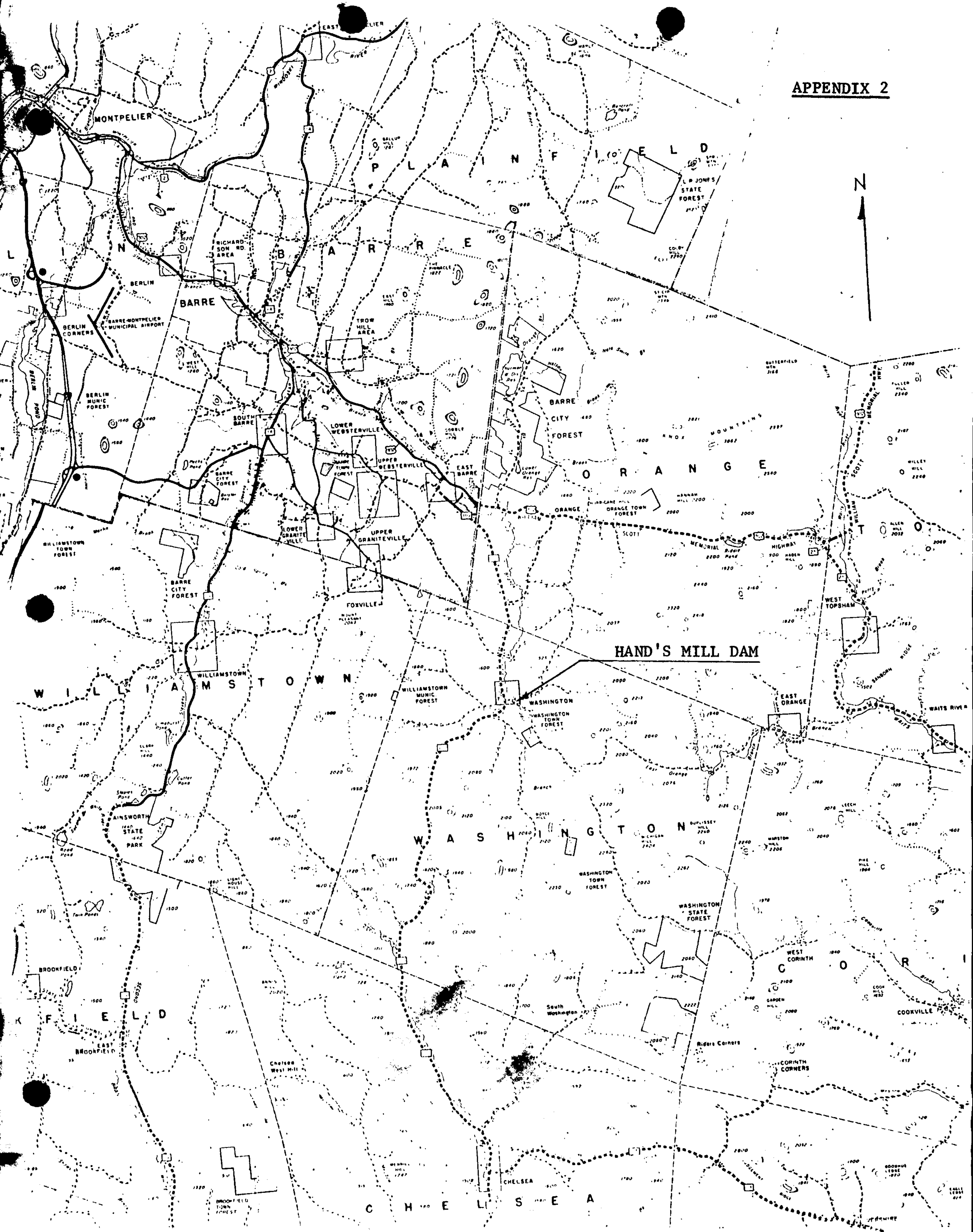
APPENDIX 1
HAND'S MILL DAM
WATERSHED BOUNDARY
Lower Websterville
East Barre
Millstone Hill
Websterville
Graniteville
Upper Graniteville
Foxville
Quarry Sch
WASHINGTON CO
ORANGE CO
Mount Pleasant
Lower Orange Res
Hurricane Hill
Hannah Hill
Orange
Lyme Emery Hill
The Notch
Washington
Washington Heights
Cherry Cem
Maple Hill Cem
Boyce Hill
Michigan Hill
Duplissey Hill
Duplissey Swamp
WASHINGTON
WILLIAMSTOWN
Hart Hollow
First Branch
Jones Pond
South Washington
WASHINGTON STATE FOREST
Garden Hill
Fish Cem
MEMORIAL HIGHWAY
Knox

APPENDIX 2



N
HAND'S MILL DAM
MONTPELIER
EAST MONTPELIER
P L A I N F I E L D
L.P. JONES STATE FOREST
B A R R E
RICHARDSON RD. AREA
BERLIN
BARRE
BARRE-MONTPELIER MUNICIPAL AIRPORT
BERLIN CORNERS
TROW HILL AREA
BERLIN POND
BERLIN MUNIC FOREST
SOUTH BARRE
LOWER WEBSTERVILLE
UPPER WEBSTERVILLE
EAST BARRE
BARRE CITY FOREST
K N O X M O U N T A I N S
O R A N G E
ORANGE
ORANGE TOWN FOREST
SCOTT MEMORIAL HIGHWAY
LOWER GRANITEVILLE
UPPER GRANITEVILLE
WILLIAMSTOWN TOWN FOREST
FOXVILLE
WEST TOPSHAM
WILLIAMSTOWN
W I L L I A M S T O W N
WILLIAMSTOWN MUNIC FOREST
WASHINGTON
WASHINGTON TOWN FOREST
EAST ORANGE
WAITS RIVER
AINSWORTH STATE PARK
W A S H I N G T O N
WASHINGTON STATE FOREST
WEST CORINTH
C O R
BROOKFIELD
F I E L D
EAST BROOKFIELD
South Washington
Riders Corners
COOKVILLE
CORINTH CORNERS
Chelsea West Hill
CHELSEA
C H E L S E A
BROOKFIELD TOWN FOREST

HAND'S MILL DAM

Looking across spillway toward east embankment

Upstream face of west embankment

Downstream face of spillway

The undersigned representatives of the U.S. Army Corps of Engineers, New England Division visually inspected the ________________ Dam on ____________________ 1973 between the hours of ________, and __________. On the basis of visual observations, the following comments are made:

____

____

____

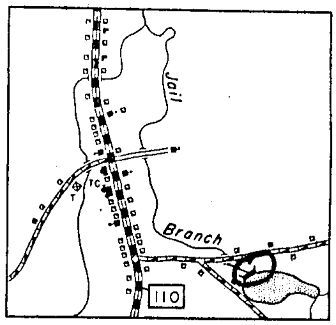
CF:
(Town Official):
Vt. Water Resources Board
Coordinator, COE
Dam Inspection Team
Mr. E. P. Gould

Location: Town of ________________, County of ____________, State of Vermont
Stream:
Map Coords.:
Other:

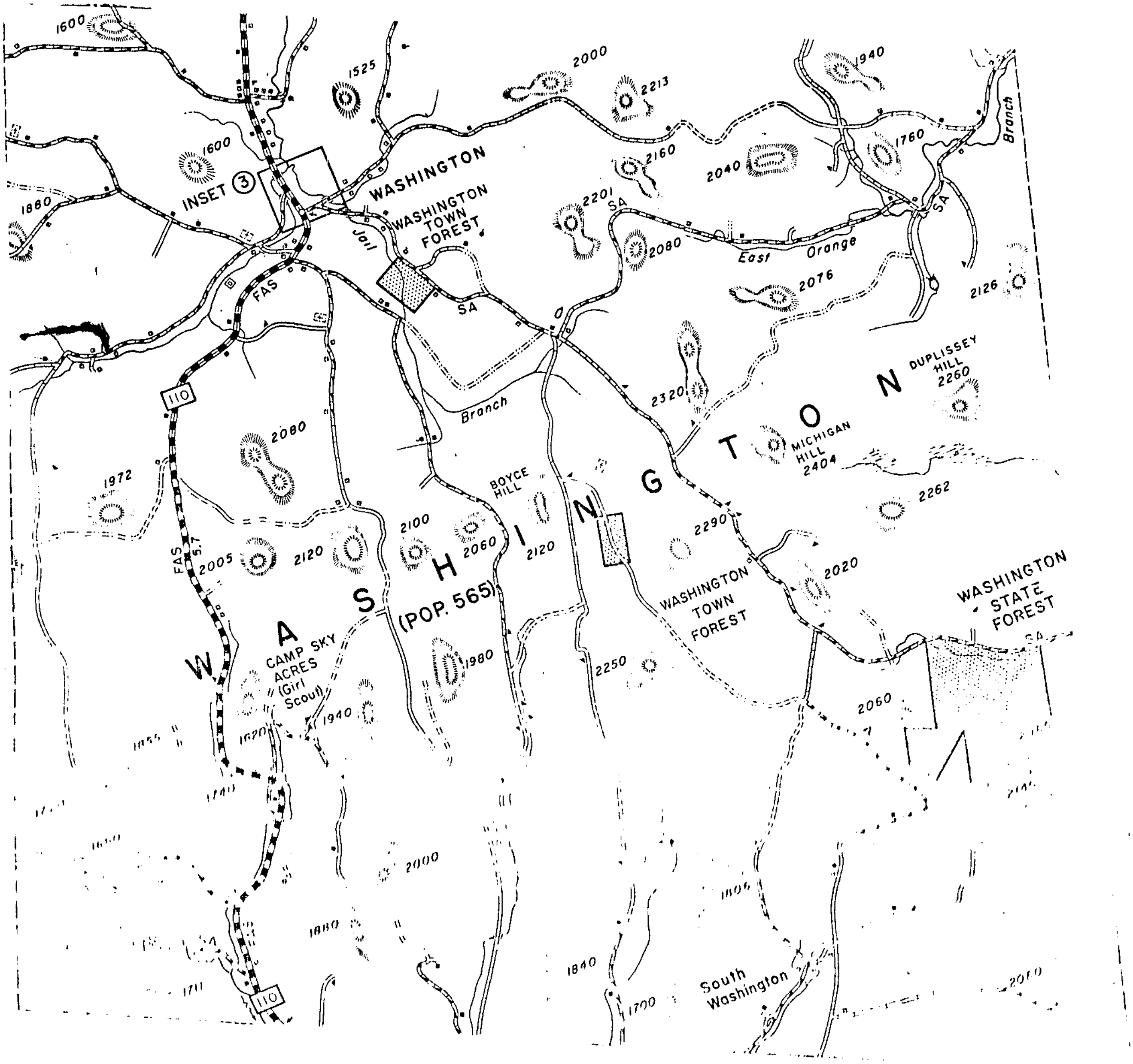
Owner:
Function of Dam:

JULY 17, 1973

Photos taken during damaged survey inspection by DWR & COE following 1973 flood.



