# TOWN OF IPSWICH
UTILITIES DEPARTMENT

272 HIGH STREET • IPSWICH, MA 01938 • (978) 356-6635 • FAX: (978) 356-6634

April 17, 2019

Ms. Page Czepiga
Executive Office of Energy and Environmental Affairs (EEA)
MEPA Office
100 Cambridge Street, Suite 900
Boston, MA 02114

Re: Ipswich Sewer Interceptor Rehabilitation and Siphon Replacement Project
EEA File #16003

Dear Ms. Czepiga:

The Ipswich Wastewater Department is pleased to respond to agency and public comments received on the Environmental Notification Form for the above-referenced project through April 12, 2019. In addition to the project background provided below, responses to written comments and key discussion points from recent interagency meetings are enclosed.

Project Background

The Ipswich Wastewater Department is responsible for the collection, conveyance, and treatment of the wastewater generated by its 2,100 customers. The original collection system dates back to 1958. The current system includes approximately 23 miles of sewer pipe, 700 manholes and five pump stations. Wastewater is conveyed by gravity through pipes ranging from 6- to 24-inches in diameter. There are four pump stations throughout town in areas where flow by gravity pipes cannot be achieved. The fifth pump station, located at the Town Wharf on East Street, receives all the wastewater from the sewer system and conveys it directly to the Wastewater Treatment Plant on Fowlers Lane.

Two critical components of the wastewater collection system are the 18-inch interceptor along the Ipswich River near Choate Bridge, and the adjacent 12-inch sewer siphon that crosses below the Ipswich River. These pipes were constructed in 1958 and remain in original condition. Failure of one or both of these pipes would have severe impact to wastewater customers, the health of the Ipswich River, shellfishing activities, and downstream bathing beaches.

In the fall of 2017, the Town worked with engineering consultant New England Civil Engineering to develop a detailed bypass plan in the event of a failure of either the interceptor or siphon. The final plan entitled "Ipswich River Interceptor Sewer and Siphon Emergency Action Plan" (EAP) was completed in March 2018 and includes two options for emergency bypass. In May 2018, the Town solicited responses from engineering firms to evaluate the interceptor and siphon for replacement or rehabilitation. The Town awarded a contract to Tighe & Bond in June 2018. Extensive field activities were completed in the summer of 2018 to document the existing condition of the pipes, evaluate alternatives, and assess environmental impacts of potential future construction activities. This evaluation is detailed in a report prepared by Tighe & Bond and titled "Ipswich River Sewer Interceptor and Siphon Evaluation." Since many of the agency and public comments relate to the Town's alternatives for upgrading the interceptor and siphon as well as maintaining adequate flows, this evaluation report and the EAP are included as attachments.

The main conclusions of the sewer interceptor and siphon evaluation were:

1. **The 18-inch interceptor pipe is exposed along the Ipswich River and susceptible to damage from objects floating down the river. The original revetment stone protecting the exterior of the interceptor has washed away.**

   The Town and Tighe & Bond evaluated several alternatives to protect the interceptor pipe and improve resiliency along the bank of the Ipswich River. A combination of concrete encasement and cured-in-place pipe (CIPP) lining was the selected as the most advantageous alternative. Together with slope stabilization including toe stone and native plantings, this alternative will restore the interceptor pipe and prevent erosion that would undermine existing concrete supports.

2. **The 12-inch sewer siphon is currently oversized and does not provide the minimum velocity required to flush solids through the system. As a single barrel siphon, there is no redundancy or means to divert flow other than emergency bypass pumping. It is also exposed in the riverbed and susceptible to damage and puncture from objects floating in the river.**

   Similar to the interceptor evaluation, the Town and Tighe & Bond assessed several alternatives to improve the hydraulics and resiliency of the sewer siphon. A new triple-barrel siphon buried deeper in the river was selected as the most advantageous solution. Until the new pipes are in place, the Town must rely on its EAP in the event of an emergency requiring bypass of the siphon.

In addition to these findings and recommendations, the Town previously evaluated bank stabilization along a portion of the Ipswich River closer to the Green Street Bridge. The Ipswich Wastewater Department plans to armor this location as it is directly adjacent to the same 18-inch sewer interceptor pipe referenced above. Preliminary plans for stabilization include habitat and toe protection anti-scour stone, and will be designed to avoid scour impacts and blend into the existing bank.

We trust the enclosed responses are satisfactory to answer the agency and public comments. Should you have any questions or additional comments, please do not hesitate to contact me at 978-356-6635.

Regards,

Vicki Halmen
Water & Wastewater Director
Town of Ipswich

cc: Ian Mead, P.E., Tighe & Bond
Amanda Houle, Tighe & Bond
Daniel Roop, P.E., Tighe & Bond

Enclosure: MEPA ENF Responses Agency & Public Comments (EEA #16003)

Ipswich Sewer Siphon & Interceptor Rehabilitation - MEPA ENF Responses Agency & Public Comments (EEA #16003)

TO: Page Czepiga, Environmental Analyst, MEPA Office

FROM: Ian Mead PE, Tighe & Bond

Amanda Houle, PWS, CERP, Tighe & Bond

Daniel Roop PE, Tighe & Bond

COPY: Vicki Halmen, Town of Ipswich

Teri Demers PE, Town of Ipswich

DATE: April 17, 2019

This memorandum is provided is in response to agency and public comments received on the ENF filed for the proposed Ipswich Sewer Siphon and Interceptor Rehabilitation Project. MEPA held a public meeting and site visit on April 5, 2019. The Massachusetts Office of Coastal Zone Management (CZM) and Massachusetts Division of Marine Fisheries (DMF) were also in attendance and participated in the discussion. Additionally, the Project Team met with MassDEP Northeast Regional Office on April 10, 2019 to discuss their questions specific to the ENF filing. Comments were also received from the U.S. Army Corps of Engineers (USACE) on April 8, 2019. A number of comments and questions focused on design alternatives and detailed analysis of alternatives. In March 2019, Tighe & Bond completed the *Ipswich Siphon and Interceptor Evaluation – Final Report.* A majority of the information requested is presented in this report (Appendix A).

Below, please find a compiled list of comments received. . Significant overlap occurred among agency comments and questions, however, the responses are organized by source of the questions (i.e., individual meetings or written comment letters). In the discussion provided below, the comments are listed first (bold font), followed by Tighe & Bond's responses (italic font).

Comments and Responses from MEPA Public Meeting and Site Visit

MEPA held a public meeting and site visit on April 5, 2019 to discuss the ENF filing. Attendees included CZM, DMF, and the Project Team (Town of Ipswich and Tighe & Bond). A number of the questions are addressed in the Evaluation Report (Appendix A), while other questions and key discussion points are addressed herein.

1. **Hydrologic and Hydraulic Analysis to address the following:**

   i. **How depth of siphon, 5-ft from top of pipe to bottom of river, was selected, and narrative of adequacy.**

   The depth of pipe burial was selected as a balance between constructability and scour protection and frost protection on the banks, with a check being past changes. The riverbed has shown scour compared to the original construction drawings, however the bedrock exposures downstream do suggest a limit to future scour depth going forward. The siphon backfill proposed is gravel as a replacement for the clay to be excavated, which could not be recompacted if reused, with a topping of existing riverbed cobble, supplemented as needed, to restore existing riverbed substrate and address permitting concerns. Therefore, *five feet provides adequate coverage for the siphons to improve resilience against river flows resulting from climate change*.

ii. Sizing of rip-rap stones and narrative of adequacy.

The original (1965) sewer protection rip rap stone was undersized; it appears to have been approximately 6-inches to 12-inches in diameter and was not able to resist river scour. The proposed bank stabilization armor stones along the sewer line will be appropriately sized as a part of the final design to resist flood velocity movement. The stone sizing will likely be 24-inches.

iii. How will velocity of water change with the proposed interceptor encasement and toe slope. Provide narrative that design will be able to withstand any increased velocity.

Tighe & Bond performed a hydrologic analysis for Ipswich River using the FEMA FIS Report for Essex County, MA and a hydraulic analysis using HEC-RAS. Under the two scenarios; mean high water (MHW) and backwater from the Atlantic Ocean, the proposed encasement of the siphon results in very minimal increases in velocity (0.5 ft/s or less), with little to no change in water surface elevation (0.1 ft maximum increase). For regulatory conditions (with backwater from the Atlantic Ocean) no-rise in water surface elevation is anticipated. The proposed repairs and rehabilitation will result in either minor impacts or no impacts on velocity and water surface elevation. No impacts are anticipated starting 100 feet upstream of the Choate Bridge, and 70 feet downstream of the Choate Bridge for both scenarios. The modifications will be designed to withstand the increased velocity. A summary of the hydrologic and hydraulic analysis is included as Appendix C. Additional hydrologic and hydraulic analysis will be performed throughout the design and prior to the permitting process to address concerns related to scour impacts and riprap sizing as described below.

iv. Demonstrate that design (toe stone, armoring, siphon) will avoid scour impacts.

Tighe & Bond will perform a scour analysis for the South Main Street Bridge following the guidance outlined in the MassDOT Bridge Manual (2013). The total scour depth (e.g., contraction scour, abutment scour, and pier scour, if applicable) will be performed in a manner consistent with the Federal Highway Administration (FHWA) Hydraulic Engineering Circular No. 18 (HEC 18) and No. 20 (HEC-20). Tighe & Bond will collect a sample of stream bed material within the channel upstream of each bridge, and another within the floodplain upstream of each bridge. The samples will be submitted to a laboratory for grain size analysis. Note that the proposed changes are not anticipated to change the downstream flow rates and the hydraulic model indicated no change 70 feet downstream of the South Main Street Bridge, so a scour analysis will not be performed at County Street.

v. Provide narrative on impact of this project on neighboring areas such as the Choate Bridge, south bank, other up and downstream structures, and river profile. Discuss if any issues are anticipated elsewhere.

Tighe & Bond will compare existing and proposed conditions' hydraulic parameters (e.g., velocity and flow depth) upstream and downstream of the design area determine anticipated hydraulic impacts. Based on preliminary results the change in velocity and flow depths due to the proposed changes are minimal (velocity changes 0.5 ft/s or less, and changes in depth of less than 0.1 ft). A scour analysis will also be performed as described in the response to the previous comment.

2. Drawing edits and details to be added to the design drawings:

i. **Existing conditions cross sections / profiles of interceptor at caissons, including riverbed sediment profile and slope up to the top of bank. Indicate top of bank elevation.**

Please see updated conceptual drawing set in Appendix D. The following edits were addressed:

a. *Existing Conditions cross sections and profiles of Interceptor at caissons*

b. *Flood Zone relative to bank*

c. *Boring Logs from North and South bank*

d. *Change symbology for temporary versus permanent access road*

e. *Profile of existing conditions*

f. *Detail on transition from proposed toe-stone and encasement to existing bank*

   i. *Stone transition details will be developed in final design as a part of the permitting process to allow for agency input and review, including transitions on both sides of the bridge, and to fit existing riverbank conditions, such as the upstream granite walls, and the eroded bank downstream of the bridge, which varies.*

ii. **For the downstream armoring and slope stabilization near Town Hall, ensure profile and plan of existing conditions is correct.**

Throughout design Tighe & Bond has used existing survey data provided by the Town. Tighe & Bond and the Town have multiple proposed restoration approaches to address erosion concerns. These include the following:

- *Coconut Coir Logs*
- *Boulder Revetment*
- *Boulder Sill*
- *Living Shoreline, Marsh*

If further survey information is necessary to more accurately present this area, further survey data will be captured.

3. **Document what the volume of the "Flood Storage Area" is between the interceptor and the building with overhang just west of the Choate Bridge.**

i. **Discuss if stones will be used to fill in this area, and if so, how will velocities and loss of storage area be affected?**

Stone fill is proposed for this area. The drainage area for the Ipswich River is approximately 148 square miles at this location with a 100-year frequency storm event peak flow rate of over 3,000 cfs. The comparatively small loss in storage area will have a negligible impact on downstream flow rates. The existing and proposed conditions velocities were evaluated, and it was determined that the change in velocity and water depth would be minor between existing and proposed conditions.

4. **Submit full Siphon and Interceptor Evaluation Report by Tighe & Bond.**

Please see attached Appendix A for full Siphon and Interceptor Evaluation Report by Tighe & Bond submitted to the Town, dated March 2019.

5. **Submit environmental impacts for all the alternatives that were considered.**

   Please see attached table in Appendix B that displays environmental impact area numbers for all alternatives. These impact numbers include the following:

   - *Coastal Bank (lf)*
   - *Land Under Waterways and Waterbodies (sf)*
   - *Land Subject to Coastal Storm Flowage (sf)*
   - *Riverfront Area (sf)*

6. **Submit Emergency Contingency Plan for area, and also include this Contingency Plan in the Construction Documents.**

   - *Please see Appendix E – Ipswich River Interceptor Sewer and Siphon Emergency Action Plan. Note that this bypass plan was successfully implemented as a part of the initial siphon evaluation work.*

7. **Provide narrative on why pipe-jacking was not selected as an alternative.**

   - *Pipe jacking was considered as a part of the alternatives evaluation, and the following points provide reasons as to why this was not recommended.*
   - *Pipe-jacking would still require excavation on either side of the river.*
   - *Pipe-jacking induces the potential to displace the existing siphon while jacking underground. There is a level of unknown that has the potential to apply pressure that could lead to sewer release in the river.*
   - *Excavation on either end of the siphon would be deeper and wider than what would be needed for open cut excavation, increasing the nature of the excavation.*
   - *A deeper hole and wider excavation would require a large amount of dewatering to keep the pit dry for the machinery. This dewatering would then have to be treated. Open cut minimizes dewatering as work will be completed in the wet.*

8. **Provide narrative on the existing conditions and design approach.**

   Existing Conditions of Siphon

   - *Siphon is currently oversized and does not provide the level of flushing velocity required to flush solids through the system. This could lead to periodic flooding and potential sewer discharges along the edge of the river as a buildup of solids would prevent flow through.*
   - *The current siphon is laid out as a single barrel and does not provide any level of redundancy in case of emergency. If there is a blockage in the siphon, or if maintenance is required, there is no way to divert flow other than the Town's Emergency Action Plan (Appendix E).*
   - *The siphon is currently exposed in the riverbed and susceptible to damage and puncture from objects floating in the river. This would lead to sewer discharge in the river.*

   Design Approach of Siphon

   - *The design intent is to properly size the siphon to promote flushing velocity throughout the system and prevent solids from building up in the siphon. This is done by reducing the diameter of the siphon.*

- *Redundancy is a requirement in the new design of the siphon. Redundancy allows for the siphon to continue operation even if there is a blockage in the line and allows siphons to be taken offline for maintenance.*
- *The new siphon will be buried deeper in the river and be protected from objects floating in the river.*
- *New design will provide real time access to flow levels on upstream side to monitor water levels.*

Existing Conditions of Interceptor

- *The current Interceptor is exposed in the river and susceptible to damage from objects floating down the river, similar to the siphon. The original revetment stone protecting the exterior of the interceptor has washed away.*
- *Because the pipe is from 1959 and has faced corrosion over time, there is the potential for sewer leakage from the pipe into the river.*
- *The current bolt and flange connections have failed and corroded away. While some are still intact, most are no longer structurally sound and no longer hold the pipe joint together.*
- *Areas along the interceptor show signs of corrosion and create the potential to undermine the concrete supports the Interceptor rest on. If undermined, these supports could collapse causing damage to the Interceptor.*

Design Approach of Interceptor

- *Encasing the Interceptor in concrete will provide protection to the interceptor from the exterior. A concrete encasement also prevents any leaks currently in the interceptor from reaching the river.*
- *Lining the interceptor will prevent leaking from the interior of the pipe, also promoting flow through the system to continue to flush solids downstream.*
- *Toe stone on the bottom of the encasement will keep the integrity of the river flow despite the change in conditions.*
- *Installing some type of slope stabilization on the backside of the concrete supports will prevent erosion that would risk undermining the concrete supports.*
- *Design will promote native plantings in area to prevent corrosion.*

9. **Provide narrative on the existing and proposed in-river habitat (in voids between rip-rap stone).**

   Low tide and underwater observations by Tighe & Bond staff noted the in-river habitat is tidal fresh water, with no signs of marine life or vegetation, just a rocky cobble/boulder to gravel substrate. The areas under and around the bridge have rectangular granite slabs on the riverbed as apparent man-made scour protection. Based on field meetings with regulatory agencies, the proposed stonework and associated interstitial voids will continue to provide habitat in the river.

10. **Provide narrative on the existing vegetation (in-river and out of river).**

    This reach of the Ipswich River is relatively devoid of vegetation, given the nature of surrounding development. Invasive trees along bank are proposed to be removed and the area re-vegetated with native plantings. Stakeholders including the Ipswich Conversation Commission will provide input for the plantings plan.

11. **Climate Change and Resilience**:

    i. **Indicate sea level design elevations, and what level / year projection that elevation represents.**

As per Section 4.6 "Risk Associated with Sea Level Rising and Flooding" page 4-14, the TR-16 standard design elevation of the 100-year storm plus three 3 feet was used for the design of this system.

ii. Indicate how many years of protection the design will be able withstand.

As stated in Section 6.1 "Recommendation" page 6-2, The installation of this new infrastructure for both sewer conveyance and protection purposes have a design life of 50 years if operation and maintenance practices are performed. At this point, these systems should be inspected to determine a level of effort required for continued operation.

iii. Provide narrative on how the design will address climate change and resilience.

As stated in Section 4.6 "Risk Associated with Sea Level Rising and Flooding" page 4-15 through 4-17, based on a review of Flood Insurance Study and FIRM mapping of the area, the Interceptor and the Siphon inlet and outlet structures are subject to flooding during the 100-year flood. The town has standardized the TR-16 requirement of elevating structure rims 3 feet above the 100-year flood zone in an effort to further increase their coastal resiliency.

12. Provide narrative with photos of what the design intent will be to address the concerns of both the interceptor / siphon work area, plus the downstream interceptor area near Town Hall.

See updated drawing set (Appendix D) that depicts photos of existing conditions at the work area. See answer to question 8 above that addresses design intent for interceptor and siphon.

13. Provide information on the impacts on adjacent resource areas.

Please see attached table in Appendix B that displays environmental impact area numbers for all alternatives. These impact numbers include the following:

- *Coastal Bank (lf)*
- *Land Under Waterways and Waterbodies (sf)*
- *Land Subject to Coastal Storm Flowage (sf)*
- *Riverfront Area (sf)*

14. Provide brief narrative on why a new pump station west of the Choate Bridge was not feasible in lieu of rehabilitating the siphon.

- *The location of the pump station would be located in the parking lot just south of local businesses stretching from 10-40 Market Street. Parking is already limited in this area and adding the footprint of a pump station would severely decrease this space. Town does not own land in proposed.*
- *The cost of a new pump station to handle the flow the Interceptor conveys on a daily basis is significantly higher than that of the rehabilitation method. A large and costly pump station would be needed as the Interceptor conveys the majority of flow from the western side of Town.*
- *By eliminating the Interceptor pipe, gravity tributary branches would need to be rerouted for flow to successfully reach the treatment plants. The effort it would take to rework the gravity system in this area to continue to serve the surrounding residences and businesses would incur significant cost.*
- *Many local businesses rely on the southern parking lot for customers to safely park and access their shops and offices. Constructing a pump station in this*

area would restrict access and require further planning and work to provide access to these parking areas.

- *A pump station in this area would require a force main to be routed to a discharge point downstream of the system. The most logical location would be the manhole the Interceptor currently discharges in. To do this, a force main would need to be installed through private property, around buildings/bridges, and through major roadways to reach its discharge location. This would be very difficult and costly. Utilizing the existing infrastructure reduces costs and eliminates public impact.*

15.General Notes

- *A vegetation and planting plan will be developed with stakeholders and Ipswich Conservation Commission and provided to the contractor.*
- *Boring logs were requested to be a part of the construction drawings. Please note the symbols marking the locations of where these borings were done. These boring logs will be incorporated into the contract documents and readily available for the contractor on site. See Appendix F for Boring Logs.*

Comments and Responses from Meeting with MassDEP

The Project Team met with MassDEP Northeast Regional Office on April 10, 2019 to discuss their questions specific to the ENF filing. A number of the Department's questions are addressed in the Evaluation Report (Appendix A). The Department requested that the alternatives analysis include a comparison of environmental impacts. The alternatives table from the Evaluation Report has been updated to include a comparison of environmental impacts as shown in Appendix B of this memorandum. Additional questions and key discussion points are addressed herein.

16. Is the interceptor actually holding up bank?

Along certain section of the interceptor the bank and vegetation (including trees) are being supported by the interceptor.

17. Is the design team assessing lateral load structurally?

The original design intent of the caissons appears to primarily have been for vertical and not lateral loads. The bank stabilization design component of this project will address lateral stabilization of the bank.

18. MassDEP wants to better understand Pump Station alternative

Please see Evaluation Report, Appendix A for details on pump station alternatives.

19. Alternatives on variations of pipe staying in the river vs moving out of river

Please see Evaluation Report, Appendix A.

20. Concerns on riprap in river as not being an aesthetic improvement

During design, the Town and Engineer intend to work with stakeholders on aesthetics related to the rip rap, encasement, and vegetation / plantings plan.

21. Consider Hydrologic & Hydraulic impacts on opposite bank of river due to water deflecting off armoring

See Preliminary Hydrologic and Hydraulic Analysis Ipswich Siphon Evaluation and Report, Appendix C.

22. Provide narrative on sequencing of construction, including dewatering, handling of dredged material, and attempt to store native stone cobble onsite for re-use.

Initial bypass pumping will be set up to convey flow around the siphon area. This will provide flexibility to the contractor for the sequence of construction. Bypass pumping will have double wall containment and continuous monitoring in case of any issues. The anticipated construction sequence for the siphon and upstream manhole structure will involve installing a sheet pile cofferdam approximately 5/8 of the way across the river from one side, with equipment on the riverbank on timber mats. The existing riverbed cobble will be removed and stored off site for later reinstallation. The clay subsoil will be excavated from the cofferdam in the wet, loaded into trucks, and hauled away with proper disposal offsite. Helical anchors will be rotationally screwed into the bottom of the excavation and pile caps installed for pipe support and anti-floatation uplift resistance. The pile cap spacing and helical anchor capacity will be established in final design. The new siphon pipes will be installed and restrained on the pile caps. The siphon pipes, with end covers, will be backfilled with gravel and riverbed cobble restoration. With internal turbidity cleared, the initial cofferdam sheets will be withdrawn and reinstalled on the opposite side of the river. The cofferdam excavation will be repeated, adding opposite side helical piles, pile caps, pipe and tied into the previously installed pipes. The cofferdam will be backfilled, top-dressed with riverbed cobble, then the cofferdam removed.

For the Interceptor, the Contractor will first install bypass pumping in case of an emergency. This pumping will not necessarily be used on a daily basis but will be there in the event that there is any rupture to the interceptor. Containment in the area is also important in case of any discharge and/or erosion from construction. Containment will prevent any construction related runoff from reaching the river. The first step will be to expose the interceptor to provide adequate clearance to install formwork. Contractor to then install the formwork and pour concrete in these areas to fully encase the interceptor pipe. Work along the river is described in narrative to additional questions below. Once concrete has fully cured, contractor can strip the formwork from the area. Contractor can then place toe stone at the foot of the concrete supports, or as erosion control in back of the concrete supports. Contractor may perform interior pipe rehabilitation (cured in place pipe lining) before or after exterior work.

23. Include narrative on how scheduling / sequencing of interceptor work will be tide-cycle dependent.

- *All work pertaining to the siphon will be done within the cofferdam and will not be tide-dependent. When the cofferdam is first set, it may be prudent to set the structure at low tide, so the least amount of water is left in the cofferdam.*
- *All work pertaining to the interceptor will have to be coordinated by the contractor around the tide schedule. Concrete pours must be done in the dry and the contractor will have to coordinate work to accomplish these tasks.*

24. Provide narrative on material temporary access road west of the Choate Bridge for interceptor work and if an excavator / equipment will be working in this area at low tides. How will equipment enter / be removed from the river?

The interceptor construction access is anticipated to be from shore to the extent possible, including formwork construction, concrete pumping and downstream stonework. Stonework upstream of the bridge with no good access, is likely to need timber mats in the river bed for equipment access around low tides for stonework installation.

25. What happens during king tide/storm tide event

Consideration for construction activities and river flow during king tide / storm tide events will be incorporated into design and the additional H&H analysis.

26. What is duration of coffer dam presence

Approximately one month of construction for each phase of the two-phase cofferdam installation is anticipated.

27. How will existing siphon be removed

During construction the siphon will be bypasses. During each phase of cofferdam and new siphon installation, the adjacent existing siphon will be removed within the cofferdam.

28. Staging area in flood zone, consider alternatives

The Town and the Engineer are looking into a staging area location that would be outside the flood zone and be suitable for construction activity.

29. Have borings been completed in this area?

Borings have been completed, see Appendix F. Boring locations are indicated on the site plan in Appendix D.

30. Will excavated materials for the siphon installation be used as cover and what will be used to replaced dredged material?

The siphon backfill proposed is gravel to replace the clay that will be excavated and disposed of off-site since it could not be recompacted if reused. The new gravel will be topped with existing riverbed cobble, supplemented as needed, to restore existing riverbed substrate and address regulatory concerns.

31. Will dewatering occur?

No. The current plan is for Contractor to work within the cofferdam in semi-wet conditions without dewatering.

32. How many helical anchors are we installing for siphon?

Helical anchors will be rotationally screwed into the bottom of the excavation and pile caps will be installed for pipe support and anti-floatation uplift resistance. The pile cap spacing and helical anchor capacity will be established in final design. The new siphon pipes will be installed and restrained on the pile caps. The siphon pipes, with end covers, will be backfilled with gravel and riverbed cobble restoration

Comments and Responses to Army Corps Questions and Comments

The following are responses to comments and questions received from the USACE on April 8, 2019:

33. The Corps also prefers the triple barrel option over a single- or double-barrel option, and that should an emergency arrive with one pipe, 2 others will provide relief. We recommend that the pipes be rotated such that all 3 are periodically used (one or 2 at a time), thereby extending the life of the proposed plan.

The Project Team agrees with this comment. The operational intent of the proposed triple barrel siphon is to rotate operation of all three siphons periodically to extend the life of the proposed siphons and to allow of necessary operations and maintenance activities for the off-line / standby siphons.

34. **ENF does not mention GP 7 (Bank and Shoreline Stabilization), which we believe is required in this case. Specifically, you are talking about riprap protection of streambanks up to 730 feet. One question emerges: Does this 730 feet extend below the high tide line, or is it partially above the high tide line? It does appear to be almost entirely below the high tide line. GP 7 is limited to 500 feet, "unless the Corps waives this criterion by making a written determination concluding that the discharge will result in no more than minimal adverse effects." We are uncertain at this point whether this project results in "minimal adverse effects." If we conclude that effects are "more than minimal," an Individual Permit will be required. To this end, we would like to see bioengineering explored as an alternative to riprap and/or hard engineering, at least part way up from the riverbed. So far, while the report discusses several alternatives, and diligently arrives at the selected plan, no discussion of bioengineering is provided. We would like to see bioengineering added to the discussion of alternatives.**

    Tighe & Bond and the Town will be considering multiple stabilization and restoration approaches to provide shoreline and bank stabilization, including bioengineering as an alternative to riprap and / or hard engineering in the Green Street Bridge work area. The permit application with the USACE will address GP 7, in addition to all other applicable GPs.

35. **We note that this pipeline replacement is for pipes placed over 50 years ago. Since that time, population has expanded, and/or the Ipswich River has been subject to considerable stresses. We recommend that the new pipeline take into consideration such things as population growth, and/or global climate change, that may result in higher elevation of the river and/or higher flows than the river currently shows.**

    The sizing of the new siphon considers future flow rates due to population growth, which is further described in the Evaluation Report, Appendix A. The interceptor, pipe work, and slope stabilization will be designed to be resilient to the 100-year plus three-foot storm.

Enclosures:

Appendix A: Ipswich Siphon and Interceptor Evaluation – Final Report, March 2019
Appendix B: Advantages and Disadvantages of Alternatives
Appendix C: Preliminary Hydrologic and Hydraulic Analysis Ipswich Siphon Evaluation and Report
Appendix D: Updated Design Drawings
Appendix E: Ipswich River Interceptor Sewer and Siphon Emergency Action Plan
Appendix F: Boring Logs

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Appendix A
Ipswich Siphon and Interceptor Evaluation - Final Report

Ipswich River Sewer Interceptor and Siphon Evaluation - FINAL

Prepared For:

Wastewater Department Ipswich, Massachusetts

March 2019

I-0066-10
April 12, 2019
Ms. Vicki Halmen
Water & Wastewater Manager
272 High Street
Ipswich, MA 01938

Re: Ipswich River Sewer Interceptor and Siphon Evaluation

Dear Ms. Halmen:

Tighe & Bond is pleased to submit to the Town of Ipswich this Technical Memorandum of the Ipswich River Siphon and Interceptor Evaluation, for your use in developing a schedule and approach for addressing these critical vulnerabilities in the Town's wastewater collection system. This evaluation was finalized in March 2019. The following is an executive summary of the memorandum.

Executive Summary

This technical memorandum provides a summary of the field investigations and evaluations performed to evaluate the existing sewer interceptor and siphon and determine what improvements are needed in order to improve this critical wastewater infrastructure.

The recommended improvements are driven by the need to repair or replace existing sewer pipe and to reduce the threat of discharge to the river due siphon or interceptor failure, while also improving hydraulic performance of the system. In addition, improvements were considered to reduce environmental impact during construction as well as considering construction costs for the proposed alternatives.

These improvements require immediate action as reducing the threat of discharge to the river is crucial to the safety of the river, its surrounding environment, and the community. The following are critical issues that must be highlighted when considering improvements to the existing sewer interceptor and siphon:

- **No Redundancy** – The current siphon does not provide any redundancy. Therefore, if there is any issue or blockage with the siphon, there would be discharge into the river or backup into residential and commercial properties, until the Town's Emergency Action Bypass Plan could be implemented.
- **Operational Issues** – Hydraulics in the siphon are unfavorable, therefore requiring frequent cleaning and maintenance which is costly and sometimes ineffective.
- **Scour of Riverbed** – Current conditions allow for scour on the riverbed undermining supports for the Interceptor and further exposing the siphon putting both pipes at a greater risk of failure.
- **Bathing Beaches and Shellfish Beds** – With the current risk of discharge, any occurrence would mean raw sewage in the river flowing downstream to shellfish beds and bathing beaches requiring closures and posing potential health risks

The tasks performed as a part of the interceptor and siphon evaluation and the associated improvement alternatives are described below:

- **Closed Circuit Television Inspection** – The field investigations for this project included the closed-circuit television (CCTV) inspection of the siphon and interceptor. During these investigations, a robotic crawler-type camera traveled through the siphon and the interceptor section of concern, and a video recording of the sewer main features and conditions were taken. National Water Main Cleaning Company (NWMCC), a sub-contractor to Tighe & Bond who specializes in sewer investigations, performed the sewer cleaning and inspection work under the direction and supervision of Tighe & Bond. Equipment on site to perform this work included a CCTV truck housing the necessary video equipment, and a vacuum truck with enough suction capacity to minimize flow in the siphon during inspection. While minimal flow still reached the siphon, complete view of the siphon was accomplished.

- **Pipe Exterior and Structural Condition Assessment** – Tighe & Bond staff reviewed historical permit and as built drawings showing the siphon crossing under the river. Based on the historic drawings, Tighe & Bond divers located and inspected the siphon underwater. The inspection consisted of a visual review of the entire length of the exposed sections of the siphon, which was video recorded with an underwater camera. During the visual inspection, the rust/scale was removed at selected locations along the siphon with a hammer, including at several of the joints. Once the rust/scale was removed, the pipe and the joints were observed.

  The interceptor pipe, which is located along the edge of the Ipswich River, was exposed at some locations. The entire length of exposed interceptor piping was not video recorded due to the relatively long length of the exposed pipe. Instead, a video was taken using the camera to document any deficiencies found along the length of the interceptor pipe. Where necessary, a hammer was used to remove corrosion byproduct (rust/scale) so that the underlying pipe or joints could be observed.

- **Manhole Investigation** – There are manholes throughout the Town of Ipswich's wastewater collection system that provide access for maintenance, including at each end of the siphon and along the interceptor. The siphon and key interceptor manholes were inspected as part of this effort. The manhole inspections provided data on manhole construction and condition, leakage problems (infiltration), the potential for inflow, and debris accumulation at the inspection locations. As noted previously, infiltration and inflow are a concern because they reduce the capacity of the sewers to convey sanitary flow, which can increase the cost to transport and treat the wastewater flow and increase the risk of overflows from occurring. New watertight frames and covers could remedy this issue and provide necessary resiliency to meet TR-16 guidelines.

- **Ipswich River Stabilization and Interceptor Rehabilitation Alternatives** – Two concepts have been narrowed down as practical approaches to structurally protect the interceptor and are being presented for consideration. Both options have the potential to provide the protection necessary for continuing use of this pipe. The original 1958 interceptor was designed as an 18″ cast iron pipe supported by 3′ diameter concrete caissons spaced 18′ on center (matching pipe section lengths). This original structure was protected circa 1965 with 1:1 rock fill revetment slope upriver and downriver of the Choate Bridge. The intent of the first option is to replace the revetment pipe protection in kind, but with larger stone. The original revetment stone was undersized, and it has washed away. Proposed revetment has been sized based on anticipated velocities in the Ipswich River and will take into consideration ice and other potential damaging natural occurrences. The pipe connections will need to be replaced because the existing bolts have corroded and are no longer securing the joints together. The lining of the pipe, along with the new clamps providing lateral strength to these joints, provides a durable system that should last up to 50 years. At this point, the joints should be inspected for consistent torque and the exterior of the pipe should be inspected for structural integrity. From a permitting consideration, this concept would not exceed the previously licensed footprint.

  The second concept presents the option of encasing the existing cast iron pipe in concrete. The benefits of this option include but are not limited to: reducing the stone fill footprint, extending the life expectancy of the cast iron pipe, structurally replacing the joint restraints with reinforced concrete and providing pipe armoring from any potentially damaging natural occurrences. Horizontal helical tie backs could be proposed to support the loading from the soil river bank and any stone placed between the pipe and the river bank that could potentially be used as a river walk. Minor revetment would be proposed to help with scour protection and for aesthetics. Slip lining the pipe would be recommended in this option to rehabilitate pipe interior, which would provide protection and improve hydraulics. The combination of the lining strengthening the interior of the pipe, and concrete encasement of the exterior of the pipe, would amount to a 50-year design life for this system. While the concrete is durable and would last longer than this lifespan, at the 50 year mark the concrete should be inspected to be sure the structural integrity of the encasement is intact.

Both concepts provide the cast iron pipe with protection, and the final design likely would use concrete encasement under the bridge and either concrete encasement or revetment for the lengths of pipe exposed upstream and downstream of the bridge.

An estimated cost to construct the two interceptor repair options is presented below. The construction cost includes the cost of materials, labor and equipment, the contractor's general conditions, the contractor's markup, and a construction contingency. The cost is based on a November 2018 Engineering News Record Construction Cost Index (ENR CCI) of 11184.

Engineer's Opinion of Probable Construction Cost

Ipswich River Stabilization and Interceptor Rehabilitation: Option 1 – Revetment Slope

TOTAL SAY	**$950,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

Engineer's Opinion of Probable Construction Cost

Ipswich River Stabilization and Interceptor Rehabilitation: Option 2 - Concrete Encasement

TOTAL SAY	**$865,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

- **Siphon River Crossing Alternatives Analysis** – The wastewater that flows through the existing siphon does not have adequate velocity, under average flow rate, to prevent the settlement of solids in the pipe. Additionally, the siphon pipe has become exposed near the north bank of the river. As such, improvement alternatives have been developed and evaluated in this report.

  Five siphon improvement or replacement alternatives were considered in this evaluation. For the siphon alternatives, both open cut excavation and Horizontal Directional Drilling were considered as options for installation. For the following alternatives each would be designed with a 50-year life expectancy, assuming regular operation and maintenance activities are carried out on the infrastructure. The following alternatives were considered to replace the existing siphon:

  1. New single barrel siphon
  2. New double barrel siphon
  3. New triple barrel siphon
  4. New gravity sewer

5. New pump station

Using the findings and results from the evaluation, the following table outlines the advantages and disadvantages of each alternative.

Advantages and Disadvantages of Ipswich Siphon Alternatives

Alternative	Construction Cost	Advantages	Disadvantages
Single Barrel Siphon (6”)	---	-Lowest cost alternative -Construction method would allow for more local contractors to perform and bid on work thus creating greater competition during the bid phase and possibly lower construction costs	-Not an acceptable alternative because cannot accommodate projected peak flow - Not an acceptable alternative because cannot provide redundancy, serviceability, or future capacity
Double Barrel Siphon (6”/6”) Open Cut Excavation	$800,000	-Relatively low-cost alternative -Can accommodate the current and projected future peak flow -Construction method would allow for more local contractors to perform and bid on work thus creating greater competition during the bid phase and possibly lower construction costs	-Not an acceptable alternative because cannot provide redundancy, serviceability, or future capacity
Triple Barrel Siphon (6”/6”/6”) Open Cut Excavation	$900,000	-Incremental cost increase compared to double barrel approach -Can accommodate the current and projected future peak flow -Provides redundancy -Construction method would allow for more local contractors to perform and bid on work thus creating greater competition during the bid phase and possibly lower construction costs -Allow for proposed pipe to be accurately set for line and grade -Unanticipated obstructions can be handled without	-Higher cost than alternatives with no redundancy -Potential schedule and cost impacts related to obtaining permits and approvals -Construction coordination associated with cofferdam construction

Advantages and Disadvantages of Ipswich Siphon Alternatives

Alternative	Construction Cost	Advantages	Disadvantages
		significant impacts	
Triple Barrel Siphon (6"/6"/6") Horizontal Directional Drill Install	$1,660,000	-Can accommodate the current and projected future peak flow -Provides redundancy -Minimize surface disturbance -Pipe can be installed below the river and groundwater table without a cofferdam -Not as complicated permitting process	-Higher cost than alternatives with no redundancy -HDD is less accurate and has potential for high points in final alignment -Space to stage the work is required -Frac-out could occur within the river -Requires rerouting of existing gravity collection system -Heavy impact on public and businesses during construction
Gravity Sewer	---	---	-Not an acceptable alternative because would result in an obstruction in a navigable water
Pump Station	$1,700,000	-Eliminates the low velocity and solids deposition concern	-Highest cost alternative -Requires rerouting of existing gravity collection system -Requires additional cost for force main installation to discharge manhole -Increases annual operation and maintenance costs

Based off these findings, a Triple Barrel Siphon by Open Cut Excavation is recommended. Under this alternative, the existing 12-inch cast iron siphon would be replaced with new, triple barrel siphons. The intent of this arrangement is that only one siphon barrel would be in use during low/average flow conditions, but during higher flows, a portion of the wastewater reaching the siphon manhole would be directed to the second siphon barrel. This approach would reduce head loss during higher flow conditions. The third barrel would only be used when one of the other siphon barrels is taken out of service for maintenance or during an emergency. Barrel operation could be rotated to allow for appropriate operations and maintenance activities.

Open-trench excavation is a proven and commonly used method of pipe installation. As a result, there would be more contractors who are able to perform and, correspondingly, bid on the work. Greater competition can result in lower bid costs. Another benefit of this construction method is that it would allow the proposed pipe to be accurately set to the proposed line and grade, rather than installing pipe in the blind, which is a downside of trenchless methods such as horizontal directional drilling or pipe jacking potentially causing the pipe to off course. In addition, unanticipated obstructions (e.g., boulders, urban fill, etc.) and various soil conditions can normally be handled without significant additional cost and without impacts to line and grade.

An opinion of probable construction cost for the proposed triple barrel siphons below the river using open-trench excavation methods was developed for this alternative. The construction cost includes the cost of materials, labor and equipment; the contractor's general conditions; the contractor's markup; and a construction contingency. The cost is based on a November 2018 Engineering News Record Construction Cost Index (ENR CCI) of 11184.

For the purposes of this evaluation, we have assumed that no ledge will be encountered. In addition, we have assumed that significant dewatering would be needed in order to install the proposed pipes. Please refer to 30% design plans in Appendix D for further details.

Engineer's Opinion of Probable Construction Cost

Ipswich River Siphon Installation: Triple Barrel Siphon – Open Cut Excavation

TOTAL SAY	**$900,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

Permitting

The following summarizes the anticipated permit-related activities that will be required to carry the recommended interceptor and siphon rehabilitation projects through construction. These proposed activities are based on a Pre-Permitting meeting and correspondence held on August 14, 2018 between the Town, Tighe & Bond, MassDEP, Ipswich Conservation Commission and the Army Corps of Engineers. Additionally, a Pre-Permitting meeting was held on March 1, 2019 at MassDEP Waterways between the Town, Tighe & Bond, and MassDEP to discuss Chapter 91 licensure requirements. The schedule for these project permit activities are summarized in the memorandum that follows. Based upon these discussions, Tighe & Bond assumes the proposed siphon and interceptor repairs will be subject to:

- Ipswich Wetlands Protection Bylaw
- Massachusetts Wetlands Protection Act (310 CMR 10.00)
- Massachusetts Public Waterfront Act (Chapter 91)
- Massachusetts Environmental Policy Act (MEPA)
- Sections 404 and 401 Clean Water Act
- Section 10 River and Harbors Act
- Section 106 National Historic Preservation Act

Funding Opportunities

Several grant opportunities have been identified that may be applicable for a pump station upgrade project. Grants could be applicable for either construction of a new pump station or rehabilitating the existing station. The table below summarizes these grant opportunities.

Recommended Sewer Interceptor and Siphon Funding Strategies

Grant Name	Purpose	Possible Award
Municipal Vulnerability Preparedness (MVP) – Action Grant	Provides support advance priority climate adaptation actions to address climate change impacts resulting from extreme weather, sea level rise, coastal flooding, and other climate impacts. *Ensure Ipswich has completed MVP Planning Process Meeting by May 2019.	$400,000
FEMA Federal Disaster Funds: Pre-Disaster Mitigation Grant Program	Mitigate the costs and impacts of future disasters. Reduce long-term risk from future hazard events.	75% of Total Project Cost
MEMA/FEMA Post-Disaster Hazard Mitigation Assistance Grant Program	Reduce or eliminate long-term risks caused by natural or man-made disasters. Only communities in Massachusetts are eligible. *Ensure the Siphon and Interceptor are on Ipswich's Hazard Mitigation Plan.	75% of Total Project Cost Non-Federal Grants can be used for the 25% match
CZM Coastal Resilience	Redesign and retrofit existing community facilities and infrastructure.	$500,000
MACP Accelerating Climate Resiliency Mini-Grant Program	Help municipalities advance strategies that protect people, places, and communities from the impact of climate change.	$15,000 - $50,000 per round (can apply multiple rounds and phase)
Seaport Economic Council	5 different grants to help stimulate the maritime economy and grow jobs. Can be used to for coastal infrastructure improvement projects that support and promote tourism, recreation, the shell-fishing industry, and improve sustainability and resilience.	$1,000,000

Executive Summary

Section 1 Introduction

Section 2 Siphon Evaluation

Section 3 Siphon River Crossing Alternatives Analysis

Section 4 Interceptor Evaluation

Table of Referenced Tables

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Section 1 Introduction

1.1 Project Overview and Goals

The Town of Ipswich Wastewater Department owns and maintains two critical and vulnerable pieces of sewer infrastructure along and beneath the Ipswich River, the Ipswich River Siphon and the Ipswich River Interceptor. The sewer piping for both pieces of infrastructure are in the tidally-influenced portion of the Ipswich River, near the historic Choate Bridge, and adjacent to numerous homes and businesses. The Town is concerned that failure of one or both of these two infrastructure components would have severe impacts to wastewater customers (through a loss in sewer service), and impacts to the health of the Ipswich River, shell-fishing activities, and downstream bathing beaches (if wastewater is released to the river).

The objective of this project is to complete an evaluation of a 450-foot long section of the 18-inch sewer interceptor located along the Ipswich River, as well as an adjacent 12-inch sewer siphon that crosses below the Ipswich River. This evaluation includes assessing the condition of the siphon and interceptor and providing recommendations to improve redundancy and resiliency to these critical components of the Town's wastewater infrastructure.

1.2 History of Siphon

The Ipswich River Siphon was constructed in 1958 and has not been improved since it was constructed. The siphon is located beneath the Ipswich River, between South Main Street and County Street, approximately 300 feet east of the Choate Bridge. It is a 130-foot long, 12-inch diameter cast iron, single barrel siphon generally located beneath the bottom of the Ipswich River. The siphon discharges into an 18-inch diameter sewer interceptor on the northern side of the river. Refer to Figure 1-1 for the siphon layout.

There is currently no redundancy for this siphon. If it were to fail, there is no other means to convey the sewage across the river, and an emergency pumping operation would be needed until the siphon could be repaired. The Ipswich River is a tidally affected river and, at the location of the siphon, it is influenced by coastal storm surges and flooding. When originally constructed, the siphon was at least two feet below the river bottom. However, over the last 60 years significant portions of the riverbed have washed away, exposing the top of pipe at some locations.

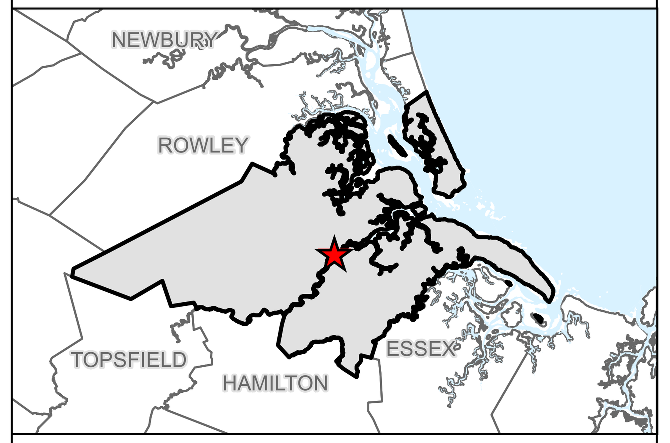
The Ipswich River Siphon has experienced overflows and backups. In order to minimize the potential for backups, the Town regularly cleans the siphon to remove material that has settled within the pipe.

FIGURE 1-1
PROJECT AREA

LEGEND

- Manhole
- Existing Sewer Main
- Pipes Targeted for Evaluation
- Existing Sidney Shurcliff Riverwalk

LOCUS MAP



0 100
Feet

1:480

NOTES

1. Based on Google Imagery (C) 2017
2. FEMA National Flood Hazard data obtained through MassGIS, Revised based on LiDAR elevations, data valid as of December 2017

Schematic Map of Sewer Interceptor and Siphon Connectivity

Ipswich, Massachusetts

February 2019

Tighe&Bond
Engineers | Environmental Specialists

1.3 Existing Ipswich River Interceptor History and Design

Similar to the siphon, the interceptor was constructed circa 1958. The 18-inch sewer interceptor collects flow from the Union Street and Market Street areas and is located along the northern bank of the Ipswich River, running through one span of the Choate Bridge. The interceptor pipe is constructed of cast iron and is supported by 18 concrete 3' diameter caissons bearing on bedrock. Much of the interceptor pipe is exposed however there are some areas buried in the bank of the river. Many of the concrete caissons, or support piers, are also exposed and vulnerable to damage from river flow, debris, and ice floating down the river. Refer to Figure 1-1 for the interceptor layout.

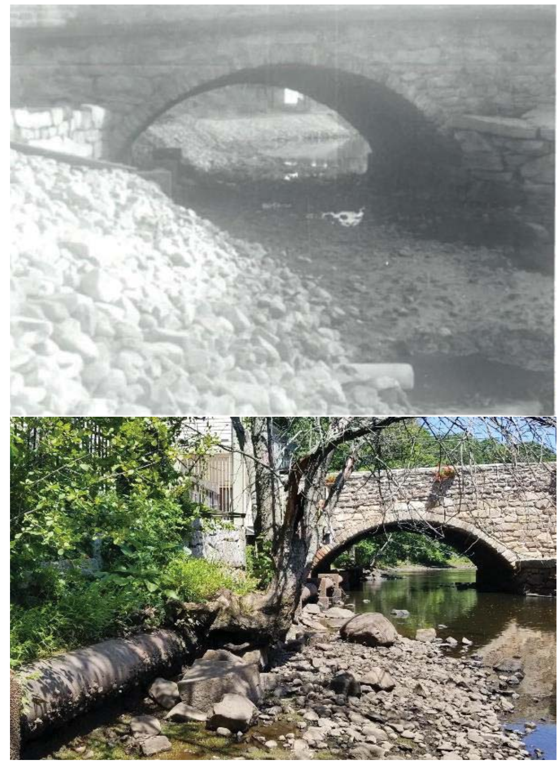


Figure 1-1. 1965 and 2018 Photos of Interceptor with and without revetment stone coverage.

The area of the interceptor under evaluation was originally covered and protected with at least one foot of stone fill. A stone on the river side of the pipe was indicated as "stone tailings" and at a very steep 1:1 slope. However, over time this stone armoring and interceptor protection has washed away, leaving the interceptor and its support piers exposed to the elements, increasing the potential for deterioration. The earth along the river bank has eroded, and the bank is partially supported in many areas by the interceptor (a loading condition that was likely not anticipated when the interceptor was originally designed/constructed). Additionally, there are multiple trees with roots growing around the interceptor. Figure 1 depicts the interceptor as it was in 1965 and how it looks at present day.

The interceptor does not have a history of overflows or backups and has been inspected and cleaned over time. Access to the interceptor manholes east of the Choate Bridge is difficult for operations staff because there is no access path, and maintenance and inspection of these manholes as well as connecting piping has not occurred in recent years.

Section 2
Siphon Evaluation

2.1 Closed Circuit Television Inspection

2.1.1 Field Investigations

The field investigations for this project included a closed-circuit television (CCTV) inspection of the siphon and interceptor occurring on August 7th-8th, 2018. During these investigations, a robotic crawler-type camera traveled through the existing siphon, and a video recording of the sewer main features and conditions were taken. National Water Main Cleaning Company (NWMCC), a sub-contractor to Tighe & Bond who specializes in sewer investigations, performed the sewer cleaning and inspection work under the direction and supervision of Tighe & Bond. Equipment on site to perform this work included a CCTV truck housing the necessary video equipment, and a vacuum truck with enough suction capacity to minimize flow in the siphon during inspection. While minimal flow still reached the siphon, complete view of the siphon was accomplished.

NWMCC's scope of work included bypassing the existing flow around the 12-inch siphon. The bypass piping transported flow from a manhole on the upstream end of the siphon, up around the Choate Bridge, into a manhole located on the Interceptor. This allowed NWMCC to clean and inspect the siphon without flow interference.

2.1.2 Field Results

In general, the CCTV inspection data collected during the field investigations indicated that the existing siphon is in fair condition. The existing siphon, while structurally in fair condition, does face minor structural issues such as surface spalling, grease buildup, and infiltration. These are minor issues that do not require emergency action pending the current project schedule.

A major issue highlighted by NWMCC in the siphon is the deposition of grease, as noted earlier. The siphon had a significant amount of grease buildup that needed to be removed. Even with the heavy cleaning done by NWMCC, some grease deposits remained, resulting in a 5% loss in the cross-sectional area of the pipe. Within the 130-foot run, there were four areas with grease deposits. These grease deposit locations are noted in Table 2-1, which provides a summary of the CCTV inspections.

TABLE 2-1
CCTV Results

Location	Upstream MH	Downstream MH	Pipe Diameter (in.)	Length (ft)	Notes
Siphon (southern bank to northern bank)	SMH 34	SMH 18	12	127.7	Grease causing 5% area loss at 4',54', 106', 120'

While concerning from a capacity standpoint, this siphon will be eliminated and replaced. Therefore, no action is currently required to further clean the siphon. There is evident cracking on the interior of the pipe, as well as grease buildup in certain areas. These areas of pipe are also sections of pipe where lining is already incorporated into design.

These issues pose the long-term risk of continued buildup of solids in the pipe, creating the potential for blockages. Because there is no redundancy, blockages could create overflows which compromise downstream clam beds and bathing beaches. However, as long as the Town continues the current operation and maintenance practices, the siphon will continue to be operable. However, this condition is by no means permanent and should only be relied on until construction of next year. In case any such issues occur before construction, the Town already has an Emergency Action Plan in place to bypass the siphon flow safely.

2.2 Pipe Exterior and Structural Condition Assessment

2.2.1 Ipswich Siphon Inspection

On July 31, 2018, Tighe & Bond performed an exterior inspection of the siphon. During the inspection, Tighe & Bond identified locations where there were apparent corrosion losses of the steel and cast-iron pipe components, missing components (nuts, bolts, flanges, etc.), soil scour/erosion and stream bed material losses over the siphon pipe, damage to the concrete piers supporting the interceptor pipe, and any other deficiencies that may cause future damage to the interceptor or the siphon.

2.2.1.1 Inspection Methods

Tighe & Bond staff reviewed historical permit and as built drawings showing the siphon crossing under the river. Based on the archive drawings, Tighe & Bond divers located and inspected the siphon. The inspection consisted of a visual review of the entire length of the exposed sections of the siphon, which was video recorded with a GoPro underwater camera. During the visual inspection, the rust/scale was removed at selected locations along the siphon with a hammer, including at several of the joints. Once the rust/scale was removed, the pipe and the joints were observed.

2.2.1.2 Siphon Inspection Results

The siphon was found to be exposed above the river bottom from approximately 52 feet from the center of SMH 34 to approximately 94 feet from the center of SMH 34 (a distance of approximately 42 feet).

The exterior of the siphon appeared to be in good condition with minor corrosion loss and approximately 1/8” of corrosion product. Steel bolts that hold together a reinforcing clamp were visually inspected after cleaning (where accessible) and have about 40 to 50% corrosion loss after cleaning. This is a concern as these bolts are near failed. The buried bolts were not excavated or inspected, and no bolts were removed to look for crevice corrosion.

Five soil probes were advanced along the siphon alignment to assess bearing soils. The purpose of this effort was to investigate the subsurface of the river along the siphon alignment to get a better understanding of what soil supports the siphon. While the depth of the Siphon is a known value, the soil supporting the pipe in this area is crucial as it effects construction costs. The results of the probes are detailed in Table 2-2 below:

TABLE 2-2
Soil Probe Results

Probe No.	Distance From Manhole (ft.)[1]	Probe Depth (ft.)[2]	Comments
1	48	1	cobble
2	56	6.1	Layer cobble over clay No refusal, clay
3	70	6.3	Layer cobble over clay No refusal, clay
4	85	5.6	Layer cobble over clay No refusal, clay
5	100	1.3	Rocky, rip rap

[1]The manhole noted is manhole SMH 34, which is closest to the river on the south bank.

[2]Depth below existing river bed.

Limited survey was performed by Tighe & Bond to determine exposed siphon and riverbed elevations at three transects: 1.) along the existing siphon, 2.) 10 feet upstream of the siphon along the river and 3.) 10 feet downstream of the siphon along the river, as illustrated in C-504 in the attached drawings. A comparison between the existing conditions and the elevation information from the 1959 archive drawings, based on manhole rim elevations, suggests the siphon was installed to the proposed elevations (the siphon was designed to have 2 feet of cover under the riverbed), and it now appears that scouring along the siphon has reduced the cover over the pipe to the extent that portions of the siphon are exposed.

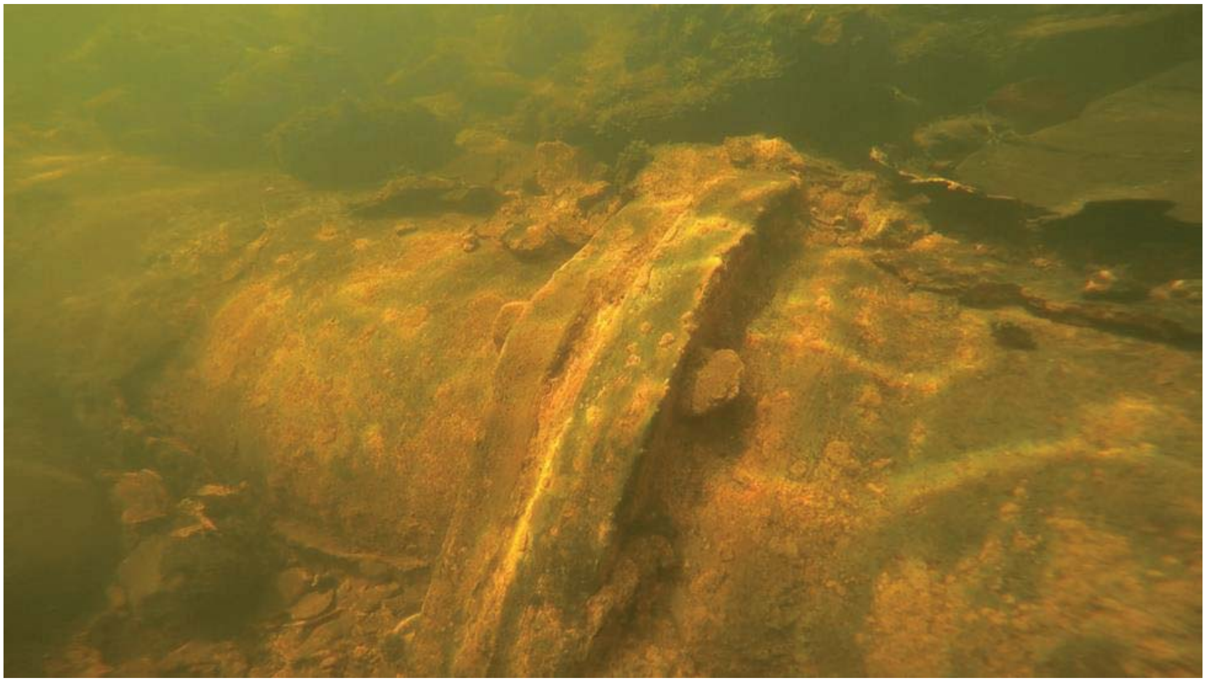


Photo 2-1.Bolted connection on exposed siphon pipe (after corrosion byproduct removal).

2.3 Manhole Investigations

2.3.1 Manhole Field Investigations

There are manholes throughout the Town of Ipswich's wastewater collection system that provide access for maintenance, including two at each end of the siphon. The manhole inspections provided data on manhole construction and condition; leakage problems (infiltration); the potential for inflow; and debris accumulation at the inspection locations. As noted previously, infiltration and inflow are a concern because they reduce the capacity of the sewers to convey sanitary flow can increase the cost to transport and treat the wastewater flow and increase the risk of SSOs occurring.

A total of 5 manholes were inspected as part of this effort on October 2, 2018 by Tighe & Bond, with the assistance of Town staff. Three access manholes were located along the Interceptor, while 2 manholes provide access for the Siphon. The inspected manholes are shown on Figure 1-1.

2.3.2 Manhole Investigation Results

A summary of the Siphon manhole inspections performed is presented in Table 2-3.

TABLE 2-3
Manhole Inspections – Siphon and Interceptor

Location	ID #	Wall Material	Condition (poor/ok/good)				General Notes	Requires Attention (Yes/No)
			Bench	Invert	Wall	Cover		
Siphon (Northern Bank)	SMH 18	Concrete Block	Good	Good	Ok	Ok	Roots growing through cracks in wall No flood proof hatch	Yes
Siphon (Southern Bank)	SMH 34	Concrete Block	Good	Good	Good	Good	No flood proof hatch	Yes

The scope of work included 2 key access manholes along the Siphon, SMHs 18 and 34. This conclusion was supported by multiple surface site investigations. SMH 34 is in good condition and does not show evidence of failure. However, due to its proximity to the river, this manhole should have a flood proof hatch and therefore requires attention. SMH 18 requires attention because roots were observed entering SMH 18. This creates the potential for infiltration to enter this manhole through the same path through which the roots enter the structure. Please see below a photo of SMH 18 showing where roots are entering the structure.

Photo 2-2.Roots visible from surface growing within SMH 18.

Due to the condition of these manholes, cleaning and lining these manholes is highly suggested. SMH 18 displays visual evidence that roots are growing through the walls of the manhole and should be a priority to clean and line. The liner will seal up these cracks and prevent further infiltration. While a contractor is on site, cleaning and lining the remainder of the manholes would prevent further issues moving forward. With SMH 18 having this issue, the remainder of the SMHs are at high risk of the same issue.

2.4 Hydraulic Capacity of Siphon

2.4.1 Current Wastewater Flows

Flow data from 2009 and 2011 was included in the Request for Responses issued by the Town of Ipswich on May 7th, 2018. Wastewater flow through the siphon was measured from March 20th to April 16th, 2009 and from March 21st to April 11th 2011. The average and peak flow rates measured during the 2011 period was 0.22 MGD and 0.31 MGD, respectively. Using these flows, an analysis of the existing conditions of the siphon was done. Please see tabulated form of flows in Table 2-4 below.

TABLE 2-4
Flow Data Used for Siphon Hydraulics

	Average Flow (MGD)	Peak Flow (MGD)
Current Flow Data	0.15	0.33
Future Flow Data	0.20	0.70

2.4.2 Hydraulic Capacity of Siphon

Key design/operating parameters of a siphon include the head loss through it and the flushing velocity. The head loss is the sum of the friction loss due to the interior surface roughness of the pipe and the losses through fittings. The available head (the elevation difference between the upstream water level and the downstream water level) must be greater than the headloss during peak flow conditions in order for the siphon to function without flow backing up into the upstream gravity sewer.

Technical Report TR-16, *Guides for the Design of Treatment Works*, 2011 Edition, as revised in 2016, recommends the following for the design of new inverted siphons:

1. Siphons should have no less than two barrels with a minimum pipe size of 6 inches each.
2. The siphons should be provided with manholes at both ends for convenient flushing and maintenance. The manholes should be vented and have adequate clearances for cleaning equipment and for inspection and flushing.
3. The design should provide for sufficient heads and pipe sizes to secure velocities of at least 3.0 feet per second for average flows under initial conditions to keep the pipe(s) clear of settleable solids.
4. Inlet and outlet details should be arranged so normal flow is diverted to one barrel and so that either barrel may be taken out of service for maintenance. Consider providing a hose connection to the siphon for flushing purposes.

TR-16 is commonly used as a guide for design and construction of sewer mains in New England. The velocities through the existing 12-inch siphon during average and peak flow conditions were calculated as 0.43 feet per second and 0.61 feet per second, respectively, well below the minimum velocity recommended by TR-16. This may be an indication that actual wastewater flows are below the wastewater flows projected during the design of the siphon.

The headloss through the siphon during peak flow conditions was also calculated. The headloss during the peak flow of 0.31 MGD was calculated as 0.09 feet. In comparison, the available head between the siphon inlet and outlet is 1.06 feet during peak flow conditions. Because the calculated headloss is less than the available head of the siphon during current peak flow conditions, the existing siphon should have adequate capacity to convey the measured peak flow.

This analysis confirms that the siphon backups experienced are related to material settling in the siphon due to low flow velocities. As indicated previously in this report, frequent cleaning of settled solids within the siphon is performed by the Town in an effort to minimize the risk of backups or overflows occurring. Note that one benefit of the double barrel siphon concept recommended in TR-16 is that it allows a smaller diameter single barrel to be used during lower flow periods, which provides a greater flow velocity. During higher flow periods, both siphon barrels would be in use.

Section 3
Siphon River Crossing Alternatives Analysis

3.1 Development of Alternatives

As described in prior sections of this report, the wastewater flow through the existing siphon does not have adequate velocity, during the average or peak flow conditions measured previously, to prevent the settlement of solids in the pipe. As such, improvement alternatives have been developed and evaluated in this report.

Five siphon improvement or replacement alternatives were considered in this evaluation:

1. New single barrel siphon
2. New double barrel siphon
3. New triple barrel siphon
4. New gravity sewer
5. New pump station

Each of these alternatives is described in the sections that follow. Please keep in mind each of these scenarios has a design life of 50 years. When considering aspects of a collection system from an asset management approach, any new part of a collection system is considered to have a life of 50 years. For all of the following alternatives, because it is new infrastructure, each will last 50 years since the installation date as long as regular operation and maintenance is maintained.

3.1.1 Current and Projected Flow Data

In order to properly size the above-mentioned alternatives, accurate flow data must be used consistently throughout the alternative analysis. To reach these values, many different flow scenarios were considered.

As stated previously, wastewater flow through the siphon was measured from March 20th to April 16th, 2009 and from March 21st to April 11th 2011. The average and peak flow rates measured during these periods were 0.22 MGD and 0.31 MGD, respectively. Also considered in this exercise was 2016 flow data, as well as future flow data.

In order to properly size the siphon, flow data was simplified into two sets of flow data: current flow and future flow. For each year of flow above, average and peak flow were considered to arrive at the current and future flow values considered when sizing the siphon. Prior to final design, these flow values must be revisited as they are crucial for sizing calculations. Table 3-2 displays these values.

TABLE 3-1
Flow Data Used for Siphon Hydraulics

	Average Flow (MGD)	Peak Flow (MGD)
Current Flow	0.15[1]	0.33[1]
Future Flow	0.2[2,3]	0.7[2,3]

1. Based off 2011 and 2016 flow data Provided by the Town.
2. Estimate based on ratio of Siphon Flow = 16% of Total Flow in Collection System.
3. Calculated using total system peak flow of 4.3 MGD as was determined to be the future collection system flow rate in 2018 Ipswich Town Wharf Pump Station Evaluation.

3.2 Siphon Installation Alternatives

3.2.1 Barrel Configuration

Siphons are designed to be able to handle peak flow with adequate flushing velocities. This may mean certain systems require more than one pipe in the ground. Depending on flow and available head, multiple barrels may be needed to achieve crucial siphon characteristics. Please see the following alternatives in an effort to find a scenario with proper flushing velocity and sufficient capacity.

3.2.1.1 New Single Barrel Siphon

Under this alternative, the existing 12-inch cast iron siphon would be replaced with a new, single barrel siphon sized to prevent backups from occurring and minimize the potential for solids deposition.

New Single Barrel Siphon Hydraulics - As discussed previously, a review of the siphon hydraulics determined that the current 12-inch single barrel siphon is large enough to prevent backups into the upstream gravity sewer from occurring. However, the siphon is too large to provide adequate velocity through the siphon to prevent the settlement of solids during average and peak flow conditions. As such, this alternative includes a review of whether a smaller siphon would provide adequate flushing velocity without causing backups to occur. A summary of the siphon hydraulics for various pipe sizes is presented in Table 3-3.

TABLE 3-2

Single Barrel Siphon
Hydraulics Summary

Siphon Dia. (in.)	Current Conditions				Future Conditions			
	Velocity at Avg. Flow (fps)[1]	Velocity at Peak Flow (fps)[2]	Headloss at Peak Flow (ft.)[2]	Exceeds Available Head?[3]	Velocity at Avg. Flow (fps)[4]	Velocity at Peak Flow (fps)[5]	Headloss at Peak Flow (ft.)[5]	Exceeds Available Head?[3]
6	1.18	2.60	0.89	No	1.58	5.52	3.67	Yes
8	0.66	1.46	0.23	No	0.89	3.10	0.96	No
12	0.30	0.65	0.04	No	0.39	1.38	0.15	No

[1]Avg. flow is approximately 0.15 MGD derived from average daily wastewater flow data from 2016 Flow and Future Flow.

[2]Peak flow is 0.33 MGD based on the peak wastewater flow measured from 2016 Flow Data.

[3]The available head at peak flow is approximately 1.2 feet, and is based on the expected difference between the predicted water level at the downstream end of the siphon and the top of the siphon pipe at the upstream end.

[4]Future avg. flow is projected to be approximately 0.2 MGD.

[5]Future peak flow is projected to be approximately 0.7 MGD.

Note that a siphon size smaller than 6-inch diameter was not considered, in accordance with TR-16 recommendations. Table 3-3 illustrates that a single barrel siphon cannot meet both the minimum velocity recommended by TR-16 and the maximum headloss required to prevent backups into the upstream portion of the sewer system. Note that although a 6-inch siphon provides less than 3 feet per second at the measured current average wastewater flow recommended by TR-16, the flow velocity at the current peak wastewater flow rate recently measured is just slightly below 3 feet per second. During the projected future peak flow conditions, the flow velocity would exceed 3 feet per second. However, the headloss would exceed the head available between the siphon inlet and outlet, which would result in wastewater surcharging the upstream 8-inch gravity sewer. This condition could result in backups within the sewer system. As such, the single barrel alternative was not considered further.

3.2.1.2 New Double Barrel Siphons

Under this alternative, the existing 12-inch cast iron siphon would be replaced with new, double barrel siphons. The intent of this arrangement is that only one siphon barrel would be in use during low/average flow conditions but, during higher flows, a portion of the wastewater reaching the siphon inlet would be directed to the second siphon barrel. This approach would reduce headloss during higher flow conditions.

New Double Barrel Siphon Hydraulics - Because 6 inch is the minimum siphon diameter recommended by TR-16 and larger siphon sizes provide insufficient flow velocity, dual 6-inch siphons were considered to reduce headloss during higher flow conditions. A single siphon barrel would provide adequate capacity to convey current average and peak flows. However, a second siphon barrel would be needed to convey the projected peak flow of 0.7 MGD. A hydraulics summary is presented in Table 3-4 and illustrates that dual 6-inch siphons have adequate capacity to convey the projected peak flow.

TABLE 3-3
Double Barrel Siphon
Hydraulics Summary

Siphon Dia. (in.)	Current Conditions				Future Conditions			
	Velocity at Avg. Flow (fps)[1]	Velocity at Peak Flow (fps)[2]	Headloss at Peak Flow (ft.)[2]	Exceeds Available Head?[3]	Velocity at Avg. Flow (fps)[4]	Velocity at Peak Flow (fps)[5]	Headloss at Peak Flow (ft.)[5]	Exceeds Available Head?[3]
6 & 6	1.18	2.60	0.89	No	1.58	2.76	1.00	No

[1]Avg. flow is approximately 0.15 MGD based on average daily wastewater flow data measured from ________.
[2]Peak flow is 0.33 MGD based on the peak wastewater flow measured from __________.
[3]The available head at peak flow is approximately 1.1 feet, and is based on the expected difference between the predicted water level at the downstream end of the siphon and the top of the 8-inch gravity sewer pipe at the upstream end.
[4]Future avg. flow is projected to be approximately 0.2 MGD.
[5]Future peak flow is projected to be approximately 0.7 MGD. This analysis assumes that half of the flow would be directed to each siphon barrel.

