May 16, 2018

Ref: 12970.00

Sudbury Conservation Commission
275 Old Lancaster Road
Sudbury, MA 01776

Re: MADEP File No. 301-1227
Abbreviated Notice of Resource Area Delineation Response to Comments
Sudbury-Hudson Transmission Reliability Project

Dear Chairman Friedlander and Commission Members:

The Sudbury Conservation Commission (the Commission) held a public hearing for the Sudbury-Hudson Transmission Reliability Project Abbreviated Notice of Resource Area Delineation (ANRAD) on February 26, 2018. This letter is a response to comments received from Nover-Armstrong, who provided a third-party review for Bordering Land Subject to Flooding (BLSF) and Bank for the two Hop Brook crossings, and Mr. David Burke, who provided a third-party review for all other wetland resource areas. In addition, this letter also addresses comments received from the Commission during the February 26, 2018 hearing. A revised set of plans is enclosed that includes all revisions requested by both third-party reviewers and the Commission. As requested by the Commission, resource area boundaries and associated Buffer Zone/AURA/RFA were left on the plans and all new and/or revised resource area boundaries and associated buffer/AURA/RFA are in red to allow for comparison and for ease in identifying the changes.

In addition to this letter, supplemental information was submitted by VHB to the Commission via email on April 6 and a meeting was held with Ms. Dineen, Mr. Tom Friedlander, and Mr. Rich Morse at Sudbury's DPW office on April 11 to review the third party review comments as a group. The following paragraphs identify all the third party reviewer's comments and the Commission's comments received to date and reflect revisions made in the field with either the third party reviewers or the Commission and/or their agent.

<u>Nover-Armstrong Comments</u>

1. **Nover-Armstrong requested that stationing be added to the plans.**

   Stationing was added to the revised plans that are enclosed with this submission. The plans with stationing were also previously hand delivered to the Sudbury Conservation Commission on March 30, 2018.

2. **Nover-Armstrong requested that the current water elevation for the eastern Hop Brook crossing be provided to compare to the FEMA mapping. In addition, they requested that a benchmark be established so the surface water elevation can be measured and monitored for changes.**

   VHB established two (2) benchmarks at the eastern Hop Brook crossing. Benchmark 1 is located upstream of the bridge on the top of the western abutment wall and is at elevation 124.46-ft

Engineers | Scientists | Planners | Designers
Union Station, Suite 219
2 Washington Square
Worcester, Massachusetts 01604
P 508.752.1001
F 508.752.1276

(NAVD88). Benchmark 2 is located downstream of the bridge on the top of the eastern abutment wall and is at elevation 126.14-ft (NAVD88). One (1) benchmark was established at the western Hop Brook crossing upstream of the bridge on the eastern abutment wall and is at elevation 166.80 (NAVD88) All benchmarks are physically marked in the field with pink paint and VHB is surveying water elevation data once every two weeks. Please see the attached figures with the benchmark locations and water elevation data at both bridge locations for additional information.

3. **Nover-Armstrong stated that the site's topography is based on aerial survey and it is unclear which areas are on-the-ground survey. They stated because of this, the ANRAD plans are not at a level of accuracy adequate to confirm the BLSF boundary shown. They recommended that VHB provide more information and details as to where on-the-ground survey was performed.**

   All of the site's topography shown on the ANRAD plans is based on aerial LiDAR (Light Detection and Ranging) data that was acquired by Eastern Topographic Inc, which was calibrated to on-the-ground control points surveyed by VHB. LiDAR is a well-established remote sensing method that uses laser pulses to measure variable distances combined with aircraft sensors and ground control, and generates precise topography. LiDAR is the industry standard for collection of base elevation data used by Federal Emergency Management Agency (FEMA) for new National Flood Insurance Program (NFIP) Flood Insurance Studies (FISs), which per the Massachusetts Wetland Protection Act (WPA), is the source for setting BLSF boundary. The LiDAR data and associated topography has an estimated vertical accuracy of 5 cm (Root Mean Square Error, RMSE) and an estimated horizontal accuracy of 10 cm (RSME). This Project's LiDAR collection created 15 to 20 actual ground points that were captured every square meter, which exceeds the American Society for Photogrammetry and Remote Sensing (ASPRS) Positional Accuracy Standards for Digital Geospatial Data for point density for 1-foot National Map Accuracy Standard Contours.

   To further confirm the accuracy of the Project's topography, VHB performed an on-the ground field survey using traditional survey methods. VHB obtained ground spot elevations along cross-sections of the entire width of the right-of-way, spaced approximately every 100-feet for the entire length of the project corridor. VHB used this data, which included over 3,842 ground spot elevations, to perform an additional quality check of the LiDAR topography. These spot elevations were overlaid on the LiDAR data so that the two elevation sources could be compared, and a variance between each ground spot elevation and LiDAR survey was calculated. The results show that of the 3,842 ground elevations taken by VHB, 94 percent were within 6-inches when compared to the LiDAR data. Based on specifications outlined in the National Map Accuracy Standards, these statistics indicate that the LiDAR data exceeds the standards for 1-foot contours.

   Based on these findings, the LiDAR based contours are at a level of accuracy that meets or exceeds industry standards, and is sufficient for delineating BLSF.

4. **Nover-Armstrong stated that it appears that there are issues with the BLSF boundary, indicating that the topography, wetland flags, and/or BLSF boundary may not be shown correctly.**

It is our opinion that the previously shown Bordering Land Subject to Flooding (BLSF) boundary, based upon the effective FEMA FIS Base Flood Elevations (BFEs), at the eastern Hop Brook crossing is the primary issue resulting in the inconsistency between the topography, wetland flags and BLSF boundary. A summary of the delineation of the BLSF and our rational for this opinion is below.

VHB used the effective BFEs to originally delineate BLSF in accordance with the Massachusetts Wetland Protection Act (WPA) Regulations. In doing so, VHB found that the effective BFEs were below the ground surface near the eastern Hop Brook crossing. The FEMA FIS BFEs were revised based on historic BFEs from the 1979 FIS at and adjacent to the eastern Hop Brook crossing as presented previously in our memorandum dated January 23, 2018, for the January 31, 2018 ANRAD supplemental submission. Nover-Armstrong agreed that this approach was generally acceptable and conservative for this location.

Since the updated January 31, 2018 ANRAD submission, VHB has completed a detailed hydrologic and hydraulic analysis for the eastern Hop Brook crossing to support the Project's design. The analysis is consistent with FEMA National Flood Insurance Program (NFIP) guidelines and specifications. As a part of this analysis, VHB completed a "corrected-effective" hydraulic model using the United States Army Corps of Engineers (USACE) Hydraulic Engineering Center's River Analysis System (HEC-RAS). The model limits extend from the confluence with Landham Brook to just downstream of Boston Post Road. The corrected-effective model represents the effective FEMA FIS model updated to current HEC-RAS modeling software, refined to include additional cross sections and detailed topography/bathymetric data, and updated hydrology. The results of the corrected effective model represent an increase in existing BFEs at and adjacent to the eastern Hop Brook crossing ranging from approximately 0.5-feet to 4.0-feet. Upstream of the eastern Hop Brook Crossing, Hop Brook steepens and the 100-year water surface profile for the corrected effective model matches the effective FEMA FIS 100-year water surface profile. The two profiles match each other just south of the Hop Brook and Boston Post Road crossing. Upstream of the crossing, the effective FEMA FIS BFEs were used to delineate the BLSF. Downstream of the confluence of Hop Brook and Landham Brook, the 100-year backwater elevation of the Sudbury River (elevation 121.0) was used to delineate the BLSF.

The corrected effective HEC-RAS model more accurately represents existing conditions at the crossing than the effective FEMA FIS and FIRM for Hop Brook, which was completed using HEC-2 (previous version of HEC-RAS) in the late 1970's. The BLSF boundary that is produced from the updated model more accurately matches the topography, surveyed wetlands, and banks. ANRAD plans were updated to show the BLSF boundary at the eastern Hop Brook crossing to the calculated base flood elevations by the corrected effective model.

A memo detailing the methodology and results is attached for your reference and information.

5. **Nover-Armstrong recommended that the floodway for Hop Brook and Dudley Brook be added onto the plans.**

The floodway for Hop Brook and Dudley Brook were added onto the enclosed revised plans.

6. **Nover-Armstrong stated that it is their opinion that significant portions of the western Hop Brook crossing bridge approach embankment consists of Bank under the Sudbury Bylaw.**

   VHB visited the western Hop Brook crossing with Mr. Burke on April 18, 2018 and with Nover Armstrong and the Commission's agent on April 24, 2018 to evaluate Bank per the Sudbury Bylaw. The methodology for delineating bank was discussed and a consensus was reached with Nover-Armstrong, Ms. Dineen, and Mr. Morse. It was also agreed that Bank for the crossing is coincident with both the Sudbury Bylaw and MWPA definition and as such, only one Bank was delineated.

   The bank was re-delineated by VHB and the points were located by survey. Ms. Dineen reviewed the points in the field and agreed with the corrected delineation. The revised bank points are located on sheets 8 and 9 of the revised ANRAD plans and consist of the following:

   Northeast Bank – BF26-BF34
   Southeast Bank – BF35-BF56
   Northwest Bank – BF57-BF77
   Southwest Bank – BF78-BF106

7. **Nover-Armstrong stated that the palustrine emergent wetland system associated with the eastern Hop Brook crossing is a braided, poorly defined low flow stream that meanders within the confines of a broad Bank system. It is their opinion that Bank should be extended in these areas. They also stated that the delineated wetlands in the northwest and southwest quadrants are devoid of vegetation and consist of standing water only; therefore, these areas should be delineated as Land Under Water Bodies and Waterways or Bank, not Bordering Vegetated Wetlands.**

   VHB visited the eastern Hop Brook crossing with Mr. Burke on April 18, 2018 and with Nover Armstrong and the Commission's agent on April 24, 2018 to evaluate Bank. The methodology for delineating bank was discussed and a consensus was reached with Nover-Armstrong, Ms. Dineen, and Mr. Morse. It was also agreed that Bank for the crossing is the mean annual high-water line, which is coincident with both the Sudbury Bylaw and MWPA definition and as such, only one Bank was delineated.

   The bank was re-delineated by VHB and the points were located by survey. The southeast bank extends on Sudbury property in an easterly direction parallel to and within 200-feet of the ROW boundary. The revised bank points are located on sheets 33 through 37 of the revised ANRAD plans and consist of the following:

   Northeast Bank – BF142-BF153
   Northwest Bank – BF117-BF141

Southeast Bank – BF154-BF340[1]

Southwest Bank – BF107-BF116

The following responses are to comments received in two separate emails from Nover-Armstrong on May 8, 2018.

8. **Nover-Armstrong stated that the southeast quadrant of the eastern Hop Brook crossing is delineated as agreed in the field, but should be shown as abutting Land Under Water as other area of Bank.**

   All hatching within Bank points, including the southeast quadrant of the eastern Hop Brook crossing, is now shown as Land Under Water.

9. **Nover-Armstrong stated that the new Bank labels are very small and should be similar in size to BVW labels.**

   The size of the text was increased for all labels, including the new Bank points, per the Commission's request.

10. **Nover-Armstrong stated that the old Bank flags should be removed from the plans.**

    Per a conversation with Ms. Debbie Dineen, the old flags, buffers, and resource area boundaries will remain on the progress print plan set and the new delineation information will be shown in red. This is so the revised lines can be easily compared to the previous delineation lines. Once the line adjustments are reviewed and agreed to by all parties, the plan set will be updated to only include the final resource areas and their associated buffers/AURAs for the Commission's use in issuing an ORAD.

11. **Nover-Armstrong stated that where the BFE changes from 124 to 123.0 and lower it appears that MAHW observed in the field is higher in many areas; see BF172-BF103.**

    Please see the discussion regarding BLSF delineation and Base Flood Elevations in comment 4 above as well as the attached memo and benchmark water elevation data.

12. **Nover-Armstrong requested that the new BLSF elevations are called out on each sheet.**

    BLSF elevations have been called out at both the BLSF linework and as a note to each plan sheet that contains BLSF.

    In addition to the BLSF labels, the ANRAD plans also include linework and labels for the Base Flood Elevations (BFE's), similar to a FEMA Flood Insurance Rate Map, that were used to delineate

[1] Although bank flags were hung in the field up to point BF340, the plans only shown up to BF328 because of the size of the sheet (24"x36") and the scale of the plans (1":20').

BLSF. Please note the BFEs and BLSF elevations are not a constant elevation in a waterway and decrease as water moves downstream. In the locations where the BLSF elevations change, the BLSF elevation callouts contain the range of elevations associated with the BLSF on that plan sheet.

13. **Nover-Armstrong stated that the attachments referenced in the response letter were not included in the May 7, 2018 draft submission.**

    The attachments are included with this submission.

14. **Nover-Armstrong stated that the floodway is not shown on the plans.**

    The floodways were taken from available FEMA data and are shown on the revised plans (dated May 16, 2018) for both Hop Brook crossings and Dudley Brook. Please note that the MWPA does not have regulations specific to floodways and does not consider it as a separate wetland resource area.

Mr. David Burke Comments

A site visit was held with Mr. Burke on April 17, 2018 to review his comments. Ms. Dineen was present for the site visit for a portion in the morning and the afternoon. Mr. Rich Morse was present for a portion of the site visit in the morning.

Mr. Burke's comments begin at the Sudbury Substation and continue west towards the Sudbury/Hudson town line.

1. **Although not listed within the comment letter, we looked at areas around the Substation to address concerns from both Dave Burke and Debbie Dineen. The following adjustments were made and agreed to while in the field on April 17, 2018:**

    - An additional flag was hung in the field (DW347A) and was located in the field by survey;
    - Flag DW398 was on the ground and was rehung/relocated and was located in the field by survey;
    - Flag DW387 was removed from the plans and DW386 is now connected directly to DW388; and
    - The potential vernal pools to the north of the substation, as presumed under the Sudbury Bylaw, were delineated and located in the field by survey. There were no egg masses identified during the delineation. The flag sequences are as follows:
        - KVP1-KVP105
        - KVP106-KVP115
        - KVP116-KVP133
        - KVP134-KVP150

- An additional potential vernal pool, as presumed in the Sudbury Bylaw, was delineated immediately outside of the ROW by a separate VHB team for a DCR bike path project. Because the DCR bike path project is state-related, access was granted to privately owned property.

2. **Dave Burke stated that there is a potential wetland swale that is approximately 150-feet long west of Wetland 3 on the south side of the tracks (refer to sheet 39) and requested that VHB complete additional review of the swales and provide our findings and conclusions.**

   This area was evaluated by VHB on May 2, 2018. There are two swales on either side of the railroad tracks that formed from the result of land alteration and compaction related to development and operation of the railroad tracks. It is in VHB's professional opinion that the swales **do not** meet the federal, state, or local wetlands criteria according to MADEP's Delineating Bordering Vegetated Wetlands (Jackson, 1995), areas subject to protection under the Wetlands Protection Act, M.G.L. c. 131, § 40 (the Act) (MADEP), U.S. Army Corps of Engineers jurisdictional wetland per the 1987 Corps of Engineers Wetlands Delineation Manual (Environmental Laboratory, 1987) and the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Northcentral and Northeast Region (U.S. Army Corps of Engineers, 2011), or wetland resource under the Sudbury Wetlands Administration Bylaw Regulations (Sudbury Conservation Commission, 2017).

