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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 – Field Investigations and Modeling Summary Memo

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Stone Environmental, Inc. (Stone) has completed data review, field investigations, modeling and concept plan development at the Hands Mill Dam as part of the overall 30% design effort. This memo provides a summary of these efforts, including data sources, methods and results of field investigations and modeling, and a concept plan for discussion.

1. Introduction

The Hands Mill Dam is a partially breached stone and concrete structure located along the Jail Branch in Washington, Vermont. The Jail Branch runs over 8 miles from the dam north and northwest into Barre, where it converges with the Stevens Branch; the Stevens Branch then flows a similar distance northwest where it flows into the Winooski River in the southeast portion of Montpelier. The watershed area draining to the Hands Mill Dam location (at 44.10569, -72.43000) is 6.65 mi^2 (StreamStats, 2020). The majority of the watershed is forested, with only 3.7% of the watershed considered developed land (NLCD 2011 classes 21-24; StreamStats, 2020).

The visible portions of the dam measure approximately 12-16 feet high and 165 feet long. While the original construction date of the dam is unknown, the Town's Hazard Mitigation Plan states that construction of the dam was completed in 1860 (Town of Washington, 2013). The dam was reconstructed after the November 1927 flood, which included construction of new concrete components at that time. It was reported that a Mill was onsite as early as 1866.

The dam is a jurisdictional dam, meaning it impounds more than 500,000 cubic feet of water and sediment, and is therefore regulated by state statute 10 V.S.A. Chapter 43 under the state's Dam Safety Program. The dam is classified by the state as a Class 2, "Significant Hazard" dam. Per the latest Dam Safety Inspection Report (VTDEC, 2016), '*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*'. A revision to the Dam Safety Rules is now in effect as of August 1, 2020 with adoption scheduled for July 2022. Under these new rules, due to the potential loss of life associated with this dam, the status may be revised to 'High Hazard'. The current condition of the dam is poor, with continued deterioration and continued breaching during significant storm events. The current condition of the dam is discussed further under Task 2-1.

2. Field Investigations

Task 2-1: Review of Existing Data

Our review of existing dam data was limited to the data and files the Winooski NRCD had collected as part of the RFP process (Attachment G), septic system information for the house directly adjacent to the dam on river left, at 16 Woodchuck Hollow Road, also provided by the Winooski NRCD and the Towns Hazard Mitigation Plan. The Attachment G data consisted mostly of VTDEC Dam Safety Inspection Reports, dating from 2016 back to 1953. The VTDEC is expected to have a new 2020 Dam Safety Inspection Report available prior to the end of the year. Despite efforts to find additional documents online via internet searches, no additional data was found.

A review of the Dam Safety Inspection Reports indicates continued deterioration of the dam over the decades, specifically the downstream wall, crest of the dam and the concrete training wall. The following provides a summary:

- Downstream Wall - The wall is made up of concrete and large stones. Loss of stones was reported frequently over multiple reports. Reports of scour to the left of the spillway were also mentioned frequently. In the 2013 inspection report, it was reported that this area has '*deteriorated rapidly, probably as a result of TS Irene and recent high water*'.
- Dam Crest - The crest was consistently reported to be in poor condition. Reports stated it was covered with vegetation and signs of overtopping, erosion and evidence of a partial breach near the mid-section with fallen concrete at the dam bottom, in line with this location.
- Concrete Training Wall – The training wall to the right of the dam was reported as being consistently covered with vegetation with cracking visible at exposed sections.
- Reports of the dam in 'poor' or 'weakened' condition date back to inspections from 1953. The 1953 report states that '*the north wing wall has fallen down and water has started to erode the earth embankment behind it*', with additional reports of seepage through the south abutment.
- Suggestions by the state for repairs date back to the 1953 report, and suggestions for retaining a professional engineer to develop plans to either reconstruct or remove the dam date back to 2001.
- A hydrologic study in a 1975 report indicated that the 'East Orange Brook' watershed was used as a reference to develop peak flood estimates for recurrence interval storm events at the dam. Similarly, Stone selected the East Orange Branch USGS gauge for our hydrologic analysis; see Task 3.

Task 2-2: Infrastructure Stability Analysis

Stone conducted a preliminary infrastructure inventory and analysis using knowledge of the project site, publicly available information and state culvert and bridge inventories. Utilities investigated included stormwater, drinking water, wastewater and overhead utilities (i.e. electric and telecom), while infrastructure investigated included bridges, roadways, rights-of-ways and the dam itself. Following our review of this data, a total of four infrastructure items were thought to require additional review with respect to dam removal and potential stability and/or conflict issues. A summary of these items is provided in Table 1 below. The bridge dimension data provided in the table was obtained from the state inventories.

Table 1. Infrastructure of Interest Within the Project Vicinity

Item	Location	Location Relative to Dam	Ownership	Notes	Vulnerability
West Corinth Road Bridge	Jail Branch at West Corinth Road	Upstream	Town	Span 15’, width 28’ (in direction of flow)	Low
Woodchuck Hollow Road Bridge	Jail Branch at Woodchuck Hollow Road	Downstream	Town	Span 18’, width 26’ (in direction of flow)	Low
Roadways	West Corinth Road and Woodchuck Hollow Road	Those directly adjacent to project area	Town	West Corinth Rd. newly paved; Woodchuck Hollow Rd. gravel	Low
Water Hydrant	Corner of West Corinth Road and Vermette Lane	Upstream	Unknown	No record of potable water system in state GIS databases	To Be Determined

As part of the geomorphic survey, (Task 2-4) Stone staff collect bankfull width measurements of Jail Branch in a reference reach approximately 100 feet upstream of the West Corinth Road bridge. The average bankfull width was 23.4 feet. Considering the span of 15 feet listed in the state bridge inventory, the bridge span is 64% of the average bankfull width. The state standard for a road-stream crossing on this sized stream requires a crossing to be 100% of the bankfull width of the upstream reach that is out of the influence of the culvert. Although undersized when considering this standard, there are no obvious signs of significant scour along the bridge abutments under the bridge, and no significant signs of erosion on either bank directly downstream of the bridge. Additionally, at this preliminary stage we do not expect removal of impounded sediment behind the dam to result in any significant stream bed adjustments at this bridge, therefore we do not expect any stability or conflict issues at this bridge.

A similar analysis was performed for the Woodchuck Hollow Road bridge. The average bankfull width measurements along the main channel of Jail Branch, upstream and downstream of the dam was 33.1 feet, as discussed in Task 2-4. Considering the span of 18 feet listed in the state bridge inventory, the bridge span is 54% of the average bankfull width. This road-stream crossing is even more undersized than the West Corinth Road bridge, however similar to that bridge, Stone did not observe any signs of significant scour or erosion along the bridge abutments or directly downstream of the bridge, respectively. The reach just upstream of the bridge is well armored with natural cobble and boulders, and a masonry wall defines the left bank just upstream of the dam. Bedrock was also observed underneath the bridge right at the bridge outlet. These hard structures and natural armoring may be two reasons why significant erosion is not observed in the immediate area. Although, hard structures such as these typically do not dissipate flow energy well, and these structures might be contributing to erosive energy conveyed further downstream, beyond the bridge. This theory would be supported by the channelized, entrenched nature of the reach a few hundred feet downstream of the bridge. As discussed under Task 2-4, entrenchment ratios were calculated for reaches throughout the project area and this particular reach had the lowest ratio, indicating that the reach is significant disconnected from adjacent floodplains. Overall, at this preliminary stage, stability or conflict issues with respect to dam removal are not a concern at this bridge, as we do not expect dam removal or pilot channel creation to result in any significant bed adjustments or scour at this bridge.

The vulnerability and potential impacts to adjacent roadways and their embankments were also considered as part of this task. Because the floodplain associated with the impounded area butts up to both road embankments associated with West Corinth and Woodchuck Hollow Roads, this assessment was warranted. Having developed a preliminary limits of disturbance, and having reviewed a range of potential pilot channel slopes that provides insight as to the extent of impounded sediment removal, at this time we do not expect dam removal, impounded sediment removal or pilot channel creation to pose any stability or conflict issues with these roadways. We believe it is possible that the current elevations at the embankment toe of slopes will remain the same, and the project work can 'blend' into the limits of these roadways. We also do not expect there to be any significant channel work required where Jail Branch meanders into Woodchuck Hollow Road, at stations 4+00 to 5+00 (i.e. just upstream of the Woodchuck Hollow Road bridge), as shown on Sheet 2 (note that Sheets 1-4 are attached to the end of this memo). If any channel modifications are made at this location, it may include small adjustments to elevations as the pilot channel is expected to tie in to the existing channel in this area.

