

November 16, 2020

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

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

Stone Project No. 20-007 Subject: Hands Mill Dam Removal – Geotechnical Report

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Stone Environmental, Inc. (Stone) has completed desktop, field, and laboratory geotechnical investigations at the Hands Mill Dam as part of the overall 30% design effort. This memo provides a summary of these investigations including field and laboratory methods, data logs, and the implications of the data for site design and construction processes.

1. Desktop Evaluation

A preliminary desktop evaluation was performed to determine the potential extents of sampling. Aerial imagery of the Hands Mill Dam location (44.10569, -72.43000) from Google Earth shows aggradation of sediment, likely coarse grained, for approximately 750 linear feet upstream of the Hands Mill Dam (See Figure 1 on the following page for approximate project extents). This area was further investigated in the field to confirm sampling locations. The number of channel samples to be collected (six in total) was predetermined and was to include a combination of pebble counts and laboratory grain size analyses (methodologies defined below). The number of floodplain samples to be collected (three in total) was also predetermined to represent the spatial extent of the left-bank floodplain.

2. Field and Laboratory Investigations

An initial site evaluation was utilized to confirm the extents of sampling. Though Google Earth aerial imagery showed aggraded sediments for approximately 750 linear feet upstream of Hands Mill Dam, visible changes in bed slope and material indicated that the direct impact of the dam on sediment impoundment was likely limited to approximately 600 linear feet upstream. Channel sediment sampling was therefore focused within this extent. Exact sampling locations were selected to maximize the range of outcomes of the grain size analyses in order to assess the variability of grain size distribution throughout the channel. One sample, HM-S6, was excluded from further analysis and was sent to archive due to extensive similarity to sample HM-S4. Floodplain samples were spaced at equidistant intervals (approximately 150 - 200 feet apart) throughout the left bank floodplain.



LEGEND



• Floodplain Soil Borings

Approximate Limits of Disturbance



Feet

Figure 1: Site Map

Hands Mill Geotechnical Memo

West Corinth Road Washington, Vermont

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Grain size analyses were performed using one (or more) of three methods at each channel sampling location: modified Wolman pebble count, laboratory sieve analysis, and/or laboratory hydrometer analysis. The modified Wolman pebble counts were performed using the methodology of Leopold (1970) where individual grains are selected using heel-to-toe spacing along cross-sectional transects. For laboratory testing, bulk sediment samples were collected to a depth of approximately 6-10 inches below the surface using a hand shovel. The samples were sent to the University of Vermont (UVM) Agricultural & Environmental Testing Laboratory (Lab) given the Lab's ability to perform a specific phosphorus content test. Laboratory sieve analyses were performed on the coarse fraction of bulk sediment samples, and laboratory hydrometer analyses were performed on the fine fraction of bulk sediment samples. Bulk sediment samples were also sent to the UVM laboratory for phosphorus content analysis via microwave digestion and inductively coupled plasma (ICP) analysis. Results of the laboratory analysis are included as Attachment 1.

Floodplain soil/sediment samples were collected to a depth of approximately three (3) feet using a hand auger. Soil characteristics, including color, moisture, consistency, and field-assessed USCS classifications were recorded on a soil boring log for each of the three samples (see Attachment 2). Field-assessed USCS classifications were determined in accordance with ASTM standards D-2487 and D-2488.

3. Results

The results of the channel and floodplain investigations are shown in Tables 1 through 3. Pebble count data were aligned with the size classes tested via hydrometer and sieve analyses at the UVM Lab for direct comparison. Figure 2 shows the cumulative grain size distribution at each of the channel sampling sites (note that the curves for HM-S4 and HM-S5 were generated from pebble count data).

Table 1 – Grain Size Distribution of Channel Samples										
Cumulative Percent Retained (%)					%)					
Sampling Site	Sample Type ¹	Larger than 3/4 Sieve ²	3/4 Sieve	1/2 Sieve	1/4 Sieve	#5 Sieve	#10 Sieve	Sand	Silt	Clay
HM-S1	B/L	-	100.0	100.0	100.0	99.9	99.7	5.9	2.0	0.1
HM-S2	B/L	-	100.0	85.0	73.3	60.8	55.2	46.6	4.7	1.2
HM-S3	B/L	-	100.0	99.9	99.9	99.3	98.6	95.8	3.4	1.6
HM-S4	B/L	-	100.0	99.4	90.2	77.3	69.8	52.4	3.4	1.0
		Cumulative Percent by Size Class (%)								
		Larger than 3/4 Sieve	3/4 Sieve	1/2 Sieve	1/4 Sieve	#5 Sieve	#10 Sieve	Sand	Silt	Clay ²
HM-S4	РС	100.0	88.0	70.0	48.0	38.0	36.0	4.0	0.1	-
HM-S5	РС	100.0	66.7	56.6	49.5	42.4		9.1	0.1	-

¹B/L are bulk samples sent to the UVM lab for analysis; PC are pebble count samples.