   Below is a description of the plot data taken from each swale.

   Swale to the South of the Tracks

   A test pit was dug down to 24-inches with a spade to determine whether hydric soils were present. The profile was as follows:

^A1	0-13"	N 2.5/0	Very stony coarse sandy loam; weak, medium granular structure; many fine and medium roots; railroad ballast
^A2	13-16"	10YR 2/1	Very stony coarse loamy sand; railroad ballast
Bwb	16-20"	10YR 4/4	Loamy sand
BC	20-14"	10YR 5/1	Gravelly sandy loam; massive; friable; many coarse 10YR 4/4 redoximorphic concentrations

   Two samples were tested with dipyridyl strips to determine whether ferrous iron was present. The presence of ferrous iron indicates reducing conditions (e.g. hydric soils). Both samples come back negative (i.e. did not react), which indicates that hydric soils are not present.

   Vegetation and signs of hydrology were also evaluated within the swale. Vegetation within the low point consists of silky dogwood (*Cornus amomum*, FACW) glossy buckthorn (*Frangula alnus*, FAC) and multiflora rose (*Rosa multiflora* FACU), with raspberry (*Rubus idaeus*, FACU) and

Morrow's honeysuckle (*Lonicera morrowii*, FACU) around the periphery. The water table was at approximately three-inches; however, it appears to be dropping rapidly and is not present within 20-inches of the surface long enough to create reducing (i.e. hydric) conditions.

Swale to the North of the Tracks

A test pit was dug down to 20-inches with a spade to determine whether hydric soils were present. The profile was as follows:

^AC1	0-7"	2.5Y 2.5/1	Very gravelly loamy sand; many fine and medium roots; diffuse, smooth boundary; railroad ballast
^AC2	7-17"	2.5Y 2.5/1	Very stony loamy coarse sand; few fine roots; railroad ballast
2C1	17-20"	2.5Y 4/3	Gravelly loam sand

Three samples were tested with dipyridyl strips to determine whether ferrous iron was present. Two samples were taken from the ballast at 4- and 11-inches and the third sample was taken at 20-inches. All three samples did not react, which indicates that hydric soils are not present.

Vegetation and signs of hydrology were also evaluated within the swale. Vegetation was very limited and included multiflora rose and glossy buckthorn; there was no herbaceous or tree species present. As with the swale to the south of the tracks, the water table was at approximately three-inches; however, it appears to be dropping rapidly and is not present within 20-inches of the surface long enough to create reducing (i.e. hydric) conditions.

Conclusion

There are two narrow swales on either side of the tracks that were flagged in the field and shown on the plans. The swale to the north is delineated as KW3-1 – KW3-8 and the swale to the south is delineated as KW4-1 – KW4-9. The tracks are approximately 8 to 15-inches higher than the swales and consist of upland herbaceous species. Although the two swales were delineated in the field and located by instrument survey, it is VHB's professional wetland scientist's opinion that they are not federal, state, or local wetlands.

3. **Dave Burke stated that the stream approximated from MassGIS data on sheet 37 is not accurate to field conditions outside of the ROW and should be adjusted.**

   VHB now has access to town property and as such, the bank points associated with this stream were extended within 200-feet of the ROW. Please see bank points BF154-BF340 on sheets 33 through 37 for the extended bank delineation and associated RFA.

4. **Dave Burke stated that he noted a short stretch of intermittent stream channel just east of DB4 and DB5 on sheet 37 (to the north of the tracks associated with stream 1).**

This area was reviewed in the field and an additional stream channel was delineated. Please see bank points KB1-KB4 and KB5-KB6 on sheet 37. KB1 connects into existing bank point DB5 and KB6 connects into existing bank point DB4.

5. **Dave Burke noted that there was an odd disconnect between Wetland 7, Wetland 8, and Vernal Pool 4. He stated that the area is interior to the wetlands and should be checked in the field.**

   This was discussed in the field with Mr. Burke and VHB explained that this area is slightly higher in elevation than the two surrounding wetlands, and is not a wetland. Mr. Burke agreed with this assessment.

6. **Dave Burke stated that wetland flags are missing for approximately 200-feet west of flag 33 (between CW33-CW36 on sheets 34 and 35) and that a long stretch of BVW is not flagged on town property.**

   VHB was granted access to town property and the BVW lines outside of the ROW on sheets 34 and 35 were extended within 100-feet of the ROW. Please see BVW points CW32-1 – CW32-20, CW33, CW34, and CW35, and its associated AURA/100' BZ for the extended wetland delineation.

7. **Dave Burke stated that the bank flags around both Hop Brook crossings should be revised on sheets 8, 33, and 34.**

   The bank delineation around both Hop Brook crossings was revised based on comments received from Nover Armstrong, Dave Burke, and the Commission. Please see the discussion under Nover Armstrong's comments 6 and 7.

8. **The culvert between Wetlands 18 and 19 on sheet 31 is not functioning and Wetland 19 is isolated. Mr. Burke believes that Wetland 19 could be a potential vernal pool.**

   This was reviewed in the field with Mr. Burke and a discussion was held regarding its potential as a vernal pool. At the time of the site visit, there was standing water present; however, there was a significant rainfall event the previous day and it was difficult to assess true field conditions. Both parties (Mr. Burke and VHB) felt that the isolated wetland likely **does not** hold water long enough (2 months) to meet the criteria for a vernal pool. VHB visited Wetland 19 on April 24 and the water level had significantly receded, which indicates that it does not hold enough water for the required two-month time period.

Water levels of Wetland 19 on April 24, 2018

9. **Dave Burke questioned whether the BVW connection on sheet 31 from Wetland 18 to Hop Brook is present in field conditions.**

   This was reviewed in the field with Mr. Burke and it was determined that the MassGIS data is incorrect. There is a berm separating Wetland 18 from Hop Brook and Wetland 18 is isolated. This connection was removed from sheet 31 and BVW point CW161 was connected to CW172 to create an isolated wetland.

10. **Dave Burke stated that the soils southwest of flag DW-209 on sheet 27 should be checked for hydric soils. While in the field with Mr. Burke, he also stated that the MassGIS intermittent stream that is shown on sheet 27 and is an extension of bank flags DB158-DB163 does not appear accurate.**

    The area around DW-209 was evaluated in the field with Mr. Burke and it was determined that hydric soils are not present and that the delineation is correct. The approximate intermittent stream from MassGIS was also evaluated and it was determined that, based on field conditions, it does not extend as shown. It was agreed that the approximate stream should be removed and that the bank points as shown are accurate and sufficient. Accordingly, this approximate intermittent stream was removed from sheet 27.

11. **Dave Burke stated that soils at flag DW-177 on sheet 21 should be checked for hydric conditions.**

This area was evaluated in the field with Mr. Burke and Ms. Dineen. The area in question is currently and accurately delineated in the field and shown on the plans as BVW. As such, no revision was necessary.

12. **Dave Burke stated that a box culvert is shown on the plans on sheet 15 and that others state that it is an intermittent stream. Nothing was delineated in the field and this area should be checked.**

    This area was evaluated in the field with Mr. Burke. While in the field, Mr. Burke spoke with an adjacent property owner that said they (the property owners) had just dug out/unplugged a 12-inch RCP that is on a town easement; this easement is present on Sudbury GIS data. There was evidence of the culvert conveying water in a north to south direction within the culvert on April 17.

    Both the north and south sides of the culvert were evaluated for the presence of bank and BVW. The north side does not have a defined bank or wetland characteristics. The south side does not have wetland vegetation; however, hydric soils are present. As such, a small BVW area was delineated within the ROW as KW1-KW7 and is shown on sheet 15. In addition, although there was no significant defined bed and bank, the centerline of a small swale on the opposite end of the culvert was delineated to the north of the tracks as KBCL1-KBCL4.

13. **Dave Burke stated that a potential vernal pool is present outside of the ROW on sheet 15 and should be checked in the field.**

    This area was evaluated in the field with Mr. Burke. A wetland depression and potential vernal pool is present; however, because it is on private property, it could not be delineated in the field. As such, this area is shown as approximate on sheet 15.

14. **Dave Burke stated that there is a vernal pool on sheet 9 300-feet east of the railroad trestle north of the tracks that should be delineated.**

    This area was evaluated in the field with Mr. Burke and Ms. Dineen and it was determined that it is not a vernal pool. This area was shown as an approximate wetland boundary on the initial ANRAD plans. However, this area is on town property and as such, was delineated as bank and BVW. Please see sheet 9 for bank points BF1-BF25 and BVW points KW2-1 – KW2-8. The area within the bank points is also hatched as Land Under Waterbodies and Waterways.

Sudbury Conservation Commission Comments

1. **Ms. Debbie Dineen stated that to be considered an intermittent stream per the Sudbury Bylaw, the stream needs to be dry for either five (Type I) or 30 (Type II) consecutive days. Ms. Dineen also stated that the Bylaw considers Type I intermittent streams to be perennial and that additional documentation needs to be submitted to prove the streams are intermittent.**

   During a meeting on April 11, 2018 with VHB, Eversource, and the Commission, it was agreed that because the intermittent stream documentation was not provided to the Commission, all streams will be shown as perennial. However, the ORAD will be written with a condition such that if the appropriate data is collected, the ORAD will be amended to reflect which stream designations are changed to intermittent.

   The plans were revised to show that all previously identified intermittent streams are perennial under the Sudbury Bylaw, and the associated RFA/AURA was offset.

2. **Ms. Dineen expressed concerns over vernal pools located on the Buddy Dog property and a discussion was held in the field regarding the ability to map their locations due to property access.**

   It was agreed that because VHB/Eversource does not have access to the property, Ms. Dineen would provide location data for the vernal pools. This location information was provided and their locations and associated AURA/BZ was added to the plans.

3. **Ms. Dineen stated that the potential vernal pool inside Wetland 1 that is visible from the woods line should be delineated and surveyed in the field.**

   The limit of the potential vernal pools, as presumed under the Sudbury Bylaw, were field delineated and surveyed. Please refer to sheets 40 through 43; the potential vernal pools were flagged as follows:

   - KVP1-KVP105
   - KVP106-KVP115
   - KVP116-KVP133
   - KVP134-KVP150

4. **Ms. Dineen stated that there is a potential wetland and vernal pool adjacent to Union Avenue and a private access driveway on sheet 28. Ms. Dineen requested that this area be evaluated and shown on the plans.**

   VHB evaluated this area in the field but could not delineate it because it is on private property. This was further discussed in the field with Ms. Dineen, Nover-Armstrong, and Mr. Burke and it was agreed that it would be shown on the plan as an approximate wetland area.

Should you have any questions concerning this supplemental submission or require additional information, please contact me at 617.607.2157 or kkinsella@vhb.com.

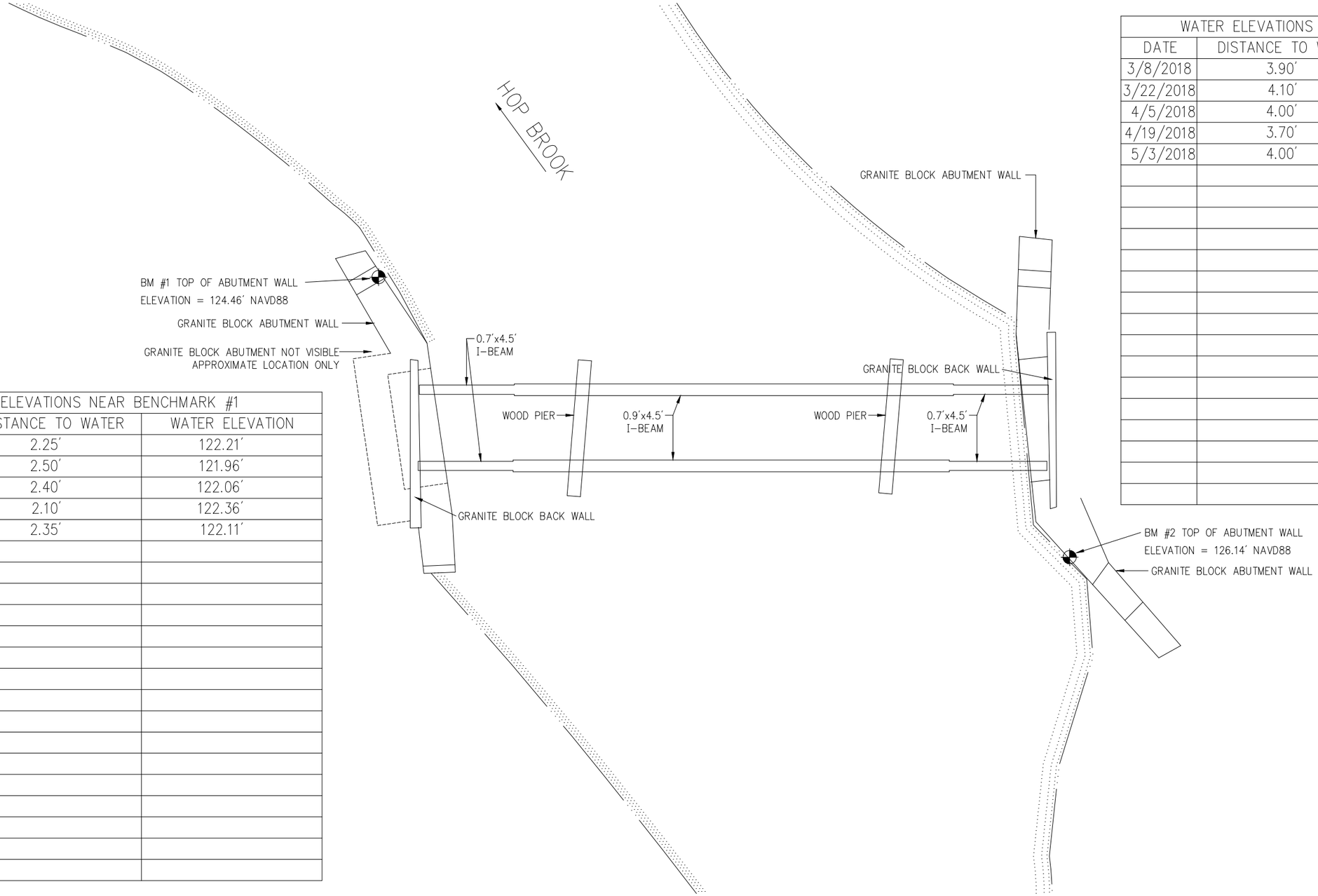
Sincerely,

Katie Kinsella

Senior Environmental Scientist

CC: Denise Bartone - Eversource Energy
Jill Provencal, MA DEP - Northern Regional Office

Attachments: Revised ANRAD plans (dated May 16, 2018)
Water Elevation Data (dated March 30, 2018 but contains elevations through May 3, 2018)
H&H Analysis Memo (dated May 3, 2018)



WATER ELEVATIONS NEAR BENCHMARK #1		
DATE	DISTANCE TO WATER	WATER ELEVATION
3/8/2018	2.25'	122.21'
3/22/2018	2.50'	121.96'
4/5/2018	2.40'	122.06'
4/19/2018	2.10'	122.36'
5/3/2018	2.35'	122.11'

WATER ELEVATIONS NEAR BENCHMARK #2		
DATE	DISTANCE TO WATER	WATER ELEVATION
3/8/2018	3.90'	122.24'
3/22/2018	4.10'	122.04'
4/5/2018	4.00'	122.14'
4/19/2018	3.70'	122.44'
5/3/2018	4.00'	122.14'

Water Elevations Under Bridge 127 Over Hop Brook
Sudbury, Mass.