The final infrastructure item of concern at this time is the hydrant located at the corner of West Corinth Road and Vermette Lane. The hydrant is of an older type, and state drinking water infrastructure GIS data shows no potable water system in the area. Regarding the Town's municipal water system as outlined in the Washington Town Plan (Washington Planning Commission, 2013), '*Water from the* [town] *well is pumped up the Corinth Road to a 70,000-gallon concrete reservoir where it is gravity feed back to the distribution system*'. It still remains to be seen if there is any water system pipe running along West Corinth Road in the vicinity of the project. Stone has contacted the Town about this issue. While we expect that any watermain line would run within the right-of-way of the road and not within the limits of the impoundment, we'll plan to obtain information regarding the hydrant and system prior to finalizing 30% designs.

The following provides a summary of data sources that supported the assessment performed under this task. The majority of the information was obtained from the Vermont Center for Geographic Information (VCGI):

- Ortho imagery - 0.3 meter Color and Color Infrared (4-band) orthoimagery (leaf-off) from 2018 VT Orthos, obtained from the VCGI Imagery Program
- LiDAR - 0.7 meter Digital Elevation Model, hydro flattened derived from 2014 lidar data (QL2), obtained from the VCGI LiDAR Program
- Stormwater, Water and Wastewater utilities – Stormwater Infrastructure (point, area and line features); Stream Crossings; Wastewater Infrastructure (point and line features); Drinking Water Infrastructure (linear features) from the VANR GIS, Open Data website
- Bridges – Bridge inventories available from the state (https://vtculverts.org/)

Task 2-3: Vegetation Survey

During the topographic survey, Stone developed an inventory of trees over 3" diameter at breast height (dbh) within the limits of disturbance that may require removal during construction of the project. Table 2 provides a summary of those trees. Note that at this time the project design is at the conceptual level (i.e. 15% design level) and certain trees along the boundary of the limits of disturbance may or may not need to be removed, depending on the details of the final design. Because of this current uncertainty, the column 'Likelihood of Removal' has been included to capture the possibility of removal relative to final design.

Table 2: Vegetation Survey Summary

#	Species	Size (dbh, inches)	Location	Likelihood of Removal
1	Willow	32	River left, near parking area	high
2	White Birch	6, double	On top of dam	high
3	Pine	24	River left, on 16 Woodchuck Hollow Road property	medium
5	Maple	18	River right, ~station 9+00	medium
4	Pine	24	River left, ~station 10+00	high
6	Pine	20	River right, ~ station 10+50	low
7	Oak	20	River right, ~ station 11+50	low
8	Pine	18	River right, ~ station 13+50	low
5	Maple	18	River right, ~station 13+75	low
10	Maple	16	River right, ~station 14+00	low

Approximate locations of these trees are provided on Sheet 2. Some of the details in Table 2 above require refinements. Due to limited time during the topographic survey and other field work, and due to difficulty in accessing some of these trees due to dense floodplain vegetation, some of the information in this table is an estimate (i.e. dbh, species, etc.) and/or has been acquired by remote surveys. Refinements will take place prior to completion of 30% designs.

Task 2-4: Geomorphic Survey

Stone completed a limited geomorphic assessment of Jail Branch upstream and downstream of the dam, and along a reference reach on September 4th, 2020.

Basic Assessment

The first portion of the assessment consisted of collecting bankfull width and depth measurements upstream and downstream of the dam to determine entrenchment ratios of Jail Branch throughout the project area, and get a general sense of geomorphic conditions within the project area. Observations and measurements were obtained at six locations, three upstream and three downstream of the dam. The results of this initial geomorphic assessment are presented in Table 3. Station data is provided in Sheet 2.

Table 3: Initial Geomorphic Assessment Results – Project Area

Location	Distance Upstream from Dam (ft)	Bankfull Width (ft)	Bankfull Depth (ft)	Flood-Prone Width (ft)	Entrenchment Ratio	Channel Description
US3	13+35	43.5	3.4	337.5	7.8	pool head
US2	10+12	28.6	4.0	494.0	17.3	riffle
US1	9+27	32.7	4.1	280.2	8.6	riffle
DS1	4+32	30.4	5.3	145.2	4.8	step
DS2	2+28	28.6	6.1	78.3	2.7	riffle
DS3	1+78	35.0	3.3	47.0	1.3	riffle

Flood-prone widths were measured at an elevation equal to twice the bankfull depth at each location, using LiDAR and knowledge of the site. Entrenchment ratios were calculated by dividing the flood-prone width by the bankfull width. Per the Rosgen Stream Classification Technique (USDA, 2007) entrenchment ratios of greater than 2.2 are considered 'Slightly Entrenched', and are generally well connected to adjacent floodplains. The lowest entrenchment ratio was recorded at the furthest downstream location (DS3), where the channel is deep and channelized for a few hundred feet downstream of the Woodchuck Hollow Road Bridge. Moving upstream from this location, channel entrenchment is gradually reduced and the channel is more connected to adjacent floodplains. Overall, floodplain connection upstream of the dam is greater than floodplain connection downstream of the dam.

The average of bankfull width and depth measurements provided in Table 3 is 33.1 feet and 4.4 feet, respectively. The largest bankfull width value of 43.5 feet measured at the most upstream location (US3) could be considered exaggerated since it is just downstream of the junction between Jail Branch and the largest tributary to Jail Branch, discharging from the northeast. This junction is suspected to be a dynamic area during high flow events, with flow and sediment transport highly influencing bank full geometry in the immediate area. The average bankfull width of 33.1 feet matches well with the calculated bankfull width based on the Vermont Regional Hydraulic Geometry Curves, where a width of 30 feet, depth of 1.8 and an area of 51 ft^2 were calculated (VTANR 2006). The average bankfull depth of 4.4 feet does not compare well with the regional curves estimate, however. One potentially theory for this is that during large storm events, the presence of the dam causes backwater effects and a slowdown of floodplain waters in the impoundment, which has led to excessive settling of sediments on floodplain surfaces overtime. The 'building up' of those surfaces has increased floodplain surface elevations resulting in deeper bankfull depths.

Reference Reach Assessment

Additional geomorphic assessment work was performed in a reference reach. Stone staff identified reference reach conditions approximately 100 feet south of the culvert at Jail Branch and West Corinth Road during the topographic survey. From that point, the reach extends another 200 feet upstream along Jail Branch. Upon review of all reaches of Jail Branch and tributaries, this section of stream was selected as a reference because it was clearly out of the impounded area, it wasn't overly impacted by anthropogenic impacts, it visually seems to be in equilibrium and it includes a fair amount of habitat features in the bed (pools, backwatered areas, favorable bed substrate, etc.). On Sheet 1, the reference reach extends from about station 20+00 to 22+00 (south of West Corinth Road, and potentially extending past this station).

Stone staff characterized the stream bed, collected bankfull measurements and collected cross section data in the reference reach. Stream bed data included the delineation of bed habitat features (i.e. step, riffle, pool, run, etc.), bed feature length, width, elevation features and frequency. For instance, three pools were found within the reference reach, with an average length of 23', average width of 10.7' and max pool depth of 1.3'. The bed material within the pools consisted of 50% cobble with small boulders, and occasional large boulders providing cover and refuge for aquatic organisms. Key pieces, or small to large boulders that made up individual stone steps found in the reach, had an average intermediate measurement of 21 inches, among the 20 pieces that were measured. The roundedness of these stones ranged from rounded to angular, with the majority of pieces being rounded, while the embeddedness of the pieces in the stream bed range from 0 to 50% imbedded. Roughness boulders, or stones that aren't included in a bed structure but exist in a random nature throughout the stream bed, and tend to add more roughness to the channel, were also observed in the reference reach. They had an average intermediate measurement of 24.6 inches, a roundedness that ranged from rounded to sub-angular, and were imbedded in the channel within a range of less than 5% to 50%. Two pebble counts were performed in the reference reach as well. The purpose of these counts is to characterize the gradation of the bed material, or distribution of different sized stones within the bed matrix. A plot of the count date as a grain size distribution is provided as Figure 1.

Bankfull measurements were collected in the reference reach. Similar measurements were also obtained in the unnamed tributary to Jail Branch, conveying flow from the northeast. Table 4 below provides a summary of bankfull measurements from each reach, along with averages. Note that while the unnamed tributary was not used as a reference reach, this tributary did exhibit reference reach characteristics and could be further investigated as a reference reach if needed, during Phase 2 design.