²Results not recorded for this combination of methodology and size class.

Table 2 – Phosphorus Content of Channel Samples				
Sampling Site	Test Description	P-Content (mg/kg)		
HM-S1	Phosphorus (P) from ICP	267.9		
HM-S2	Phosphorus (P) from ICP	343.3		
HM-S3	Phosphorus (P) from ICP	206.1		
HM-S4	Phosphorus (P) from ICP	426.5		



Figure 2 – Cumulative grain size distribution curves for channel samples HM-S1 through HM-S5. HM-S4 and HM-S5 curves were generated using pebble count data.

Table 3 – Soil Characteristics of Floodplain Samples ³						
Sampling Site	ampling Site Composite Relative Soil Compositere		Predominant USCS Classification			
HM-FP1	Moist to Wet	Dark Brown	SM (Silty Sand)			
HM-FP2	Moist to Wet	Brown	SM (Silty Sand)			
HM-FP3	Moist to Wet	Brown/Grey Brown	SM/ML (Silt with Fine Sand)			

³See individual soil boring logs for more detailed information at respective soil layers.

4. Discussion

As is common with pebble counts, the sampling data show that the pebble count samples tended towards the coarser fraction of the impounded bed sediment material than the Lab tested bulk samples. However, both the Lab samples and pebble counts indicate that the median grain size (d_{50}) of the channel material is less than 10 mm (1 cm) in diameter. Particles of this size are highly mobile via both rolling and entrainment during common storm events. Both sample types also indicate that approximately 75% or more of the impounded bed sediment is finer than 25 mm (approximately 1 inch) in diameter. Coarse gravel in this size class is still likely to mobilize during storm flow events based on a simple incipient motion approximation using the critical Shields Number.

The average phosphorus (P) content of the impounded channel sediment is approximately 311 mg P/kg sediment. The total amount of phosphorus removed can be estimated based on 1) the extent of the impoundment, 2) an assumption that the majority of the phosphorus is contained within the active sediment layer (top 10 cm), and 3) an assumption that approximately 30% of the phosphorus is biologically available (value provided by the VANR workgroup). Review of publicly available LiDAR and aerial photography, and confirmation with field-run survey yields a total area of approximately 15,000 ft² of sediment impoundment. Based on the above assumptions and an average P loading of 311 mg/kg, the total bioavailable phosphorus to be removed associated with the proposed dam removal is 21 kg (or 46 lbs.). This estimate is limited to the sediment impounded within the confines of the channel. Floodplain sediments were not tested for P content, however utilizing the same assumptions as above, the same loading rate of 311 mg/kg, and the surface area of the proposed floodplain bench excavation (approximately 18,000 ft²) an additional 25 kg (55 lbs.) of phosphorus would be removed. If the entire impounded depth was assumed to contain phosphorus-laden sediments, the total P removals from channel and floodplain sediments would increase to 317 kg (699 lbs.) and 381 kg (840 lbs.), respectively. See Attachment 3 for supporting calculations.

Field evaluation of floodplain soils revealed that the floodplain soils are predominantly silty sands, or USCS classification SM. Based on this characterization, the soils are likely limited to a maximum grade of 2H:1V outside of the channel limits. The internal friction angle of SM soils is approximately 30 to 35 degrees, depending upon the fractions of silt and sand, therefore precluding the ability to permanently grade these soils to a slope exceeding 2H:1V. Sandy soils do not generally achieve high levels of compaction in comparison to silty or clayey soils, and silty soils are subject to the highest relative amounts of post-construction settlement, particularly in regions with highly active freeze-thaw. Caution should therefore be taken to limit steep grading to the maximum extent practicable.

5. References

Leopold, L.B. 1970. An improved method for size distribution of stream-bed gravel. Water Resources Research. 6(5):1357-1366.

Town of Washington and Central Valley Regional Planning Commission, 2013. Local Hazard Mitigation Plan. Created August, 2013 – Adopted April, 2014.