101 Walnut Street PO Box 9151
Watertown, MA 02471 - 617.924.1770

0 4 8 16 Feet

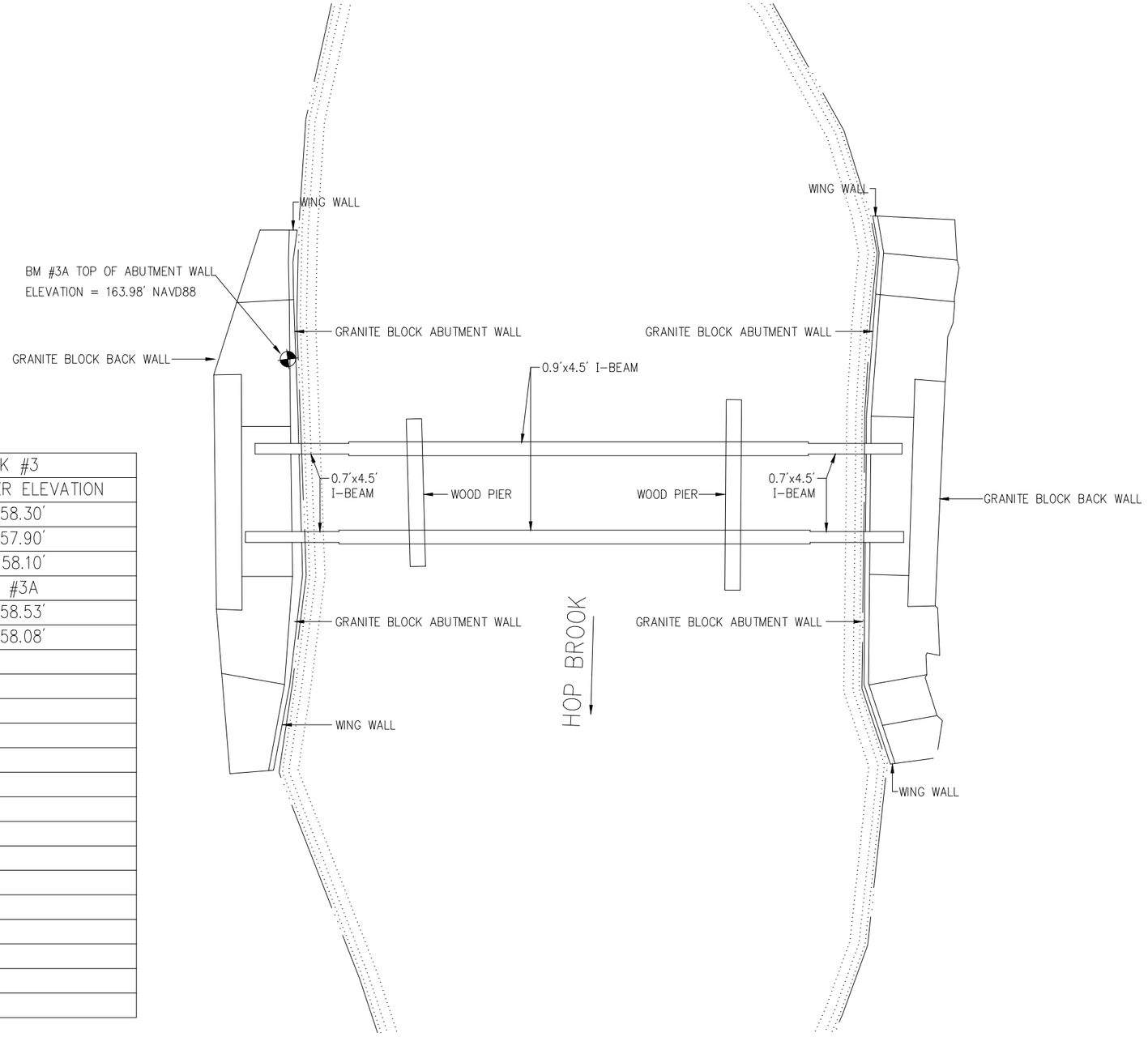
March 30, 2018

Scale: 1"=8'

12970.01_WatElev.dwg

12970.01

WATER ELEVATIONS NEAR BENCHMARK #3		
DATE	DISTANCE TO WATER	WATER ELEVATION
3/8/2018	8.50′	158.30′
3/22/2018	8.90′	157.90′
4/5/2018	8.70′	158.10′
WATER ELEVATIONS NEAR BENCHMARK #3A		
4/19/2018	5.45′	158.53′
5/3/2018	5.90′	158.08′



vhb
101 Walnut Street PO Box 9151
Watertown, MA 02471 - 617.924.1770

0 4 8 16 Feet

Water Elevations Under Bridge 128 Over Hop Brook
Sudbury, Mass.

March 30, 2018

Scale: 1″=8′

12970.01_WatElev.dwg

12970.01

Memorandum

To: Sudbury Conservation Commission Date: May 3, 2018

Project #: 14009.00

From: Mark Costa, PE
Erika Towne, EIT

Re: Sudbury-Hudson Reliability Project
Abbreviated Notice of Resource Area Delineation
Bordering Land Subject to Flooding – Hydrologic & Hydraulic Analysis

---

Vanasse Hangen Brustlin on behalf of the NSTAR Electric Company d/b/a Eversource Energy is submitting a revised Abbreviated Notice of Resource Area Delineation (ANRAD) plans for the Sudbury-Hudson Transmission Reliability Project (the Project). The plans have been updated to include a revised delineation of the Bordering Land Subject to Flooding (BLSF) for Hop Brook between Boston Post Road and Landham Road.

VHB previously submitted a supplemental ANRAD on January 31, 2018 that included delineation of Bordering Land Subject to Flooding (BLSF). Since the updated January 31, 2018 ANRAD submission, VHB completed a detailed hydrologic and hydraulic analysis for the eastern Hop Brook crossing to support the Project's design. Figures 1 and 2 highlights the location and extents of this analysis. The analysis is consistent with FEMA National Flood Insurance Program (NFIP) guidelines and specifications. As a part of this analysis, VHB completed a "corrected-effective" hydraulic model using the United States Army Corps of Engineers (USACE) Hydraulic Engineering Center's River Analysis System (HEC-RAS). The corrected-effective model represents the effective FEMA FIS model updated to current HEC-RAS modeling software, refined to include additional cross sections and detailed topography/bathymetric data, and updated hydrology. The results of the corrected effective model represent an increase in existing Base Flood Elevations (BFEs) at and adjacent to the eastern Hop Brook crossing ranging from approximately 0.5-feet to 4.0-feet. The corrected effective model BFEs more accurately matches the topography, surveyed wetlands, and banks. The current FEMA FIS is based on a late 1970's flood study that was completed HEC-2 (previous version of HEC-RAS). VHB thus concluded that the BLSF should be updated using the revised corrective effective model as outlined in the project's Response to Comments letter. This memorandum summarizes methodology and results of the hydrologic and hydraulic analysis used for the corrected effective model and the revised BLSF elevations.

Hydrologic Analysis

The following describes the methodology and results of the hydrologic analysis of Hop Brook at the study location.

Methodology

VHB estimated hydrology for Hop Brook at the study location using regression equations defined in United States Geological Survey (USGS) *Scientific Investigations Report (SIR) 2016-5156, Magnitude of Flood Flows at Selected Annual Exceedance Probabilities for Streams in Massachusetts*. VHB used the USGS StreamStats web application to calculate the contributing watershed parameters and corresponding peak flow for different storm events. StreamStats uses a Digital Elevation Model (DEM) to delineate the drainage area to the point of interest, and determine the mean elevation and total storage of that drainage area. StreamStats calculated the contributing drainage area to study area of approximately 15.5 square miles, which consists of 11.6% waterbodies and wetlands, and has a mean elevation of 225 feet. Figure 3 is the delineated watershed limits.

101 Walnut Street
PO Box 9151
Watertown, MA 02472-4026
P 617.924.1770

Results

Table 1 is the calculated peak discharge rates using the USGS regression equations. The calculated peak flow discharge was compared to the FEMA FIS peak discharges. The 1% annual exceedance event calculated peak flow rate is over 10 percent higher than the effective FEMA peak discharges, therefore the corrected effective model will use the calculated USGS regression equation peak discharges.

Table 1: Peak Discharges - Hop Brook

Return Period (years)	Annual Exceedance Probability (%)	USGS Regression Equation Peak Discharge (cfs)	FEMA FIS Peak Discharge (cfs)	Percent Difference
Q100	1	1230	920	(29%)

Hydraulic Analysis

The following section describes the methodology and results of the hydraulic analysis of Hop Brook at the study location.

Methodology

VHB developed a step-backwater hydraulic model for the river crossing using the U.S. Army Corps of Engineers HEC-RAS (ver. 5.0.3) software to analyze the water surface elevations of Hop Brook.

VHB requested hydrologic and hydraulic backup data for the effective model from FEMA to begin the development of the corrected effective model. VHB received the data in paper format and determined that the effective FEMA model was completed using HEC-2 (predecessor model of HEC-RAS) in the late 1970's, which cannot be directly opened in HEC-RAS. Therefore, VHB transcribed the HEC-2 data acquired from FEMA into a format that can be uploaded into HEC-RAS to create a "duplicate effective" model in HEC-RAS. The duplicate effective model represents the effective FEMA study updated to the current HEC-RAS modeling software. The duplicate effective model was then updated with additional cross sections and detailed topography/bathymetric data, and updated hydrology to create the corrected effective model.

Model Input Parameters

The corrected effective model includes several inputs including model geometry, downstream boundary conditions, manning's roughness coefficients, and ineffective flow areas which are detailed below.

Model Geometry

VHB used the HEC-GeoRAS add-on for ArcGIS 10.5 to generate georeferenced hydraulic model geometry. VHB digitized the following key input parameters using HEC-GeoRAS:

- Stream Centerline
- Channel Banks
- Channel and Overbank Flow Paths

- Cross Sections
- Ineffective Flow Areas

VHB delineated the channel centerline line based on surveyed bathymetry. The channel centerline was drawn along the approximate channel thalweg (lowest point along the channel bed). The downstream limit of the model begins at river station 440 and continues to the upstream limit of the model at river station 2740. These river stations match river stations in the effective FEMA model for Hop Brook. Figure 1 shows the locations of each cross section and its corresponding river station.

VHB delineated the left and right banks to represent the approximate location of the top of the channel banks/change in mannings' roughness. The left and right overbank flow paths were drawn to represent the approximate center of mass of the overbank flow.

The corrected effective model has seven (7) cross-sections from the effective FEMA model. Two (2) cross-sections were added between the two upstream FEMA cross-sections to contribute more detail to the model and more accurately represent existing and proposed conditions. Additional cross-sections were also added from the bathymetric survey of Hop Brook, which was conducted by VHB on February 15, 2018. This survey measured the top of slope elevation of each bank, bottom of slope elevation of each bank, and the elevation of the center of the river along fourteen (14) cross-sections of Hop Brook. The most upstream cross-section is located approximately 500 feet upstream of Bridge 127, and the most downstream cross-section is located approximately 220 feet downstream of Bridge 127. Thirteen (13) of the fourteen (14) surveyed cross-sections were used in the Corrected Effective model. Altogether, there is a total of twenty-two (22) cross-sections in the Corrected Effective model.

VHB used the HEC-RAS software (version 5.0.3) to simulate flood profiles along Hop Brook. Figure 1 shows the HEC-RAS model setup. VHB has developed an Corrective Effective model to best represent the existing conditions using:

- VHB Ground Survey 2015 and 2017
- Bathymetric data from a survey VHB conducted on February 15, 2018
- VHB flown LiDAR along the ROW by plane on May 16, 2017
- USGS 2016 LiDAR imagery

The bathymetric and VHB LiDAR data were combined to make a topographic surface surrounding Hop Brook and Bridge 127. The USGS 2016 LiDAR imagery was used to supplement this surface where no other data was available. The detailed cross sections across Hop Brook and the surrounding area were created using this combined surface.

VHB used the above data to produce an existing conditions hydraulic model illustrating the effects of the proposed Bridge 127 upon Hop Brook. The existing crossing has a 44.8-foot span with stone abutments, two wooden piers, steel girders, and timber ties and track forming the bridge. The existing low chord elevation is 120.6 feet and the existing girders are submerged under base flow conditions. The bridge has no deck beyond the timber ties.

A HEC-RAS geometry input file was created with final cross sections at the following locations:

Table 2: HEC-RAS Stationing

Station	Description
2740	Upstream Limit of Study – 1255'± to Bridge No. 127
2370	Copied FEMA Cross Section from effective model
2270	Copied FEMA Cross Section from effective model
2170	FEMA Cross Section from effective model
1987	Survey Cross Section Supplemented with LiDAR
1861	Survey Cross Section Supplemented with LiDAR
1789	Survey Cross Section Supplemented with LiDAR
1702	Survey Cross Section Supplemented with LiDAR
1663	Survey Cross Section Supplemented with LiDAR
1625	Survey Cross Section Supplemented with LiDAR
1582	Survey Cross Section Supplemented with LiDAR
1531	Survey Cross Section Supplemented with LiDAR
1506	Just Upstream of Existing Bridge
1484	Center(±) of Bridge No. 127
1462	Just Downstream of Existing Bridge
1422	Survey Cross Section Supplemented with LiDAR
1383	Survey Cross Section Supplemented with LiDAR
1263	Survey Cross Section Supplemented with LiDAR
1065	FEMA Cross Section from effective model
470	FEMA Cross Section from effective model
460	FEMA Cross Section from effective model
450	FEMA Cross Section from effective model
440	Downstream Limit of Study – 1044'± to Bridge No. 127

Downstream Boundary Conditions

The corrected effective model was analyzed using the normal depth Reach Boundary Condition. The normal depth of Hop Brook is set at the downstream end of the model based on the stream's geometric profile. This Reach Boundary Condition was chosen to remain consistent with the effective FEMA model, which used normal depth as the Reach Boundary Condition.

Manning's Roughness Coefficient

VHB assigned roughness factors, (Manning's n value) for the existing stream conditions, wetlands, and floodplain limits for the fifteen (15) additional cross sections added to the model that are not from the effective FEMA model. The

Manning's n values for the cross sections from the effective FEMA model did not change. The selection of manning's n for various land uses are shown below in Table 3.

Table 3: Manning's "n" Table

Land Use	Manning's "n"
Hop Brook	0.035
Wetland	0.045
Wooded Overbank	0.08

Contraction/Expansion Coefficients

VHB set the model expansion and contraction coefficients to 0.1 and 0.3, respectively, for all cross sections, with the exception of three sections: the two cross sections immediately upstream and one cross section downstream from Bridge 127. These cross sections use expansion and contraction coefficients of 0.3 and 0.5, respectively, based on bridge modeling guidance from the HEC-RAS User Manual.