The dual 6-inch siphons do not provide a flow velocity of 3 feet per second during average daily flow conditions, as recommended by TR-16, based on the limited flow data available. However, a smaller siphon diameter, which would provide a greater flow velocity, is not recommended by TR-16. Note that flow velocities approaching 3 feet per second are anticipated during high flow periods, which may help to flush out solids that have settled in the pipe during lower flow periods.

The following table presents a cost estimate for the installation of a double barrel siphon.

TABLE 3-4
Engineer's Opinion of Probable Construction Cost
Double Barrel Siphons – Open Trench Excavation

Item	Quantity	Units	Unit Cost	Total Cost
6-inch siphon below river	200	LF	$350	$70,000
6-inch siphon beyond river	100	LF	$450	$45,000
Siphon entrance and exit manholes	2	EA	$30,000	$60,000
Down Stream Check Valves	2	EA	$1,500	$3,000
Cofferdam	1	LS	$225,000	$225,000
Trench dewatering	1	LS	$75,000	$75,000
Timber mats	1	LS	$35,000	$35,000
River bed restoration	1	LS	$10,000	$10,000
Surface restoration (beyond river)	200	SY	$50	$10,000
Subtotal				**$534,500**
Contingency (20%)				$106,900
Design (10%)				$53,450
Construction Admin (15%)				$80,175
Police (5%)				$26,725
TOTAL				**$801,750**
TOTAL SAY				**$800,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

The disadvantage of this alternative is that it does not provide complete redundancy to accommodate the projected peak flow rate. That is, with one siphon out of service, the remaining siphon does not have sufficient capacity to accommodate the projected peak wastewater flow. This prevents operators from being able to perform maintenance on a siphon for an extended period of time, while limiting future capacity of the siphon.

The cost to install a third barrel during construction would be incremental as the only quantity changing would be linear foot of pipe installed. Installation would require the same effort, as cofferdam and restoration limits would be the same. The cost difference moving from a double barrel siphon to a third barrel siphon is $100,000.

For this incremental cost, the siphon would have greater redundancy, serviceability, and future capacity. These three factors minimize the risk of overflow discharge in the system.

3.2.1.3 New Triple Barrel Siphons

Under this alternative, the existing 12-inch cast iron siphon would be replaced with new, triple barrel siphons. The intent of this arrangement is that only one siphon barrel would be in use during low/average flow conditions but, during higher flows, a portion of the wastewater reaching the siphon inlet would be directed to the second siphon barrel. This approach would reduce headloss during higher flow conditions. The third barrel would only be used when one of the other siphon barrels is taken out of service for maintenance or during an emergency. This third barrel also provides future capacity for the system, preventing the need for future construction if there is an unanticipated increase inflows.

New Triple Barrel Siphon Hydraulics - The siphon hydraulics are as described under the double barrel siphon hydraulics section. The only purpose the third barrel is serving is redundancy for the collection system.

The benefit of this alternative over the double barrel siphon alternative is that it provides sufficient redundancy so that one barrel could be taken out of service and still accommodate the projected peak flow rate with the remaining two barrels. This redundancy provides a security for extreme scenarios and the flexibility to properly maintain the siphon. The disadvantage is that it is a more expensive option.

3.2.2 Construction Methods

The siphons may be installed using various construction methods. The two methods that we consider to be most appropriate for this application include:

1. Traditional open cut excavation
2. Horizontal directional drilling

Traditional Open Cut Excavation

Open-trench excavation is the most common and conventional method of gravity sewer installation. Under this alternative, heavy equipment (typically an excavator) would be used to dig a trench along the entire length of the proposed sewer. Once a portion of the trench is excavated, the proposed sewer would be lowered into it, set to the required line and grade, and then subsequently backfilled with appropriate soils/material. Subsequently, surface repairs would be made to the areas disturbed during construction (e.g., pavement patches, lawn restoration, etc.). In order to protect workers during construction, excavation support systems are typically required to stabilize and support the walls of the pipe trench (e.g., trench boxes, slide rail systems, or steel sheeting).

Features/items of specific concern related to installing the siphons by open cut excavation are described below.

Environmental Permitting

The Ipswich River and its associated buffer zones are resource areas requiring protection through the Massachusetts Wetlands Protection Act (MAWPA). As such, the Town would need to obtain a wetlands permit through the Ipswich Conservation Commission for the siphon installation.

In addition, a General Permit with the Army Corps of Engineers would need to be obtained for work within the river. It also may be necessary for the Town to obtain a 401 Water Quality Certification (WQC) from MassDEP, in accordance with Massachusetts Regulation 314 CMR 9.00, based on the estimated volume of material that will need to dredged within the river to install the proposed pipe (greater than 100 cubic yards). As part of the process of obtaining the WQC, sediment samples would need to be collected and analyzed in accordance with

314 CMR 9.07(2)(a) prior to filing an application for the 401 WQC. The regulations also dictate requirements for dredged spoils transport and disposal.

The permitting/approval effort and the potential environmental impacts are expected to be greater for the open trench construction alternative than for horizontal directional drilling.

Control of Water

A cofferdam would need to be constructed within the river to allow the work to occur in relatively dry conditions, which would be a significant expense. In addition, temporary trench dewatering during construction is expected to be necessary and can be a significant expense.

Advantages/Disadvantages of Open Cut Excavation

Open-trench excavation is a proven and commonly used method of pipe construction. As a result, there would be more local contractors who are able to perform and, correspondingly, bid on the work. Greater competition can result in lower construction costs. Another benefit of this construction method is that it would allow the proposed pipe to be accurately set to the proposed line and grade. In addition, unanticipated obstructions (e.g., boulders, urban fill, etc.) and various soil conditions can normally be handled without significant additional cost and without impacts to line and grade.

Disadvantages include the following, as described above:

1. Potential schedule and cost impacts related to obtaining permits and approvals for this option
2. Construction difficulties associated with cofferdam construction and potential high groundwater

Engineer's Opinion of Probable Construction Cost

An estimated cost to construct the proposed triple barrel siphons below the river using open-trench excavation methods was developed for this alternative and is presented in Table 3-5. The construction cost includes the cost of materials, labor and equipment; the contractor's general conditions; the contractor's markup; and a construction contingency. The cost is based on a November 2018 Engineering News Record Construction Cost Index (ENR CCI) of 11184.

For the purposes of this evaluation, we have assumed that no ledge will be encountered. In addition, we have assumed that significant dewatering would be needed in order to install the proposed pipes.

TABLE 3-5
Engineer's Opinion of Probable Construction Cost
Triple Barrel Siphons – Open Trench Excavation

Item	Quantity	Units	Unit Cost	Total Cost
6-inch siphon below river	300	LF	$350	$105,000
6-inch siphon beyond river	150	LF	$450	$67,500
Siphon entrance and exit manholes	2	EA	$30,000	$60,000
Down Stream Check Valves	3	EA	$1,500	$4,500
Cofferdam	1	LS	$225,000	$225,000
Trench dewatering	1	LS	$75,000	$75,000
Timber mats	1	LS	$35,000	$35,000
River bed restoration	1	LS	$10,000	$10,000
Surface restoration (beyond river)	300	SY	$50	$15,000
Subtotal				$597,000
Contingency (20%)				$119,400
Design (10%)				$59,700
Construction Admin (15%)				$89,550
Police (5%)				$29,850
Total				$895,500
TOTAL SAY				**$900,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

Horizontal Directional Drilling

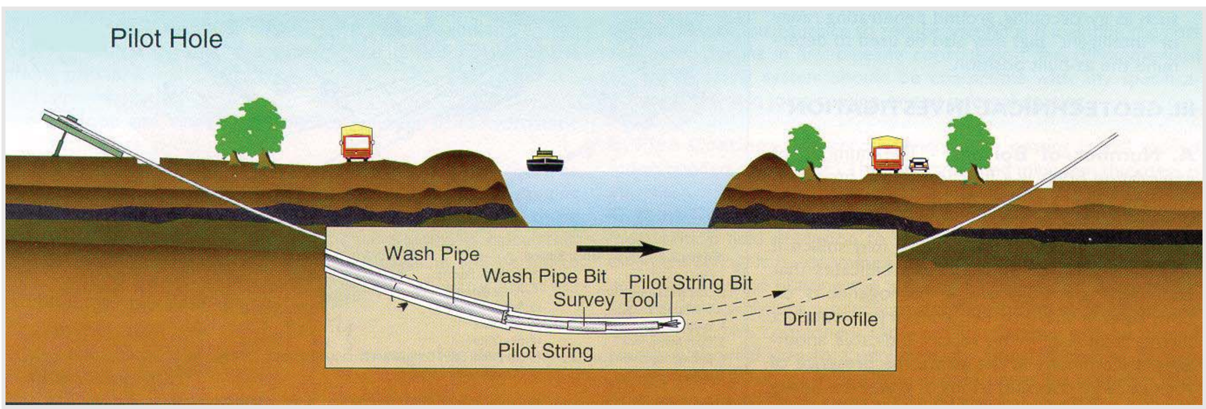
Horizontal directional drilling (HDD) is an appealing alternative to open cut construction for siphon installations as it is a trenchless method of pipe installation and is typically used to avoid an obstacle such as a river, stream, wetlands, highway, railway or runway. HDD was initially developed in the 1970s and is commonly used to install transmission mains for the energy and communication industries and water/sewer pressure pipes, where a high degree of vertical and horizontal accuracy is not required.

An HDD approach would prevent any temporary restrictions of flow in the Ipswich River, as well as prevent any risk of pollution or contamination from the active construction site. While this method does seem to be the most appealing from an environmental perspective. HDD installation at this site could be difficult. The following describes HDD install methodology.

Drilling typically starts at a downward angle on one side of the obstacle and, as the drill passes beneath the obstacle, the drill path is angled upward toward the surface on the other side. The HDD procedure is typically performed in three steps: (1) drilling the pilot hole, (2) reaming, and (3) pullback, as described below.

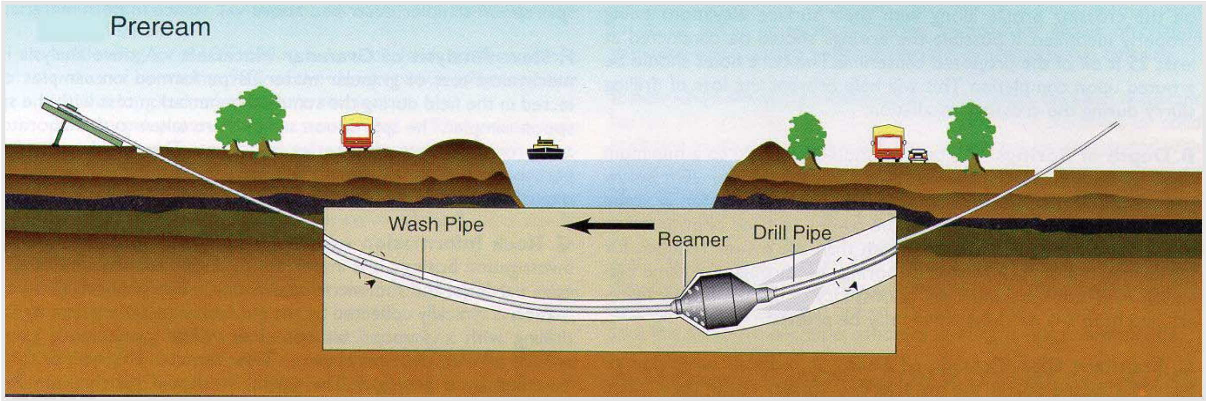
Drilling the Pilot Hole – A bore is launched from the surface, making a starting pit unnecessary. The drill bit is directed downward at an angle until the required depth is reached. From this point, the path of the bore is leveled and carefully guided towards its exit point, which is often the ground surface. For pipe installations, the exit point is typically within a constructed exit pit. The drill string is advanced rod by rod, the joints of which can be deflected slightly to change the direction of the drill alignment. Location and depth are monitored with electronic tracking equipment which also provides crew members with data needed to adjust steering.

As the pilot hole is drilled, an environmentally safe bentonite slurry is typically pumped through the hollow drill rods. The slurry has several functions including stabilization of the hole, lubrication of the drill string, and transportation of the spoils away from the drilling head and back to the surface at the entry point. The spoil-laden slurry collected at the entry point is routed through screening equipment and re-circulated in the drilling operations.



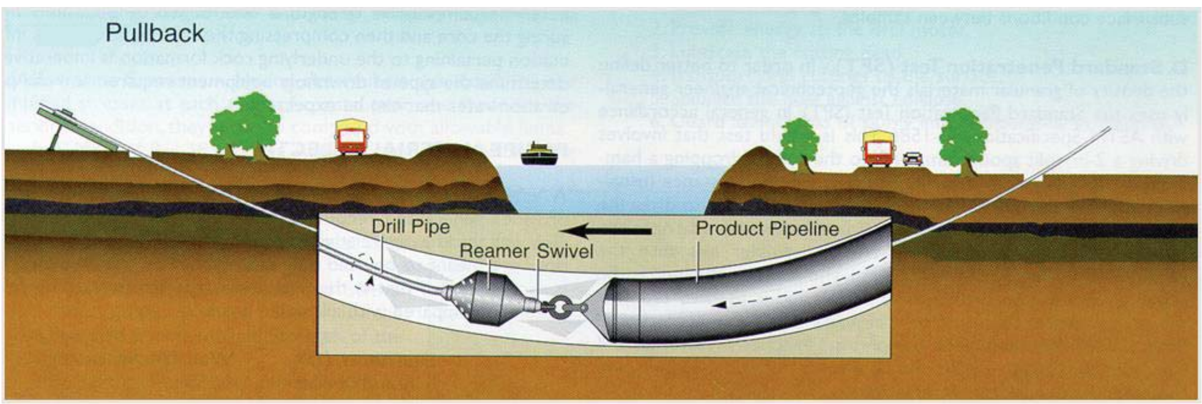
Source: Directional Crossing Contractors Association website

Reaming - Reaming (also referred to as pre-reaming) is performed to enlarge the hole created by the pilot hole to accept the pipe. Once the pilot hole is completed and verified as correct, the drill bit is removed on the exit side of the alignment and a reamer tool is attached and pulled back. Similar to the pilot hole step, a bentonite slurry is pumped through the drill rods to assist with reaming, transporting soils, and lubricating the drill string.



Source: Directional Crossing Contractors Association website

Pullback - During the pullback process the pipe is pulled back through the hole enlarged by the reaming process. Pullback is sometimes performed simultaneously with the reaming process. High-density polyethylene pipe is often used for the HDD process because of its flexibility and the ability to weld the pipe joints together to form an essentially continuous pipeline. On the exit side of the alignment, the pipe sections are typically laid on the ground.



Source: Directional Crossing Contractors Association website

Features/items of specific concern related to installing the siphons by horizontal directional drilling are described below.

Alignment Accuracy

Horizontal directional drilling is a less accurate method of pipe installation than open trench excavation. Pipe line and grade may also be impacted if obstructions are encountered, such as cobbles, boulders and urban fill, which could result in deviations from the planned alignment. Therefore, there is no guarantee that there will not be high or low spots in the final alignment of the pipe. Because the proposed pipes are siphons, which will operate under pressure (rather than a gravity sewer line), the typical accuracy of an HDD drive is expected to be sufficient.

Staging Area

Sufficient space is required to setup the drive equipment and layout the pipe string that would need to be pulled from the exit pit back to the drive location.

In addition, the drive equipment would need to be set back from the siphon inlet structure a sufficient distance to allow the pipe string to be advanced along a gradual arc. Based on discussions with HDD contractors, a radius of 250’ is expected to be needed for a 6-inch pipe.

Breakout/Frac-out

“Frac-out” is the unintentional return of drilling fluids (the bentonite slurry) to the surface during HDD and can occur during the HDD process, depending on the pipe depth. The risk of frac-out occurring is reduced as the depth of cover is increased. Note that the bentonite is stable and non-toxic. The siphon depth below the river bed would be designed to minimize the risk of frac-out.

Bend Radius

A limiting design aspect of HDD is the bend radius a drill can achieve. A bend radius is essentially the rate at which the drill can dive to a specified depth and rise back up to break through the surface on the other side of the obstacle. Many factors tie into this rate, including pipe size and subsurface material. In this case, a carrier pipe of 12” would be required for a 6” and 8” HDPE pipe. The bigger the pipe, the longer and flatter the bend radius. According to multiple drilling contractors, industry standards allow for a bend radius of 300’-350’ for HDD in heavy clay. If encountering any type of rock, a bend radius usually increases to almost 700’. These horizontal lengths refer to the radius of a circle at which the slope of the bore path mirrors.

In Ipswich, the subsurface is clay. This was determined by an in-river investigation discussed earlier. One thing to note is that the extent of the in-river investigation found clay between 8’ and 19’. The drilling contractors suggested a 10’ pipe depth below the river. If, upon further investigation, rock was found at this depth it would increase the bend radius to 700’. For this exercise, clay was assumed to be uniform to 10’ below the riverbed.

With a known subsurface material of clay, and a carrier pipe size of 12”, drilling contractors determined a 300’ bend radius would be suitable for this drill. This bend radius was confirmed with multiple drilling contractors to ensure accuracy and safety. This bend radius determines the horizontal distance required for a successful drill.

Re-Route of Existing Collection System and Land Acquisition

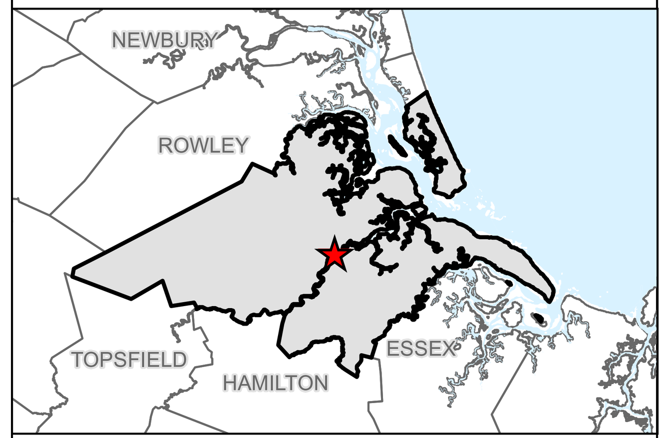
The following diagram outlines the new alignment of the collection system based off HDD siphon installation.

FIGURE 3-1
PROPOSED DIRECTIONAL DRILL SEWER OPTION

LEGEND

- Manhole
- Existing Sewer Main
- Abandoned
- Horizontal Directional Drill Bore Path
- New Sewer
- Pipes Targeted for Evaluation
- Approximate Parcel Boundary

LOCUS MAP



0 100
Feet

1:480

NOTES

1. Based on Google Imagery (C) 2017
2. FEMA National Flood Hazard data obtained through MassGIS, Revised based on LiDAR elevations, data valid as of December 2017

Schematic Map of Sewer Interceptor and Siphon Connectivity

Ipswich, Massachusetts

February 2019

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Engineers | Environmental Specialists

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As you notice from the diagram, SMH 34 would be relocated to a location just off the parking lot area. The bore path would run through the middle of the parking lot, to the existing SMH 18 which would stay in its original location.

However, what you also may notice from the diagram is the reconfiguration of the existing collection system. When SMH 34 moves south to account for the HDD drill, existing flow needs to be redirected to catch all flow. The sewer coming from the Elm Street and County Street is not an issue as elevation allows for new gravity sewer to run from SMH 38 to the new location of SMH 34. However, the issue lies with the flow coming from the West.

Please see diagram below for the layout of required land acquisition:

FIGURE 3-2
NECESSARY ACQUIRED LAND FOR NEW COLLECTION SYSTEM

LEGEND

Necessary Acquired Land
Approximate Parcel Boundary

LOCUS MAP

0 50
Feet

1:240

NOTES

1. Based on Google Imagery (C) 2017
2. FEMA National Flood Hazard data obtained through MassGIS, Revised based on LiDAR elevations, data valid as of December 2017

Schematic Map of Sewer Interceptor and Siphon Connectivity

Ipswich, Massachusetts

February 2019

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As you can see, land running west to east from South Main Street to the back of the parking lot at 4 South Main Street is needed for the gravity sewer run collecting flow from the South Main Street area. The area running north to south from the edge of the river to the back of the parklingl lot is needed for the location of the bore path. While land acquistion is never ideal and can prove to be difficult and costly, these acquisitions are necessaary for the collection system to function properly.

Advantages and Disadvantages of HDD

Benefits of the HDD process are that it minimizes surface disturbances and can be performed in a variety of soil conditions. In addition, HDD can be performed below the river and groundwater table without a cofferdam. This construction method would also simplify environmental permitting/approvals since the river bottom would not be disturbed.

Disadvantages include the following, as described above:

1. The HDD method is a less accurate method of pipe installation than open cut excavation. There is the potential for multiple high points and/or low points in the final alignment.
2. Space to stage the work is required.
3. Frac-out could occur within the river.
4. Existing Sewer Re-route

Engineer's Opinion of Probable Construction Cost

An estimated cost to construct the proposed siphons below the river by horizontal directional drilling was developed for this alternative and is presented in Table 3-6. The construction cost includes the cost of materials, labor and equipment; the contractor's general conditions; the contractor's markup; and a construction contingency. The cost is based on a November 2018 Engineering News Record Construction Cost Index (ENR CCI) of 11184.

For the purposes of this evaluation, we have assumed that no ledge will be encountered.

TABLE 3-6
Engineer's Opinion of Probable Construction Cost
Triple Barrel Siphons Installed by HDD

Item	Quantity	Units	Unit Cost	Total Cost
6-inch pipe installed by HDD	750	LF	$1,000	$750,000
8-inch gravity sewer	655	LF	$425	$278,375
Siphon entrance manhole	1	LS	$25,000	$25,000
Siphon exit manhole	1	LS	$40,000	$40,000
Down Stream Check Valves	3	EA	$1,500	$4,500
Surface restoration	150	SY	$50	$7,500
Subtotal				**$1,105,375**
Contingency (20%)				$221,075
Design (10%)				$110,538
Construction Admin (15%)				$165,806
Police (5%)				$55,269
TOTAL				**$1,658,063**
TOTAL SAY				**$1,660,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

3.3 New Gravity Sewer Alternative

3.3.1 Gravity Sewer Layout

Under this alterative, we evaluated whether the existing siphon could be replaced with a new gravity sewer crossing the river. Assuming that the existing siphon inlet and outlet inverts are used for the gravity sewer, a 12-inch sewer would need to be installed at an approximate slope of 0.4% in order to convey the predicted peak flow of 0.7 MGD flowing at approximately 2/3 full. Sewers are typically designed so that they do not flow full at the projected peak flow conditions.

This sewer would need to be installed above the river bed on piers in order to maintain the required continuous slope between the existing inverts on each side of the river. In fact, during some periods the sewer main would be above the river water level. Figure 3-3 displays the current water elevation versus the realistic 12" gravity sewer elevation.

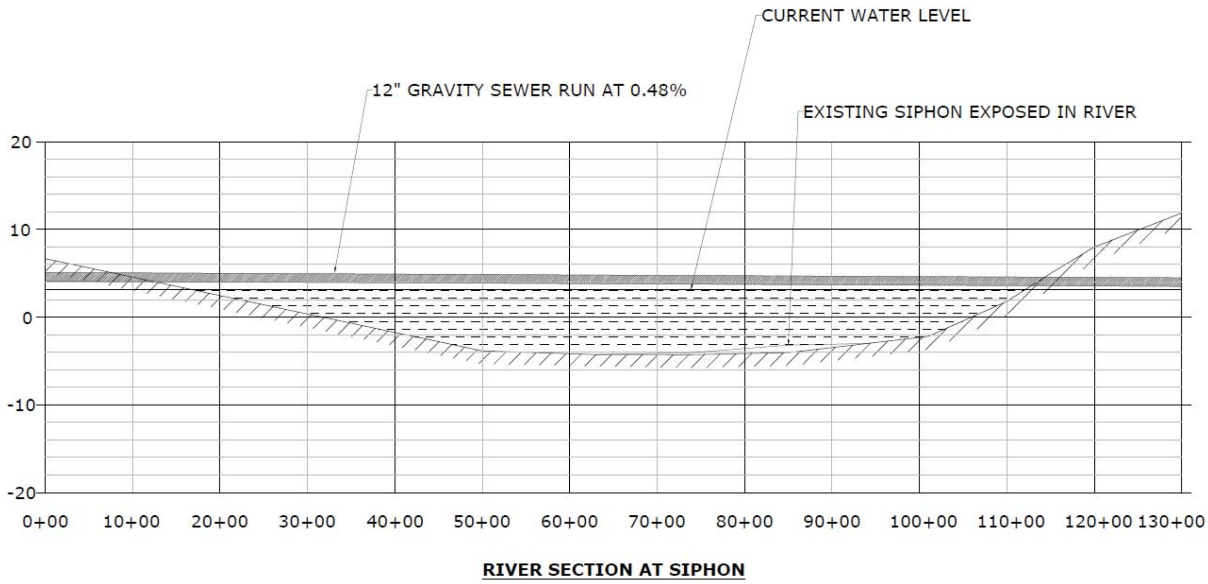


Figure 3-3. Profile View of Deep Gravity Sewer

This alternative was not considered further because the Ipswich River is a navigable water and obstructions such as this are not allowed within navigable waters.

3.4 New Pump Station Alternative

Pump stations are essential to collection systems that require flow to move through fluctuating elevations where gravity systems are not possible. Gravity collection systems can operate at a very minimum slope and still provide enough flushing velocity to keep all solids and debris moving through the pipe. However, no matter the system, flow will eventually need to travel against gravity. Pump stations can push flow from a lower elevation to a higher elevation to reset flow at a high point in a system to allow for continued gravity flow.

Ideally, a pump station is installed in line with the gravity sewer system to allow for flow to continue in the same path. However, a driving factor for the location of a pump station is land for construction. A pump station not only requires a space that allows for deep excavation, but also the proper configuration for both a gravity pipe to enter the station and a pressurized pipe to leave the station in the direction of the discharge manhole. With these driving factors, along with the price of land, a middle ground is sometimes difficult to find.

Under this alternative, a new pump station and force main would be constructed to replace the existing siphon. The pump station would be constructed near the upstream end of the siphon to collect the wastewater that currently flows to the siphon. That wastewater flow would be pumped across the Ipswich River through an appropriately sized force main to the existing siphon outlet structure.

Two important considerations related to the construction of a new pump station are: 1.) the availability of land in the vicinity of the proposed force main river crossing and 2.) the public acceptance of a pump station near the river.

In this case, waterfront property along the river creates a challenge. Ideal locations create a costly land purchase, while also ruining the aesthetics of the waterfront. The public may understand the importance of a municipal wastewater collection system, but most would not appreciate the system affecting the scenery of the Ipswich River. For these reasons, the location next to the Police Department seemed to be the most feasible.

While still close to the river, this location is setback from the main scenic areas. It is away from the historic Choate Bridge and downtown area. While it is close to County Street, a high traffic and visible area, the pump station will be in the back of this parking area away from the public's line of sight. This land is already owned by the Town, which would hopefully allow for an effortless transfer of land.

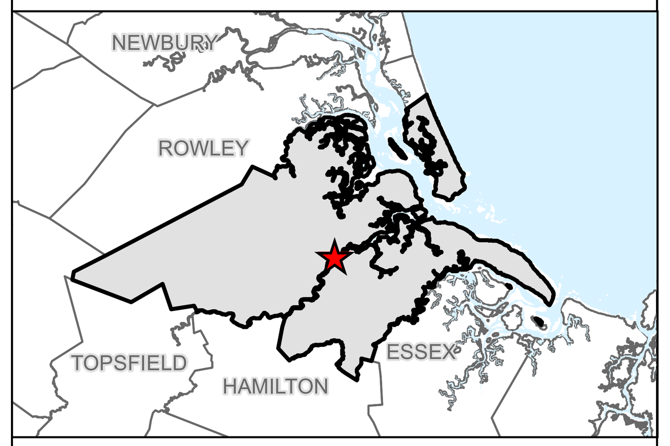
The benefit of this location, which is a significant distance away from the edge of the river, is that it does not impact river front aesthetics. However, it adds significantly to the cost of this alternative because of the new gravity sewers that would be required to redirect flow to the pump station. A preliminary layout of the new sewers is also shown in Figure 3-3. Please see image below:

FIGURE 3-3
ADJUSTMENT OF EXISTING COLLECTION SYSTEM FOR PUMP STATION

LEGEND

- Manhole
- Existing Sewer Main
- Proposed Gravity Sewer Path
- Proposed 6" Force Main Sewer Path
- Pipes Targeted for Evaluation
- Approximate Parcel Boundary

LOCUS MAP



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Feet

1:480

NOTES

1. Based on Google Imagery (C) 2017
2. FEMA National Flood Hazard data obtained through MassGIS, Revised based on LiDAR elevations, data valid as of December 2017

Schematic Map of Sewer Interceptor and Siphon Connectivity

Ipswich, Massachusetts

February 2019

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In this image, the arrows represent the direction of flow. As you can see, all flow meets at SMH 34 on the edge of the Ipswich River. The intent of this alternative is to redirect flow from the existing Siphon to the downstream discharge manhole across the County Street bridge. At this point, it will continue running east by gravity.

While flow could be captured and redirected at alternate points, capturing flow from SMH 34 and redirecting it towards the proposed location of the pump station made the most sense from both a cost and public disturbance perspective. By capturing all flow from these areas and only having to run one new gravity sewer mainline, minimal residential sewer services would be disturbed, road restoration and road closures could be avoided, and the existing collection system would face less of an impact. A new sewer pipe could be installed where the existing collection system is located now, preventing any need for an alternate corridor and additional easements.

A major issue from a cost and constructability perspective with this alternative is the crossing on the County Street Bridge. Currently, the water main crossing the County Street Bridge is suspended on the side of the bridge, as there is no room to bury the pipe in the shallow roadway. Therefore, the force main crossing this area needs to be suspended similar to the water main. However, this is difficult as the pipe must be securely fastened to the bridge while minimizing public visual. Installing an exposed sewer pipe over this bridge is not a welcoming visual to the public, especially over the waterway. Burying this pipe in the roadway is much more appealing, it simply isn't possible due to the depth of pavement over the bridge.

3.4.1 Estimated Construction Cost

The estimated construction cost of the pump station and associated work is presented in Table 3-7. Please note that the pump station cost assumes that a masonry building will be constructed to house the controls and a generator along with a separate concrete wetwell with submersible pumps. In addition, the work would include construction of a valve vault. If this alternative is pursued, an adjustment to the pump station features may be considered to reduce costs. For example, the building could be eliminated and, instead, the controls could be placed in a pedestal-mounted enclosure and the generator could be provided with its own enclosure. In addition, the generator could be eliminated and replaced with a plug for connection to a temporary/portable generator.

As noted under the other alternatives, the construction cost includes the cost of materials, labor and equipment; the contractor's general conditions; the contractor's markup; and a construction contingency. The cost is based on a November 2018 Engineering News Record Construction Cost Index (ENR CCI) of 11184.

Note that under this alternative the Town would also have to pay for the operation and maintenance costs associated with this new pump station (energy costs, labor to operate and maintain the station, periodic parts/equipment replacement, etc.).

TABLE 3-7
Engineer's Opinion of Probable Construction Cost
New Pump Station and Associated Piping

Item	Quantity	Units	Unit Cost	Total Cost
Pump station	1	LS	$625,000	$650,000
8-inch gravity sewer	620	LF	$450	$279,000
4-inch force main	660	LF	$225	$148,500
Site Improvements	1	LS	$55,000	$55,000
Subtotal				**$1,132,500**
Contingency (20%)				$226,500
Design (10%)				$113,250
Construction Admin (15%)				$169,875
Police (5%)				$56,625
TOTAL				**$1,698,750**
TOTAL SAY				**$1,700,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

3.5 Comparison of Alternatives

The alternatives developed were compared in this section. A list of the advantages and disadvantages associated with each alternative is presented in Table 3-8.

TABLE 3-8
Advantages and Disadvantages of Alternatives
Ipswich Interceptor and Siphon Evaluation

Alternative	Construction Cost	Advantages	Disadvantages
Single barrel Siphon (6")	---	-Lowest cost alternative	- Not an acceptable alternative because cannot accommodate projected peak flow - Not an acceptable alternative because cannot not provide redundancy, serviceability, or future capacity
Double Barrel Siphon (6"/6") Open Cut	$800,000	-Relatively low-cost alternative -Can accommodate the	-Not an acceptable alternative because cannot provide redundancy,

TABLE 3-8
Advantages and Disadvantages of Alternatives
Ipswich Interceptor and Siphon Evaluation

Alternative	Construction Cost	Advantages	Disadvantages
Excavation		current and projected future peak flow	serviceability, or future capacity
Triple Barrel Siphon (6"/6"/6") Open Cut Excavation	$900,000	-Incremental cost increase compared to double barrel approach -Can accommodate the current and projected future peak flow -Provides redundancy -More local contractors able to perform and bid on work -Greater competition can result in lower construction costs -Allow for proposed pipe to be accurately set for line and grade -Unanticipated obstructions can be handled normally without significant impacts	-Higher cost than alternatives with no redundancy -Potential schedule and cost impacts related to obtaining permits and approvals -Construction difficulties associated with cofferdam construction and potential high groundwater
Triple Barrel Siphon (6"/6"/6") Horizontal Directional Drill Install	$1,660,000	-Can accommodate the current and projected future peak flow -Provides redundancy -Minimize surface disturbance -Pipe can be installed below the river and groundwater table without a cofferdam -Simply environmental permitting or approvals since the river bottom would not be disturbed	-Higher cost than alternatives with no redundancy -HDD is less accurate and has potential for high points in final alignment -Space to stage the work is required -Frac-out could occur within the river -Requires rerouting of existing gravity collection system -Heavy impact on public during construction

TABLE 3-8
Advantages and Disadvantages of Alternatives
Ipswich Interceptor and Siphon Evaluation

Alternative	Construction Cost	Advantages	Disadvantages
Gravity Sewer	---	---	-Not an acceptable alternative because would result in an obstruction in a navigable water
Pump Station	$1,700,000	-Eliminates the low velocity and solids deposition concern	-Highest cost alternative -Requires rerouting of existing gravity collection system -Requires additional cost for force main installation to discharge manhole -Increases annual operation and maintenance costs

Section 4 Interceptor Evaluation

4.1 Closed Circuit Television Inspection

4.1.1 Field Investigation

As discussed in Section 2.1.1, the field investigations for this project included a closed-circuit television (CCTV) inspection of the interceptor occurring on August 7th-8th, 2018. During these investigations, a robotic crawler-type camera traveled through the existing siphon, and a video recording of the sewer main features and conditions were taken. National Water Main Cleaning Company (NWMCC), a sub-contractor to Tighe & Bond who specializes in sewer investigations, performed the sewer cleaning and inspection work under the direction and supervision of Tighe & Bond. Equipment on site to perform this work included a CCTV truck housing the necessary video equipment, and a vacuum truck to clean excess debris out of the existing manholes to provide a clear path for the camera.

NWMCC cleaned and subsequently inspected the section of the interceptor of concern. NWMCC started their work at the upstream manhole (SMH 20) at the western end of the Interceptor. Both CCTV inspections areas for the Siphon and Interceptor are highlighted in yellow in Figure 1-1.

4.1.2 Field Results

The existing interceptor is in fair condition, where the CCTV results do not show any serious defects. Please see table below highlighting observations in the Interceptor:

TABLE 4-1
CCTV Results

Location	Upstream MH	Downstream MH	Pipe Diameter (in.)	Length (ft)	Notes
Interceptor (West of Choate Bridge to Eastern side)	SMH 20	SMH 19	18	339.2	Grease causing 5% area loss at 52' Surface spalling occurring at 70', 70', 71', 76', 92', 92', 100', 111', 116', 339' Multiple Cracks at 100'
Interceptor (East of Choate Bridge to Downstream Siphon Manhole)	SMH 19	SMH 18	18	146.4	Defective Tap break-in at 55' Infiltration (Gusher) at 55' at tap break in)

The Interceptor will not be replaced and needs to be reinforced. Some structural concerns (cracking and spalling) and infiltration were observed within the interceptor, as noted in Table 2-1. The structural concerns were considered minor to moderate. The spalling observed looked to be to the top course of the interior of the pipe facing deterioration over time to the point where the surface lost its smooth interior. The cracking can be seen in Photo 2-1. In addition, some grease deposition was observed in the interceptor, similar to the siphon.

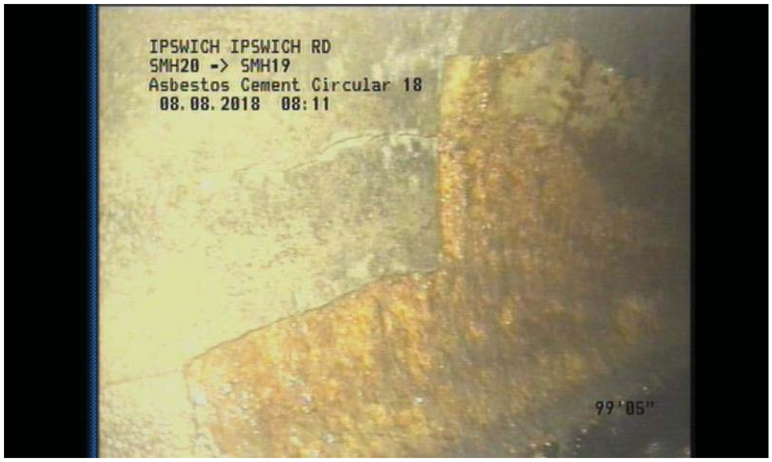


Photo 4-1. Multiple Cracks in Interceptor at 100 ft.

This cracking does not jeopardize the structurally integrity of the pipe. However, if allowed to continue under this pressure this could lead to further damage. Therefore, an effective solution without having to dig up the pipe is to line the pipe. Slip lining the pipe inserts a structural sleeve on the inside surface of the pipe, eliminating structural concerns such as this one.

One area to note is a defective tap break-in occurring 55 feet downstream of SMH 19. A defective tap break in is when a tap for a service is made on the sewer main after installation. If not done carefully, infiltration can occur at the joint where the new service is tied into the main. While concerning, this is not a major area of concern as the interceptor has plenty of capacity to handle this excess flow. If this added flow contributed to backups in the interceptor, this would need to be dealt with immediately. In this case, the infiltration is negligible from a capacity standpoint. Please see photo below of defective tap break in.

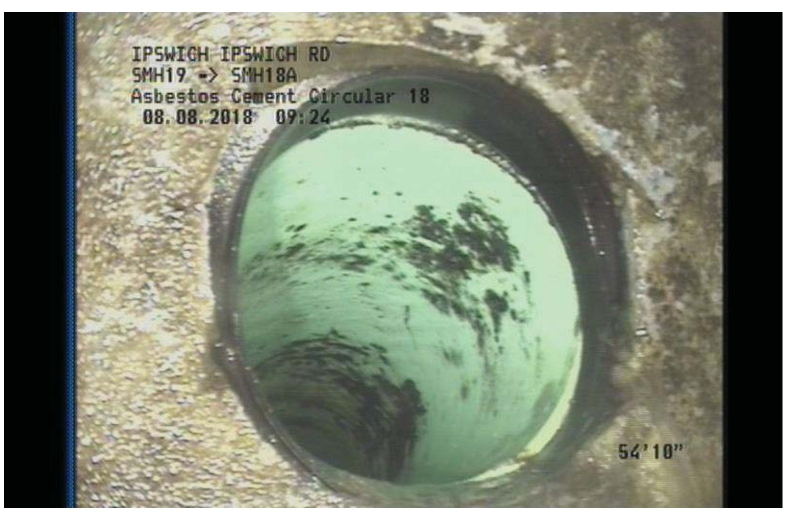


Photo 4-2. Defective Tap Break In

While difficult to make out, there is a gap between the black rubber gasket and the cement wall of the pipe. The gap ranges from 3 o'clock to 6 o'clock. The connection with the pipe is clearly skewed as the pipe is not centered on the joint, which pulls the rubber gasket away from the edges of the pipe, creating the void. To fix this issue, a similar fix can be used as the discussed above. While slip lining the interceptor, the same contractor can insert a similar sleeve into the service and seal up this joint.

4.2 Pipe Exterior and Structural Condition Assessment

4.2.1 Ipswich Interceptor Inspection

On July 31, 2018, Tighe & Bond performed an exterior inspection of the interceptor and siphon. During the inspection, Tighe & Bond identified locations where there were apparent corrosion losses of the steel and cast-iron pipe components, missing components (nuts, bolts, flanges, etc.), soil scour/erosion and stream bed material losses over the siphon pipe, damage to the concrete piers supporting the interceptor pipe, and any other deficiencies that may cause future damage to the interceptor or the siphon. The exposed pipe joints are mechanically connected with clamps secured with steel bolts. While the original cast iron pipe seems to be push on joints, as a reinforcement, a Cast Iron Bell Joint leak clamp was installed around each joint to increase strength. The bolts connecting these two sides of the joints run across the joint and tighten at the flange. The steel bolts (5/8" dia.) have varying degrees of corrosion. In many locations there is extensive corrosion loss on these bolts. Two of the Steel bolts were even found to be completely corroded through after corrosion byproduct removal (see Photos 5 & 6). At one location, corrosion byproduct removal showed the Cast Iron Dresser clamp bolt flange was completely corroded away. This location can be seen in Photo 4 below.

4.2.1.1 Interceptor Inspection Methods

The interceptor pipe, which is located along the edge of the Ipswich River, was exposed at some locations. The entire length of exposed interceptor piping was not video recorded due to the relatively long length of the exposed pipe. Instead, a video was taken using the GoPro camera to document any deficiencies found along the length of the interceptor pipe. Where necessary, a hammer was used to remove corrosion byproduct (rust/scale) so that we could observe the underlying pipe or joints.

A visual inspection was also performed along the banks of the river to the east of the South Main Street Bridge, where the interceptor is located but not exposed. Measurements of the depth of earth cover over the interceptor were taken using a probe. Portions of this inspection were documented with photos and videos.

While soil probes were done to investigate in river conditions, borings were done on the southern side of the river next to SMH 34 to observe deeper subsurface conditions. The boring reached 29' below grade, observing mostly sand and clay conditions. Sand and gravel were encountered to 8' below grade, at which point the subsurface switched to clay until 18' below the surface. At 18', the boring encountered sand and gravel until the end of exploration at 29'. This boring log can be found in the Appendix section.

4.2.1.2 Interceptor Inspection Results

The interceptor is located along the north bank of the Ipswich River, near the South Main Street bridge. The interceptor is above grade at the existing stone retaining wall to the west of the bridge and goes back below grade on the east side of the bridge, as shown on Figure 1-1.

Where the interceptor is exposed, it is supported on concrete caissons consisting of a rectangular cast-in-place concrete upper pipe connection, supported on a lower foundation consisting of a 3-foot diameter concrete caisson, installed to bedrock (mostly buried), at an 18-foot spacing along the pipe (adjacent to each pipe joint). For the most part, the concrete is in satisfactory condition, although some surface weathering was observed. One of the supports at the east side of the bridge appears to be missing the lower caisson (perhaps not installed due to rocky conditions) with a void under the upper concrete area. A pipe support at the western end of the exposed pipe run has some concrete deterioration/spalling, that may be attributed to freeze-thaw damage.

The pipe exterior that could be viewed appeared to be in generally good condition, although the eastern portion of the exposed section of the interceptor had corrosion byproducts/tubercles that were difficult to remove, making an evaluation of the pipe condition difficult in this area. Removal of rust/scale was only performed at joint locations to avoid damaging the cast iron pipe.

Photo 4-3.Overview of interceptor pipe running parallel to river and under the bridge.

Photo 4-4.Bank erosion around the interceptor pipe. It appears this section of pipe was originally buried, but scour from the river has exposed the pipe over time.

Photo 4-5.Typical corrosion of the bottom bolts on the interceptor pipe joints. In this instance, the coupling flanges are also corroding to the point of failure.

Photo 4-6.Typical corrosion of the top bolts of the interceptor joints. The Bell Joint Leak Clamps are generally still structurally intact, but the bolts have lost enough diameter that they may no longer be providing restraint. Because these bolts have lost enough diameter, these clamps do not provide much support.

Photo 4-7.Corrosion of failed bolt.

Photo 4-8.Scour hole under concrete pier supporting the interceptor pipe just to the east of the bridge.

Photo 4-9.Concrete damage on a support pier for the interceptor pipe.

Photo 4-10.Connection into the interceptor pipe at the retaining wall to the west of the South Main Street bridge.

Photo 4-11.West end of the exposed section of the interceptor.

4.3 Hydraulic Capacity of Interceptor

4.3.1 Current Wastewater Flows

The Interceptor is an 18-inch Cast Iron pipe supported by concreted footings every 20 feet along the northern bank of the Ipswich River from west to east underneath the Choate Bridge. The Interceptor carries flow from the Union Street and Market Street areas eastward along the river, towards the Ipswich Town Wharf Pump Station.

When flowing full, the interceptor has a hydraulic capacity of 3.1 MGD. This is based on the design slope of 0.002 feet/foot for the interceptor segment of concern, which was taken from the 1958 record plans, the diameter of the pipe, and the estimated roughness coefficient of the pipe of 64 (Existing Cast Iron).

While the Interceptor, when fully charged, can carry 3.1 MGD, the peak flow measured during wastewater flow monitoring from March 20th to April 16th, 2009 and from March 21rd to April 11th, 2011 was 1.93 MGD.

4.4 Manhole Investigation

4.4.1 Manhole Field Investigations

There are manholes throughout the Town of Ipswich's wastewater collection system that provide access for maintenance to the Interceptor. The manhole inspections provided data on manhole construction and condition; leakage problems (infiltration); the potential for inflow; and debris accumulation at the inspection locations. As noted previously, infiltration and inflow are a concern because they reduce the capacity of the sewers to convey sanitary flow can increase the cost to transport and treat the wastewater flow and increase the risk of SSOs occurring.

A total of 5 manholes were inspected as part of this effort on October 2, 2018 by Tighe & Bond, with the assistance of Town staff. Three access manholes were located along the Interceptor, while two manholes provide access for the Siphon. The inspected manholes are shown on Figure 1-1.

4.4.2 Manhole Investigation Results

A summary of the Interceptor manhole inspections performed is presented in Table 2-3.

TABLE 4-2
Manhole Inspections – Interceptor

Location	ID #	Wall Material	Condition (poor/ok/good)				General Notes	Requires Attention (Yes/No)
			Bench	Invert	Wall	Cover		
Interceptor (Middle)	SMH 19	Concrete Block	Good	Good	Ok	Ok	Rusted Access Rungs No flood proof hatch	Yes
Interceptor (Western End)	SMH 20	Concrete Block	Good	Good	Ok	Ok	Low Voltage wire around MH Cover in rock area Rocks enter when open No flood proof hatch	Yes

The scope of work included 3 key access manholes along the Interceptor. Notice from the table above only 2 were inspected: SMHs 19 and 20. The only key access manhole not inspected was the manhole between SMH 18 and 19, which proved to be a wye into the Interceptor. While in the area, other manholes were inspected and one item to note is that SMH 17A was not found. Whether it is buried or not there, there is no visual evidence that SMH 17A exists. This conclusion was supported by multiple surface site investigations. However, the SMHs that were inspected do have some defects. SMHs 19 and 20 are the two key access manholes that require attention.

SMH 19 had an issue with surrounding vegetation growing in through the rim. This prevents the rim from fully closing creating a void for debris to fall in. This is an easy fix, as this vegetation can be cleared form the cover area. Please see image below:

Photo 4-12.Vegetation surrounding cover of SMH 19.

Rusted rungs were also observed within SMH 19, as shown in Photo 4-13.


Photo 4-13.Corroded access rungs in SMH 19.

At SMH 20, there is a low voltage wire surrounding the MH which creates an unsafe environment. The origin of this wire is unknown, however to speculate this could be some type of lighting or power for a surrounding neighbor. This does not appear to be a major wire, and therefore should be relatively easy to reroute. The manhole is also in a rock garden, and rocks can potentially fall into the manhole when the cover is removed. To remedy this issue, an additional row of bricks should be added underneath the frame. This will raise the cover of the manhole above the grade line of stone, eliminating the risk of rock from falling in.

Photo 4-14.Wire and rock garden creating access issue to SMH 20.

Due to the condition of these manholes, cleaning and lining these manholes is highly suggested. The liner will seal up these cracks and prevent further infiltration. While a contractor is on site, cleaning and lining the remainder of the manholes would prevent further issues moving forward.

Because of their location adjacent to the river, we recommend that all manhole frames and covers be made water-tight.

4.5 Existing Ipswich River Stabilization

4.5.1 Existing Stabilization Efforts

The bank along the north side of the Ipswich River, to the east of the South Main Street bridge, is eroding and the original stone fill pipe covering is mostly missing. The original 1958 interceptor was designed as an 18" cast iron pipe supported by 3' diameter concrete caissons spaced 18' on center (matching pipe section lengths). This original structure was protected circa 1965 with 1:1 rock fill revetment slope upriver and downriver of the Choate Bridge. Some of the trees along the top of the bank have grown around the interceptor and appear to be falling into the river with the potential to damage the pipe. Please see below photo of existing rip rap located over the Interceptor to protect the pipe facing West under Choate Bridge.

Photo 4-15. Existing Rip Rap Protecting Interceptor facing West

It is recommended that the trees located over the interceptor be removed, and missing rock fill be replaced with adequately sized stone riprap, possibly in combination with reinforced concrete encasement around the interceptor.

4.6 Risk Associated with Sea Level Rising and Flooding

4.6.1 Potential Risk

Due to the proximity of the siphon and interceptor to the Ipswich River, potential flooding risks should be considered to improve resiliency. TR-16 indicates that "*All systems should evaluate sewer lines that run cross country through easements located in a 100-year floodplain. The sewer manholes in these sections should be protected from I/I in flood conditions. Considerations to include water-tight manholes or* *manholes raised above the 100- year flood level*." In addition, TR-16 indicates that "*Solid or watertight manhole covers should be used in areas subject to flooding.*"

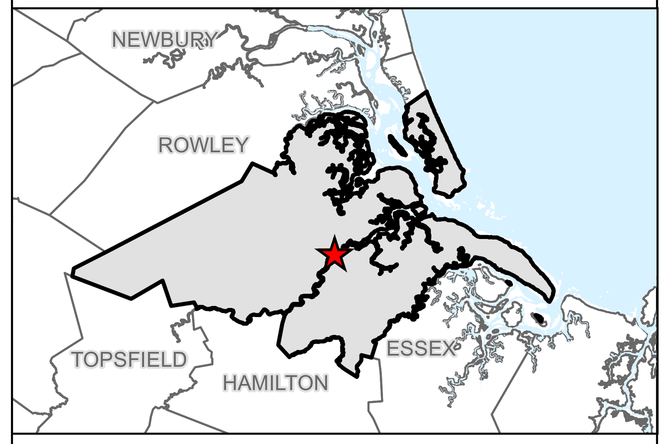
Based on a review of Flood Insurance Study and FIRM Mapping of the area, the interceptor and the siphon inlet and outlet structures are subject to flooding during the 100-year flood. The 100-year flood elevation boundaries are shown on Figure 2-1.

FIGURE 4-1
100 YEAR FLOOD ZONE

LEGEND

- Manhole
- 100 Year Flood Zone*
- Approximate Parcel Boundary

LOCUS MAP



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NOTES

1. Based on Google Imagery (C) 2017
2. FEMA National Flood Hazard data obtained through MassGIS, *Revised based on LiDAR elevations, data valid as of December 2017

Schematic Map of Sewer Interceptor and Siphon Connectivity

Ipswich, Massachusetts

February 2019

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The blue dashed lines represent the 100 Year Flood Zone, while the red dashed line represents the 100 year flood zone plus three feet of elevation. The town has standardized the TR-16 requirement of elevating structure rims 3' above the 100 year flood zone in effort to further their coastal resiliency. Significant flood water entering the sewer system is a concern because it can result in basement backups, sanitary sewer overflows, and the discharge of raw sewage to the river. In addition, the large quantity of flow entering the sewer system may impact wastewater treatment facility operations.

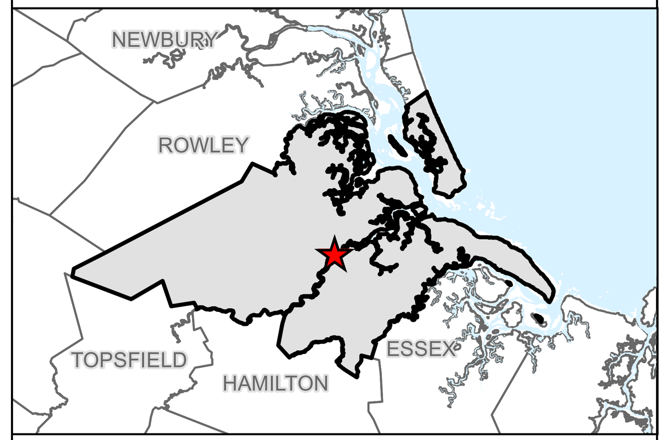
These flood zones conflict with the elevation of many structures in this area. Please see Table 2-7 and Figure 4-2 below displaying these results.

FIGURE 4-2 MANHOLES WITHIN 100 YEAR FLOOD AND TR 16 ZONE

LEGEND

- Manhole
- Gravity
- Force Main
- Pipes Targeted for Evaluation
- 100-Year Flood + 3 feet
- 100 Year Flood Zone
- Existing Sidney Shurcliff Riverwalk
- Existing Ipswich Riverwalk
- Proposed Ipswich Riverwalk Extension

LOCUS MAP



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NOTES

1. Based on Google Imagery (C) 2017
2. FEMA National Flood Hazard data obtained through MassGIS, Revised based on LiDAR elevations, data valid as of December 2017

Schematic Map of Sewer Interceptor and Siphon Connectivity

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TABLE 4-3
Manholes Within Flood Zone and TR 16 Zone (100 year Flood Zone + 3')

MH ID	Rim Elevation	Within 100 Year Flood Zone (ELEV = 10')	Within TR 16 Resilient Design Zone (ELEV = 13')
SMH 17A	10.68[1]	No	Yes
SMH 18	11.88[1]	No	Yes
SMH 18A	9.41[1]	Yes	Yes
SMH 18B	13.99[1]	No	No
SMH 19	8.17[1]	Yes	Yes
SMH 20	7.18[1]	Yes	Yes
SMH 20A	7.87[1]	Yes	Yes
SMH 34	6.67[1]	Yes	Yes
SMH 35	11.63[1]	No	Yes
SMH 36	n/a	No	Yes
SMH 37	n/a	No	Yes
SMH 38A	14.12[1]	No	No
SMH (B.O.)	5.52[1]	Yes	Yes

[1]Rim elevation provided by H.L.Graham Sewer Plans dated 05-29-2018.(NAVD 1988).

As you can see, just under half of the manholes in this area will be underwater during a 100-year storm event. In order to comply with TR-16, these manholes would need to be raised above the 100-year flood elevation or provided with watertight covers.

Based on interceptor manhole rim elevations taken from an existing survey, some manhole rims would need to be raised almost 7 feet to be above the 100-year flood level. Because raising these manholes would be an eye sore along the river and make access for maintenance difficult, this alternative is not recommended. Instead, Tighe & Bond recommends the existing manhole covers that are below the 100-year flood elevation be replaced with watertight covers. These covers would reduce the risk of flood waters entering the sewer system. The estimated cost to replace an existing frame and cover with a watertight frame and cover is approximately $1,200 per cover. This price includes a new watertight frame, cover, and all associated equipment and labor.

This number is based off a quote from a local distributor of collection system products. While the frame and cover are valued at $1,200, additional charges for associated labor, equipment, anti-flotation anchoring, and contingency is factored in. This would provide the Town with watertight manhole covers creating a resilient system that would hold up in flooding scenarios.

The only concern with this solution is if these covers prevent pressure release out of these watertight covers, backups could occur upstream in people's homes. While overflows should not occur due to the new siphon design, there is always the potential for a catastrophic event. Therefore, all precautions must be taken.

Possible watertight covers that could be used to counteract this scenario are Combine Sewer Overflow (CSO) covers. These covers are watertight, not allowing any inflow from the surface. However, if pressure is built up to the surface of the manhole, and discharge is needed to prevent backup of the collection system, these covers allow for pressure release in the form of discharge.

Section 5
Interceptor Rehabilitation and Protection

5.1 Pipe Joints - Restraint Options

The existing joints of the 18” Cast Iron Interceptor are sealed by a gasket within the push on joint of the pipe, as well as a Bell Joint Leak Clamp. While the gasket of the push on joint should provide an adequate seal, these Bell Joint Leak Clamps were installed as an added measure of reinforcement due to the critical location of the Interceptor. Bell Joint Leak Clamps are clamps that attach on either side of a joint, then tie together with threaded rod. On one end of this connection, a rubber gasket provides the grip needed to pull the spigot end of the pipe into the bell. This pulling force comes from the tightened threaded rod between the two clamps on the pipe. These clamps prove to be very useful as they can be installed after pipe installation without having to cut the pipe.

Over time, the threaded rod of the existing bell joint leak clamps has corroded and lost its structural purpose. Some may appear to be in good condition, but most are very brittle and barely still intact. Please see pictures below of discussed corrosion.

Photo 5-1. Existing Bell Joint Leak Clamp on Interceptor.

Photo 5-2. Existing Bell Joint Leak Clamp and concrete caisson.

Photo 5-3. Corroded bolt of existing Bell Joint Leak Clamp.

As you can see, the pipe joint has a sufficient seal and there is no visible leaking. However, the threaded rods that tie the existing bell joint leak clamp together and provides the pull force needed for reinforcement are barely intact. In fact, some areas, as pictured on the right, are so bad it can be assumed they are no longer serving a structural purpose.

The biggest concern with these joints is that if these bolts fail, the joint could loosen enough for the seal to break. If broken, sewage from this main Interceptor could begin discharging directly into the river. Currently, there is no visible leakage in the river from these joints, however only about half of these joints are exposed. Some are encased in tree roots, while others are only partially exposed due to the embankment.

Towards the front of the photo, the joint is partially encased by the embankment where bolt condition is not visible. Farther down the pipe run, a tree's roots encase the Interceptor. Not only does this prevent a visual inspection, but also pose a threat if the tree falls and brings the pipe with it. It cannot be determined if these joints are currently leaking. Whether they are or not, these joints pose a serious threat to the environment as the seal keeping the sewage in the pipe is jeopardized.

While completely replacing this pipe is currently not an option, measures need to be taken to reinforce these joints and eliminate the risk of failure of these joints. There are two viable options that could reinforce these joints to achieve structural integrity. Both options have a design life of 50 years until a thorough inspection is suggested to determine their structural integrity. These two options include: (1) Install new Bell Joint Leak Clamp with Stainless Steel hardware and (2) Encase the existing pipe in concrete.

Install new Bell Joint Leak Clamp with Stainless Steel hardware – As discussed earlier, Bell Joint Leak Clamps are essential for pipe repairs as it avoids the need to cut out the existing pipe. In this case, cutting out a small piece of the 18” Cast Iron pipe is not an option due to the amount of flow in the pipe.

To properly install a new clamp, the existing would have to be removed. While this may cause some concern, removing the existing clamp for a short amount of time should not be an issue. As seen in the picture above, concrete caissons hold the pipe in place at every joint. Because the joint will be stable during the short amount of time the existing is removed, the gasket and seal will not have enough time to separate.

In some areas, the embankment would have to be excavated to provide adequate room for install. In others, trees may need to be removed to expose the joint.

One aspect of the clamp that would be altered is the hardware and threaded rod. To prevent corrosion in this environment, stainless steel would be utilized in all hardware of the clamp that could face corrosion. This is crucial as this will assure longevity in the lifespan of these clamps.

In addition to these clamps, CIPP lining is necessary to assure no leaks in the stretches of pipe spanning the caissons. While these clamps provide stability at every joint, internal protection from leaking in the pipe is crucial for protection. CIPP lining will eliminate leaks, as well as provide a more ideal interior of the pipe for pipe flow. A major benefit of CIPP lining of pipe is that it resets the design life of the pipe, providing a 50-year lifespan for proper flow.

The CIPP lining, along with the new clamps providing lateral strength to these joints, provides a durable system that should last up to 50 years. At this point, the joints should be inspected for consistent torque and the exterior of the pipe should be inspected for structural integrity.

Encase the existing pipe joints in concrete – Encasement of the entire pipe in concrete would eliminate any chance of leaking in the joints of the Interceptor. Concrete, when allowed to cure properly, provides an impervious layer to liquids. Concrete encasement would plug any small leak due to a failed gasket on a joint.

To stabilize the pipe during installation, concrete caissons were poured from the riverbed up and around the Cast Iron pipe. This provided vertical support for the pipe and helped minimize lateral movement due to loads from the embankment. While in this scenario the concrete supports the pipe, it could be used to eliminate risk in the joints. Forms would need to be installed along the pipe, extending down far enough into the riverbed to support the new concretes weight. However, if poured along the entire pipe length, would eliminate any chance of risk associated with the joints.

One major benefit of concrete encasement would be the protection factor it provides the Interceptor. Concrete encasement prevents any external forces from damaging the Interceptor. If any sort of force was applied to the Interceptor, the concrete would absorb this force prior to affecting the Interceptor.

In this scenario, CIPP lining is also recommended as it will eliminate all possible leaking areas. While concrete will partially serve this purpose, CIP lining is the only approach that will completely seal the pipe. The CIPP lining will again provide a smooth interior pipe surface that promotes pipe flow, and reset the design life of the pipe.

The combination of the CIPP lining strengthening the interior of the pipe, and concrete encasement of the exterior of the pipe, would amount to a 50-year design life for this system. While the concrete is very durable and would last longer than this lifespan, at the 50 year mark the concrete should be inspected to be sure the structural integrity of the encasement is intact.

5.2 Armoring/Encasement

Two concepts have been narrowed down as the most realistic in terms of how to structurally protect the interceptor and are being presented for consideration. Both options have the potential to provide the protection necessary for continuing use of this pipe. The intention of the revetment replacement concept is to replace the revetment pipe protection in kind, but with larger stone. The original revetment stone was undersized, and it has washed away. Proposed revetment has been sized based on anticipated velocities in the Ipswich River and will take into consideration ice and other potential damaging natural occurrences. The pipe connections will need to be replaced because the existing bolts have corroded and are no longer securing the joints together. From a permitting consideration, concept one would be the easiest option because the original fill footprint would not be exceeded. While the original footprint shows a slope of 1:1, a much steeper slope, the historical revetment slope reaches a higher elevation above the pipe. The new revetment stone, with a shallower slope of 2:1, only reaches to the top of the pipe. Because it finishes at a lower elevation, the toe of the revetment stone covers the same horizontal distance as that of the toe of the historical revetment stone. Please see attached Appendices (C and D) for further detail.

Engineer's Opinion of Probable Construction Cost

An estimated cost to install a stone revetment to stabilize the existing siphon is presented in Table 2-7. The construction cost includes the cost of materials, labor and equipment; the contractor's general conditions; the contractor's markup; and a construction contingency.

TABLE 5-1

Engineer's Opinion of Probable Construction Cost

Existing River Stabilization. Revetment Slope

Description	Quantity	Unit	Unit Cost	Total Cost
Armor Stone	2500	TON	$175.00	$437,500
Underlayer-Stone	54	CY	$90.00	$4,877
Rockfill	300	CY	$100.00	$30,000
Helical Anchors	10	EA	$1,000.00	$10,000
Helical Pile Cap and Tie down Strap	10	EA	$1,750.00	$17,500
EBAA Oversized 1118HD Restraint Harness	18	EA	$3,250.00	$58,500
CIPP Lining of Interceptor	490	LF	$125.00	$61,250
Cast-In-Place Concrete	15	CY	$1,000.00	$15,000
Subtotal				**$634,627**

Contingency (20%)	$126,925
Design (10%)	$63,463
Construction Admin (15%)	$95,194
Police (5%)	$31,731
TOTAL	**$951,940**
TOTAL SAY	**$950,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

Concept two presents the option of encasing the existing cast iron pipe in concrete. The benefits of this option include but are not limited to: reducing the stone fill footprint, extending the life expectancy of the cast iron pipe, structurally replacing the joint restraints with reinforced concrete and providing pipe armoring from any potentially damaging natural occurrences. Horizontal helical tie backs would be proposed to support the loading from the soil river bank and any stone placed between the pipe and the river bank that could potentially be used as a river walk. Minor revetment would be proposed to help with scour protection and for aesthetics. In this option, thermal expansion is a concern that would need to be further evaluated. Encasing the entire length of the pipe would turn the flexible pipe into a rigid structure. Slip lining the pipe would be recommended in this option to prevent any leakage in the unlikely event that differential settlement could cause the pipe to crack within the casement. Both concepts provide the cast iron pipe with protection, and the final design likely would use concrete encasement under the bridge and either concrete encasement or revetment for the lengths of pipe exposed upstream and downstream of the bridge. Construction access will be a significant challenge at this site and bidder means and methods could favor one concept over another, depending on approach to moving rocks or pumping concrete.

Engineer’s Opinion of Probable Construction Cost

An estimated cost to install a concrete encasement of the pipe to stabilize the existing siphon is presented in Table 2-8. The construction cost includes the cost of materials, labor and equipment; the contractor’s general conditions; the contractor’s markup; and a construction contingency.

TABLE 5-2
Engineer’s Opinion of Probable Construction Cost
Existing River Stabilization. Concrete Encasement

Description	Unit	Quantity	Unit Cost	TOTAL $
Armor Stone	TON	1250	$175.00	$218,750
Rockfill	CY	300	$100.00	$30,000
Helical Anchors	EA	22	$1,000.00	$22,000
Helical Pile Cap and Tie down Strap	EA	10	$1,750.00	$17,500
Cofferdam for Concrete Pours	SF	3675	$46.00	$169,050
CIPP Lining of Interceptor	LF	490	$125.00	$61,250
Cast-In-Place Concrete	CY	55	$1,000.00	$55,000
Subtotal				**$573,550**

Contingency (20%)	$114,710
Design (10%)	$57,355
Construction Admin (15%)	$86,033
Police (5%)	$28,678
TOTAL	**$860,325**
TOTAL SAY	**$860,000**

This is an engineer's Opinion of probable Construction Cost (OPCC). Tighe & Bond has no control over the cost or availability of labor, equipment or materials, or over market conditions or the Contractor's method of pricing, and that the estimates of probable construction costs are made on the basis of the Tighe & Bond's professional judgment and experience. Tighe & Bond makes no guarantee nor warranty, expressed or implied, that the bids or the negotiated cost of the Work will not vary from this estimate of the Probable Construction Cost.

5.3 Proposed Easement Vehicular Access and Northern Bank Restoration

As previously mentioned, there is no permanent access to the Manholes on the North side of the river. This provides limitations to wastewater staff to provide adequate operation and maintenance activities. For example, manhole cleanings and manhole inspections. As a part of this project, construction activities will need to take place on the north side of the river. Additionally, it is recommended that all trees and vegetation between this road and the river be removed.

It is important to note that once construction activities are complete, thorough vegetation will be returned to this area as well as a type of bank stabilization system to prevent any washouts or erosion. Vegetation north of the access road will be coordinated between the Town and Abutter preferences. Throughout design, the Town will coordinate with abutters with options for restoration of the area around the project. While input is helpful, it is important that design intent is kept in the forefront of discussion. Additionally, it is recommended that an existing conditions landscape/garden plan be developed for properties that will be affected by this project. Having the existing conditions in the contract is crucial towards restoration to appease all property owners affected by construction.

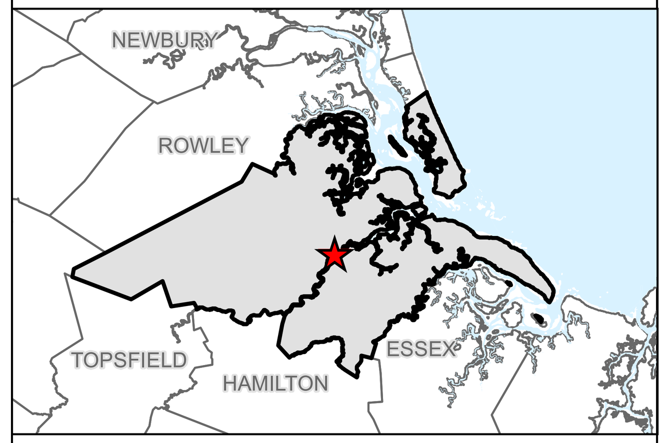
In order to provide access during construction, and to provide a means of access for future access to Interceptor and Siphon, it is recommended that a permanent gravel access road be constructed along with temporary work areas. It is recommended that a 14’ wide road mad of compacted processed gravel road be installed. Figure 4-1 below is the proposed access area for the gravel roadway. Notice the shaded area going east to west from County Street.

FIGURE 5-1 TEMPORARY WORK AREAS & GRAVEL ACCESS ROAD

LEGEND

- Temporary Construction Easement
- Permanent Gravel Access Road
- Temporary Gravel Access Road
- Approximate Parcel Boundary

LOCUS MAP



0 50
Feet

1:360

NOTES

1. Based on Google Imagery (C) 2017
2. FEMA National Flood Hazard data obtained through MassGIS, Revised based on LiDAR elevations, data valid as of December 2017

Schematic Map of Sewer Interceptor and Siphon Connectivity

Ipswich, Massachusetts

February 2019

Tighe&Bond
Engineers | Environmental Specialists

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Section 6
Recommendations and Next Steps

6.1 Recommendation

After completing the investigations, field work, and analysis portions of this project, Tighe & Bond gathered a thorough understanding of the existing collection system, of both its interior and exterior conditions. Based off these findings, Tighe & Bond recommends the following course of action:

- Triple Barrel Siphon Installation
    - 6” HDPE Primary barrel
    - 6” HDPE Secondary barrel
    - 6” or 8” HDPE Emergency Overflow barrel (To be determined by Town)
- Open Cut Siphon Installation with Cofferdam approach
- Protecting the exterior of the Interceptor
    - Concrete Encasement
    - Toe Stone
- Protecting the interior of the Interceptor
    - CIPP lining of pipe
- Reinforcing the Interceptor joints
    - Concrete Encasement
- Achieving Resiliency in Manhole Covers
    - Installing watertight manhole covers at all manholes at risk of flooding

Installing a Triple Barrel Siphon provides the town with the opportunity to operate an ideal system that achieves adequate flushing velocities minimizing cleaning frequency and blockages. While achieving proper flushing velocities, the system has enough capacity to operate even under maximum future flows. Even if there is a massive influx of flow greater than what is expected, design has incorporated a third emergency overflow siphon that would account for this increase. This would prevent the Town from relying on their Emergency Action Plan, already having a plan in place to combat massive flows. Not only does this provide redundancy, but it saves a possible Siphon upgrade project in the future.