Attachment 1: UVM Laboratory Analyses

Agricultural & Environmental Testing Laboratory and UVM Extension

	repared ron.		
		Order #:	10372
	Meghan Arpino		
	Stone Env. Inc.		
	5353 Stone Cutters Way		
	Montpelier, VT 05602		
mar	pino@stone-env.com	Received:	9/9/2020
845	323-3436	Reported:	10/7/2020
		VT County:	Washington

Particle Size Analysis (Hydrometer)

Bouyoucos Hydrometer

Lab #	Sample Name	Description	Value	Unit of Measure
70001	HM-S1	Sand (0.05 - 2 mm)	94.1	% (dry wt)
		Silt (0.002 - 0.05 mm)	3.9	% (dry wt)
		Clay (< 0.002 mm)	2.0	% (dry wt)
		Texture class	Sand	
70002	HM-S2			
		Sand (0.05 - 2 mm)	90.0	% (dry wt)
		Silt (0.002 - 0.05 mm)	7.5	% (dry wt)
		Clay (< 0.002 mm)	2.5	% (dry wt)
		Texture class	Sand	

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70003	HM-S3	Sand (0.05 - 2 mm)	96.4	% (dry wt)
		Silt (0.002 - 0.05 mm)	1.8	% (dry wt)
		Clay (< 0.002 mm)	1.7	% (dry wt)
		Texture class	Sand	
70004	HM-84	Sand (0.05 - 2 mm)	93.5	% (dry wt)
		Silt (0.002 - 0.05 mm)	4.5	% (dry wt)
		Clay (< 0.002 mm)	2.0	% (dry wt)
		Texture class	Sand	

If you have questions about these results, contact the lab at agtesting@uvm.edu.

UVM Agricultural Environmental Testing Laboratory 262 Jeffords Hall, 63 Carrigan Dr Burlington, VT 05405-1737 agtesting@uvm.edu 802-656-3030 www.uvm.edu/pss/ag_testing 2 of 4

Agricultural & Environmental Testing Laboratory and UVM Extension

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Montpelier, VT 05602		
marpino@stone-env.com	Received:	9/9/2020
845 323-3436	Reported:	10/7/2020
	VT County:	Washington

Particle Size Analysis (Large Sieve)

Large Sieve

Lab #	Sample Name	Description	Value	Unit of Measure
70005	HM-S1	Retained by 3/4 Sieve	< 0.1	% (dry wt)
		Retained by 1/2 Sieve	< 0.1	% (dry wt)
		Retained by 1/4 Sieve	< 0.1	% (dry wt)
		Retained by #5 Sieve	0.1	% (dry wt)
		Retained by #10 Sieve	0.4	% (dry wt)
70006	HM-S2			
		Retained by 3/4 Sieve	15.0	% (dry wt)
		Retained by 1/2 Sieve	11.7	% (dry wt)
		Retained by 1/4 Sieve	12.5	% (dry wt)
		Retained by #5 Sieve	5.6	% (dry wt)
		Retained by #10 Sieve	8.6	% (dry wt)

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3 of 4

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70007	HM-S3	Retained by 3/4 Sieve	< 0.1	% (dry wt)
		Retained by 1/2 Sieve	< 0.1	% (dry wt)
		Retained by 1/4 Sieve	0.6	% (dry wt)
		Retained by #5 Sieve	0.7	% (dry wt)
		Retained by #10 Sieve	2.8	% (dry wt)
70008	HM-S4	Patainad by 3/4 Siava	0.6	% (dry yt)
		Retained by 5/4 Sieve	0.0	% (ury wt)
		Retained by 1/2 Sieve	9.2	% (dry wt)
		Retained by 1/4 Sieve	12.9	% (dry wt)
		Retained by #5 Sieve	7.5	% (dry wt)
		Retained by #10 Sieve	17.4	% (dry wt)

If you have questions about these results, contact the lab at agtesting@uvm.edu.

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	Meghan Arpino		
	Stone Env. Inc.		
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	Montpelier, VT 05602		
ma	urpino@stone-env.com	Received:	9/9/2020
845	5 323-3436	Reported:	10/7/2020
		VT County:	Washingtor
	-		

Lab - Microwave digest + ICP analysis

Lab #	Sample Name	Description	Value	Unit of Measure
70009	HM-S1	Phosphorus (P) from ICP	267.9	mg/kg
70010	HM-S2			
		Phosphorus (P) from ICP	343.3	mg/kg
70011	HM-S3	Phosphorus (P) from ICP	206.1	mg/kg
70012	HM-S4	Phosphorus (P) from ICP	426.5	mg/kg

If you have questions about these results, contact the lab at agtesting@uvm.edu.