Ineffective Flow Area

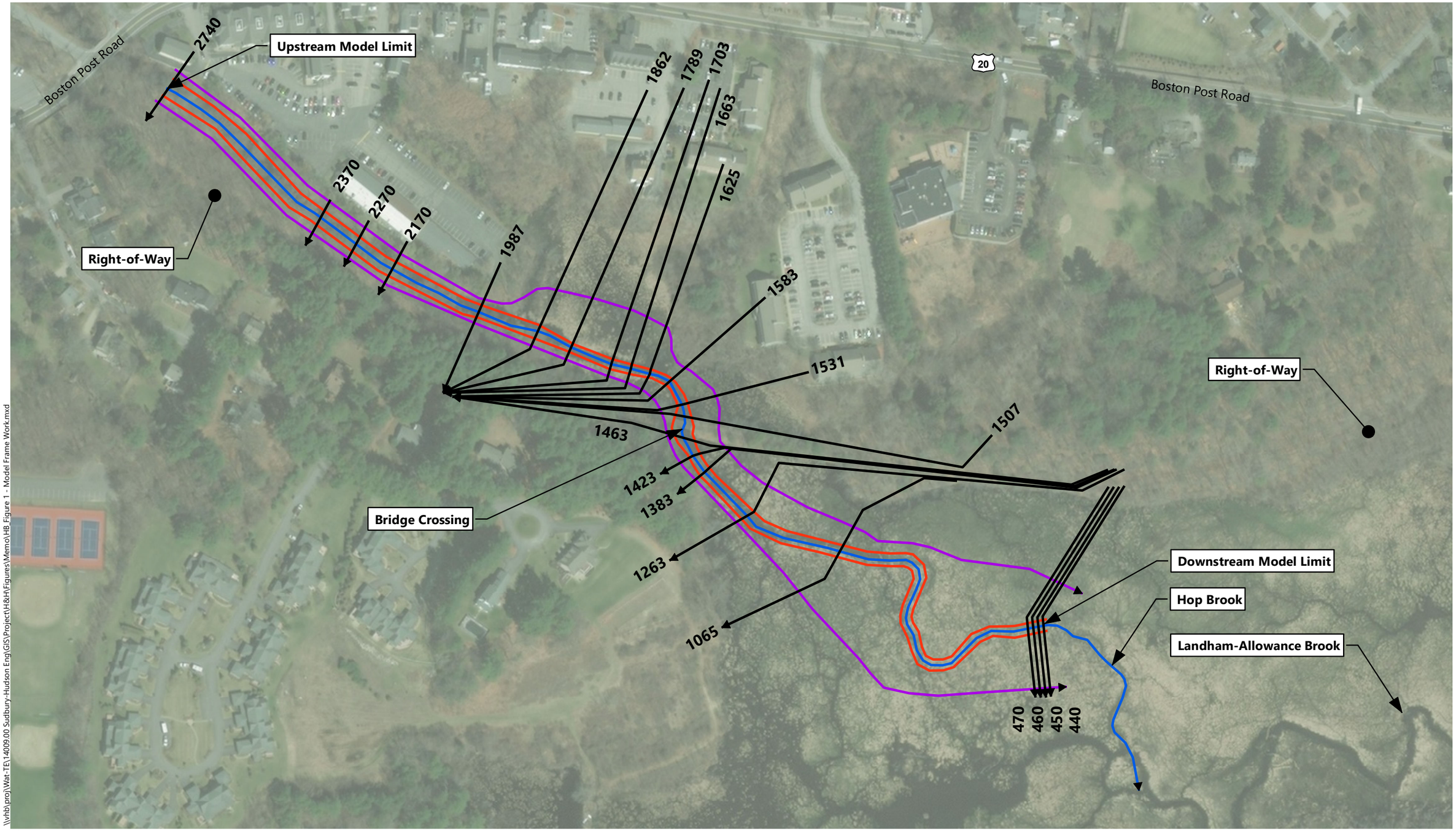
Ineffective flow areas were assigned to portions of the model cross sections. Ineffective flow areas were assigned to areas that would be inundated but provide no active flood flow. These areas include depressions within the floodplain and areas immediately upstream and downstream of the bridge approach embankments.

Results

Table 4 is the calculated water surface elevations for the 1% annual exceedance event for Hop Brook between Boston Post Road and Landham Road. Appendix A is the HEC-RAS cross sections with 1% annual exceedance event water surface elevations.

Table 4: 1% Annual Exceedance Event – Water Surface Elevations

Station	Water Surface Elevation
2740	130.57
2370	126.85
2270	126.13
2170	126
1987	126.07
1861	126.22
1789	126.22
1702	126.21
1663	126.21
1625	126.21
1582	126.17
1531	126.14
1506	126.13
1484	Bridge
1462	123.95
1422	123.47
1383	123.13
1263	122.67
1065	122.35
470	121.48
460	121.45
450	121.42
440	121.38

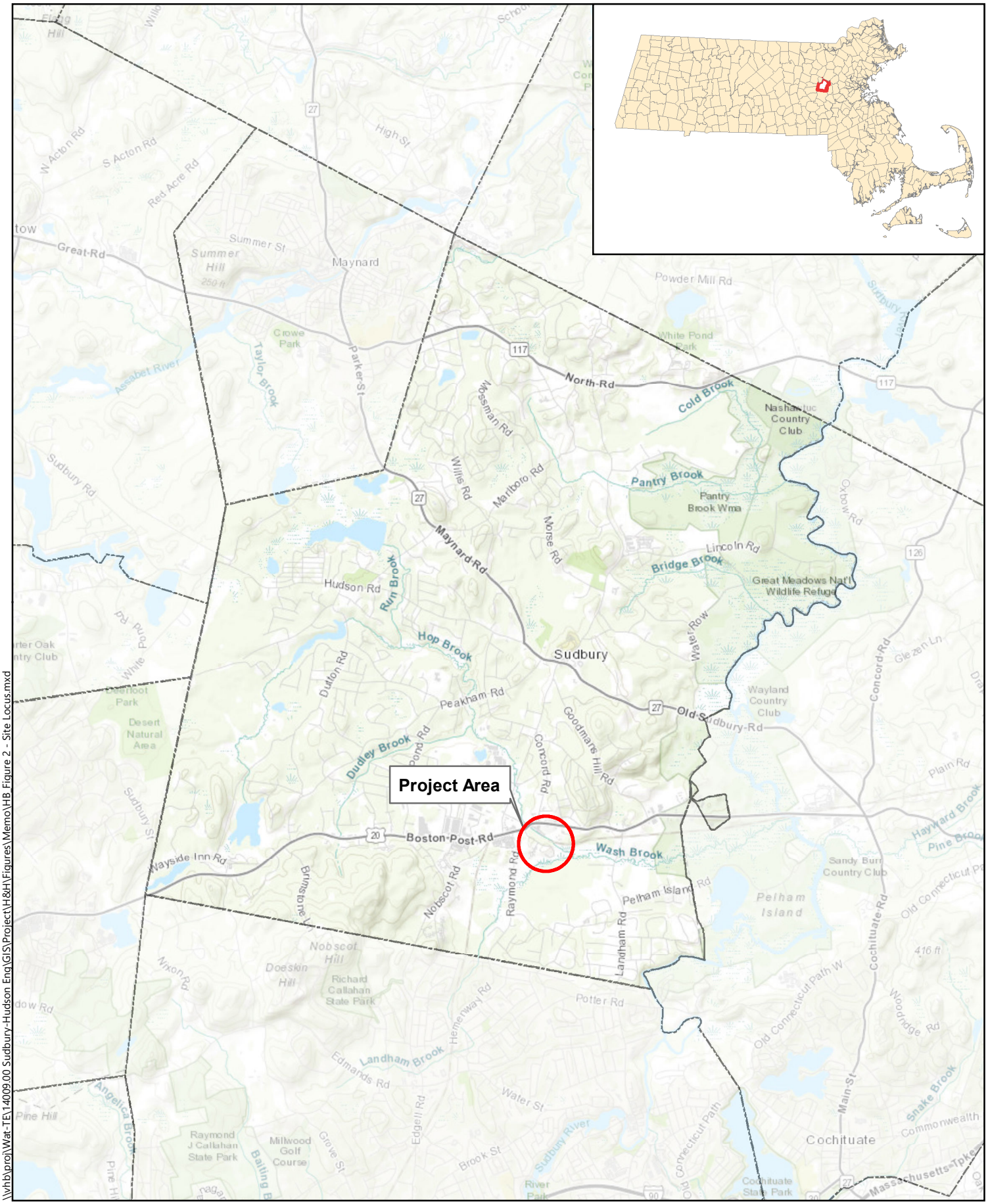


\\vhb\proj\Wat-TE\14009.00 Sudbury-Hudson Eng\GIS\Project\H&H\Figures\Memo\HB_Figure 1 - Model Frame Work.mxd

Sudbury-Hudson Transmission Reliability Project | Sudbury, Massachusetts

Model Frame Work

Source Info: Google

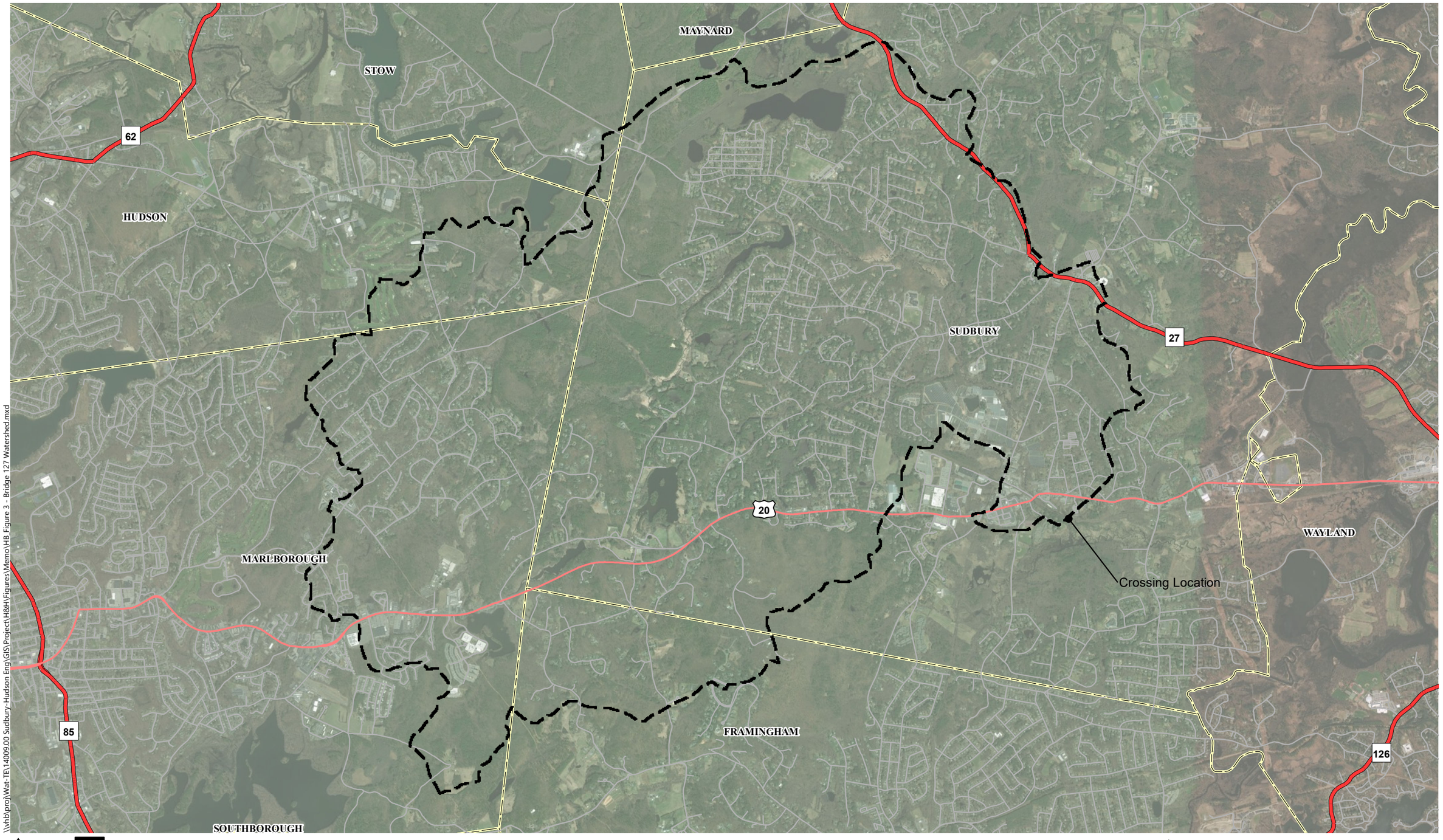


\\vhb\proj\Wat-TE\14009.00 Sudbury-Hudson Eng\GIS\Project\H&H\Figures\Memo\HB Figure 2 - Site Locus.mxd

0 1 2 Miles

Sudbury-Hudson
Transmission Reliability Project | Sudbury, Massachusetts

Site Locus
Source Info: MassGIS



\\vhb\proj\Wat-TE\14009.00 Sudbury-Hudson Eng\GIS\Project\H&H\Figures\Memo\HB Figure 3 - Bridge 127 Watershed.mxd

0 1000 2000 4000 Feet

Watershed

Town Boundaries

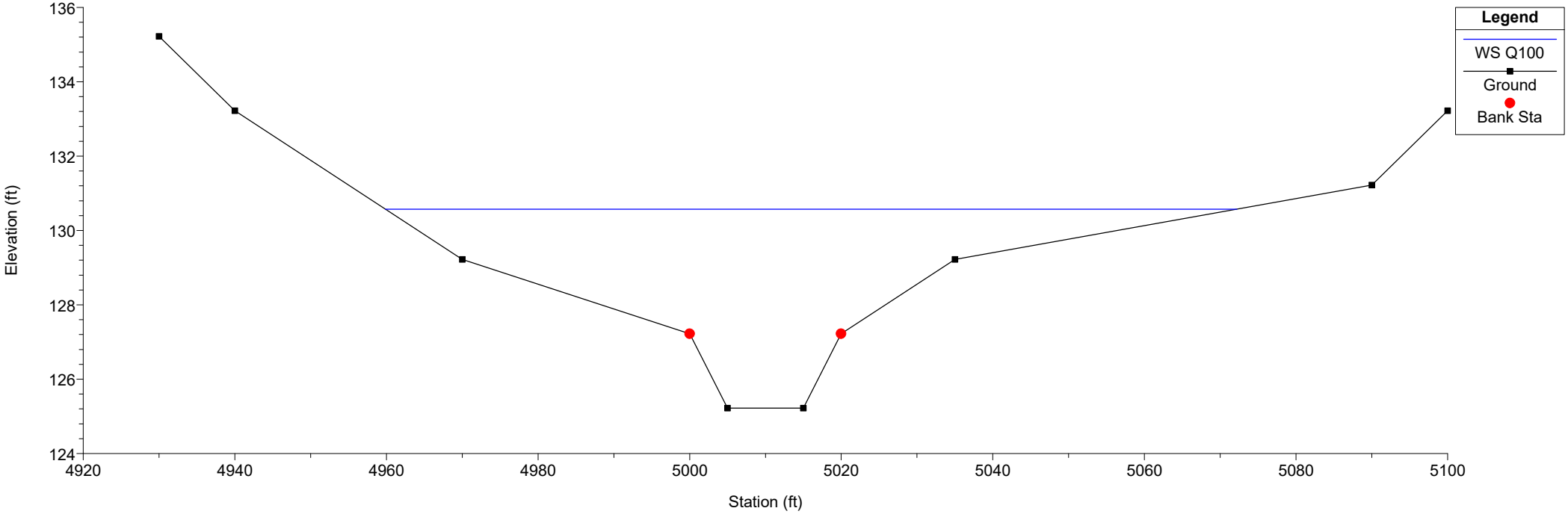
Sudbury-Hudson Transmission Reliability Project | Sudbury, Massachusetts