Table 4: Initial Geomorphic Assessment Results – Reference Reach

Reach	Location	Bankfull Width (ft)	Bankfull Depth (ft)
Jail Branch Reference Reach	BF1	25.2	2.33
	BF2	25.8	1.8
	BF3	19.3	1.68
	Avg.	*23.4*	*1.9*
Unnamed Tributary	TRIB-BF1	18.2	2.22
	TRIB-BF2	17.9	1.84
	TRIB-BF3	20.2	1.68
	Avg.	*18.8*	*1.9*

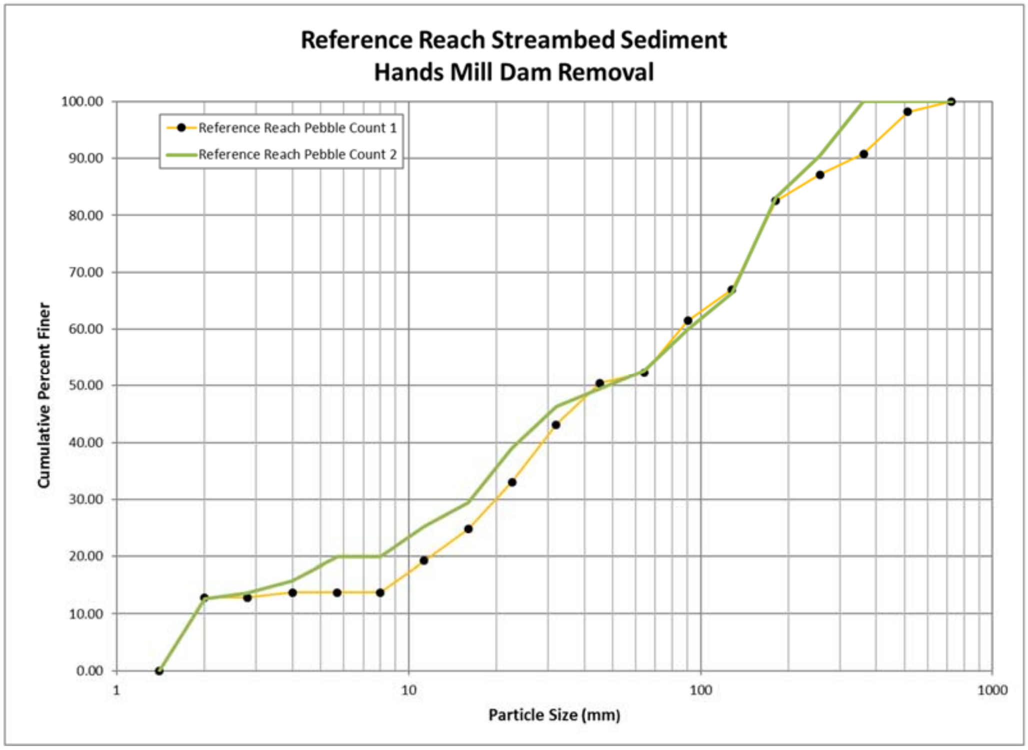

Figure 1. Grain size distribution plots for two pebble counts in the reference reach along Jail Branch.

Reference Reach and Pilot Channel Section

Cross section data was collected in the reference reach during the topographic survey. While the bankfull width and depth measurements at the reference reach were understandably smaller than those of the main channel discussed above in this section (due to a smaller watershed size), the reference reach section was 'scaled up', such that the bankfull width and depth of the pilot channel section match average bankfull dimensions for the main channel. While performing this scaling, Stone staff maintained the overall geometric ratios of the reference reach, specifically the depth from bottom bank to the overbank or adjacent floodplains. Reference reaches were well connected to adjacent floodplains, and this detail was maintained in the pilot channel section. Overall, the bankfull width set for the pilot channel cross section is 29 ± 2 feet, while the depth was set to approximately 2.5 feet. This is consistent with calculations based on the Vermont Regional Hydraulic Geometry Curves discussed above.

A bankfull width 'range' and an approximate depth are proposed to incorporate a reasonable amount of variability in the design to simulate conditions in the natural environment, such that the project doesn't look 'constructed' following implementation. Variability in constructed channel width and depth should facilitate channel diversity, complexity of channel bedforms and ensure an abundance of aquatic habitat. The proposed pilot channel cross section is provided in Sheet 4 as the 'Typical Channel Cross Section'. Note that at this time only one pilot channel cross section is provided since the types of lands along the overbank in the reference reaches is consistent over significant lengths of reference reach conditions (i.e. floodplain with little to no wetlands present along the overbank). Additional cross sections can be considered in Phase 2 if wetlands will be anticipated adjacent to the pilot channel.

Task 2-5: Topographic Survey

Stone staff mobilized at the site on August 11 and 12, 2020 to perform the topographic survey. A GPS base and rover were used 1) to set control points throughout the project area to establish horizontal and vertical control, 2) to collect longitudinal profile and cross-section data upstream and downstream of the dam and 3) to collect details of structures such as the dam, bridges, infrastructure and utilities.

Stone established four control points throughout the site, all of which were established in the vicinity of the dam and downstream bridge. Locations and descriptions of control points are provided on Sheet 2 and were set in road pavement, at utility poles and at the downstream bridge headwall. As a quality control measure, Stone regularly checked back to control points to assess equipment precision and data accuracy. Any discrepancies found to be over 0.1 feet resulted in resurveying of relevant data.

The extent of the survey data is shown on Sheet 1. Approximately 2,200 feet of longitudinal profile was collected along Jail Branch, including reference reaches upstream of the site, down to a few hundred feet beyond the bridge at Woodchuck Hollow Road. Approximately 500 feet of longitudinal profile of the unnamed tributary to Jail Branch, conveying flow from the northeast was surveyed, along with two additional tributaries conveying flow from the west up to Vermette Road. Typical features collected as part of the longitudinal profiles specific to fish habitat included top and bottom of steps, pool head and tail crest, maximum pool depth, riffle head and tail, etc. Longitudinal profile data is used to define reach slopes, which is a primary dataset in designing the pilot channel; therefore a large amount of this data was collected as part of the survey.

Additional cross section data was collected along the main channel within the project area, including top of bank, bottom of bank, thalweg, bars and other bed features. The dam was surveyed and detailed, and roads and utilities were also located during the survey. Where Stone was unable to access land to survey, we combined our survey data with LiDAR data made available by the State.

Stone staff uploaded the survey data into AutoCAD to develop the project basemap, which included a 3-dimensional surface (i.e. triangular irregular network, or TIN) of the project site and development of 1-foot contours based on the TIN. A longitudinal profile along the thalweg of the stream channel is provided on Sheet 4.

Task 2-6: Sediment Probing

Probing Methods

On August 26, 2020, Stone performed sediment probing within the impoundment, from directly behind the dam to approximately 130 feet upstream using an extendible steel tile rod. Probing was completed at 15 locations as shown on Sheet 3. At each location, the steel tile rod was advanced into the streambed by hand or driven into the streambed using a hammer, depending on the difficulty advancing the probe into the bed sediment. When the steel rod was unable to be driven further into the streambed, the nature of refusal, including resistance, vibrations, and audible cues, were noted.

To compare the probing depths to the bottom of the dam elevation and to ultimately assess the potential for AOP following dam removal, a temporary datum of 0.0' was set at the impoundment water surface. The bottom of the dam relative to this datum measured approximately 11-13' down, along the face of the dam. Therefore, at any probing location where we were able to drive 12' or more of rod under the water surface, we considered the tip of the rod to be approximately even with, or below, the bottom of the dam.

At each probing location, in addition to refusal data, the total rod depth from the water surface to refusal was measured and recorded. Water depths were also recorded at each location, in addition to positioning data used to plot the locations (see Sheet 3).

Probing Results

Overall, exploratory probing provided insight into refusal elevations and the nature of refusal immediately upstream of the dam. The results at each location are summarized in Table 5.

Where vibrations and audible cues indicated refusal via bedrock at a few locations, a lack of refusal at other locations indicated either 1) the absence of bedrock and/or an AOP barrier or 2) a different type of material at depth that would require additional driving of the probing rod. At many of these locations, substantial hammering and effort would typically only result in a half inch, or inch advancement over time. And at a few locations that followed the thalweg, suction force (in the presence of muck) or resistance force (in the presence of sand/gravel) posed major challenges in retrieving the probing equipment, and therefore some explorations were abandoned for fear of losing equipment. When a probing location was abandoned, a new probing location was attempted close by in order to eliminate any data gaps.

Overall, Stone staff attempted to drive the probe to 12' below water surface to confirm a lack of bedrock and/or barrier at the estimated bottom of dam elevation. While the results in the table indicate that there seems to be a path upstream of the dam where bedrock and/or barriers are not present down to the bottom of dam elevation, it's important to understand that the probe diameter used for the explorations is approximately ½" in diameter and the accuracy of this data should be considered coarse, with limitations based on the equipment used and density of explorations.