UVM Agricultural Environmental Testing Laboratory 262 Jeffords Hall, 63 Carrigan Dr Burlington, VT 05405-1737 agtesting@uvm.edu 802-656-3030 www.uvm.edu/pss/ag_testing 1 of 1

Attachment 2: Floodplain Soil Boring Logs

Boring Log Form

535 Stone Cutters Way / Montpelier / VT / 05602 / USA 802.229.4541 / info@stone-env.com / www.stone-env.com

Hands Mill Dam Removal in Washington, Vermont

Sponsor St	ponsor Study Number:			Stone Study Number: 20-007					
Described	By : Matt Scl	nley		Date: 11/	Date: 11/5/2020				
Recorded	By: Matt Sch	ley		Location: Washington, Vermont					
Vegetatio	n: Dense, We	t-Tolerant	t	Topogra	Topographic Setting: Floodplain				
Slope: Very Low (Floodplain)				Land use	: Scrub/Shru	b			
Comments	: ~65 degrees	F and sunr	ny at time of sample; recent	snowmelt in	creased soil m	noisture conditic	ons		
Boring # H	IM-FP1 (Most D	Downstrear	m)						
Depth (ft)	Color	Mottles	USCS Classification	Moisture	Consistence	Boundary Distinctness	Comments		
0 – 1′	Dark Brown	F/1/F	SM (Silty Sand)	D/M	VFR	G	Some organic material throughout		
1 – 2′	Dark Brown	F/1/F	SM (Silty Sand)	M/W	FR	G	Silt fraction declines with depth		
2 – 2.5′	Dark Brown	F/1/F	SM (Silty Sand)	W	FR	G	GW Encountered @ 26" BGS		
2.5 – 3'	Brown	C/2/P	SW (Well-Graded Sand)	W	L	A			
Key:			1		Мо	isture: m=moist, w=	wet, d=dry		
Color: Munsel	lSoil Color Chart (1	994) codes refe	er to Hue, Value & Chroma		Cor	nsistence: l=loose, fr=	=friable, fi=firm, vfr=very friable, vfi=very firm,		
Mottles: Expre	ssed as abundance/s	ize/contrast			xfi=	extremely firm			
Abundance: f=	=rew;m=many;c=co	ommon			BOU	undary: Distinctness ((D) g=gradual, a=abrupt		
Contrast: f=fa	int: d=distict: p=pr	: cominent			ESI RG	S = below ground sur	rface		
Sonnast 1-1a	ing a listic, p-p	omnone				e below ground sur			

https://stoneenvironmentalvt-my.sharepoint.com/personal/mschley_stone-env_com/Documents/Desktop/Project Documents/Hands Mill Geotech/HM-FP1 Boring Log.docx

Boring Log Form

535 Stone Cutters Way / Montpelier / VT / 05602 / USA 802.229.4541 / info@stone-env.com / www.stone-env.com

Hands Mill Dam Removal in Washington, Vermont

Sponsor Study Number:				Stone Study Number: 20-007						
Described By : Matt Schley Recorded By: Matt Schley Vegetation: Dense, Wet-Tolerant Slope: Very Low (Floodplain)				Date: 11/	Date: 11/5/2020					
				Location	Location: Washington, Vermont					
				Topogra	Topographic Setting: Floodplain					
				Land use: Scrub/Shrub						
Comments	: ~65 degrees	F and sun	ny at time of sample; recent	snowmelt in	creased soil n	noisture conditic	ons			
Boring # H	IM-FP2									
Depth (ft)	Color	Mottles	USCS Classification	Moisture	Consistence	Boundary Distinctness	Comments			
0 – 0.5′	Dark Brown	F/1/F	SM (Silty Sand)	D/M	VFR	G	Some organic material throughout			
0.5 – 1.5′	Brown	F/1/F	SM (Silty Sand)	М	FR	G	Silt fraction declines with depth			
1.5 – 2.5′	Brown	F/1/F	SM (Silty Sand)	M/W	FR	G				
2.5 – 3'	Grey Brown	M/1/F	SP (Poorly-Graded Sand)	W	FR	G	GW Encountered @ 32" BGS			
Key:					Me	Moisture: m=moist, w=wet, d=dry				
Color: MunsellSoil Color Chart (1994) codes refer to Hue, Value & Chroma					Consistence: l=loose, fr=friable, fi=firm, vfr=very friable, vfi=very fir					
Mottles: Expressed as abundance/size/contrast					xfi	xfi=extremely firm				
Abundance: $t=tew;m=many;c=common$					Во	Boundary: Distinctness (D) g=gradual, a=abrupt				
Size: 1=fine;2=medium;5=coarse					ES	ESHGW = estimated seasonal high groundwater table				
Contrast: f=faint; d=distict; p=prominent					bG5= below ground surface					

https://stoneenvironmentalvt-my.sharepoint.com/personal/mschley_stone-env_com/Documents/Desktop/Project Documents/Hands Mill Geotech/HM-FP2 Boring Log.docx