Bridge 127 Watershed

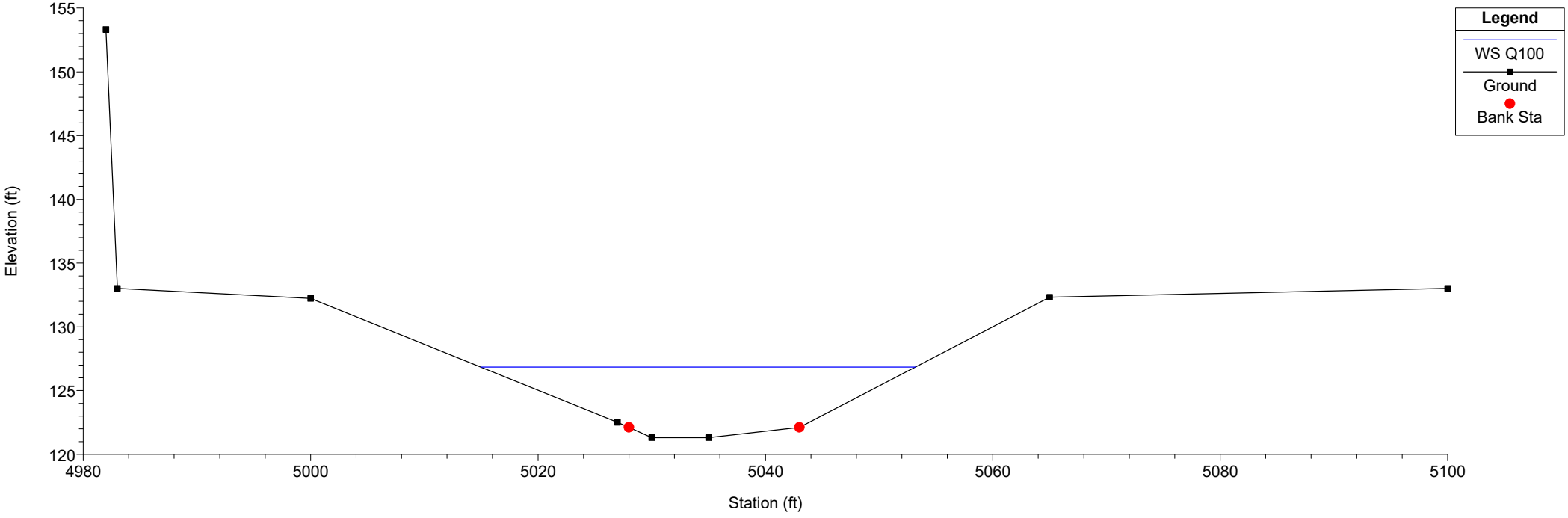
Source Info: Google, NOAA

Appendix A: HEC-RAS Cross Sections

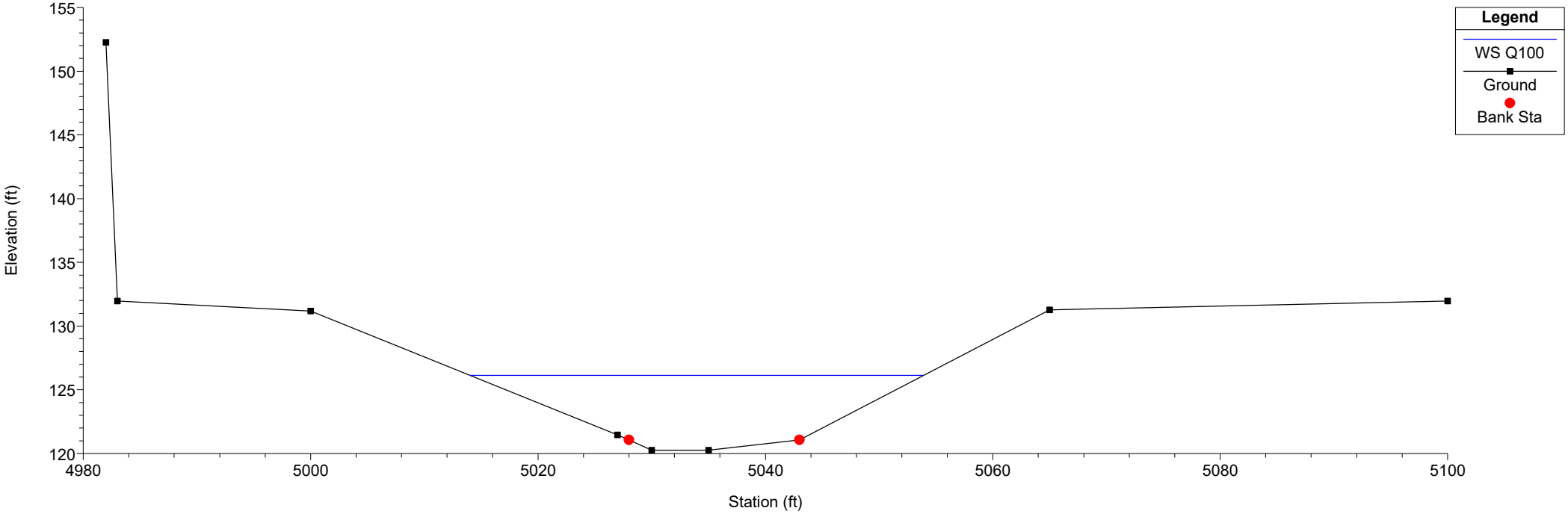
HopBrook_BR127 Plan: CorrectedEffective
RS = 2740



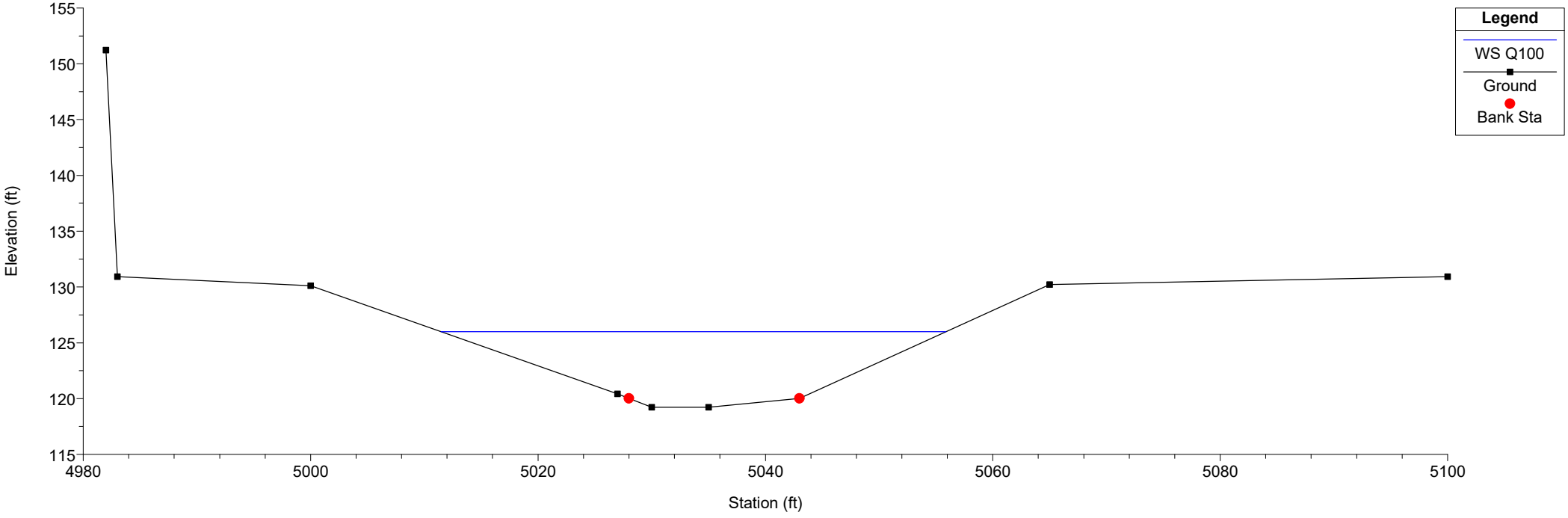
HopBrook_BR127 Plan: CorrectedEffective
RS = 2370



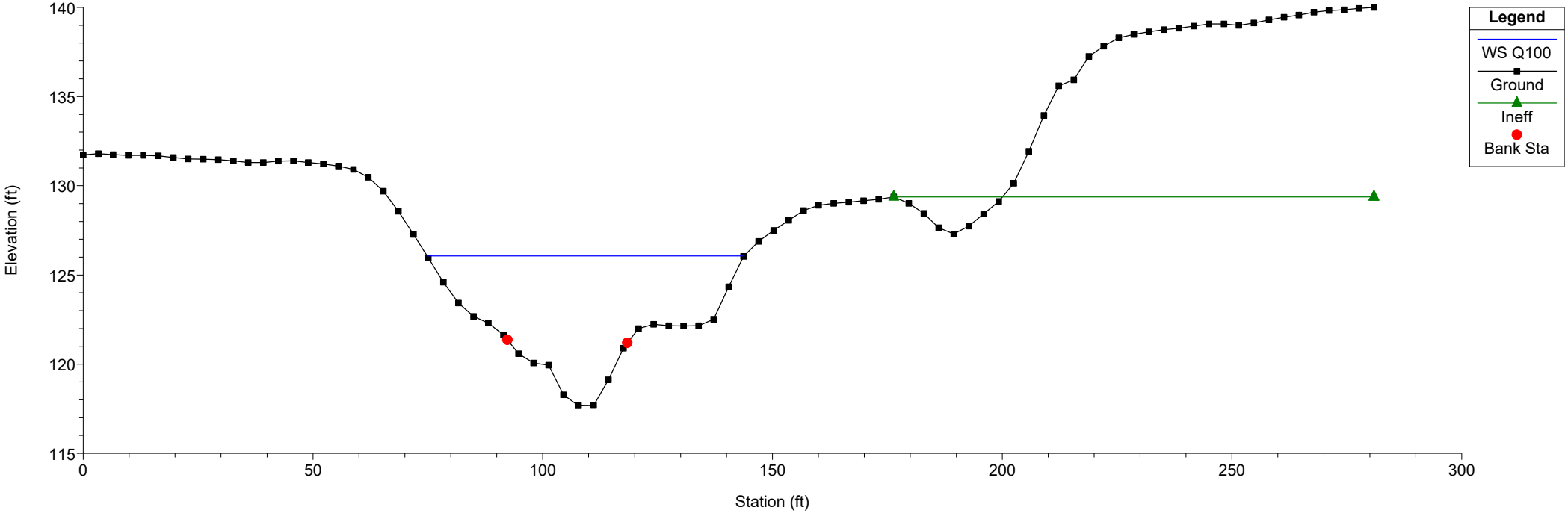
HopBrook_BR127 Plan: CorrectedEffective
RS = 2270



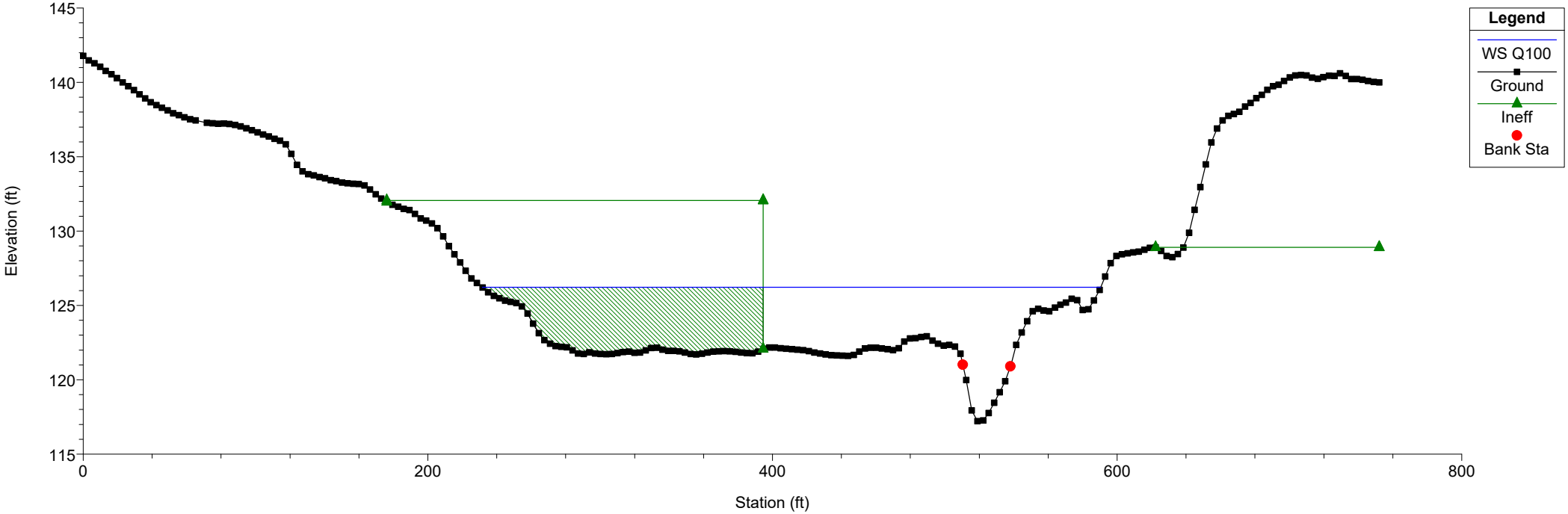
HopBrook_BR127 Plan: CorrectedEffective
RS = 2170