INSET (3)
WASHINGTON
SCALE



Hand's Mill Dam
Washington

6-19-92 Warm Overcast

Π Don Spies
N Jim Hu[illegible]
Ø Jim Thom[illegible]

6-20-92 Warm Overcast

Π DHS
N JH
Ø JT

COPY

DIETZGEN NO. [illegible]

Sta.	Rod Reading	Stadia Interval	Distance	Horiz. ∠	Vert. ∠
	(BS)	(H.I.)			
BM #1	1.50	101.50			
BM #1	1.50	0.53	53	39°-24'	-
1	3.00	0.69	69	18°-5'	-
2	3.18	0.61	61	2°-14'	-
3	7.07	0.60	60	353°-48'	-
4	4.56	0.33	33	15°-21.5'	-
5	4.57	0.32	32	14°-56'	-
6	7.72	0.39	39	348°-46'	-
7	4.97	0.22	22	348°-46'	-
8	5.41	0.19	19	320°-33'	-
9	7.50	0.22	22	320°-33'	-
10	4.65	0.07	7	320°-33'	-
11	4.99	0.13	13	292°-48'	-
12	5.17	0.27	27	271°-8'	-
13	5.47	0.28	28	283°-43'	-
14	7.43	0.32	32	289°-43'	-
15	7.68	0.35	35	289°-43'	-
16	5.60	0.32	32	281°-0'	-
17	7.22	0.38	38	281°-0'	-
18	7.71	0.42	42	281°-0'	-
19	5.35	0.34	34	273°-10'	-
20	7.74	0.48	48	273°-10'	-
21	5.54	0.43	43	263°-13'	-

Elev. 0° 0' = S 21° 30' E ([illegible])

100.00	X chiseled in peak outcrop on east side of road
100.00	
98.57	1 edge of road
98.32	2 edge of road
94.13	3 bottom of bank
96.94	4 edge of road
96.93	5 top of bank
93.78	6 bottom of bank
[illegible]	7 top of bank
96.02	8 top of bank
94.00	9 edge of water
96.[illegible]	10 ℄ of dam
96.[illegible]	11 ℄ of dam
[illegible]	12 ℄ of dam
96.03	13 top of bank
94.07	14 bottom of bank
93.86	15 edge of water
95.80	16 top of bank
94.28	17 bottom of bank
93.79	18 edge of water
96.15	19 top of bank
93.76	20 edge of water
95.36	21 top of bank

Sta.	Rod Reading	Stadia Interval	Distance	Horiz. ∠	Verti ∠
22	9.06	0.52	52	263°-13'	-
23	5.98	0.48	48	261°-0'	-
24	6.43	0.53	53	257°-24'	-
25	6.04	0.47	47	257°-24'	-
26	6.12	0.36	36	259°-36'	-
27	5.56	0.33	33	259°-36'	-
28	8.26	0.33	33	251°-5'	-
29	5.92	0.14	14	252°-0'	-
30	5.10	0.06	6	249°-33'	-
31	5.53	0.06	6	125°-0'	-
32	6.39	0.13	13	126°-53'	-
33	7.92	0.29	29	145°-11'	-
34	8.05	0.31	31	141°-32'	-
35	7.90	0.45	45	116°-54'	-
36	5.05	0.10	10	30°-30'	-
37	8.23	0.12	12	208°-52'	-
38	10.78	0.18	18	176°-8'	-
39	12.02	0.24	24	206°-36'	-
40	12.47	0.29	29	203°-41'	-
41	11.55	0.26	26	187°-0'	-
42	9.16	0.23	23	154°-33'	-
43	7.53	0.13	13	151°-49'	-
44	9.68	0.23	23	245°-47'	-
45	10.49	0.26	26	229°-13'	-

Elev.	$0° 0'$ = mag S 21° 30' E	
[illegible]	22	[illegible]
95.[illegible]	23	top of bank
95.07	24	top of bank
95.[illegible]	25	top of bank
[illegible]	26	top of bank
[illegible]	27	top of bank
93.24	28	bank
95.5[illegible]	29	top of bank
96.1[illegible]	30	top of bank
95.97	31	top of bank
[illegible]	32	top of bank
[illegible].58	33	top of bank
93.45	34	edge of road
93.65	35	edge of road
96.45	36	℄ of dam
93.2[illegible]	37	bank
90.22	38	bottom of bank
89.[illegible]	39	bottom of bank
89.03	40	bank
89.95	41	bank
92.34	42	bank
[illegible]	43	bank
[illegible]	44	bank
[illegible]	45	bank

Sta.	Rod Reading	Stadia Interval	Distance	Horiz. ∠	Vert. ∠
	(BS)	(H.I.)			
BM #1	1.09	101.09			
BM #1	1.09	0.88	88	58°-3'	-
1	4.61	0.40	40	81°-42'	-
2	9.43	0.07	7	197°-38'	-
3	7.55	0.12	12	135°-3'	-
4	8.64	0.15	15	[illegible]°-15'	-
5	9.70	0.29	29	207°-23'	-
6	6.38	0.42	42	200°-48'	-
~~7~~	~~14.00~~	~~0.19~~		~~162°-[illegible]~~	~~[illegible]~~
8	12.63	0.33	32	202°-29'	-8°-17'
9	14.51	0.19	19	16[illegible]°-34'	2°-39'
10	8.39	0.17	17	246°-36'	-
11	8.95	0.14	14	228°-35'	-
12	8.88	0.27	27	234°-26'	-
13	8.68	0.22	22	251°-8'	-
14	11.44	0.24	24	250°-47'	-
15	7.13	0.26	26	276°-15'	-
16	8.73	0.22	22	272°-0'	-
17	10.93	0.25	25	269°-25'	-
18	6.99	0.51	51	278°-0'	-
19	6.99	0.88	88	278°-44'	-
20	6.98	0.90	90	280°-14'	-
21	4.84	0.92	92	280°-[illegible]'	-

Elev. 0°-0' = mag S 21°-30'E

100.00

100.00

[illegible]	1	1st setup [illegible]
91.66	2	bottom of bank
93.59	3	top [illegible] wall
92.45	4	top stone wall
[illegible]	5	[illegible]
94.71	6	[illegible]
	~~7~~	~~bottom [illegible]~~
83.75	8	bottom corner
85.70	9	bottom [illegible] wall
92.[illegible]	10	bottom of bank
92.14	11	bottom of bank
92.21	12	end of bank
92.[illegible]	13	end of bank
[illegible]	14	top concrete, outside edge (downstream)
93.94	15	top concrete, outside edge (downstream)
92.36	16	top concrete, outside edge (downstream)
90.16	17	top concrete, outside edge (downstream)
91.10	18	top ~~spillway~~, outside edge (downstream)
9[illegible]	19	top spillway, outside edge (downstream)
9[illegible]	20	top spillway, outside edge (downstream)
91.25	21	top of ~~[illegible]~~ abutment

Note: width top of spillway = 2.75'

Sta.	Rod Reading	Stadia Interval	Distance	Horiz. ∠	Vert. ∠
22	14.00	0.88	87	27[illegible]° 4'	4°-57'
23	14.00	0.76	75	274°-31'	5°-28'
24	14.03	0.50	49	274°-6'	9°-28'
25	14.50	0.26	24	260°-10'	16°-41'
	(B.S.)	(H.I.)			
BM #1	2.41	102.41			
BM #1	2.41	1.87	187	82°-46'	–
1	5.92	1.54	154	96°-32'	–
2	6.25	0.19	19	113°-58'	–
3	5.41	0.16	16	113°-58'	–
4	7.85	0.16	16	99°-22'	–
5	8.52	0.17	17	89°-40'	–
6	7.18	0.15	15	137°-36'	–
7	10.66	(0.24) 0.34	(24) 34	150°-9'	–
8	13.38	0.26	26	156°-6'	–
9	9.19	0.08	8	30°-36'	–
10	6.13	0.09	9	193°-6'	–
11	8.42	0.15	15	196°-47'	–
12	14.40	0.16	16	196°-47'	–
13	4.68	0.07	7	281°-40'	–
14	9.38	0.25	25	308-43'	–
15	4.90	0.23	23	289°-17'	–
16	5.92	0.25	25	27[illegible]°-6'	–

0° 0' = mag S 21° 30' E

80.84	22	[illegible] spillway wall
79.52	23	bottom spillway wall
78.95	24	bottom spillway wall
79.44	25	bottom spillway wall
140.00		
140.00		
96.49	1	1st setup point
96.14	2	top abutment
[illegible]	3	℄ dam
[illegible]6	4	bottom of bank
93.[illegible]	5	edge of water
[illegible]	6	bank
[illegible]	7	top stone wall [illegible]
82.03	8	bottom stone wall, [illegible]
93.22	9	edge of water
96.25	10	bank
[illegible]	11	top stone wall
[illegible]	12	bottom stone wall
92.73	13	℄ of dam
93.03	14	edge of water
[illegible]	15	℄ of dam
96.49	16	bank

Sta.	Rod Reading	Stadia Interval	Distance	Horiz ∡	Vert ∡
17	14.81	0.29	29	166°-0'	-
18	14.58	0.22	22	201°-0'	-
		6-20-72			
	(B.S.)	(H.I.)			
BM #1	2.49	102.49			
BM #1	2.49	1.88	188	61°-18'	-
1	6.92	1.09	109	103°-49'	-
2	8.23	1.01	101	98°-9'	-
BM #2	6.32	0.19	19	89°-51'	-
	(B.S.)	(H.I.)			
BM #2	7.23	103.40			
BM #2	7.23	0.44	44	89°-36'	-
1	5.19	0.24	24	90°-5[illegible]'	-
2	7.55	0.11	11	161°-31'	-
3	12.79	0.11	11	167° 31'	-
4	8.66	0.28	28	286°-22'	-
5	4.60	0.27	27	272°-26'	-
6	7.40	0.28	28	254°-56'	-
7	11.65	0.29	29	239°-37'	-
8	13.23	0.33	33	229° 24'	-