Table 5. Probing Results Upstream of Dam

Probe ID	Water Depth (ft)	Description	Height Above Dam Bottom (ft)
P-1		No data – equipment malfunction	
P-2		No data – equipment malfunction	
P-3	3.15	No refusal, hard sand layer (?), abandon	5.85
P-3-2	3.18	Refusal, boulder/bedrock	4.8
P-4	3.16	Refusal, boulder/bedrock	4.5
P-5	2.15	No refusal, muck, abandon	3.3
P-6	2.56	No refusal	**-0.31**
P-7	2.45	Refusal, no boulder/bedrock, but hard layer	8.45
P-8	0.92	No refusal	**0.00**
P-9	2.34	Refusal, sand/debris	3.98
P-10	1.75	Refusal, sand/debris	8.89
P-11	1.75	No refusal	3.08
P-12	0.37	Refusal, boulder/bedrock	1.94
P-13	2.32	No refusal, muck, abandon	3.14
P-14	1.4	No refusal	**0.55**
P-15	1.94	No refusal	**0.27**
P-16	2.05	No refusal	**0.43**

Recommendations for Potential AOP

Further inspection of the data indicates the path from P-6 and P-8 at the dam, extending upstream to P-15, P-16 and P-14 indicates that there are areas at depth with no obstructions at the bottom of dam elevation. It should be noted however, that explorations just upstream of the dam (i.e. 5-10 feet upstream) at locations P-7, P-9 and P-10 indicated refusal due to hard layers and/or debris. While probing results like this are expected along the perimeter of a dam, due to potentially variability in dam construction and dimensions, our probing efforts cannot confirm what the dam is directly built on. In other words, bedrock or an AOP barrier may still exist just under the dam structure or within a few feet of its perimeter. Confirmation of what the dam was built on can potentially be confirmed via ground penetration radar (GPR) surveys, or via dam removal during the construction phase. For the purposes of this conceptual memo, Stone has confirmed that there seems to be a path with no obstructions at the bottom of dam elevation, from about 15 feet behind the dam upstream approximately 125 feet, to the visible portion of the training wall along river right.

Task 2-7: Impounded Sediment Characterization

Impounded Sediment Volume Estimate

Stone estimated the volume of impounded sediment wedge behind the dam based on 1) the topographic survey data, 2) the probing data and 3) the use of the proposed pilot channel slope and section, as a proxy for the historical channel. The topographic survey data was used essentially as the existing, or current surface, while the probing depths and proposed pilot channel section was used to mimic the channel that existed prior to dam construction. We thought using the pilot channel slope and section as a proxy to the relic channel was feasible since it is set to a slope that is very similar to adjacent reaches, and also matches bankfull dimensions of adjacent reaches. This methodology should do a fair job in estimating the wedge of impounded sediment behind the dam, in the channel and immediate bank areas.

Additionally, in order to estimate the amount of impounded sediment that may have settled on relic floodplains, Stone made additional considerations. Upon inspection of the existing conditions surface provided on Sheet 1, there seems to be a substantial amount of floodplain along river left within the project area, while on river right the contours seem to slope gently from uplands towards the river right bank of the Jail Branch. While at this time we do not have data with respect to pre-dam floodplain elevations along either bank, one can assume that prior to dam construction, much of the natural floodplain area for this system within the project area existed along river left, and due to the impounding nature of the dam, over approximately 160 years this natural floodplain filled in with sediment to some degree, similar to the channel. In order to account for settling of sediments not only in the channel, but in the floodplains as well, for this conceptual calculation Stone revised the pilot channel cross section to include an 80 foot wide floodplain bench. Using the pilot channel slope and this altered section as a proxy for the historical channel and floodplain area, for the purposes of this calculation only, we estimate that a total of 14,300 CY of impounded sediment exists behind the dam, above the relic channel and within the historic floodplains along river left. The limit of impounded sediment, based on our interpretation of the bed sediment, topographic data and sediment wedge, is at approximate Station 13+25, and is indicated by a note on Sheet 3.

Volume Potentially Released During an Uncontrolled Failure

With respect to the amount of material that may be mobilized during an uncontrolled failure, based on this conceptual level of this study, and lack of a project sediment transport model, this can be difficult to estimate. However, if we make the assumption that the sediment transported will be limited to the impounded area and the stream will want to ‘find’ a stable slope during a hypothetical large storm event, we can assume that the channel will headcut back to approximate station 14+00, or the limits of our proposed pilot channel.

Assumptions regarding the amount of dam failure are required as well. Considering the dam removal alternatives presented under Task 4-2 below, we can assume that the extent of dam failure is equal to the median value of proposed dam removal, or 94 linear feet of dam failure.

While the extent of potential headcut matches the upstream limit of our pilot channel construction, and since the extent of dam failure matches Alternative A3, which is the alternative evaluated for this memo, for the purposes of this exercise we'll make the conservative assumption that the amount of material that may be mobilized during an uncontrolled failure is equal to the amount of material we proposed to remove as part of Alternative A3, or 11,100 CY. The details of proposed sediment removal for this alternative are discussed further under Task 4-1.

Note that the assumptions made to support this calculation are arbitrary and were only made to develop a rough conceptual idea and estimate of potential material that could move beyond the dam given a dam failure. In the event of a failure, many different variables would be at play and a number of different factors could lead to a wide range of release scenarios.

Volume Released During and After Dam Removal

Similar to other dam removal projects in Vermont, this project will be required to file for a state Stream Alteration Permit, a US Army Corps of Engineers Vermont Category 2 General Permit, and other similar permits, where the prevention of sediment transport to downstream reaches is of primary concern. These permits will require the contractor to have erosion protection and sediment controls in place prior to any work; will require that a plan be in place for bypassing flows around the work area; and may require staged land disturbance to ensure limitations on concurrent disturbances of soils. However even with these controls in place, there will be a small amount of sediment that may bypass these controls and be transported downstream. Based on our experience with dam removals, the transported amount can usually be considered negligible, or, as a temporary negative impact (i.e. lasting hours to days) that is out-weighted by the long term gain (lasting years to decades) realized by the completion of a large dam removal and/or restoration project, where the work included restoration of geomorphic functions, floodplain connectivity, aquatic organism passage, etc.

Reviewing the text and calculations presented thus far in this section, the theoretical quantity of sediment that could be released after dam removal would be the total impounded sediment volume of 14,300 CY minus the quantity of sediment proposed for removal as part of the conceptual design (11,100 CY for A3), or 3,200 CY. However, with regards to the pilot channel 'Typical Channel Cross Section' as shown on Sheet 4, final design will incorporate the establishment of vegetation and erosion controls that will help to stabilize any impounded sediments that will remain behind, as part of the proposed final design grading system. The vegetation selected should not only be native, but relatively quick growing, and including rooting systems that will ensure soil stability over the long term and life of the project. Observed by Stone staff during field work, there are robust stands of willow onsite, within the floodplains and along the stream banks. The revegetation plan should undoubtedly include use of existing onsite willow stakes, in addition to other native species on new surfaces to ensure quick establishment of deep rooting vegetation. Erosion control fabrics made of natural fibers (i.e. coir or coconut fiber matting) can also be used along new surfaces to promote new surface stability while vegetation takes time to root and establish.

Realistically speaking, any sediment released following dam removal will most likely be significantly below the amount calculated in the paragraph above (3,200 CY) with the expectation that the design and vegetation establishment will be successful. More appropriately, the potential quantity to mobilize will be dependent upon any channel adjustments the system might go through as a result of dam removal and pilot channel construction. For example, if following dam removal the Jail Branch attempts to find equilibrium by moving significantly further into a meander bend that was part of the final design, creating an eroded bank resulting in sediment conveyed downstream, the released quantity can be estimated from the amount of soil loss at the meander and quantified by field measurements. Given the tendency of these natural systems to adjust, the design/construction tolerances and limits on construction funding, post-project adjustments are common and almost inevitable. Predicting their quantity in terms of sediment volume, however, is difficult in any design stage.

Overall, if the pilot channel is designed at a slope that matches adjacent channel slopes, within reason (i.e. +/- 25% of adjacent slopes), and stabilization of disturbed surfaces (i.e. banks, floodplain surfaces, slopes, etc.) is successful, the majority of sediment conveyed after dam removal should equal the bed load of the fluvial system. Additions to that quantity are possible if there are post-project channel adjustments that result in bed, bank or floodplain surface erosion, as discussed in the preceding paragraph.