Boring Log Form

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Hands Mill Dam Removal in Washington, Vermont

Sponsor Study Number:				Stone Study Number: 20-007					
Described By : Matt Schley				Date: 11/	Date: 11/5/2020				
Recorded By: Matt Schley Vegetation: Dense, Wet-Tolerant Slope: Very Low (Floodplain)				Location	Location: Washington, Vermont Topographic Setting: Floodplain				
				Topograp					
				Land use: Scrub/Shrub					
Comments	: ~65 degrees	F and sunr	ny at time of sample; recent	snowmelt in	creased soil r	moisture conditio	ons		
Boring # H	IM-FP3 (Most L	Jpstream)							
Depth (ft)	Color	Mottles	USCS Classification	Moisture	Consistence	e Boundary Distinctness	Comments		
0 – 0.5′	Dark Brown	F/1/F	ML (Silt with Fine Sand)	D/M	VFR	G	High organic material content throughout		
0.5 – 1.5′	Brown	F/1/F	SM (Silty Sand)	М	VFR	G			
1.5 – 2.5′	Grey Brown	F/1/F	SM (Silty Sand)	M/W	FR	G			
2.5 – 3'	Grey Brown	F/1/F	ML (Silt with Fine Sand)	W	FI	G			
Key:			1	М	Moisture: m=moist, w=wet, d=dry				
Color: MunsellSoil Color Chart (1994) codes refer to Hue, Value & Chroma					Co	Consistence: l=loose, fr=friable, fi=firm, vfr=very friable, vfi=very firm,			
Mottles: Expressed as abundance/size/contrast					xfi	xfi=extremely firm			
Abundance: f=few;m=many;c=common					Во	Boundary: Distinctness (D) g=gradual, a=abrupt			
Size: 1=fine;2=medium;3=coarse					E	ESHGW= estimated seasonal high groundwater table			
Contrast: f=faint; d=distict; p=prominent					BO	BUS= below ground surface			

https://stoneenvironmentalvt-my.sharepoint.com/personal/mschley_stone-env_com/Documents/Desktop/Project Documents/Hands Mill Geotech/HM-FP3 Boring Log.docx

Attachment 3: Phosphorus Loading Calculations

Hands Mill Dam P Removal Calculations

	Assume full sediment depth	Assume 10-cm sediment depth (active layer) ¹	Full sediment deph over floodplain bench	10-cm sediment depth over floodplain bench
Area of impounded sediment	0.34	0.34	0.41	0.41 acres
Area of impounded sediment	15000	15000	18000	18000 ft ²
Sediment depth ²	5	0.328	5	0.328 ft
Total sediment volume	75000	4921	90000	5904 ft ³
Sediment density (estimated)	100	100	100	100 lb./ft ³
Sediment mass	7,500,000	492,126	9,000,000	590,400 lb.
Sediment mass	3,401,943	223,225	4,082,331	267,801 kg
Sediment TP conc. (estimated) ³	311	311	311	311 mg P/kg sediment
Total P mass	1,058	69	1,270	83 kg
Bioavailable P fraction ¹	0.3	0.3	0.3	0.3 g/g
Total bioavailable P mass	317	21	381	25 kg

1. Constants assumed per preliminary guidance of ANR's P Capture by Natural Resources Restoration

Projects Workgroup (November 26, 2019)

2. Average 5-ft sediment depth over area of impoundment is an assumption based on impoundment

3. Assumed representative value (total P in impounded sediment behind Levesque Dam near East Montpelier, VT) from: Chalmers, A. 1998. Distribution of Phosphorus in Bed Sediments of the Winooski River Watershed, Vermont, 1997. USGS Fact Sheet FS-108-98.

Area of Impoundment Calculations

25	ft
600	ft
15000	ft ²
30	ft
600	ft
18000	ft ²
	25 600 15000 30 600 18000