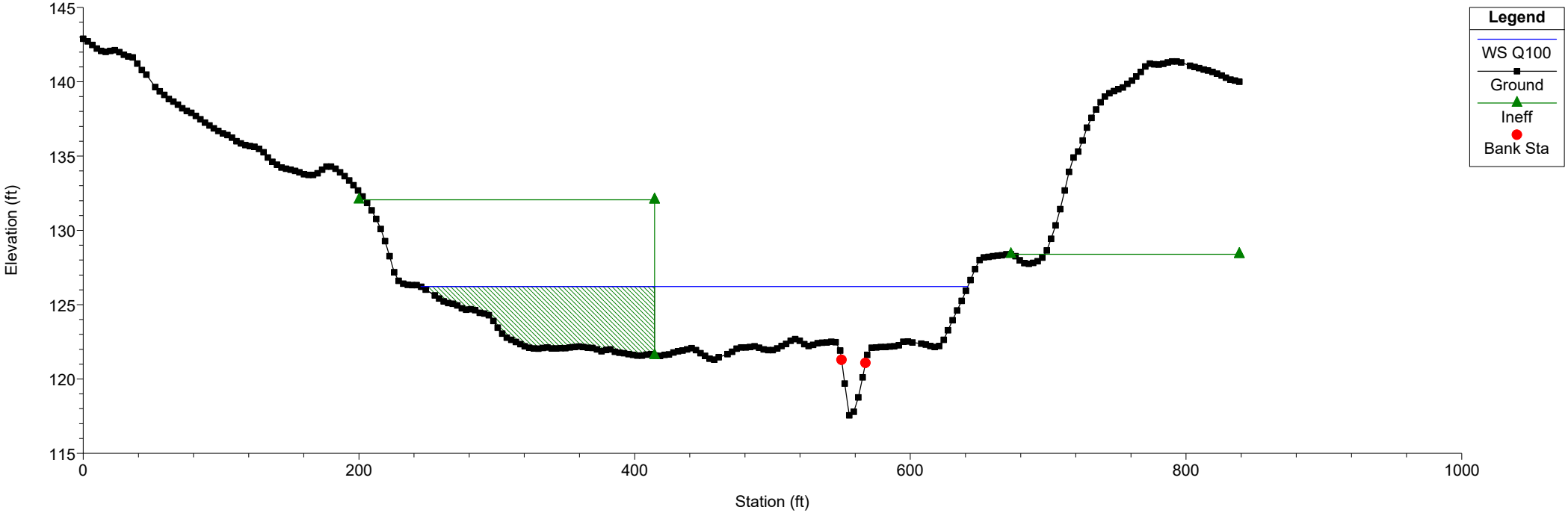
HopBrook_BR127 Plan: CorrectedEffective
RS = 1987.491



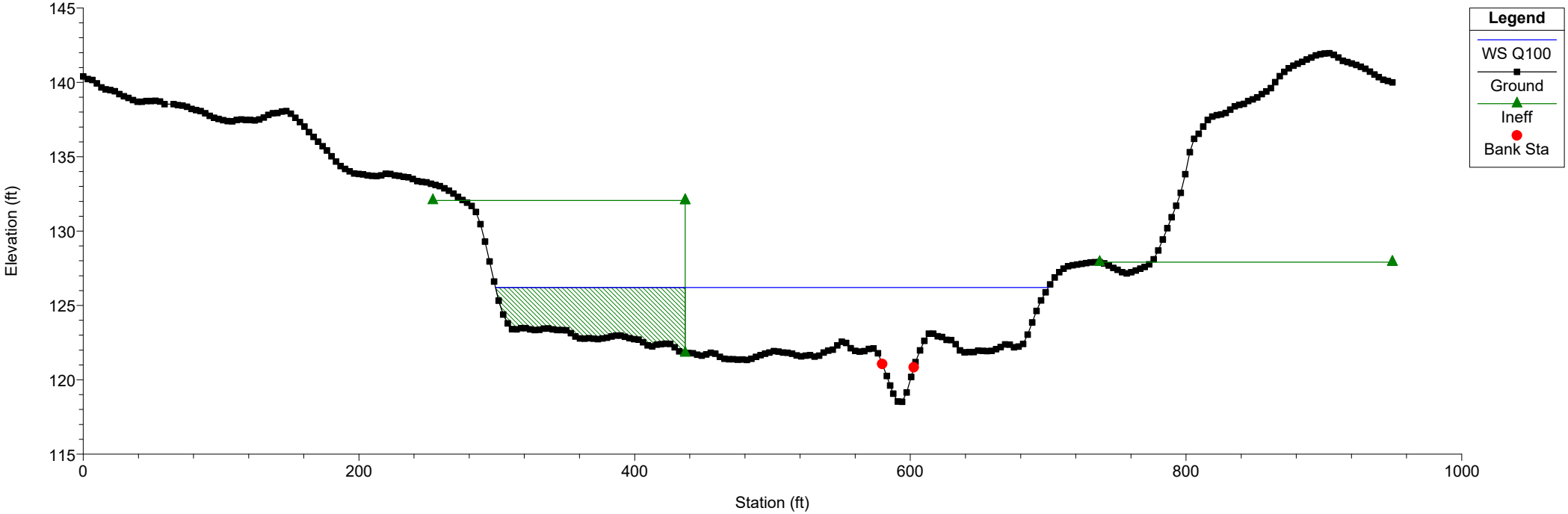
HopBrook_BR127 Plan: CorrectedEffective
RS = 1861.771



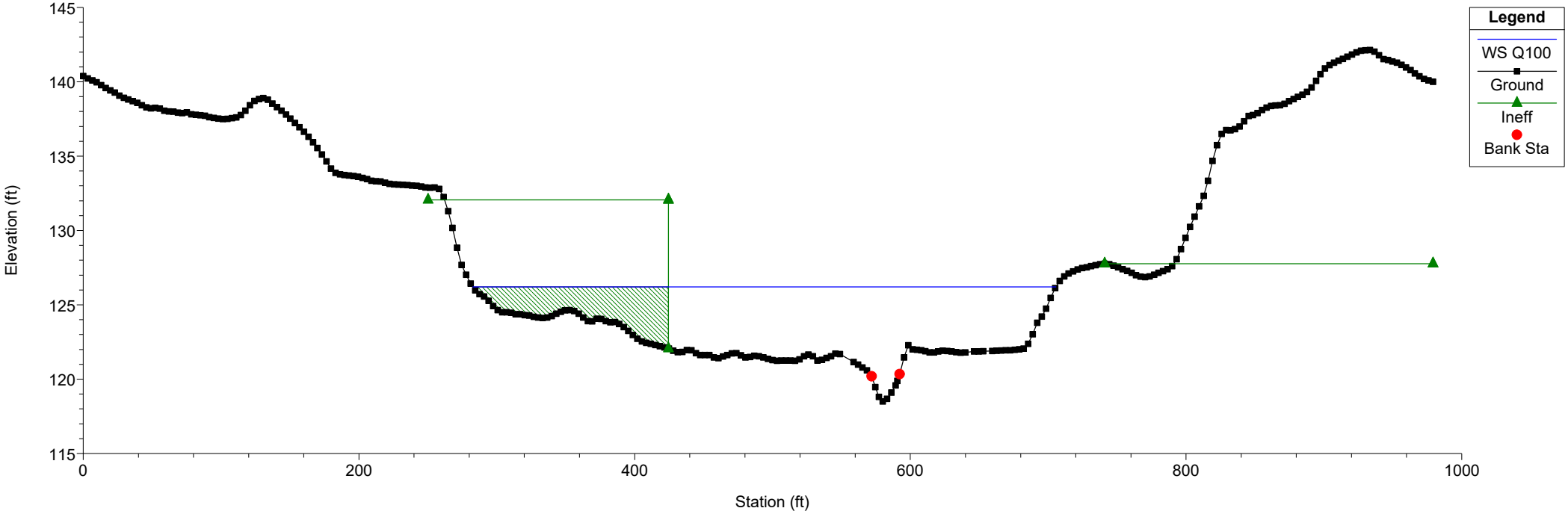
HopBrook_BR127 Plan: CorrectedEffective
RS = 1789.106



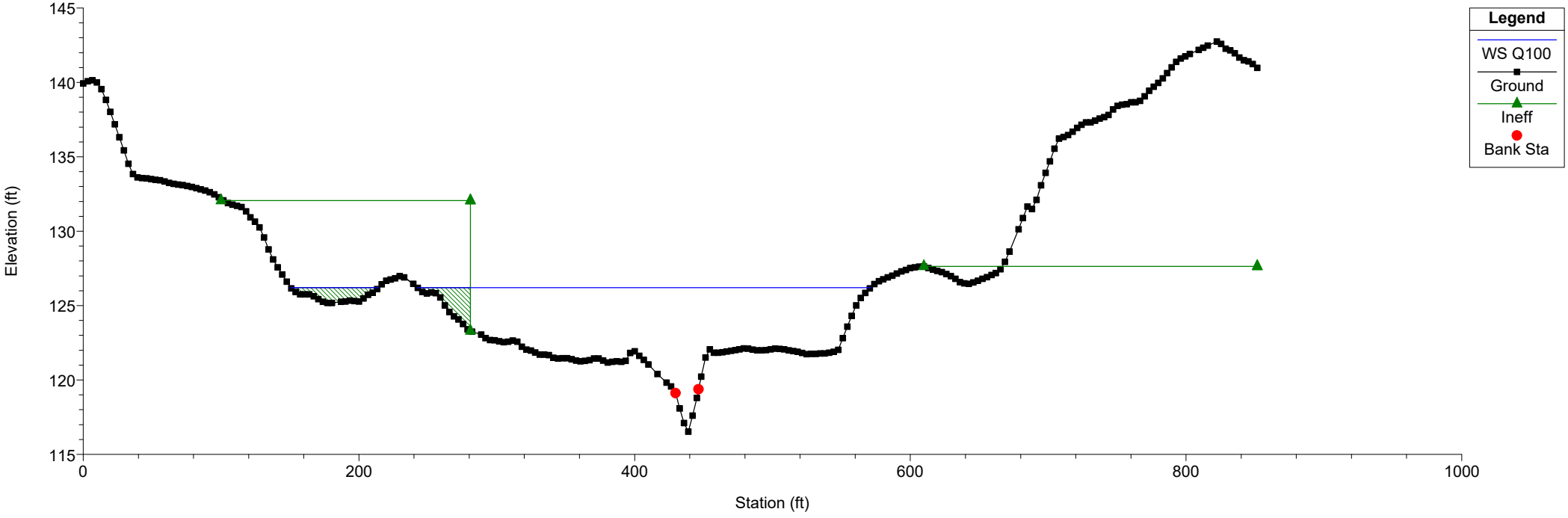
HopBrook_BR127 Plan: CorrectedEffective
RS = 1702.912



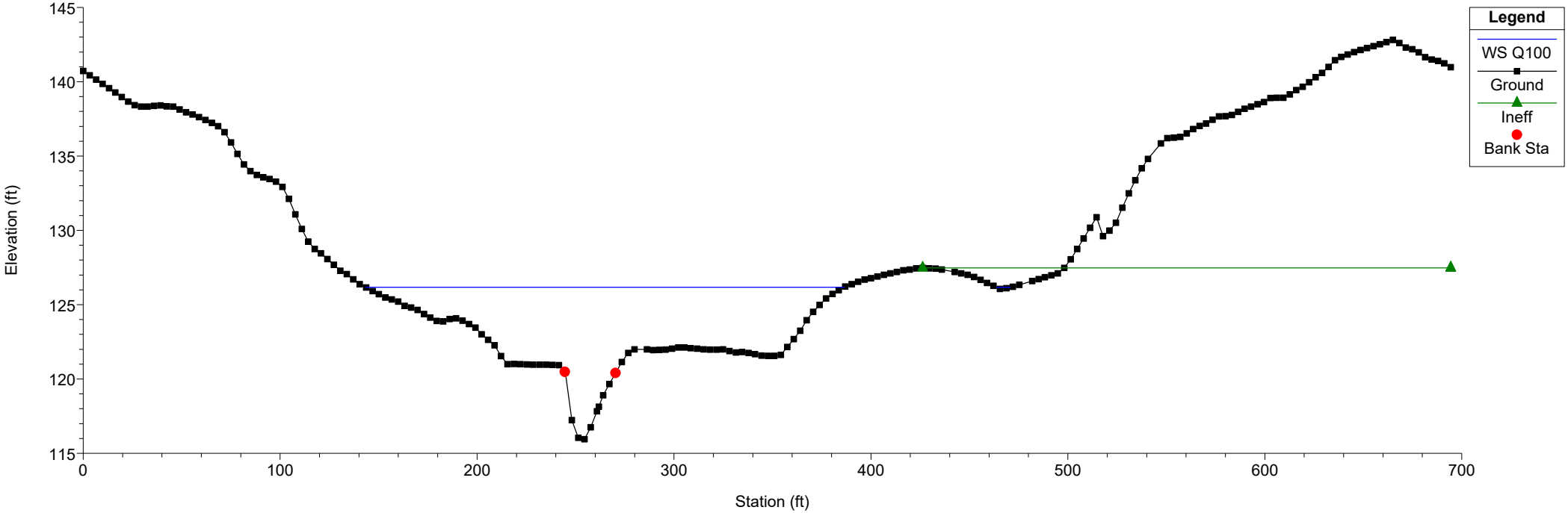
HopBrook_BR127 Plan: CorrectedEffective
RS = 1663.412



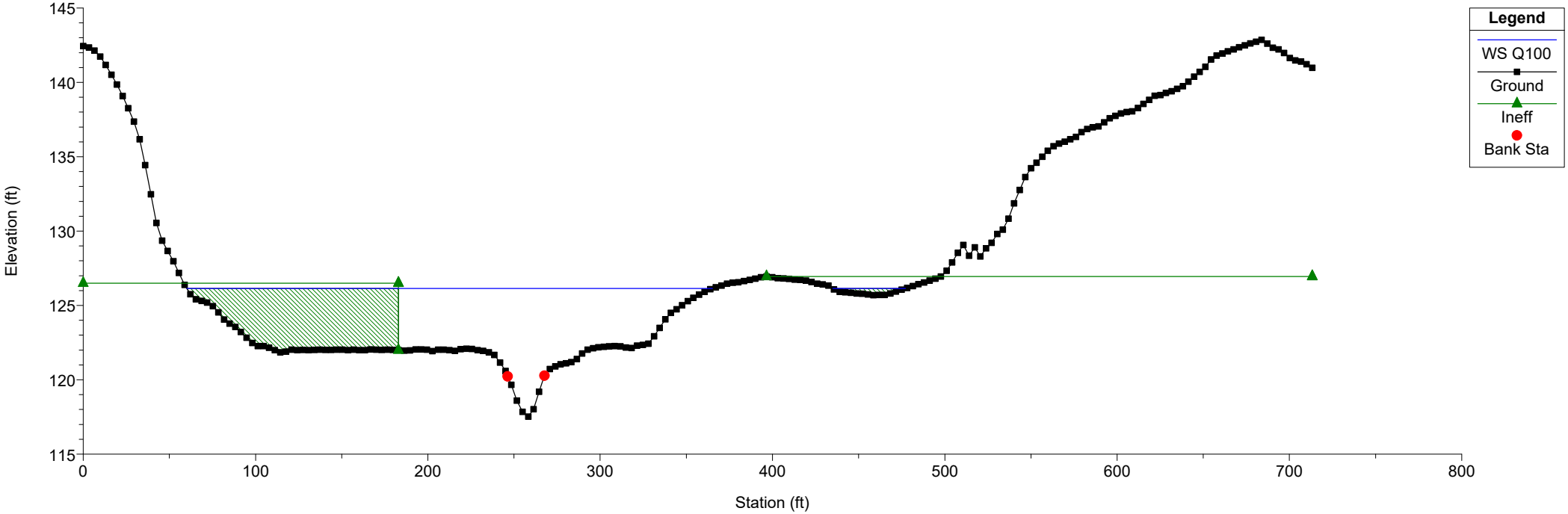
HopBrook_BR127 Plan: CorrectedEffective
RS = 1625.026