Bed Sediment Observations

On September 4th, 2020, Stone mobilized onsite to collect sediment samples. Stone collected 5 sediment grab samples within the limits of the impoundment to characterize the quality of impounded sediment. The samples were collected in a linear fashion throughout the impoundment, and samples were collected from visibly distinct, or different bed material types. The sample locations were located via GPS and are shown via green square symbols and text on Sheet 3. Stone staff waded to each sample location and used a shovel to collect sediment samples from the first 6 inches of depth. Samples were placed in appropriate jars and bags, placed in a cooler with ice, and sent to the University of Vermont Laboratory for grain size distribution (ASTM D6913) and total phosphorous (EPA 3050B). While we anticipated having lab results by the writing of this memo and planned on discussing the results, the laboratory has yet to provide results and therefore they are not included. As soon as they are received, Stone plans to share the results with the project group.

At two of the five sediment sampling locations, samples included a mix of large material (i.e. cobble, gravel down to fine sand) along with smaller material (smaller than fine sand). Stone performed pebble counts at these two locations, and the count data will be appended to the grain size distribution data once received by the lab. In addition to the sampling, Stone recorded observations of bed sediment while wading upstream. Table 6 provides a summary of those observations:

Table 6. Summary of Bed Sediment Observations

Sampling Station	Dominant Particle Size (inches)	Bed Sediment Observations
HM-S1	Silt to fine sand	The finest/smallest material in the impoundment; dark brown to black color
HM-S2	Silt to coarse sand	Very little to no gravel
HM-S3	Coarse sand, trace silt	Very little to no gravel
HM-S4	Medium gravels	Midchannel bar and beaver dam upstream of this area
HM-S5	Gravel and cobble	Bed looking more like reference reaches; most likely limit of impoundment
HM-S6	Medium gravels	No sample

Sediment Quality Analysis

During collection, Stone observed the sediment and sampling location for visible and olfactory cues for any contamination. None of the samples exhibited any sheens, films or other visible signs of contamination, and there were no odors, beyond the typical organic/sulfur smell associated with the fine sediments that exist behind the dam. Stone continued the sediment quality analysis by performing a desktop review of past and present land use in the watershed, and also a review of state websites that provided publicly available information regarding known contaminated sites. Specifically, Stone created a GIS project and imported a high resolution land cover data set (developed by the Vermont Spatial Analysis Laboratory; published 2019), in addition to a hazardous sites layer downloaded from VCGI (updated 2016). A review of the current and historical land use, and a lack of any contaminated sites within the watershed provided no reason to pursue additional sediment quality analyses in Phase 2 of this project.

We had intended to utilize the sediment sampling data, specifically the grain size distribution results to further determine whether additional analyses would be required. This intention was based on whether the impounded sediments were predominantly silts and/or clays, understanding that finer particles are more likely to retain chemicals compared to medium to coarse sands. The sediment sampling results are not yet in hand, so this portion of our analysis has not been completed. However, since our land use analysis did not produce any significant sources of contamination within the watershed, at this time we feel there is still no reason to pursue additional analyses.

Sediment Management Plan

At this conceptual level, our plan for managing sediment associated with dam removal consists of the following items:

1) Impounded Sediment - Complete 30% pilot channel design (profile, planform and section) and finalize sediment removal quantity
    a. Obtain grain size distribution results from lab for five sediment samples; complete characterization of surficial impounded sediment, to support disposal/reuse plan
    b. Phase 2 to include determining either disposal sites and/or beneficial users of excavated sediment; also include plan for trucking relative to safety and neighborhood impacts
2) Potential Volume Release During Construction – Phase 2 design to include input from Agencies via permitting process, and inclusion of sediment transport controls (i.e. EPSC, flow bypass, etc.) in design and to be implemented during construction
3) Potential Volume Release After Construction - Complete 30% design for pilot channel section, specifically long term vegetation establishment design for floodplain surfaces and slope stabilization

The details of this management plan will be further fleshed out during completion of 30% designs and during Phase 2 designs, as appropriate.

3. Modeling

Task 3: 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 due (61 years), its comparable watershed size (8.8 mi^2), proximity to the site, location along an unregulated stream and the fact that it is still 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 7.

Table 7: 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 8.

Table 8: 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. 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 conceptual design, each steady flow analysis was completed using a subcritical flow regime, which is well suited for preliminary dam removal evaluations. For the final 30% design deliverables, if warranted we will consider using a mixed flow regime, which is suitable for situations where flow may pass through subcritical to supercritical or supercritical to subcritical regimes. 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 proposed conditions models. For the purposes of this memo, the model began after the junction of Jail Branch and the Unnamed Tributary and a constant discharge was used throughout the system. For the final 30% design deliverable, the model will be modified to include the tributary junctions and incoming flows will be apportioned to each tributary based on tributary watershed size. Table 7 lists the peak flow conditions simulated and Table 8 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 2.

Proposed Conditions Hydraulic Analysis

For this memo, Stone developed a one-dimensional hydraulic model to simulate flow conditions for Alternative A3. The other alternatives (as listed under Task 4-2) will be run as part of the 30% design effort and results will be provided in the final 30% design report. The model for Alternative A3 was developed based on approximately 94 linear feet of dam removal, the extents of which are shown on Sheet 3. 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 4 (see dashed blue line in the profile at top of sheet) and the dimensions of the Typical Channel Cross Section also provided on Sheet 4, which includes bank stabilization measures and incorporation of a 30' wide floodplain bench along river left (green shaded area on Sheet 3).

With respect to dam removal, the following three scenarios have been developed as part of the alternative's analysis (Task 4-2). As discussed above, only A3 was modeled for the purposes of this memo:

1. Alternative A1: No Action.
2. Alternative A2: Removal of 44 linear feet, including the embankment section and principal concrete spillway.
3. Alternative A3: Removal of 94 linear feet, including the embankment section, principal concrete spillway and 50 linear feet of the concrete/stone wall. This would remove all of the concrete/stone wall and only leave the concrete training wall in place.
4. Alternative A4: Removal of the entire dam (165 plus any dam portions that are buried).

Table 9 below provides a comparison of the 100-year recurrence interval flood water surface elevations at the dam for the existing condition and Alternative A3. Figure 2 provides a plot of water surface elevations for the existing condition and proposed condition, for Alternative A3. Note that the stream thalweg for the existing condition is black, and the thalweg for A3 is pink.

Table 9: Water Surface Elevation Comparison for the 100-Year Recurrence Interval Flow

Scenario	100-yr WSE (ft)	Linear Feet of Dam Removed
Existing	1281.16	0
Alternative A1	1281.16	0
Alternative A2	TBD	44
Alternative A3	1266.13	94
Alternative A4	TBD	165

Abbreviations: ft = feet; WSE = water surface elevation
Date and Author: 09-15-2020 / GMB