Open Cut Siphon installation is not only the cheapest option ($900,000), but it makes the most sense for the design. With three barrels being installed, an open trench would allow a contractor to lay three pipes next to each other at equal spacing and consistently. With an HDD approach, the pipe profile is unknown between the enter and exit point of the run. The pipes could differ in spacing, elevation, and slope. Slope is crucial for siphons as operators must have the ability to jet and clean the siphons. New slope design considers the slope and bend radius of the new siphons to allow for maintenance activities. While Open Cut Siphon installation is the cheapest option, there needs to be substantial reasons to spend the extra money on another alternative. While both the Pump Station and HDD alternatives don't affect the river, these alternatives greatly affect the existing collection systems. The land acquisitions and traffic closures would have a massive public impact. Protecting the Interceptor by Concrete Encasement is not only the cheaper option, but the more durable and resilient approach. Concrete encasement not only secures the failed joints of the interceptor but provides a high level of protection to the exterior of the pipe. While there is some concern losing visual of the pipe when performing maintenance years later, markings on the concrete to signify bends, services, or any irregularities would be incorporated into the concrete to clearly mark these areas. A uniform concrete encasement seals all possible areas of leaking on the exterior of the pipe. This encasement, in combination with the CIPP lining, will provide two layers of new sealant to keep flow within the pipe and not leaking into the river.

The concrete encasement creates a hard, flat, vertical surface along the riverbank that needs to be supplemented to promote river flow. To counteract this, a layer of toe stone would be installed along the base of the concrete encasement. This toe stone would stay within the permitted footprint and not effect river flow, but create a natural look to the bottom area of the concrete and promote aquatic life in the natural environment. The toe stone would only reach about halfway up the vertical flat face of concrete. To cover the rest of the harsh faced concrete, a plan needs to be developed during design that will cover the remaining decking of this area.

The installation of this new infrastructure for both sewer conveyance and protection purposes have a design life of 50 years if operation and maintenance practices are performed. At this point, these systems should be inspected to determine a level of effort required for continued operation.

These improvements require immediate action as reducing the threat of discharge to the river is crucial to the safety of the river and its surrounding environment. The following are critical issues that must be highlighted when considering improvements to the existing collection system:

- **No Redundancy** – The current system does not provide any redundancy and therefore if there is any issue with the existing siphon, only the Town's Emergency Action Plan is in place to convey flow across the Ipswich River
- **Operational Issues** – Hydraulics in the siphon are unfavorable which therefore requires frequent cleaning and maintenance which is costly and sometimes ineffective
- **Scour of Riverbed** – Current conditions allow for scour on the riverbed undermining supports for the Interceptor and further exposing the siphon putting both pipes at a greater risk of rupture
- **Bathing Beaches and Shellfish Beds** – With the current risk of discharge, any occurrence would mean raw sewage in the river flowing downstream to shellfish beds and bathing beaches requiring closures and posing potential health risks

6.2 Permitting Requirements

The following summarizes the anticipated permit-related activities that will be required to carry the interceptor and siphon rehabilitation projects through construction. These proposed activities are based on a Pre-Permitting meeting and correspondence held on August 14, 2018 between the Town, Tighe & Bond, MassDEP, Ipswich Conservation Commission and the Army Corps of Engineers. Additionally, a Pre-Permitting meeting was held on March 1, 2019 at MassDEP Waterways between the Town, Tighe & Bond, and MassDEP to discuss Chapter 91 licensure requirements. The schedule for these project permit activities are summarized in Figure 5-1.

Sewer Siphon & Interceptor Repairs

The installation of a replacement siphon and encasement of the existing sewer interceptor pipe along the Ipswich River will require direct work within coastal resource areas subject to local, state, and federal wetland regulations. The Town of Ipswich and Tighe & Bond conducted a pre-permitting coordination meeting with MassDEP, the Corps, and the Ipswich Conservation Agent to discuss and confirm permitting approaches relative to the project's purpose and need and possible design approaches. Based upon these discussions, Tighe & Bond assumes the proposed siphon and interceptor repairs will be subject to:

- Ipswich Wetlands Protection Bylaw
- Massachusetts Wetlands Protection Act (310 CMR 10.00)
- Massachusetts Public Waterfront Act (Chapter 91)
- Massachusetts Environmental Policy Act (MEPA)
- Sections 404 and 401 Clean Water Act
- Section 10 River and Harbors Act
- Section 106 National Historic Preservation Act

We have identified the anticipated list of permits below that would be needed for the proposed sewer infrastructure repairs and anticipate the following scope of services required for each permit, as noted in the subsections below.

MEPA Environmental Notification Form - The MEPA review process provides for coordinated state agency and public review of projects that meet certain review thresholds defined at 301 CMR 11.03 and that require a state agency action (e.g., permit, financial assistance, or a land transfer). Through the MEPA process, relevant state agencies are required to identify any aspects of the proposed project that require additional analysis or mitigation prior to completion of the agency action. Single and complete projects must be considered for MEPA review; division of a project into elements for separate MEPA review is defined as segmentation and is not allowable.

Both the siphon repairs and interceptor protection work require state approval (i.e., Agency Action), which, in this case, would be a Chapter 91 Waterways License and a

Section 401 Water Quality Certificate for the siphon replacement. Additionally, if the project will receive state funding (i.e., Financial Assistance), the MEPA jurisdiction will be broad and will review all portions of the project. We anticipate the proposed project will trigger one or more review thresholds related to wetlands, including impacts to coastal bank and new fill or structure in a regulatory floodway.

These triggers are review thresholds for an Environmental Notification Form (ENF) and additional MEPA review if the Secretary so requires. Based on our current assumptions related to the combined project impacts, we expect that the project will not trigger a mandatory Environmental Impact Report (EIR). Therefore, for the purposes of this overview, we have assumed the preparation of only an ENF submittal for filing with MEPA. The ENF will describe the project, its alternatives, and proposed mitigation measures. It will also describe how the project will comply with the performance standards of any required state permits. The ENF will also discuss compliance with the Office of Coastal Zone Management's (CZM) Federal Consistency Standards.

The ENF will be produced and distributed in accordance with the MEPA circulation requirements. As part of this task we would coordinate and attend the MEPA public site meeting for the project and respond to any comments or questions from MEPA, other regulatory officials, and/or the public. We assume that all project elements will be submitted under one ENF filing, regardless of phasing, to ensure compliance with MEPA's anti-segmentation requirements. Upon issuance of a MEPA Certificate, the Certificate is valid for a period of five years.

The following tasks would be completed as part of the MEPA ENF documentation:

- Alternatives analysis narrative and conceptual level design plans (prepared under other tasks and/or prior efforts)
- Drafting, preparation, project team review, and submittal of the ENF
- MEPA site visit attendance and coordination
- Response to public comments and follow-up coordination with MEPA
- Other permit applications, aside from MEPA, will cover the bridge replacement and tide gate removal only

***Wetlands Protection Act & Ipswich Wetlands Protection Bylaw Notice of Intent* -** A Notice of Intent (NOI) will be required for the sewer siphon and interceptor work within jurisdictional resource areas in accordance with the Massachusetts Wetlands Protection Act (WPA) M.G.L. Chapter 131 Section 40 and implementing regulations (310 CMR 10.00), along with the Ipswich Wetlands Protection Bylaw and regulations. Work associated with the project is expected to occur within Land Under Water, Coastal Bank, Riverfront Area, Land Subject to Coastal Storm Flowage, and the 100-foot Buffer Zone, at a minimum.

Accordingly, we would prepare and submit an NOI concurrently to the Conservation Commission and MassDEP. The NOI will demonstrate how the proposed work meets, to the extent feasible, the performance standards established for each resource area where work is proposed, or otherwise qualifies for Limited Project Status. The NOI application would include the following:

- The appropriate permit application forms
- Project narrative including construction sequence
- Resource maps (e.g., USGS, floodplain, tax map);
- Site photographs
- Site plans and drawings depicting the existing conditions and the proposed activities
- Request for certified list of abutters and abutter notification
- Alternatives analysis
- Written response to MassDEP comments generated from NOI review
- Attendance at one site walk with the Conservation Commission
- Attendance at two public hearings with the Conservation Commission

After an Order of Conditions is received from the Conservation Commission, we would record the order at the Essex County Registry of Deeds. Following the completion of construction activities, a Request for Certificate of Compliance to close out the project would be developed.

Section 401 Water Quality Certification - A Section 401 Water Quality Certification (WQC) application filing with MassDEP is required if a project results in a loss of 5,000 square feet cumulatively of bordering or isolated vegetated wetlands and land under water, if the amount of any proposed dredging is greater than 100 cubic yards, or if any of the other thresholds listed in 314 CMR 9.04 are met. Based upon our understanding of the proposed design, the project is anticipated to alter more than 5,000 sf of land under water and will require review and approval under Section 401 by MassDEP.

MassDEP confirmed that a joint Section 401/Chapter 91 application will need to be prepared, as the nature of the proposed activity requires this manner of review through their Boston office. We will seek input from MassDEP and Corps on the format of the submittal, but we anticipate that following items will be completed as part of the joint application:

- Cover letter articulating the joint application;
- Section 401/Chapter 91 forms and documentation;
- Public Notice for Section 401;
- Figures and drawings in conformance with MassDEP requirements; and
- WPA NOI as an attachment.

We have assumed during the review process that MassDEP will require additional information from the project proponent, and, following MassDEP's review of the supplemental documentation they will approve and issue a 401 WQC and Chapter 91 Permit.

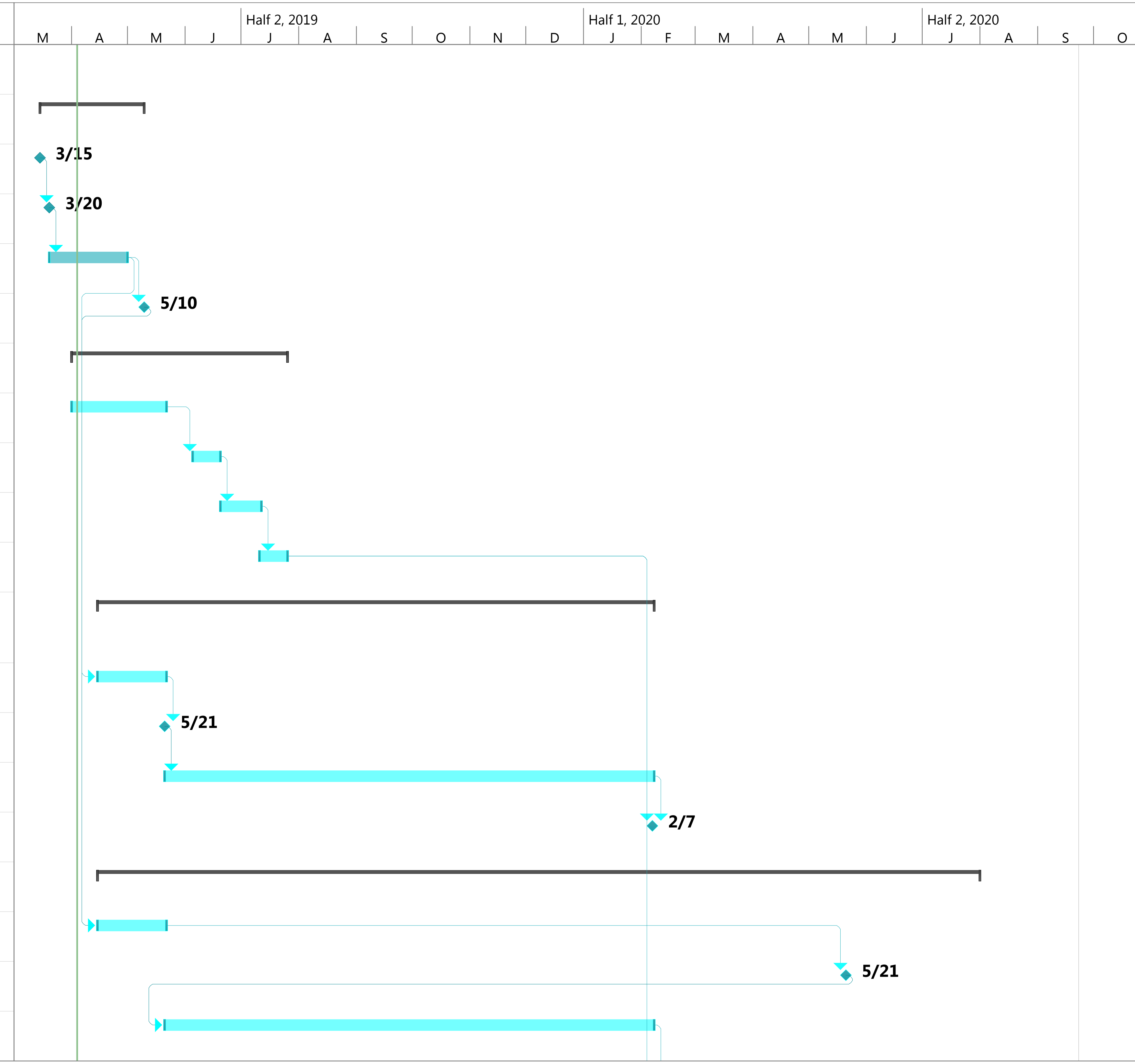
Corps Pre-Construction Notification - Corps authorization under Section 404 of the Federal Clean Water Act and Section 10 of the Rivers and Harbors Act is anticipated due to work within Waters of the United States (i.e., a tidal portion of the Ipswich River). Temporary and permanent impacts to wetlands in excess of 5,000 square feet but less than one acre, or which otherwise do not meet Self-Verification review thresholds, are subject to review under a Pre-Construction Notification (PCN) under the Massachusetts General Permit (MA GP). Based upon our current understanding of the project, specifically that the project will be redesigned to limit wetland impacts to less than 1 acre, a PCN application will be required with the Corps. A PCN application will be filed jointly with the Corps and MassDEP.

The MA GP also requires notification to the State Historic Preservation Officer (SHPO) at Massachusetts Historical Commission (MHC) and Tribal Historic Preservation Officers (THPOs) pursuant to Section 106 of the National Historic Preservation Act. To fulfill this regulatory requirement, Tighe & Bond will mail a copy of the MEPA ENF to the SHPO and THPOs describing the proposed activities and providing a general description of the area where construction is proposed. MHC issues a determination that the proposed activities will or will not adversely affect historic and/or cultural resources or they may request additional information or archaeological surveys within undisturbed or undeveloped areas. At this time, we are assuming that the project will not result in the need for additional information or for archaeological surveys within undeveloped areas.

Chapter 91 Waterways - The project area occurs within a tidal, jurisdictional waterway pursuant to the MA Public Waterfront Act (Chapter 91). Replacement of the sewer siphon and encasement of the interceptor pipe will require Chapter 91 authorization. The Town has confirmed and provided documentation that a 1959 license exists for construction of both the siphon and the interceptor, and a second license issued in 1965 permitted the encasement of the sewer interceptor in rip rap, with the exception of the interceptor beneath the Choate Bridge. Based on our March 1, 2019 meeting with MassDEP Waterways, it was determined that we will need to develop a Chapter 91 license application and project plans in the required License format for submittal to MassDEP, as these projects are not considered to be maintenance activities. We would notify abutters and provide copies of the filings in accordance with MassDEP's distribution requirements. We would address any comments from MassDEP during the review process and would record the License and License plans at the Registry of Deeds upon authorization. It is noted that on an average, the estimated timeframe for this process is one year.

Assumptions - For the purposes of the above-resented planning overview scope of services, it is assumed that coordination with the Massachusetts Natural Heritage and Endangered Species Program will not be necessary, as the project site is not currently mapped as state-listed rare species habitat. It is also assumed that the project will not require a mandatory EIR filing under MEPA, and an additional cultural and/or archaeological study will not be required by MHC.

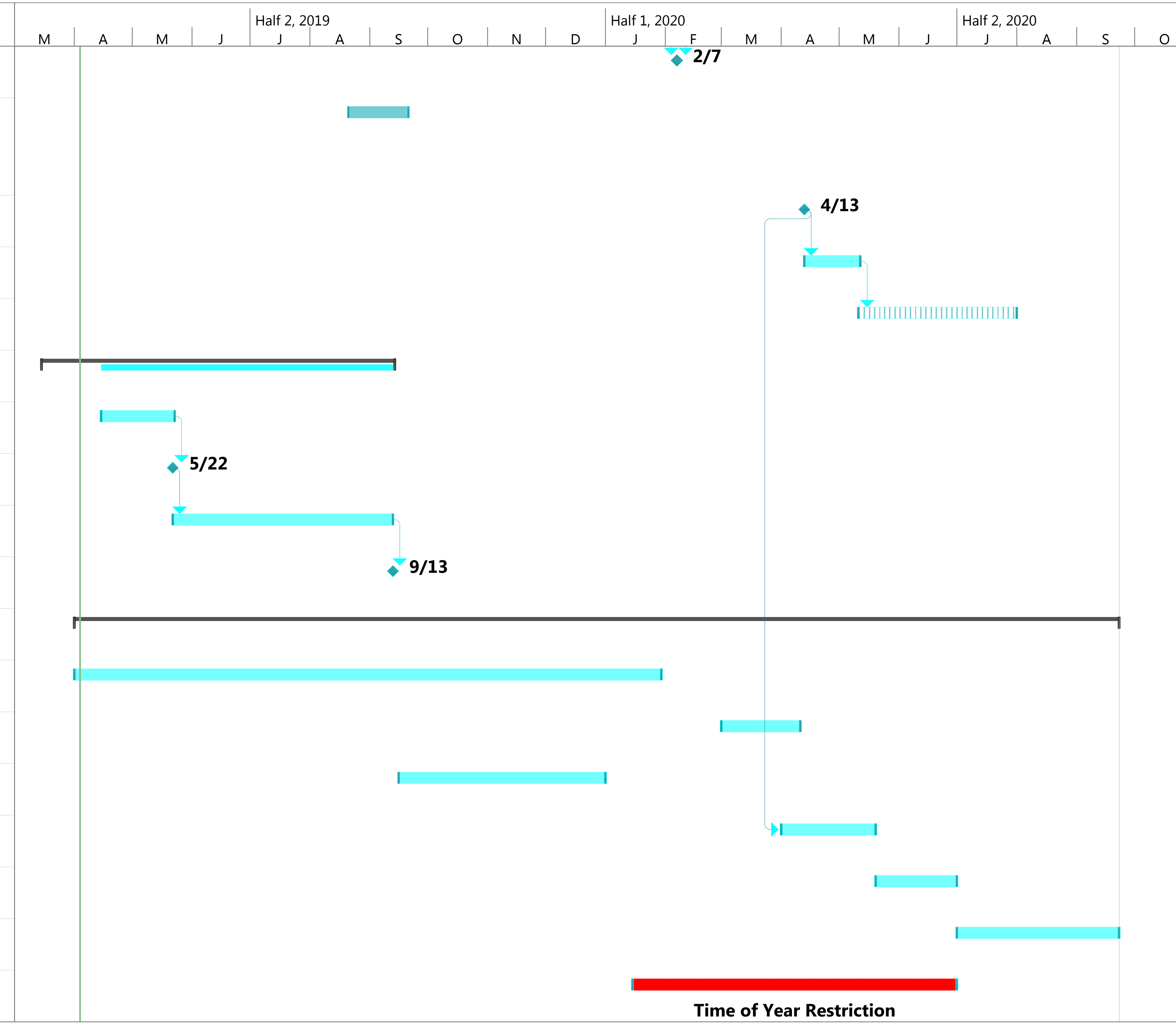
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Permitting for Siphon & Interceptor Construction**			
2		**MEPA Env Notification Form & Site Visit**	**40 days**	**Fri 3/15/19**	**Fri 5/10/19**
3		Submit ENF	0 days	Fri 3/15/19	Fri 3/15/19
4		MEPA ENF Publication	0 days	Wed 3/20/19	Wed 3/20/19
5		MEPA Review, Public Comment Period, MEPA Site Visit	30 days	Wed 3/20/19	Tue 4/30/19
6		MEPA Final Response	0 days	Fri 5/10/19	Fri 5/10/19
7		**Notice of Intent & Hearings (Good for 3 Years)**	**84 days**	**Mon 4/1/19**	**Thu 7/25/19**
8		Prepare NOI	37 days	Mon 4/1/19	Tue 5/21/19
9		Hearing (Assume 2)	11 days	Wed 6/5/19	Wed 6/19/19
10		Issuance of Order of Conditions (OOC)	16 days	Thu 6/20/19	Thu 7/11/19
11		10 Business Day Appeal Period then Record OOC at Registry	11 days	Thu 7/11/19	Thu 7/25/19
12		**Section 401 Water Quality Certification (File Jointly with Chapter 91)**	**215 days**	**Mon 4/15/19**	**Fri 2/7/20**
13		Prepare WQC	27 days	Mon 4/15/19	Tue 5/21/19
14		Submit WQC to MassDEP	0 days	Tue 5/21/19	Tue 5/21/19
15		WQC Reviewed by MassDEP	189 days	Tue 5/21/19	Fri 2/7/20
16		WQC Approved by MassDEP	0 days	Fri 2/7/20	Fri 2/7/20
17		**Chapter 91 (File Jointly with WQC)**	**340 days**	**Mon 4/15/19**	**Fri 7/31/20**
18		Prepare Chapter 91 Submission	27 days	Mon 4/15/19	Tue 5/21/19
19		Submit Chapter 91 to MassDEP Boston	0 days	Thu 5/21/20	Thu 5/21/20
20		Chapter 91 Reviewed by MassDEP	189 days	Tue 5/21/19	Fri 2/7/20



Project: Updated Permitting Sc
Date: Thu 4/4/19

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

ID		Task Mode	Task Name	Duration	Start	Finish
21			Chapter 91 Approved by MassDEP	0 days	Fri 2/7/20	Fri 2/7/20
22			Publish in Local Papers, Notify Abutters for 30 Day Comments Period (2-3 months from submittal date)	23 days	Wed 8/21/19	Fri 9/20/19
23			Written Determination	0 days	Mon 4/13/20	Mon 4/13/20
24			Appeal Period	21 days	Mon 4/13/20	Mon 5/11/20
25			Record License at Registry of Deeds within 60 Days	60 days	Mon 5/11/20	Fri 7/31/20
26			**Army Corps Pre-Construction Notification (PCN)**	**131 days**	**Fri 3/15/19**	**Fri 9/13/19**
27			Prepare PCN	28 days	Mon 4/15/19	Wed 5/22/19
28			File PCN	0 days	Wed 5/22/19	Wed 5/22/19
29			Army Corps Review	82 days	Wed 5/22/19	Thu 9/12/19
30			Army Corps Authorization	0 days	Fri 9/13/19	Fri 9/13/19
31			**Final Design / Funding / Bidding / Construction Phase**	**387 days**	**Mon 4/1/19**	**Tue 9/22/20**
32			Final Design	218 days	Mon 4/1/19	Wed 1/29/20
33			Design & Permitting Grants: CZM Coastal Resilience & MVP Action	31 days	Sun 3/1/20	Fri 4/10/20
34			Construction Grant Application: FEMA Pre-Disaster Mitigation	77 days	Mon 9/16/19	Tue 12/31/19
35			Project Bidding / Award	35 days	Wed 4/1/20	Tue 5/19/20
36			Construction Submittals, Mobilization, Out of River Work	30 days	Wed 5/20/20	Tue 6/30/20
37			In-River Construction Activities	60 days	Wed 7/1/20	Tue 9/22/20
38			Army Corp Time of Year Restriction to River Distrubance	120 days	Wed 1/15/20	Tue 6/30/20



Project: Updated Permitting Sc
Date: Thu 4/4/19

Task	Project Summary	Manual Task	Start-only	Deadline
Split	Inactive Task	Duration-only	Finish-only	Progress
Milestone	Inactive Milestone	Manual Summary Rollup	External Tasks	Manual Progress
Summary	Inactive Summary	Manual Summary	External Milestone	

6.3 Funding Opportunities

Improvements to the interceptor range from approximately $612,000 to $950,000 depending on the selected method, while improvements to the siphon range from approximately $900,000 to $1,700,000 depending on the selected method. While these costs may seem significant, it should be remembered that the consequences of failure to either the siphon or interceptor severe to the public's health, shell fishing, commerce, properties and other activities in Ipswich. Additionally, there are grants that could be pursued to help fund these projects.

Several grant opportunities have been identified that may be applicable for the siphon and interceptor rehabilitation Table 5-1 below summarizes these grant opportunities.

Some of the grants listed below have requirements that could derail from the scope of work and schedule the Town would like to adhere to. Based on conversations between the Town and Tighe & Bond, it was concluded that the Town would like to pursue the Massachusetts Emergency Management Agency's (MEMA) Post-Disaster Hazard Mitigation Assistance Grant Program. This federally funded program provides significant opportunities to reduce, minimize, or eliminate potential damages to property and infrastructure from natural hazard events. A benefit-cost analysis (BCA) would be required as a part of the application process using FEMA's BCA software to measure all of the significant direct benefits of the mitigation project against the costs. If awarded Funding for this specific grant can be spread over 36 months and cover activities such as engineering, permitting, and design. Additionally, this grant could be utilized to reimburse the Town for engineering and permitting fees expended towards the Siphon and Interceptor project after August 24, 2018. Applications are due April 4, 2018 and the Town will need to ensure that the siphon and interceptor are both on the Town's Hazard Mitigation Plan for them to be eligible for funding.

TABLE 6-1
Available Funding Strategies

Grant Name	Purpose	Possible Award
FEMA Federal Disaster Funds: Pre-Disaster Mitigation Grant Program	Mitigate the costs and impacts of future disasters. Reduce long-term risk from future hazard events. *Ensure the siphon and interceptor are on Ipswich's hazard mitigation plan.	75% of Total Project Cost
MEMA/FEMA Post-Disaster Hazard Mitigation Assistance Grant Program	Reduce or eliminate long-term risks caused by natural or man-made disasters. Only communities in Massachusetts are eligible. *Ensure the siphon and interceptor are on Ipswich's hazard mitigation plan.	75% of Total Project Cost Non-Federal Grants can be used for the 25% match
CZM Coastal Resilience	-Redesign and retrofit existing community facilities and infrastructure	$500,000
MACP Accelerating Climate Resiliency Mini-Grant Program	-Help municipalities advance strategies that protect people, places, and communities from the impact of climate change.	$15,000 - $50,000 per round (can apply multiple rounds and phase)

Grant Name	Purpose	Possible Award
MVP Grant, Municipal Vulnerability Preparedness – Action Grant	-Provides support to begin the process of planning for climate change resiliency and implementing priority projects *Ensure Ipswich has completed MVP Planning Process Meeting	$400,000
Seaport Economic Council	-5 different grants to help stimulate the maritime economy and grow jobs. Can be used to for coastal infrastructure improvement projects that support and promote tourism, recreation, the shell-fishing industry, and improve sustainability and resilience.	$1,000,000

J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Report_Evaluation\Final Report\Final Report 2019-03-05\Final Report Sent to Town.doc

Appendix A
Manhole Investigation Photos

SMH 18

Rim:

Wall:

Invert:

SMH 19

Rim:

Collar:

Wall:

Invert:

SMH 20

Rim:

Collar:

Wall:

SMH 34

Rim:

Collar:

Invert:

Invert:

Appendix B
Closed Circuit Television Inspection Reports

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail:

Project Information

Project name :	Project No. :	Contact :	Date :
TIG001-18 08.07.18-08.08.18 Merged			**8/20/2018**

Client:	**Tighe & Bond**
Contact Name:	**Daniel Oliver Roop**
Department:	**Project Engineer**
Po Box:	
Street:	**One University Avenue, Suite 100**
City:	**Westwood, MA 02090**
Telephone:	**781.708.9827**
Fax:	
Mobile:	
E-mail:	**DORoop@tighebond.com**

Site:	
Contact Name:	
Department:	
Po Box:	
Street:	
City:	
Telephone:	
Fax:	
Mobile:	
E-mail:	

Contractor	**National Water Main Cleaning Co.**
Contact Name:	
Department:	
Po Box:	
Street:	**25 Marshall St**
City:	**Canton MA 02021**
Telephone:	**800-422-0815**
Fax:	**781-828-2473**
Mobile:	
E-mail:	

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail :

Defect Grade Description

Project Name :	Project number :	Contact :	Date :
TIG001-18 08.07.18-08.08.18 Merged			**8/20/2018**

1: Excellent Condition

Minor Defects- Failure unlikley in the foreseeable future

2: Good Condition

Defects that have not begun to deteriorate- Pipe unlikely to fail for at least 20 years.

3: Fair Condition

Moderate defects that will continue to deteriorate- Pipe may fail in 10-20 years.

4: Poor Condition

Severe Defects that will become Grade 5 defects within the foerseeable future- Pipe will probably fail in 5-10 years

5: Immediate Attention

Defects require immediate attention- Pipe has failed or will likely fail within the next 5 years or sooner.

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail:

Inspection Report

Date	P/O. No.	Weather	Surveyor's Name	Pipe Segment Reference	Section No.
8/7/2018		**Dry**	**BILL DEGROATE**		**1**
Certificate No.	Survey Customer	System Owner	Date Cleaned	Pre-Cleaning	Sewer Category
07007097			**8/7/2018**	**Heavy Cleaning**	

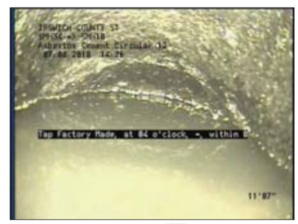
Street123	**COUNTY ST**	Use of Sewer	**Sanitary**	Upstream MH	**SMH34**
City	**IPSWICH**	Drainage Area		Dowstream MH	**SMH18**
Loc. details		Flow Control	**Bypassed**	Dir. of Survey	**Downstream**
Location Code	**Easement/Right of way**	Length surveyed	**127.70 ft**	Section Length	**127.70 ft**

Purpose of Survey	**Maintenance Related**	Joint Length	
Year Laid		Dia./Height	**12 inch**
Year Rehabilitated		Material	**Asbestos Cement**
Tape / Media No.		Lining Method	

Add. Information :

1:315	Position		Code	Observation	Grade
SMH34	0.00		AMH	Upstream Manhole, Survey Begins	
	4.00	S1	DAGS	Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Start	M 2
	11.61		TF	Tap Factory Made, at 04 o'clock, -, within 8 inches of joint: NO, 6"	
	54.24	F1	DAGS	Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Finish	M 2
	106.28	S2	DAGS	Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Start	M 2
	119.79	F2	DAGS	Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Finish	M 2
SMH18	127.70		AMH	Downstream Manhole, Survey Ends	

4 FT



11.61 FT

54.24 FT

106.28 FT

119.79 FT

QSR	QMR	SPR	MPR	OPR	SPRI	MPRI	OPRI
0000	**2B00**	**0**	**26**	**26**	**0**	**2**	**2**

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail:

Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**COUNTY ST**			**1**

Photo: SMH34-SMH18-08202018-DAGS-4.0031-155652.jpg
4FT, Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Start

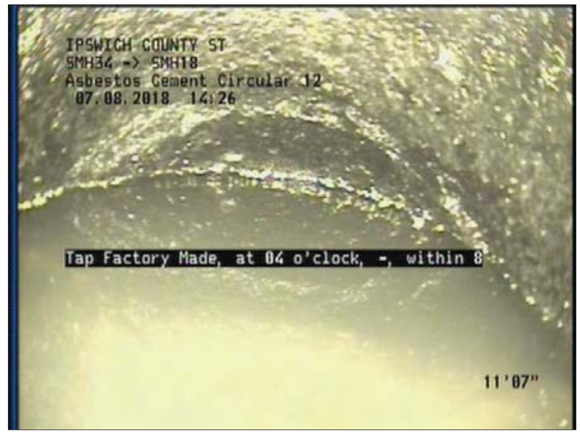


Photo: SMH34-SMH18-08202018-TF-11.6089-155726.jpg
11.61FT, Tap Factory Made, at 04 o'clock, -, within 8 inches of joint: NO, 6"

Photo: SMH34-SMH18-08202018-DAGS-54.2415-155752.jpg
54.24FT, Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Finish

Photo: SMH34-SMH18-08202018-DAGS-106.2814-155812.jpg
106.28FT, Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Start

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail:

Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**COUNTY ST**			**1**

Photo: SMH34-SMH18-08202018-DAGS-119.7917-155847.jpg
119.79FT, Deposits Attached Grease, 5 %of cross sectional area, at 12 o'clock, , within 8 inches of joint: YES, Finish

Photo: SMH34-SMH18-08202018-AMH-127.6978-155859.jpg
127.7FT, Downstream Manhole, Survey Ends

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail:

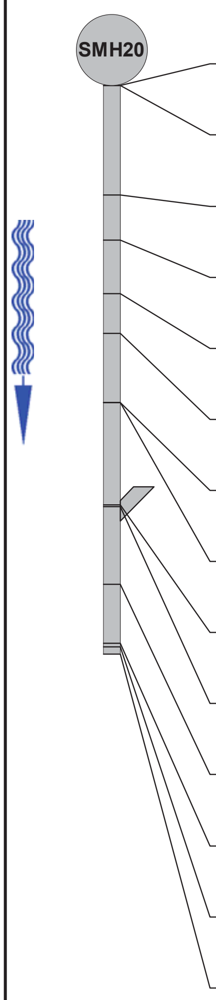
Inspection Report

Date	P/O. No.	Weather	Surveyor's Name	Pipe Segment Reference	Section No.
8/8/2018		**Dry**	**BILL DEGROATE**	**18" INTERCEPTOR**	**2**
Certificate No.	Survey Customer	System Owner	Date Cleaned	Pre-Cleaning	Sewer Category
07007097			**8/8/2018**	**Heavy Cleaning**	

Street123	**IPSWICH RD**	Use of Sewer	**Sanitary**	Upstream MH	**SMH20**
City	**IPSWICH**	Drainage Area		Dowstream MH	**SMH19**
Loc. details		Flow Control	**Not Controlled**	Dir. of Survey	**Downstream**
Location Code	**Easement/Right of way**	Length surveyed	**339.16 ft**	Section Length	**339.16 ft**

Purpose of Survey	**Maintenance Related**	Joint Length	
Year Laid		Dia./Height	**18 inch**
Year Rehabilitated		Material	**Asbestos Cement**
Tape / Media No.		Lining Method	

Add. Information :



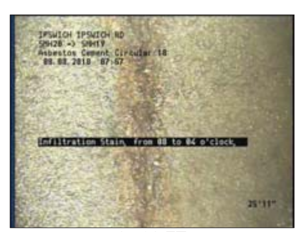
1:270	Position		Code	Observation	Grade
	0.00		AMH	Upstream Manhole, Survey Begins	
	0.00		MWL	Water Level, 50 %of cross sectional area	
	13.61	S1	SRI	Surface Roughness Increased, from 11 to 01 o'clock, within 8 inches of joint: YES, Start	S 1
	19.31	F1	SRI	Surface Roughness Increased, from 11 to 01 o'clock, within 8 inches of joint: YES, Finish	S 1
	25.92		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
	30.92	S2	SRI	Surface Roughness Increased, from 10 to 11 o'clock, within 8 inches of joint: YES, Start	S 1
	39.53	F2	SRI	Surface Roughness Increased, from 10 to 11 o'clock, within 8 inches of joint: YES, Finish	S 1
	39.53	S3	SRI	Surface Roughness Increased, from 10 to 02 o'clock, within 8 inches of joint: YES, Start	S 1
	52.24		DAGS	Deposits Attached Grease, 5 %of cross sectional area, at 08 o'clock, , within 8 inches of joint: YES	M 2
	52.54		TBA	Tap Break-In Active, at 10 o'clock, -, within 8 inches of joint: NO, 4"	
	62.15		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
	69.55		SSS	Surface Spalling, from 01 to 04 o'clock, within 8 inches of joint: YES	S 2
	69.95		SSS	Surface Spalling, from 08 to 10 o'clock, within 8 inches of joint: NO	S 2
	70.85	S4	SSS	Surface Spalling, at 08 o'clock, within 8 inches of joint: YES, Start	S 2


0 FT


0 FT


13.61 FT


19.31 FT

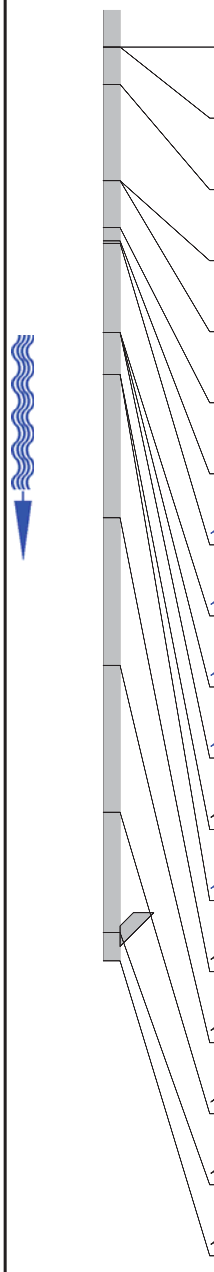

25.92 FT

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
City : Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
Email:

Inspection Report

Date :	Job number :	Weather : **Dry**	Operator : **BILL DEGROATE**	Counter : **2**	Section name :
Present :	Vehicle :	Camera :	Preset :	Cleaned : **Heavy Cleaning**	Rate :



1:270 Position		Code	Observation	Rate
75.66	F4	SSS	Surface Spalling, at 08 o'clock, within 8 inches of joint: YES, Finish	S 2
75.66	F3	SRI	Surface Roughness Increased, from 10 to 02 o'clock, within 8 inches of joint: YES, Finish	S 1
80.26		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
92.27	S5	SSS	Surface Spalling, at 09 o'clock, within 8 inches of joint: YES, Start	S 2
92.27	S6	SSS	Surface Spalling, at 03 o'clock, within 8 inches of joint: YES, Start	S 2
98.18		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
99.78		CM	Crack Multiple, from 03 to 04 o'clock, within 8 inches of joint: NO	S 3
100.08	S7	SSS	Surface Spalling, from 09 to 12 o'clock, within 8 inches of joint: YES, Start	S 2
111.19	F7	SSS	Surface Spalling, from 09 to 12 o'clock, within 8 inches of joint: YES, Finish	S 2
111.19	S8	SSS	Surface Spalling, from 08 to 09 o'clock, within 8 inches of joint: YES, Start	S 2
111.19	5	SSS	Surface Spalling, at 09 o'clock, within 8 inches of joint: YES	S 2
116.39		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
116.39	F8	SSS	Surface Spalling, from 08 to 09 o'clock, within 8 inches of joint: YES, Finish	S 2
134.30		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
152.62		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
170.93		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
185.94		TB	Tap Break-In, at 10 o'clock, -, within 8 inches of joint: NO, 4"	
189.45		IS	Infiltration Stain, from 12 to 04 o'clock, within 8 inches of joint: YES	

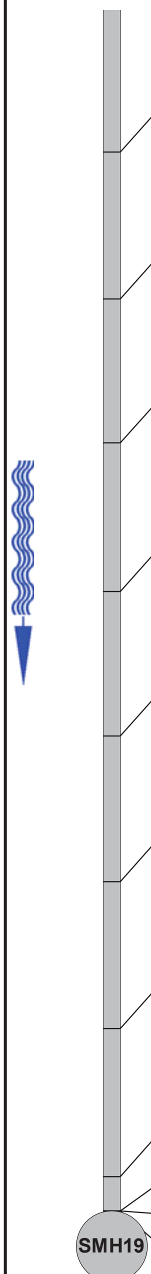
City : IPSWICH

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
City : Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
Email:

Inspection Report

Date :	Job number :	Weather :	Operator :	Counter :	Section name :
		Dry	**BILL DEGROATE**	**2**	
Present :	**Vehicle :**	**Camera :**	**Preset :**	**Cleaned :**	**Rate :**
				Heavy Cleaning	



1:270	Position		Code	Observation	Rate
	207.26		IS	Infiltration Stain, from 08 to 03 o'clock, within 8 inches of joint: YES	
	225.57		IS	Infiltration Stain, from 12 to 04 o'clock, within 8 inches of joint: YES	
	243.49		IS	Infiltration Stain, from 12 to 03 o'clock, within 8 inches of joint: YES	
	262.00		IS	Infiltration Stain, from 08 to 03 o'clock, within 8 inches of joint: YES	
	280.01		IS	Infiltration Stain, from 02 to 04 o'clock, within 8 inches of joint: YES	
	298.13		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
	316.44		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
	334.86		IS	Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES	
	339.16	F6	SSS	Surface Spalling, at 03 o'clock, within 8 inches of joint: YES, Finish	S 2
	339.16	F5	SSS	Surface Spalling, at 09 o'clock, within 8 inches of joint: YES, Finish	S 2
	339.16		AMH	Downstream Manhole, Survey Ends	

QSR	QMR	SPR	MPR	OPR	SPRI	MPRI	OPRI
312T	**2100**	**223**	**2**	**225**	**1.92**	**2**	**1.92**

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail:

Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

Photo: SMH20-SMH19-08202018-AMH-0-160046.jpg
0FT, Upstream Manhole, Survey Begins

Photo: SMH20-SMH19-08202018-MWL-0-160629.jpg
0FT, Water Level, 50 %of cross sectional area

Photo: SMH20-SMH19-08202018-SRI-13.6104-160715.jpg
13.61FT, Surface Roughness Increased, from 11 to 01 o'clock, within 8 inches of joint: YES, Start

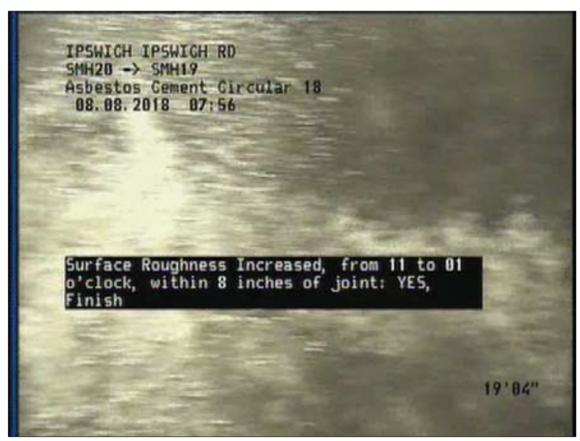


Photo: SMH20-SMH19-08202018-SRI-19.3148-160728.jpg
19.31FT, Surface Roughness Increased, from 11 to 01 o'clock, within 8 inches of joint: YES, Finish

The Environmental Protection Specialists

National Water Main Cleaning Co.
25 Marshall St
Canton MA 02021
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Fax: 781-828-2473
E-mail:

Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

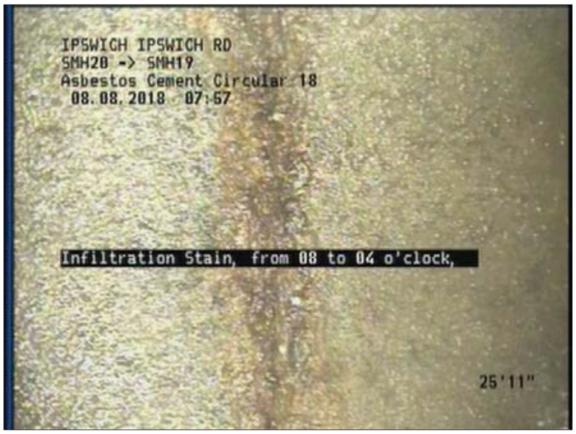

Photo: SMH20-SMH19-08202018-IS-25.9198-160828.jpg
25.92FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

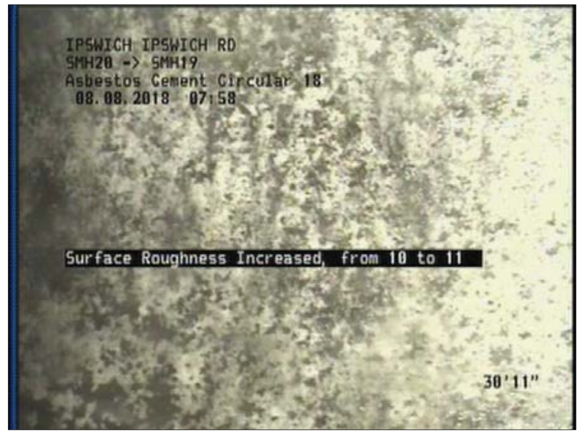

Photo: SMH20-SMH19-08202018-SRI-30.9237-160838.jpg
30.92FT, Surface Roughness Increased, from 10 to 11 o'clock, within 8 inches of joint: YES, Start

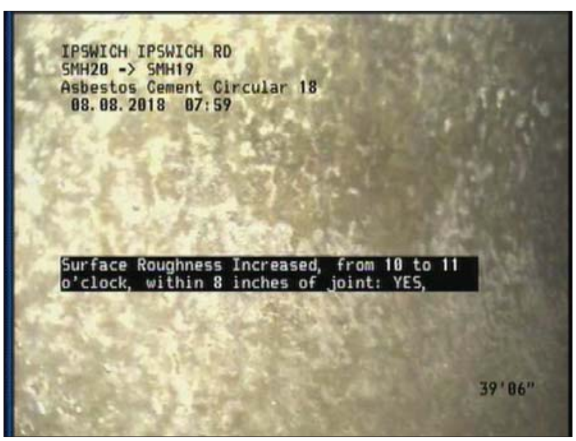

Photo: SMH20-SMH19-08202018-SRI-39.5303-160930.jpg
39.53FT, Surface Roughness Increased, from 10 to 11 o'clock, within 8 inches of joint: YES, Finish

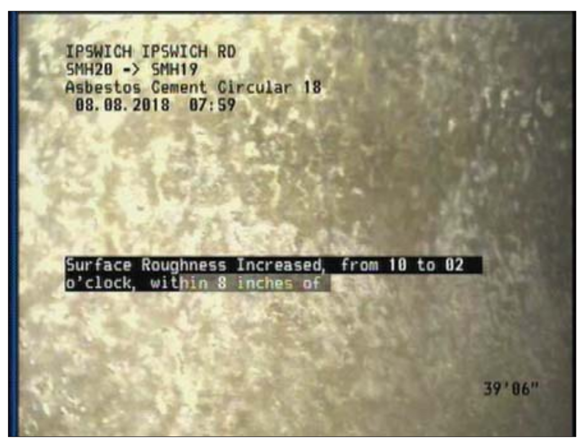

Photo: SMH20-SMH19-08202018-SRI-39.5303-160939.jpg
39.53FT, Surface Roughness Increased, from 10 to 02 o'clock, within 8 inches of joint: YES, Start

The Environmental Protection Specialists

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25 Marshall St
Canton MA 02021
Tel: 800-422-0815
Fax: 781-828-2473
E-mail:

Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

Photo: SMH20-SMH19-08202018-DAGS-52.24-161007.jpg
52.24FT, Deposits Attached Grease, 5 %of cross sectional area, at 08 o'clock, , within 8 inches of joint: YES

Photo: SMH20-SMH19-08202018-TBA-52.5402-161034.jpg
52.54FT, Tap Break-In Active, at 10 o'clock, -, within 8 inches of joint: NO, 4"

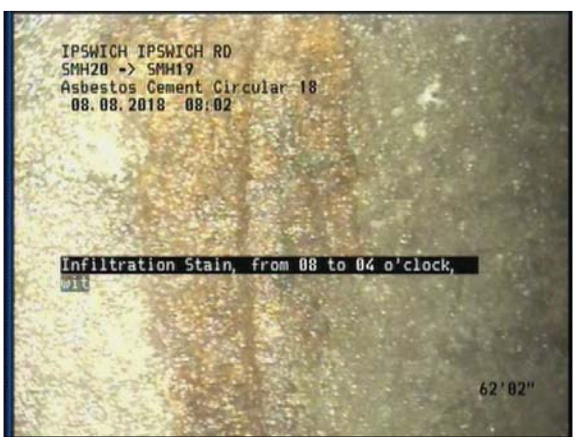

Photo: SMH20-SMH19-08202018-IS-62.1476-161049.jpg
62.15FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

Photo: SMH20-SMH19-08202018-SSS-69.5533-161135.jpg
69.55FT, Surface Spalling, from 01 to 04 o'clock, within 8 inches of joint: YES

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E-mail:

Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

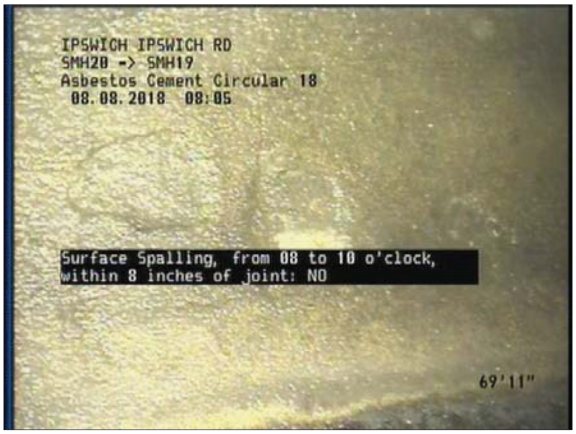

Photo: SMH20-SMH19-08202018-SSS-69.9536-161207.jpg
69.95FT, Surface Spalling, from 08 to 10 o'clock, within 8 inches of joint: NO

Photo: SMH20-SMH19-08202018-SSS-70.8543-161256.jpg
70.85FT, Surface Spalling, at 08 o'clock, within 8 inches of joint: YES, Start

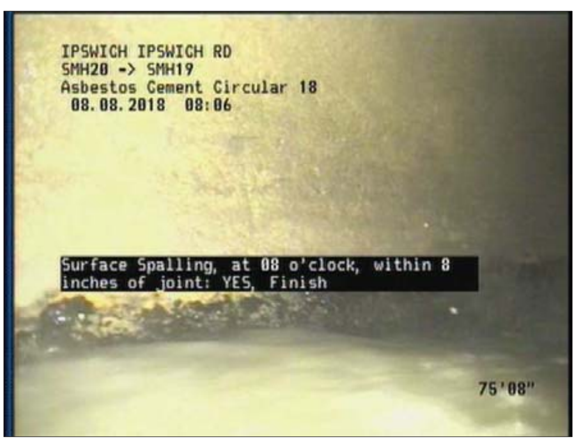

Photo: SMH20-SMH19-08202018-SSS-75.6579-161428.jpg
75.66FT, Surface Spalling, at 08 o'clock, within 8 inches of joint: YES, Finish

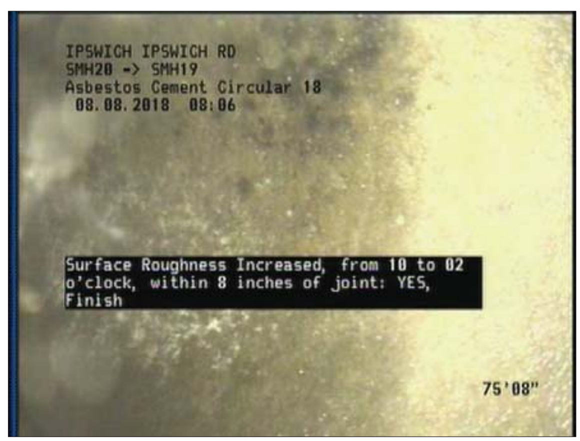

Photo: SMH20-SMH19-08202018-SRI-75.6579-161327.jpg
75.66FT, Surface Roughness Increased, from 10 to 02 o'clock, within 8 inches of joint: YES, Finish

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City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

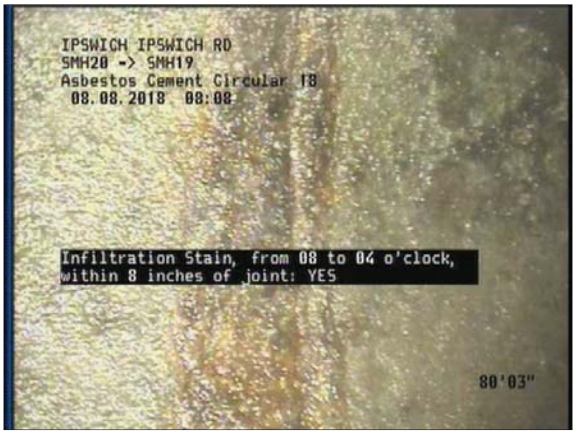

Photo: SMH20-SMH19-08202018-IS-80.2615-161523.jpg
80.26FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

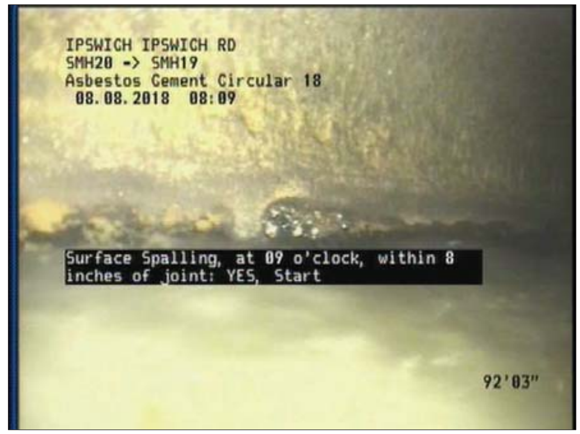

Photo: SMH20-SMH19-08202018-SSS-92.2707-161553.jpg
92.27FT, Surface Spalling, at 09 o'clock, within 8 inches of joint: YES, Start

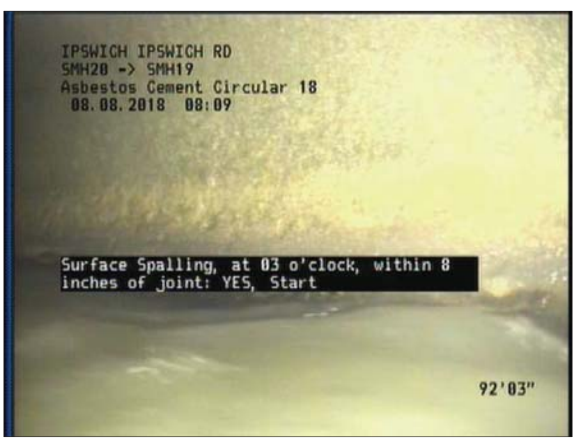

Photo: SMH20-SMH19-08202018-SSS-92.2707-161611.jpg
92.27FT, Surface Spalling, at 03 o'clock, within 8 inches of joint: YES, Start

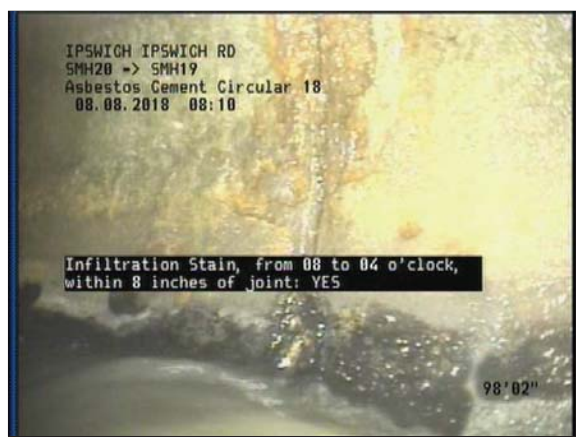

Photo: SMH20-SMH19-08202018-IS-98.1752-161803.jpg
98.18FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

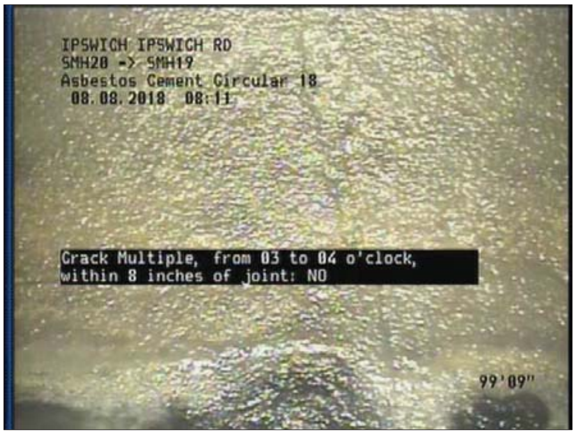

Photo: SMH20-SMH19-08202018-CM-99.7764-161705.jpg
99.78FT, Crack Multiple, from 03 to 04 o'clock, within 8 inches of joint: NO

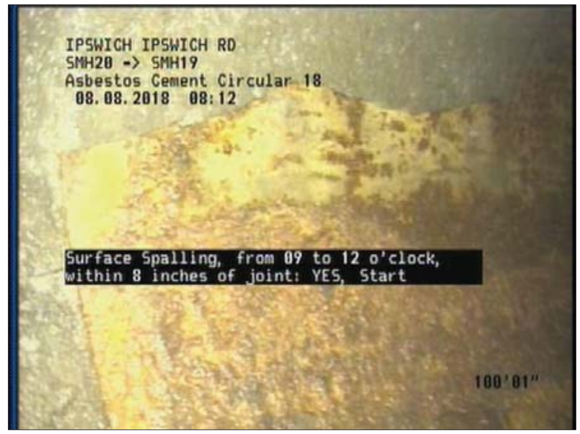

Photo: SMH20-SMH19-08202018-SSS-100.0766-161935.jpg
100.08FT, Surface Spalling, from 09 to 12 o'clock, within 8 inches of joint: YES, Start

Photo: SMH20-SMH19-08202018-SSS-111.1851-162004.jpg
111.19FT, Surface Spalling, from 09 to 12 o'clock, within 8 inches of joint: YES, Finish

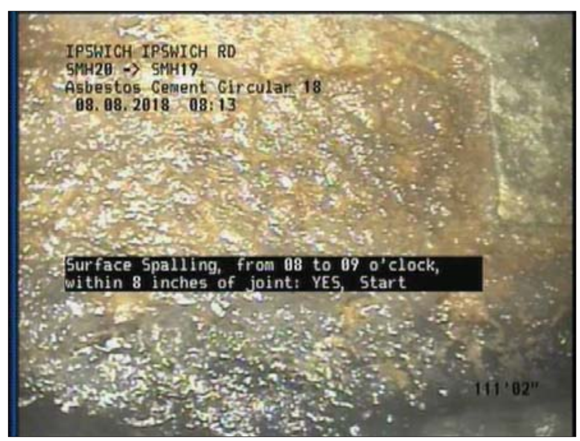

Photo: SMH20-SMH19-08202018-SSS-111.1851-162154.jpg
111.19FT, Surface Spalling, from 08 to 09 o'clock, within 8 inches of joint: YES, Start

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

Photo: SMH20-SMH19-08202018-SSS-111.1851-162033.jpg
111.19FT, Surface Spalling, at 09 o'clock, within 8 inches of joint: YES

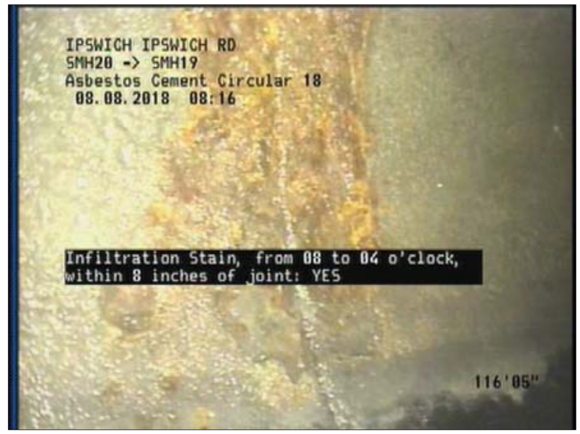

Photo: SMH20-SMH19-08202018-IS-116.3891-163428.jpg
116.39FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

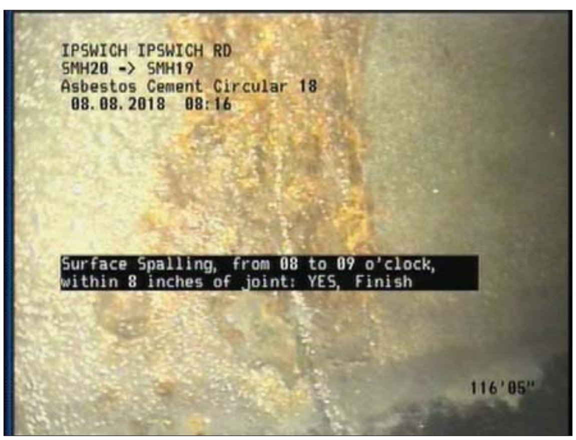

Photo: SMH20-SMH19-08202018-SSS-116.3891-163441.jpg
116.39FT, Surface Spalling, from 08 to 09 o'clock, within 8 inches of joint: YES, Finish

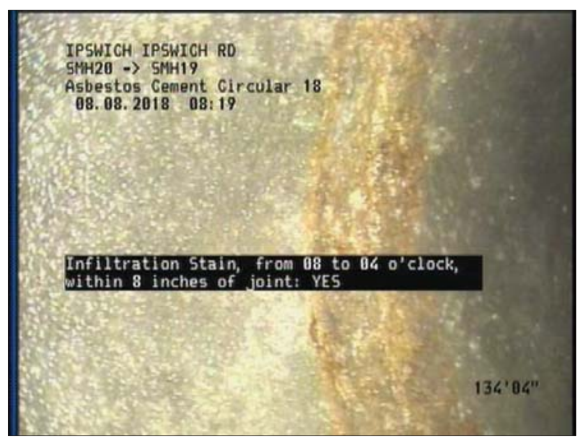

Photo: SMH20-SMH19-08202018-IS-134.3028-163451.jpg
134.3FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

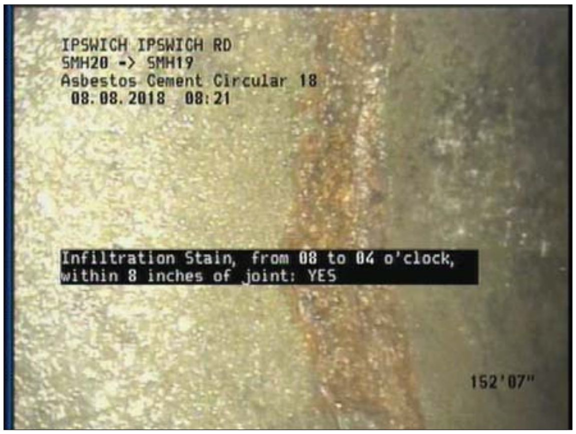

Photo: SMH20-SMH19-08202018-IS-152.6169-163510.jpg
152.62FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

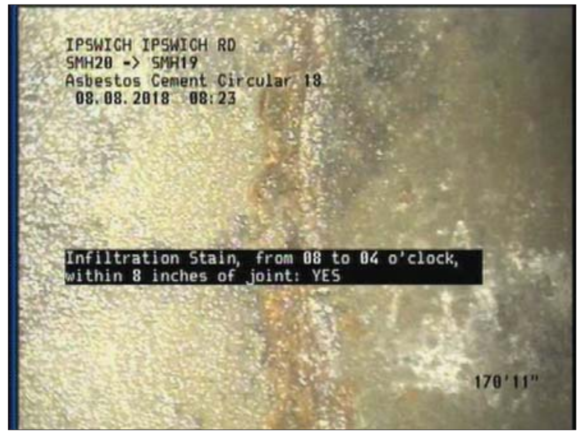

Photo: SMH20-SMH19-08202018-IS-170.9309-163611.jpg
170.93FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

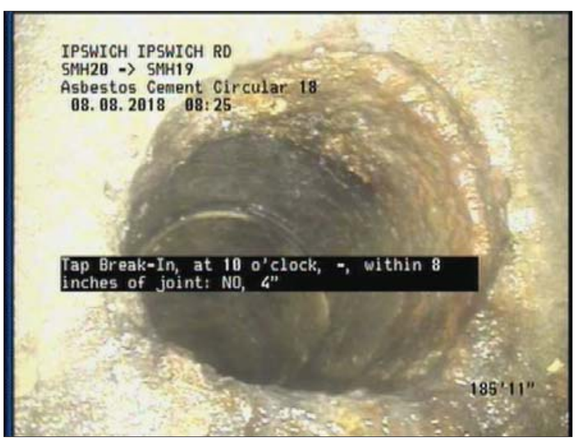

Photo: SMH20-SMH19-08202018-TB-185.9424-163643.jpg
185.94FT, Tap Break-In, at 10 o'clock, -, within 8 inches of joint: NO, 4"

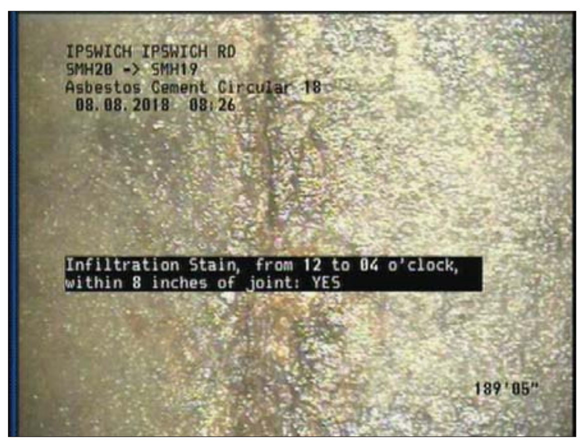

Photo: SMH20-SMH19-08202018-IS-189.4451-163713.jpg
189.45FT, Infiltration Stain, from 12 to 04 o'clock, within 8 inches of joint: YES

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City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

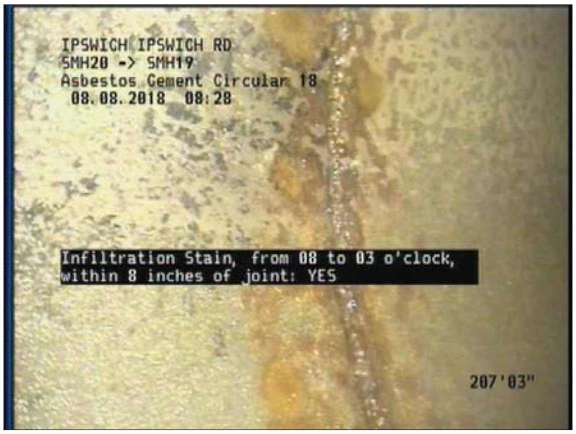

Photo: SMH20-SMH19-08202018-IS-207.2587-163744.jpg
207.26FT, Infiltration Stain, from 08 to 03 o'clock, within 8 inches of joint: YES

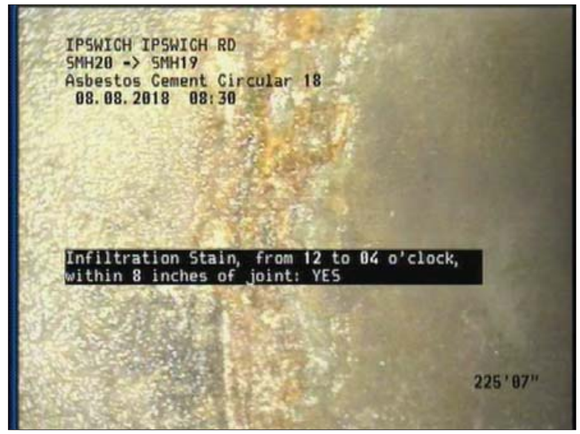

Photo: SMH20-SMH19-08202018-IS-225.5727-163758.jpg
225.57FT, Infiltration Stain, from 12 to 04 o'clock, within 8 inches of joint: YES

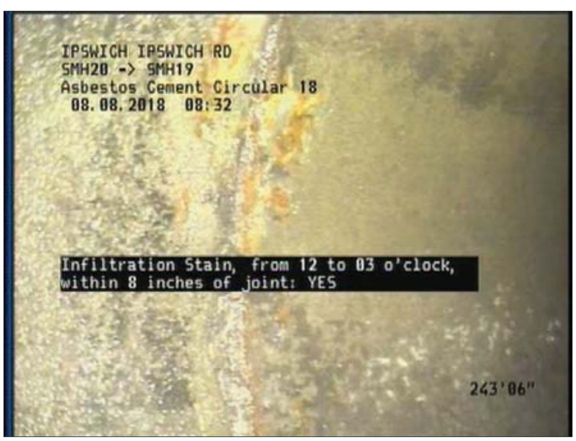

Photo: SMH20-SMH19-08202018-IS-243.4865-163818.jpg
243.49FT, Infiltration Stain, from 12 to 03 o'clock, within 8 inches of joint: YES

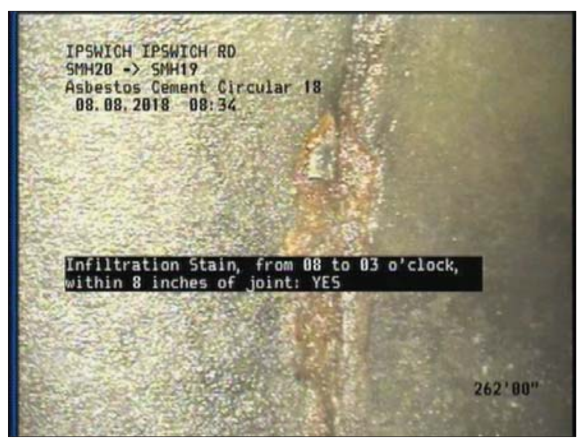

Photo: SMH20-SMH19-08202018-IS-262.0006-163859.jpg
262FT, Infiltration Stain, from 08 to 03 o'clock, within 8 inches of joint: YES

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

Photo: SMH20-SMH19-08202018-IS-280.0144-164005.jpg
280.01FT, Infiltration Stain, from 02 to 04 o'clock, within 8 inches of joint: YES

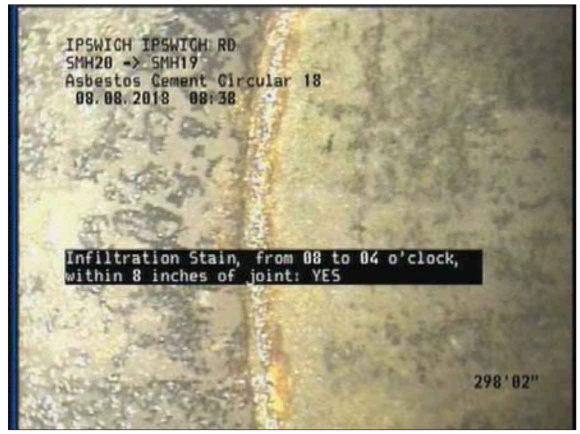

Photo: SMH20-SMH19-08202018-IS-298.1283-164037.jpg
298.13FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