Elev. 0° 0' = mag S 21° 30' E

87.14	17	in field
87.88	18	in field

0° 0' = mag S

100.00		
100.00		
95.57	1	[illegible]
94.26	2	[illegible]
96.17		top [illegible] of earth fi
96.17		
96.17		
98.21	1	3rd [illegible] point
95.85	2	top stone wall
90.61	3	bottom stone wall
94.74	4	edge of [illegible]
98.80	5	℄ of dam
96.00	6	bank
91.75	7	bottom of bank
90.11	8	in field

Sta.	Rod Reading	Stadia Interval	Distance	Horiz. ∡	Vert. ∡
9	14.52	0.24	24	168°-14'	—
10	7.35	0.17	17	24[illegible]° [illegible]'	—
11	9.98	0.17	17	2[illegible]°-18'	—
	(B.S.)	(H.I.)			
~~BM #2~~	~~6.59~~				
~~BM #2~~	~~6.59~~	~~1.18~~		~~93°-22'~~	—
	(B.S.)	(H.I.)			
BM #2	6.27	102.44			
BM #2	6.27	1.18	118	93°-25'	—
1	4.96	0.74	74	95°-23'	—
2	9.44	0.31	31	86°-13'	—
3	4.92	0.29	29	100°-29'	—
4	8.21	0.28	28	113°-53'	—
5	11.91	0.30	30	127°-49'	—
6	12.79	0.32	32	135°-20'	—
7	8.69	0.10	10	37°-29'	—
8	8.26	0.08	8	46°-28'	—
9	4.83	0.08	8	100°-58'	—
10	7.50	0.07	7	155°-29'	—
11	10.95	0.11	11	166°-7'	—
12	11.69	0.17	17	170°-14'	—

Elev. 0° 0' - Ma... S

88.88	9	in field
96.05	10	end of wall top
93.12	11	end of wall bottom
96.17		
96.17		
97.48	1	4th setup point
92.00	2	edge of water
97.52	3	℄ of dam
94.25	4	bank
90.58	5	bottom of bank
39.15	6	in field
93.75	7	edge of water
94.13	8	bottom of bank
97.61	9	℄ of dam
94.44	10	bank
91.49	11	bottom of bank
90.75	12	in field

Sta.	Rod Reading	Stadia Interval	Distance	Horiz. ∠	Vert. ∠
13	8.68	0.25	25	327°-32'	—
14	8.40	0.20	20	302°-1[illegible]'	—
15	4.10	0.18	18	274°-44'	—
16	6.13	0.20	20	257°-45'	—
17	9.44	0.23	23	242°-3'	—
18	9.65	0.27	27	233°-4'	—
19	8.70	0.41	41	292°-54'	—
20	7.38	0.39	39	283°-31'	—
21	4.10	0.40	40	271°-27'	—
22	6.36	0.42	42	255°-0'	—
23	7.87	0.42	42	247°-24'	—
24	4.36	0.49	49	272°-37'	—
25	6.48	0.63	63	274°-31'	—
26	8.73	0.43	43	235°-11'	—
27	5.49	0.64	64	24[illegible]°-3[illegible]'	—
28	8.22	0.67	67	292°-44'	—
BM#1	2.46	2.76	2[illegible]6	72°-28'	—

Elev 0° 0' mag S

93.76	13	edge of water
94.04	14	bottom of bank
98.34	15	℄ of dam
96.31	16	bank
93.00	17	bottom of bank
92.99	18	in field
93.44	19	edge of water
95.46	20	bottom of bank
98.31	21	℄ of dam
96.08	22	bank
94.57	23	bottom of bank
99.08	24	℄ of dam
95.96	25	℄ of dam
93.71	26	in field
96.95	27	in field
94.22	28	in mud flat

99.98

Hand's Mill Dam Washington	Spillway Capacity	D. H. Spies	1/2

~~$Q = CLH^{3/2}$ C = 3.50~~

~~$= 3.50(64)(2.0)^{3/2}$ L = 64'~~

~~$= 224(2.83)$ H = 2.0~~

~~$= 634$ cfs.~~

revised 5-16-75 DHS

Drainage Area

1st	2nd	3rd	4th	Average
47.22	53.87	60.41	67.04	6.75
40.47	47.22	53.87	60.41	6.65
6.75	6.65	6.54	6.63	6.54
				6.63
				4 | 26.57
				6.64 sq. in.

1 sq. in. = 0.973 sq. mi.

D.A. = 6.64 (0.973) = 6.45 sq. mi.

WILLIAMSTOWN 7.5 MI.
(BARRE)
WILLIAMSTOWN
Mount Pleasant
First Branch
Washington Heights
WASHINGTON
Hart Hollow
Boyce Hill
South Washington
Jail Branch
Washington
Lyme Emery Hill
The Notch
Michigan Hill
Duplissey Hill
Duplissey Swamp
Washington State Forest
Garden Hill
Marston Hill
West Corinth
East Orange
Leech Hill
Pike Hill
Cook Hill
Sanborn
Hurricane

Hand's Mill Dam

Don Spies
May 16, 1975

Hydrology

Flows at Hand's Mill Dam will be determined from the adjacent East Orange Brook Watershed. The fifty-year and one hundred year peak flows were calaculated for East Orange and transposed to Hand's Mill using the following formula:

$$Q_{at\ site} = Q_{at\ gage} \left(\frac{\text{Drainage Area at Site}}{\text{Drainage Area at Gage}} \right)$$

	Q_{50}	Q_{100}
E. Orange Brook	790	914
Hand's Mill Dam	618	715

Hydraulic

The eroded section will be treated as a broad crested weir with a bottom width of eight feet, crest elevation two lower than the spillway and one end contraction. The spillway will be considered as a sharp crested weir with a crest length of 68' and one end contraction.

flow through eroded area:

$$Q_1 = 2.85 L_1 \left(H_1 + \frac{V_{a_1}^2}{2g}\right)^{3/2}$$

where $L_1 = 8 - 0.1\left(H_1 + \frac{V_{a_1}^2}{2g}\right)$

flow over spillway

$$Q_2 = 3.30 L_2 \left(H_2 + \frac{V_{a_2}^2}{2g}\right)^{3/2}$$

where $L_2 = 68 - 0.1\left(H_2 + \frac{V_{a_2}^2}{2g}\right)$

and $H_2 = H_1 - 2.0$

Table of Stage versus Discharge

H_1	Q_1	Q_2	Total
0	0	0	0
1	30	0	30
2	84	0	84
3	148	259	407
4	221	804	1025

Assuming a straight line relation for discharge between $H_1 = 3'$ and $H_1 = 4'$ then the stage for the 50-year flow is:

$$H_1 = 3 + \frac{618 - 407}{1025 - 407} = 3 + \frac{211}{618} = 3.34'$$ and

for the 100-year flow is:

$$H_1 = 3 + \frac{715 - 407}{618} = 3 + \frac{308}{618} = 3.50'$$

4-23-75

Hoyle's Mill Dam
lower bridge concrete ~~w/ wood~~ concrete deck on
steel ~~beams~~ girders
16' wide x 8.5' high.
Heavy material placed in south
end dam. w/s ~1' below top of spillway
water going around south end
face of spillway badly deteriorated
silt level practically at top spillway.

Setup # 2

Sta. 8

H.I. = 101.09 $\measuredangle$ = 8° 17'

R = 0.33   Rod Reading = 12.63

From Table II, Elementary Surveying

h = 97.92 ; v = 14.26

H = 97.92 (0.33) = 32'

V = 14.26 (0.33) = 4.71'

Elev. = 101.09 - 12.63 - 4.71

= 101.09 - 17.34

= 83.75

Sta. 9

H.I. = 101.09 $\measuredangle$ = 2° 39'

R = 0.19   Rod Reading = 14.51

From Table II, Elementary Surveying

h = 99.78 ; v = 4.62

H = 99.78 (0.19) = 19'

V = 4.62 (0.19) = 0.88

Elev. = 101.09 - 14.51 - 0.88

= 101.09 - 15.39

= 85.70

Sta. 22

H. I. = 101.09 $\qquad \measuredangle = 4°57'$

R = 0.88 $\qquad$ Rod Reading = 14.00

From Table II, <u>Elementary</u> <u>Surveying</u>

h = 99.25 ; v = 8.60

H = 99.25 (0.88) = 87'

V = 8.60 (0.88) = 7.57'

Elev. = 101.09 − 14.00 − 7.57

= 101.09 − 21.57

= 79.52

Sta. 23

H. I. = 101.09 $\qquad \measuredangle = 5°28'$

R = 0.76 $\qquad$ Rod Reading = 14.00

From Table II, <u>Elementary</u> <u>Surveying</u>

h = 99.09 ; v = 9.48

H = 99.09 (0.76) = 75'

V = 9.48 (0.76) = 7.20'

Elev. = 101.09 − 14.00 − 7.20

= 101.09 − 21.20

= 80.89

Sta. 24

$H.I. = 101.09$ $\measuredangle = 9° - 28'$

$R = 0.50$ Rod Reading = 14.03

From Table II, Elementary Surveying

$h = 97.29$; $v = 16.22$

$H = 97.29(0.50) = 49'$

$V = 16.22(0.50) = 8.11'$

$$\begin{aligned} \text{Elev.} &= 101.09 - 14.03 - 8.11 \\ &= 101.09 = 22.14 \\ &= 78.95 \end{aligned}$$

Sta. 25

$H.I. = 101.09$ $\measuredangle\ 16° - 41'$

$R = 0.26$ Rod Reading = 14.50

From Table II, Elementary Surveying

$h = 91.75$; $V = 27.50$

$H = 91.75(0.26) = 24'$

$V = 27.50(0.26) = 7.15'$

$$\begin{aligned} \text{Elev.} &= 101.09 - 14.50 - 7.15 \\ &= 101.09 - 21.65 \\ &= 79.44 \end{aligned}$$

Times-Argus
9-21-72

GUS. BARRE-MONT

Water Resources Approves Of Washington Pond

WASHINGTON — The Department of Water Resources has found the water quality of the Hand's Mill Pond to be well within the limit suitable for recreation purposes. The pond has been considered by the Washington Planning Commission as a possible recreation site for the town.

John Malter, an official of Water Resources Department, told members about the survey findings in their meeting at the Town Clerk's Office Wednesday night. He and Donald Spies, also from the department, discussed the site with members.

Spies, who took a survey of the dam, consisting of a concrete spillway and land banks said another spring like the last could cause a slight rupture of the dam. Although he said the danger is not great in the event of the rupture, the cellar of an adjacent home could be flooded. He said trees and shrub on the banks also serve to weaken the structure because they attract and hold water. A report on the structure will be available in the winter and Spies said there is nothing binding about the findings.

Members and officials discussed possible methods of eliminating the hazard which included the possibility of lowering the dam and reducing the pond level.