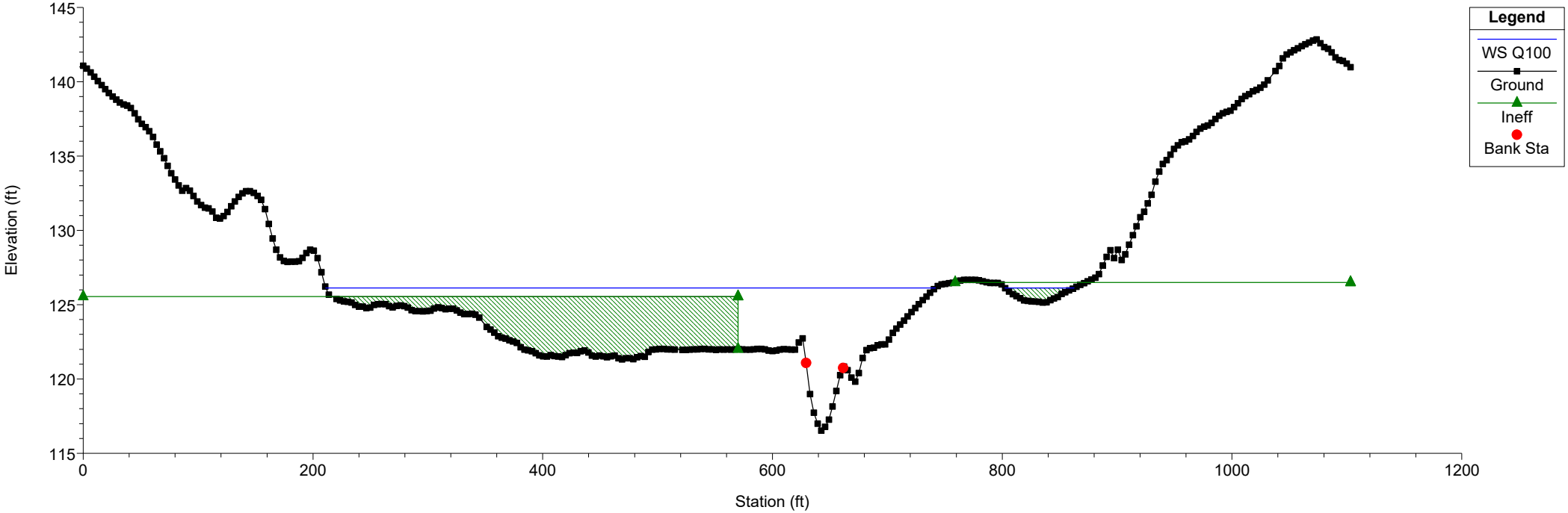
HopBrook_BR127 Plan: CorrectedEffective
RS = 1582.567



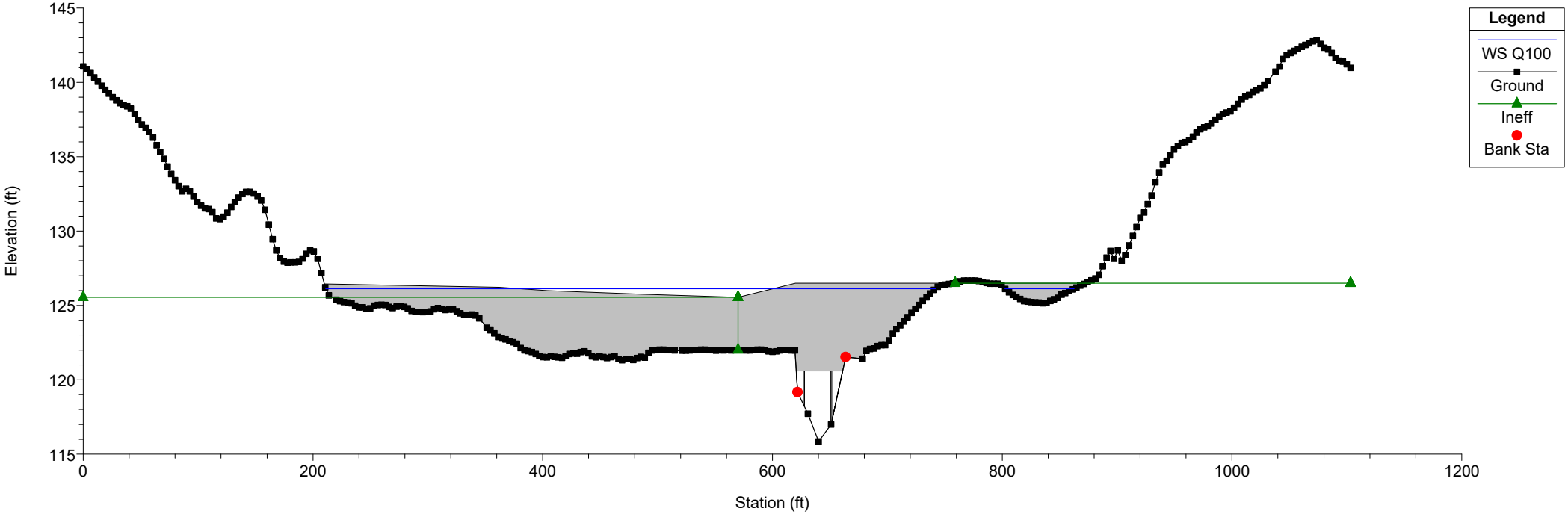
HopBrook_BR127 Plan: CorrectedEffective
RS = 1531.017



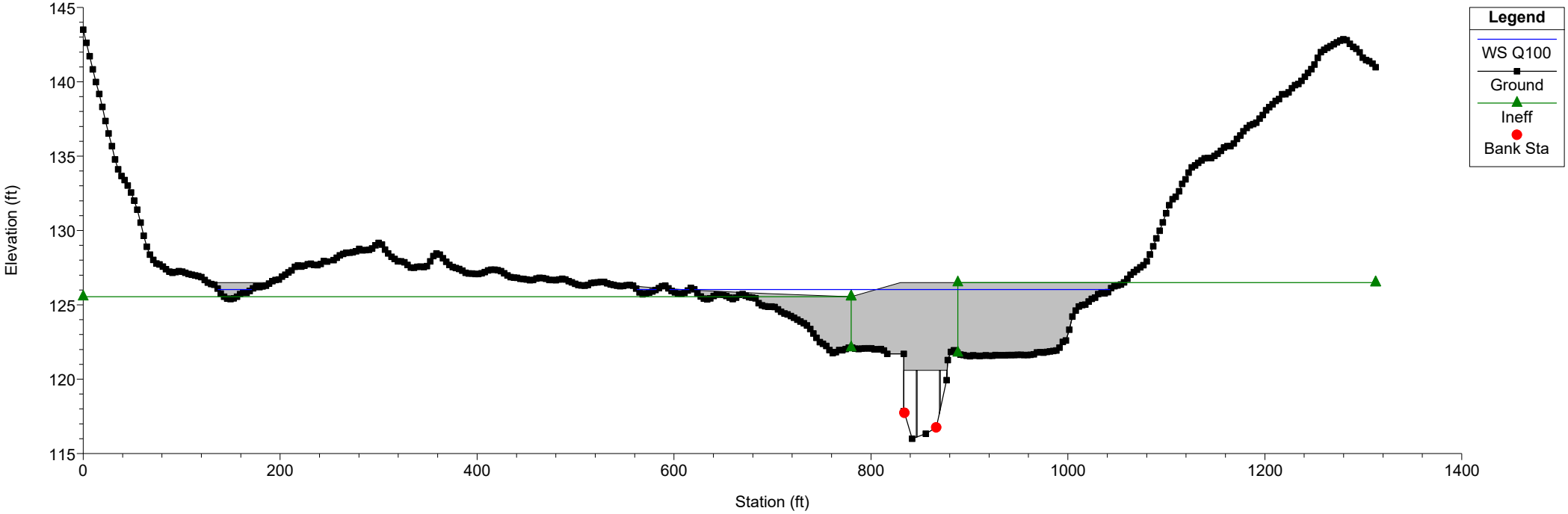
HopBrook_BR127 Plan: CorrectedEffective
RS = 1506.993



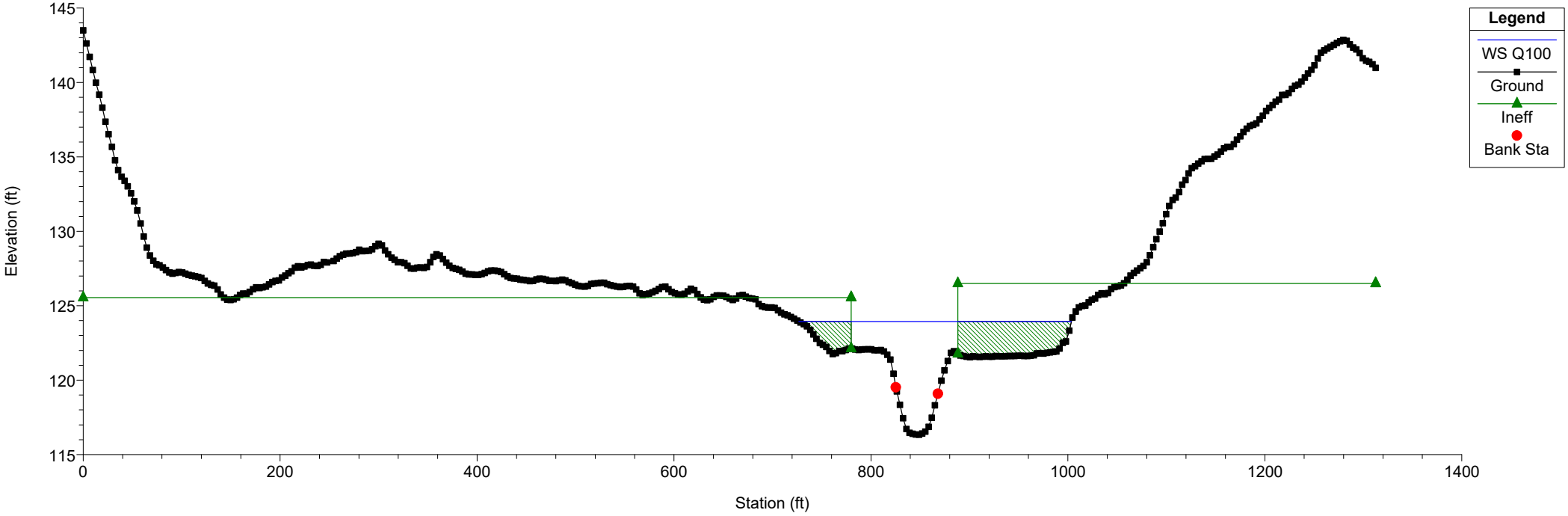
HopBrook_BR127 Plan: CorrectedEffective
RS = 1484.805 BR



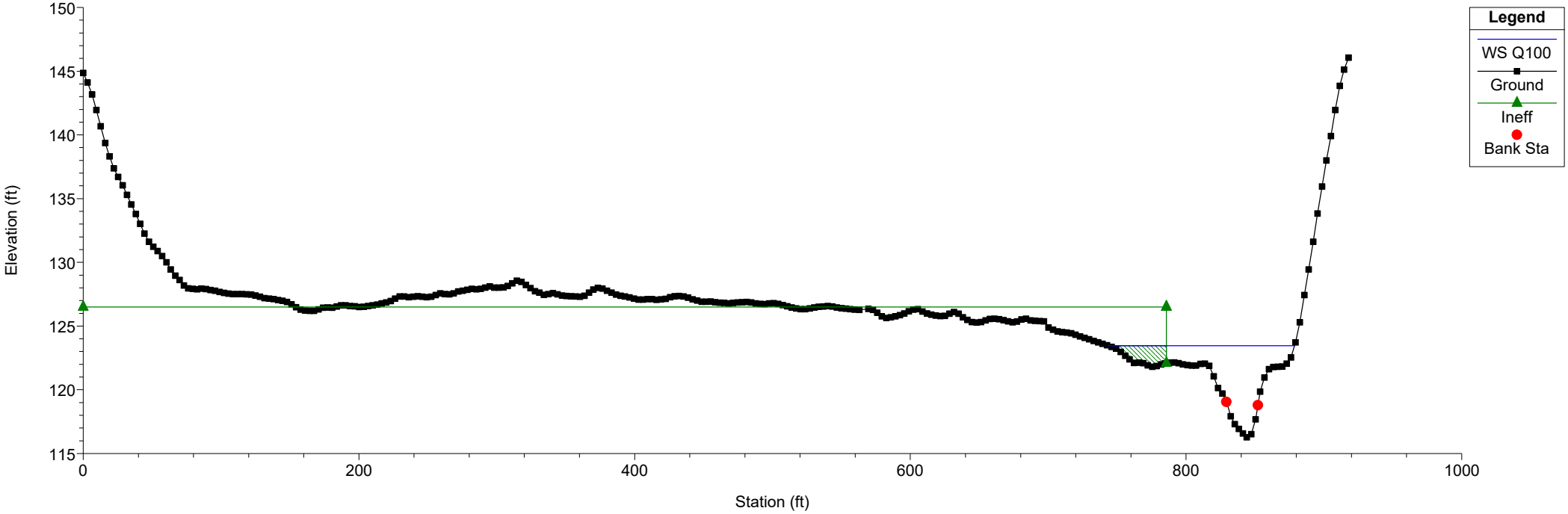
HopBrook_BR127 Plan: CorrectedEffective
RS = 1484.805 BR