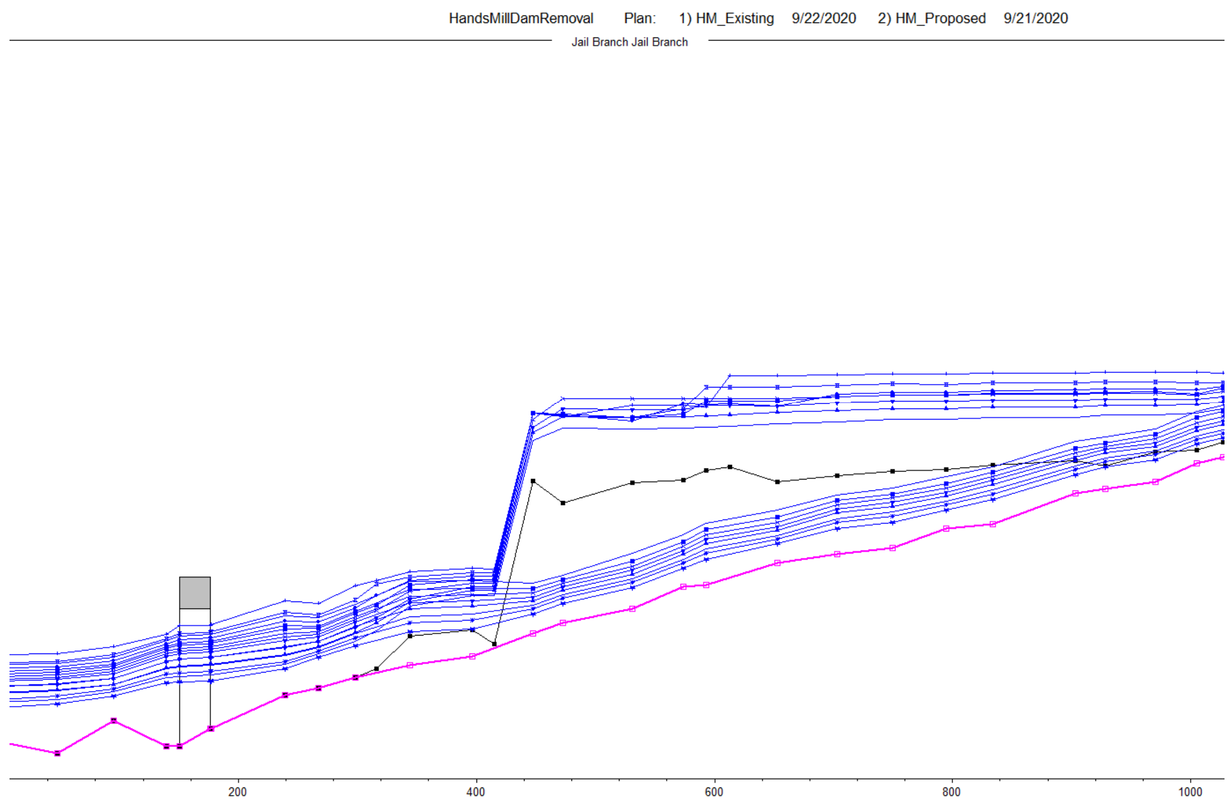

Figure 2. Profile of HEC-RAS output showing water surface elevations for existing and proposed conditions. Water surface elevations (blue lines) that follow pilot channel thalweg (pink line) are storm peak flow water surfaces following dam removal.

While Alternatives A2 and A4 still need to be run, it is evident that most removal scenarios should provide significant improvement and reduction in water surface elevations compared to those of the existing condition. While Scenario A3 provides an improvement in water surface elevation (i.e. >15' WSE reduction) for the median amount of dam removal, we expect that Alternatives A2 and A4 will produce water surface elevation reductions in proportion to the amount of dam removed. As we move through the 30% design, in addition to cost optimization considerations that will be part of the Benefit Cost Analysis (BCA), we'll also consider public safety, as well as both long term channel and structure stability when considering the most appropriate alternative.

4. Field Investigations and Modeling Summary Memo

Task 4-1: General Concept Design

Stone developed a concept designed based on characteristics of the reference reach, keeping in mind infrastructure constraints throughout the project area, maintenance of floodplain connection, construction access and reasonable construction costs.

Based on inspection of the longitudinal profile developed from the topographic survey, the average slope of the reference reach was 1.5%. A similar average slope of 1.7% was observed in the unnamed tributary. Using the more conservative slope observed in the reference reach, a slope of 1.5% was used as a basis of design for the pilot channel.

Typical of other dam removal and channel restoration projects, a downstream starting point, or tie in point where the pilot channel would begin was required. As shown on Sheet 4, there is a large sediment wedge just downstream of the dam. This material consists of medium to large sized boulders that is most likely comprised of dam material that has broken off over the past few decades, material that has been transported downstream and over the dam during large storm events, and native surficial material that has been exposed due to high erosive forces. We expect that this material is immobile in this location except during extreme storm events. Because most of this material is sourced from the dam itself and its presence in this location is not geomorphically appropriate, we proposed to remove the sediment wedge material and tie in the pilot channel just downstream of the wedge, at the first downstream grade control at approximate station 5+08. It is estimated that the sediment wedge is made up of approximately 550 CY and it's anticipated that this material will be incorporated into other parts of the design (as stone steps, bank stabilization, etc.).

Continuing upstream with a series of riffles and 1' stone steps at an average pilot channel slope of 1.5%, the pilot channel meets the existing channel bed at approximate station 14+00. This conceptual design results in a total of 7 stone steps and riffle sequences ranging from 70-140 feet long.

The pilot channel in cross section would follow the 'Typical Channel Cross Section' as shown on Sheet 4. The pilot channel cross section design includes bankfull dimensions as discussed earlier, a 30' wide floodplain bench along river left and will slope up from that bench back to existing grades, at an approximate 2:1 (H:V) slope. The floodplain bench would be planted with native vegetation and the 2:1 slope would also be planted with similar vegetation and stabilization measures (i.e. live stakes, fascines, etc.). For this concept design, the floodplain bench was maintained along river left due to the proximity of residential housing, the Town yard and natural grade features that exist along river right. As discussed under Task 2-7, construction of this cross section over the extents of channel restoration results in an estimated impounded sediment removal volume of 11,100 CY.

The concept plan also includes approximately 94 linear feet of dam removal, including the embankment section, principal concrete spillway and 50 linear feet of the concrete/stone wall. This would remove all of the concrete/stone wall and only leave the concrete training wall in place. The total amount of dam material to be removed is estimated at 286 CY. Total material cuts at the dam are estimated to range from 12-14 feet.

Sheet 3 also shows an approximate proposed pilot channel right top of bank in the vicinity of the dam. While this boundary is conceptual, it connects the upstream right bank with the same bank downstream, while taking into account the proximity of the Town yard and existing grades. Overall, the geometry of this concept pilot channel in the vicinity of the dam, particularly the planform is not geomorphically consistent with the planform of Jail Branch outside of the project area. As we move through 30% design, Stone will consider adjustments to planform in the dam area and will consider channel realignment, in order to achieve a planform that is more natural and consistent with reaches in and out of the project area.

1.1.1. Task 4-2: Alternatives Analysis

Based on field work, modeling and concept design development performed thus far, Stone has developed the following project alternatives:

- A1 - No Action – The dam and impounded sediment remain in place. Given the trajectory of historical inspections and current state of the dam, the potential for dam failure would be expected to increase over time.
- A2 - Removal of 44 linear feet – Includes the embankment section and principal concrete spillway only. While this alternative would not allow the continuance of a floodplain bench through the dam area, this alternative is included for comparison purposes.
- A3 - Removal of 94 linear feet – Including the embankment section and principal concrete spillway, and 50 linear feet of the concrete/stone wall. This would remove all of the concrete/stone wall and only leave the concrete training wall in place.

- A4 - Removal of entire dam - 165 linear feet plus any dam portions that are buried. This alternative may be required if cuts in the dam area are deep enough (i.e. ~12 feet) such that the concrete training wall is undermined, and would not be stable over the long term.

While Alternative A3 was run through the hydraulic model for the purposes of this memo, A2 and A4 will also be run through the model as part of the 30% design effort. And while all alternatives were not modeled for this memo, we were able to develop costs for each alternative, based on quantities calculated. Table 10 below provides a summary of the typical engineering opinion of probable costs (OPCs) for each alternative, in addition to life cycle costs calculated per Attachment B of the RFP.

Table 10: Summary of Costs for Alternatives

Alternative	Typical Engineering OPC ($)	Life Cycle Costs ($)
A1	$0	$0
A2	$340,100	$181,843
A3	$372,000	$193,442
A4	$405,400	$205,560

Date and Author: 09-21-2020 / GMB
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The OPCs have been developed to the 15% design level. They include volumes for concrete and sediment removal, and other quantities estimated from the drawings and knowledge of the site. We've used unit costs based on 2-year average unit cost data maintained by VTrans (http://vtrans.vermont.gov/cost-estimating), and unit costs from recent construction projects for similar bid items. Per standard cost estimating methodologies developed by the US Army Corps of Engineers, the OPC includes a 20% contingency to account for unforeseen construction costs related to site conditions, variability in pricing, etc. Also per Corps standards, as the project advances through subsequent design refinements and estimates of costs become more certain, the contingency will be reduced down to 10% for the 100% design submittal. The costs also include mobilization/demobilization costs, estimated at 10% of the construction costs. These costs do not include final design engineering fees, permitting or bid phase services (however those costs will be provided in the final 30% design report).