George Plumb offered to evaluate the pond as a recreation site and he will inspect the site with Paul Vermette, selectman.

Members also approved the extension of a power line requested by the Washington Electric Cooperative of East Montpelier. The extension received earlier approval from town selectmen and the Central Vermont Regional Planning Commission. The line will run adjacent to the road.

ARTMENT OF WATER RESOURC

MEMORANDUM

ROUTING		
GENERAL		
TO	NOTED	DATE
JAM		
RJW		
JEC		
SUSPEND TO		
FILE Hands Mill Dam		

TO: Fred Kent, Chief, Water Resources Laboratory

FROM: John Malter

RE:

DATE: August 14, 1972

The Town of Washington is currently assessing potential water-based recreation sites. The impoundment behind the Hands Mill Dam in Washington is of major interest. I would like three water samples from this site analyzed for total and fecal coliform. This should give us a handle as to whether the water quality at this site is suitable for a water-based recreation area in this town. George Plumb from the Division of Recreation is obtaining the samples.

Thank you for your assistance.

ROUTING		
GENERAL		
TO	NOTED	DATE
JEC	[illegible]	
DHS	DHS	5-17-72
SUSPEND TO		
FILE ✓		

May 17, 1972

Board of Selectmen
Town of Washington
Washington, Vermont 05675

Dear Sir:

The Vermont Water Resources Board is charged with the authority to investigate certain dams under the jurisdiction of the Board. The investigations are primarily to assure the public that the dams are in a safe state of upkeep and repair, and are also adequate to pass the flows of water which may reasonably be expected. This does not in any way relieve the owners of the structure from their usual responsibility, however.

In order to obtain factual data regarding the structure, the Department of Water Resources will be making an investigation which will include an inspection of the structure (dam), an analysis of the capacity and adequacy of the spillway, and other related data, to be submitted in a report form.

Several investigations will be conducted between June 1, 1972 and September 1, 1972. Mand's Mill Dam has been selected for such an investigation. The report and conclusions of the investigations will be available to the owners and other interested parties at the office of the Department of Water Resources. If you have any questions regarding the procedure or information, please feel free to contact this office. Your cooperation with our agents will be greatly appreciated.

Sincerely yours,

John E. Cerutti, Director
Management & Engineering Division

JEC/[illegible]/kmp

DEPARTMENT OF WATER RESOURCES
MONTPELIER, VERMONT

ROUTING		
GENERAL		
TO	NOTED	DATE
:TEC		
DHS	DHS	
SUSPEND TO		
FILE Green Dam and Hand's Mill Dam ✓		

OFFICE MEMORANDUM

TO: File

FROM: Donald H. Spies

SUBJECT: Meeting of Board of Selectmen, Washington, Vermont

DATE: May 21, 1971

On May 19, 1970, this writer attended the subject meeting in order to keep informed of the situation regarding the town road at the Green Dam site and also, to inform the Selectmen of the situation at the Hand's Mill Dam. Mr. Raymond Green and a neighbor, Mr. Harold Heinzelman, were present and gave testimony on their own behalf in favor of having the road removed from the town lists and changing it to a trail. The Selectmen were in favor of abandoning the road, however, they were hesitant to do so because they were not sure of the legalities involved. The end result, so far as the Department is concerned, is that the Town will attempt to have the road removed from their list, and if this is not possible, Mr. Green will have the road relocated around his impoundment. The Selectmen are to send a letter to this writer stating their views and the final decision reached at the meeting.

After the above discussion, this writer informed the Selectmen of the erosion of the west abutment of Hand's Mill Dam. It was pointed out to the Selectmen that immediate action was not absolutely essential, but that they should consider some sort of remedial action. They stated that the matter would be taken into consideration.

April 12, 1953

Inspection by John E. Cerutti
Dept. of Water Resources

Washington Dam   April 2 1953   jec

North wing wall has fallen down and water has started to erode the earth embankment behind it.

Earth embankment is 3' above spillway section and appears quite stable

Section of dam south of spillway appears to be in worse condition. Water is leaking thru the South abut. of spillway. Old retaining wall is badly broken up & water going thru it. Water is leaking thru part of dam that forms foundation of mill.

There is about a 30' section of dam to South of the mill. This section has been overtopped and the downstream slope is eroded. Top of this section is about 2' above spillway

Although there may be a short apron at the bottom of the spillway the water appears to be quite deep and it is believed some erosion is taken place & may be working back under the spillway apron.

jec

X

STATE OF VERMONT
WATER CONSERVATION BOARD

MONTPELIER, VERMONT

REPORT ON HAND'S MILL DAM
IN WASHINGTON, VERMONT

A report is made herein on the weakened condition of a dam in the town of Washington, Vermont.

GENERAL

This dam is located on Jail Branch on the upstream edge of the Village of Washington. It is presently owned by Mr. Clarence H. Hand who acquired the property in 1947. The mechanical power feature of this development has been abandoned, its principle purpose now is for the storage of logs for the saw mill at the site.

For this dam the pondage is small being about 2 acres in surface area and a little over 500,000 cubic feet in volume. The drainage area is 6 square miles.

Layout of the dam

The dam, about 260 feet long, is made up of an earth embankment section flanking a heavy concrete spillway section. This spillway section is between 60 and 70 feet long and reaches a maximum depth of 22 feet above channel bottom.

In cross section, it indicates a flat crest 2 feet wide and 2 feet below the top of the dam, with both faces sloping outward about 3 on 1 on the downstream side and 1 on 1 on the upstream side. Rubble concrete end-walls retain the embankment. Also a short concrete apron 5 to 6 feet wide, is provided at the downstream toe. No flashboards are used on the crest.

Extending northward from the spillway is an earth embankment about 180 feet long and about 10 feet high at maximum section. It has an average top width of 8 feet and side slopes at a natural angle of repose. A short length of this embankment is retained on the downstream side by a stone wall.

To the south of the spillway is a short embankment section which also serves as part of the foundation for the saw mill. It is topped by a masonry wall, partly extended into the embankment. An abandoned intake and a sluicway exist at this end of the spillway.

Observations and comments

From an examination of the dam, made on May 23, 1950, the writer noted the physical condition of the dam as follows:

The dam is an old structure (probably over 45 years) in a somewhat abandoned stage. Originally, it has a timber spillway section, but this was destroyed in the November 1927 flood, and afterwards replaced by the present massive concrete section. This "newer" section is in the best condition. As indicated in Figure 1, it has a minor degree of surface scaling. Some scour of the soft foundation material underneath the apron has occurred, particularly along the north half, but its progress has not reached a stage where stability of the section might be seriously concerned.

The older, original masonry end sections, are badly broken up. In such a condition is the south abutment wall shown in Figure 2. This is the top portion which has partly failed and leaks considerably. The lower portion of the section is still in a sound condition.

Figure 3 shows the condition of the north abutment wall which also serves to retain the embankment. The poor quality concrete has been eroded away in time so that stability of the wall is in question. Not only has the base of this wall been decomposed but also some of the material behind it has been washed out. A deep hole, about 6 feet in diameter and 10 feet deep now exists. Here is a likely point of failure, much so if aggravated by high water.

The embankment section, in general, has settled and stabilized itself. It is uneven and overgrown with brush. Beavers have burrowed into the section and have caused small local cave-ins. Some seepage was detected. The nature of the material making up the embankment is not known.

A check on the probable maximum flood (in ~~[illegible]~~ proportion to the November 1927 flood) indicates that a peak flow of 3600 c.f.s. is possible. Because of a limited discharge capacity, the dam would be overtopped with this size of flood. With this type of dam, overtopping would mean failure.

CONCLUSIONS

From a routine investigation the writer comes up with this dam which, in his opinion, is in a weakened condition. The ~~impending~~ impending failure of the dam would cause flooding in the vicinity. However, the extent of flood damage is limited because of the relatively small storage volume involved.

The dam needs immediate repairs to restore its stability. Consideration should also be given to improving the discharge capacity.

Stephen H Haybrook
Stephen H. Haybrook
Hydraulic Engineer

July 6, 1950
Report # 141

Figure 1.-Spillway face and apron of the dam. The north embankment section continues in the background.

Figure 2.-Disintegrated condition of the south abutment wall.

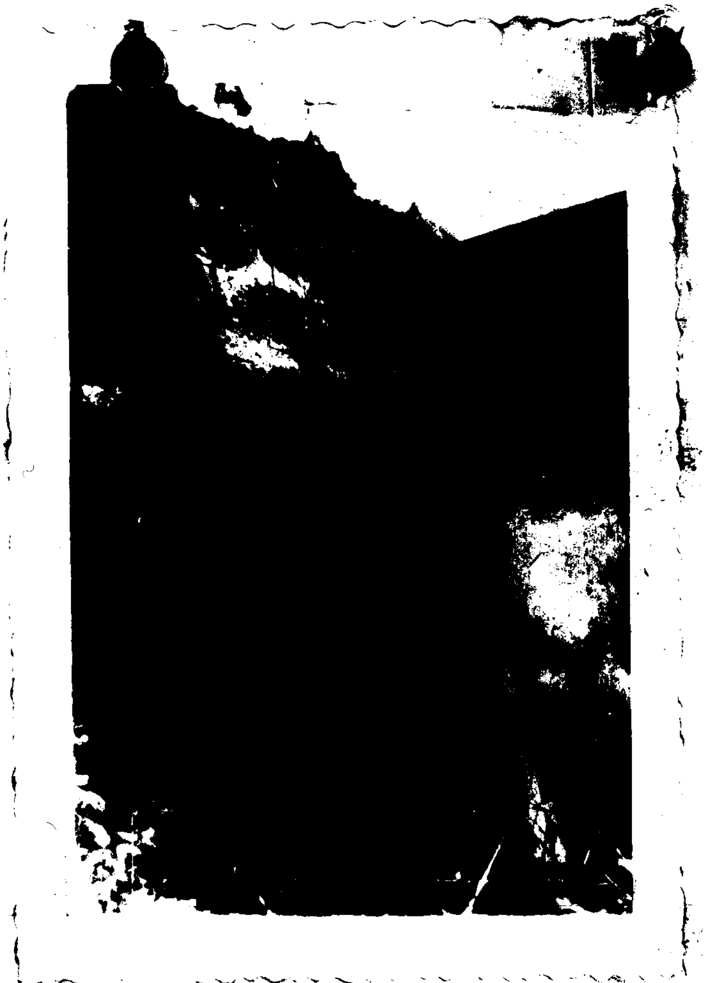


Figure 3.—A closeup of the north abutment wall. Note the scour through and under the section.