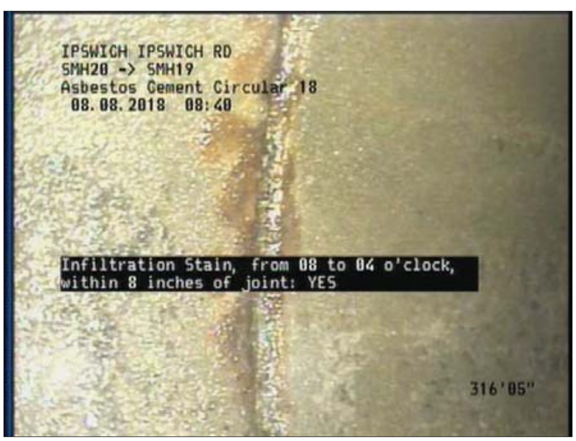

Photo: SMH20-SMH19-08202018-IS-316.4423-164129.jpg
316.44FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

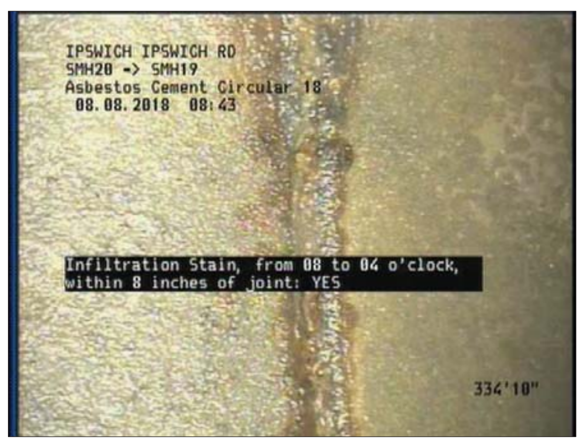

Photo: SMH20-SMH19-08202018-IS-334.8564-164153.jpg
334.86FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**2**

Photo: SMH20-SMH19-08202018-SSS-339.1597-164227.jpg
339.16FT, Surface Spalling, at 03 o'clock, within 8 inches of joint: YES, Finish

Photo: SMH20-SMH19-08202018-SSS-339.1597-164236.jpg
339.16FT, Surface Spalling, at 09 o'clock, within 8 inches of joint: YES, Finish

Photo: SMH20-SMH19-08202018-AMH-339.1597-164243.jpg
339.16FT, Downstream Manhole, Survey Ends

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E-mail:

Inspection Report

Date	P/O. No.	Weather	Surveyor's Name	Pipe Segment Reference	Section No.
8/8/2018		**Dry**	**BILL DEGROATE**		**3**
Certificate No.	Survey Customer	System Owner	Date Cleaned	Pre-Cleaning	Sewer Category
07007097			**8/8/2018**	**Heavy Cleaning**	

Street123	**IPSWICH RD**	Use of Sewer	**Sanitary**	Upstream MH	**SMH19**
City	**IPSWICH**	Drainage Area		Dowstream MH	**SMH18**
Loc. details		Flow Control	**Not Controlled**	Dir. of Survey	**Downstream**
Location Code	**Easement/Right of way**	Length surveyed	**146.41 ft**	Section Length	**146.41 ft**

Purpose of Survey	**Maintenance Related**	Joint Length	
Year Laid		Dia./Height	**18 inch**
Year Rehabilitated		Material	**Asbestos Cement**
Tape / Media No.		Lining Method	

Add. Information :

1:360	Position	Code	Observation	Grade
SMH19	0.00	AMH	Upstream Manhole, Survey Begins	
	0.00	MWL	Water Level, 30 %of cross sectional area	
	10.31	TF	Tap Factory Made, at 12 o'clock, -, within 8 inches of joint: YES, 4"	
	54.84	TBD	Tap Break-In Defective, at 10 o'clock, -, , within 8 inches of joint: NO, 6"	M 3
	54.94	IG	Infiltration Gusher, at 10 o'clock, within 8 inches of joint: NO	M 5
	139.21	TS	Tap Saddle, at 12 o'clock, -, within 8 inches of joint: NO, 4"	
SMH18	146.41	AMH	Downstream Manhole, Survey Ends	


0 FT


0 FT


10.31 FT


54.84 FT


54.94 FT

QSR	QMR	SPR	MPR	OPR	SPRI	MPRI	OPRI
0000	5131	0	8	8	0	4	4

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Inspection photos

City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**3**

Photo: SMH19-SMH18-08202018-AMH-0-164331.jpg
0FT, Upstream Manhole, Survey Begins

Photo: SMH19-SMH18-08202018-MWL-0-164356.jpg
0FT, Water Level, 30 %of cross sectional area

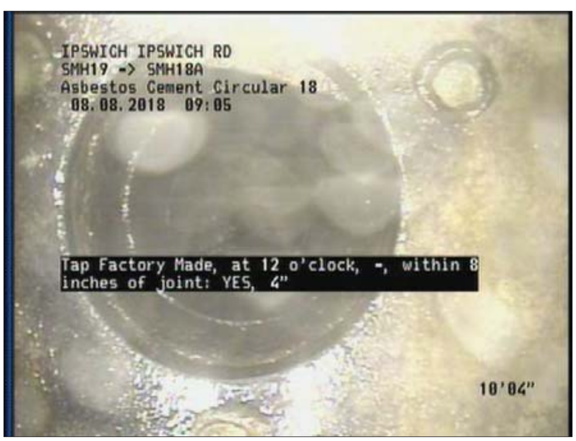

Photo: SMH19-SMH18-08202018-TF-10.3079-164420.jpg
10.31FT, Tap Factory Made, at 12 o'clock, -, within 8 inches of joint: YES, 4"

Photo: SMH19-SMH18-08202018-TBD-54.842-164440.jpg
54.84FT, Tap Break-In Defective, at 10 o'clock, -, , within 8 inches of joint: NO, 6"

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City :	Street :	Date :	Pipe Segment Reference :	Section No :
IPSWICH	**IPSWICH RD**			**3**

Photo: SMH19-SMH18-08202018-IG-54.9421-164511.jpg
54.94FT, Infiltration Gusher, at 10 o'clock, within 8 inches of joint: NO

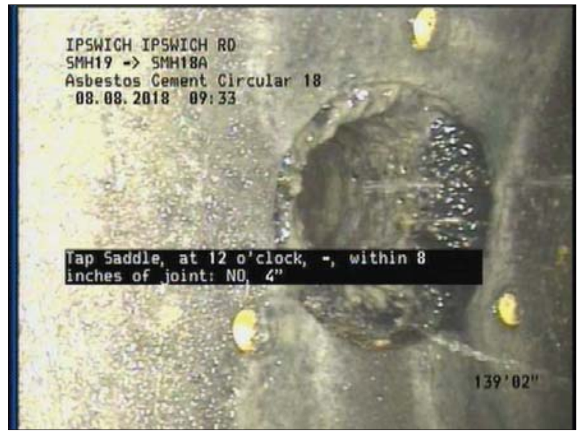
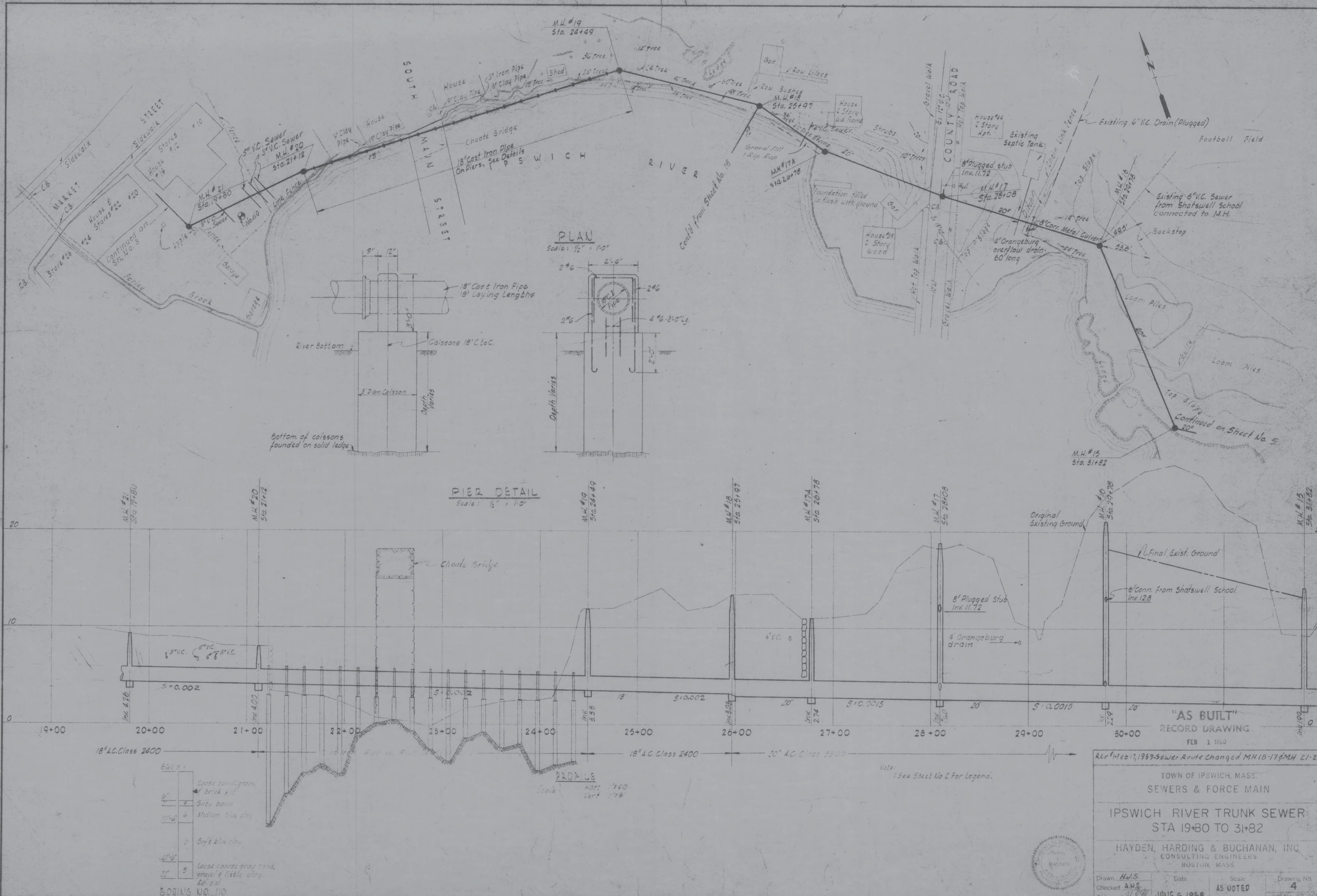


Photo: SMH19-SMH18-08202018-TS-139.2066-164533.jpg
139.21FT, Tap Saddle, at 12 o'clock, -, within 8 inches of joint: NO, 4"

Photo: SMH19-SMH18-08202018-AMH-146.4121-164549.jpg
146.41FT, Downstream Manhole, Survey Ends

Appendix C
1958 Siphon and Interceptor Drawings

Appendix C
1958 Siphon and Interceptor Drawings


M.H. #19
Sta. 24+49
M.H. #18
Sta. 25+97
M.H. #20
Sta. 21+12
M.H. #21
Sta. 19+80
MARKET
STREET
SOUTH MAIN STREET
Choate Bridge
18" Cast Iron Pipe
On Piers, See Details
IPSWICH RIVER
Cont'd from Sheet No. 18
Continued on Sh. No. 3
Forley Brook
M.H. #17A
Sta. 26+78
M.H. #17
Sta. 28+08
8" Plugged Stub
Inv. 11.72
COUNTY ROAD
Existing 6" V.C. Drain (Plugged)
Football Field
Existing Septic Tank
M.H. #16
Sta. 29+78
Existing 6" V.C. Sewer from Shatswell School connected to M.H.
Backstop
8" Corr. Metal Culvert
4" Orangeburg overflow drain 60' long
Foundation filled in flush with ground
Loam Piles
Top Slope
Continued on Sheet No. 5
M.H. #15
Sta. 31+82
PLAN
Scale: 1/2" = 1'-0"
18" Cast Iron Pipe
18' Laying Lengths
River Bottom
Caissons 18" C.I.&C.
Depth Varies
Bottom of caissons founded on solid ledge
PIER DETAIL
Scale: 1/2" = 1'-0"
Choate Bridge
Original Existing Ground
Final Exist. Ground
6" Conn. from Shatswell School
Inv. 12.8
8" Plugged Stub
Inv. 11.72
4" Orangeburg drain
S=0.002
S=0.0015
19+00
20+00
21+00
22+00
23+00
24+00
25+00
26+00
27+00
28+00
29+00
30+00
18" A.C. Class 2400
20" A.C. Class 2400
PROFILE
Scale Horz. 1"=40' Vert. 1"=4'
Note:
1. See Sheet No. 2 for Legend.
BORING NO. 110
"AS BUILT"
RECORD DRAWING
FEB 1 1960
Rev. Feb 17, 1959 - Sewer Route Changed MH 18-17 & MH 21-20
TOWN OF IPSWICH, MASS.
SEWERS & FORCE MAIN
IPSWICH RIVER TRUNK SEWER
STA 19+80 TO 31+82
HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASS.
Drawn H.J.S.
Checked A.H.G.
Date JUNE 6, 1958
Scale AS NOTED
Drawing No. 4


12" Plugged stub - for connection to future sewer from County Road
M.H.#38 - Sta. 2+78
Existing sewer connected into M.H.
Exist. Sewer
Exist. Septic Tank
Garage
Plugged
2-4" V.C. Sewer Drains
County Road Connection
12"
Sta. 25+97
Trunk Sewer Continued on Sheet No. 4
M.H.#18
Sta. 0-20
18"
Blow-off M.H.
6" Gate Valve
M.H.#34
Sta. 1+20
IPSWICH RIVER
Continuation Sheet No. 4
Sheet Metal Shop
Water & Light Dept.
Buried Cable
ELM STREET
Town Hall
Existing sewer
Bldg.
Tree
Fence
Gas Station
6" Sewer Connection from Town Hall into M.H.#37
M.H.#37
Sta. 7+35
8" Plugged stub
M.H.#35
Sta. 3+31
M.H.#36
Sta. 4+69
10" V.C. Storm Drain
Boring No. 112
2-4" V.C. Sewers
1-6" V.C. Sewer
SOUTH MAIN STREET
Plugged
BRIDGE
Bldg.
Bldg. #11
Bldg. #13
Ford Co.
Chevrolet Co.
PLAN
Scale 1" = 40'
Elev. 9.0±
Loose dirty yellow sand & Gravel fill
Firm sand, gravel & brick fill
Medium yellow clay
Ground water level fluctuates with the tide
BORING NO. 112
Existing Ground
2-4" V.C. Sewer Drains
12" Plugged stub for connection to future sewer from County Road
12"
S = 0.003
Inv. 4.10
Inv. 8.94
0+00
1+00
2+00
3+00
COUNTY ROAD CONNECTION
12" A.C., Class 1500
Blow-off Manhole
Existing ground
2-4" V.C. Sewers
1-6" V.C. Sewers
Stone wall
2'-0" Min. Cover
22½° Bend
12" x 6" Blow-off Branch
12" C.I. Mechanical Joint Pipe
12" C.I. Bell & Spigot Joint
18" Inv. 3.03
12" Inv. 3.50
12" Inv. 4.10
8" Inv. 4.43
S = 0.004
Inv. 5.17
Inv. 5.83
Inv. 6.89
SOUTH MAIN STREET
8" A.C., Class 1500
PROFILE
Scale: Hor. 1" = 40'
Vert. 1" = 4'
Note: See Sheet No. 2 for Legend
"AS BUILT"
RECORD DRAWING
FEB 1 1960
OPTION No. II
TOWN OF IPSWICH, MASS.
SEWERS & FORCE MAIN
SOUTH MAIN ST. SEWER
STA. 0-20 TO 7+35
COUNTY ROAD CONNECTION
STA. 0+00 TO 2+78
HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASS.
Drawn
Checked
Date
JUNE 6, 1958
Scale
AS NOTED
Drawing No.
18

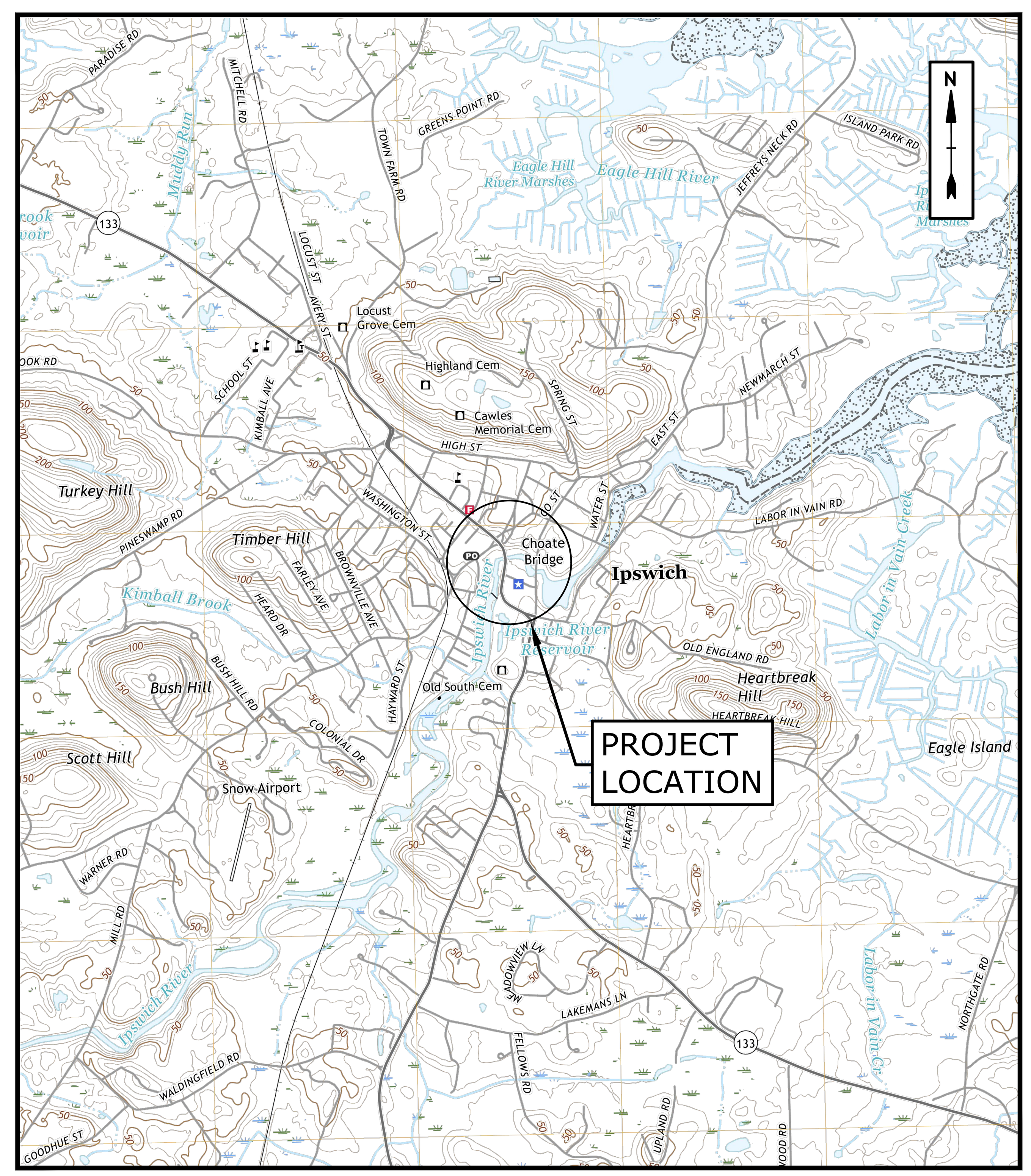
Appendix D
Design Drawings

TOWN OF IPSWICH, MASSACHUSETTS

SEWER INTERCEPTOR AND SIPHON REHABILITATION

MARCH 2019

LIST OF DRAWINGS	
SHEET NO.	TITLE
1	COVER
2	INTERCEPTOR REHABILITATION CONCEPTS - SITE PLAN
3	INTERCEPTOR REHABILITATION - DETAILS 1
4	INTERCEPTOR REHABILITATION -DETAILS 2
5	EXISTING SIPHON SECTIONS
6	PROPOSED SIPHON SECTIONS
7	DETAILS



PREPARED BY:

Tighe&Bond
www.tighebond.com

STEPHEN E. SIEGAL, P.E.

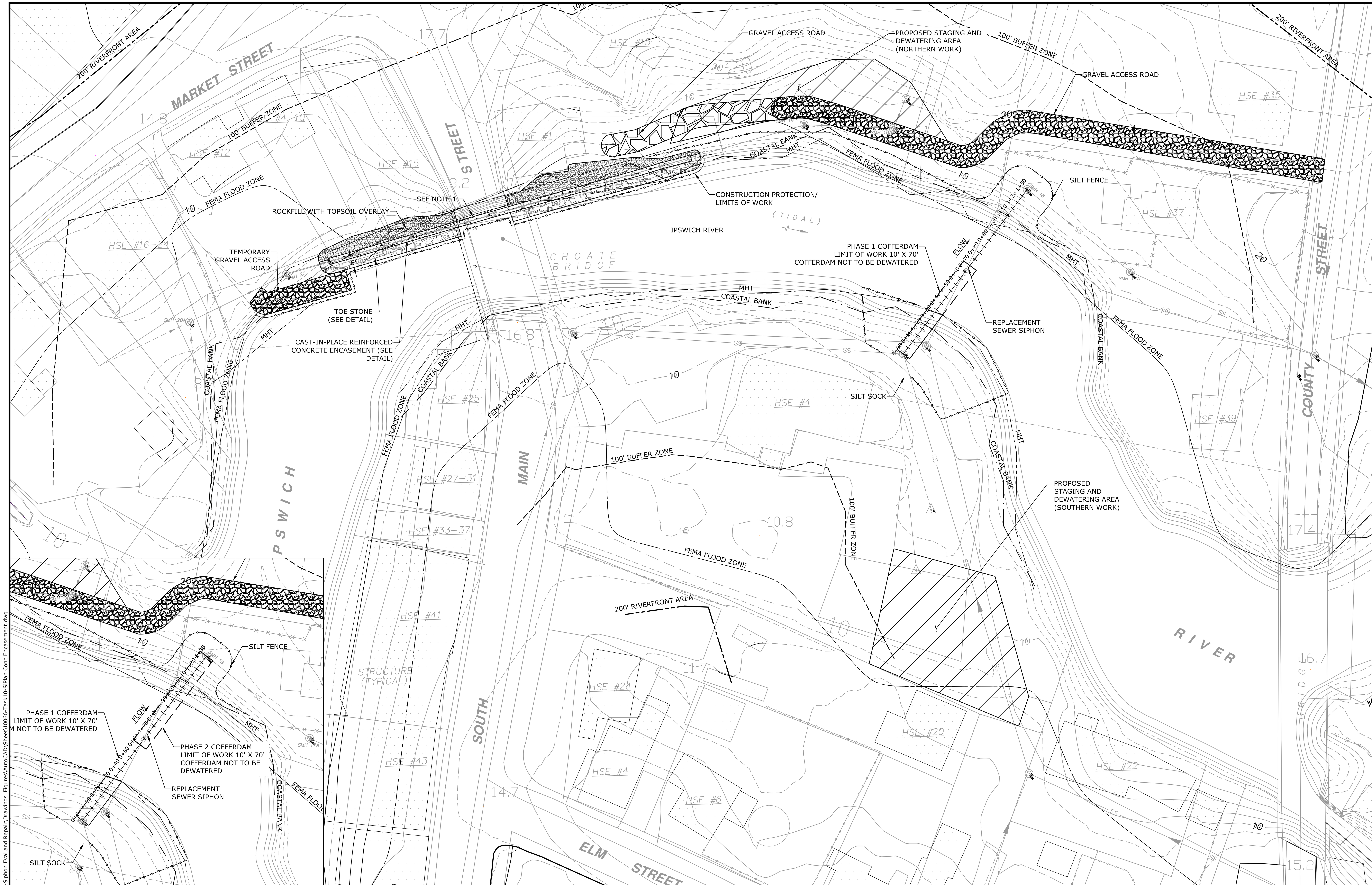
DANIEL O. ROOP, P.E.

PREPARED FOR:

TOWN OF IPSWICH
WATER & WASTEWATER DIRECTOR, VICKI HALMEN
TOWN MANAGER, ANTHONY MARINO

CONCEPTUAL DRAWINGS
NOT FOR CONSTRUCTION

Last Saved: 2/28/2019
Plotted On: Feb 28, 2019–1:14pm By: SAT
Tighe & Bond: J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Xref\I0066-Task10-Cover.dwg



PHASE 2 COFFERDAM

CONCRETE ENCASEMENT

SCALE IN FEET 0 30' 60'
GRAPHIC SCALE

N

NOTE:
1. OMIT SHEET PILE UNDER BRIDGE DUE TO OVERHEAD SPACE CONSTRAINT

REFERENCE PLANS:
1. "SANITARY SEWER PLAN VICINITY OF SOUTH MAIN STREET TO COUNTY STREET" DATED 3/14/2018 REVISED 5/29/2018 IN FEET RELATIVE TO NAVD88. IN RIVER BATHYMETRY NOT PROVIDED AND WATER LEVELS NOT GIVEN.
2. "PLAN ACCOMPANYING PETITION OF TOWN OF IPSWICH TO REPLACE FILL AND SEWER PIPELINE WITH CROSSING IN THE IPSWICH RIVER, IPSWICH, MASS" DATED 4/27/1959.

Last Saved: 3/4/2019
Plotted On: Mar 04, 2019-11:50am By: SAT
Tighe & Bond: J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-SiPlan Conc Encasement.dwg

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CONCEPTUAL DRAWINGS

NOT FOR CONSTRUCTION

Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

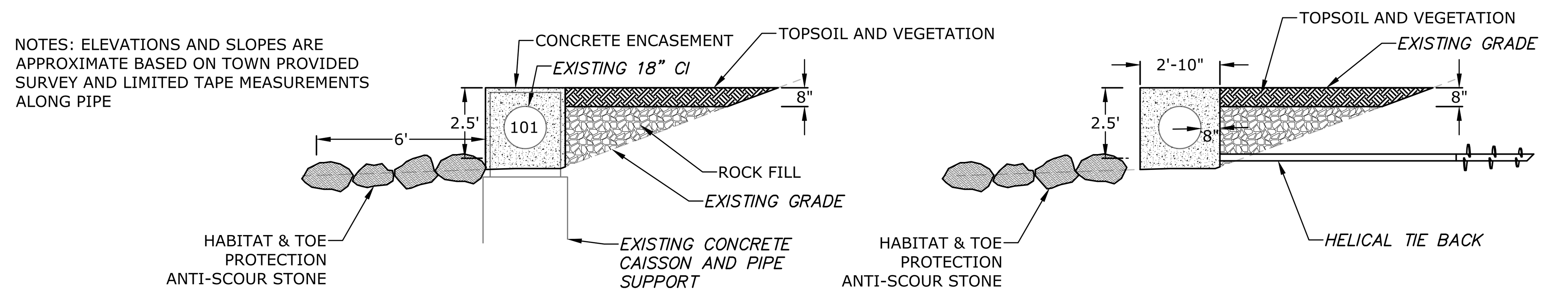
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-SiPlan Conc Encasement.dwg	
DRAWN BY:	LPT/JAK
CHECKED:	DOR, SAT
APPROVED:	SES

INTERCEPTOR REHABILITATION SITE PLAN

SCALE: 1"=30'

SHEET 2

NOTES: ELEVATIONS AND SLOPES ARE APPROXIMATE BASED ON TOWN PROVIDED SURVEY AND LIMITED TAPE MEASUREMENTS ALONG PIPE



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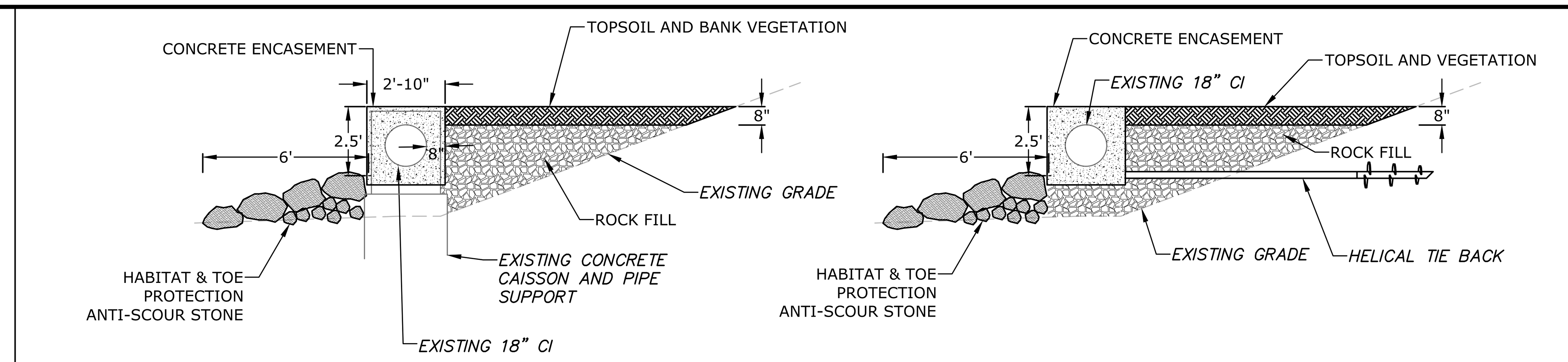

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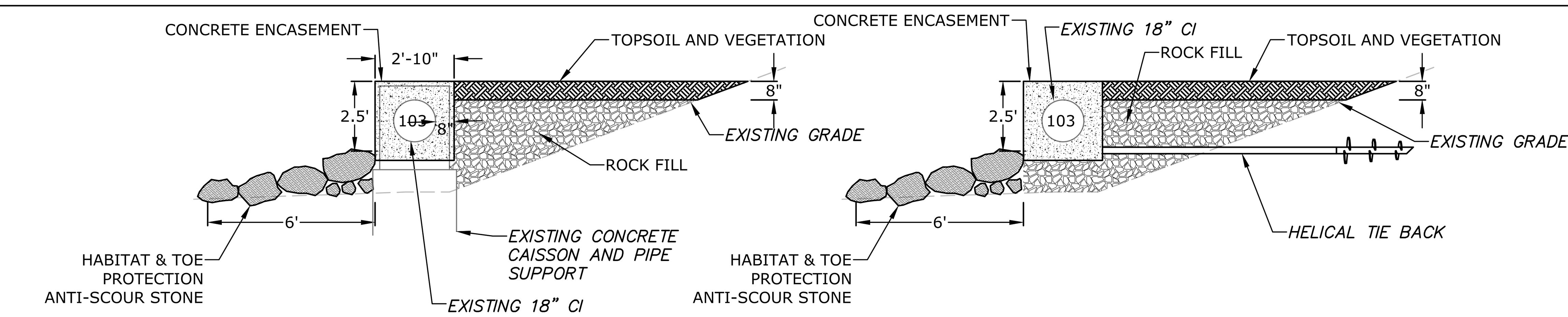

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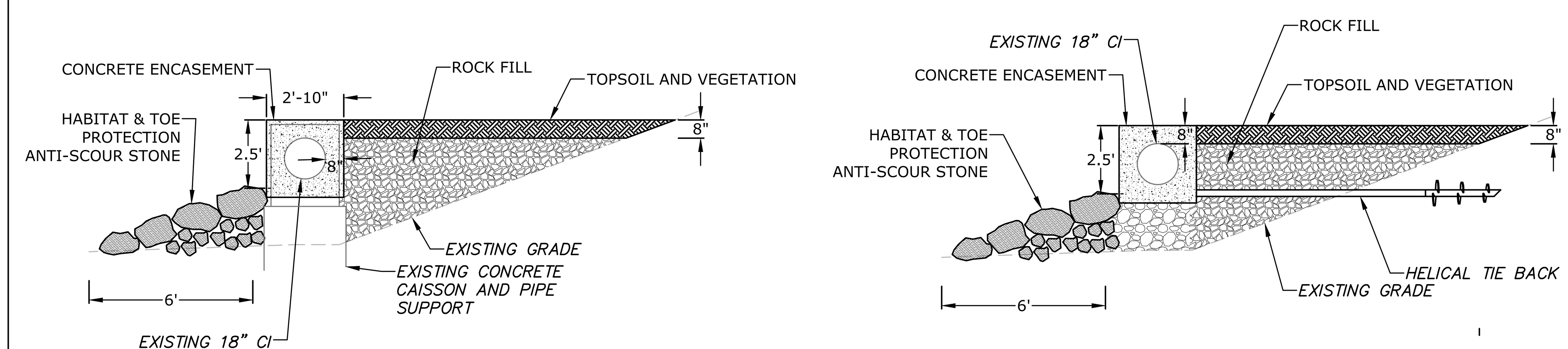

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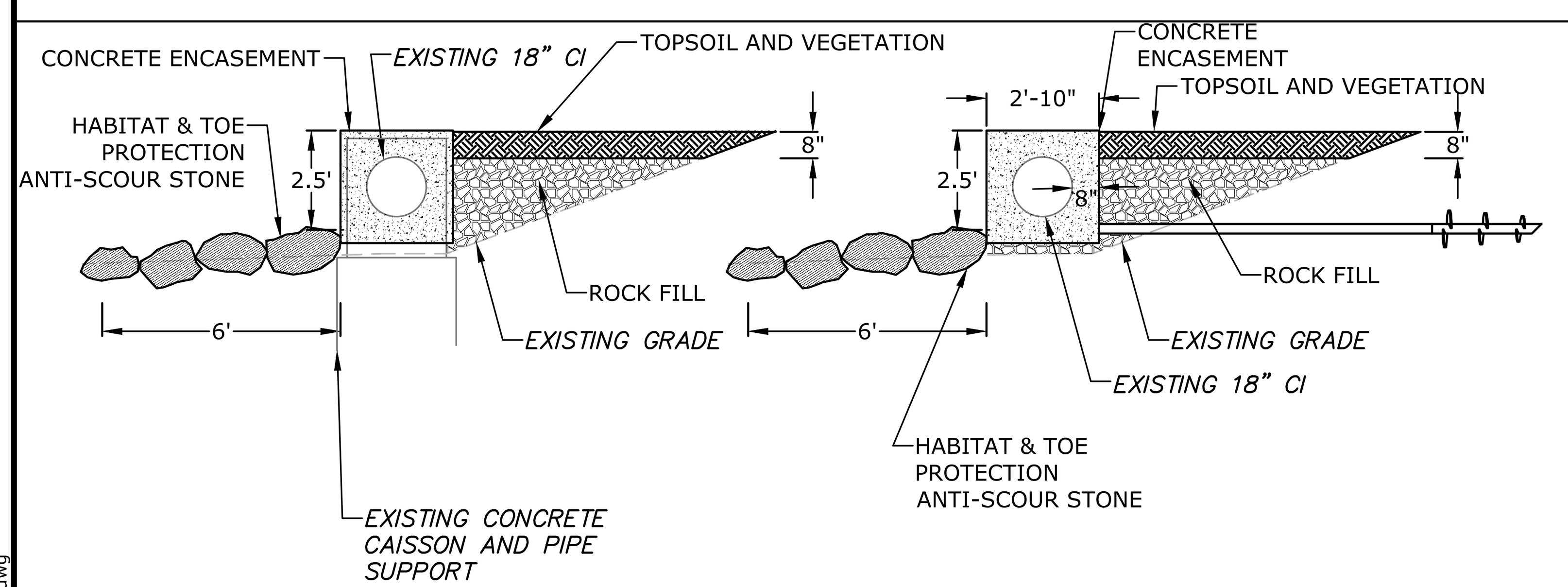

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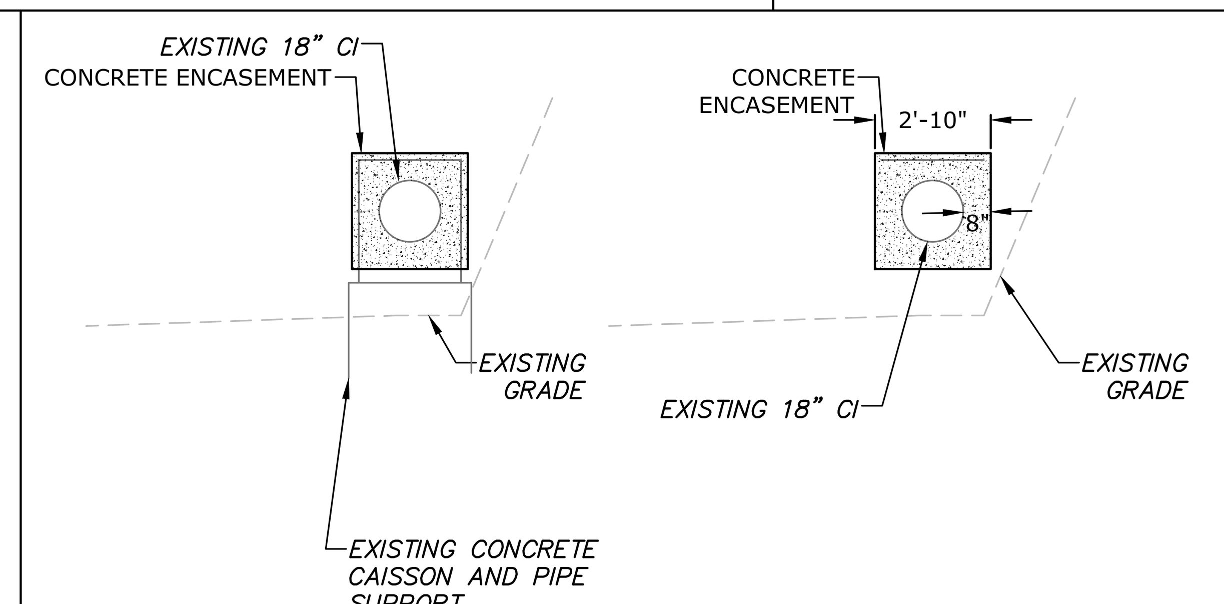
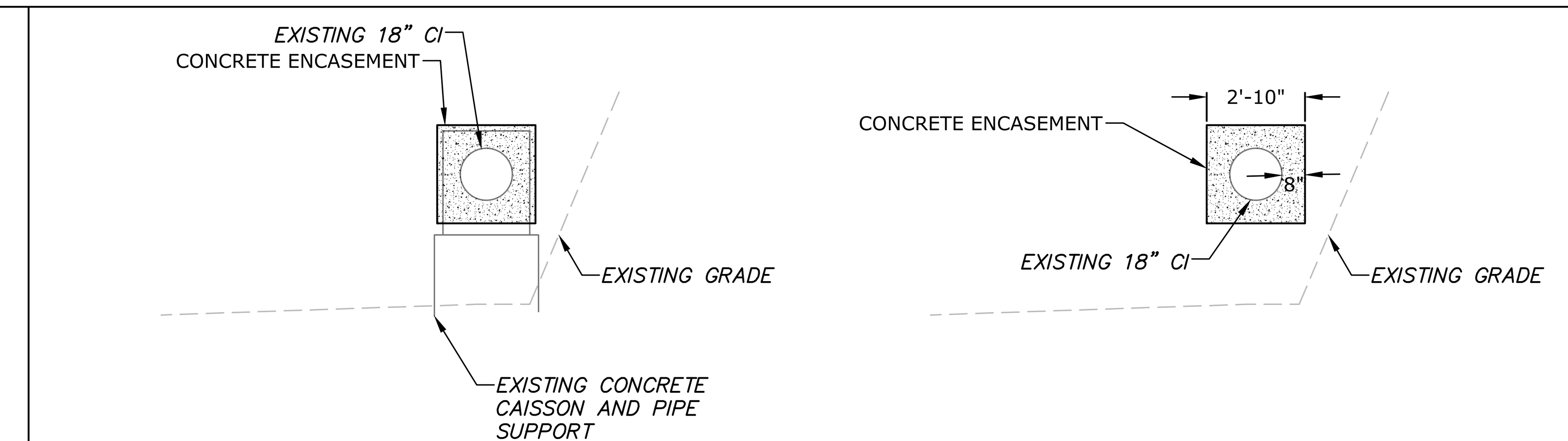


CONCRETE PEDESTAL #106 CROSS SECTION (UNDER BRIDGE)



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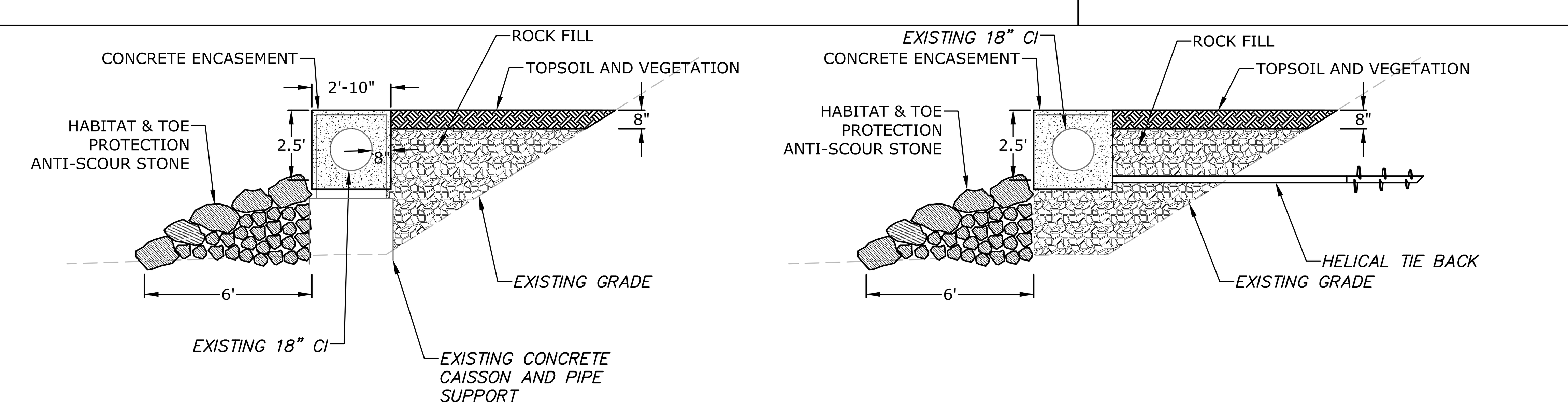

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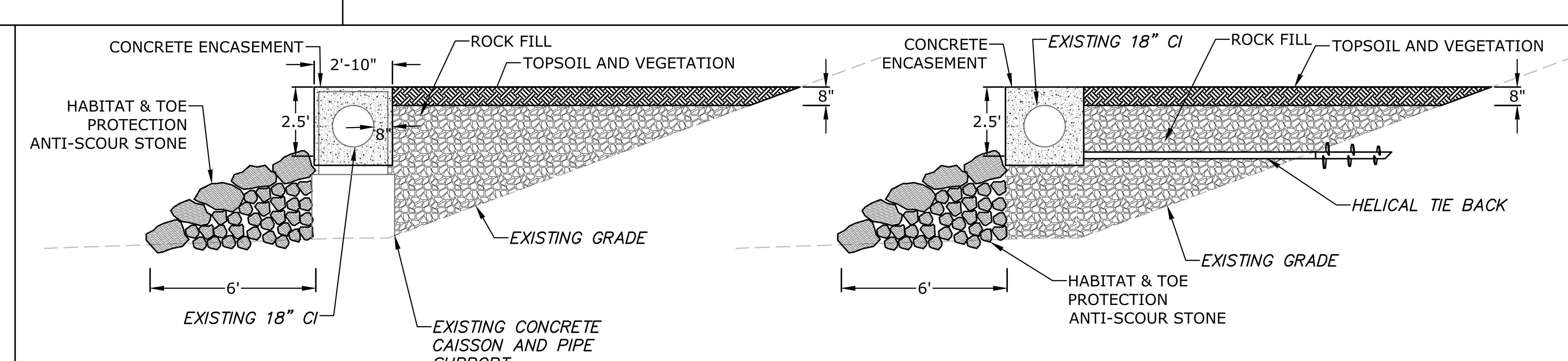

CONCRETE PEDESTAL #109 CROSS SECTION

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CONCEPTUAL DRAWINGS

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

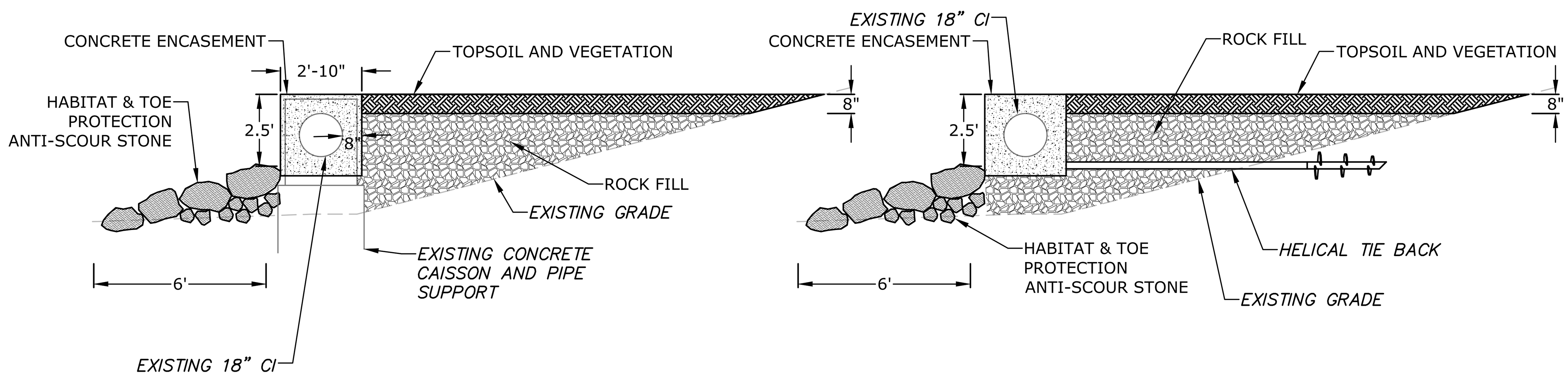
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK, SAT
CHECKED:	DCM
APPROVED:	SES

INTERCEPTOR REHABILITATION - DETAILS 1

SCALE: AS SHOWN

SHEET 3

Last Saved: 2/27/2019
Plotted On:Feb 28, 2019-1:30pm By: SAT
Tighe & Bond:J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg



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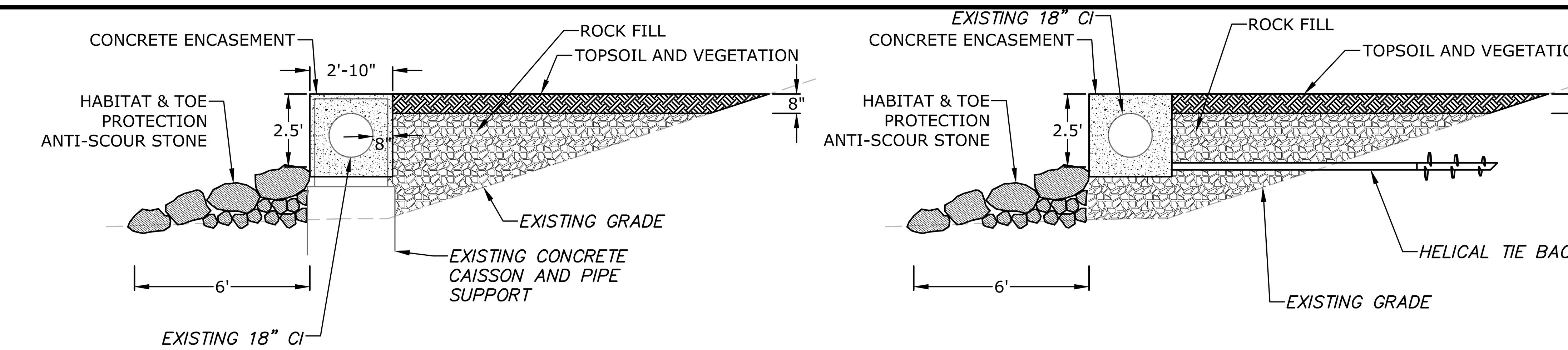

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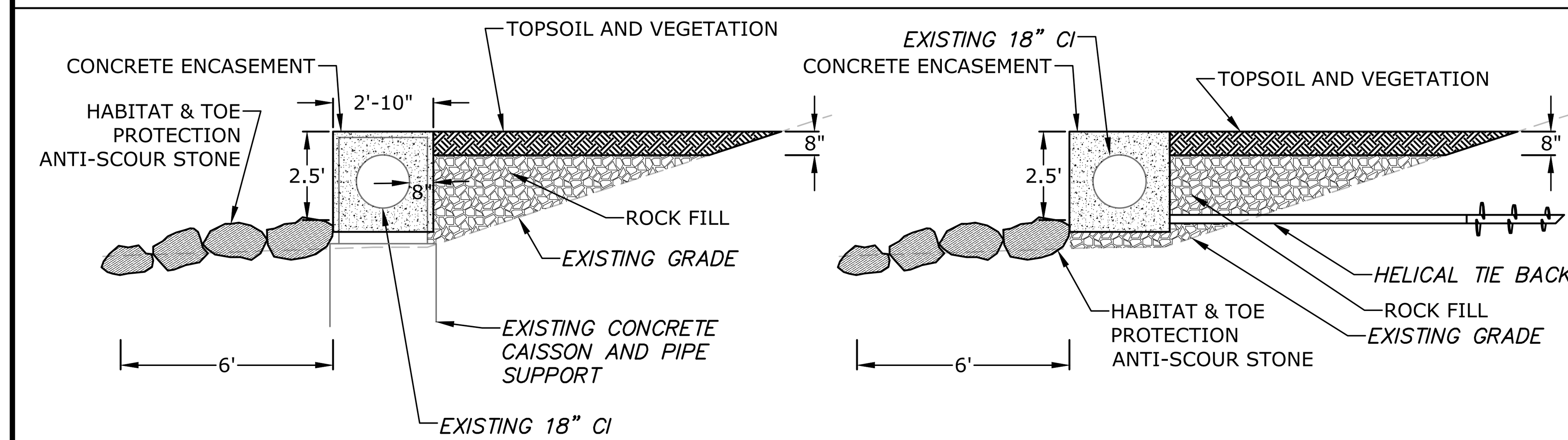

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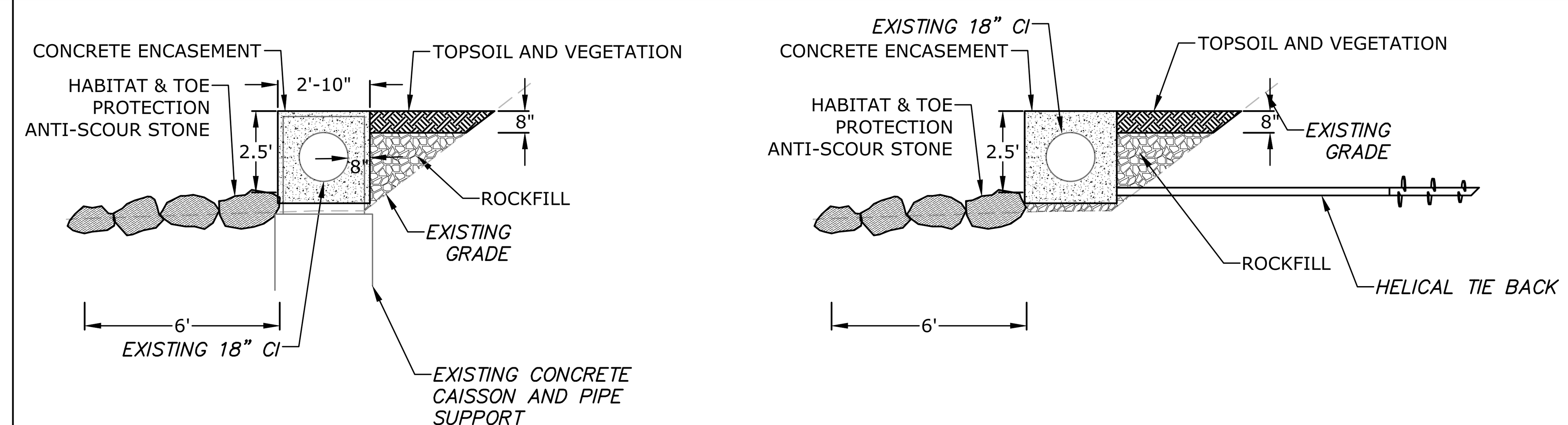

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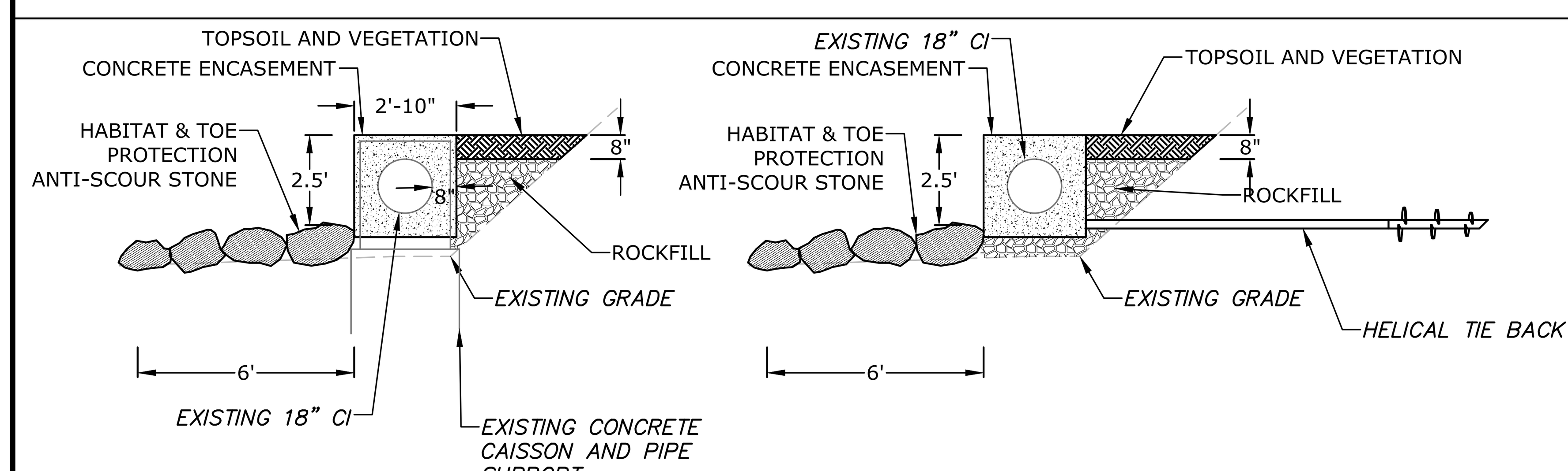

CONCRETE PEDESTAL #114 CROSS SECTION

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CONCEPTUAL DRAWINGS

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

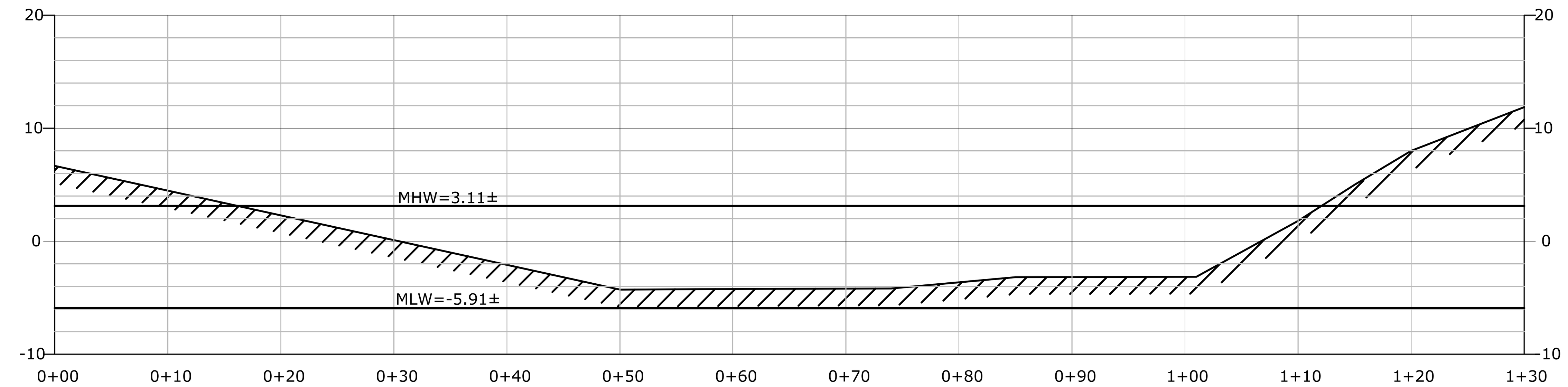
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK, SAT
CHECKED:	DCM
APPROVED:	SES

INTERCEPTOR REHABILITATION - DETAILS 2

SCALE: AS SHOWN

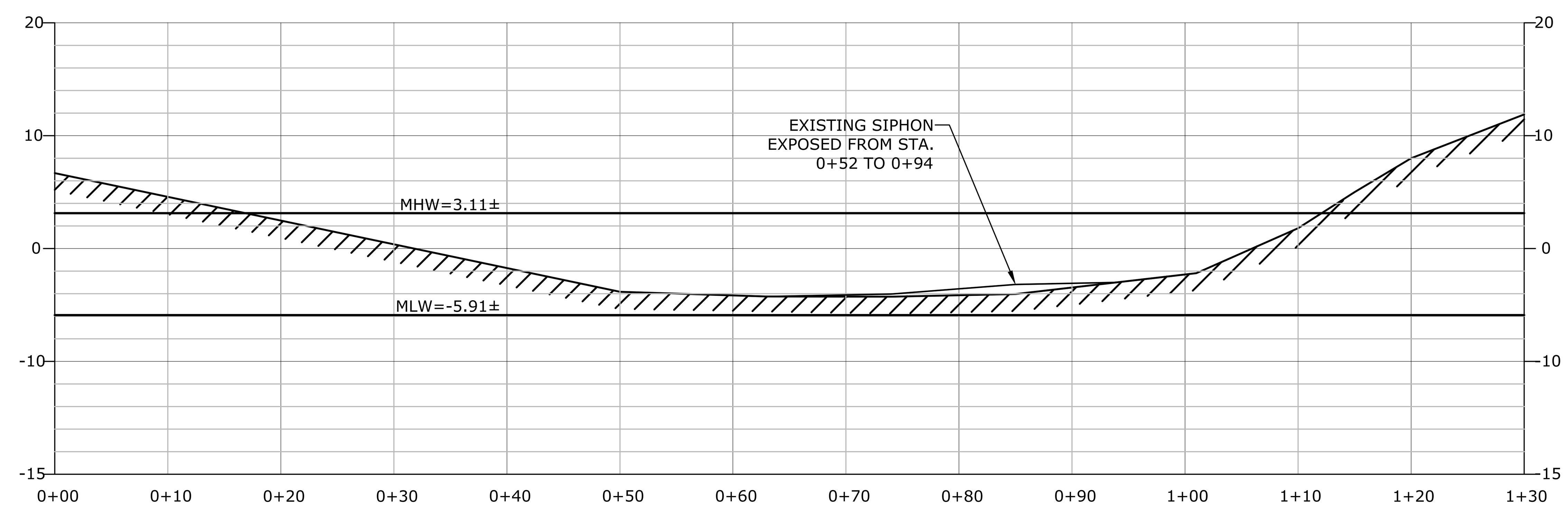
SHEET 4

Last Saved: 2/27/2019
Plotted On:Feb 28, 2019-1:31pm By: SAT
Tighe & Bond:J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg



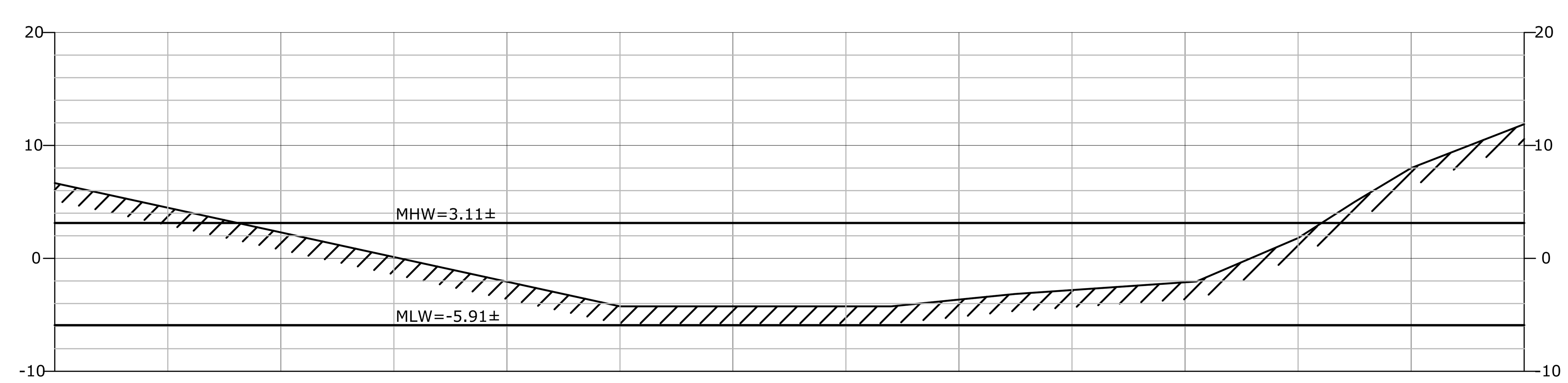
RIVER SECTION 10' UP RIVER OF SIPHON

SCALE IN FEET
0 10' 20'
GRAPHIC SCALE



RIVER SECTION AT SIPHON

SCALE IN FEET
0 10' 20'
GRAPHIC SCALE



RIVER SECTION 10' DOWN RIVER OF SIPHON

SCALE IN FEET
0 10' 20'
GRAPHIC SCALE

NOTES:
1. STATIONING & ELEVATIONS IN FEET WITH STA. 0+00 AT CENTER OF SMH 34 COVER.
2. ELEVATIONS TAKEN BY AUTO LEVEL, ROD AND STATIONING BY TAPE. VERTICAL DATUM BASED ON RIM ELEVATION OF SMH 34 ARCHIVE DATA IN NAVD88.
3. WATER ELEVATIONS VARY WITH RIVER FLOW & TIDES.

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CONCEPTUAL DRAWINGS

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK
CHECKED:	DCM
APPROVED:	SES

EXISTING SIPHON SECTIONS

SCALE: AS SHOWN

SHEET 5

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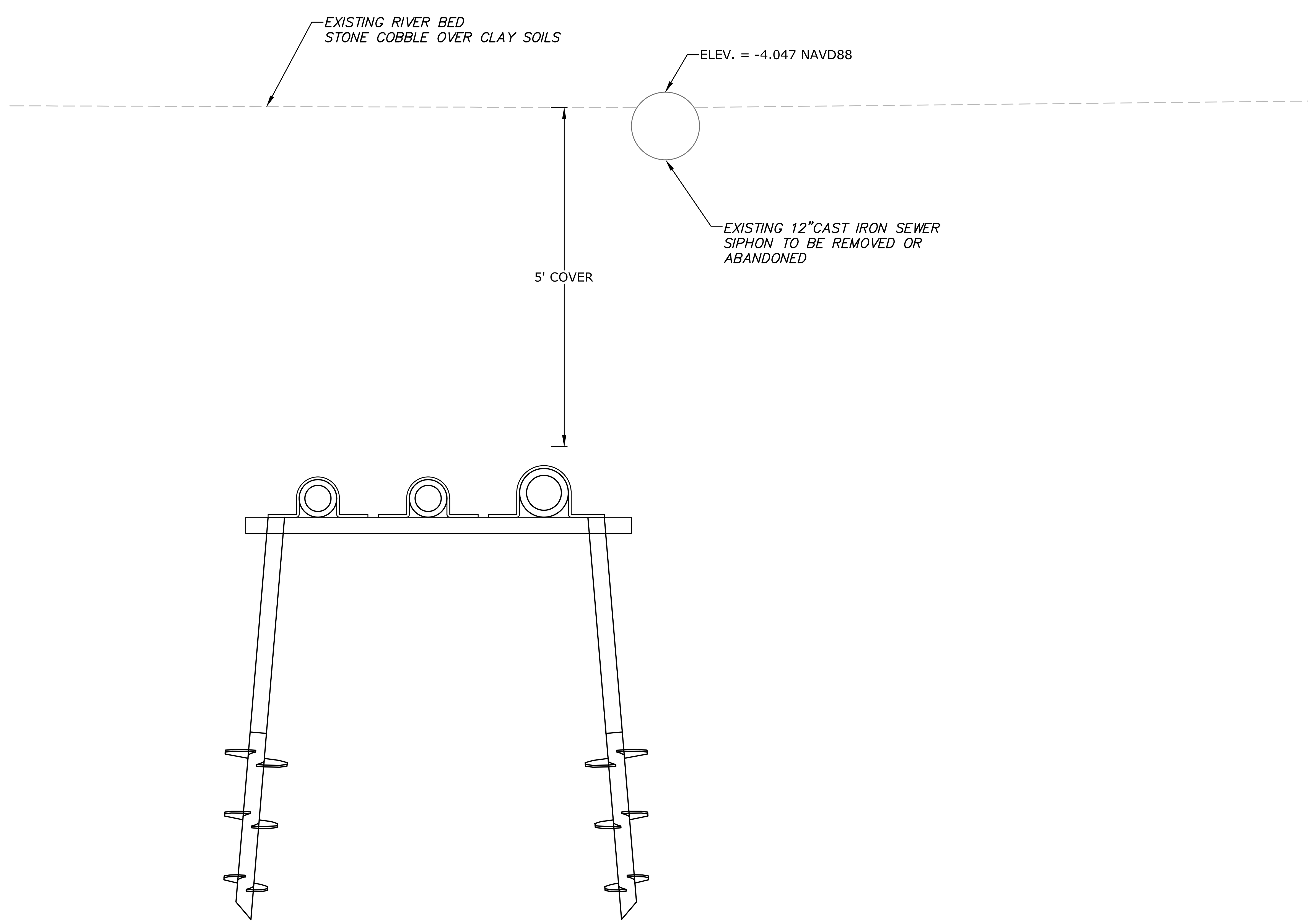
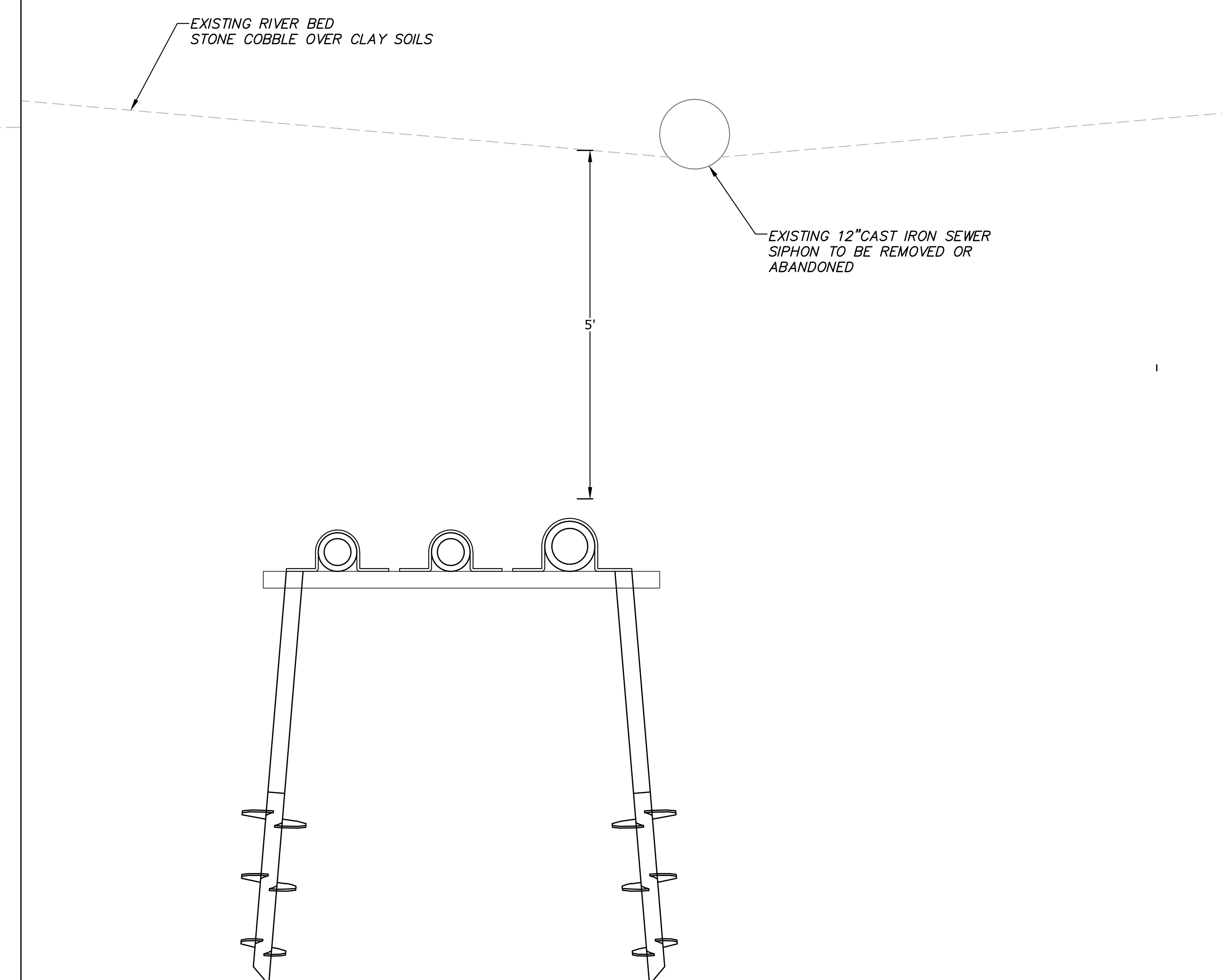


SIPHON CROSS SECTION A-A STA. 0+74.00

0 1' 2' 3'
GRAPHIC SCALE



SIPHON CROSS SECTION B-B STA. 0+85.00

0 1' 2' 3'
GRAPHIC SCALE

CONCEPTUAL DRAWINGS

NOT FOR CONSTRUCTION

Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

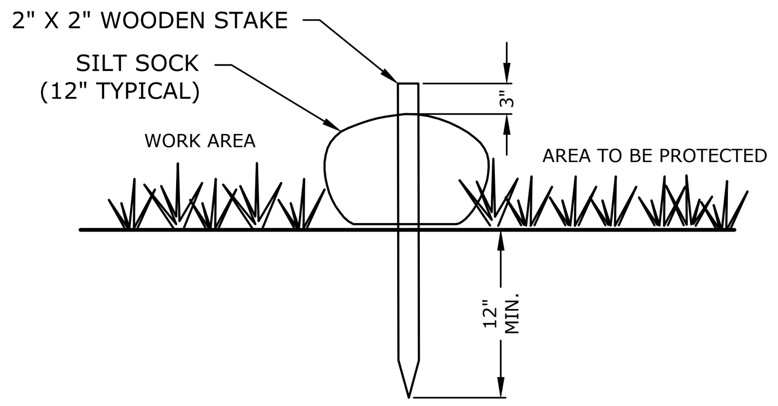
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK
CHECKED:	DCM
APPROVED:	SES

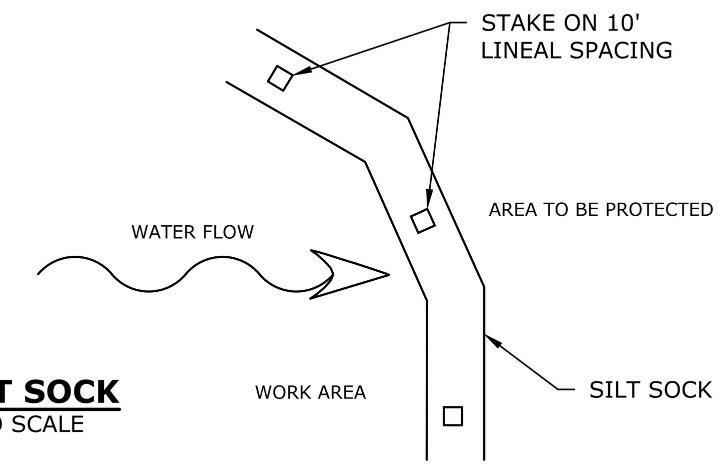
PROPOSED SIPHON SECTIONS

SCALE: AS SHOWN

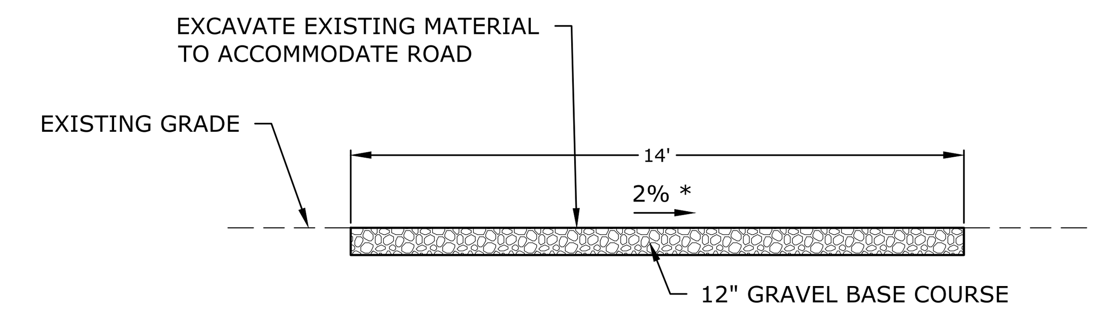
SHEET 6

NOTES:
1. SILT SOCK SHALL BE SILT SOXX BY FILTREXX OR APPROVED EQUAL.
2. SILT SOCK SHALL BE FILLED WITH FILTERMEDIA BY FILTREXX OR APPROVED EQUAL.
3. WHERE TWO SILT SOCKS ARE JOINED, A MINIMUM OF 2 FEET OF OVERLAP SHALL BE MAINTAINED.
4. SILT SOCKS SHALL BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
5. CONTRACTOR TO INSTALL SILT SOCK IN J-HOOK OR SMILE CONFIGURATION TO LIMIT CONCENTRATION OF STORMWATER RUNOFF AT A SINGLE DISHCARGE POINT.