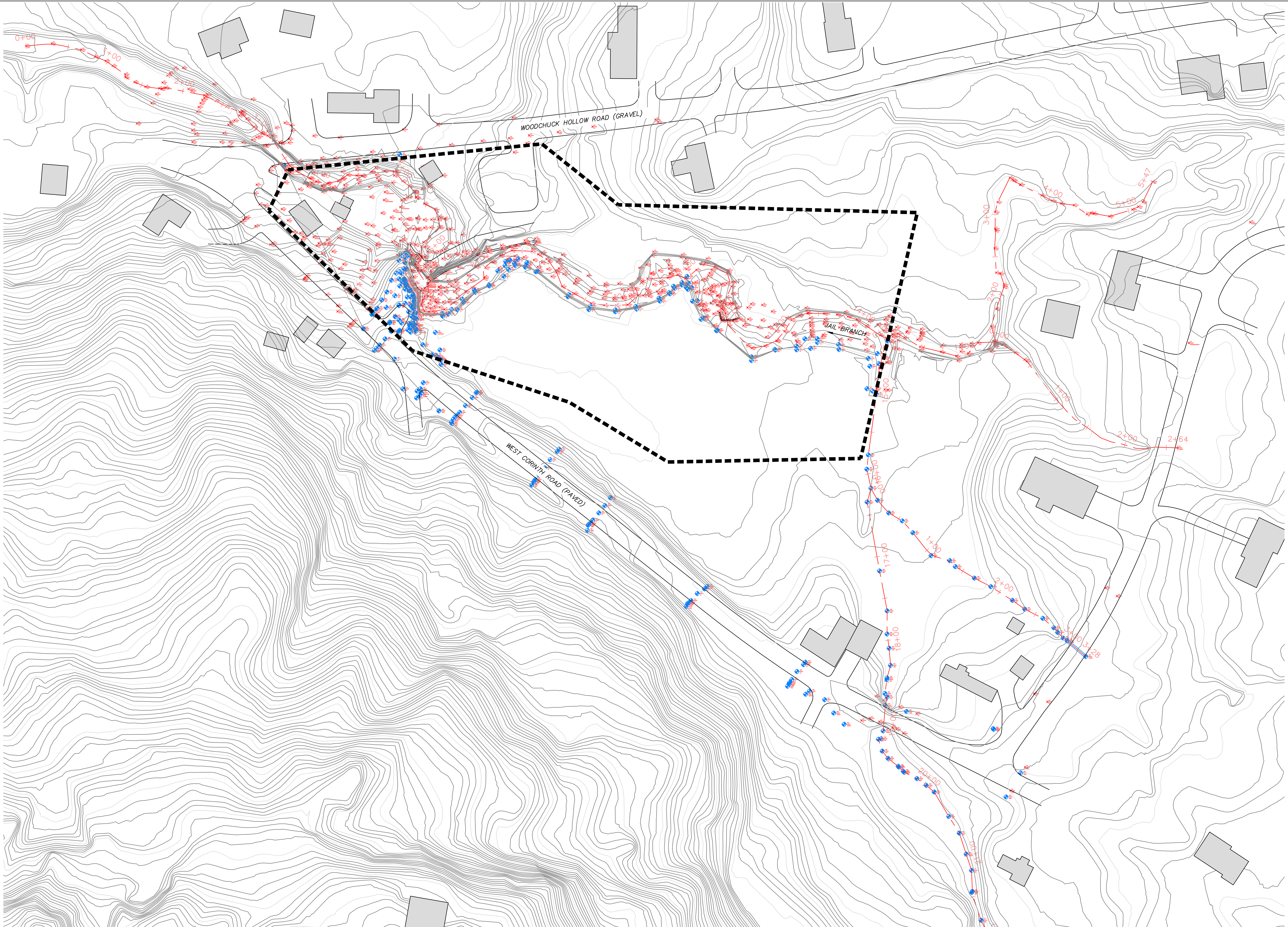
Life cycle costs were based on Attachment B to the RFP, and the United States Department of Agriculture Rural Utilities Service Bulletin 1780-2, Preliminary Engineering Reports for the Water and Waste Disposal Program, as provided on the state's State Revolving Fund website (https://dec.vermont.gov/water-investment/water-financing/srf/srfstep1/PER). Life cycle cost analysis (LCCA) consists of adding all initial and ongoing costs of the project over the life of the project, subtracting the salvage value of the project at the end of that time, and adjusting for inflation. With regards to annual costs, Stone assumed an annual cost of $2,000 to account for vegetation establishment and/or management, over an assumed 20 year project life. We also assumed $5,000 of 'repairs' every five years of the course of the project, accounting for any repairs or stabilization that may be required due to channel adjustments or any other unforeseen issues.

Although not included here, as part of the proposal we suggested that a phased removal be considered as a dam removal alternative. In this approach, a contractor would mobilize to the site 2-4 times total, typically once per year, and remove a portion of the dam, allowing a portion of the impounded sediment to move downstream over the course of that year. This approach might be more appropriate for impounded sediments that are more coarse, as compared to very fine sediments that may negatively impact downstream biota, with the repeated releases. As part of the final 30% design effort, Stone could evaluate this option to see if it would result in reduced construction costs, compared to a typical removal project that involves the excavation and hauling of the impounded sediment. It should also be noted that this approach has been considered for other Vermont dam removals and regulators are familiar with the approach. This alternative can be pursued pending discussions with the Winooski NRCD and stakeholders, and results of the sediment analysis.

5. References

Town of Washington Planning Commission, 2013. Washington Town Plan. Adopted by the Board of Selectmen, November 12, 2013.

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



Site Plan
Scale: 1" = 60'

Legend

- 1280 Major Contour
- 1275 Minor Contour
- Edge of Road
- Proposed Limits of Disturbance

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FILE:

DRAWING CREDITS

DRAWN ON: 9/4/2020
DRAWN BY: BAM/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

60 0 60 120 240 ft
12 0 30 60 m

1 inch = 60 feet
(1 : 720)

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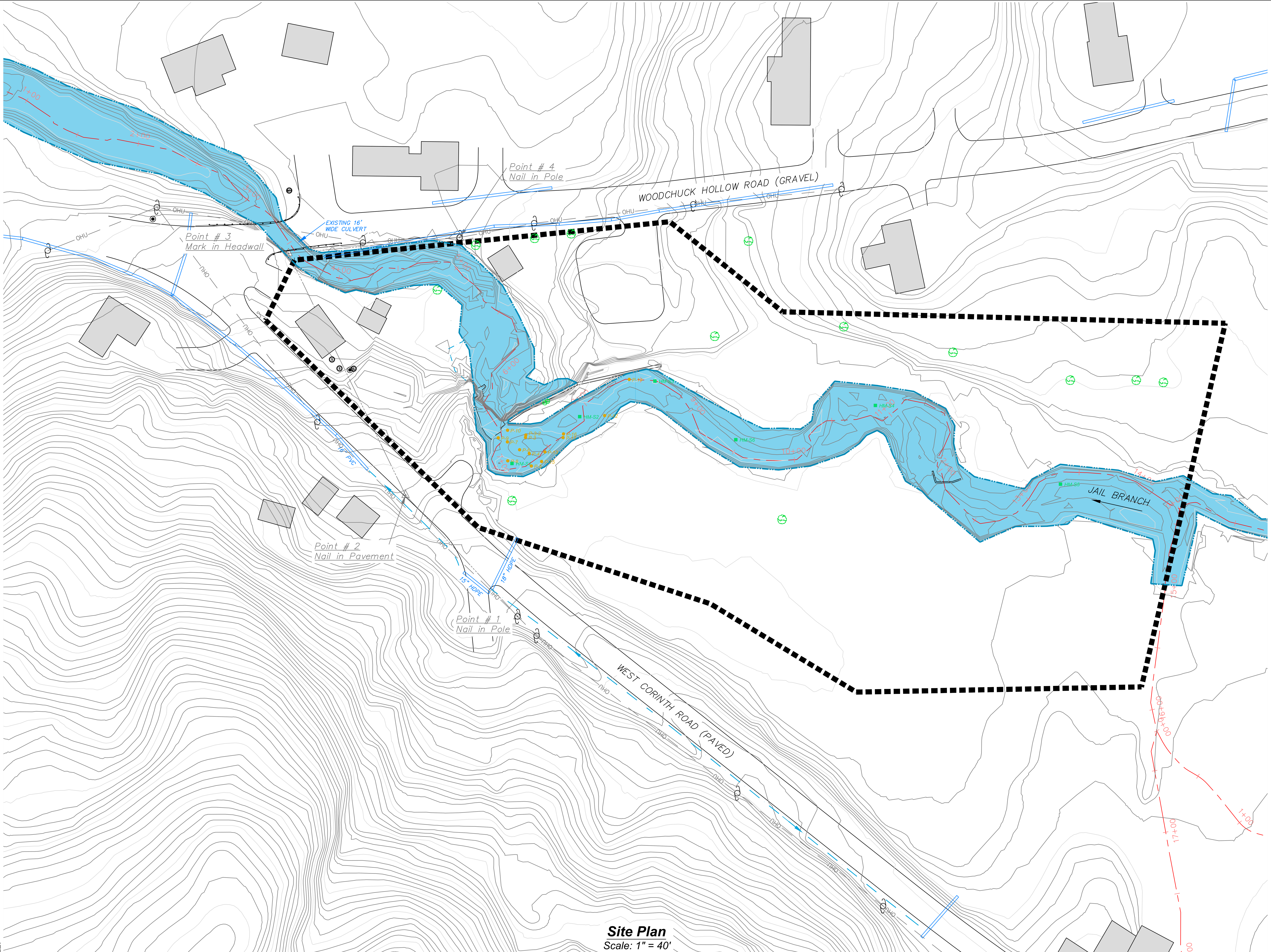
HANDS MILL DAM REMOVAL
AT JAIL BRANCH
SURVEY EXTENTS PLAN AND LIMITS OF DISTURBANCE

WASHINGTON VERMONT

FIGURE NO.