Attachment 6: Damage Costs Table

Damage Costs Calculations Table

Location	1st Floor[1] (sq ft)	Assessment Value[1] ($)	Year Built[1]	Occupancy Class[2]	Flood Depth[3] (ft)	Building Damage Cost	Contents Damage Cost	Total Damage Cost
2973 VT Rte. 110	**2000**	500,000.00	1848	Church/Membership organization	1 to 2	*Not enough data on building to identify appropriate damage curve		
72 School Lane	**19240**	2,193,400.00		Shools/Libraries	<1	*Not enough data on building to identify approporiate damage curve		
16 Woodchuck Hollow Rd.	744	77,000.00	1900	Single Family Dwelling	3 to 6	44,394.40	26,164	70,558.40
39 Woodchuck Hollow Rd.	900	115,800.00	1870	Single Family Dwelling	0 to 2	8,370.00	4,500.00	12,870.00
64 West Corinth Rd.	816	73,500.00	1900	Single Family Dwelling	<1	7,588.80	4,080.00	11,668.80
29 Woodchuck Hollow Rd.	1344	190,300.00	1969	Single Family Dwelling	<1	12,499.20	6,720.00	19,219.20
31 Woodchuck Hollow Rd.	1248	161,700.00	1969	Single Family Dwelling	<1	11,606.40	6,240.00	17,846.40
33 Woodchuck Hollow Rd.	1318	39,000.00	1972	Single Family Dwelling	<1	12,257.40	6,590.00	18,847.40
73 Fairgrounds Rd.	1539	135,400.00	1989	Single Family Dwelling	<1	14,312.70	7,695.00	22,007.70
2895 VT Route 110	**2000**	334,000.00	1880	Single Family Dwelling	1 to 2	30,400.00	17,399.99	47,799.99
40 School Lane	**1500**	**50,000.00**		Single Family Dwelling	1 to 2	22,800.00	13,050.00	35,850.00
57 Fairgrounds Rd.	*Outbuilding at 73 Fairgrounds included in dam breach assessment*				<1	N/A	N/A	N/A
56 Fairgrounds Rd.	*Outbuilding at 73 Fairgrounds included in dam breach assessment*				1 to 2	N/A	N/A	N/A
							Total	**$256,668**

[1]Values provided by Washington, VT Town Clerk's Office in December 2020. Bolded values were estimated by the Town Clerk.

[2]Occupancy class, dirupstion cost, and rental cost data choosen based on available property information and are from Table 3 in the Benefit-Cost Analysis Sustainment and Enhancement: Standard Economic Value Methodology Report Version 9.0 (FEMA, 2020).

[3]Flood depths from DSS-Wise Lite Dam Failute Analysis and Flood Innundation Maps Report Model Results table.

[4] Building and Contents Damage values taken from a USACE Generic Damage Curve developed for each property in the BCA V.6.0 Toolkit using the provided first floor square footage for a given residential property.

Attachment 7: Loss of Life and Injury Table

Loss of Life and Injury Cost Calculations

Description of Injury	**Economic Value[1]**	**Number of Instances[2]**	**Total Costs**
Minor	15,000.00	40	600,000.00
Fatal	7,500,000.00	3	22,500,000.00
		Total	**23,100,000.00**

[1]Value from Table 6 of the Benefit-Cost Analysis Sustainment and Enhancement: Standard Economic Value Methodology Report Version 9.0 (FEMA, 2020).

[2]Daytime PAR from dam failure report used for minor injuries. Number of residents at 16 Woodchuck Hollow road used for fatalities (From dam failure report: flood depth of 3 to 6 ft, velocities of 3 to 6 ft/s, immediate peak flood arrival).

Attachment 8: Displacement Costs Table

Displace Cost Calculations for Professional Expected Damages Before Mitigation

Location	1st Floor[1] (sq ft)	Assessment Value[1] ($)	Year Built[1]	Occupancy Class[2]	Flood Depth[3] (ft)	Disruption Cost[2]	Recovery Time[4] (Min. Months)	Total Rental Cost[2] (Rental Cost x sq ft x displacement time or recovery time in months)	Displacement Cost (Diruption Cost + Total Rental Cost)
2973 VT Rte. 110	**2000**	500,000.00	1848	Church/Membership organization	1 to 2	$1,900.00	13	$26,520.00	$28,420.00
72 School Lane	**19240**	2,193,400.00		Shools/Libraries	<1	$18,278.00	12	$235,497.60	$253,775.60
16 Woodchuck Hollow Rd.	744	77,000.00	1900	Single Family Dwelling	3 to 6	$610.08	12	$6,071.04	$6,681.12
39 Woodchuck Hollow Rd.	900	115,800.00	1870	Single Family Dwelling	0 to 2	$738.00	12	$7,344.00	$8,082.00
64 West Corinth Rd.	816	73,500.00	1900	Single Family Dwelling	<1	$669.12	12	$6,658.56	$7,327.68
29 Woodchuck Hollow Rd.	1344	190,300.00	1969	Single Family Dwelling	<1	$1,102.08	12	$10,967.04	$12,069.12
31 Woodchuck Hollow Rd.	1248	161,700.00	1969	Single Family Dwelling	<1	$1,023.36	12	$10,183.68	$11,207.04
33 Woodchuck Hollow Rd.	1318	39,000.00	1972	Single Family Dwelling	<1	$1,080.76	12	$10,754.88	$11,835.64
73 Fairgrounds Rd.	1539	135,400.00	1989	Single Family Dwelling	<1	$1,261.98	12	$12,558.24	$13,820.22
2895 VT Route 110	**2000**	334,000.00	1880	Single Family Dwelling	1 to 2	$1,640.00	12	$16,320.00	$17,960.00
40 School Lane	**1500**	**50,000.00**		Single Family Dwelling	1 to 2	$1,230.00	12	$12,240.00	$13,470.00
57 Fairgrounds Rd.	*Outbuilding at 73 Fairgrounds included in dam breach assessment*				<1	N/A	N/A	N/A	N/A
56 Fairgrounds Rd.	*Outbuilding at 73 Fairgrounds included in dam breach assessment*				1 to 2	N/A	N/A	N/A	N/A
								Total	**$384,648.42**

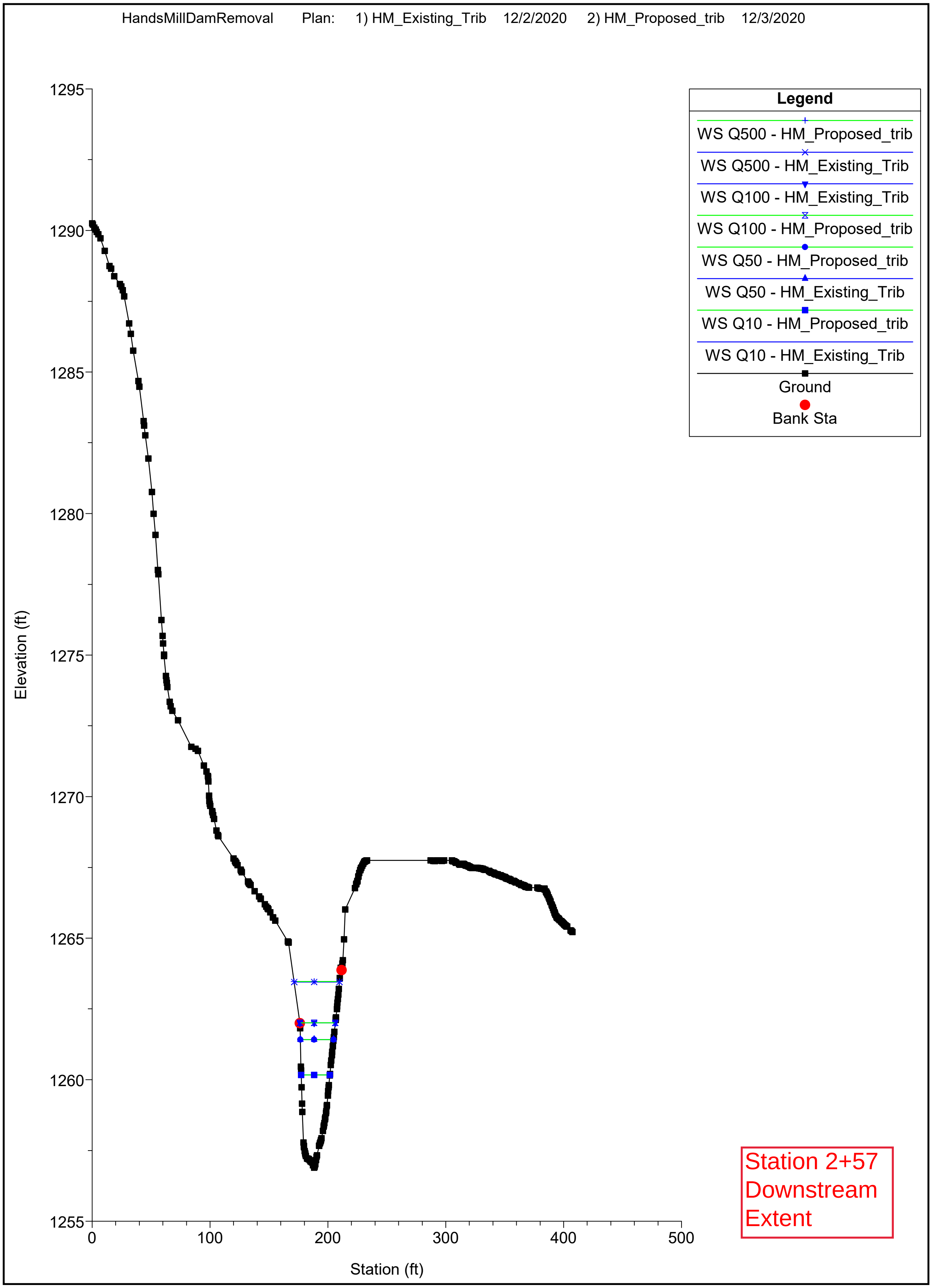
[1]Values provided by Washington, VT Town Clerk's Office in December 2020. Bolded values were estimated by the Town Clerk.