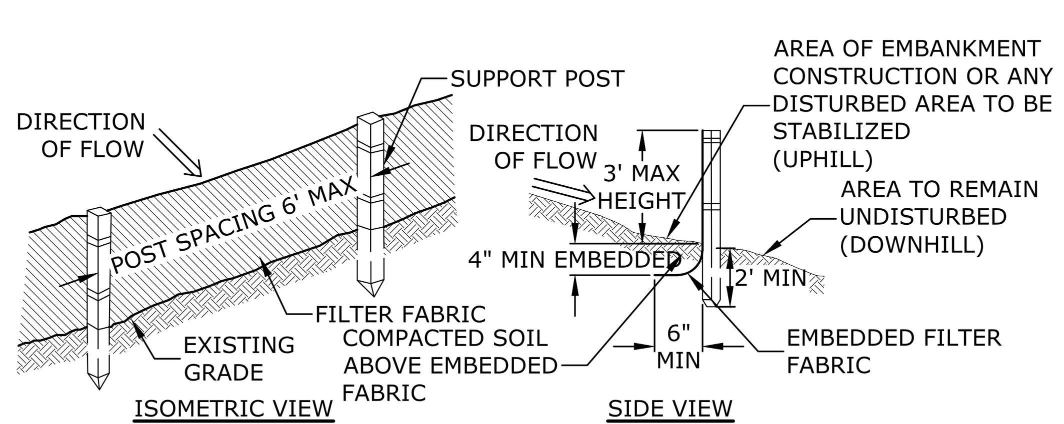
SILT SOCK
NO SCALE



* SLOPE AS REQUIRED FOR DRAINAGE (2% MAX)

TYPICAL ACCESS ROAD SECTION
NO SCALE

NOTES:
1. SILT FENCE SHALL BE INSTALLED PER MANUFACTURER'S RECOMMENDATIONS.
2. ADJOINING SECTIONS OF THE FENCE SHALL BE OVERLAPPED BY 6 INCHES, FOLDED AND STAPLED TO A SUPPORT POST.
3. THE MAXIMUM CONTRIBUTING DRAINAGE AREA ABOVE THE FENCE SHOULD BE LESS THAN ¼ ACRE PER 100 LINEAR FEET OF FENCE;
4. THE MAXIMUM LENGTH OF SLOPE ABOVE THE FENCE SHOULD BE 100 FEET;
5. THE MAXIMUM SLOPE ABOVE THE FENCE SHOULD BE 2:1;
6. FENCES SHOULD BE INSTALLED FOLLOWING THE CONTOUR OF THE LAND AS CLOSELY AS POSSIBLE, AND
    a. THE ENDS OF THE FENCE SHOULD BE FLARED UPSLOPE;
    b. THE FABRIC SHOULD BE EMBEDDED A MINIMUM OF 4 INCHES IN DEPTH AND 4 INCHES IN WIDTH IN A TRENCH EXCAVATED INTO THE GROUND, OR IF SITE CONDITIONS INCLUDE FROZEN GROUND, LEDGE, OR THE PRESENCE OF HEAVY ROOTS, THE BASE OF THE FABRIC SHOULD BE EMBEDDED WITH A MINIMUM THICKNESS OF 8 INCHES OF ¾-INCH STONE;
    c. THE SOIL SHOULD BE COMPACTED OVER THE EMBEDDED FABRIC;
    d. SUPPORT POSTS SHOULD BE SIZED AND ANCHORED ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS WITH MAXIMUM POST SPACING OF 6 FEET;
    e. ADJOINING SECTIONS OF THE FENCE SHOULD BE OVERLAPPED BY A MINIMUM OF 6 INCHES (24 INCHES IS PREFERRED), FOLDED AND STAPLED TO A SUPPORT POST. IF METAL POSTS ARE USED, FABRIC SHOULD BE WIRE-TIED DIRECTLY TO THE POSTS WITH THREE DIAGONAL TIES.
5. SILT FENCING SHOULD NOT BE STAPLED OR NAILED TO TREES.
6. THE FILTER FABRIC SHOULD BE A PERVIOUS SHEET OF PROPYLENE, NYLON, POLYESTER OR ETHYLENE YARN AND SHOULD BE CERTIFIED BY THE MANUFACTURER OR SUPPLIER.
7. THE FILTER FABRIC SHOULD CONTAIN ULTRAVIOLET RAY INHIBITORS AND STABILIZERS TO PROVIDE A MINIMUM OF 6 MONTHS OF EXPECTED USABLE CONSTRUCTION LIFE AT A TEMPERATURE RANGE OF 0 DEGREES FAHRENHEIT TO 120 DEGREES FAHRENHEIT.
8. POSTS FOR SILT FENCES SHOULD BE EITHER 4-INCH DIAMETER WOOD OR 1.33 POUNDS PER LINEAR FOOT STEEL WITH A MINIMUM LENGTH OF 5 FEET. STEEL POSTS SHOULD HAVE PROJECTIONS FOR FASTENING WIRE TO THEM. POSTS SHOULD BE PLACED ON THE DOWNSLOPE SIDE OF THE FABRIC.
9. THE HEIGHT OF A SILT FENCE SHOULD NOT EXCEED 36 INCHES AS HIGHER FENCES MAY IMPOUND VOLUMES OF WATER SUFFICIENT TO CAUSE FAILURE OF THE STRUCTURE.
10. THE FILTER FABRIC SHOULD BE PURCHASED IN A CONTINUOUS ROLL CUT TO THE LENGTH OF THE BARRIER TO AVOID THE USE OF JOINTS. WHEN JOINTS ARE NECESSARY, FILTER CLOTH SHOULD BE SPLICED TOGETHER ONLY AT SUPPORT POST, WITH A MINIMUM 6-INCH OVERLAP, AND SECURELY SEALED.
11. A MANUFACTURED SILT FENCE SYSTEM WITH INTEGRAL POSTS MAY BE USED.
12. POST SPACING SHOULD NOT EXCEED 6 FEET.
13. CONTRACTOR TO INSTALL SILT FENCE IN J-HOOK OR SMILE CONFIGURATION TO LIMIT CONCENTRATION OF STORMWATER RUNOFF AT A SINGLE DISHCARGE POINT.
14. A TRENCH SHOULD BE EXCAVATED APPROXIMATELY 4 INCHES WIDE AND 4 INCHES DEEP ALONG THE LINE OF POSTS AND UPGRADIENT FROM THE BARRIER.
15. THE STANDARD STRENGTH OF FILTER FABRIC SHOULD BE STAPLED OR WIRED TO THE POST, AND 8 INCHES OF THE FABRIC SHOULD BE EXTENDED INTO THE TRENCH. THE FABRIC SHOULD NOT EXTEND MORE THAN 36 INCHES ABOVE THE ORIGINAL GROUND SURFACE.
16. THE INSTALLATION TRENCH SHOULD BE BACKFILLED AND THE SOIL COMPACTED OVER THE FILTER FABRIC.
17. SILT FENCE MAY BE INSTALLED BY “SLICING” USING MECHANICAL EQUIPMENT SPECIFICALLY DESIGNED FOR THIS PROCEDURE. THE SLICING METHOD USES AN IMPLEMENT TOWED BEHIND A TRACTOR TO “PLOW” OR SLICE THE SILT FENCE MATERIAL INTO THE SOIL. THE SLICING METHOD MINIMALLY DISRUPTS THE SOIL UPWARD AND SLIGHTLY DISPLACES THE SOIL, MAINTAINING THE SOIL'S PROFILE AND CREATING AN OPTIMAL CONDITION FOR SUBSEQUENT MECHANICAL COMPACTION.
18. SILT FENCES SHOULD BE INSTALLED WITH “SMILES” OR “J-HOOKS” TO REDUCE THE DRAINAGE AREA THAT ANY SEGMENT WILL IMPOUND.
19. SILT FENCES PLACED AT THE TOE OF A SLOPE SHOULD BE SET AT LEAST 6 FEET FROM THE TOE TO ALLOW SPACE FOR SHALLOW PONDING AND TO ALLOW FOR MAINTENANCE ACCESS WITHOUT DISTURBING THE SLOPE.
20. SILT FENCES SHOULD BE REMOVED WHEN THEY HAVE SERVED THEIR USEFUL PURPOSE, BUT NOT BEFORE THE UPSLOPE AREAS HAVE BEEN PERMANENTLY STABILIZED.



SILT FENCE
NO SCALE

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CONCEPTUAL DRAWINGS

NOT FOR CONSTRUCTION

Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK
CHECKED:	DCM
APPROVED:	SES

DETAILS

SCALE: AS SHOWN

SHEET 7

Appendix E
Boring Logs from Southern Side of River

Tighe&Bond
Engineers | Environmental Specialists

Boring No. B-1
Page 1 of 1
File No. I-0066
Checked by:

Project: Ipswich Siphon and Sewer Design
Location: Ipswich River near South Main Street, Ipswich
Client: Town of Ipswich

Drilling Co. New England Boring Contractors
Foreman: W. Hoeckele
T&B Rep.: J. Libby
Date Start: 8/15/18 End: 8/15/18
Location See Exploration Location Plan
GS. Elev. Datum:

	Casing	Sampler
Type	Casing	Split Spoon
I.D./O.D.	4"/4.5"	1-3/8"/2"
Hammer Wt.	140#	140#
Hammer Fall	30"	30"
Rig Make/Model	Track Rig	

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
See Note 1				

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes	Well Construction
		S1/6	0-2	2-2		S1:Loose, brown, fine to medium SAND, some Silt, trace Gravel, dry	SAND		No Well Installed
				5-6					
		S2/5	2-4	4-2		S2:Loose, brown, fine to coarse SAND, little Gravel, little Silt, dry			
				2-2			4'		
5		S3/3	4-6	3-2		S3:Loose, brown GRAVEL, some fine to coarse SAND, trace Silt, wet	GRAVEL	1	
	31			6-18			6'		
	47	S4/4	6-8	9-5		S4:Loose, brown, fine to coarse SAND, some Silt, little Gravel, wet	SAND		
	48			5-8			8'	2	
	Push	S5/20	8-10	2-5		S5:Stiff, grey CLAY, wet	CLAY		
10	Push			6-7					
	Push	S6/24	10-12	10-7		S6:Stiff, grey CLAY, wet			
	Push			6-7			12'		
	Push	S7/24	12-14	1-3		S7:Medium, grey, Silty CLAY, wet	Silty CLAY		
	Push			4-4					
15	Push	S8/24	14-16	1-1		S8:Soft, grey, Silty CLAY, wet			
	Push			2-2					
	Push	S9/28	16-18	1-3		S9:Medium, grey, Silty CLAY, wet; some Gravel at tip			
	Push			2-13			18'	3	
	Push	S10/11	18-20	6-10		S10:Medium Dense, grey Gravel, some Silt, little Clay, trace fine to coarse SAND, wet	Gravel		
20	64			11-13			20'		
	52	S11/4	20-22	7-8		S11:Medium Dense, grey, fine to coarse SAND, some Gravel, little Silt, trace Clay, wet	SAND		
	32			9-10					
	53								
	52								
25	53	S12/6	24-26	14-14		S12:Medium Dense, grey, fine to coarse SAND, some Gravel, little Silt, trace Clay, wet			
				14-14					
		S13/5	27-29	18-8		S11:Medium Dense, grey, fine to coarse SAND, some Gravel, little Silt, trace Clay, wet			
				11-45			29'		
30						**End of Exploration at 29 ft**			

Notes:
1. Groundwater encountered at approximately 4 ft BGS, based on sample wetness.
2. Based on drillers observations, clay started at approximately 7.5ft BGS.
3. Based on drillers observations, gravel started at approximately 17.5 ft BGS.
4. During casing recovery the bottom casing (4ft), threads, and 1ft of the second to bottom casing sheared off at approximately 19ft BGS.

Proportions Used

TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	

Appendix B
Advantages and Disadvantages of Alternatives

Alternative	Construction Cost	Environmental Impact Areas				Advantages	Disadvantages
		Rescource Area	Temporary Impacts	Permanent Impacts	Total Proposed Disturbance		
Single barrel Siphon (6”)	---					-Lowest cost alternative	- Not an acceptable alternative because cannot accommodate projected peak flow - Not an acceptable alternative because cannot not provide redundancy, serviceability, or future capacity
Second Barrel Siphon (6”/6”/6”)		Coastal Bank (lf)	39	671	710		
(6”/6”)		LUWW (sf)	1,898	7,321	9,219		
Open Cut		LSCSF (sf)	13,426	12,067	25,493	-Can accommodate the current and projected future peak flow	
		Riverfront Area (sf)	20,251	21,654	41,905		
		Total (sf)	**35,614**	**41,713**	**77,327**		
Excavation		**Total +10% Contingency (sf)**	**39,175**	**45,884**	**85,060**		
Triple Barrel Siphon (6”/6”/6”)		Coastal Bank (lf)	39	671	710	-Incremental cost increase compared to double barrel approach	-Higher cost than alternatives with no redundancy
Open Cut		LUWW (sf)	1,898	7,321	9,219	-Can accommodate the current and projected future peak flow	-Potential schedule and cost impacts related to obtaining permits and approvals
Excavation		LSCSF (sf)	13,426	12,067	25,493	-Provides redundancy	-Construction difficulties associated with cofferdam construction and potential high groundwater
	$900,000	Riverfront Area (sf)	20,251	21,654	41,905	-More local contractors able to perform and bid on work	
		Total (sf)	**35,614**	**41,713**	**77,327**	-Greater competition can result in lower construction costs	
		Total +10% Contingency (sf)	**39,175**	**45,884**	**85,060**	-Allow for proposed pipe to be accurately set for line and grade	
						-Unanticipated obstructions can be handled normally without significant impacts	
Triple Barrel Siphon (6”/6”/6”)		Coastal Bank (lf)	138	586	724	-Can accommodate the current and projected future peak flow	-Higher cost than alternatives with no redundancy
Horizontal Directional Drill Install		LUWW (sf)	183	6478	6661	-Provides redundancy	-HDD is less accurate and has potential for high points in final alignment
		LSCSF (sf)	10920	14728	25648	-Minimize surface disturbance	Large laydown area is required to stage the work. This area can become covered in drill mud.
	$1,660,000	Riverfront Area (sf)	23464	23330	46794	-Pipe can be installed below the river and groundwater table without a cofferdam	Frac-out (or blow out) could occur resulting in loss of drilling mud into the river
		Total (sf)	**34,567**	**44,535**	**79,102**	-Simply environmental permitting or approvals since the river bottom would not be disturbed	-Requires rerouting of existing gravity collection system
		Total +10% Contingency (sf)	**38,024**	**48,989**	**87,012**		-Heavy impact on public during construction
Pipe Jacking							
Gravity Sewer	---					---	-Not an acceptable alternative because would result in an obstruction in a navigable water
		Coastal Bank (lf)	138	573	711		-Highest cost alternative
		LUWW (sf)	183	6,023	6,206		-Requires rerouting of existing gravity collection system
		LSCSF (sf)	10920	14,162	25,082		-Requires additional cost for force main installation to discharge manhole
Pump Station	$1,700,000	Riverfront Area (sf)	18464	27,939	46,403	-Eliminates the low velocity and solids deposition concern	
		Total (sf)	**29,567**	**48,124**	**77,691**		
		Total +10% Contingency (sf)	**32,524**	**52,936**	**85,460**		-Increases annual operation and maintenance costs

Appendix C
Preliminary Hydrologic and Hydraulic Analysis Ipswich Siphon Evaluation and Repair

Ipswich Siphon Rehabilitation – Preliminary Hydraulic Analysis

TO: MEPA

FROM: David L. Azinheira, PE, CFM; Christina Wu

COPY: Ian Mead, PE, BCEE; Daniel O. Roop, PE

DATE: April 15, 2019

The purpose of this memorandum is to summarize the preliminary results of the hydrologic and hydraulic (H&H) analysis of the proposed siphon rehabilitation across the Ipswich River in Ipswich, Massachusetts performed by Tighe & Bond. Tighe & Bond performed this preliminary evaluation as part of the Ipswich Sewer Interceptor Rehabilitation and Siphon Replacement Project during Environmental Notification Form (ENF) review by the Massachusetts Environmental Policy Act Office (MEPA). Based on this preliminary analysis, the proposed encasement of the siphon within the Ipswich River will result in minimal changes in the velocity and water surface elevation during the 10-, 50-, 100-, and 500-year flood events during both backwater (using FEMA regulatory backwater elevations) and non-backwater (using Mean High Water) conditions.

1. Description of Siphon

The existing sewer siphon is an 18" cast iron interceptor that is located along the northern bank of the Ipswich River between South Main street and County Street and crosses the river approximately 300 downstream (east) of the South Main Street Bridge (also known as Choate Bridge). The Town of Ipswich intends to rehabilitate and protect the existing interceptor by encasing it in concrete for physical protection and install toe stone at the base to protect from undercutting. The northern side of the interceptor will be stabilized and filled with native soil. An overview of the project area is provided in Attachment A.

2. Methodology

Tighe & Bond performed a preliminary H&H analysis using hydrologic information provided in the Federal Emergency Management Agency (FEMA) Flood Insurance Study (FIS) Report for Essex County, Massachusetts revised July 19, 2018. We then used these values in HEC-RAS, an Army Corps of Engineers Hydraulic Modeling Program, to perform the preliminary H&H analysis. Dimensions of the Choate Bridge were provided by the historical construction drawings of the existing sewer siphon. Tighe & Bond compared existing conditions to the proposed conditions under both backwater and non-backwater conditions during the 10-, 50-, 100-, and 500-year flood events.

2.1 Hydrology

The hydrologic parameters used for this analysis are provided by the FEMA FIS Report for Essex County, Massachusetts. The peak discharges for each flood event are published in the FIS Report for the Ipswich River at Central Street in Ipswich, MA provided in Table 1. The flow rates were checked using regression analysis following the Zarriello 2017[1] approach available in the USGS Streamstats program[2]. The FIS flow rates fall within the 95-percent prediction intervals computed as part of the regression analysis. The backwater elevations are published in the FIS Report for the entire shoreline within Ipswich and are also shown in Table 1. Relevant pages from the FEMA FIS report are included in Attachment B. Mean High Water was established as 4.2 feet NAVD88 using National Oceanic and Atmospheric Administration (NOAA) Tide Station 8443970 in Boston, Massachusetts and NOAA Tide Station 8423898 in Fort Point New Hampshire.

TABLE 1
Summary of Hydrologic Parameters from FEMA and Regression Analysis

Flood Frequency	Peak Discharge, cfs	Regression Lower Limit of 95-percent Confidence Interval	Regression Upper Limit of 95-percent Confidence Interval	Atlantic Ocean Backwater Elevation, NAVD88
10-Year	2,023	1,400	5,730	7.7
50-Year	3,016	2,030	9,460	8.4
100-Year	3,251	2,280	11,300	8.7
500-Year	4,196	2,910	16,500	9.4

Two separate downstream boundary conditions were modeled for this study:

1. Backwater elevations from the Atlantic Ocean consistent with FEMA regulatory requirements.
2. Mean High Water elevations that provide less conservative water surface elevations, but will better represents potential changes due to construction if design storms occurred during more typical tide levels.

By looking at changes during both regulatory backwater conditions, and more typical high tide conditions, the potential impacts of the proposed construction are analyzed.

2.2 Hydraulics

To develop the HEC-RAS model, Tighe & Bond created a geometric representation of the channel using a LiDAR Digital Elevation Model (DEM) available from MassGIS. The LiDAR DEM was used to develop cross sections across the channel at points representing changes in channel geometry, slope, and roughness. Elevations of the siphon, channel bottom, and the Choate Bridge were determined using the survey performed by HL Graham Associates, Inc in March 2018, as well as the 1959 Siphon-Interceptor Plans. The hydrologic parameters from

[1] Zarriello, P.J.,2017, Magnitude of flood flows at selected annual exceedance probabilities for streams in Massachusetts: U.S. Geological Survey Scientific Investigations Report 2016–5156, 99 p.

[2] U.S. Geological Survey, 2016, The StreamStats program, online at http://streamstats.usgs.gov, accessed August 21, 2018.

the FEMA FIS Report were used as boundary conditions in the steady-state HEC-RAS hydraulic model. This preliminary model begins immediately downstream of the Ipswich Mills Dam and ends approximately 225 feet downstream of the siphon crossing using 17 cross sections. An overview of the modeled cross sections is provided in Attachment A. The Choate Bridge is modeled as two arches each spanning 30 feet with a height of 12 feet.

3. Results

The HEC-RAS model was analyzed using the above described hydrology and hydraulic methodology. The model results for the 10-, 50-, 100-, and 500-year flood events during backwater from the Atlantic Ocean and mean high water (MHW) conditions are presented in the tables below. Attachment C contains the model output for each of the flood events.

During backwater conditions from the Atlantic Ocean, the model suggests very little difference between the existing and proposed conditions in terms of velocity, and no change in water surface elevation. In this scenario, there is a difference in velocity of 0 to 0.3 ft/s between the existing and proposed conditions. The largest change in velocity are observed during the 500-year food event. In terms of water surface elevation, the changes are by less than 0.1 foot during any of the modeled flood events. The Atlantic Ocean backwater conditions are the regulatory FEMA conditions, so the proposed changes are determined to results in no-rise per the requirements of 44 Code of Federal Regulations (CFR) Section 60.3 (d) (3) for development within a regulated floodway.

During mean high water, the model also suggests minimal impact on velocity and water surface elevations due to proposed conditions. In terms of velocity, the model suggests a change ranging from 0 to 0.5 ft/s, with the largest difference occurring during the 500-year flood event. Changes in water surface elevation between existing and proposed conditions range from 0 ft to 0.1 ft, with the largest difference occurring during the 100- and 500-year flood events.

TABLE 2

Scenario 1: Downstream Backwater from Atlantic Ocean (From FEMA FIS Report) – Channel Velocities (ft/s)

		10-Year			50-Year			100-Year			500-Year		
Survey Cross Section	HEC-RAS Cross Section	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
	7177.681	2.0	2.0	0.0	2.7	2.7	0.0	2.8	2.8	0.0	3.2	3.2	0.0
	7019.873	2.9	2.9	0.0	3.9	3.9	0.0	4.0	4.0	0.0	4.6	4.6	0.0
	6858.394	1.9	1.9	0.0	2.6	2.6	0.0	2.7	2.7	0.0	3.0	3.0	0.0
	6784.991	1.7	1.7	0.0	2.2	2.2	0.0	2.3	2.3	0.0	2.6	2.6	0.0
	6696.837	1.9	1.9	0.0	2.5	2.5	0.0	2.6	2.6	0.0	3.0	3.0	0.0
102	6679.995	2.1	2.1	0.0	2.8	2.8	0.0	2.9	2.9	0.0	3.4	3.3	0.0
103	6664.527	2.2	2.2	0.1	2.9	3.0	0.1	3.0	3.1	0.1	3.6	3.6	0.0
104	6650.343	2.2	2.3	0.1	2.9	3.1	0.2	3.0	3.2	0.2	3.4	3.6	0.2
BRIDGE	6594.157												
109	6557.818	2.9	3.0	0.1	4.0	4.1	0.1	4.2	4.3	0.1	5.1	5.2	0.1
110	6544.761	2.8	2.7	-0.1	4.0	3.8	-0.2	4.2	4.0	-0.2	5.0	4.8	-0.3
	6527.842	2.7	2.7	0.0	3.8	3.8	0.0	3.9	3.9	0.0	4.8	4.8	0.0
	6439.968	2.1	2.1	0.0	2.9	2.9	0.0	3.1	3.1	0.0	3.7	3.7	0.0
SIPHON	6304.708	2.4	2.4	0.0	3.2	3.2	0.0	3.2	3.2	0.0	3.7	3.7	0.0
	6240.809	1.9	1.9	0.0	2.6	2.6	0.0	2.7	2.7	0.0	3.2	3.2	0.0
	6168.817	1.9	1.9	0.0	2.7	2.7	0.0	2.8	2.8	0.0	3.3	3.3	0.0
	6080.248	1.6	1.6	0.0	2.2	2.2	0.0	2.4	2.4	0.0	2.9	2.9	0.0

TABLE 3
Scenario 1: Downstream Backwater from Atlantic Ocean (From FEMA FIS Report) – Water Surface Elevation (NAVD88)

		10-Year			50-Year			100-Year			500-Year		
Survey Cross Section	HEC-RAS Cross Section	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
	7177.681	8.0	8.0	0.0	9.1	9.1	0.0	9.5	9.5	0.0	10.7	10.7	0.0
	7019.873	7.9	8.0	0.0	8.9	8.9	0.0	9.3	9.3	0.0	10.5	10.5	0.0
	6858.394	8.0	8.0	0.0	9.0	9.0	0.0	9.4	9.4	0.0	10.6	10.6	0.0
	6784.991	8.0	8.0	0.0	9.0	9.0	0.0	9.4	9.4	0.0	10.6	10.6	0.0
	6696.837	8.0	8.0	0.0	9.0	9.0	0.0	9.4	9.4	0.0	10.6	10.6	0.0
102	6679.995	8.0	8.0	0.0	9.0	9.0	0.0	9.3	9.4	0.0	10.5	10.5	0.0
103	6664.527	7.9	7.9	0.0	8.9	8.9	0.0	9.3	9.3	0.0	10.5	10.5	0.0
104	6650.343	7.9	7.9	0.0	8.9	8.9	0.0	9.3	9.3	0.0	10.5	10.5	0.0
BRIDGE	6594.157												
109	6557.818	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.4	9.4	0.0
110	6544.761	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.3	9.4	0.0
	6527.842	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.4	9.4	0.0
	6439.968	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.4	9.4	0.0
SIPHON	6304.708	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.4	9.4	0.0
	6240.809	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.4	9.4	0.0
	6168.817	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.4	9.4	0.0
	6080.248	7.7	7.7	0.0	8.4	8.4	0.0	8.7	8.7	0.0	9.4	9.4	0.0

TABLE 4
Scenario 2: Downstream Backwater from Atlantic Ocean (From FEMA FIS Report) – Channel Velocities (ft/s)

		10-Year			50-Year			100-Year			500-Year		
Survey Cross Section	HEC-RAS Cross Section	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
	7177.681	2.8	2.8	0.0	3.8	3.8	0.0	4.0	4.0	0.0	4.6	4.6	0.0
	7019.873	4.5	4.5	0.0	6.1	6.1	0.0	6.4	6.4	0.0	7.4	7.4	0.0
	6858.394	2.9	2.9	0.0	3.9	3.9	0.0	4.1	4.1	0.0	4.7	4.7	0.0
	6784.991	2.4	2.4	0.0	3.3	3.3	0.0	3.5	3.5	0.0	4.0	4.0	0.0
	6696.837	2.7	2.7	0.0	3.8	3.8	0.0	4.0	4.0	0.0	4.6	4.6	0.0
102	6679.995	3.1	3.0	0.0	4.2	4.2	-0.1	4.5	4.4	0.0	5.2	5.2	0.0
103	6664.527	3.3	3.4	0.1	4.5	4.7	0.2	4.7	5.0	0.2	5.5	5.8	0.3
104	6650.343	3.3	3.6	0.2	4.6	4.9	0.3	4.8	5.2	0.4	5.6	6.0	0.5
BRIDGE	6594.157												
109	6557.818	4.3	4.4	0.2	6.2	6.5	0.3	6.7	7.0	0.3	8.4	8.8	0.4
110	6544.761	4.3	4.1	-0.2	6.3	6.1	-0.3	6.8	6.5	-0.3	8.5	8.2	-0.4
	6527.842	4.0	4.0	0.0	5.8	5.8	0.0	6.2	6.2	0.0	7.8	7.8	0.0
	6439.968	3.1	3.1	0.0	4.6	4.6	0.0	4.9	4.9	0.0	6.1	6.1	0.0
SIPHON	6304.708	3.9	3.9	0.0	5.8	5.8	0.0	6.3	6.3	0.0	8.2	8.2	0.0
	6240.809	3.0	3.0	0.0	4.5	4.5	0.0	4.8	4.8	0.0	6.2	6.2	0.0
	6168.817	3.0	3.0	0.0	4.5	4.5	0.0	4.9	4.9	0.0	6.3	6.3	0.0
	6080.248	2.3	2.3	0.0	3.4	3.4	0.0	3.7	3.7	0.0	4.8	4.8	0.0

TABLE 5
Scenario 2: Downstream Backwater from Atlantic Ocean (From FEMA FIS Report) – Water Surface Elevation (NAVD88)

		10-Year			50-Year			100-Year			500-Year		
Survey Cross Section	HEC-RAS Cross Section	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference	Existing	Proposed	Difference
	7177.681	4.9	4.9	0.0	5.7	5.7	0.0	6.0	6.0	0.0	6.9	6.9	0.0
	7019.873	4.7	4.7	0.0	5.2	5.3	0.0	5.4	5.4	0.0	6.3	6.3	0.0
	6858.394	4.7	4.7	0.0	5.4	5.4	0.0	5.6	5.6	0.0	6.5	6.5	0.0
	6784.991	4.7	4.7	0.0	5.4	5.4	0.0	5.6	5.6	0.0	6.5	6.5	0.0
	6696.837	4.7	4.7	0.0	5.3	5.3	0.0	5.5	5.5	0.0	6.4	6.4	0.0
102	6679.995	4.7	4.7	0.0	5.2	5.3	0.0	5.4	5.4	0.0	6.3	6.3	0.0
103	6664.527	4.6	4.6	0.0	5.2	5.2	0.0	5.4	5.3	0.0	6.2	6.1	-0.1
104	6650.343	4.6	4.6	0.0	5.2	5.1	0.0	5.3	5.3	-0.1	6.2	6.1	-0.1
BRIDGE	6594.157												
109	6557.818	4.3	4.3	0.0	4.4	4.4	0.0	4.5	4.5	0.0	4.7	4.7	0.0
110	6544.761	4.3	4.3	0.0	4.4	4.4	0.0	4.4	4.5	0.0	4.6	4.7	0.1
	6527.842	4.3	4.3	0.0	4.4	4.4	0.0	4.5	4.5	0.0	4.7	4.7	0.0
	6439.968	4.3	4.3	0.0	4.5	4.5	0.0	4.6	4.6	0.0	4.8	4.8	0.0
SIPHON	6304.708	4.2	4.2	0.0	4.1	4.1	0.0	4.1	4.1	0.0	4.1	4.1	0.0
	6240.809	4.2	4.2	0.0	4.2	4.2	0.0	4.2	4.2	0.0	4.2	4.2	0.0
	6168.817	4.2	4.2	0.0	4.2	4.2	0.0	4.2	4.2	0.0	4.1	4.1	0.0
	6080.248	4.2	4.2	0.0	4.2	4.2	0.0	4.2	4.2	0.0	4.2	4.2	0.0

4. Conclusion

Based on the results of this preliminary hydrologic and hydraulic analysis of the Ipswich River in Ipswich, Massachusetts, Tighe & Bond believes that:

- The proposed repairs and rehabilitation will result in either minor impacts or no impacts on velocity and water surface elevations.
- No impacts are anticipated 100 feet or greater upstream of Choate Bridge, nor 70 feet or greater downstream of Choate Bridge.
- It is anticipated that the bank protection will provide a net increase to bank stability.

While the hydraulic changes are considered minor, a formal scour analysis will be performed for both backwater conditions as part of final design to evaluate if any changes in scour potential are anticipated. The sizing of stones for the bank toe will also be determined as part of final design.

Attachments

Attachment A – Figures

Attachment B – Data from FEMA

Attachment C – HEC-RAS Modeling Results

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ATTACHMENT A
Figures

FIGURE 1
SITE AERIAL OVERVIEW

Ipswich, Massachusetts
Sewer Interceptor and
Siphon Rehabilitation

April 2019

1:3,600

0 100 200 300
Feet

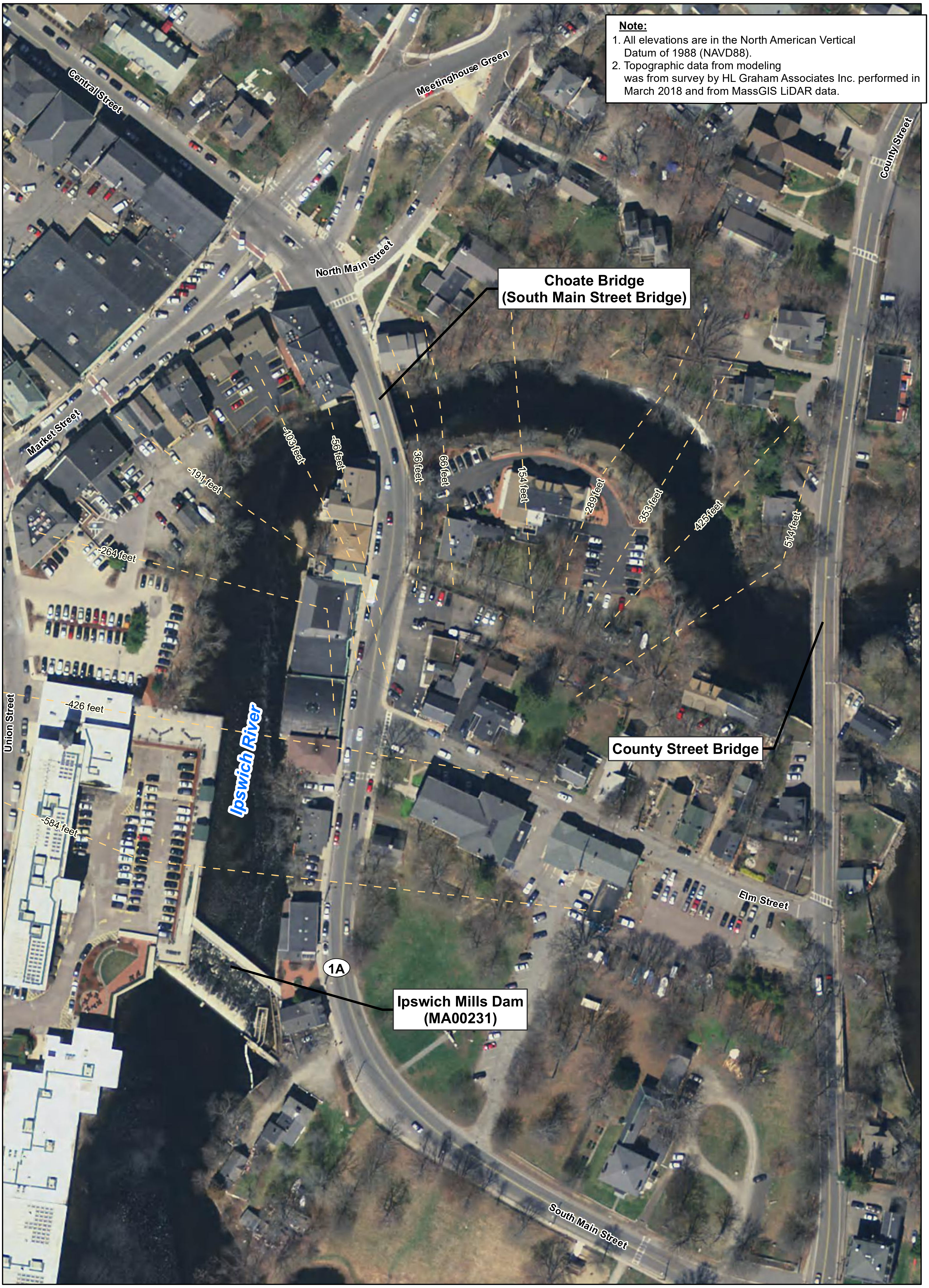
N

Tighe&Bond
Engineers | Environmental Specialists

Based on MassGIS Color Orthophotography (2013)

ebond.com\data\Data\Projects\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Report_Evaluation\Preliminary Hydraulic Analysis\Attachment A\MXD\Ipswich_Ortho.mxd

I-0066



LEGEND

Model Cross Section (label indicates feet downstream of Choate Bridge)

1 in = 100 ft

0 50 100

Feet

N

FIGURE 2
HYDRAULIC MODEL GEOMETRY

Ipswich, Massachusetts
Sewer Interceptor and
Siphon Rehabilitation

Tighe&Bond
Engineers | Environmental Specialists

Based on MassGIS Color Orthophotography (2013).

April 2019

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I-0066

ATTACHMENT B

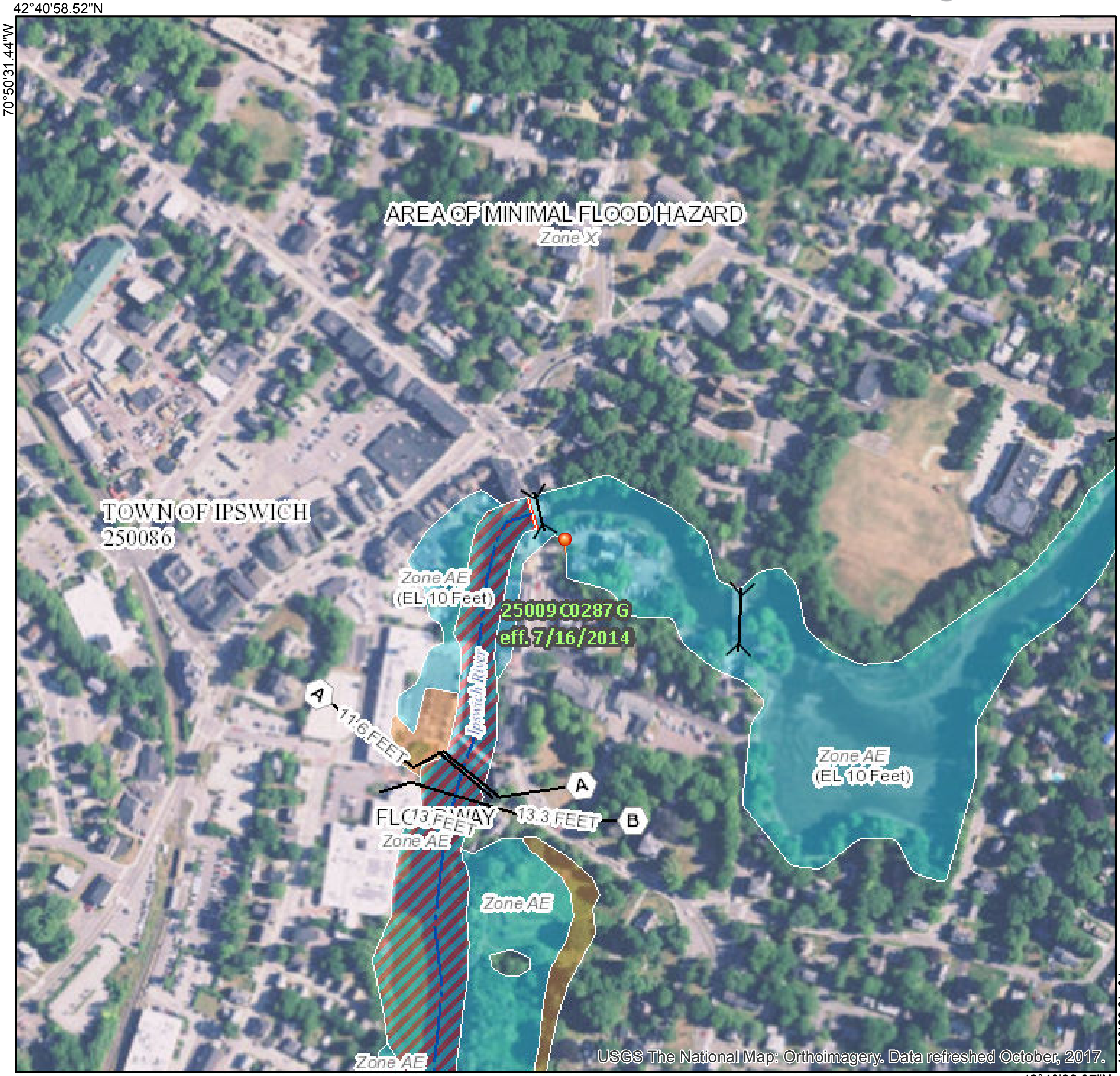
Data from FEMA

National Flood Hazard Layer FIRMette

FEMA

42°40'58.52"N

70°50'31.44"W



70°49'53.98"W

42°40'32.07"N

Feet 1:6,000

0 250 500 1,000 1,500 2,000

Legend

SEE FIS REPORT FOR DETAILED LEGEND AND INDEX MAP FOR FIRM PANEL LAYOUT

SPECIAL FLOOD HAZARD AREAS

- Without Base Flood Elevation (BFE) *Zone A, V, A99*
- With BFE or Depth *Zone AE, AO, AH, VE, AR*
- Regulatory Floodway

OTHER AREAS OF FLOOD HAZARD

- 0.2% Annual Chance Flood Hazard, Areas of 1% annual chance flood with average depth less than one foot or with drainage areas of less than one square mile *Zone X*
- Future Conditions 1% Annual Chance Flood Hazard *Zone X*
- Area with Reduced Flood Risk due to Levee. See Notes. *Zone X*
- Area with Flood Risk due to Levee *Zone D*

OTHER AREAS

- NO SCREEN Area of Minimal Flood Hazard *Zone X*
- Effective LOMRs
- Area of Undetermined Flood Hazard *Zone D*

GENERAL STRUCTURES

- Channel, Culvert, or Storm Sewer
- Levee, Dike, or Floodwall

OTHER FEATURES

- B 20.2 / 17.5 Cross Sections with 1% Annual Chance Water Surface Elevation
- 8 Coastal Transect
- 513 Base Flood Elevation Line (BFE)
- Limit of Study
- Jurisdiction Boundary
- Coastal Transect Baseline
- Profile Baseline
- Hydrographic Feature

MAP PANELS

- Digital Data Available
- No Digital Data Available
- Unmapped

N

The pin displayed on the map is an approximate point selected by the user and does not represent an authoritative property location.

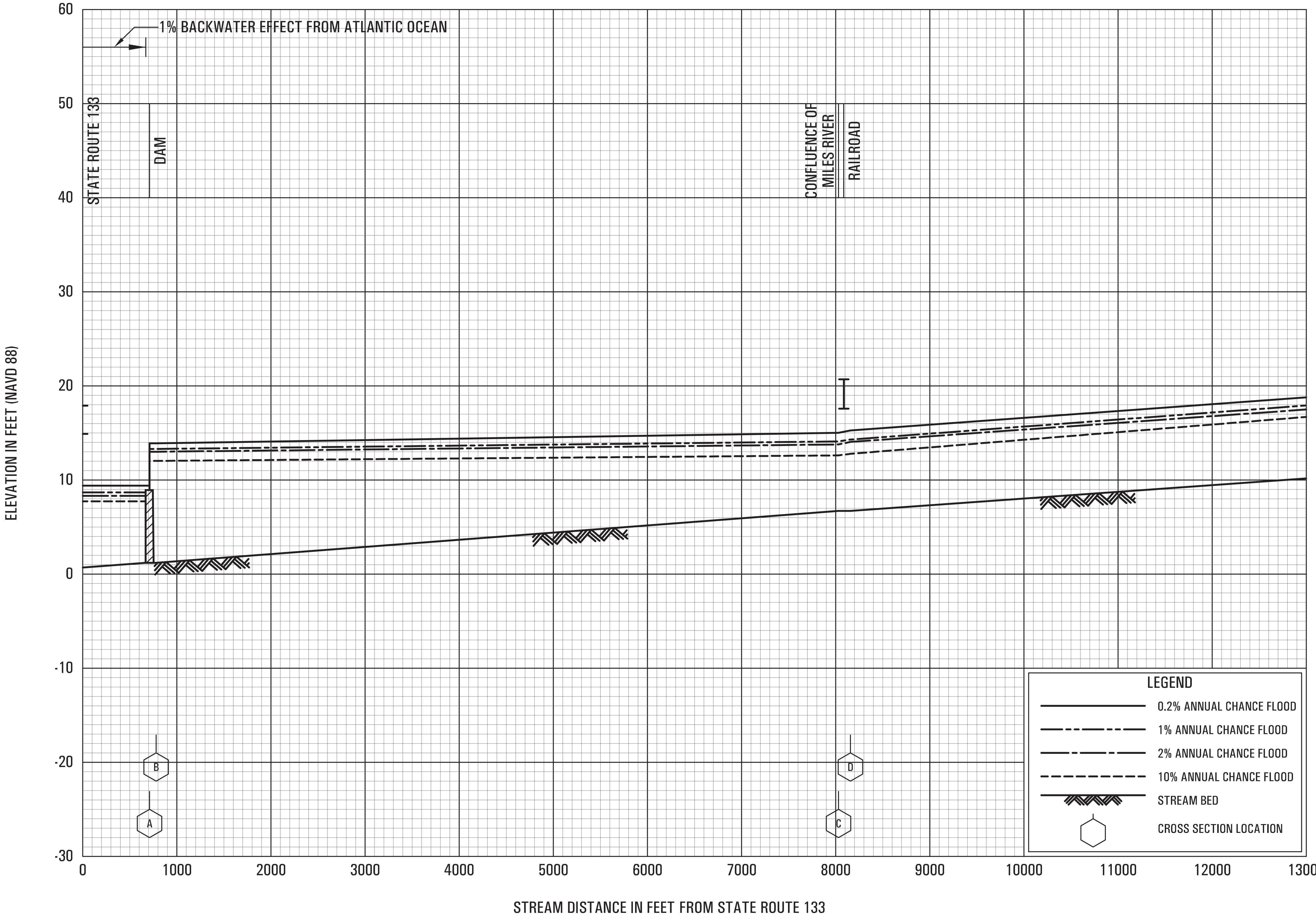
This map complies with FEMA's standards for the use of digital flood maps if it is not void as described below. The basemap shown complies with FEMA's basemap accuracy standards

The flood hazard information is derived directly from the authoritative NFHL web services provided by FEMA. This map was exported on 3/5/2019 at 8:34:30 AM and does not reflect changes or amendments subsequent to this date and time. The NFHL and effective information may change or become superseded by new data over time.

This map image is void if the one or more of the following map elements do not appear: basemap imagery, flood zone labels, legend, scale bar, map creation date, community identifiers, FIRM panel number, and FIRM effective date. Map images for unmapped and unmodernized areas cannot be used for regulatory purposes.

TABLE 6 – SUMMARY OF DISCHARGES-continued

FLOODING SOURCE AND LOCATION	DRAINAGE AREA (SQUARE MILES)	PEAK DISCHARGES (CUBIC FEET PER SECOND) 10-PERCENT ANNUAL CHANCE	2-PERCENT ANNUAL CHANCE	1-PERCENT ANNUAL CHANCE	0.2-PERCENT ANNUAL CHANCE
Hussey Brook					
IPSWICH RIVER					
At Central Street in Ipswich	148.00	2,023	3,016	3,251	4,196
At corporate limits in Topsfield	120.90	1,880	2,700	3,070	3,980
At confluence with Mile Brook	109.30	1,755	2,520	2,860	3,725
IPSWICH RIVER – cont'd					
At confluence of Branch of Ipswich	92.60	1,360	2,080	2,440	3,430
At Middleton/Topsfield / Boxford Corporate Limits in Middleton	76.10	1,077	1,584	1,829	2,478
Downstream of Boston Brook in Middleton	71.90	1,023	1,506	1,741	2,366
Downstream of Tributary A to Ipswich River	53.80	790	1,173	1,362	1,872
Middleton/Danvers Corporate Limits south of State Route 114	50.90	750	1,120	1,300	1,790
Downstream of Norris Brook in Danvers	48.20	720	1,070	1,240	1,710
At Peabody/Danvers/ Middleton Corporate Limits	44.60	630	930	1,130	1,620
At Middleton/North Reading Corporate Limits	42.50	630	930	1,130	1,620
JACKMAN BROOK					
Georgetown/Newbury	1.38	24	39	47	72



FLOOD PROFILES

IPSWICH RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

ESSEX COUNTY, MA

(ALL JURISDICTIONS)

The pre-countywide stillwater elevations for the 10-, 2-, 1-, and 0.2-percent-annual-chance floods have been determined and are shown in Table 8. The analyses reported in this study reflect the stillwater elevations, shown in Table 8, due to tidal and wind setup effects and include the contributions from wave action effects.

TABLE 8 - PRECOUNTYWIDE SUMMARY OF STILLWATER ELEVATIONS

	ELEVATION (feet NAVD 88)[1]			
FLOODING SOURCE AND LOCATION	10-PERCENT	2-PERCENT	1-PERCENT	0.2-PERCENT
ATLANTIC OCEAN				
Affecting Essex Bay for Its entire length within The corporate limits of Essex	7.8	8.5	8.8	9.5
North Coast In Gloucester	7.8	8.6	8.9	9.6
South Coast In Gloucester	7.1	7.9	8.2	9.0
Entire shoreline within Ipswich	7.7	8.4	8.7	9.4
At Nahant Bay In Lynn	7.6	8.4	8.8	9.6
Saugus River General Edwards Bridge to Salem Turnpike in Lynn	7.2	7.8	8.2	9.0
Salem Turnpike to Boston Street in Lynn	6.7	7.3	7.6	8.4
At Lynn Harbor In Lynn	8.0	8.8	9.2	9.9
Entire coastline of Manchester	7.3	8.1	8.4	9.2
Entire coastline of Marblehead	7.6	8.4	8.8	9.5
Entire coastline within Nanhant	7.7	8.5	8.9	9.7

[1]North American Vertical Datum of 1988

ATTACHMENT C
HEC-RAS Modeling Results

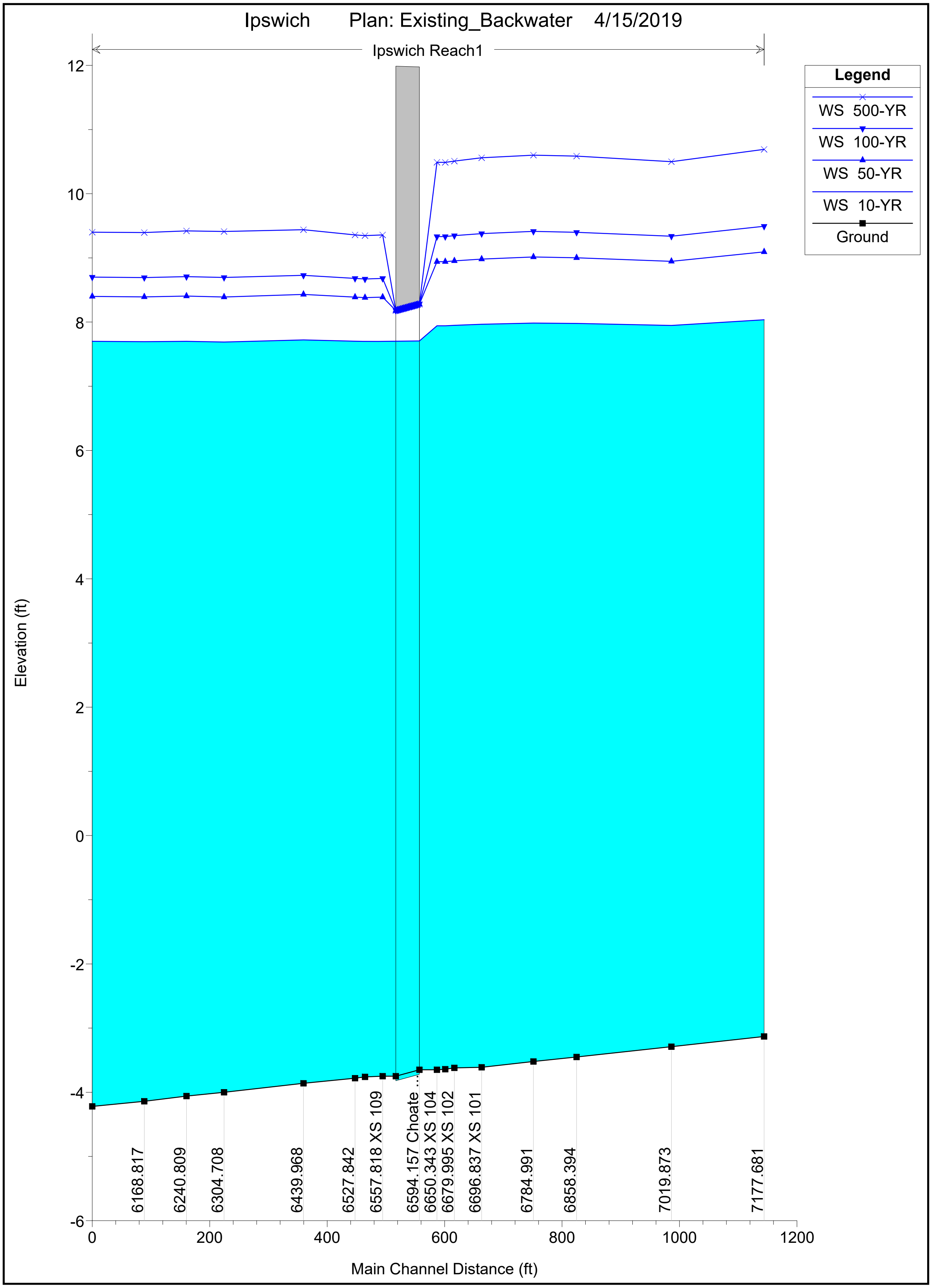
SCENARIO 1: ATLANTIC OCEAN BACKWATER - EXISTING CONDITIONS

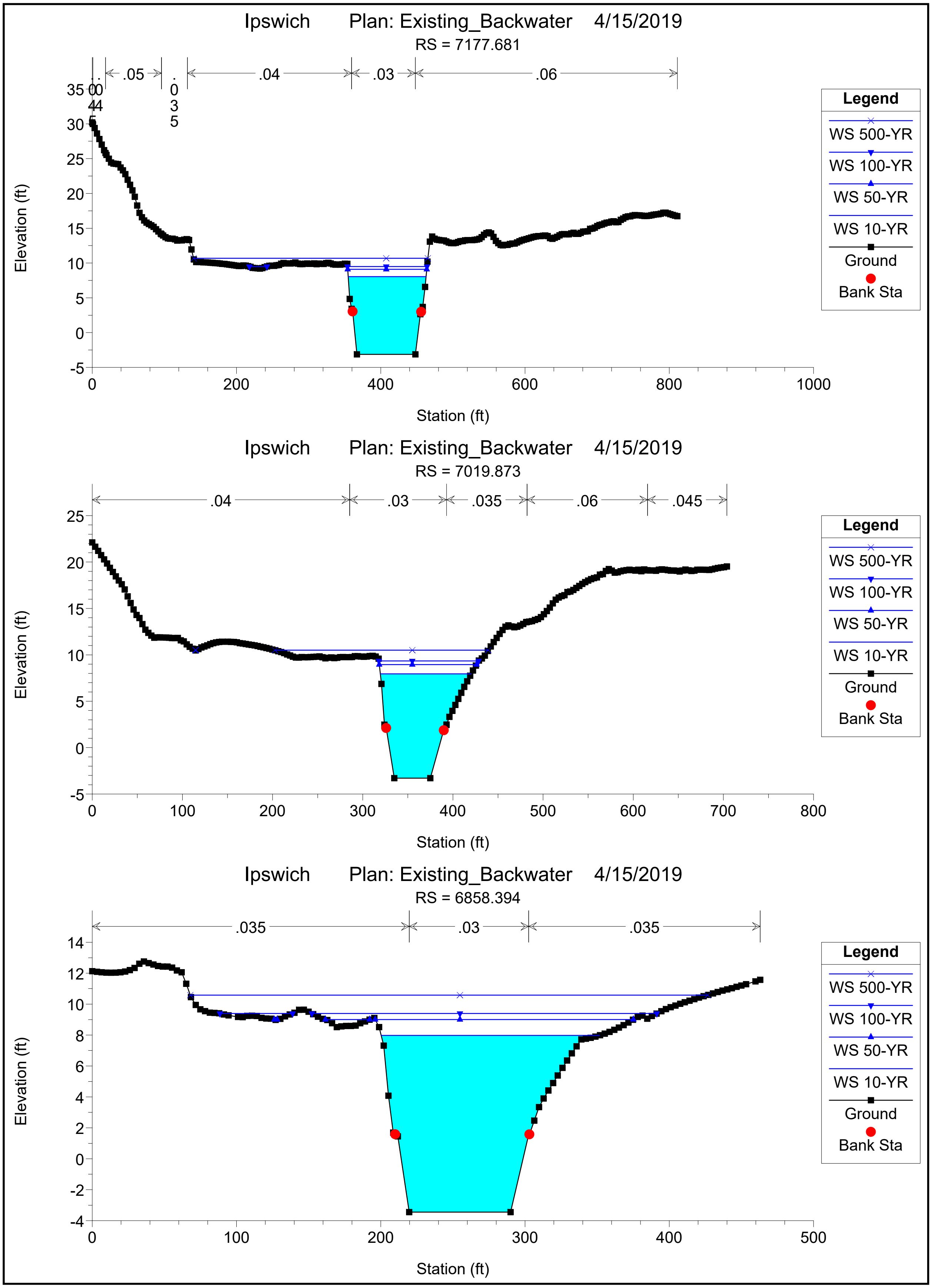
HEC-RAS Plan: backwater River: Ipswich Reach: Reach1

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	7177.681	10-YR	2023.00	-3.13	8.03	1.97	1057.21
Reach1	7177.681	50-YR	3016.00	-3.13	9.09	2.66	1172.20
Reach1	7177.681	100-YR	3251.00	-3.13	9.49	2.77	1220.12
Reach1	7177.681	500-YR	4196.00	-3.13	10.69	3.18	1536.61
Reach1	7019.873	10-YR	2023.00	-3.29	7.94	2.89	765.47
Reach1	7019.873	50-YR	3016.00	-3.29	8.94	3.86	869.38
Reach1	7019.873	100-YR	3251.00	-3.29	9.33	3.99	912.22
Reach1	7019.873	500-YR	4196.00	-3.29	10.49	4.57	1123.73
Reach1	6858.394	10-YR	2023.00	-3.45	7.98	1.93	1141.80
Reach1	6858.394	50-YR	3016.00	-3.45	9.00	2.59	1320.43
Reach1	6858.394	100-YR	3251.00	-3.45	9.39	2.69	1420.51
Reach1	6858.394	500-YR	4196.00	-3.45	10.58	3.00	1815.62
Reach1	6784.991	10-YR	2023.00	-3.52	7.98	1.65	1323.34
Reach1	6784.991	50-YR	3016.00	-3.52	9.01	2.22	1546.45
Reach1	6784.991	100-YR	3251.00	-3.52	9.41	2.29	1650.90
Reach1	6784.991	500-YR	4196.00	-3.52	10.60	2.59	1988.40
Reach1	6696.837	10-YR	2023.00	-3.61	7.96	1.88	1143.67
Reach1	6696.837	50-YR	3016.00	-3.61	8.98	2.54	1320.19
Reach1	6696.837	100-YR	3251.00	-3.61	9.37	2.62	1406.44
Reach1	6696.837	500-YR	4196.00	-3.61	10.55	2.97	1700.66
Reach1	6679.995	10-YR	2023.00	-3.62	7.95	2.08	1050.06
Reach1	6679.995	50-YR	3016.00	-3.62	8.95	2.81	1182.42
Reach1	6679.995	100-YR	3251.00	-3.62	9.34	2.91	1247.23
Reach1	6679.995	500-YR	4196.00	-3.62	10.50	3.38	1504.12
Reach1	6664.527	10-YR	2023.00	-3.64	7.94	2.18	1008.56
Reach1	6664.527	50-YR	3016.00	-3.64	8.94	2.93	1134.27
Reach1	6664.527	100-YR	3251.00	-3.64	9.33	3.04	1186.41
Reach1	6664.527	500-YR	4196.00	-3.64	10.48	3.55	1375.99
Reach1	6650.343	10-YR	2023.00	-3.65	7.94	2.16	1017.57
Reach1	6650.343	50-YR	3016.00	-3.65	8.94	2.88	1153.11
Reach1	6650.343	100-YR	3251.00	-3.65	9.33	2.98	1209.26
Reach1	6650.343	500-YR	4196.00	-3.65	10.49	3.42	1385.62
Reach1	6594.157		Culvert				
Reach1	6557.818	10-YR	2023.00	-3.75	7.70	2.86	756.55
Reach1	6557.818	50-YR	3016.00	-3.75	8.38	3.98	817.64
Reach1	6557.818	100-YR	3251.00	-3.75	8.67	4.18	844.44
Reach1	6557.818	500-YR	4196.00	-3.75	9.35	5.07	908.61
Reach1	6544.761	10-YR	2023.00	-3.76	7.69	2.84	765.28
Reach1	6544.761	50-YR	3016.00	-3.76	8.38	3.96	828.87
Reach1	6544.761	100-YR	3251.00	-3.76	8.67	4.15	856.91
Reach1	6544.761	500-YR	4196.00	-3.76	9.34	5.03	923.86

HEC-RAS Plan: backwater River: Ipswich Reach: Reach1 (Continued)

Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	6527.842	10-YR	2023.00	-3.78	7.70	2.69	801.06
Reach1	6527.842	50-YR	3016.00	-3.78	8.39	3.75	869.49
Reach1	6527.842	100-YR	3251.00	-3.78	8.68	3.94	899.95
Reach1	6527.842	500-YR	4196.00	-3.78	9.36	4.80	990.13
Reach1	6439.968	10-YR	2023.00	-3.86	7.72	2.12	1038.16
Reach1	6439.968	50-YR	3016.00	-3.86	8.43	2.94	1154.00
Reach1	6439.968	100-YR	3251.00	-3.86	8.73	3.08	1212.51
Reach1	6439.968	500-YR	4196.00	-3.86	9.44	3.67	1393.40
Reach1	6304.708	10-YR	2023.00	-4.00	7.69	2.36	959.86
Reach1	6304.708	50-YR	3016.00	-4.00	8.39	3.15	1115.98
Reach1	6304.708	100-YR	3251.00	-4.00	8.70	3.22	1195.30
Reach1	6304.708	500-YR	4196.00	-4.00	9.41	3.67	1392.17
Reach1	6240.809	10-YR	2023.00	-4.06	7.70	1.93	1240.25
Reach1	6240.809	50-YR	3016.00	-4.06	8.41	2.62	1404.72
Reach1	6240.809	100-YR	3251.00	-4.06	8.71	2.72	1479.90
Reach1	6240.809	500-YR	4196.00	-4.06	9.42	3.21	1667.03
Reach1	6168.817	10-YR	2023.00	-4.14	7.70	1.92	1164.34
Reach1	6168.817	50-YR	3016.00	-4.14	8.39	2.65	1290.87
Reach1	6168.817	100-YR	3251.00	-4.14	8.69	2.76	1352.05
Reach1	6168.817	500-YR	4196.00	-4.14	9.40	3.29	1498.55
Reach1	6080.248	10-YR	2023.00	-4.22	7.70	1.59	1317.55
Reach1	6080.248	50-YR	3016.00	-4.22	8.40	2.23	1410.70
Reach1	6080.248	100-YR	3251.00	-4.22	8.70	2.35	1451.51
Reach1	6080.248	500-YR	4196.00	-4.22	9.40	2.86	1549.15