1



Legend

- Survey Control Point
- Major Contour
- Minor Contour
- Parcel Boundaries
- Edge of Road
- Guard Rail
- Overhead Utility
- Tree
- River Top of Bank
- Thalweg Spot Elevations
- Utility Pole
- Manhole
- Sanitary Manhole or Septic Cover
- Well
- Vent
- Hydrant
- Water Valve
- Stormwater Pipe
- Stormwater Swale
- Sediment Probing Location
- Sediment Sampling Location
- Proposed Limits of Disturbance

Survey Notes:

1. The vertical datum refers to NAVD88. Horizontal datum refers to Vermont State Plane Grid NAD83. Contour interval = 1 foot.
2. Contours were created using two sources of data: 1) a topographic survey of the channel bed, banks, floodplains and structural features collected by Stone Environmental, and 2) LiDAR data of upland features, obtained from the Vermont Center for Geographic Information.
3. Site survey was performed on August 11 and 12, 2020 by Gabe Bolin, PE, of Stone Environmental, Inc. using a Stonex S900 GPS base and rover.
4. Survey data provided in these plans do not represent a boundary survey.
5. Utility locations shown on this plan should be considered approximate. Contractor is required to verify utility locations prior to work.

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DRAWING SCALE
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40 0 40 80 160 ft
8 0 20 40 m
1 inch = 40 feet
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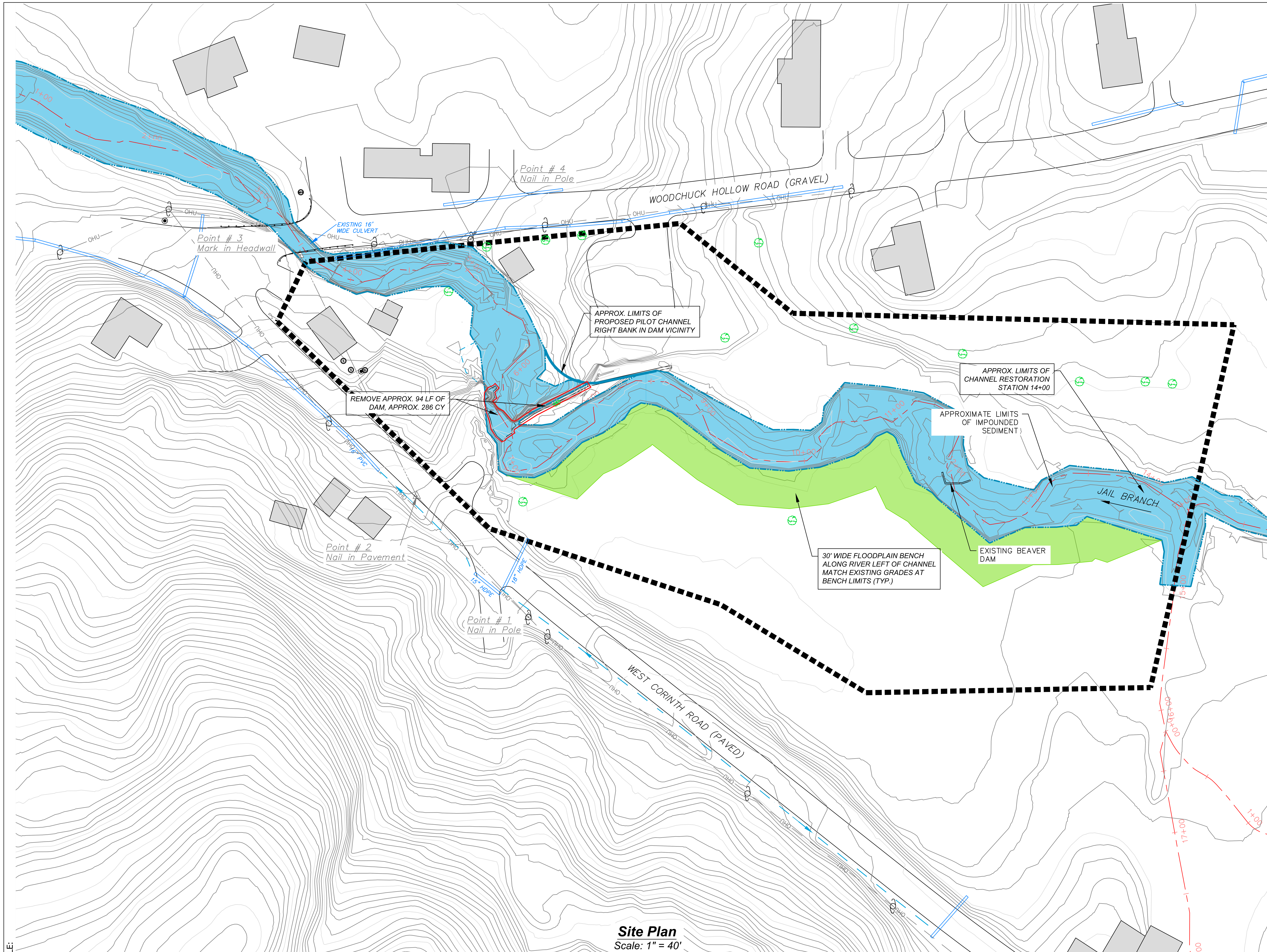
HANDS MILL DAM REMOVAL
AT JAIL BRANCH
EXISTING CONDITIONS

WASHINGTON VERMONT

FIGURE NO.
2



Site Plan

Scale: 1" = 40'

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DRAWING SCALE

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40 0 40 80 160 ft
8 0 20 40 m

1 inch = 40 feet
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HANDS MILL DAM REMOVAL
AT JAIL BRANCH
CONCEPT PLAN

WASHINGTON VERMONT

FIGURE NO.

3

Existing and Proposed Longitudinal Profile

Horizontal Scale: 1" = 30'
Vertical Scale: 1" = 15'

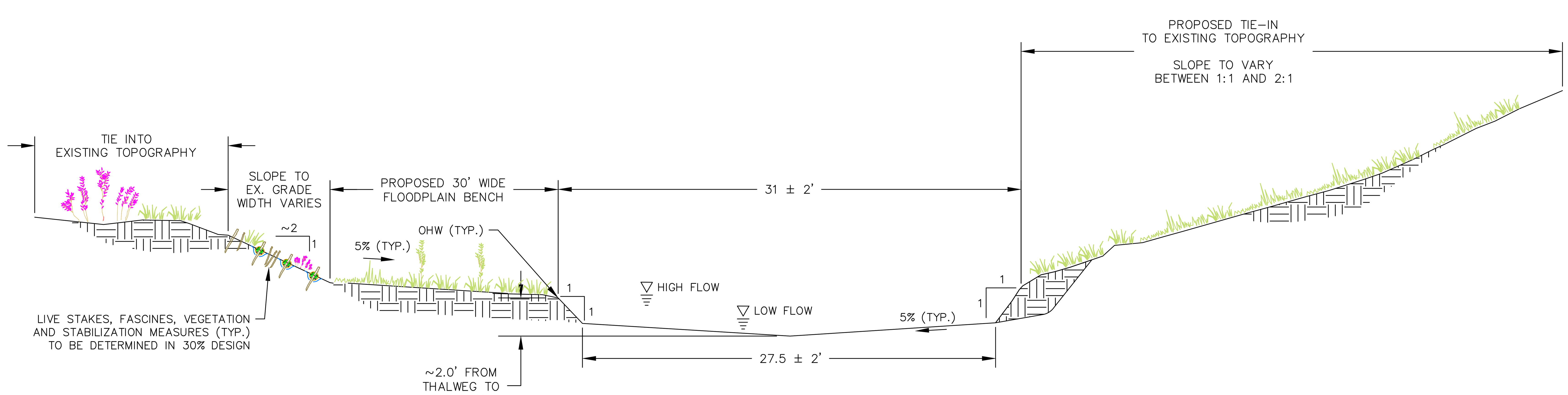
Legend

Existing Channel Thalweg

Proposed Pilot Channel Thalweg

Channel Restoration Profile Notes:

1. The profile has a vertical scale exaggeration of 2.



Typical Channel Cross Section

Scale: 1" = 5'

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HANDS MILL DAM REMOVAL
AT JAIL BRANCH
LONGITUDINAL PROFILE AND DETAILS

WASHINGTON VERMONT

FIGURE NO. 4