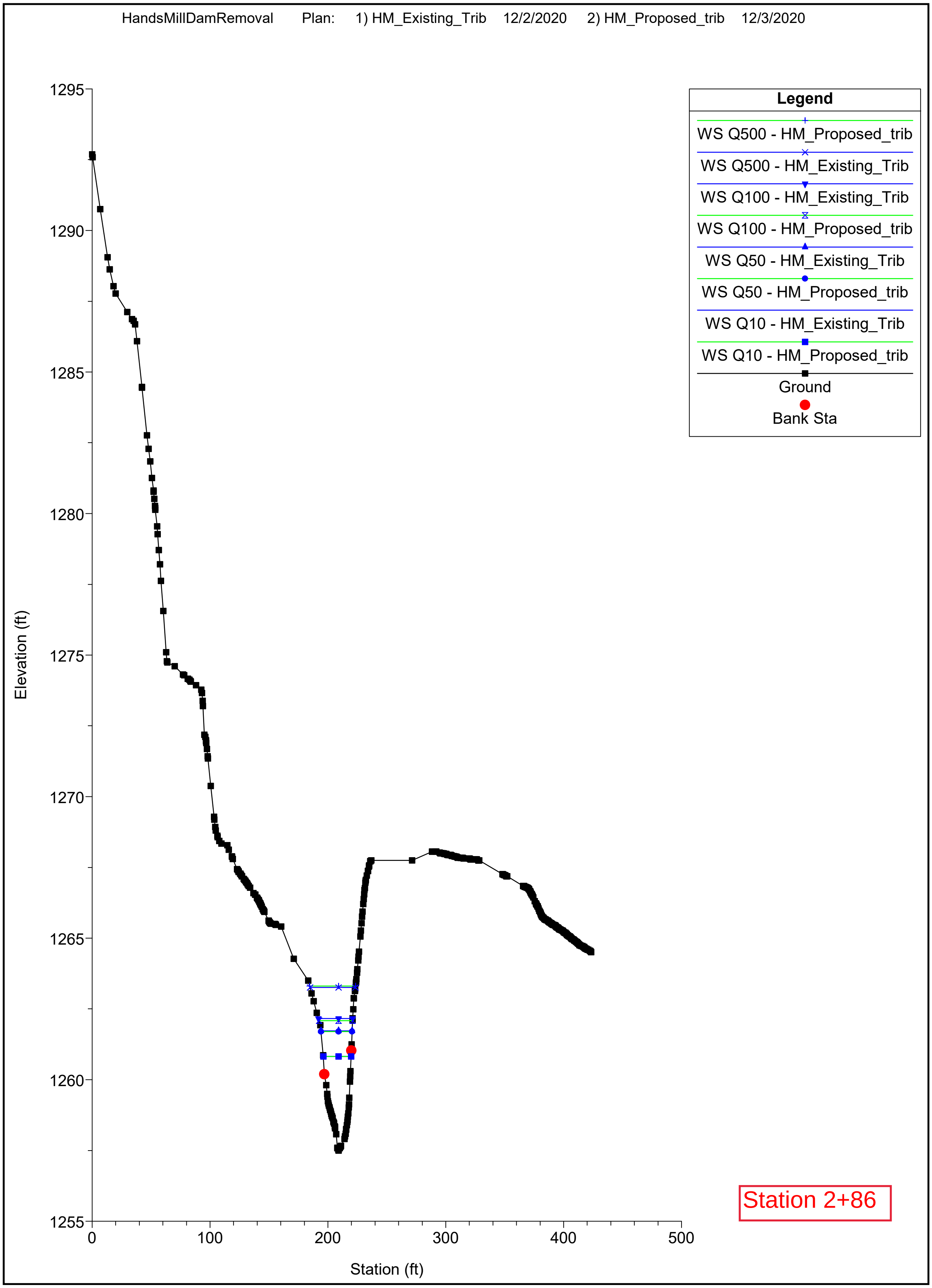
[2]Occupancy class, dirupstion cost, and rental cost data choosen based on available property information and are from Table 3 in the Benefit-Cost Analysis Sustainment and Enhancement: Standard Economic Value Methodology Report Version 9.0 (FEMA, 2020).

[3]Flood depths from DSS-Wise Lite Dam Failute Analysis and Flood Innundation Maps Report Model Results table.

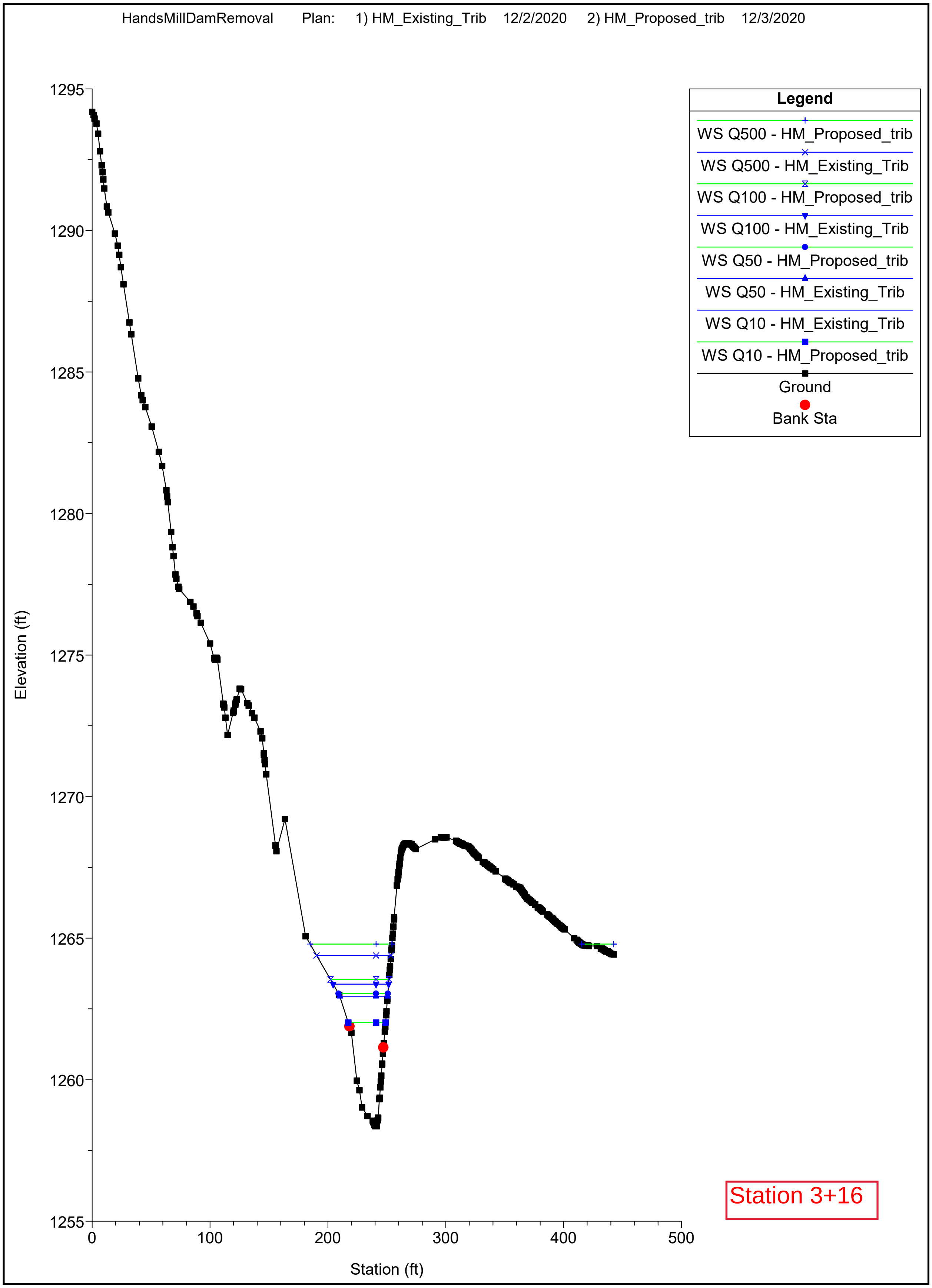
[4]Recovery time for non-residential properties determined from flood depth and Table 4 in the Benefit-Cost Analysis Sustainment and Enhancement: Standard Economic Value Methodology Report Version 9.0 (FEMA, 2020). For residential properties, a recovery time of 12 months was assumed.