Ipswich Plan: Existing_Backwater 4/15/2019
Ipswich Reach1
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Elevation (ft)
Main Channel Distance (ft)
6168.817
6240.809
6304.708
6439.968
6527.842
6557.818 XS 109
6594.157 Choate ...
6650.343 XS 104
6679.995 XS 102
6696.837 XS 101
6784.991
6858.394
7019.873
7177.681
12
10
8
6
4
2
0
-2
-4
-6
0
200
400
600
800
1000
1200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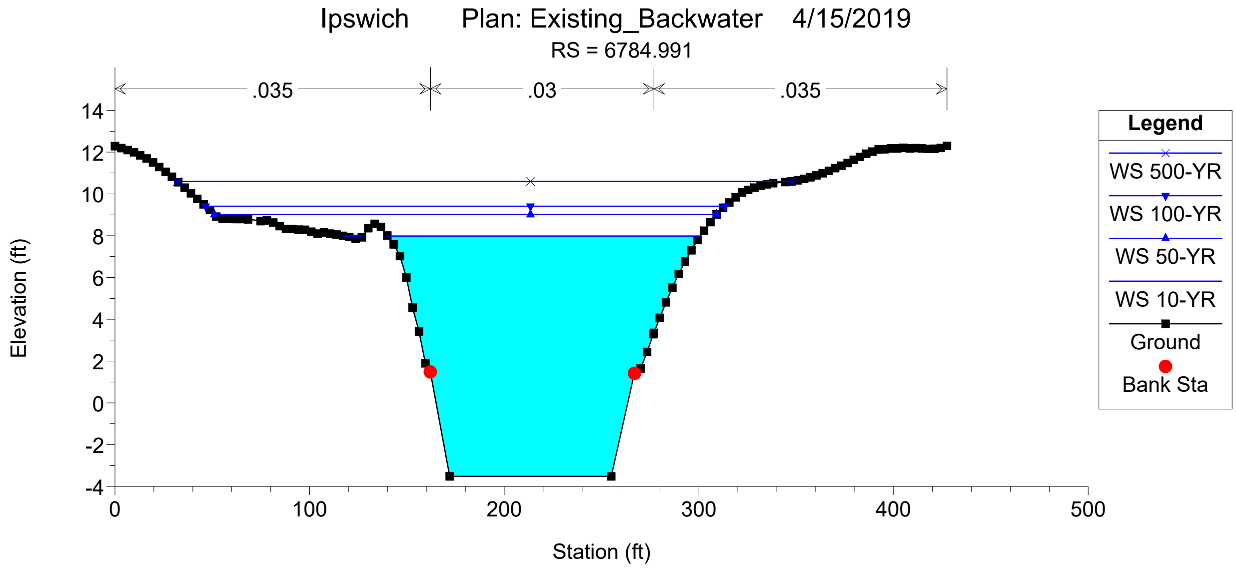
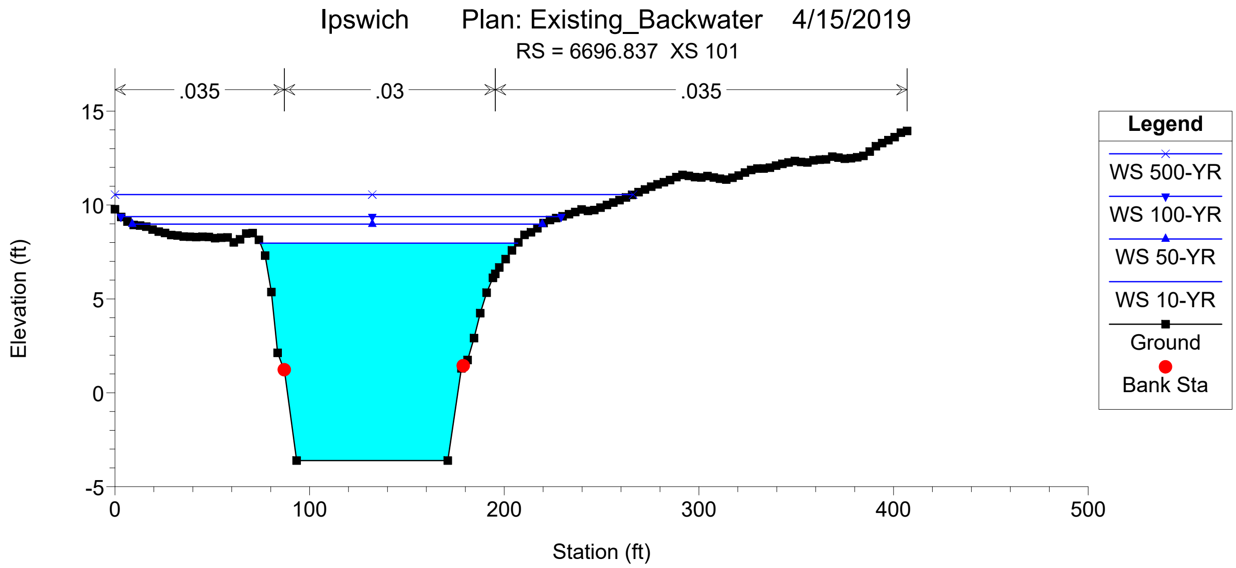
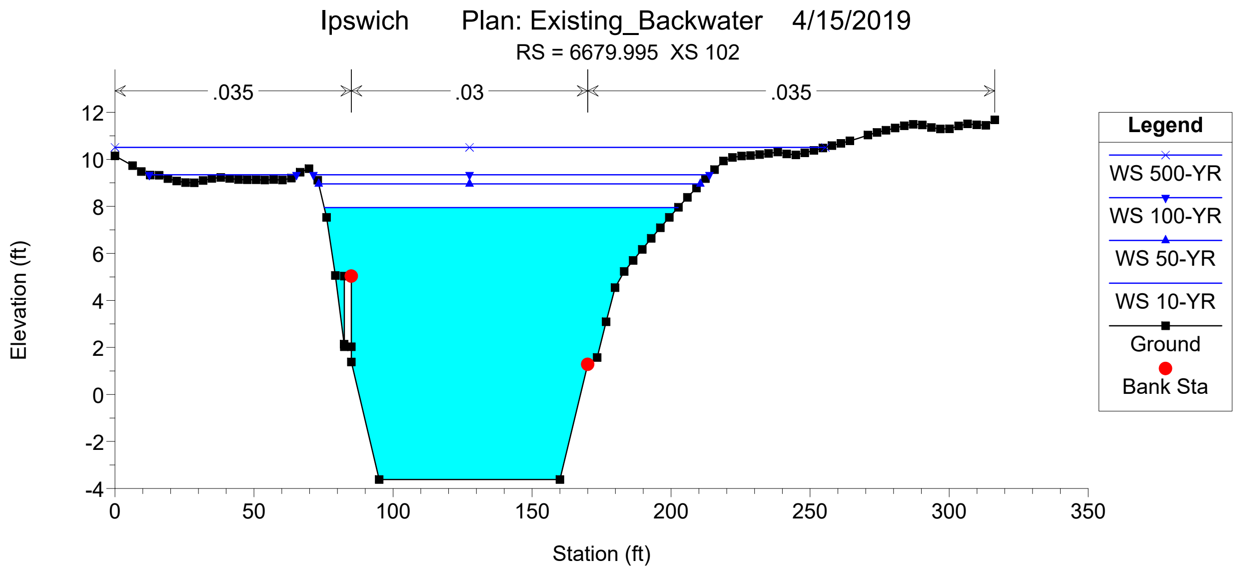
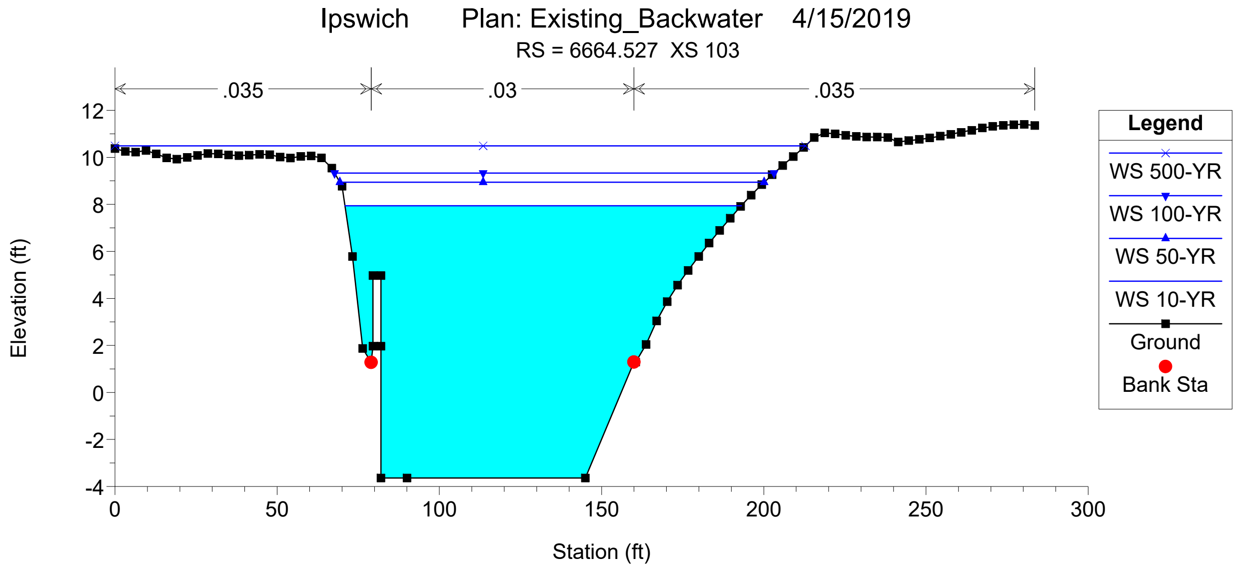
RS = 7177.681
.05
.04
.03
.06
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta
Ipswich Plan: Existing_Backwater 4/15/2019
RS = 7019.873
.04
.03
.035
.06
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta
Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6858.394
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

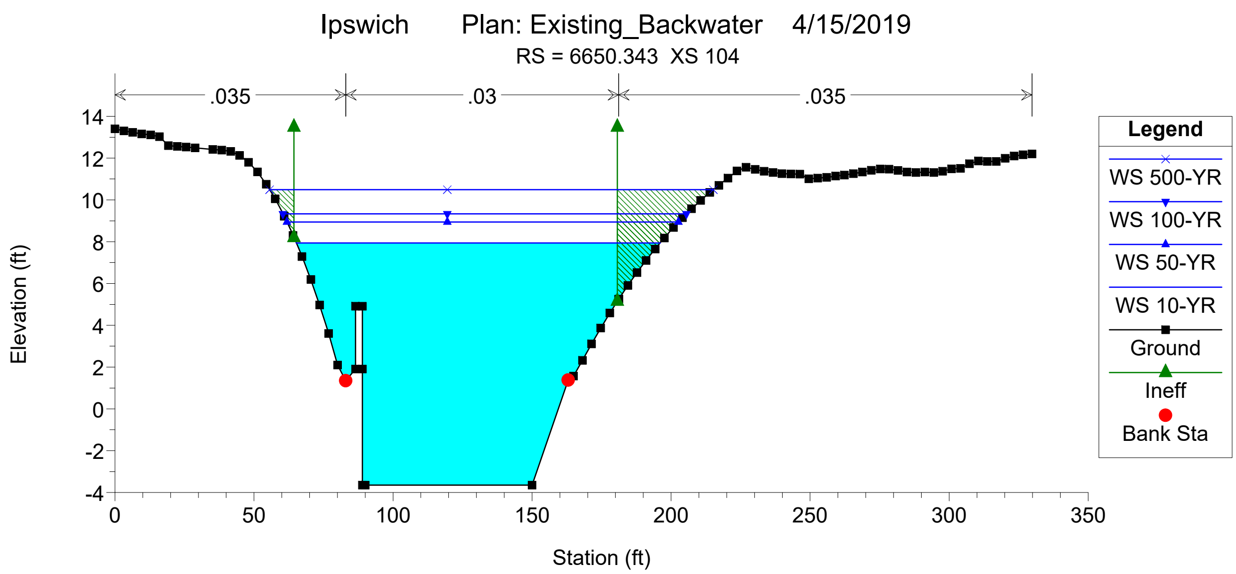

Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6784.991
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6696.837 XS 101
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

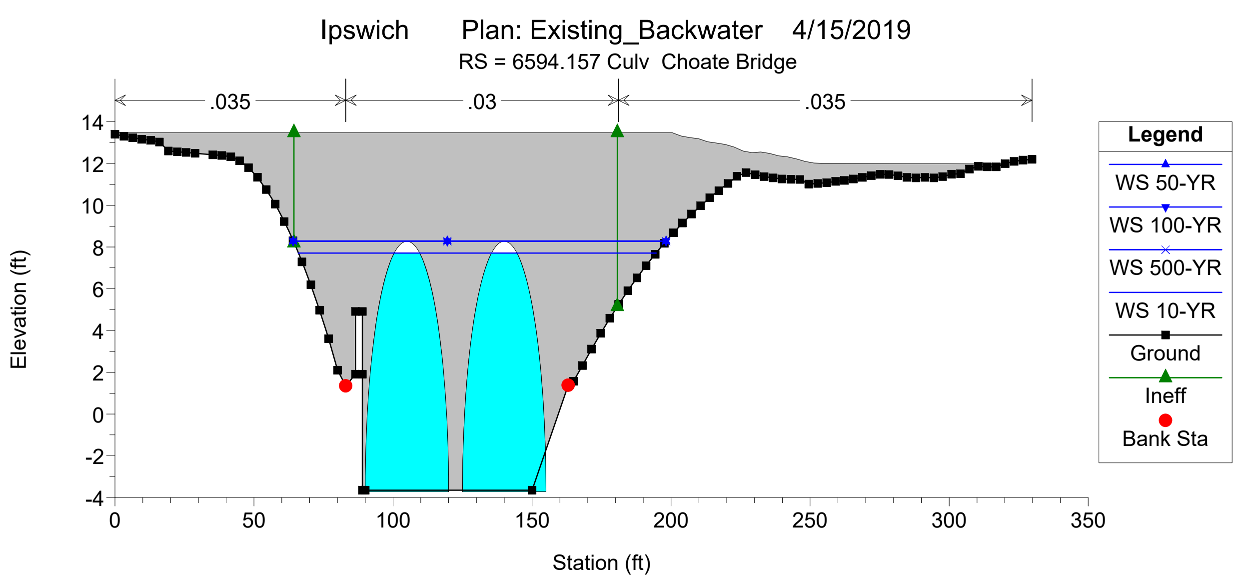

Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6679.995 XS 102
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta



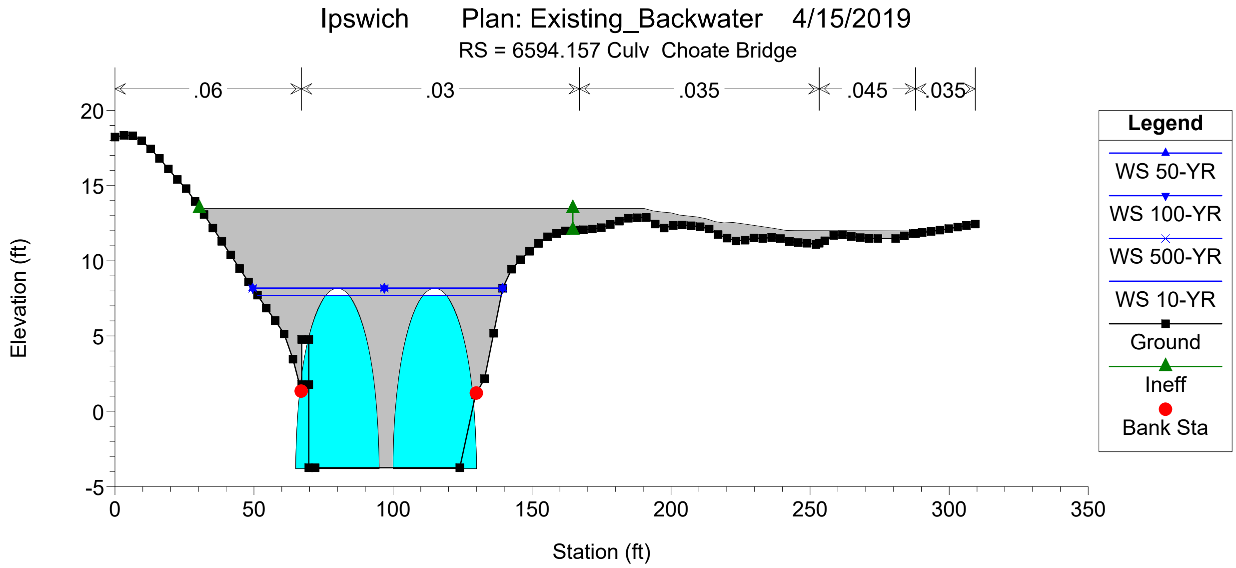
Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6664.527 XS 103
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

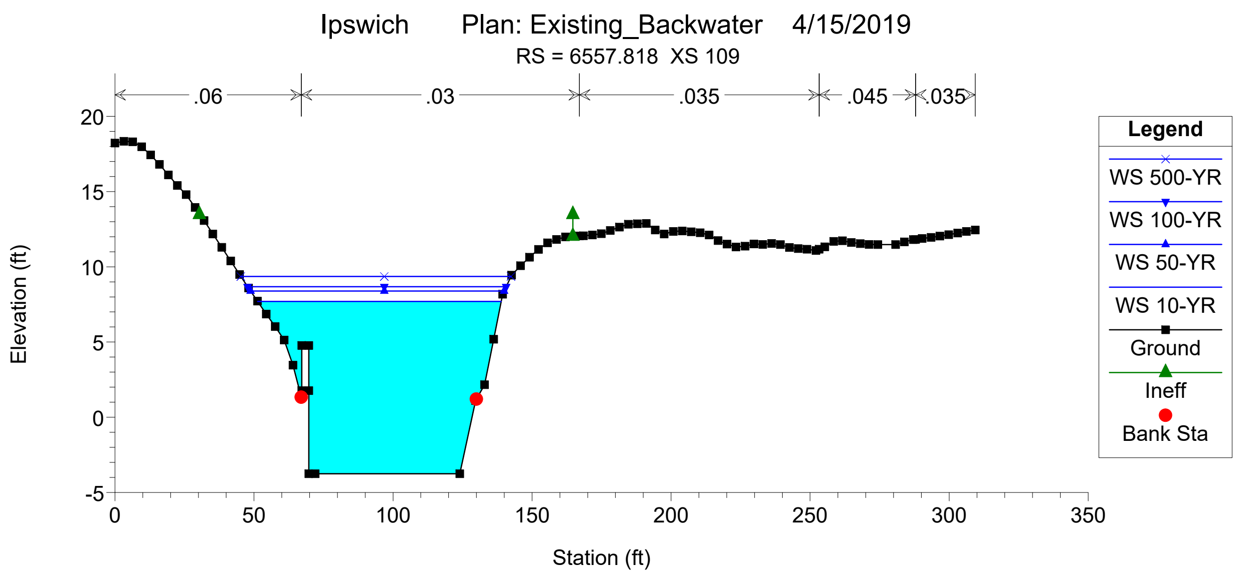


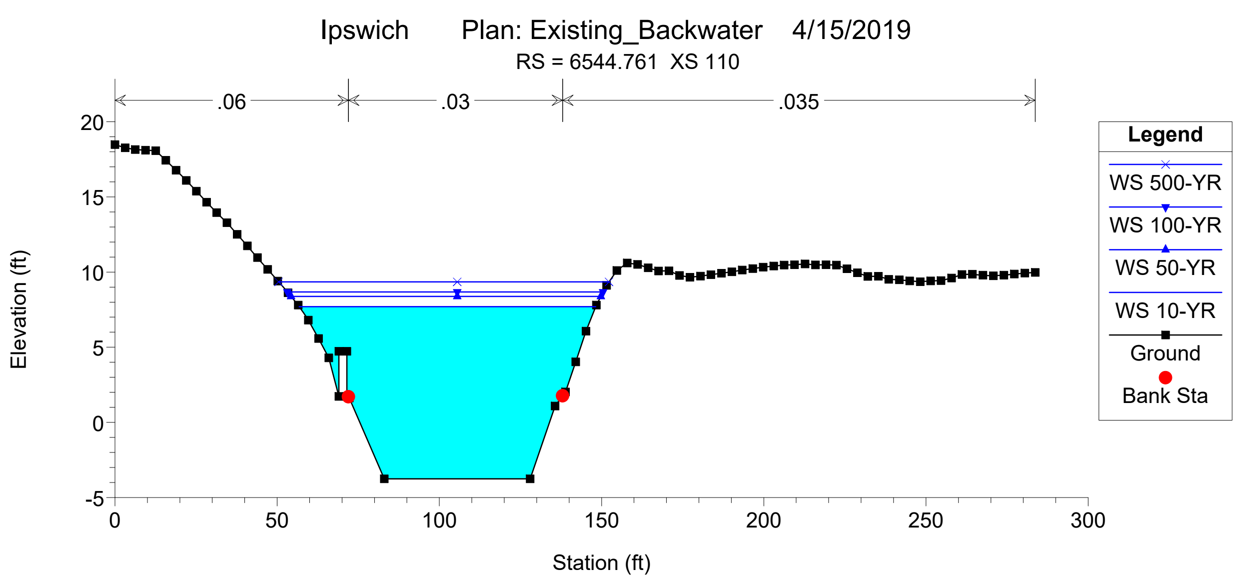
Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6650.343 XS 104
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

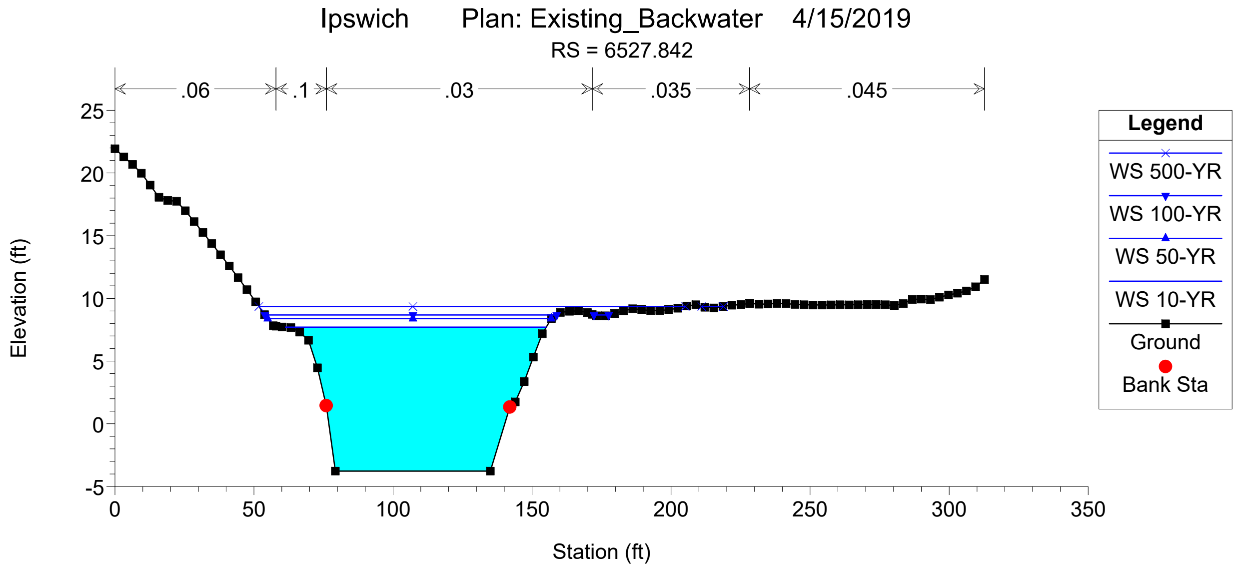


Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6594.157 Culv Choate Bridge
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 50-YR
WS 100-YR
WS 500-YR
WS 10-YR
Ground
Ineff
Bank Sta

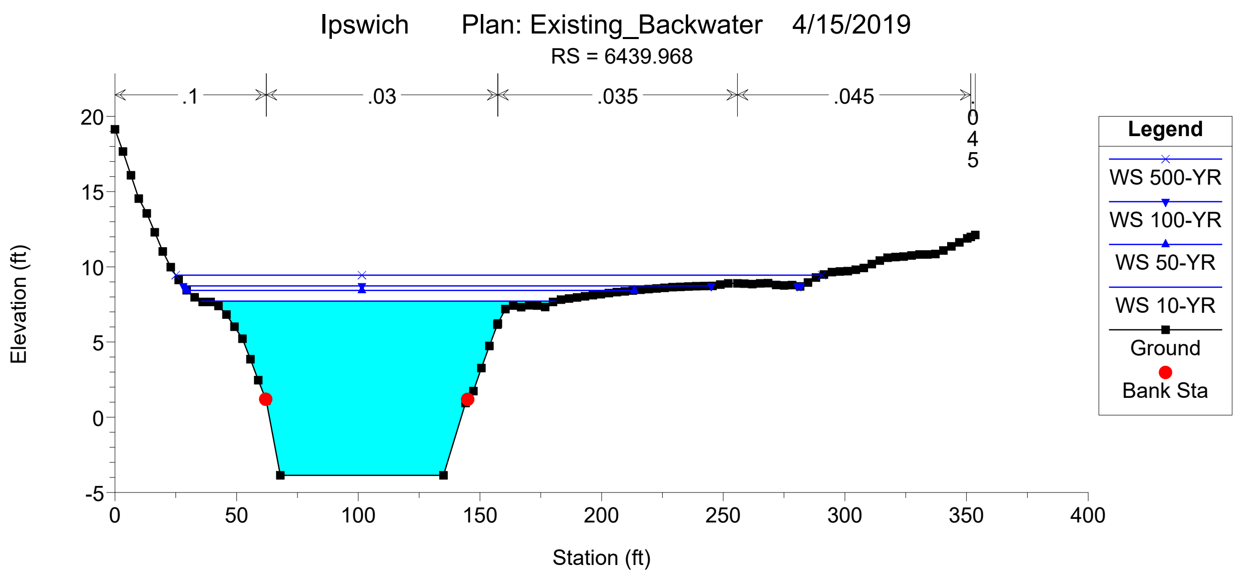

Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6594.157 Culv Choate Bridge
.06
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 50-YR
WS 100-YR
WS 500-YR
WS 10-YR
Ground
Ineff
Bank Sta


Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6557.818 XS 109
.06
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

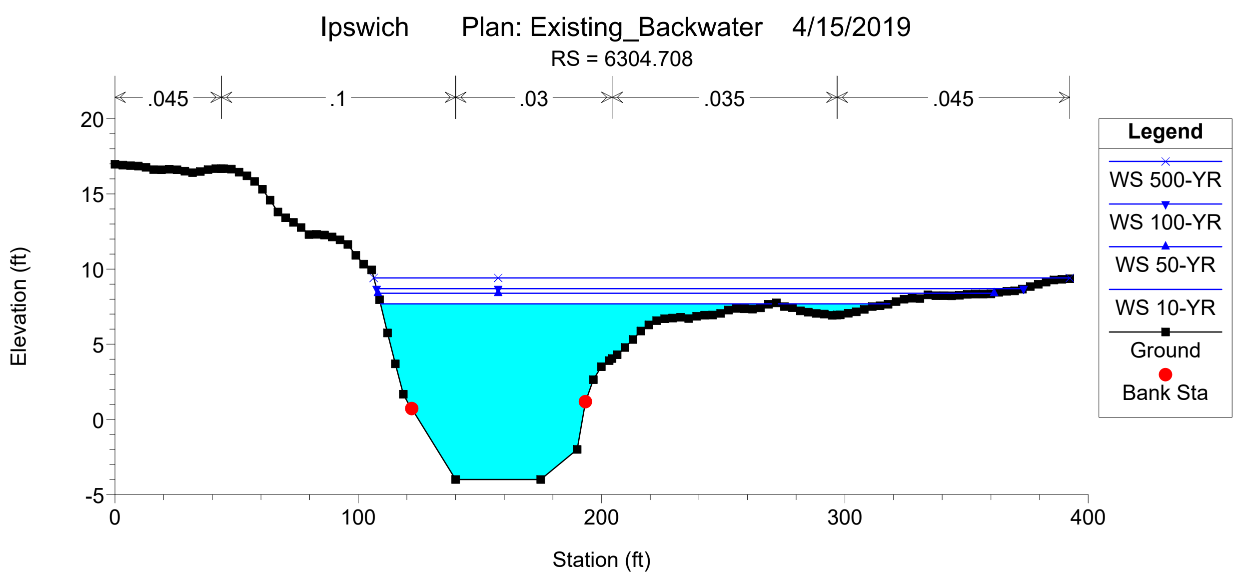

Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6544.761 XS 110
.06
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta



Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6527.842
.06
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta



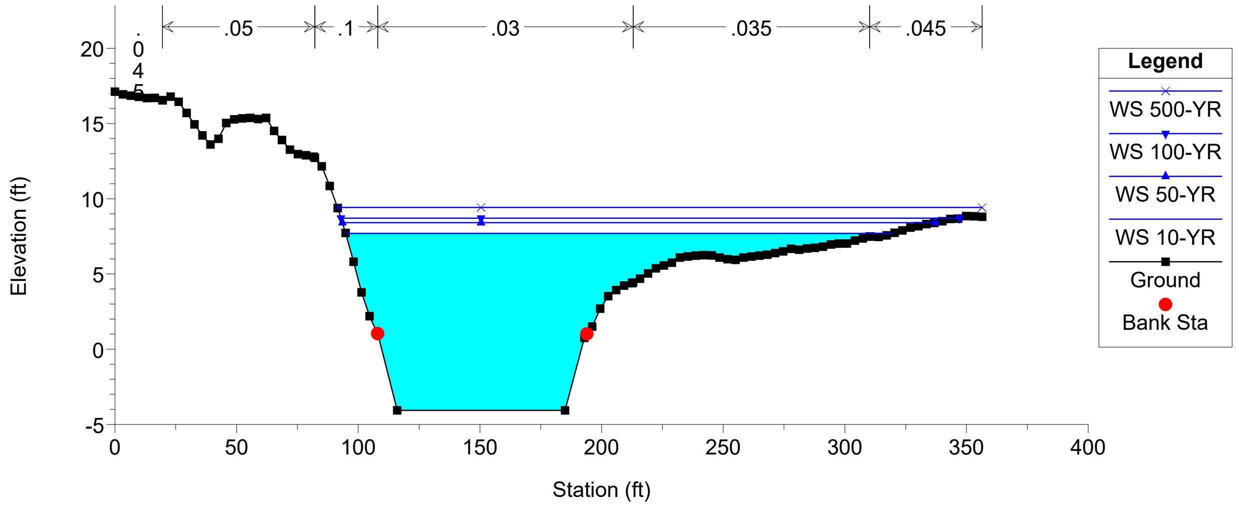
Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6439.968
.1
.03
.035
.045
0
4
5
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta



Ipswich Plan: Existing_Backwater 4/15/2019
RS = 6304.708
.045
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

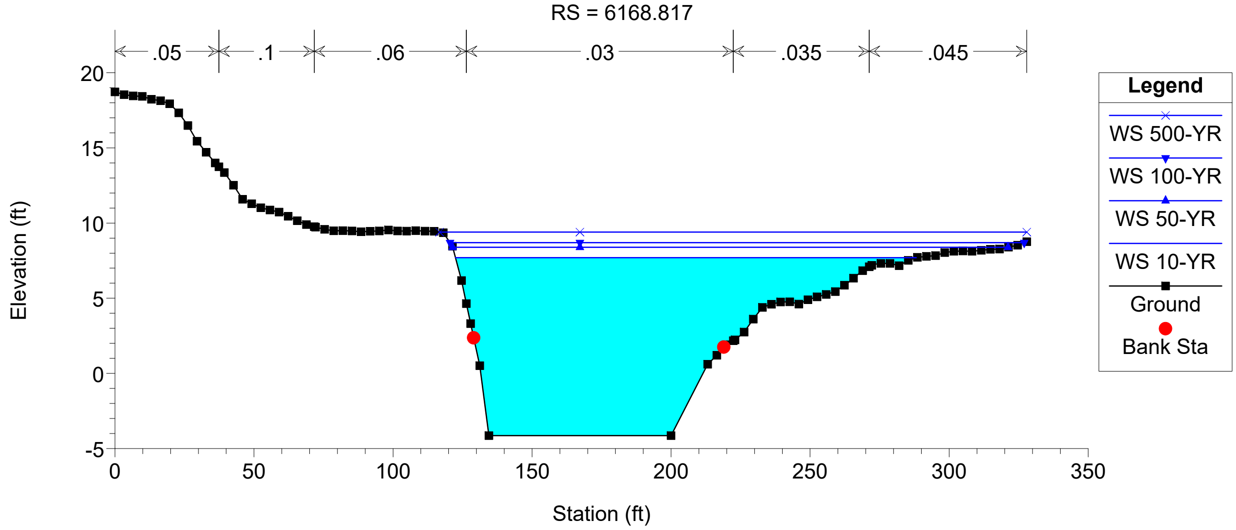
Ipswich Plan: Existing_Backwater 4/15/2019

RS = 6240.809



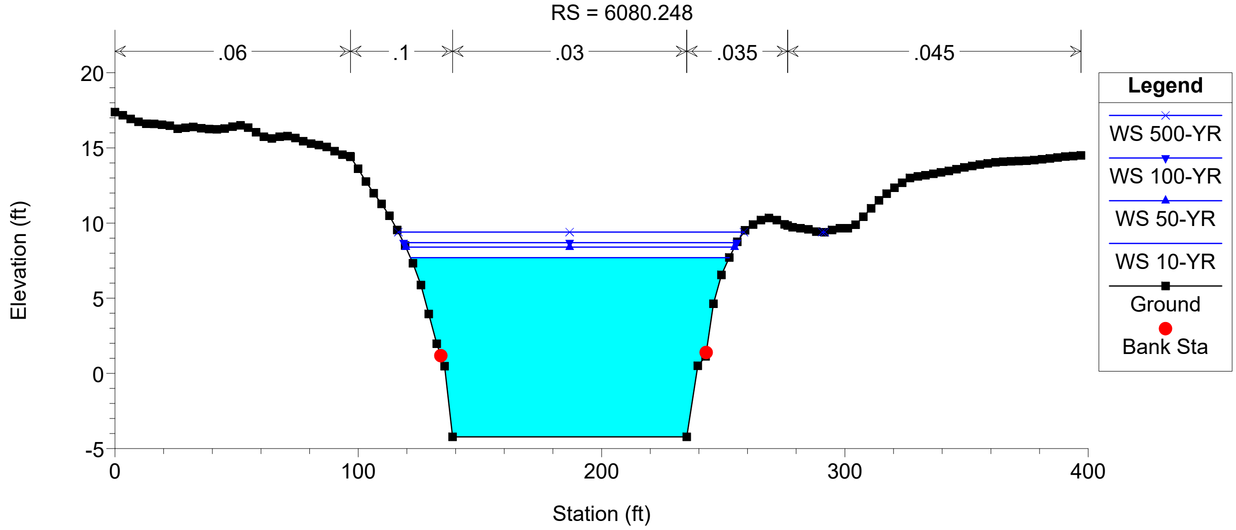
Ipswich Plan: Existing_Backwater 4/15/2019

RS = 6168.817



Ipswich Plan: Existing_Backwater 4/15/2019

RS = 6080.248



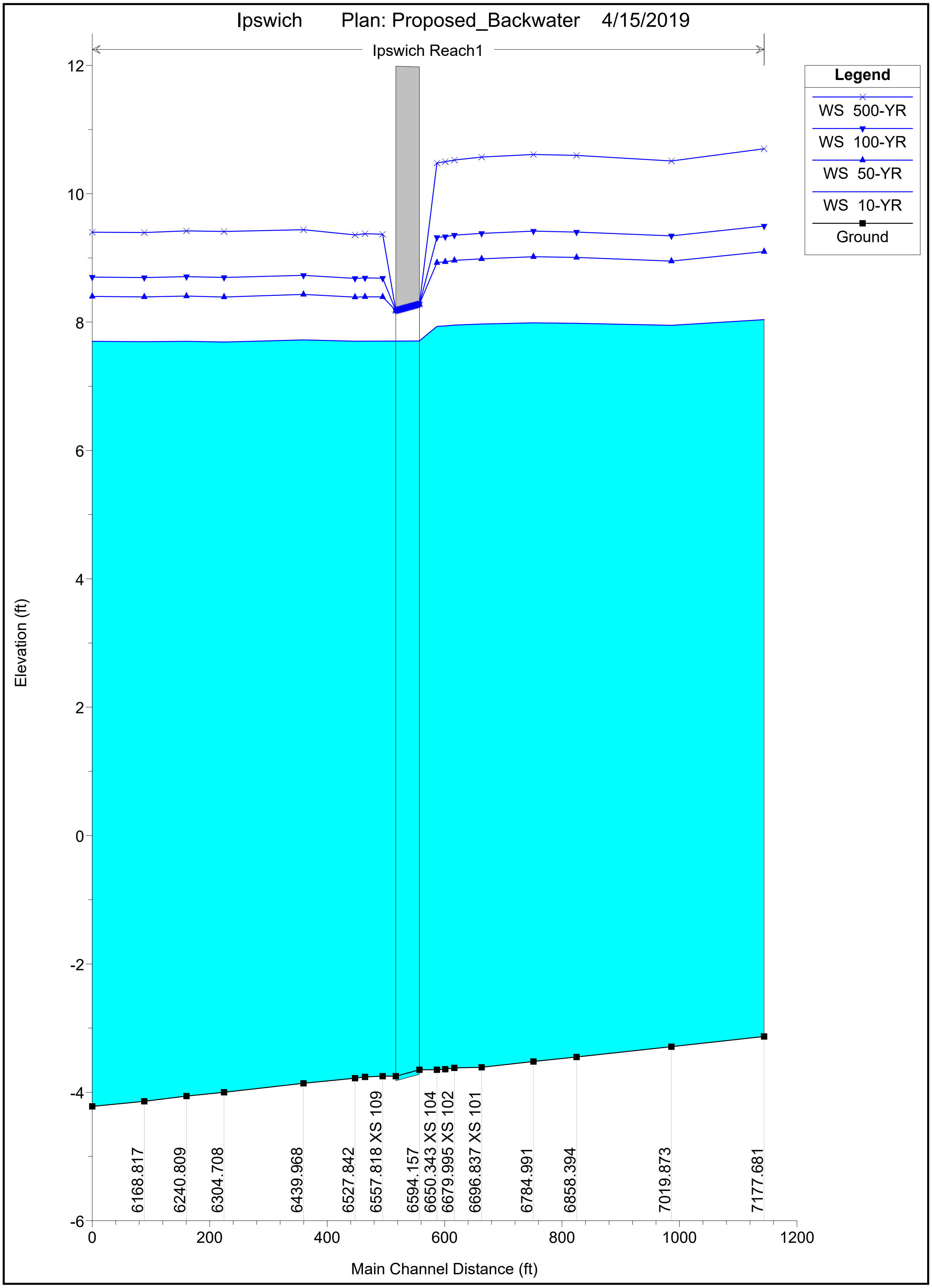
SCENARIO 1: ATLANTIC OCEAN BACKWATER - PROPOSED CONDITIONS

HEC-RAS Plan: prop backwater River: Ipswich Reach: Reach1

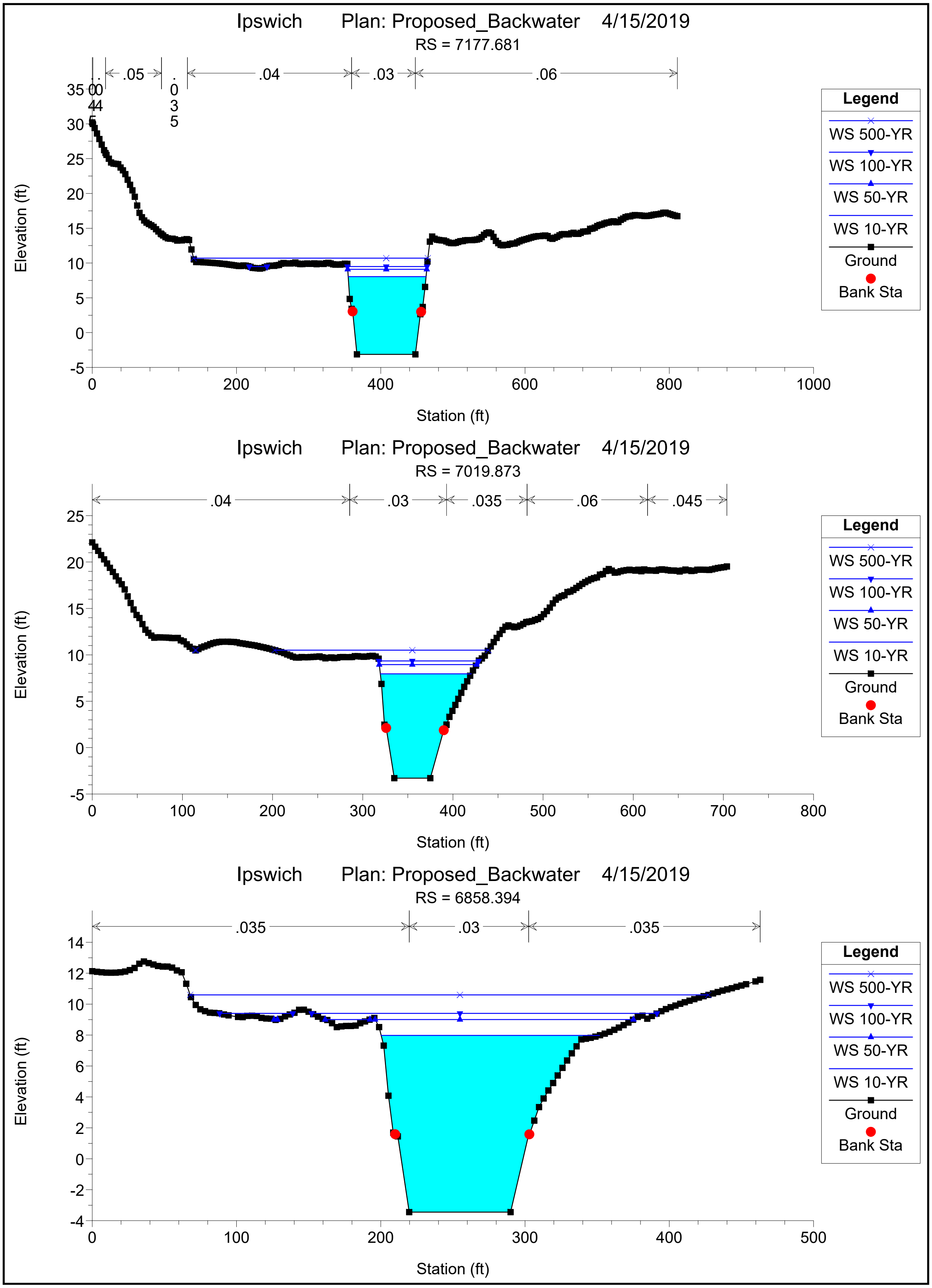
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	7177.681	10-YR	2023.00	-3.13	8.03	1.97	1057.27
Reach1	7177.681	50-YR	3016.00	-3.13	9.09	2.66	1172.23
Reach1	7177.681	100-YR	3251.00	-3.13	9.49	2.77	1220.13
Reach1	7177.681	500-YR	4196.00	-3.13	10.69	3.18	1536.85
Reach1	7019.873	10-YR	2023.00	-3.29	7.95	2.89	765.53
Reach1	7019.873	50-YR	3016.00	-3.29	8.94	3.86	869.41
Reach1	7019.873	100-YR	3251.00	-3.29	9.33	3.99	912.23
Reach1	7019.873	500-YR	4196.00	-3.29	10.49	4.57	1123.92
Reach1	6858.394	10-YR	2023.00	-3.45	7.98	1.93	1141.89
Reach1	6858.394	50-YR	3016.00	-3.45	9.00	2.59	1320.49
Reach1	6858.394	100-YR	3251.00	-3.45	9.39	2.69	1420.53
Reach1	6858.394	500-YR	4196.00	-3.45	10.58	3.00	1815.89
Reach1	6784.991	10-YR	2023.00	-3.52	7.98	1.65	1323.44
Reach1	6784.991	50-YR	3016.00	-3.52	9.01	2.22	1546.53
Reach1	6784.991	100-YR	3251.00	-3.52	9.41	2.29	1650.91
Reach1	6784.991	500-YR	4196.00	-3.52	10.60	2.59	1988.64
Reach1	6696.837	10-YR	2023.00	-3.61	7.96	1.88	1143.74
Reach1	6696.837	50-YR	3016.00	-3.61	8.98	2.54	1320.26
Reach1	6696.837	100-YR	3251.00	-3.61	9.37	2.62	1406.46
Reach1	6696.837	500-YR	4196.00	-3.61	10.55	2.97	1700.86
Reach1	6679.995	10-YR	2023.00	-3.62	7.95	2.06	1051.48
Reach1	6679.995	50-YR	3016.00	-3.62	8.95	2.77	1184.37
Reach1	6679.995	100-YR	3251.00	-3.62	9.35	2.87	1249.47
Reach1	6679.995	500-YR	4196.00	-3.62	10.51	3.33	1507.42
Reach1	6664.527	10-YR	2023.00	-3.64	7.94	2.24	973.46
Reach1	6664.527	50-YR	3016.00	-3.64	8.93	3.00	1098.87
Reach1	6664.527	100-YR	3251.00	-3.64	9.32	3.11	1151.04
Reach1	6664.527	500-YR	4196.00	-3.64	10.48	3.57	1341.56
Reach1	6650.343	10-YR	2023.00	-3.65	7.93	2.30	964.96
Reach1	6650.343	50-YR	3016.00	-3.65	8.92	3.07	1099.61
Reach1	6650.343	100-YR	3251.00	-3.65	9.32	3.17	1155.68
Reach1	6650.343	500-YR	4196.00	-3.65	10.48	3.63	1331.97
Reach1	6594.157		Culvert				
Reach1	6557.818	10-YR	2023.00	-3.75	7.70	2.96	727.43
Reach1	6557.818	50-YR	3016.00	-3.75	8.38	4.11	788.57
Reach1	6557.818	100-YR	3251.00	-3.75	8.68	4.30	815.42
Reach1	6557.818	500-YR	4196.00	-3.75	9.35	5.20	879.98
Reach1	6544.761	10-YR	2023.00	-3.76	7.70	2.72	773.39
Reach1	6544.761	50-YR	3016.00	-3.76	8.39	3.78	837.96
Reach1	6544.761	100-YR	3251.00	-3.76	8.69	3.95	866.28
Reach1	6544.761	500-YR	4196.00	-3.76	9.38	4.77	934.92

HEC-RAS Plan: prop backwater River: Ipswich Reach: Reach1 (Continued)

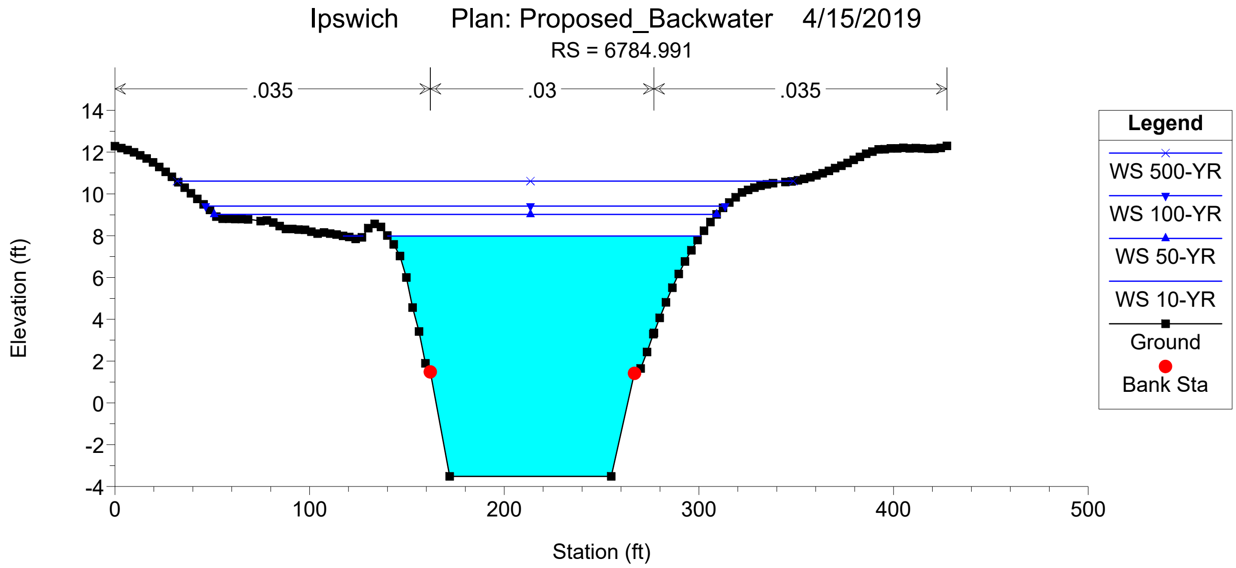
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	6527.842	10-YR	2023.00	-3.78	7.70	2.69	801.06
Reach1	6527.842	50-YR	3016.00	-3.78	8.39	3.75	869.49
Reach1	6527.842	100-YR	3251.00	-3.78	8.68	3.94	899.95
Reach1	6527.842	500-YR	4196.00	-3.78	9.36	4.80	990.13
Reach1	6439.968	10-YR	2023.00	-3.86	7.72	2.12	1038.16
Reach1	6439.968	50-YR	3016.00	-3.86	8.43	2.94	1154.00
Reach1	6439.968	100-YR	3251.00	-3.86	8.73	3.08	1212.51
Reach1	6439.968	500-YR	4196.00	-3.86	9.44	3.67	1393.40
Reach1	6304.708	10-YR	2023.00	-4.00	7.69	2.36	959.86
Reach1	6304.708	50-YR	3016.00	-4.00	8.39	3.15	1115.98
Reach1	6304.708	100-YR	3251.00	-4.00	8.70	3.22	1195.30
Reach1	6304.708	500-YR	4196.00	-4.00	9.41	3.67	1392.17
Reach1	6240.809	10-YR	2023.00	-4.06	7.70	1.93	1240.25
Reach1	6240.809	50-YR	3016.00	-4.06	8.41	2.62	1404.72
Reach1	6240.809	100-YR	3251.00	-4.06	8.71	2.72	1479.90
Reach1	6240.809	500-YR	4196.00	-4.06	9.42	3.21	1667.03
Reach1	6168.817	10-YR	2023.00	-4.14	7.70	1.92	1164.34
Reach1	6168.817	50-YR	3016.00	-4.14	8.39	2.65	1290.87
Reach1	6168.817	100-YR	3251.00	-4.14	8.69	2.76	1352.05
Reach1	6168.817	500-YR	4196.00	-4.14	9.40	3.29	1498.55
Reach1	6080.248	10-YR	2023.00	-4.22	7.70	1.59	1317.55
Reach1	6080.248	50-YR	3016.00	-4.22	8.40	2.23	1410.70
Reach1	6080.248	100-YR	3251.00	-4.22	8.70	2.35	1451.51
Reach1	6080.248	500-YR	4196.00	-4.22	9.40	2.86	1549.15

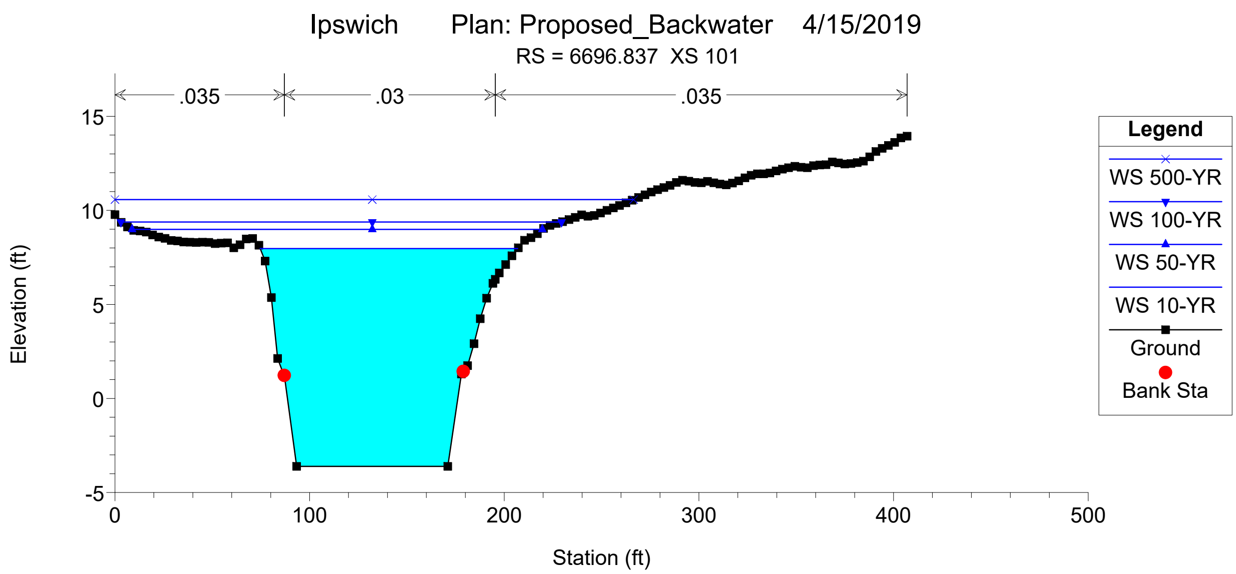


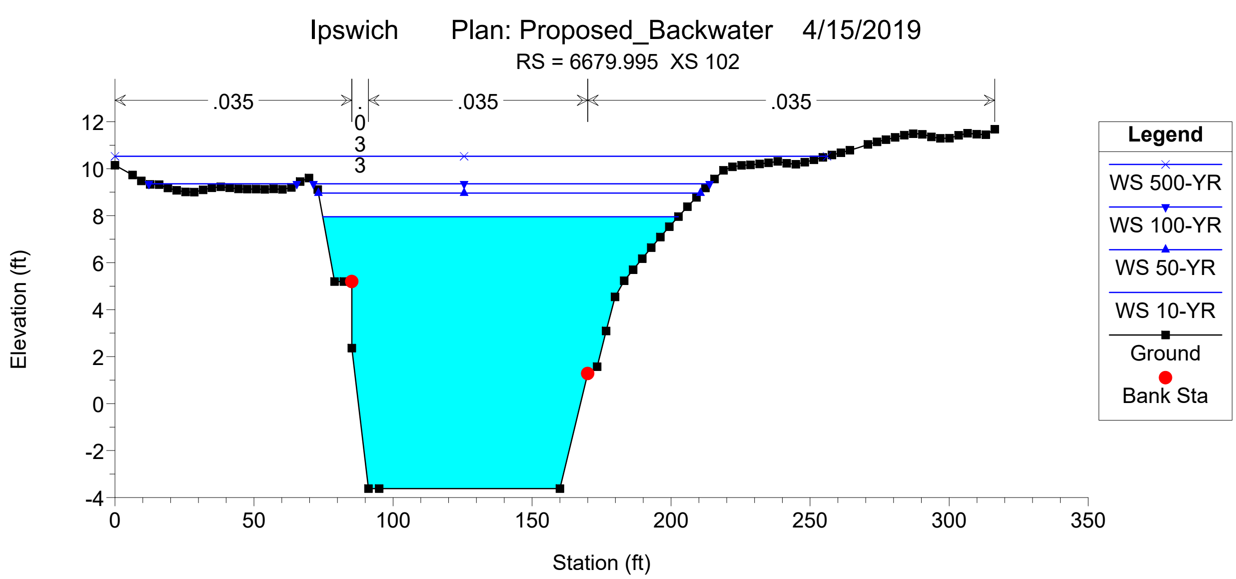
Ipswich Plan: Proposed_Backwater 4/15/2019
Ipswich Reach1
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Elevation (ft)
Main Channel Distance (ft)
12
10
8
6
4
2
0
-2
-4
-6
0
200
400
600
800
1000
1200
6168.817
6240.809
6304.708
6439.968
6527.842
6557.818 XS 109
6594.157
6650.343 XS 104
6679.995 XS 102
6696.837 XS 101
6784.991
6858.394
7019.873
7177.681

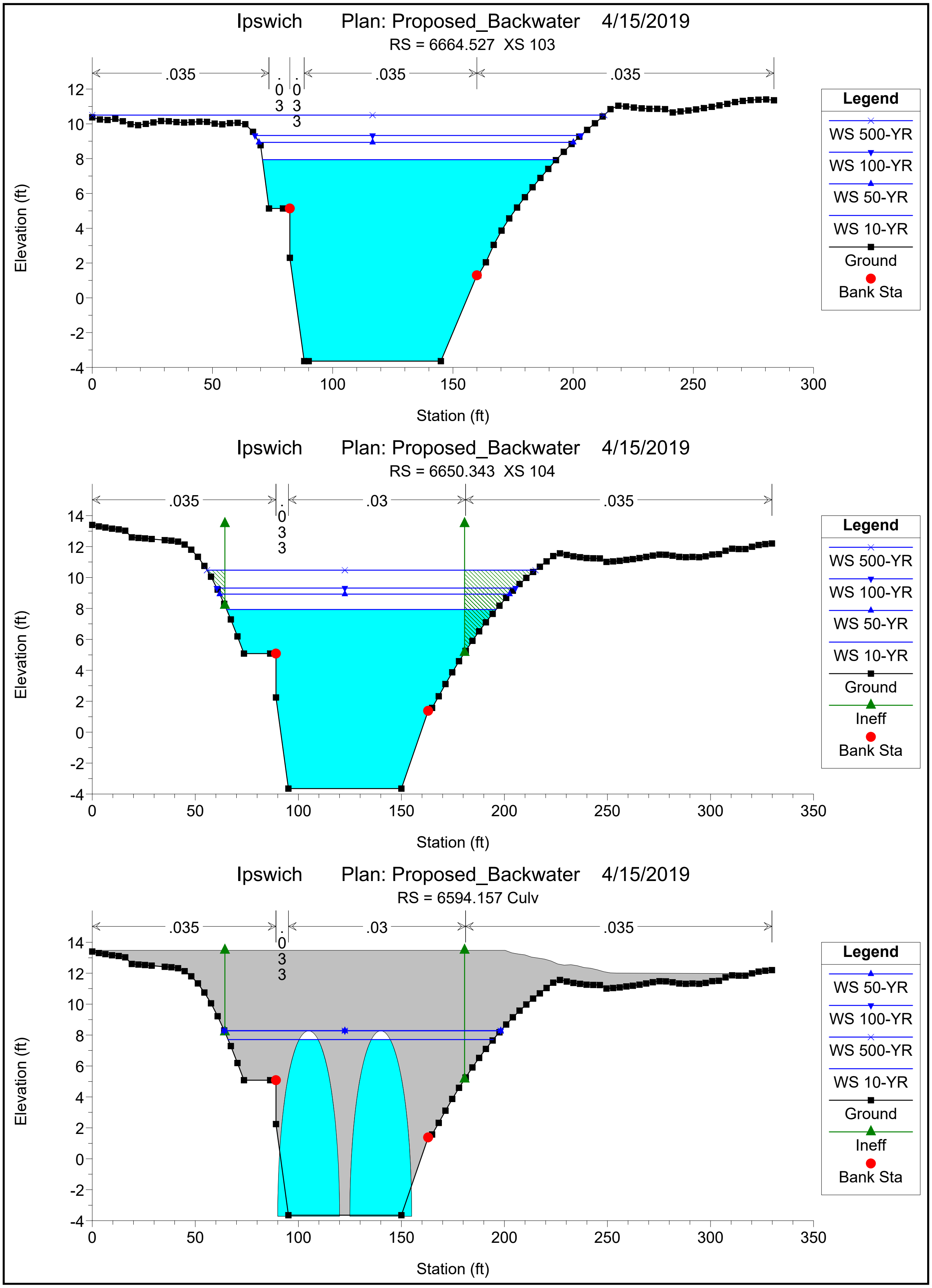


Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 7177.681
.05
.04
.03
.06
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta
Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 7019.873
.04
.03
.035
.06
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta
Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6858.394
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

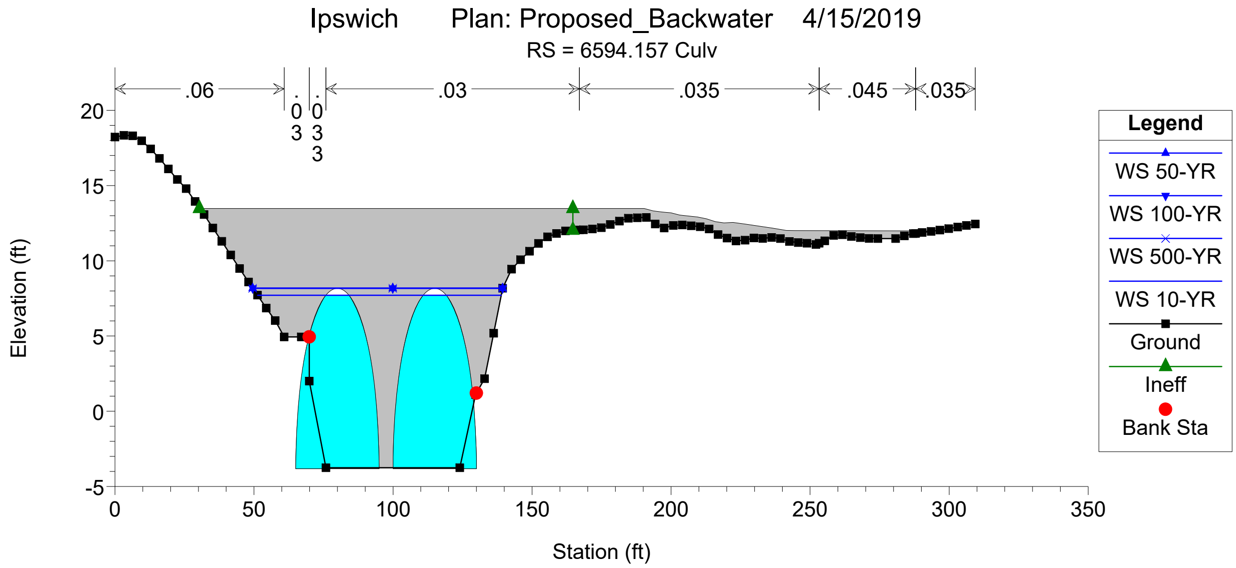

Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6784.991
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

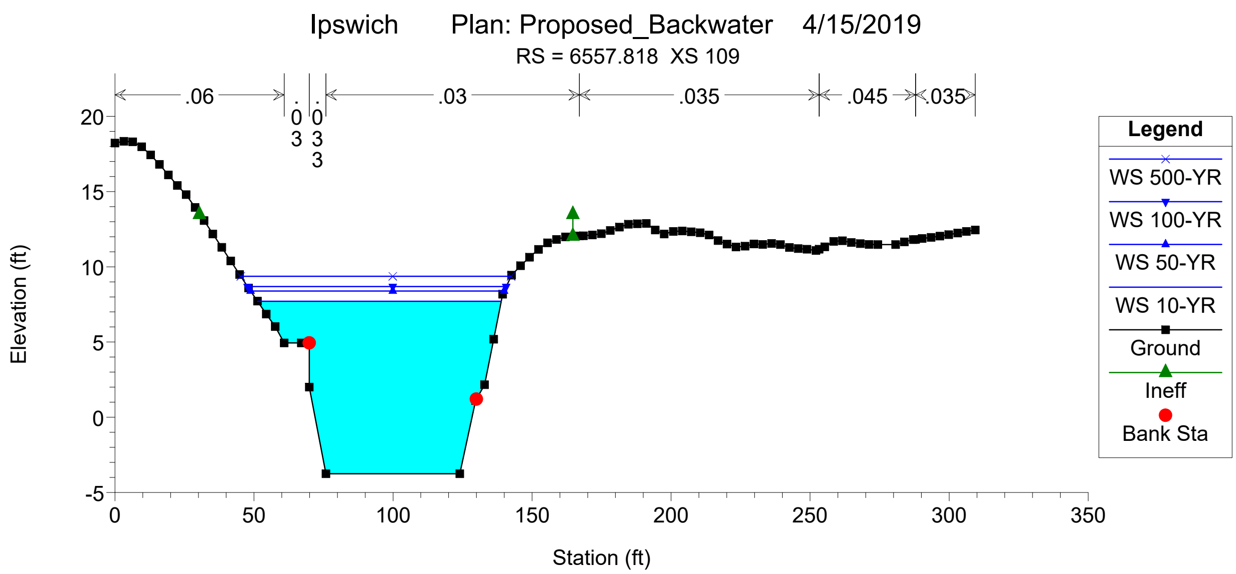

Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6696.837 XS 101
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

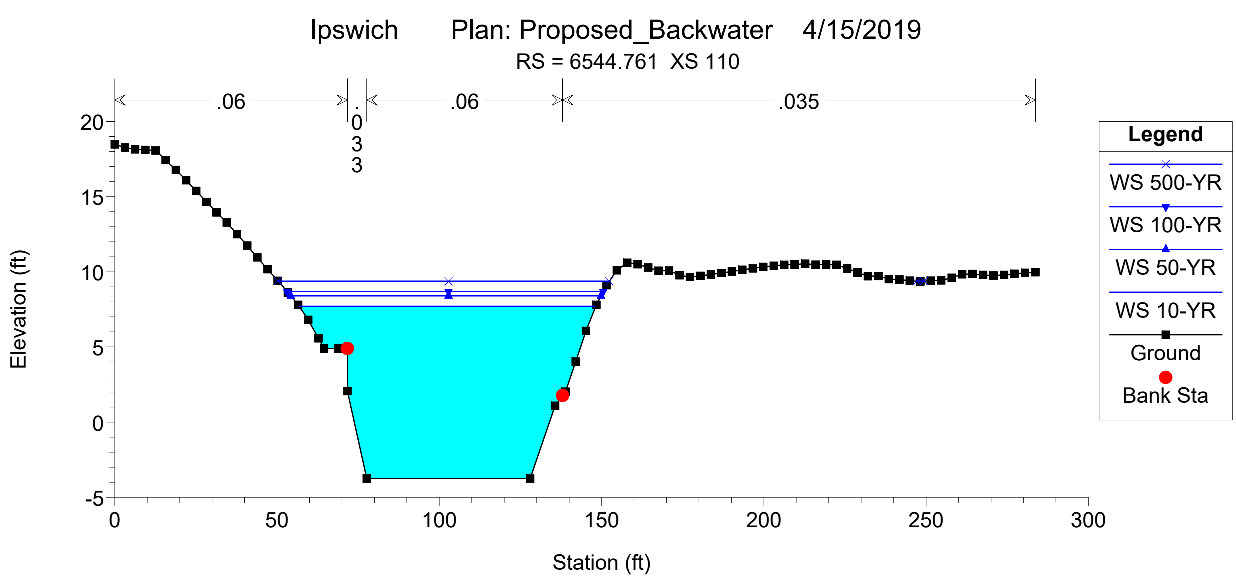

Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6679.995 XS 102
.035
.033
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

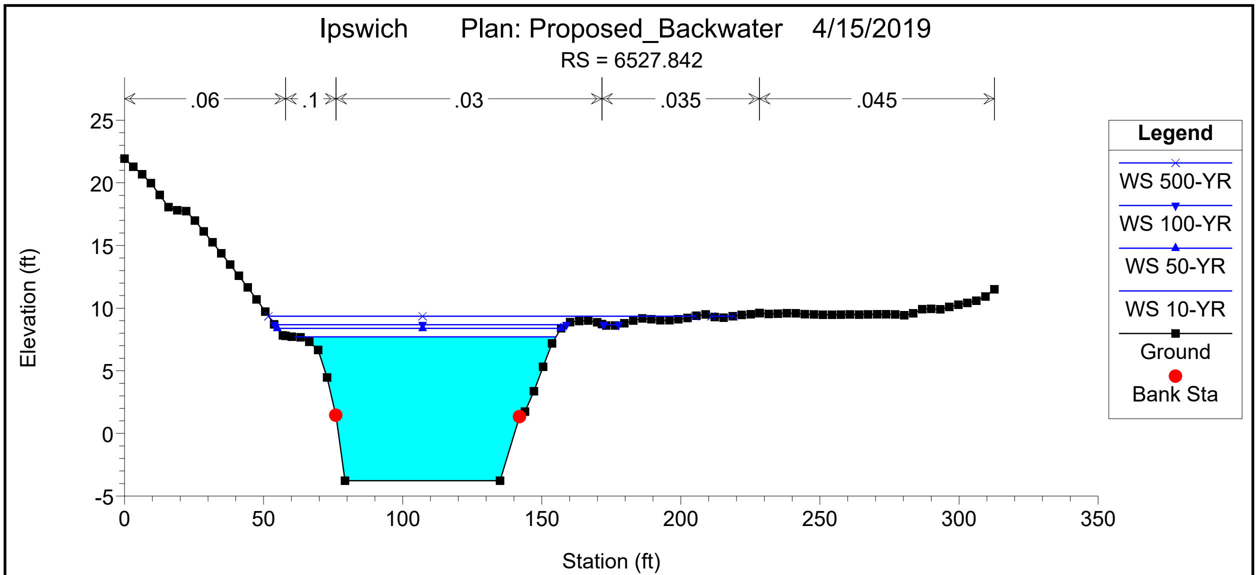


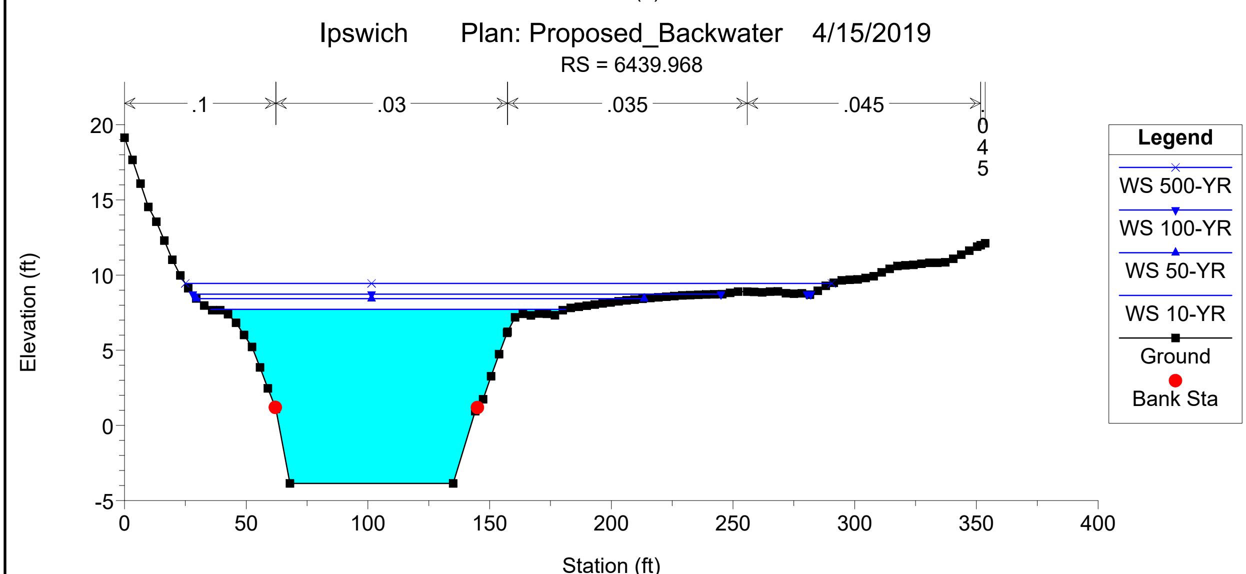
Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6664.527 XS 103
.035
.035
.035
.033
.033
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta
Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6650.343 XS 104
.035
.033
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta
Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6594.157 Culv
.035
.033
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 50-YR
WS 100-YR
WS 500-YR
WS 10-YR
Ground
Ineff
Bank Sta