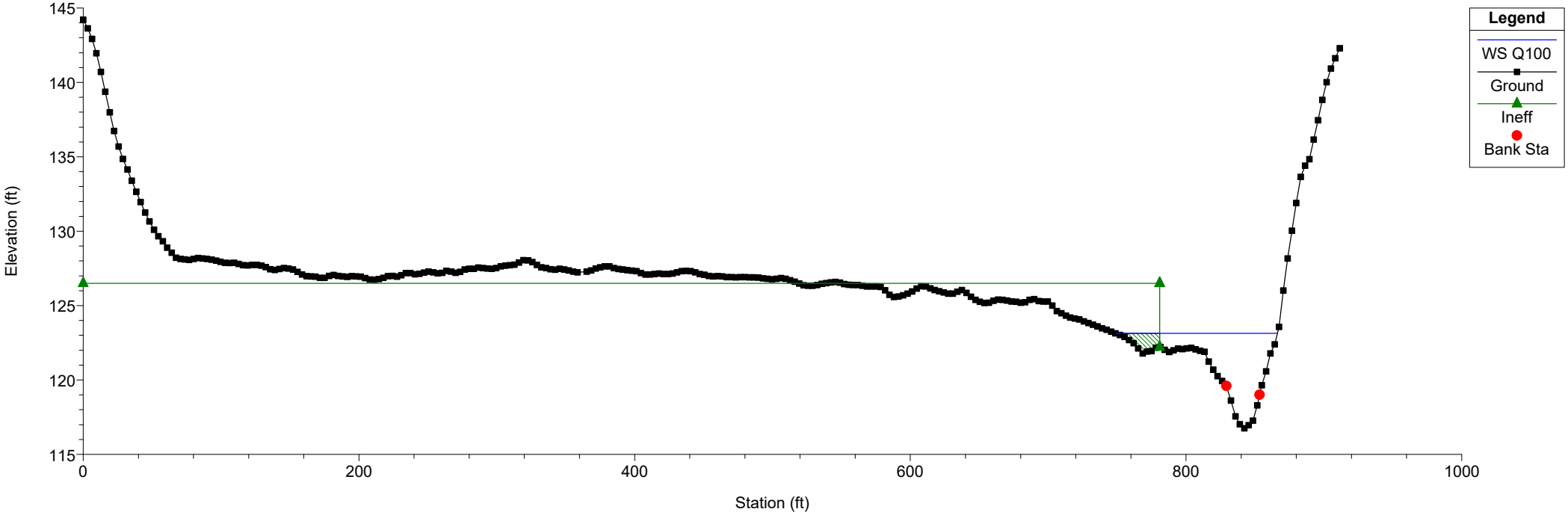
HopBrook_BR127 Plan: CorrectedEffective
RS = 1462.736



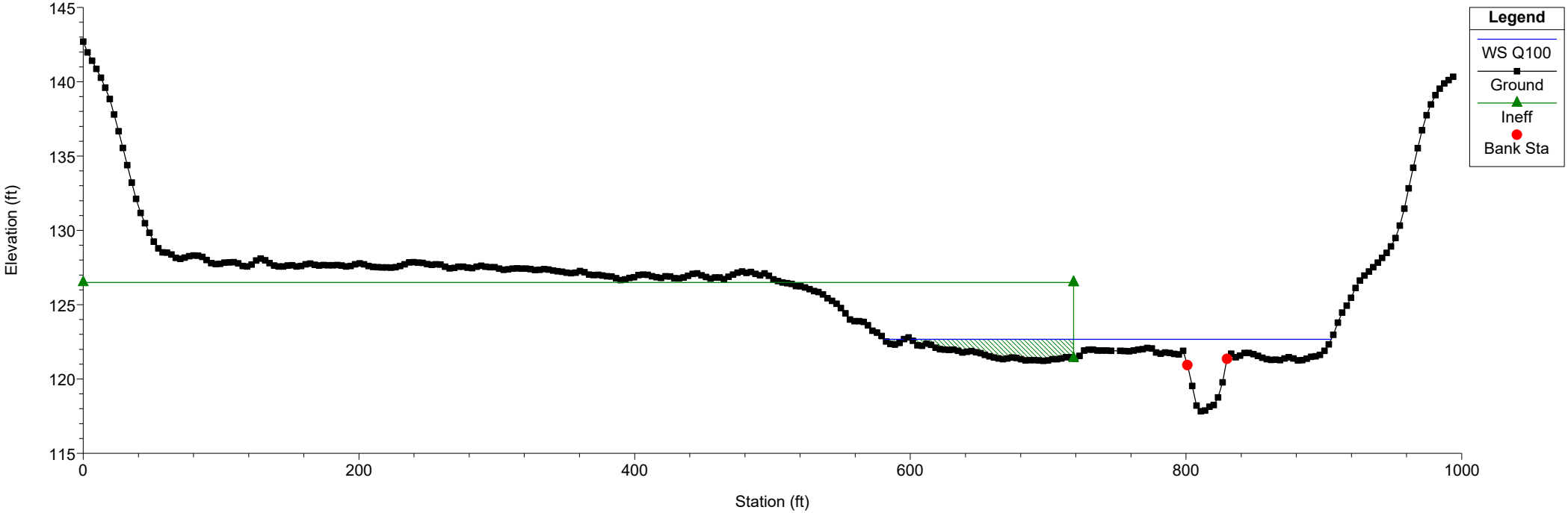
HopBrook_BR127 Plan: CorrectedEffective
RS = 1422.894



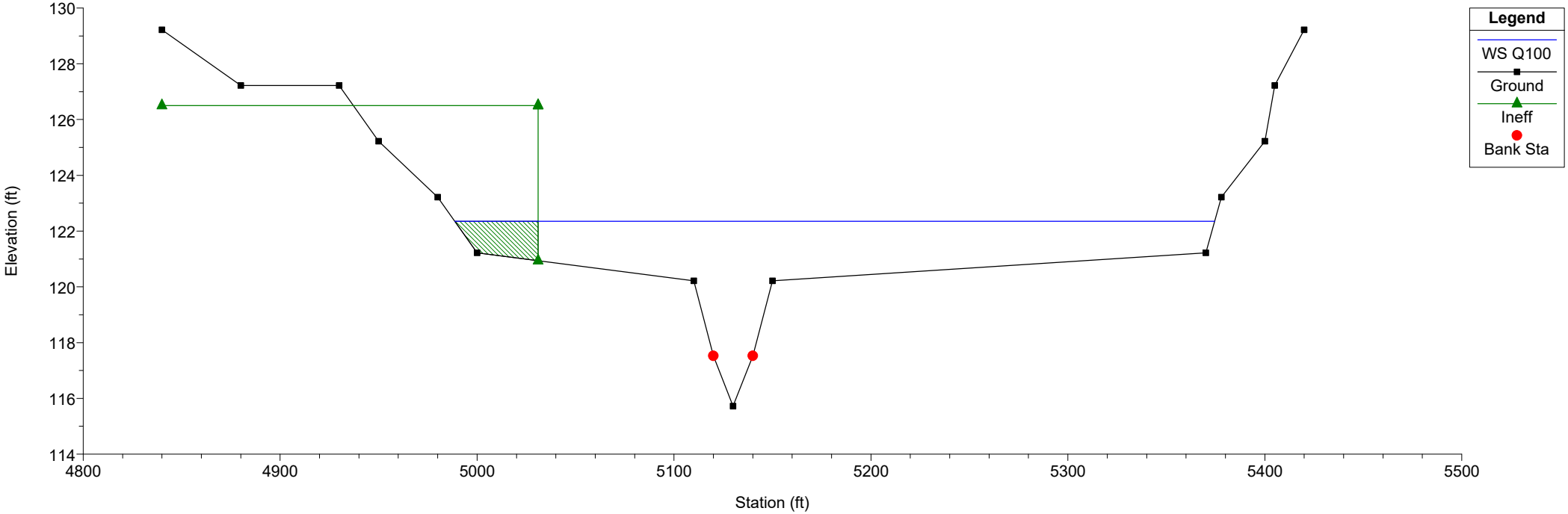
HopBrook_BR127 Plan: CorrectedEffective
RS = 1383.179



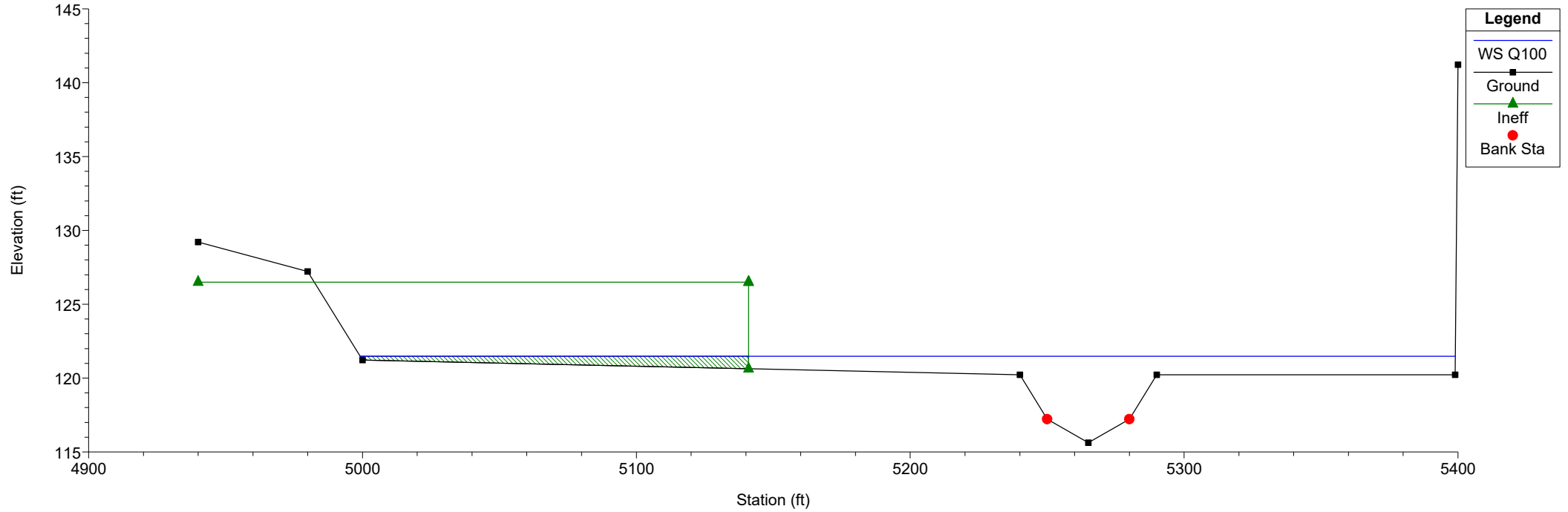
HopBrook_BR127 Plan: CorrectedEffective
RS = 1263.12



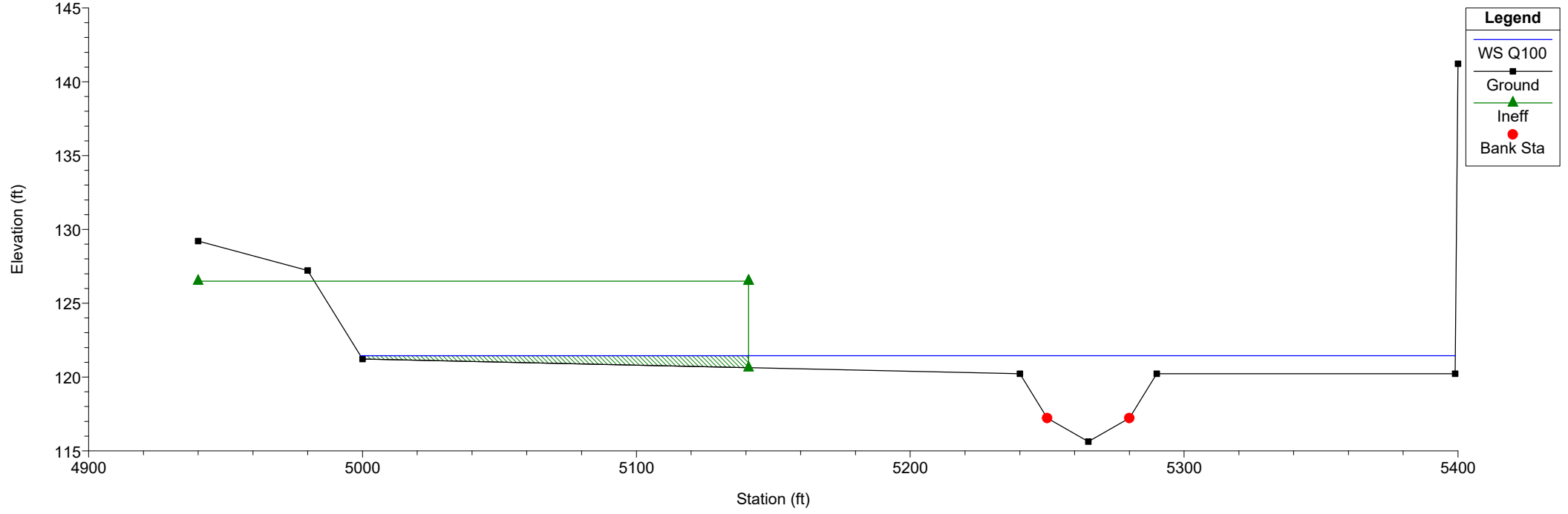
HopBrook_BR127 Plan: CorrectedEffective
RS = 1065



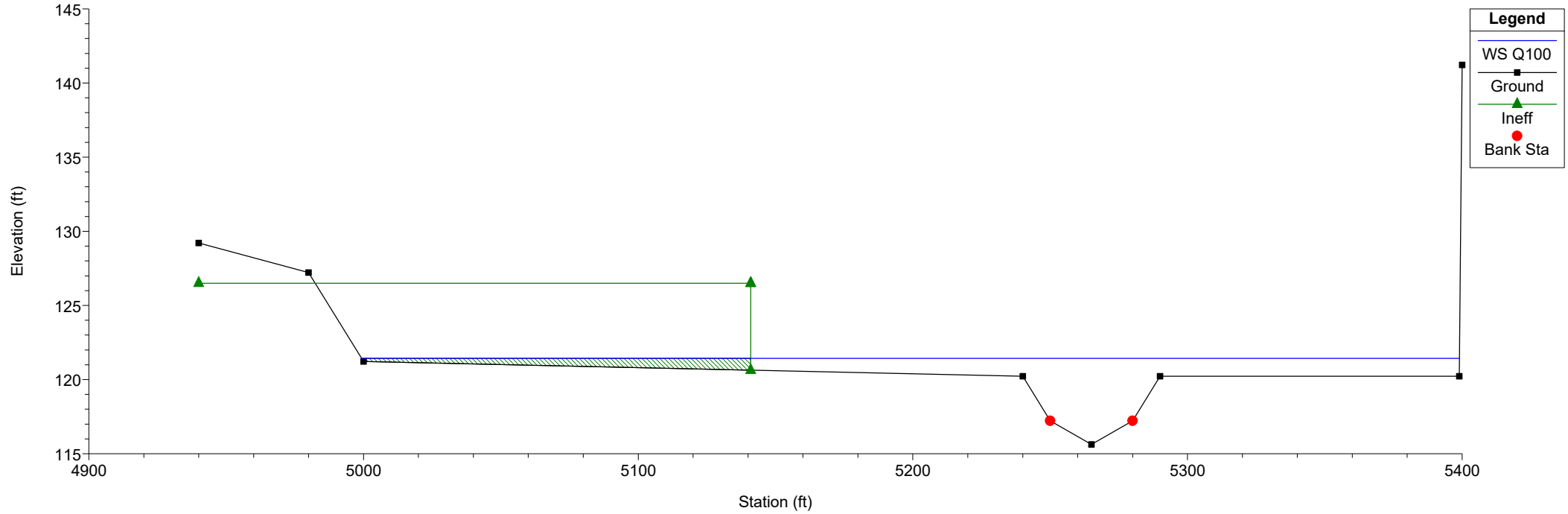
HopBrook_BR127 Plan: CorrectedEffective
RS = 470 This is a REPEATED section.



HopBrook_BR127 Plan: CorrectedEffective
RS = 460 This is a REPEATED section.



HopBrook_BR127 Plan: CorrectedEffective
RS = 450 This is a REPEATED section.



HopBrook_BR127 Plan: CorrectedEffective
RS = 440 XS working upstream from confluence of Hop Brook and Landham-All