Attachment 9: HEC-RAS Output Figures

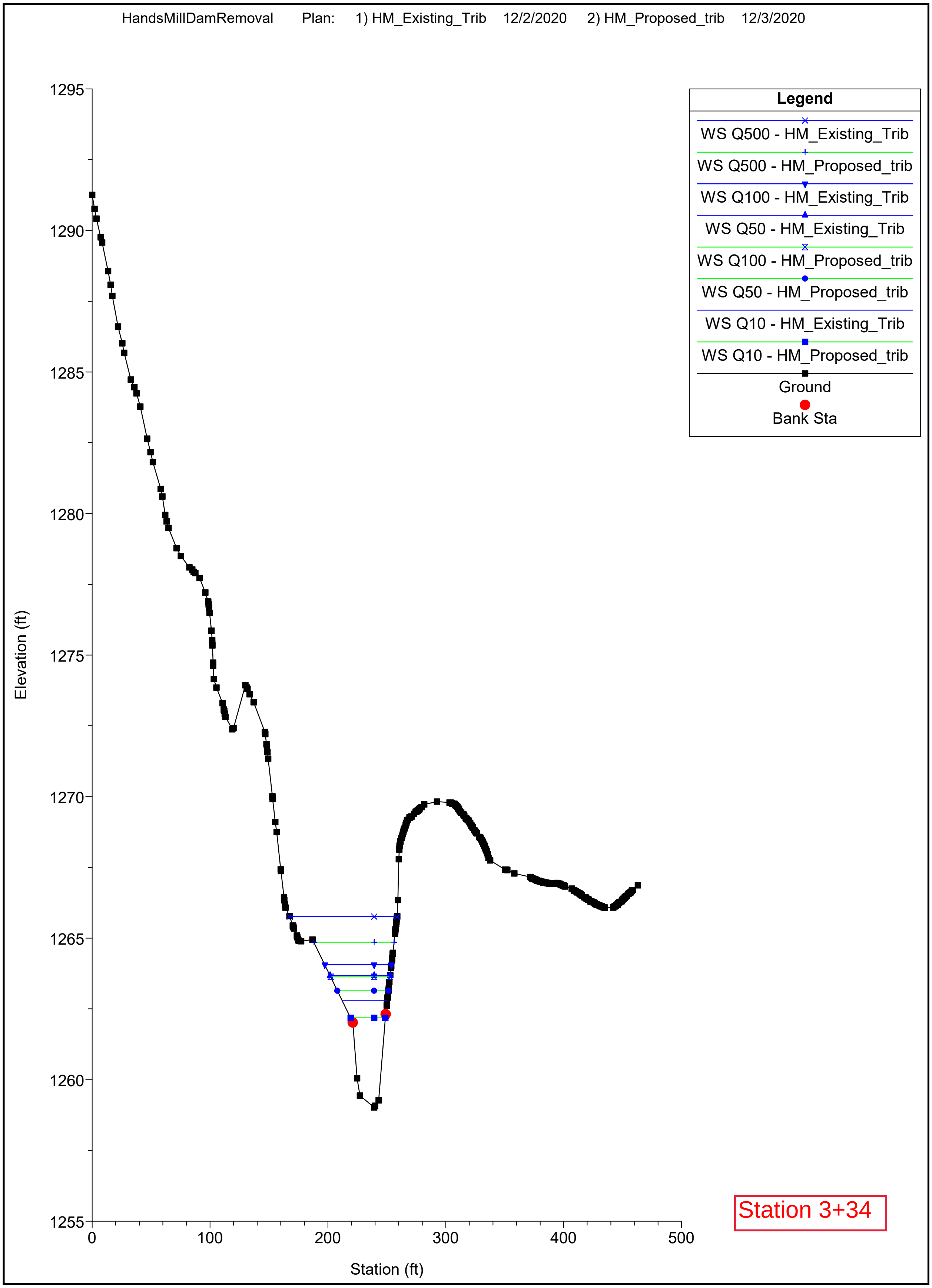

HandsMillDamRemoval Plan: 1) HM_Existing_Trib 12/2/2020 2) HM_Proposed_trib 12/3/2020
Legend
WS Q500 - HM_Proposed_trib
WS Q500 - HM_Existing_Trib
WS Q100 - HM_Existing_Trib
WS Q100 - HM_Proposed_trib
WS Q50 - HM_Proposed_trib
WS Q50 - HM_Existing_Trib
WS Q10 - HM_Proposed_trib
WS Q10 - HM_Existing_Trib
Ground
Bank Sta
Elevation (ft)
1295
1290
1285
1280
1275
1270
1265
1260
1255
0
100
200
300
400
500
Station (ft)
Station 2+57
Downstream
Extent



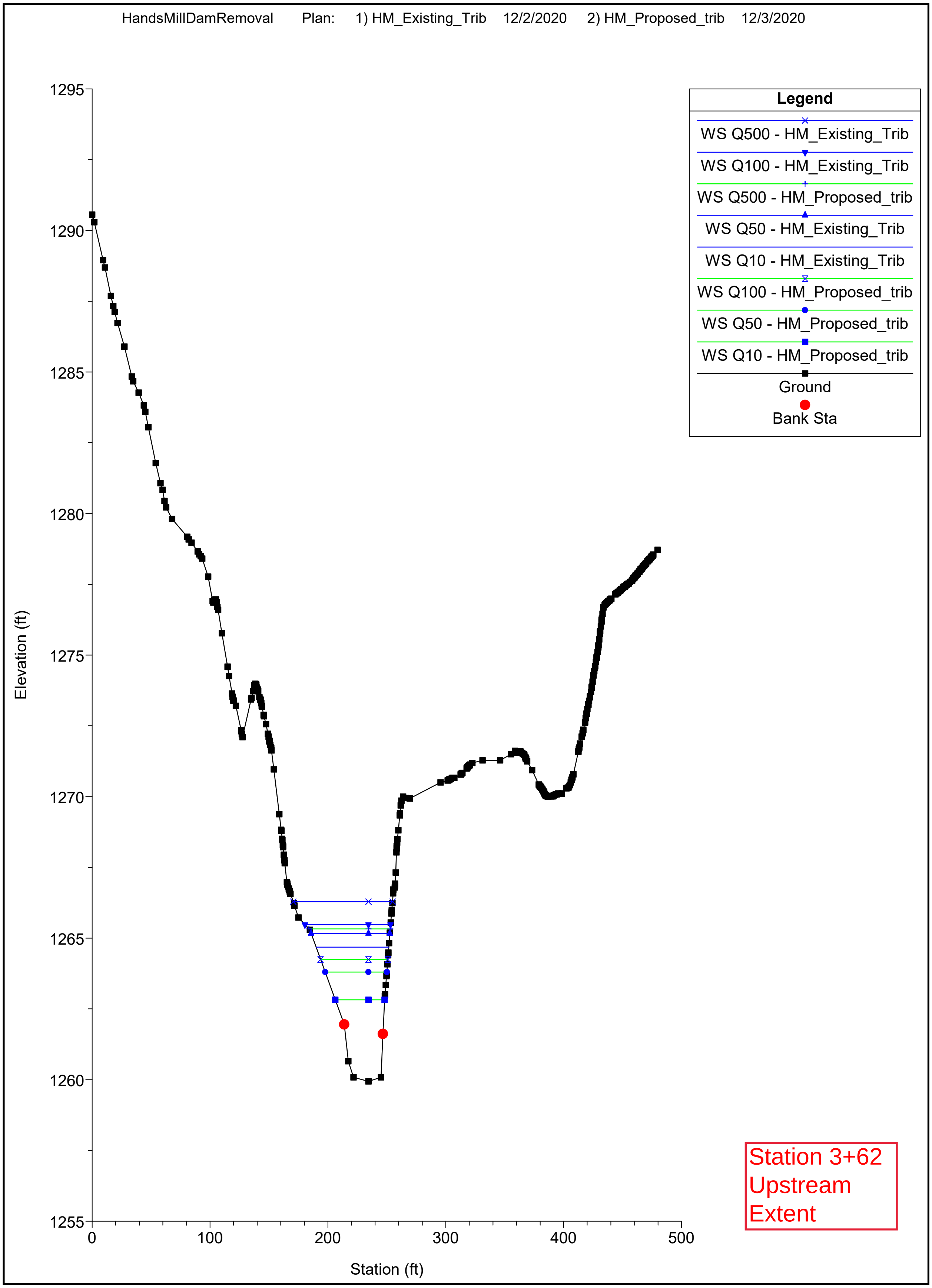
HandsMillDamRemoval Plan: 1) HM_Existing_Trib 12/2/2020 2) HM_Proposed_trib 12/3/2020
Legend
WS Q500 - HM_Proposed_trib
WS Q500 - HM_Existing_Trib
WS Q100 - HM_Existing_Trib
WS Q100 - HM_Proposed_trib
WS Q50 - HM_Existing_Trib
WS Q50 - HM_Proposed_trib
WS Q10 - HM_Existing_Trib
WS Q10 - HM_Proposed_trib
Ground
Bank Sta
Elevation (ft)
Station (ft)
1295
1290
1285
1280
1275
1270
1265
1260
1255
0
100
200
300
400
500
Station 2+86



HandsMillDamRemoval Plan: 1) HM_Existing_Trib 12/2/2020 2) HM_Proposed_trib 12/3/2020
Legend
WS Q500 - HM_Proposed_trib
WS Q500 - HM_Existing_Trib
WS Q100 - HM_Proposed_trib
WS Q100 - HM_Existing_Trib
WS Q50 - HM_Proposed_trib
WS Q50 - HM_Existing_Trib
WS Q10 - HM_Existing_Trib
WS Q10 - HM_Proposed_trib
Ground
Bank Sta
Elevation (ft)
1295
1290
1285
1280
1275
1270
1265
1260
1255
0
100
200
300
400
500
Station (ft)
Station 3+16



HandsMillDamRemoval Plan: 1) HM_Existing_Trib 12/2/2020 2) HM_Proposed_trib 12/3/2020
Legend
WS Q500 - HM_Existing_Trib
WS Q500 - HM_Proposed_trib
WS Q100 - HM_Existing_Trib
WS Q50 - HM_Existing_Trib
WS Q100 - HM_Proposed_trib
WS Q50 - HM_Proposed_trib
WS Q10 - HM_Existing_Trib
WS Q10 - HM_Proposed_trib
Ground
Bank Sta
Elevation (ft)
1295
1290
1285
1280
1275
1270
1265
1260
1255
0
100
200
300
400
500
Station (ft)
Station 3+34


HandsMillDamRemoval Plan: 1) HM_Existing_Trib 12/2/2020 2) HM_Proposed_trib 12/3/2020
Legend
WS Q500 - HM_Existing_Trib
WS Q100 - HM_Existing_Trib
WS Q500 - HM_Proposed_trib
WS Q50 - HM_Existing_Trib
WS Q10 - HM_Existing_Trib
WS Q100 - HM_Proposed_trib
WS Q50 - HM_Proposed_trib
WS Q10 - HM_Proposed_trib
Ground
Bank Sta
Elevation (ft)
Station (ft)
1295
1290
1285
1280
1275
1270
1265
1260
1255
0
100
200
300
400
500
Station 3+62
Upstream
Extent

Attachment 10: Ecosystem Benefits Map

30% DESIGN PLANS, NOT FOR PERMITTING OR CONSTRUCTION

FILE:

DRAWING CREDITS

DRAWN ON: 9/4/2020
DRAWN BY: GMB
CHECKED ON:
CHECKED BY:
PROJECT NO: 20-007

REVISIONS

#	DATE	DRWN	CHK'D	APP'D	DESCRIPTION

DRAWING SCALE

DRAWINGS ARE HALF SCALE WHEN PRINTED ON 11x17

40 0 40 80 160 ft
8 0 20 40 m

1 inch = 40 feet
(1 : 480)

STONE ENVIRONMENTAL
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HANDS MILL DAM REMOVAL
AT JAIL BRANCH
CHANNEL RESTORATION PLAN - ECOSYSTEM BENEFITS

WASHINGTON VERMONT

FIGURE NO. X

Attachment 11: 16 Woodchuck Hollow Road Topographic Survey Image

Hands Mill Dam Removal – BCA Analysis

16 Woodchuck Hollow Road – Location of Topographic Survey Shot to Estimate Finished Flood Elevation

December, 2020

Source: Bing Maps

Attachment 13: Hands Mill H&H Memo

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January 6, 2021

MEMO

To: Gianna Petito, District Manager, Winooski Natural Resources Conservation District

From: Gabe Bolin, PE, Meghan Arpino, Stone Environmental, Inc.

Stone Project No. 20-007
Subject: Hands Mill Dam Removal – H&H Analysis Memo

Stone Environmental, Inc. (Stone) had completed hydrologic and hydraulic analysis as part of the Hands Mill Dam Removal 30% design effort. This memo provides a summary of the analysis completed.

1. Selected Alternative

Based on field work, modeling and concept design development, Stone developed four project alternatives that were evaluated via an Alternatives Analysis. Alternative 4 (A4) was selected as the final alternative, which includes removal of the entire visible portion of the dam (165 linear feet) plus a portion of the dam that is buried along river right. The removal extents include the embankment section and principal concrete spillway, 67 linear feet of the concrete/stone wall, 70 linear feet of the visible portion of the concrete training wall and 30 linear feet of the buried portion of the concrete training wall.