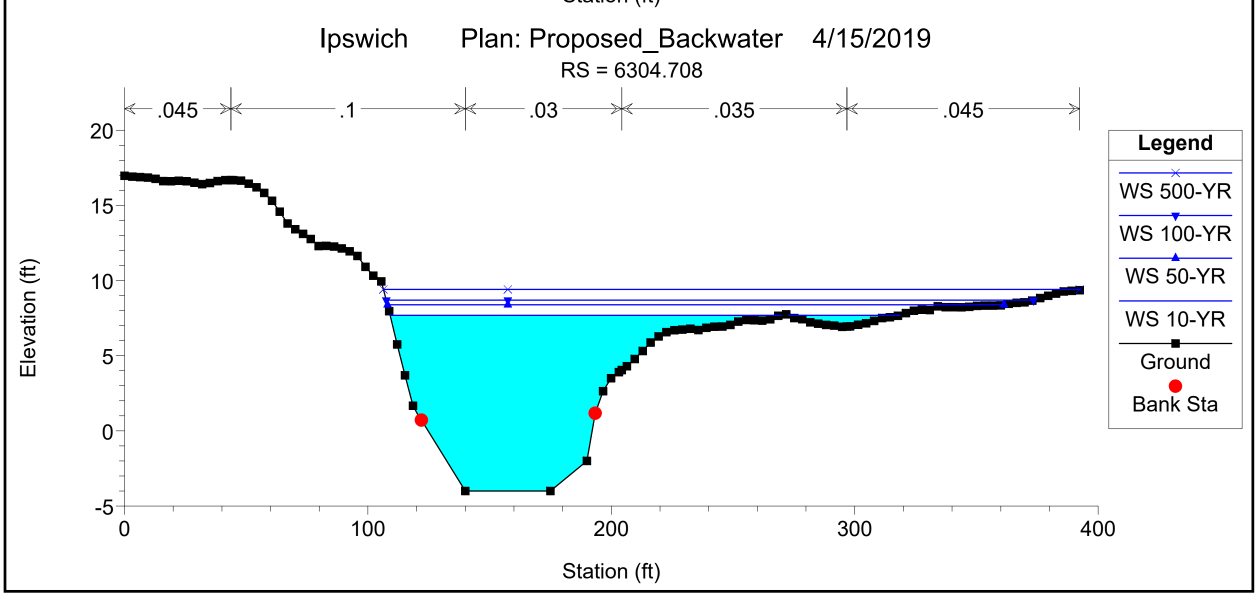

Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6594.157 Culv
.06
.033
.033
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 50-YR
WS 100-YR
WS 500-YR
WS 10-YR
Ground
Ineff
Bank Sta

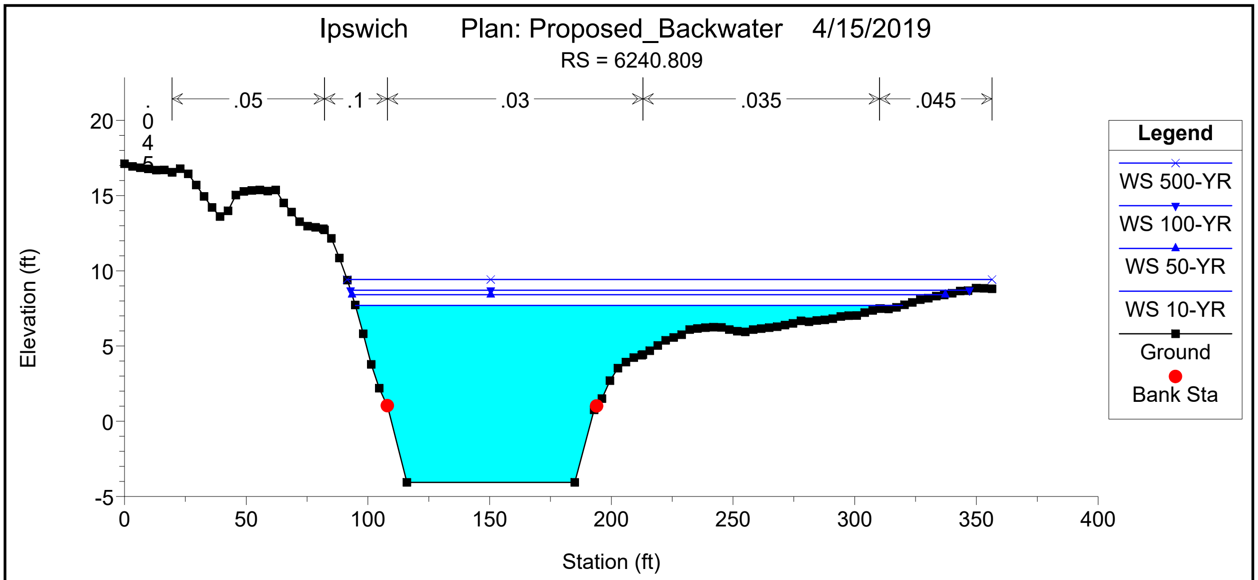

Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6557.818 XS 109
.06
.033
.033
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

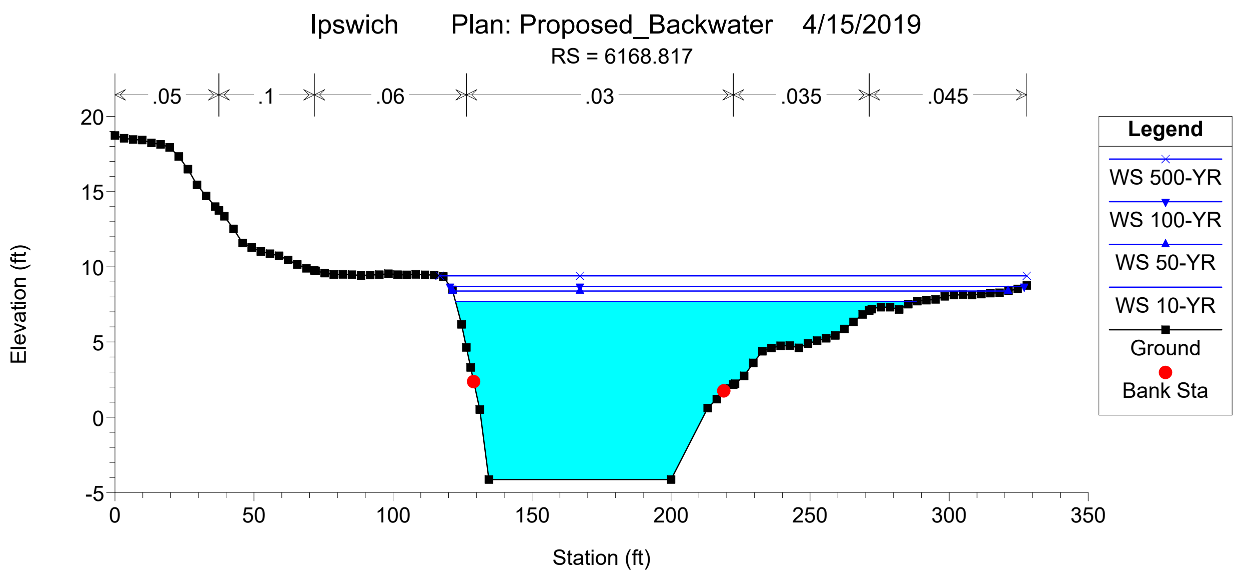

Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6544.761 XS 110
.06
.033
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

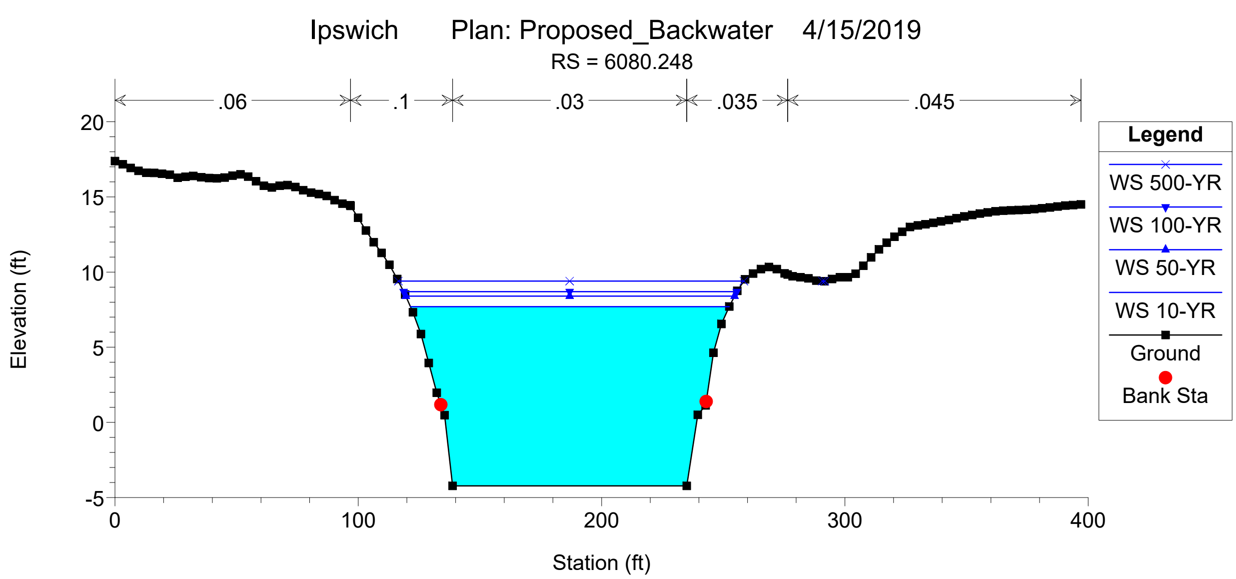

Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6527.842
.06
.1
.03
.035
.045
Elevation (ft)
25
20
15
10
5
0
-5
0
50
100
150
200
250
300
350
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6439.968
.1
.03
.035
.045
0
4
5
Elevation (ft)
20
15
10
5
0
-5
0
50
100
150
200
250
300
350
400
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6304.708
.045
.1
.03
.035
.045
Elevation (ft)
20
15
10
5
0
-5
0
100
200
300
400
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6240.809
.05
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6168.817
.05
.1
.06
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_Backwater 4/15/2019
RS = 6080.248
.06
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

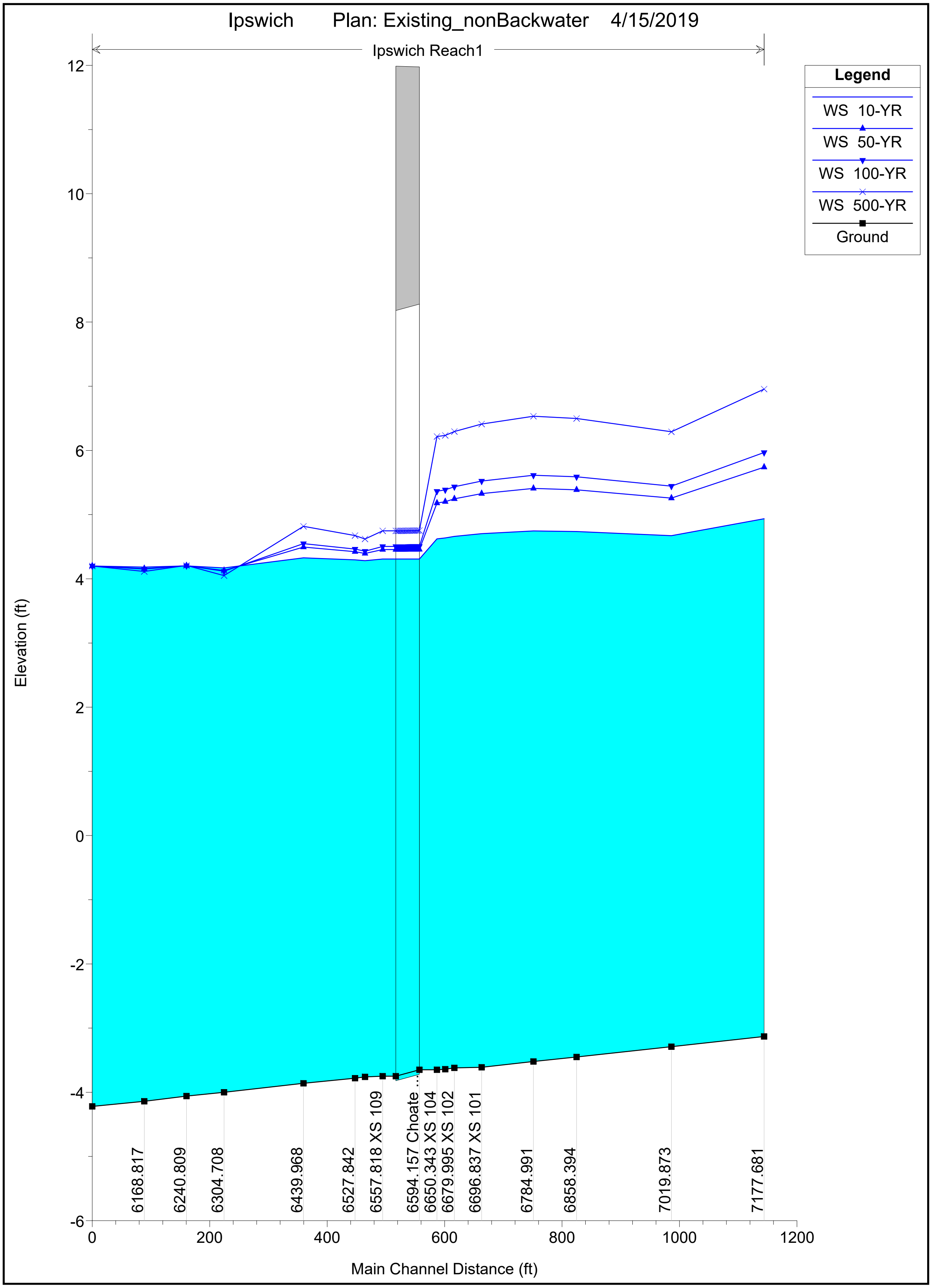
SCENARIO 2: MEAN HIGH WATER - EXISTING CONDITIONS

HEC-RAS Plan: existing NONbackwater River: Ipswich Reach: Reach1

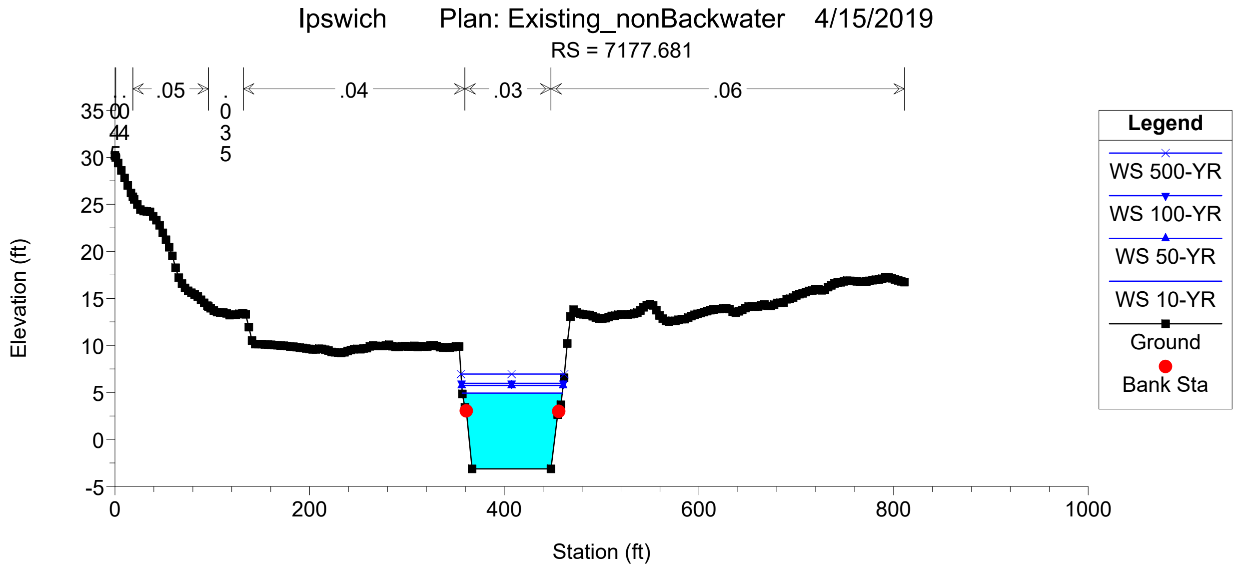
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	7177.681	10-YR	2023.00	-3.13	4.93	2.80	729.64
Reach1	7177.681	50-YR	3016.00	-3.13	5.72	3.77	811.63
Reach1	7177.681	100-YR	3251.00	-3.13	5.95	3.95	835.57
Reach1	7177.681	500-YR	4196.00	-3.13	6.93	4.57	938.73
Reach1	7019.873	10-YR	2023.00	-3.29	4.66	4.46	469.32
Reach1	7019.873	50-YR	3016.00	-3.29	5.23	6.10	516.32
Reach1	7019.873	100-YR	3251.00	-3.29	5.42	6.40	531.89
Reach1	7019.873	500-YR	4196.00	-3.29	6.25	7.37	604.77
Reach1	6858.394	10-YR	2023.00	-3.45	4.73	2.86	729.55
Reach1	6858.394	50-YR	3016.00	-3.45	5.37	3.91	803.68
Reach1	6858.394	100-YR	3251.00	-3.45	5.57	4.10	827.63
Reach1	6858.394	500-YR	4196.00	-3.45	6.46	4.73	938.25
Reach1	6784.991	10-YR	2023.00	-3.52	4.74	2.44	858.18
Reach1	6784.991	50-YR	3016.00	-3.52	5.39	3.33	944.34
Reach1	6784.991	100-YR	3251.00	-3.52	5.59	3.49	971.95
Reach1	6784.991	500-YR	4196.00	-3.52	6.50	4.03	1098.63
Reach1	6696.837	10-YR	2023.00	-3.61	4.69	2.74	758.31
Reach1	6696.837	50-YR	3016.00	-3.61	5.30	3.78	825.07
Reach1	6696.837	100-YR	3251.00	-3.61	5.50	3.97	846.75
Reach1	6696.837	500-YR	4196.00	-3.61	6.37	4.63	946.61
Reach1	6679.995	10-YR	2023.00	-3.62	4.65	3.06	678.35
Reach1	6679.995	50-YR	3016.00	-3.62	5.22	4.23	735.93
Reach1	6679.995	100-YR	3251.00	-3.62	5.41	4.46	755.51
Reach1	6679.995	500-YR	4196.00	-3.62	6.26	5.19	847.77
Reach1	6664.527	10-YR	2023.00	-3.64	4.63	3.26	643.61
Reach1	6664.527	50-YR	3016.00	-3.64	5.18	4.51	698.60
Reach1	6664.527	100-YR	3251.00	-3.64	5.36	4.74	717.57
Reach1	6664.527	500-YR	4196.00	-3.64	6.20	5.50	806.62
Reach1	6650.343	10-YR	2023.00	-3.65	4.61	3.34	630.33
Reach1	6650.343	50-YR	3016.00	-3.65	5.16	4.61	686.86
Reach1	6650.343	100-YR	3251.00	-3.65	5.34	4.84	706.64
Reach1	6650.343	500-YR	4196.00	-3.65	6.18	5.57	800.80
Reach1	6594.157		Culvert				
Reach1	6557.818	10-YR	2023.00	-3.75	4.30	4.25	487.01
Reach1	6557.818	50-YR	3016.00	-3.75	4.43	6.23	496.31
Reach1	6557.818	100-YR	3251.00	-3.75	4.47	6.68	499.48
Reach1	6557.818	500-YR	4196.00	-3.75	4.69	8.37	515.12
Reach1	6544.761	10-YR	2023.00	-3.76	4.27	4.29	480.58
Reach1	6544.761	50-YR	3016.00	-3.76	4.37	6.31	488.01
Reach1	6544.761	100-YR	3251.00	-3.76	4.41	6.77	490.45
Reach1	6544.761	500-YR	4196.00	-3.76	4.58	8.53	503.16

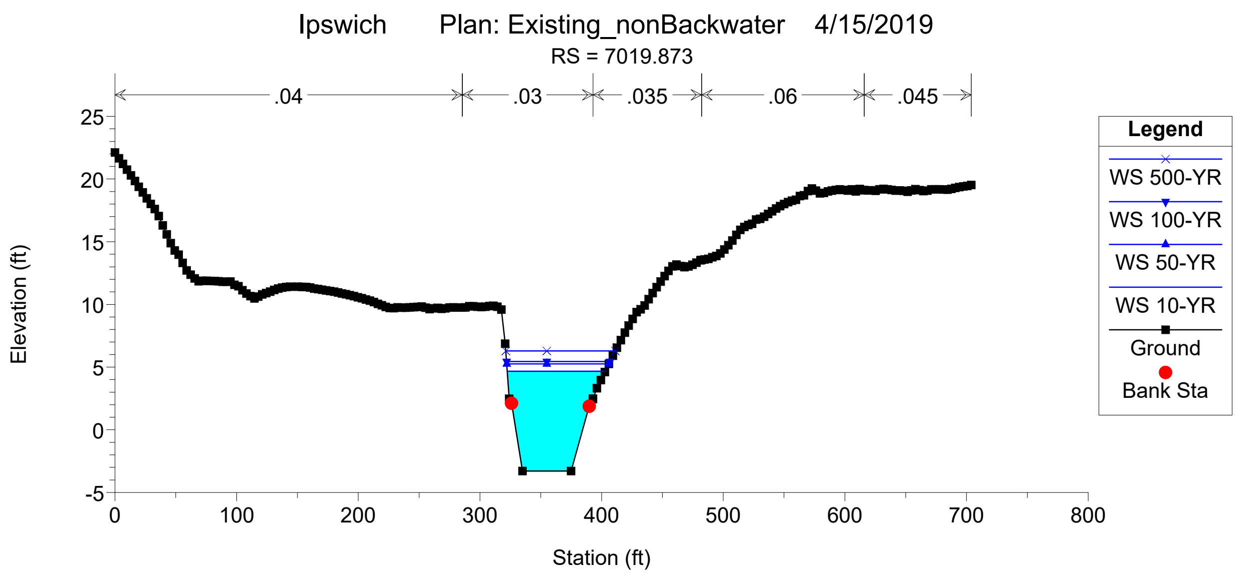
HEC-RAS Plan: existing NONbackwater   River: Ipswich   Reach: Reach1 (Continued)

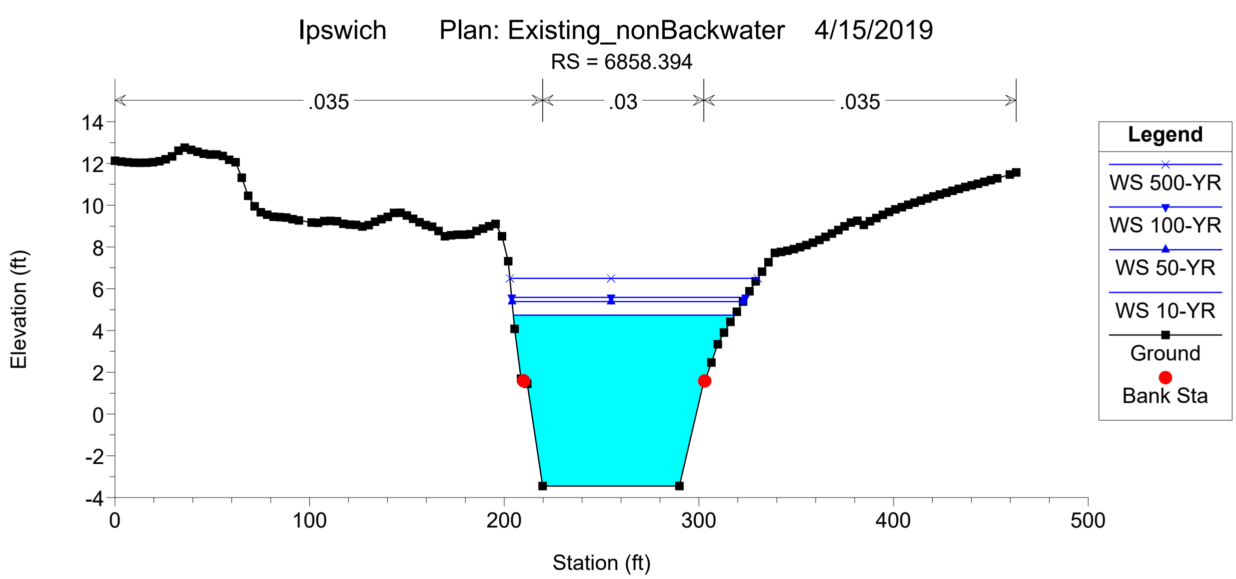
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	6527.842	10-YR	2023.00	-3.78	4.29	3.96	522.54
Reach1	6527.842	50-YR	3016.00	-3.78	4.42	5.80	532.24
Reach1	6527.842	100-YR	3251.00	-3.78	4.46	6.22	535.38
Reach1	6527.842	500-YR	4196.00	-3.78	4.67	7.81	551.48
Reach1	6439.968	10-YR	2023.00	-3.86	4.33	3.14	663.28
Reach1	6439.968	50-YR	3016.00	-3.86	4.49	4.58	679.90
Reach1	6439.968	100-YR	3251.00	-3.86	4.55	4.90	685.20
Reach1	6439.968	500-YR	4196.00	-3.86	4.82	6.11	712.23
Reach1	6304.708	10-YR	2023.00	-4.00	4.17	3.87	541.85
Reach1	6304.708	50-YR	3016.00	-4.00	4.13	5.80	538.17
Reach1	6304.708	100-YR	3251.00	-4.00	4.12	6.26	537.13
Reach1	6304.708	500-YR	4196.00	-4.00	4.05	8.17	531.04
Reach1	6240.809	10-YR	2023.00	-4.06	4.20	3.01	697.26
Reach1	6240.809	50-YR	3016.00	-4.06	4.20	4.48	697.45
Reach1	6240.809	100-YR	3251.00	-4.06	4.20	4.83	697.66
Reach1	6240.809	500-YR	4196.00	-4.06	4.21	6.23	698.22
Reach1	6168.817	10-YR	2023.00	-4.14	4.18	3.00	687.04
Reach1	6168.817	50-YR	3016.00	-4.14	4.16	4.49	684.57
Reach1	6168.817	100-YR	3251.00	-4.14	4.15	4.85	683.81
Reach1	6168.817	500-YR	4196.00	-4.14	4.11	6.29	680.00
Reach1	6080.248	10-YR	2023.00	-4.22	4.20	2.31	886.61
Reach1	6080.248	50-YR	3016.00	-4.22	4.20	3.44	886.61
Reach1	6080.248	100-YR	3251.00	-4.22	4.20	3.71	886.61
Reach1	6080.248	500-YR	4196.00	-4.22	4.20	4.79	886.61

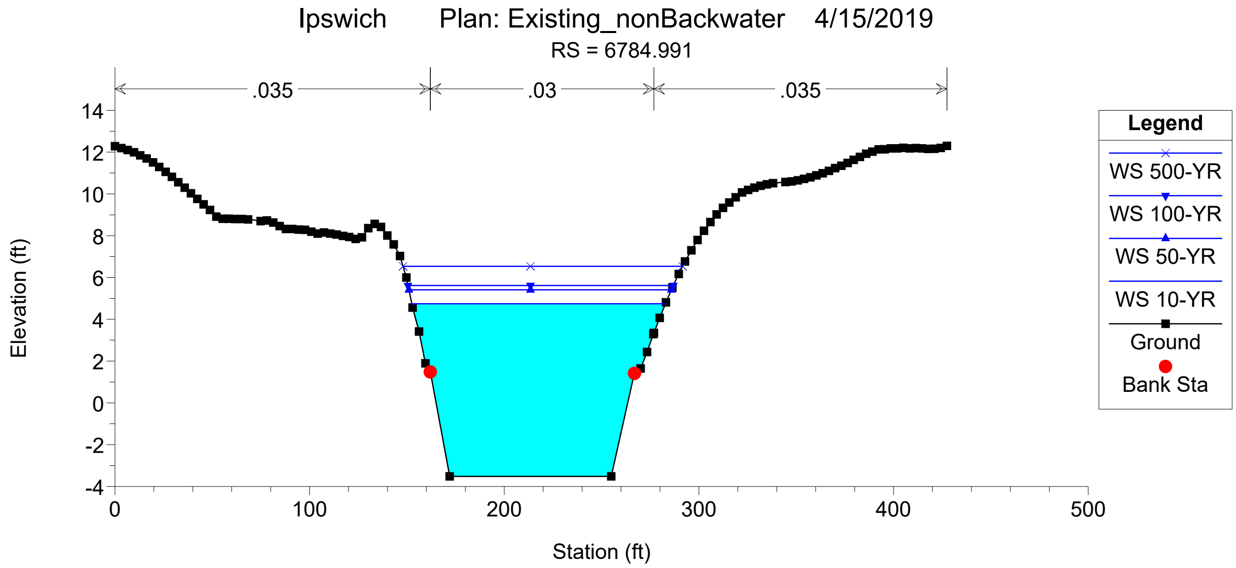


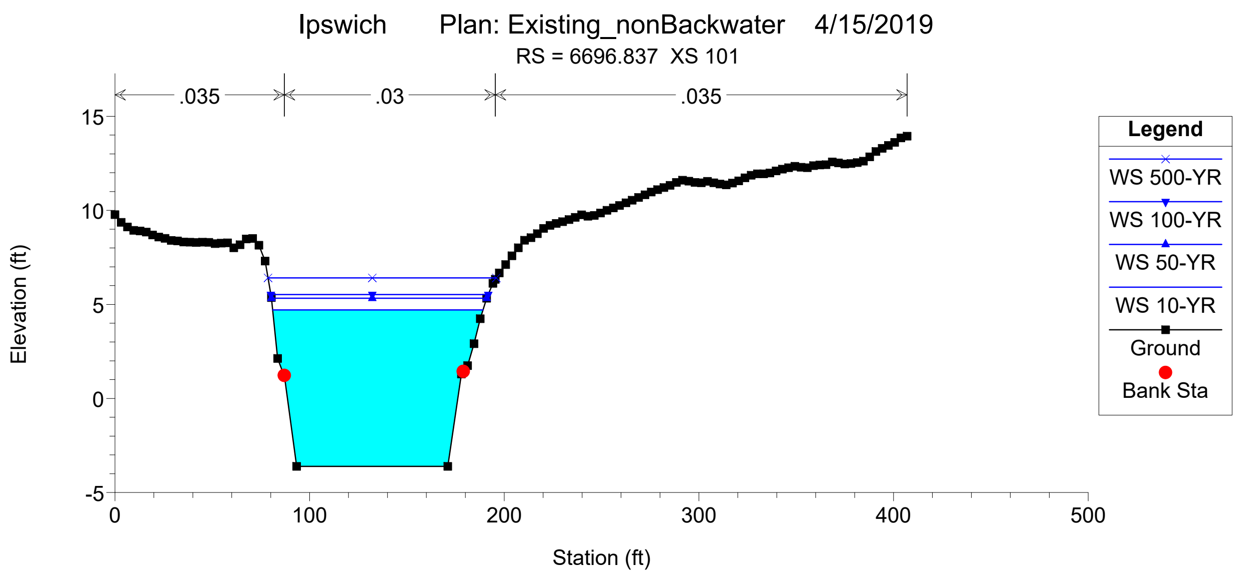
Ipswich Plan: Existing_nonBackwater 4/15/2019
Ipswich Reach1
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Elevation (ft)
Main Channel Distance (ft)
12
10
8
6
4
2
0
-2
-4
-6
0
200
400
600
800
1000
1200
6168.817
6240.809
6304.708
6439.968
6527.842
6557.818 XS 109
6594.157 Choate ...
6650.343 XS 104
6679.995 XS 102
6696.837 XS 101
6784.991
6858.394
7019.873
7177.681

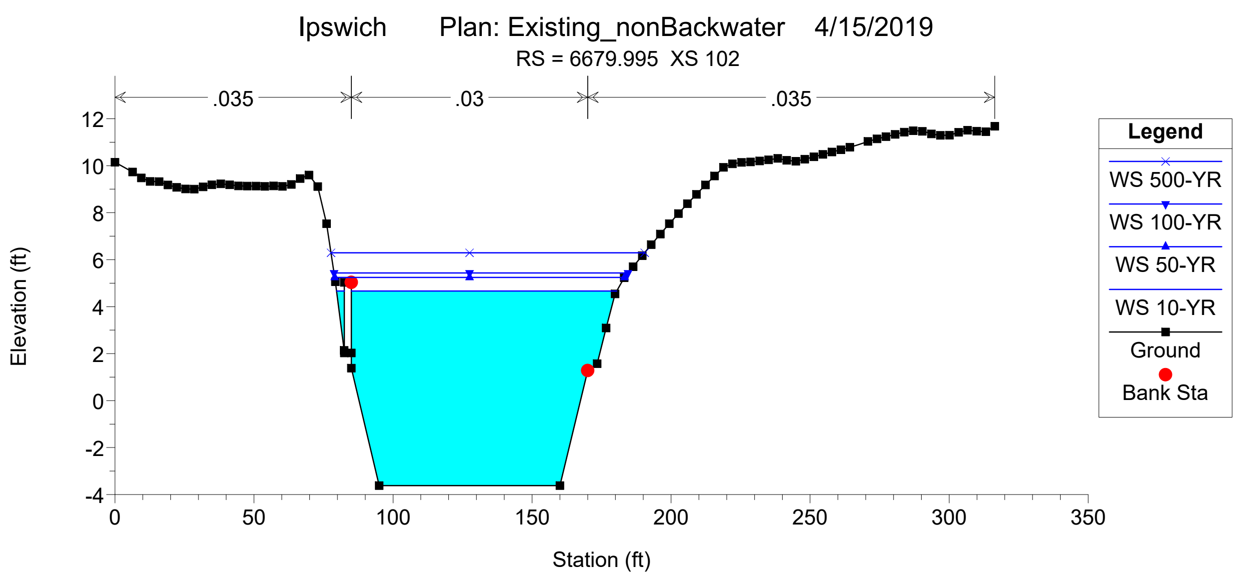

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 7177.681
.05
.04
.03
.06
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

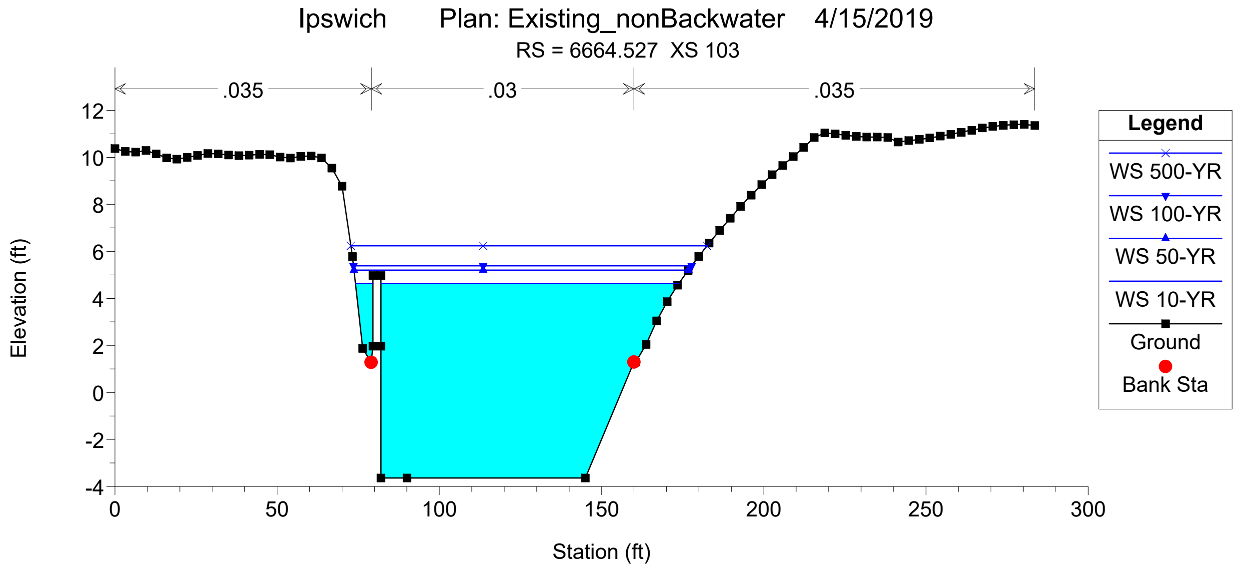

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 7019.873
.04
.03
.035
.06
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

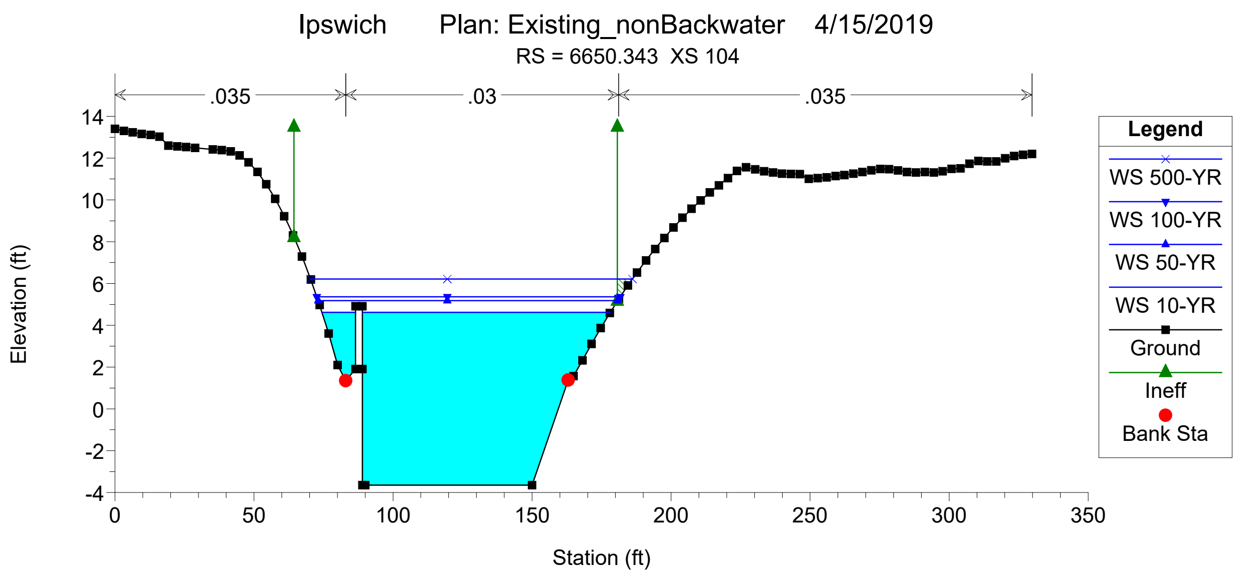

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6858.394
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

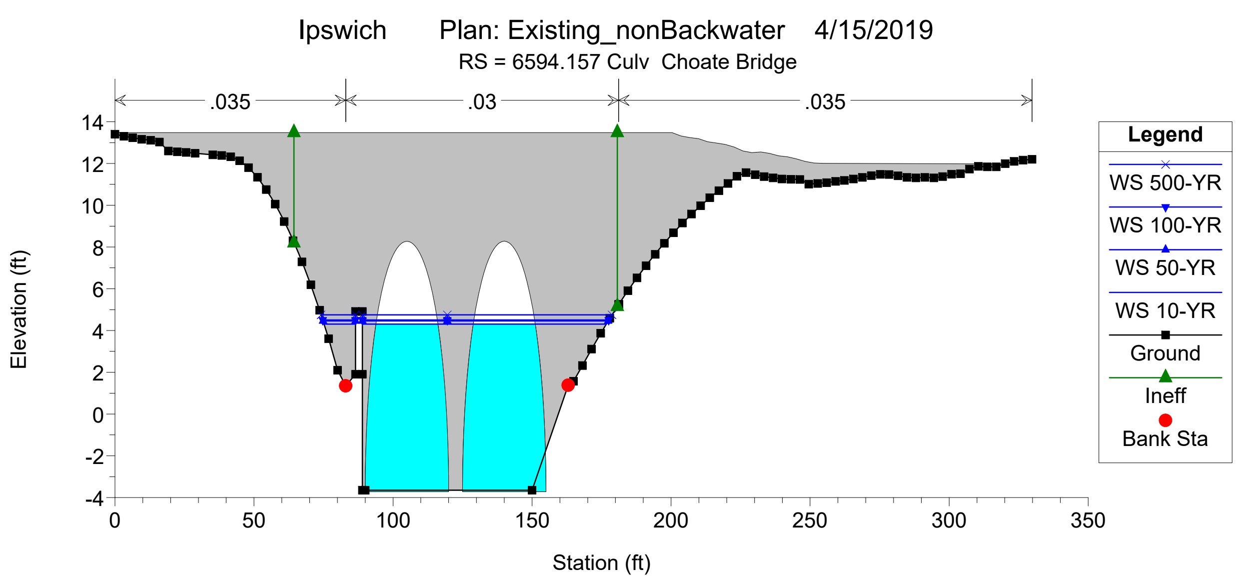

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6784.991
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

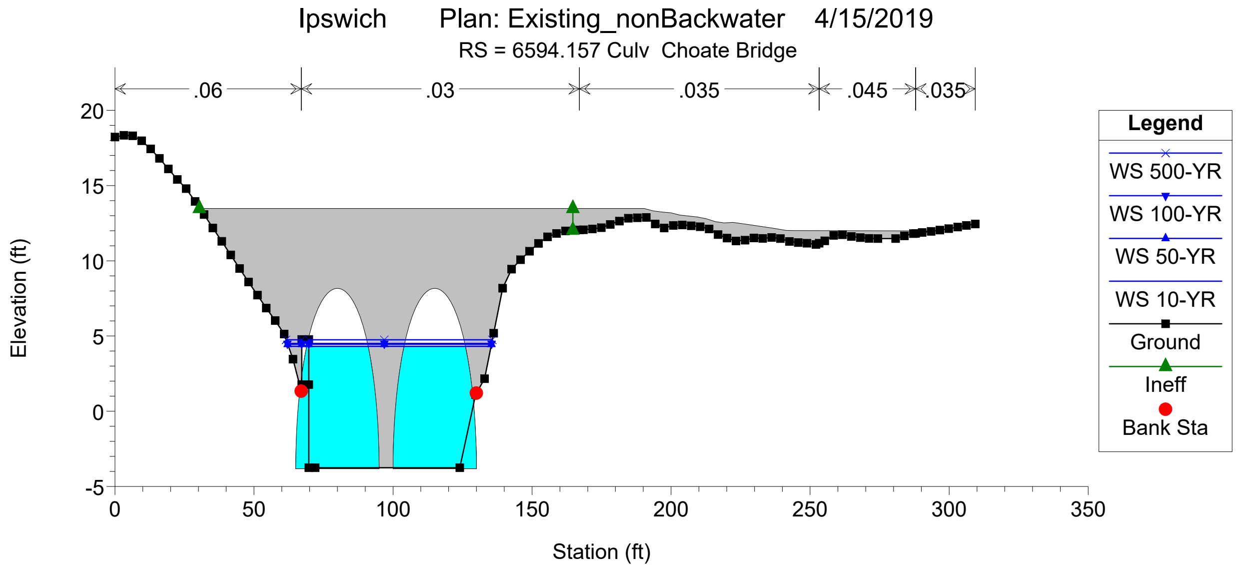

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6696.837 XS 101
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

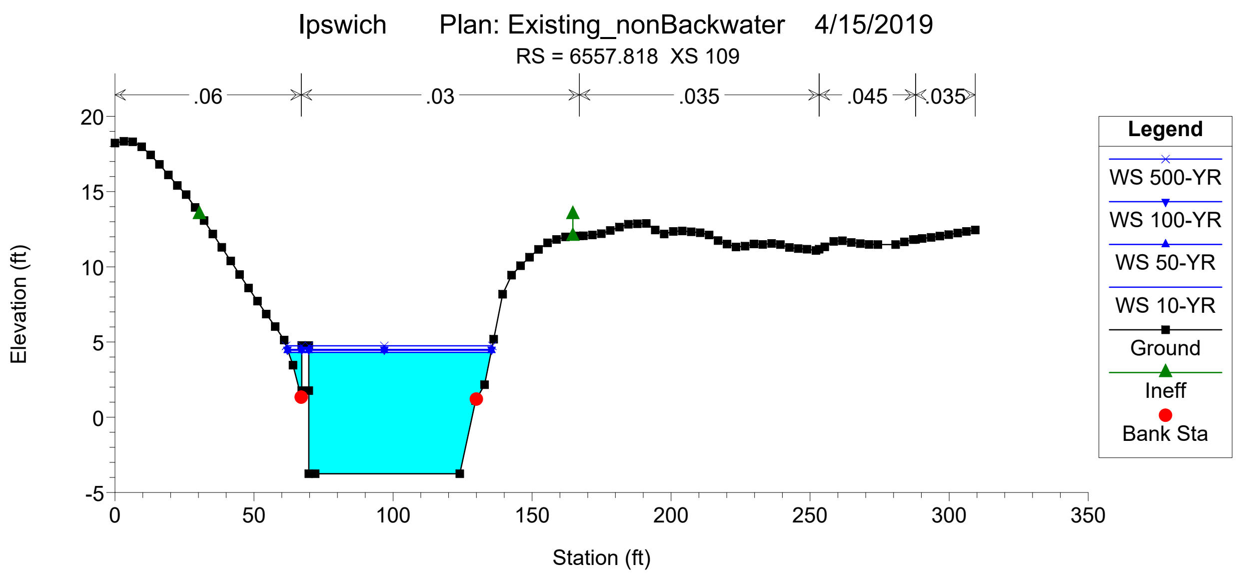

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6679.995 XS 102
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

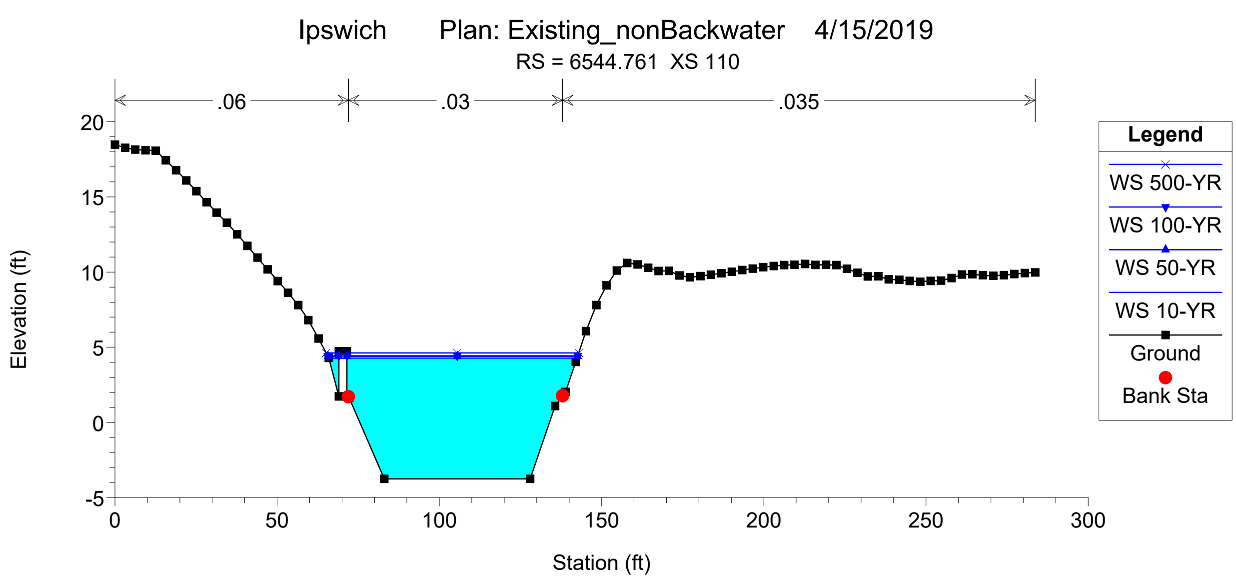

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6664.527 XS 103
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

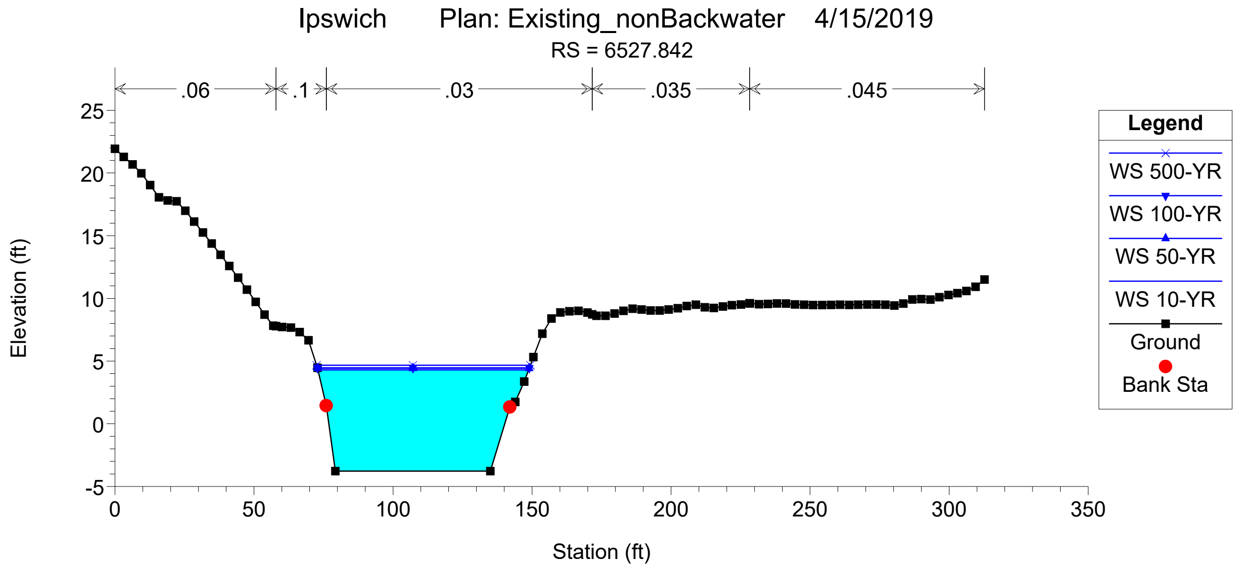

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6650.343 XS 104
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

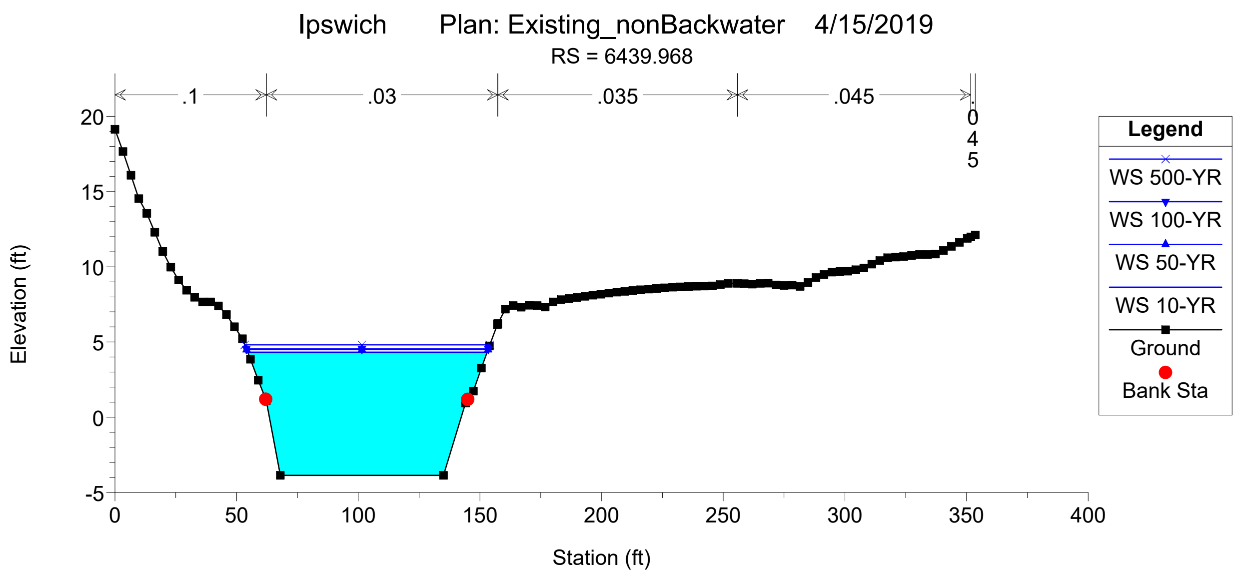

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6594.157 Culv Choate Bridge
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

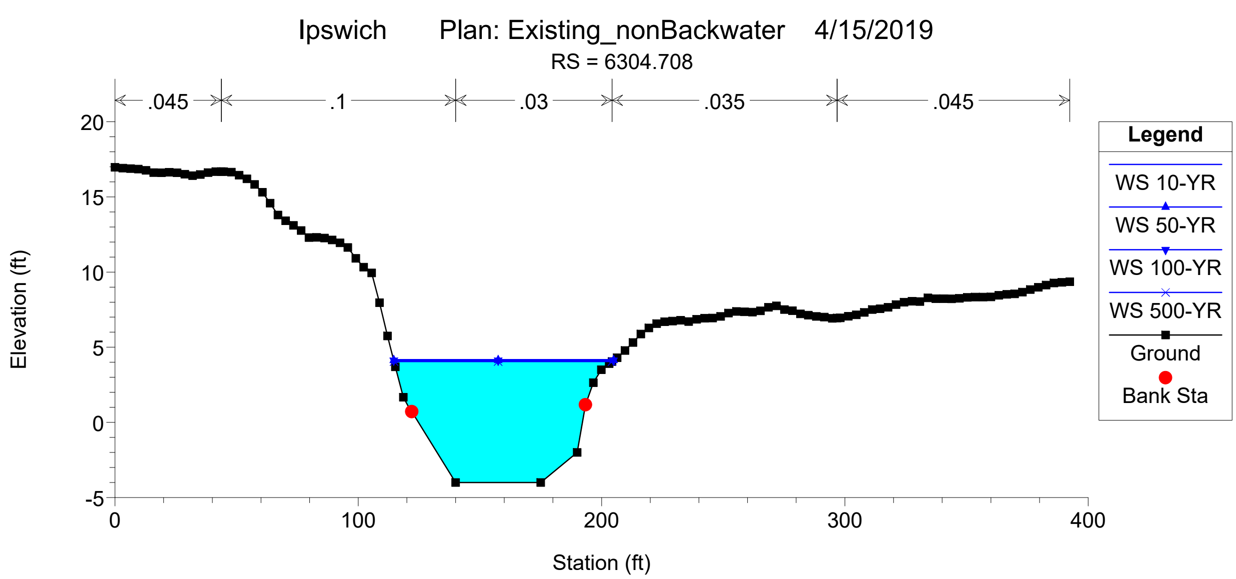

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6594.157 Culv Choate Bridge
.06
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

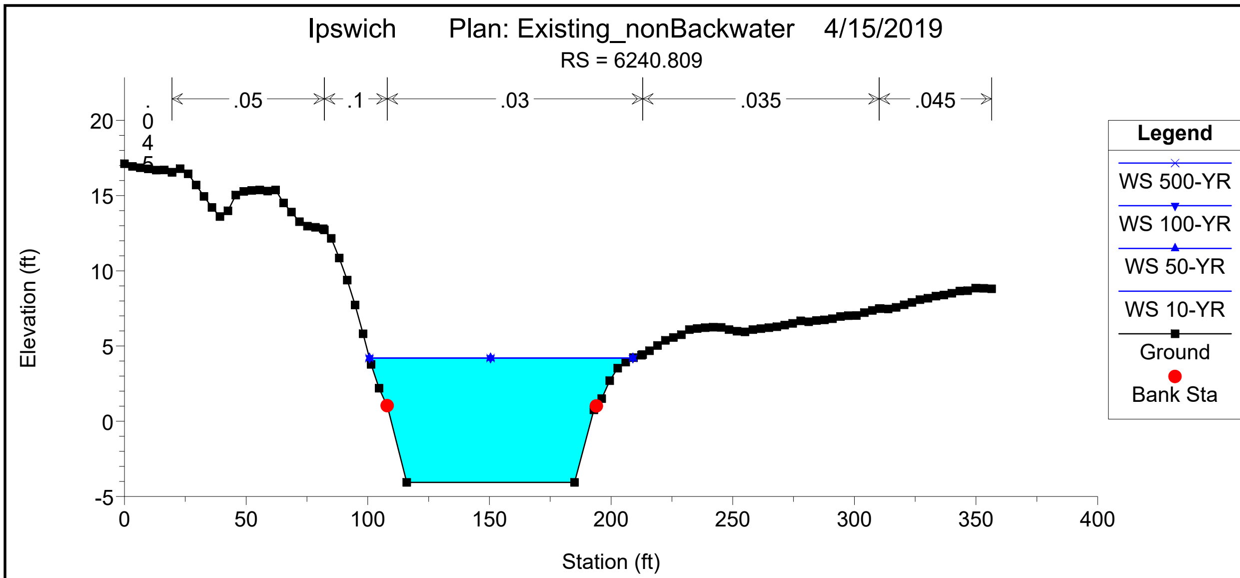

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6557.818 XS 109
.06
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

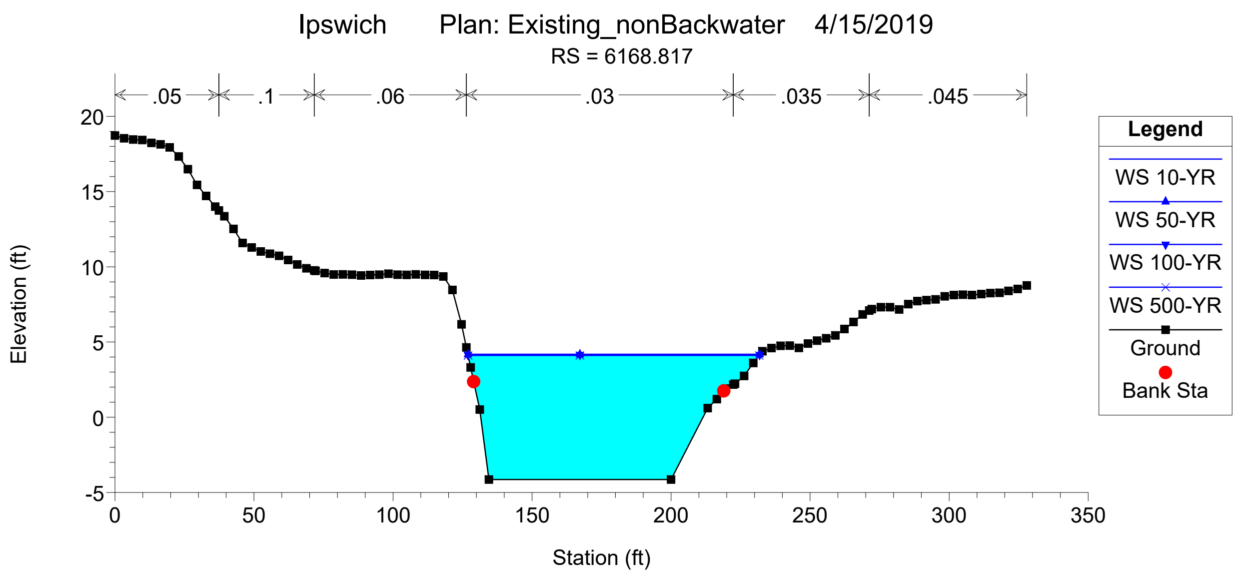

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6544.761 XS 110
.06
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

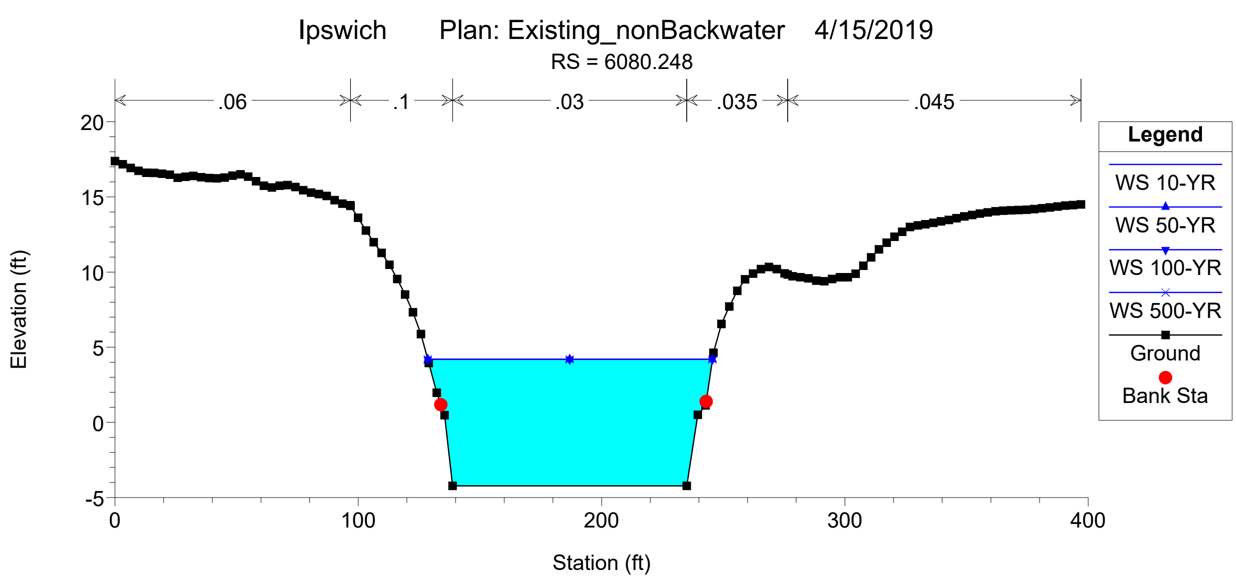

Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6527.842
.06
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6439.968
.1
.03
.035
.045
0
4
5
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6304.708
.045
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Bank Sta


Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6240.809
.05
.1
.03
.035
.045
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6168.817
.05
.1
.06
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Bank Sta


Ipswich Plan: Existing_nonBackwater 4/15/2019
RS = 6080.248
.06
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Bank Sta

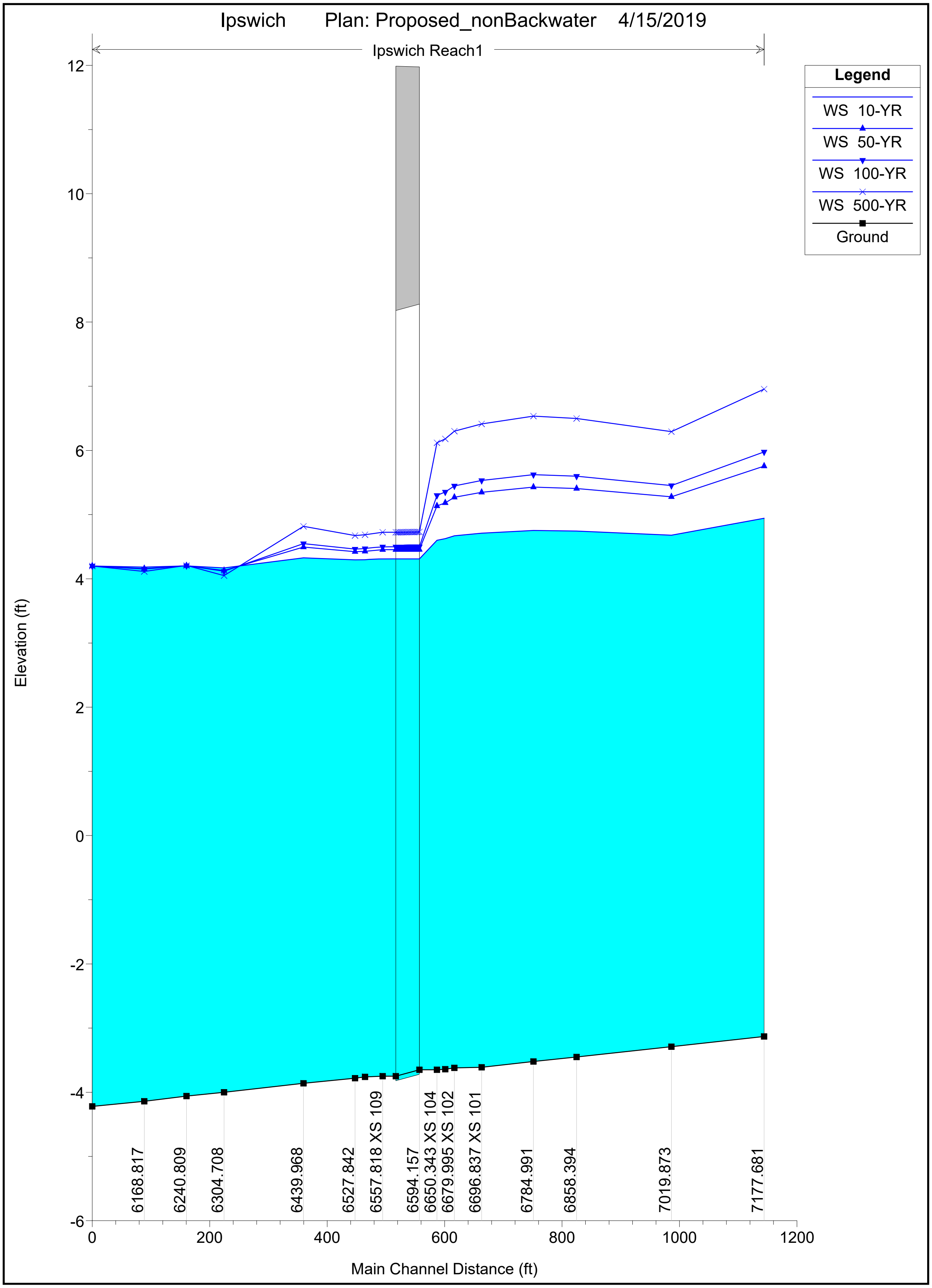
SCENARIO 2: MEAN HIGH WATER - PROPOSED CONDITIONS

HEC-RAS Plan: prop NONbackwater River: Ipswich Reach: Reach1

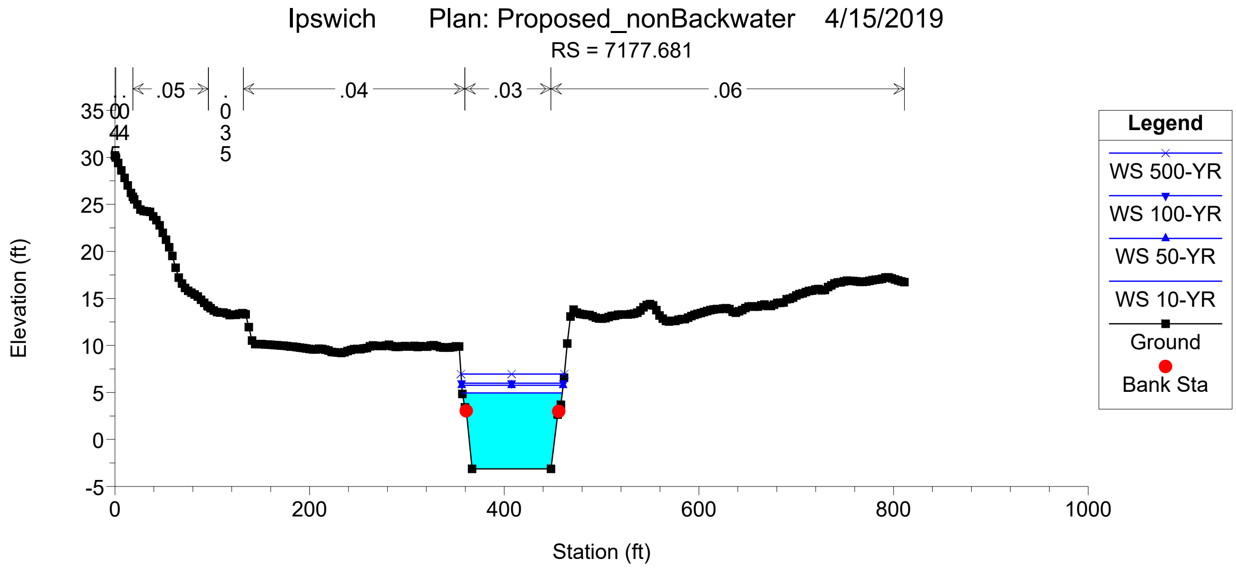
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	7177.681	10-YR	2023.00	-3.13	4.93	2.80	730.13
Reach1	7177.681	50-YR	3016.00	-3.13	5.74	3.76	813.27
Reach1	7177.681	100-YR	3251.00	-3.13	5.96	3.95	836.20
Reach1	7177.681	500-YR	4196.00	-3.13	6.93	4.57	938.64
Reach1	7019.873	10-YR	2023.00	-3.29	4.67	4.45	469.75
Reach1	7019.873	50-YR	3016.00	-3.29	5.25	6.08	517.92
Reach1	7019.873	100-YR	3251.00	-3.29	5.43	6.39	532.52
Reach1	7019.873	500-YR	4196.00	-3.29	6.25	7.37	604.67
Reach1	6858.394	10-YR	2023.00	-3.45	4.73	2.86	730.15
Reach1	6858.394	50-YR	3016.00	-3.45	5.38	3.90	805.88
Reach1	6858.394	100-YR	3251.00	-3.45	5.57	4.10	828.49
Reach1	6858.394	500-YR	4196.00	-3.45	6.46	4.74	938.12
Reach1	6784.991	10-YR	2023.00	-3.52	4.74	2.44	858.87
Reach1	6784.991	50-YR	3016.00	-3.52	5.41	3.32	946.84
Reach1	6784.991	100-YR	3251.00	-3.52	5.60	3.49	972.92
Reach1	6784.991	500-YR	4196.00	-3.52	6.50	4.03	1098.48
Reach1	6696.837	10-YR	2023.00	-3.61	4.70	2.74	758.89
Reach1	6696.837	50-YR	3016.00	-3.61	5.32	3.77	827.16
Reach1	6696.837	100-YR	3251.00	-3.61	5.51	3.97	847.57
Reach1	6696.837	500-YR	4196.00	-3.61	6.37	4.63	946.49
Reach1	6679.995	10-YR	2023.00	-3.62	4.66	3.03	681.15
Reach1	6679.995	50-YR	3016.00	-3.62	5.25	4.18	738.22
Reach1	6679.995	100-YR	3251.00	-3.62	5.42	4.41	756.62
Reach1	6679.995	500-YR	4196.00	-3.62	6.26	5.15	848.43
Reach1	6664.527	10-YR	2023.00	-3.64	4.61	3.39	610.56
Reach1	6664.527	50-YR	3016.00	-3.64	5.16	4.70	661.51
Reach1	6664.527	100-YR	3251.00	-3.64	5.33	4.95	678.74
Reach1	6664.527	500-YR	4196.00	-3.64	6.14	5.75	765.65
Reach1	6650.343	10-YR	2023.00	-3.65	4.59	3.56	583.21
Reach1	6650.343	50-YR	3016.00	-3.65	5.11	4.94	630.77
Reach1	6650.343	100-YR	3251.00	-3.65	5.27	5.21	648.13
Reach1	6650.343	500-YR	4196.00	-3.65	6.08	6.03	737.89
Reach1	6594.157		Culvert				
Reach1	6557.818	10-YR	2023.00	-3.75	4.30	4.44	461.51
Reach1	6557.818	50-YR	3016.00	-3.75	4.42	6.51	469.86
Reach1	6557.818	100-YR	3251.00	-3.75	4.47	6.98	472.54
Reach1	6557.818	500-YR	4196.00	-3.75	4.67	8.77	485.86
Reach1	6544.761	10-YR	2023.00	-3.76	4.29	4.14	492.22
Reach1	6544.761	50-YR	3016.00	-3.76	4.42	6.06	501.13
Reach1	6544.761	100-YR	3251.00	-3.76	4.46	6.49	504.01
Reach1	6544.761	500-YR	4196.00	-3.76	4.66	8.15	518.59