Alternative 4 was selected over other alternatives due to the depth of sediment removal directly behind the dam (approximately 14' deep) and the need to remove the majority of the concrete training wall due to potential undermining of the wall by the excavation, if the wall were to remain in place. Besides the length and extent of dam removal, all other project components were the same across each alternative.

2. Hydrologic and Hydraulic Modeling

Hydrologic Peak Flow Analysis

Stone staff delineated the geographical region contributing flow to the site and determined the watershed size to be 6.65 mi^2. Streamflow data from nearby USGS gauges were then used to determine peak flow rates using a gauge transfer technique. Stone located 3 gauges within 50 miles of the site and chose 2 of those 3 gauges for further analysis based on watershed size relative to the Jail Branch watershed, geology and surficial soils, length of period of record, and presence of obstructions to flow (ex. dam or withdrawal). At each gauge, a Log-Pearson Type III distribution was used to determine the 2-, 5-, 10-, 25-, 50- and 100-yr recurrence interval design flows. For each gauge, an additional hydrologic analysis was performed that compared records to data collected after 1970, to identify if the hydrology at each site was impacted by a recent shift in hydrologic regimes as a result of climate change. The resulting distributions were plotted and compared to the StreamStats distribution.

The East Orange Branch, near East Orange, Vermont gauge (#01139800) was selected to determine peak flows at the site due to its long period of record (61 years), its comparable watershed size (8.8 mi^2), proximity to the site, location along an unregulated stream and current status as an active gauge. Because the post-1970 flows were higher than those corresponding to the entire record at this particular gauge, the post-1970 flows were used for our analyses.

The USGS gauge transfer technique was used to relate the calculated peak flows at the East Orange Branch gauge to the site using the following equation:

$$Q_u = \left(\frac{A_u}{A_g}\right)^b Q_g$$

where Q_u is the estimated flow statistic for the ungauged site, A_u is the drainage area for the ungauged site, A_g is the drainage area for the stream gauging station, Q_g is the flow statistic for the stream gauging station, and $_b$, depending on the state, may be the exponent of drainage area from the appropriate regression equation, a value determined by the author of the state report, or 1 where not defined in the state report (for this project a value of 1 was used).

The resulting peak storm flows for Jail Branch are provided in Table 1.

Table 1: Summary of Peak Flows at Jail Branch

Recurrence Interval	Flow (ft^3/s)
2	215
5	336
10	433
25	576
50	701
100	839

Abbreviations: ft = feet; s = second
Date and Author: 09-14-2020 / MRA
Pathname: O:\PROJ-20\WRM\20-007 Hands Mill Dam\Data\Hydrology\HandsMill_FPF_and_Summary.xlsx

Fish Passage Flows Analysis

High and low fish passage flows were estimated to assess potential fish passage conditions at the site following dam removal. Daily streamflow data was downloaded from the East Orange Branch gauge and used to calculate the 5% and 95% exceedance flows (seasonal high and low flow) during September to November, when brook trout migration is likely. The 5% and 95% exceedance flows were also calculated using daily streamflow data from the entire year. The fish passage flows calculated for both time intervals are provided in Table 2.

Table 2: Fish Passage Flows at Jail Branch

Flow	Sept – Nov Fish Passage Flow (ft^3/s)	All Months Fish Passage Flow (ft^3/s)
High	15.6	31.7
Base	4.0	6.7
Low	1.2	1.3

Abbreviations: ft = feet; s = second
Date and Author: 09-14-2020 / MRA
Path Pathname: O:\PROJ-20\WRM\20-007 Hands Mill Dam\Data\Hydrology\HandsMill_FPF_and_Summary.xlsx

The flow scenarios above were simulated using a hydraulic model described below.

Hydraulic Model Development

Stone used the US Army Corps of Engineers (USACE) Hydrologic Engineering Center's River Analysis System model (HEC-RAS; http://www.hec.usace.army.mil/software/hec-ras/) to develop a one-dimensional, steady flow hydraulic model of Jail Branch, the dam and its floodplains. This model was used to simulate the peak flows and fish passage flows calculated above for existing and proposed conditions.

The basemap developed as part of Stone's assessment of the existing conditions at the site was the source of the topography and bathymetry for the existing conditions hydraulic model. The basemap was developed in a relative datum and will be tied to NAVD88 datum during 100% design. Stone staff exported the TIN surface as a digital elevation model (DEM) and then imported the DEM into HEC-RAS Mapper to create a terrain model, which supported the development of the geometry file in HEC-RAS.

Once the geometry file was created, the dam structure and features such as natural levees, ineffective flow areas, stream bank stations, distances between cross-sections, Manning's roughness coefficient at each cross-section were more fully defined. Survey data collected by Stone staff were used to specify the dam locations and dimensions in the existing conditions model. Manning's n values were selected based on channel surface roughness, vegetation, and channel features such as pools.

HES-RAS requires boundary conditions to set the starting water surface elevation at the upstream and/or downstream ends of the river system being modeled. Additionally, a flow regime (subcritical, supercritical, or mixed) must be selected for each analysis. For this 30% design, each steady flow analysis was completed using a subcritical flow regime, which is well suited for preliminary dam removal evaluations. Since the subcritical flow regime was used, only a downstream boundary condition was specified. The downstream boundary condition was set to normal depth with an energy slope of 0.0055, for all flow profiles. The energy slope was estimated based on the channel slope in the vicinity of the downstream cross sections. The boundary condition was set at cross-sections sufficiently far away from the area of interest as to minimize errors due to estimating the starting water surface elevation.

The peak flow and fish passage flow values calculated using gauge transfer and statistical techniques were entered into the HEC-RAS flow file that was used for both the existing conditions and the proposed conditions model. For this final 30% design deliverable, the model included the tributary junction at Jail Branch and the Unnamed Tributary and incoming flows were apportioned to each tributary based on tributary watershed size. Table 1 lists the peak flow conditions simulated and Table 2 lists the fish passage flow simulated.

Existing Conditions Hydraulic Analysis

The hydraulic analysis completed for the existing conditions provides insight into the expected water surface elevations, water velocities, flood inundation limits, and barriers to fish passage for the flow scenarios analyzed. A longitudinal profile for existing conditions, including water surface elevations for specific flow scenarios, is provided as Figure 1.

Proposed Conditions Hydraulic Analysis for the Selected Alternative

Stone developed a one-dimensional hydraulic model to simulate flow conditions for the selected alternative (Alternative A4). The model for Alternative A4 was developed based on approximately 195 total linear feet of dam removal, the extents of which are shown on Sheets 5 and 6 of the plans. The model also incorporates the removal of approximately 11,100 CY of impounded sediment behind the dam; which is simulated in the model via a revised pilot channel slope as shown on Sheet 7 (see dashed blue line in the profile at top of sheet) and the dimensions of the Typical Channel Cross Section also provided on Sheet 7, which includes bank stabilization measures and incorporation of a 30' wide floodplain bench along river left (green shaded area on Sheet 6).

Table 3 below provides a comparison of the 100-year recurrence interval flood water surface elevations at the dam for the existing condition and Alternative A4. Figure 1 provides a plot of water surface elevations for the existing condition and proposed condition, for Alternative A4.

Table 3: Water Surface Elevation Comparison for the 100-Year Recurrence Interval Flow

Scenario	100-yr WSE[1] (ft)	Linear Feet of Dam Removed
Existing	1279.79	0
Alternative A4	1265.15	195

Abbreviations: ft = feet; WSE = water surface elevation
[1]WSE presented in a relative datum and will be tied to NAVD88 during 100% design development
Date and Author: 1-5-2021 / MRA/GMB

It is evident that Alternative A4 provides significant reduction in water surface elevations compared to those of the existing conditions, with a peak water surface reduction of 14.64 feet for the 100-year recurrence interval storm event. Similar reductions apply for other significant recurrence intervals (i.e. 10-, 25- and 50-year intervals). In addition to these peak water surface elevation reductions and mitigation of flooding, the dam removal also improves public safety by removing a high hazard dam that has been deteriorating over the past few decades.

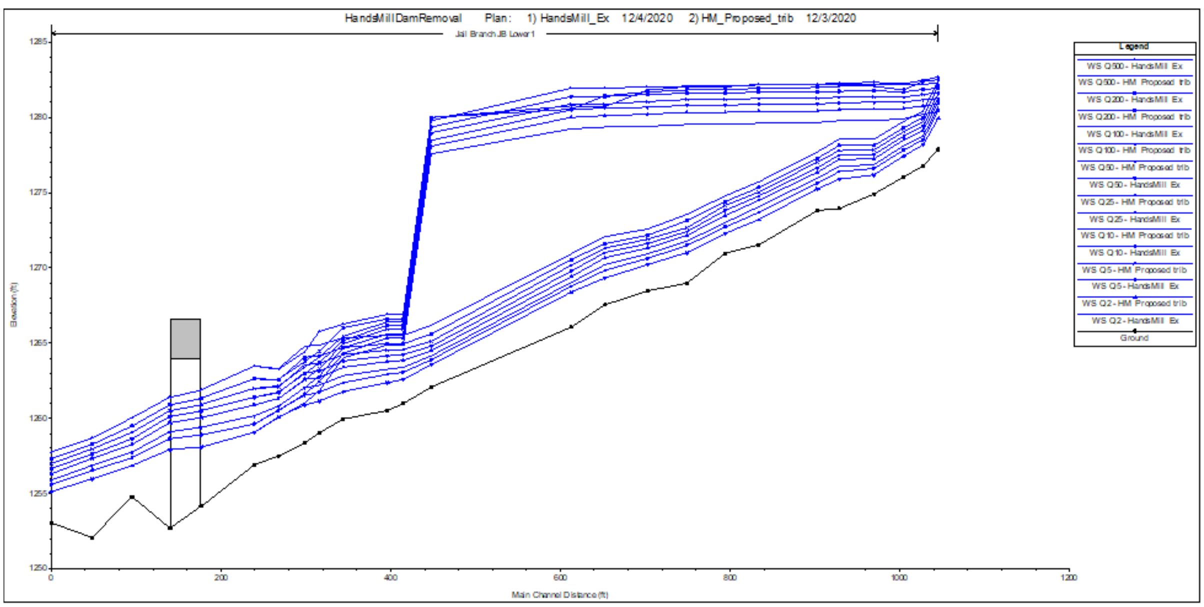

Figure 1. Profile of HEC-RAS output showing water surface elevations for existing and proposed conditions. Water surface elevations (blue lines) that follow pilot channel thalweg (black line) are storm peak flow water surfaces following dam removal.