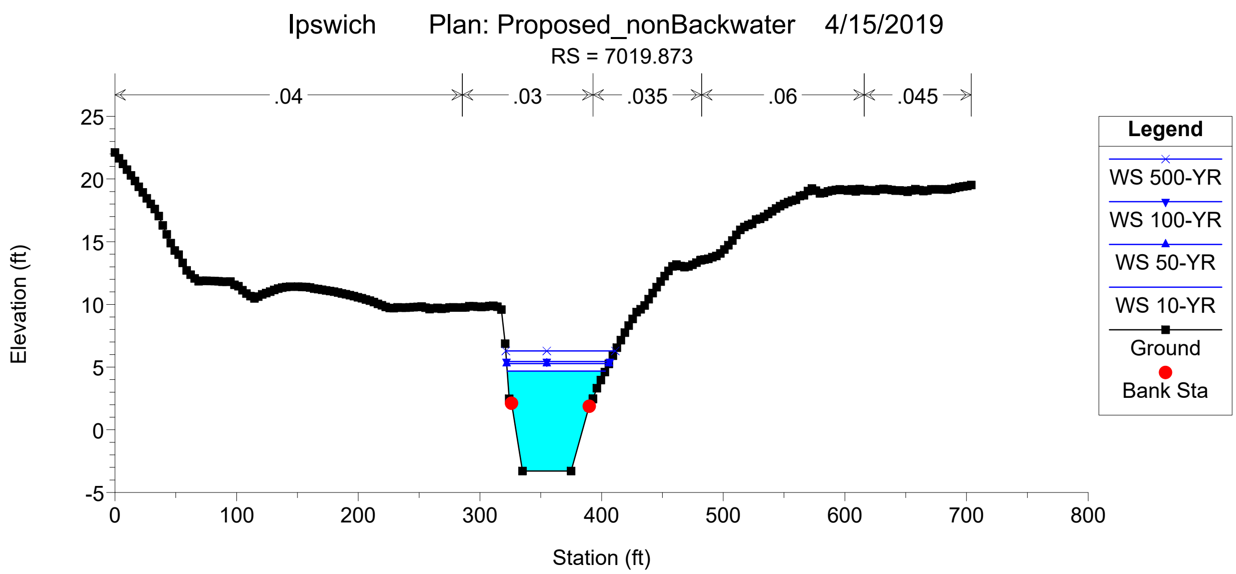
HEC-RAS Plan: prop NONbackwater   River: Ipswich   Reach: Reach1 (Continued)

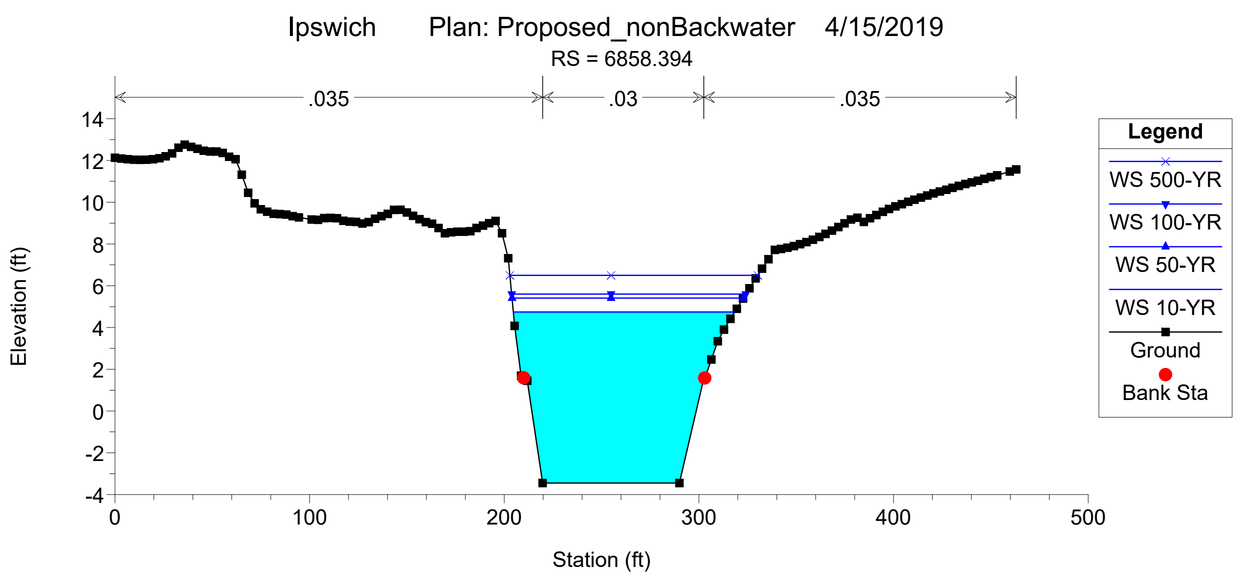
Reach	River Sta	Profile	Q Total	Min Ch El	W.S. Elev	Vel Chnl	Flow Area
			(cfs)	(ft)	(ft)	(ft/s)	(sq ft)
Reach1	6527.842	10-YR	2023.00	-3.78	4.29	3.96	522.54
Reach1	6527.842	50-YR	3016.00	-3.78	4.42	5.80	532.24
Reach1	6527.842	100-YR	3251.00	-3.78	4.46	6.22	535.38
Reach1	6527.842	500-YR	4196.00	-3.78	4.67	7.81	551.48
Reach1	6439.968	10-YR	2023.00	-3.86	4.33	3.14	663.28
Reach1	6439.968	50-YR	3016.00	-3.86	4.49	4.58	679.90
Reach1	6439.968	100-YR	3251.00	-3.86	4.55	4.90	685.20
Reach1	6439.968	500-YR	4196.00	-3.86	4.82	6.11	712.23
Reach1	6304.708	10-YR	2023.00	-4.00	4.17	3.87	541.85
Reach1	6304.708	50-YR	3016.00	-4.00	4.13	5.80	538.17
Reach1	6304.708	100-YR	3251.00	-4.00	4.12	6.26	537.13
Reach1	6304.708	500-YR	4196.00	-4.00	4.05	8.17	531.04
Reach1	6240.809	10-YR	2023.00	-4.06	4.20	3.01	697.26
Reach1	6240.809	50-YR	3016.00	-4.06	4.20	4.48	697.45
Reach1	6240.809	100-YR	3251.00	-4.06	4.20	4.83	697.66
Reach1	6240.809	500-YR	4196.00	-4.06	4.21	6.23	698.22
Reach1	6168.817	10-YR	2023.00	-4.14	4.18	3.00	687.04
Reach1	6168.817	50-YR	3016.00	-4.14	4.16	4.49	684.57
Reach1	6168.817	100-YR	3251.00	-4.14	4.15	4.85	683.81
Reach1	6168.817	500-YR	4196.00	-4.14	4.11	6.29	680.00
Reach1	6080.248	10-YR	2023.00	-4.22	4.20	2.31	886.61
Reach1	6080.248	50-YR	3016.00	-4.22	4.20	3.44	886.61
Reach1	6080.248	100-YR	3251.00	-4.22	4.20	3.71	886.61
Reach1	6080.248	500-YR	4196.00	-4.22	4.20	4.79	886.61

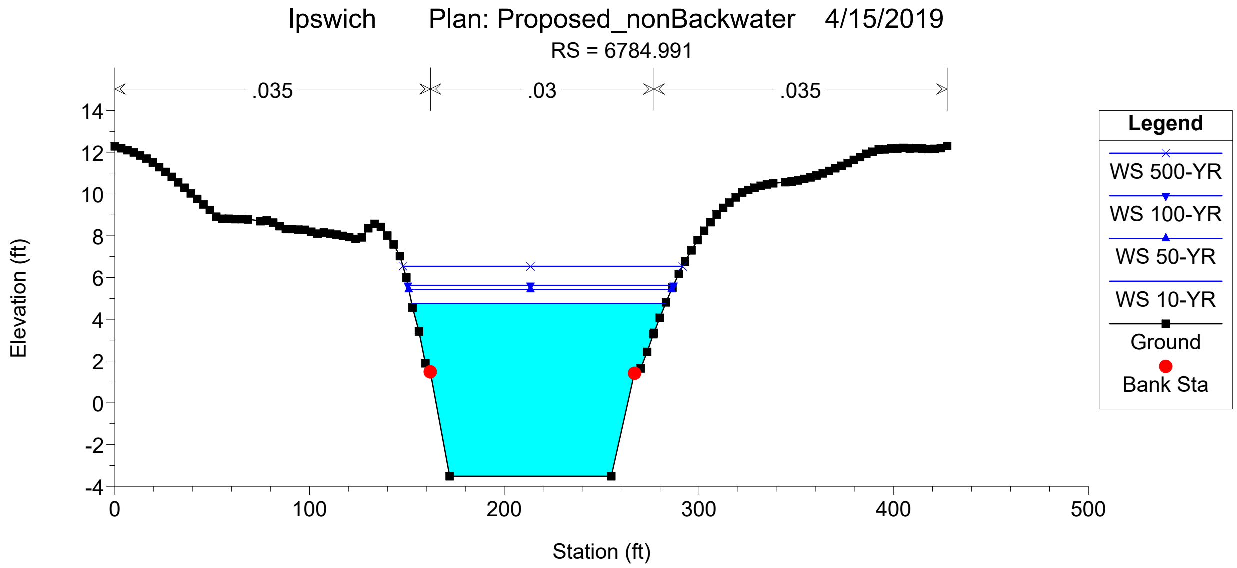


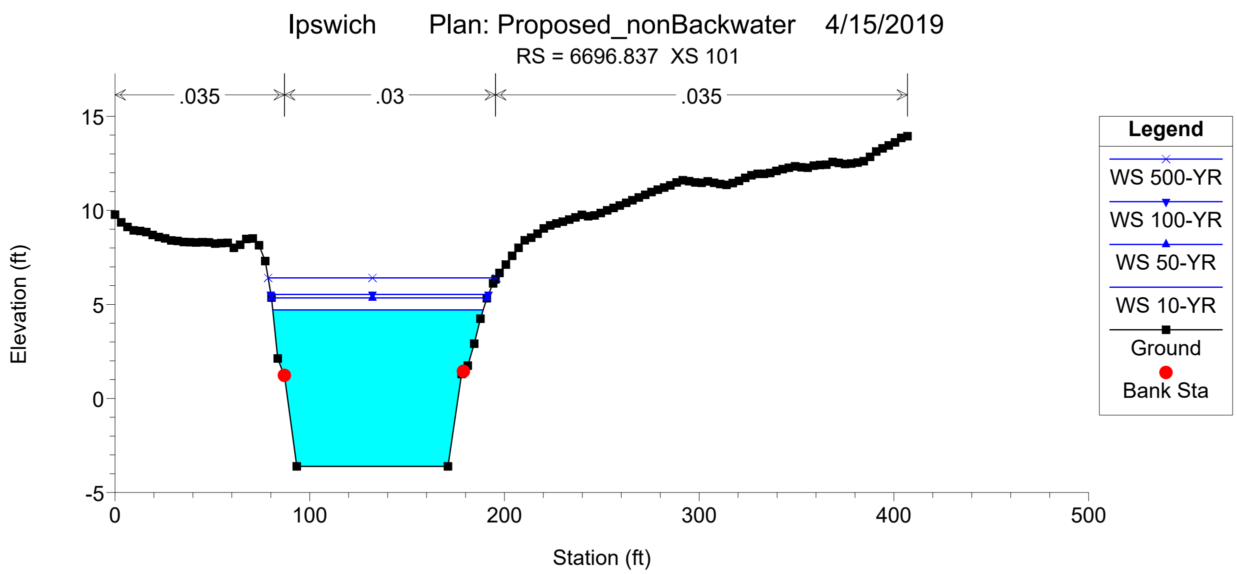
Ipswich Plan: Proposed_nonBackwater 4/15/2019
Ipswich Reach1
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Elevation (ft)
12
10
8
6
4
2
0
-2
-4
-6
6168.817
6240.809
6304.708
6439.968
6527.842
6557.818 XS 109
6594.157
6650.343 XS 104
6679.995 XS 102
6696.837 XS 101
6784.991
6858.394
7019.873
7177.681
0
200
400
600
800
1000
1200
Main Channel Distance (ft)

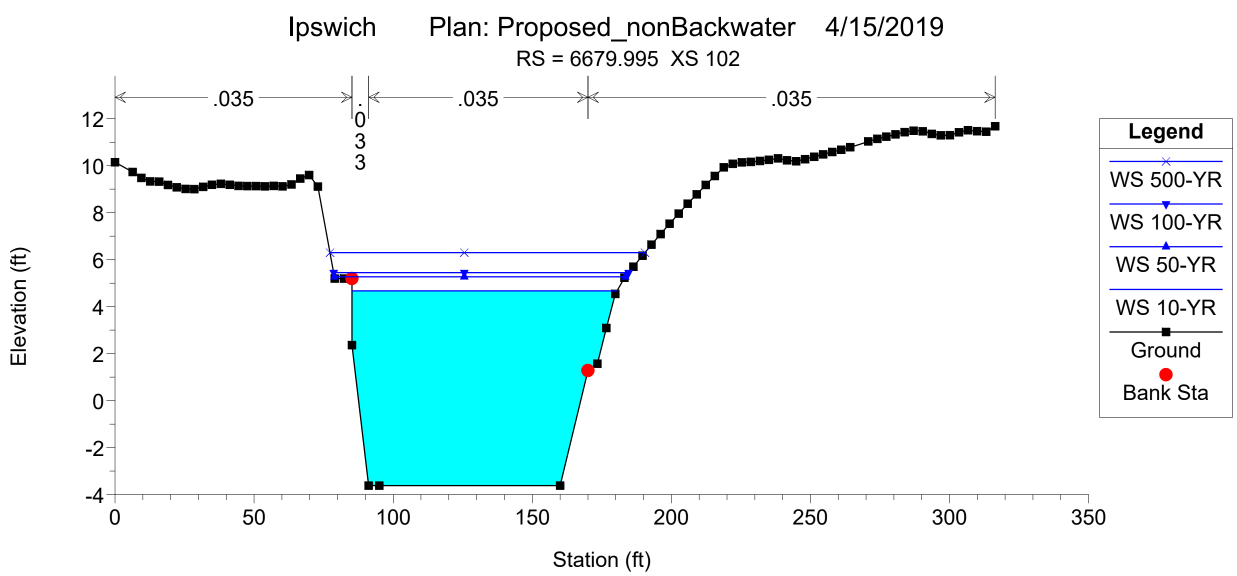

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 7177.681
.05
.04
.03
.06
Elevation (ft)
35
30
25
20
15
10
5
0
-5
0
200
400
600
800
1000
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

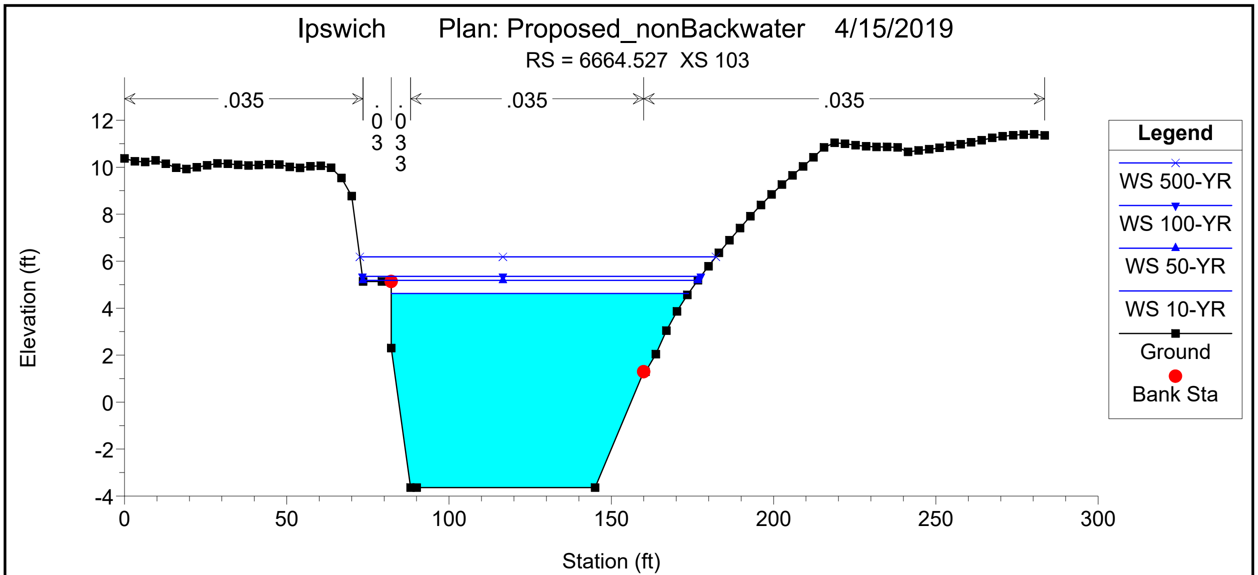

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 7019.873
.04
.03
.035
.06
.045
Elevation (ft)
25
20
15
10
5
0
-5
0
100
200
300
400
500
600
700
800
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6858.394
.035
.03
.035
Elevation (ft)
14
12
10
8
6
4
2
0
-2
-4
0
100
200
300
400
500
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

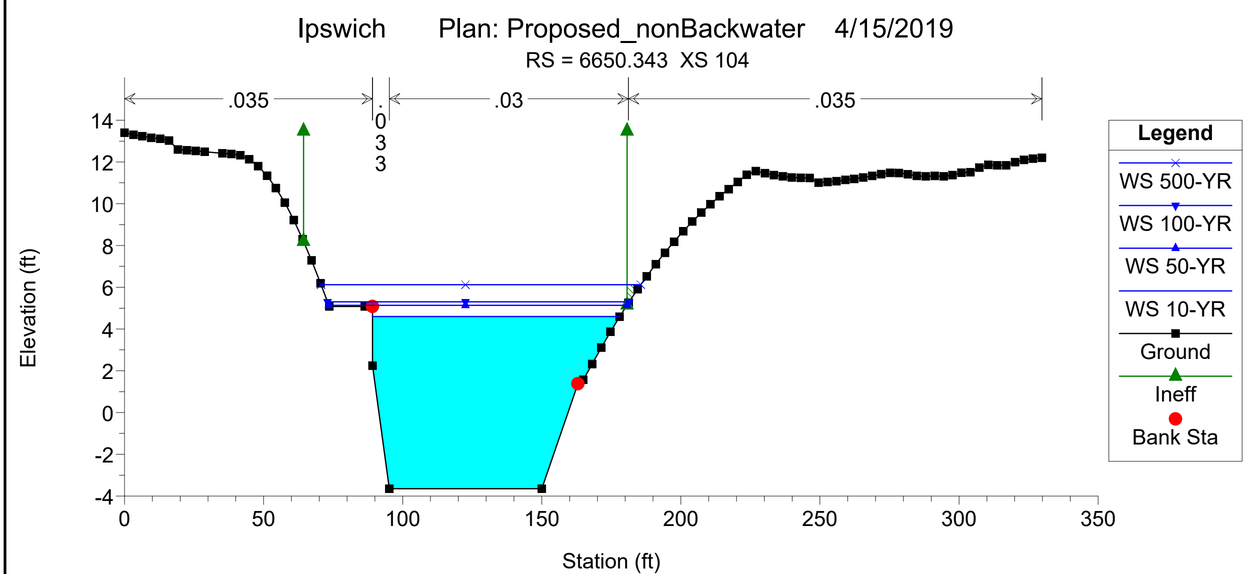

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6784.991
.035
.03
.035
Elevation (ft)
14
12
10
8
6
4
2
0
-2
-4
0
100
200
300
400
500
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6696.837 XS 101
.035
.03
.035
Elevation (ft)
15
10
5
0
-5
0
100
200
300
400
500
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

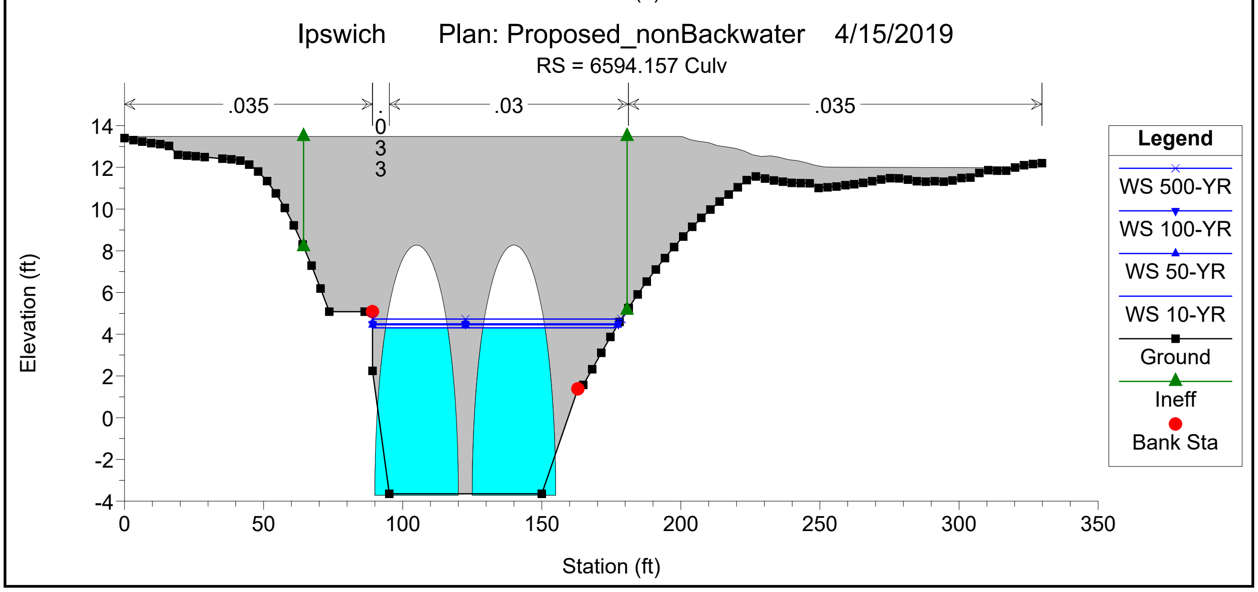

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6679.995 XS 102
.035
.033
.035
.035
Elevation (ft)
12
10
8
6
4
2
0
-2
-4
0
50
100
150
200
250
300
350
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta



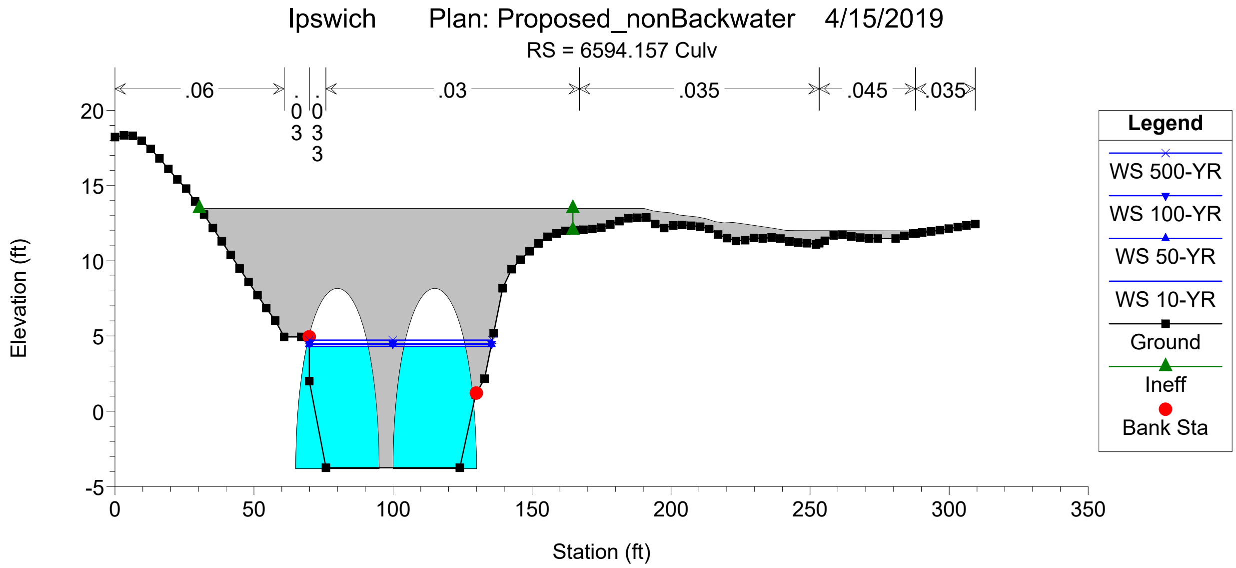
Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6664.527 XS 103
.035
.035
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

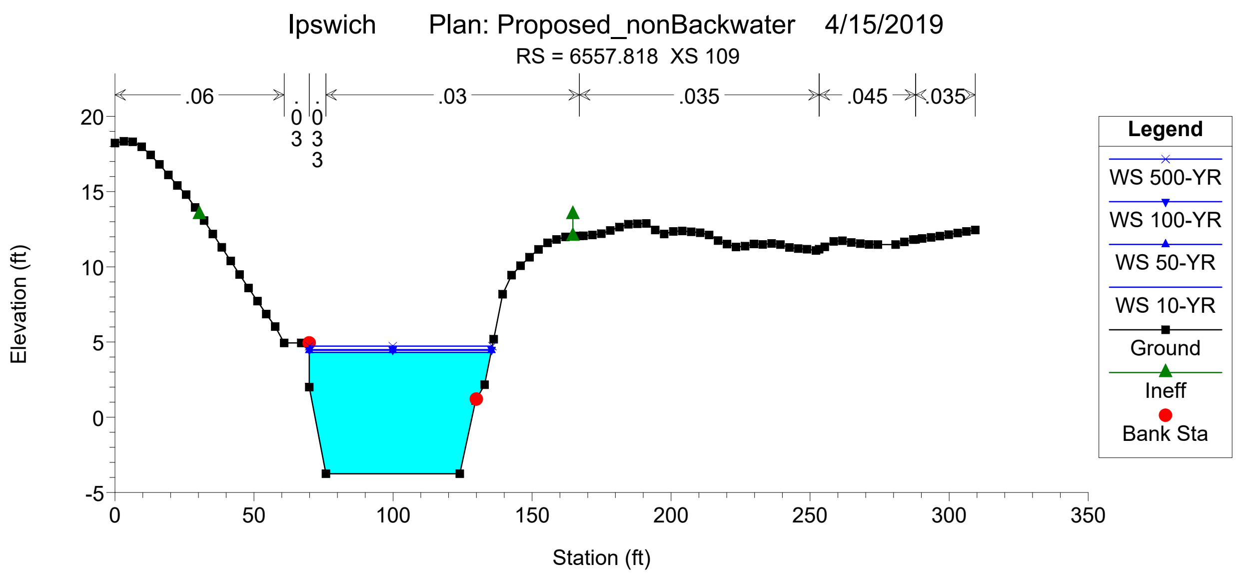


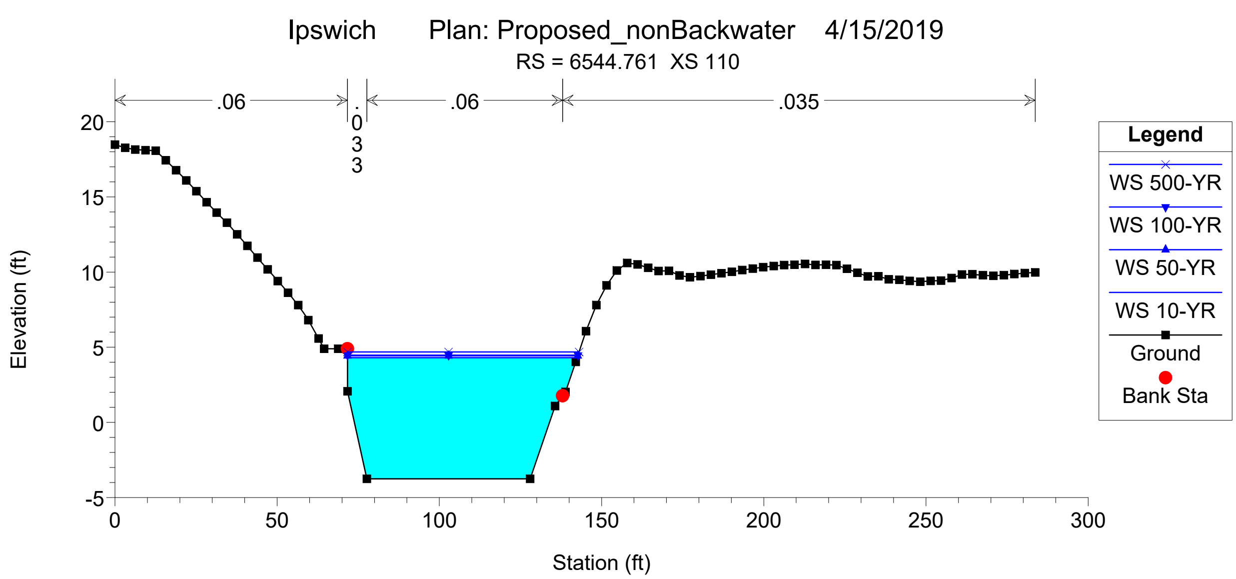
Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6650.343 XS 104
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

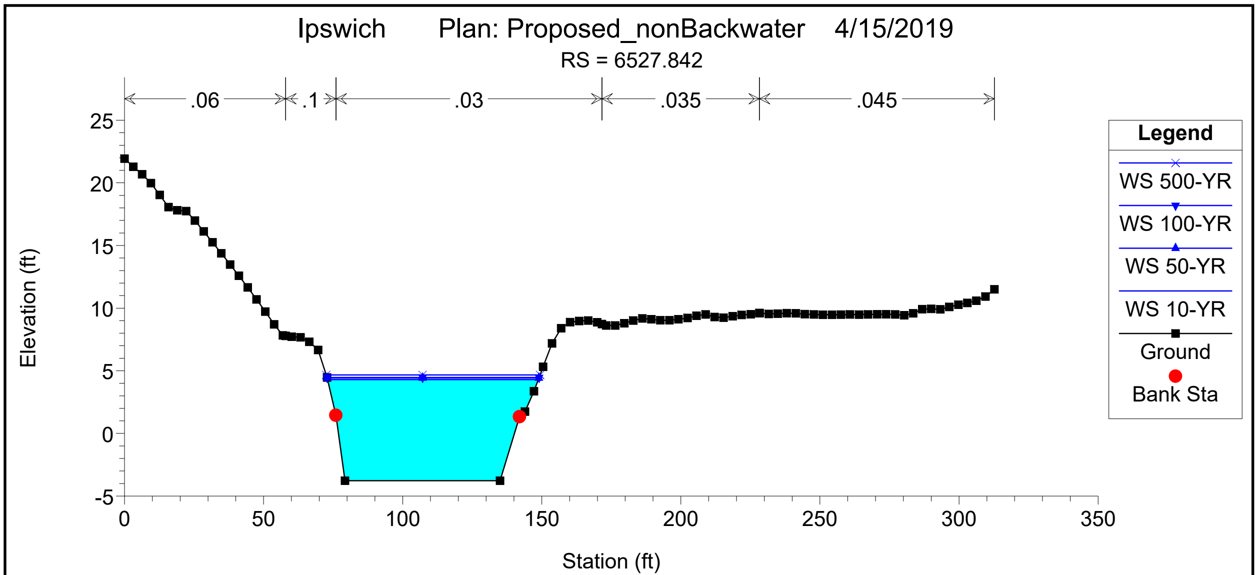


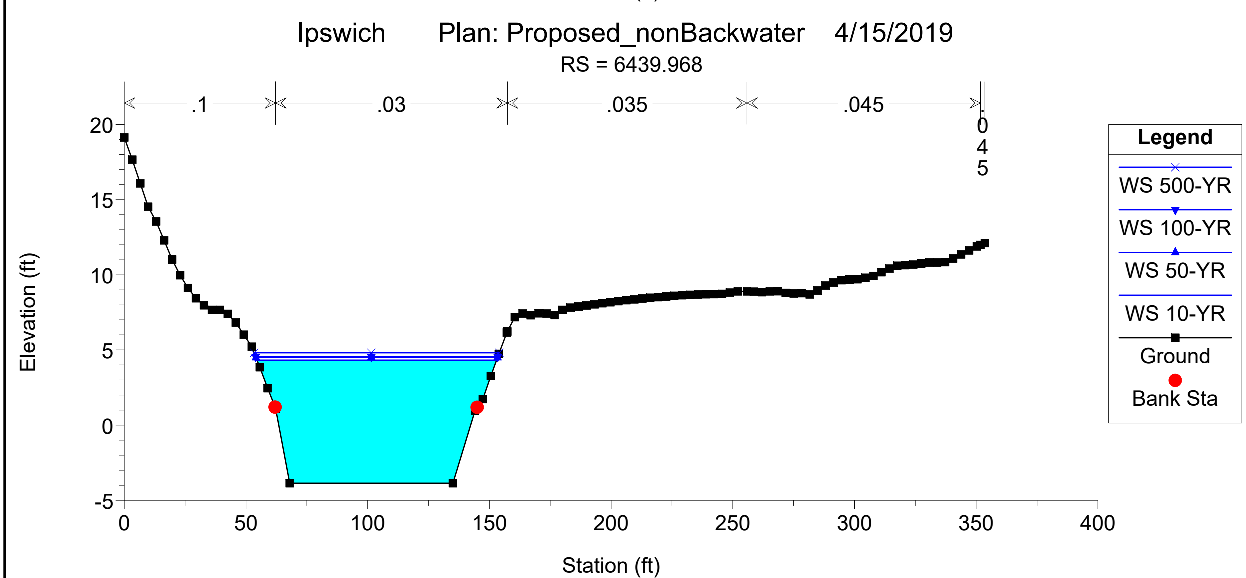
Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6594.157 Culv
.035
.03
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

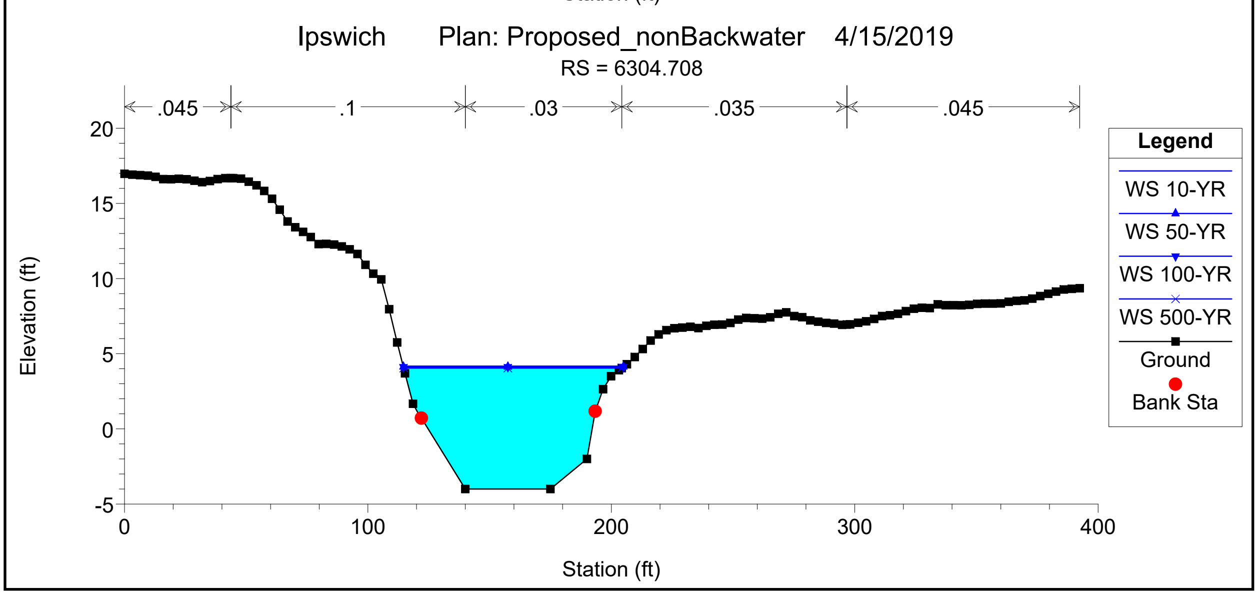

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6594.157 Culv
.06
.033
.033
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

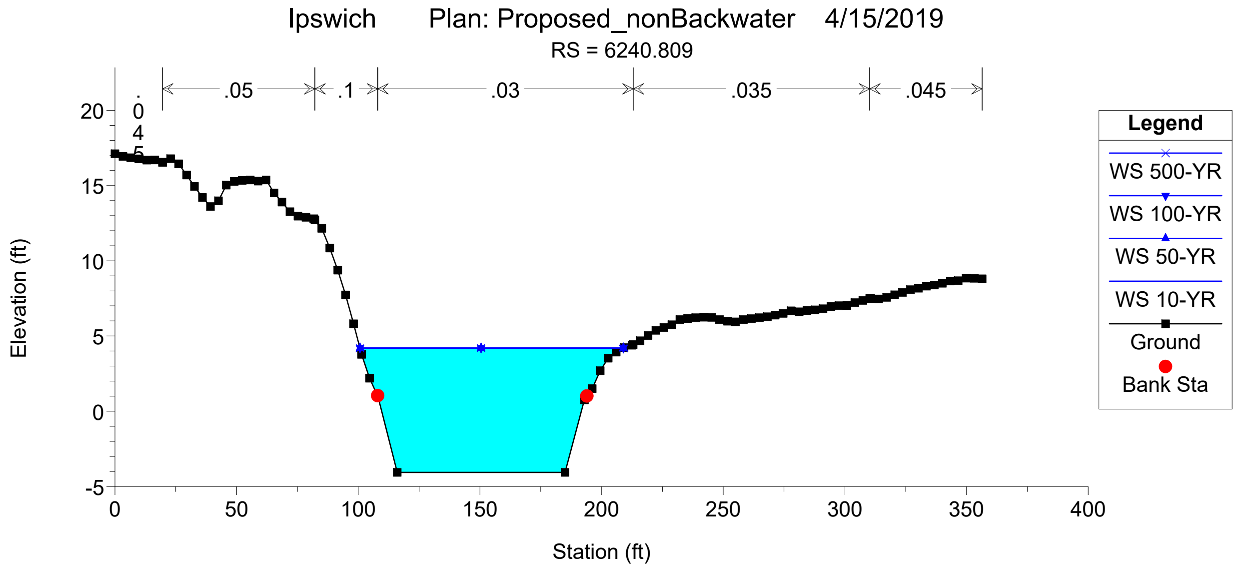

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6557.818 XS 109
.06
.033
.033
.03
.035
.045
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Ineff
Bank Sta

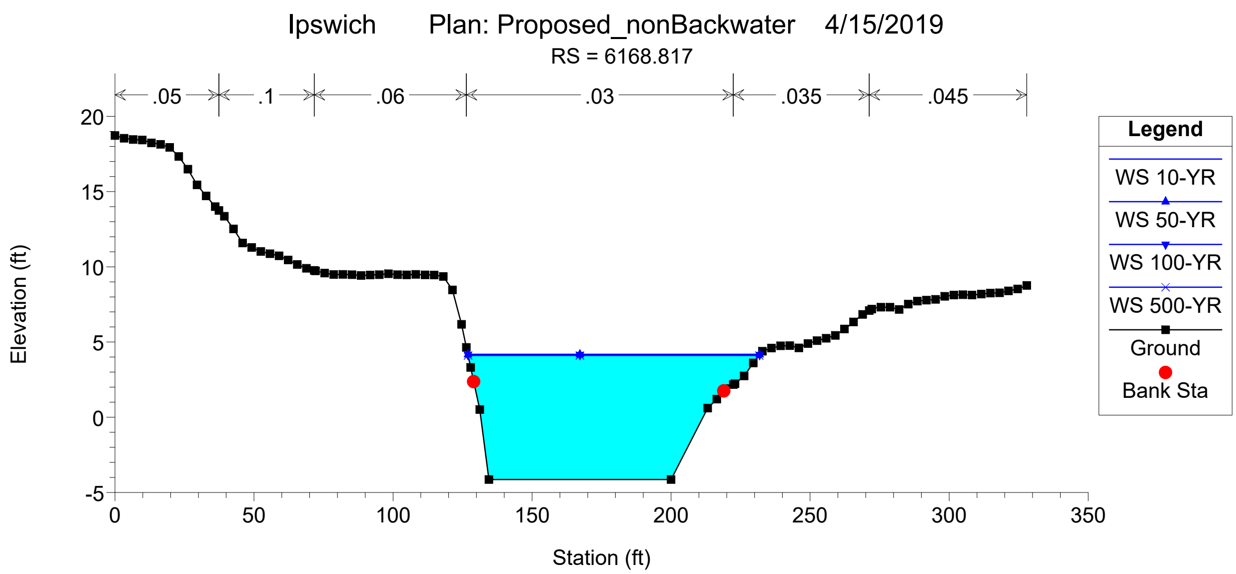

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6544.761 XS 110
.06
.033
.06
.035
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta

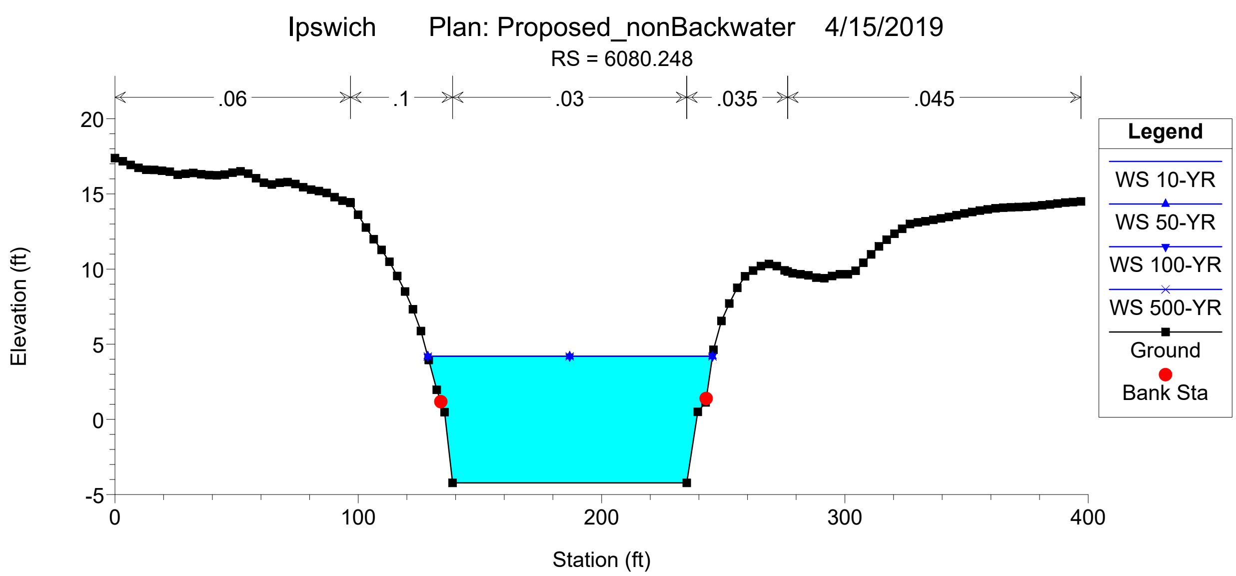

Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6527.842
.06
.1
.03
.035
.045
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)


Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6439.968
.1
.03
.035
.045
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)


Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6304.708
.045
.1
.03
.035
.045
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Bank Sta
Elevation (ft)
Station (ft)


Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6240.809
.05
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 500-YR
WS 100-YR
WS 50-YR
WS 10-YR
Ground
Bank Sta


Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6168.817
.05
.1
.06
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Bank Sta


Ipswich Plan: Proposed_nonBackwater 4/15/2019
RS = 6080.248
.06
.1
.03
.035
.045
Elevation (ft)
Station (ft)
Legend
WS 10-YR
WS 50-YR
WS 100-YR
WS 500-YR
Ground
Bank Sta

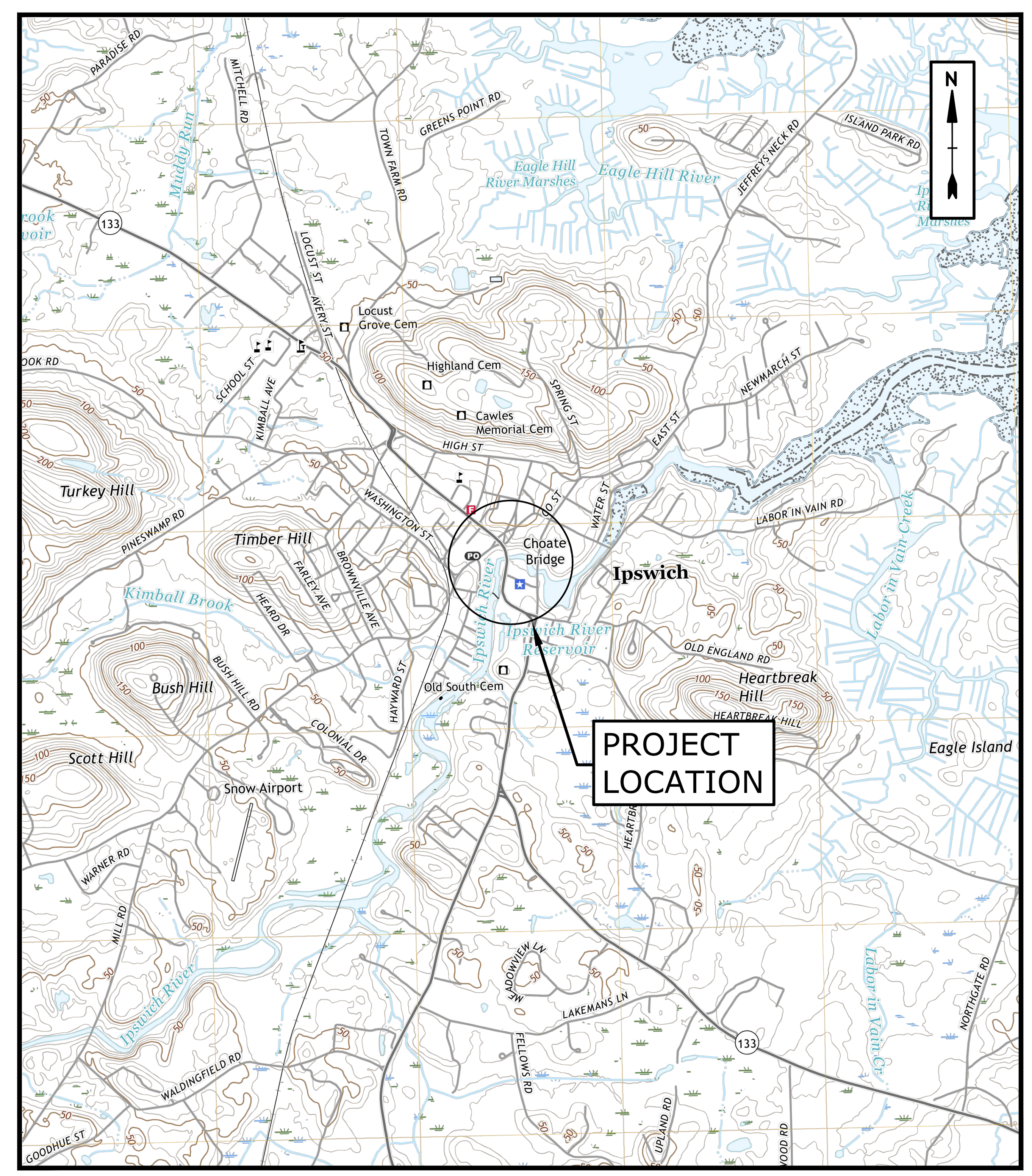
Appendix D
Design Drawings

TOWN OF IPSWICH, MASSACHUSETTS

SEWER INTERCEPTOR AND SIPHON REHABILITATION

APRIL 2019

LIST OF DRAWINGS	
SHEET NO.	TITLE
1	COVER
2	INTERCEPTOR REHABILITATION CONCEPTS - SITE PLAN (1)
3	INTERCEPTOR REHABILITATION CONCEPTS - SITE PLAN (2)
4	INTERCEPTOR REHABILITATION - DETAILS 1
5	INTERCEPTOR REHABILITATION -DETAILS 2
6	EXISTING SIPHON SECTIONS
7	PROPOSED SIPHON SECTIONS
8	DETAILS
9	DOWNSTREAM REVETMENT DETAILS



PREPARED BY:
Tighe&Bond
www.tighebond.com

PREPARED FOR:

TOWN OF IPSWICH
WATER & WASTEWATER DIRECTOR, VICKI HALMEN
TOWN MANAGER, ANTHONY MARINO

CONCEPTUAL DRAWINGS
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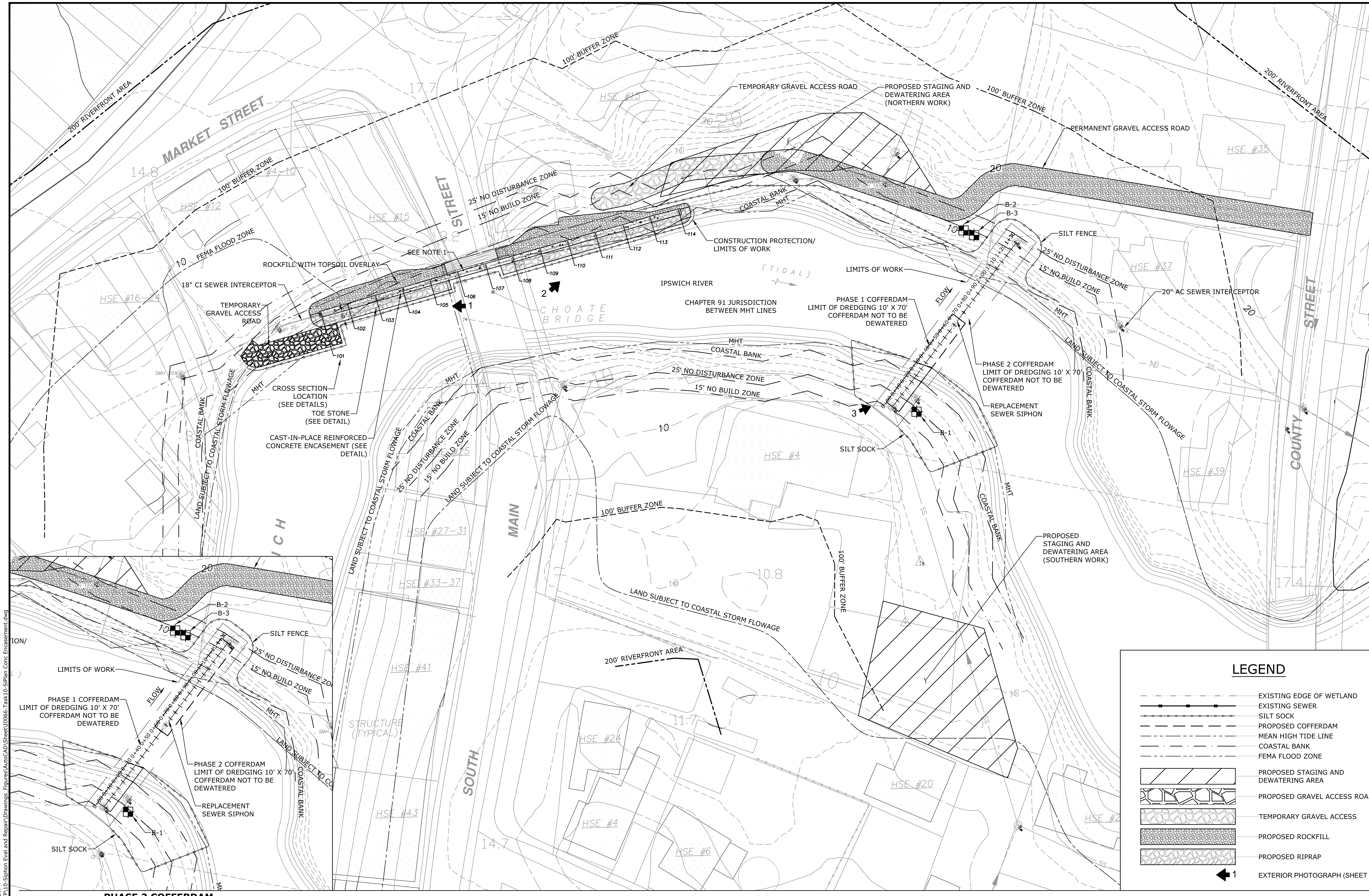
Last Saved: 3/13/2019
Plotted On: Apr 04, 2019–3:01pm By: SAT
Tighe & Bond: J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Xref\I0066-Task10-Cover.dwg



CONCRETE ENCASEMENT

SCALE IN FEET 0 30' 60'

GRAPHIC SCALE

N

NOTE:
1. OMIT SHEET PILE UNDER BRIDGE DUE TO OVERHEAD SPACE CONSTRAINT
2. SEE SHEET 8 FOR EXTERIOR PHOTOGRAPHS

REFERENCE PLANS:
1. "SANITARY SEWER PLAN VICINITY OF SOUTH MAIN STREET TO COUNTY STREET" DATED 3/14/2018 REVISED 5/29/2018 IN FEET RELATIVE TO NAVD88. IN RIVER BATHYMETRY NOT PROVIDED AND WATER LEVELS NOT GIVEN.
2. "PLAN ACCOMPANYING PETITION OF TOWN OF IPSWICH TO REPLACE FILL AND SEWER PIPELINE WITH CROSSING IN THE IPSWICH RIVER, IPSWICH, MASS" DATED 4/27/1959.

Last Saved: 4/17/2019
Plotted On:Apr 17, 2019-1:05pm By: SAT
Tighe & Bond:J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-SiPlan Conc Encasement.dwg

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CONCEPTUAL DRAWINGS
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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

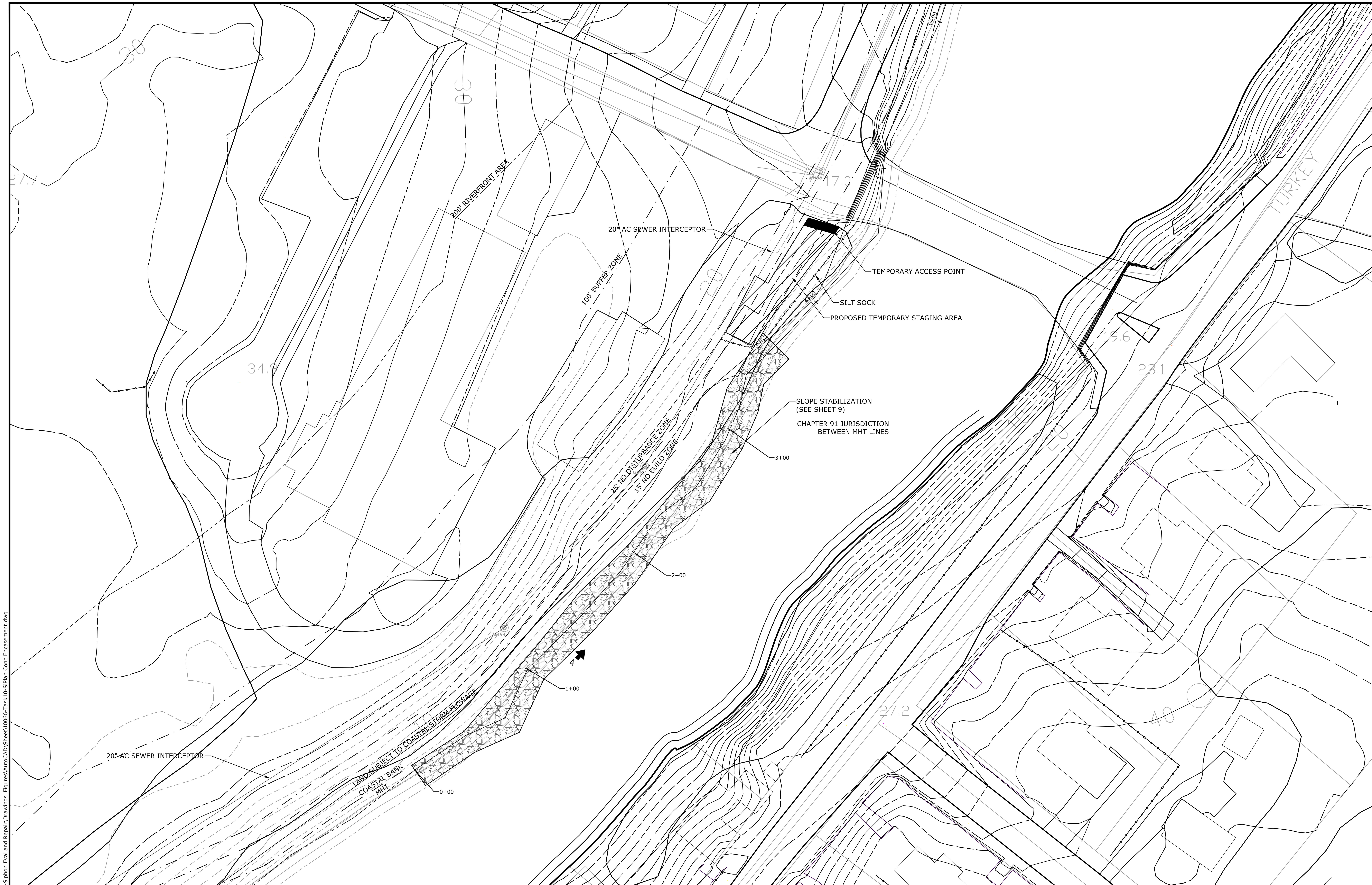
MARK	DATE	DESCRIPTION

PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-SiPlan Conc Encasement.dwg	
DRAWN BY:	LPT/JAK
CHECKED:	DOR, SAT
APPROVED:	SES

INTERCEPTOR REHABILITATION SITE PLAN (1)

SCALE: 1"=30'

SHEET 2



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CONCEPTUAL DRAWINGS

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-SiPlan Conc Encasement.dwg	
DRAWN BY:	LPT/JAK
CHECKED:	DOR, SAT
APPROVED:	SES

INTERCEPTOR REHABILITATION SITE PLAN (2)

SCALE: 1"=30'

SHEET 3

CONCRETE ENCASEMENT

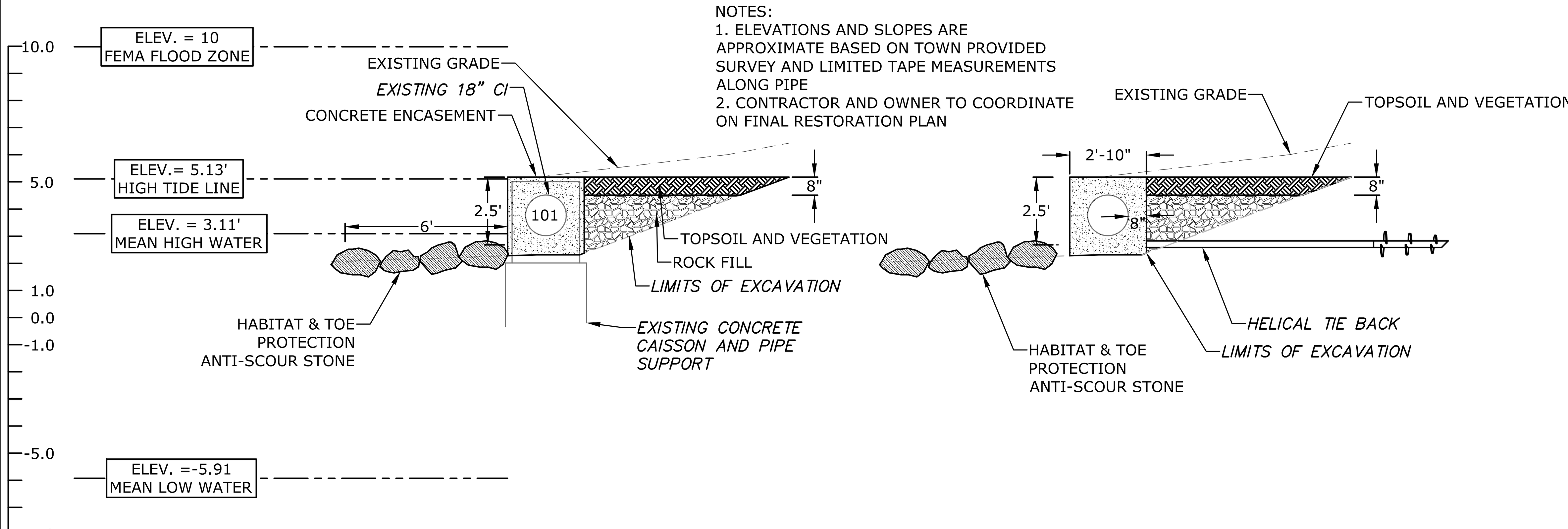
SCALE IN FEET
0 30' 60'
GRAPHIC SCALE

N

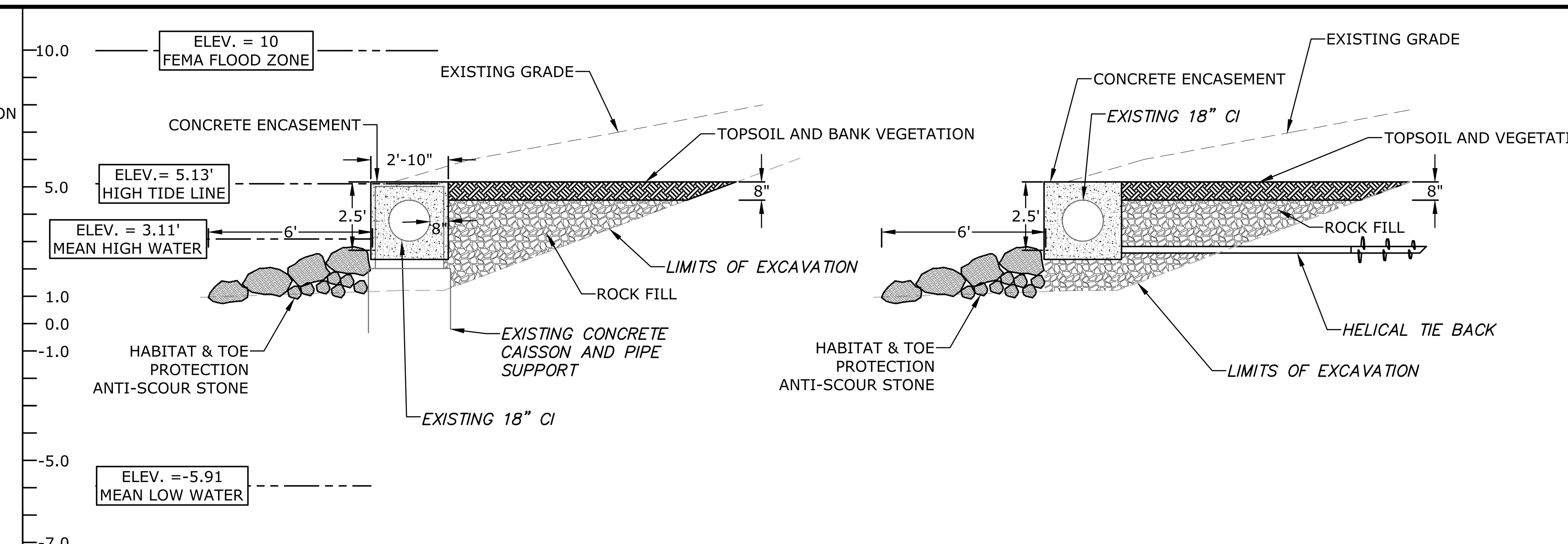
REFERENCE PLANS:
1. "SANITARY SEWER PLAN VICINITY OF SOUTH MAIN STREET TO COUNTY STREET" DATED 3/14/2018 REVISED 5/29/2018 IN FEET RELATIVE TO NAVD88. IN RIVER BATHYMETRY NOT PROVIDED AND WATER LEVELS NOT GIVEN.
2. "PLAN ACCOMPANYING PETITION OF TOWN OF IPSWICH TO REPLACE FILL AND SEWER PIPELINE WITH CROSSING IN THE IPSWICH RIVER, IPSWICH, MASS" DATED 4/27/1959.

Last Saved: 4/17/2019
Plotted On:Apr 17, 2019-1:09pm By: SAT
Tighe & Bond: J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-SiPlan Conc Encasement.dwg

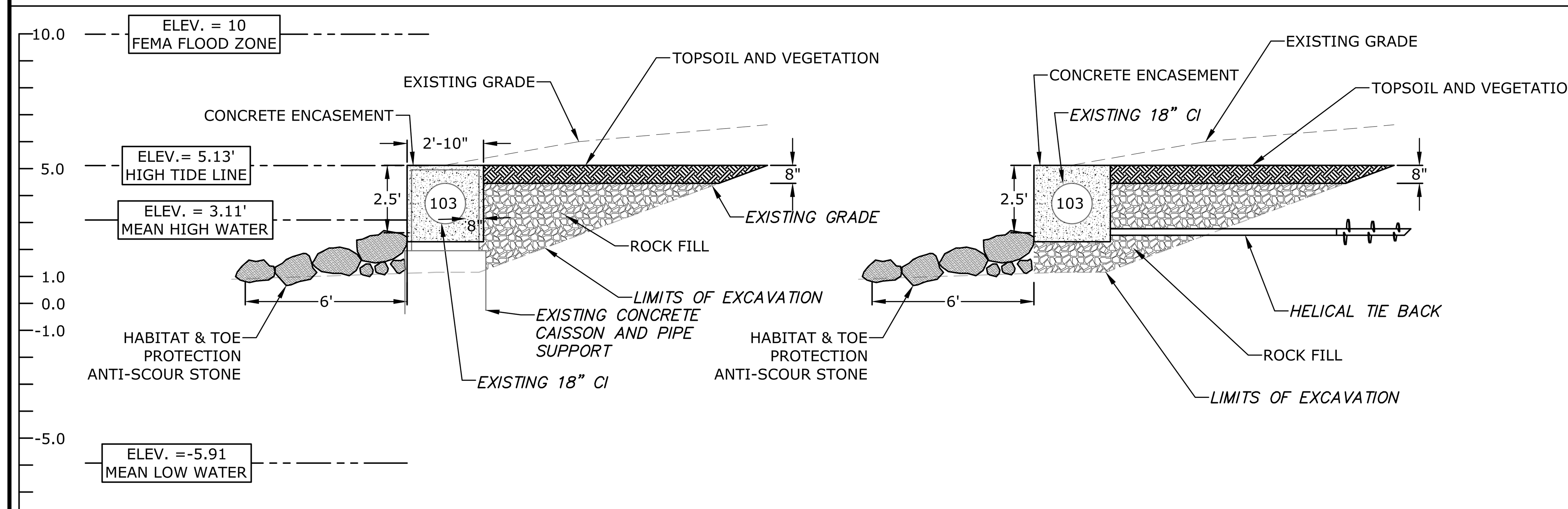
NOTES:
1. ELEVATIONS AND SLOPES ARE APPROXIMATE BASED ON TOWN PROVIDED SURVEY AND LIMITED TAPE MEASUREMENTS ALONG PIPE
2. CONTRACTOR AND OWNER TO COORDINATE ON FINAL RESTORATION PLAN



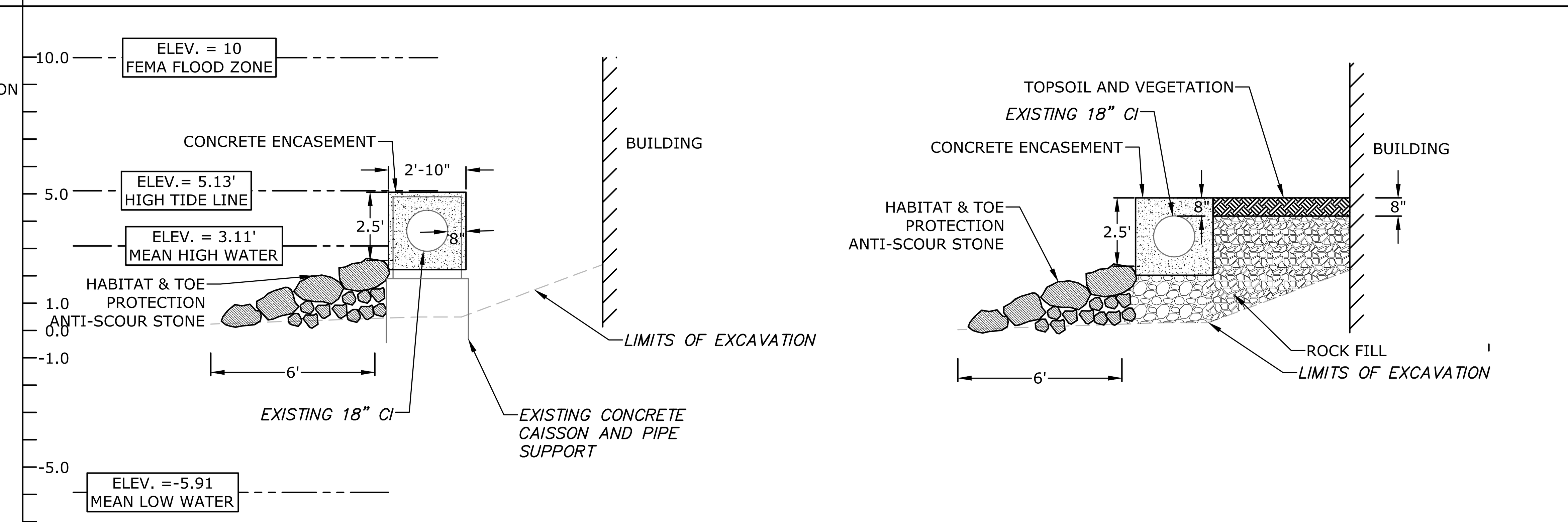
CONCRETE PEDESTAL #101 CROSS SECTION



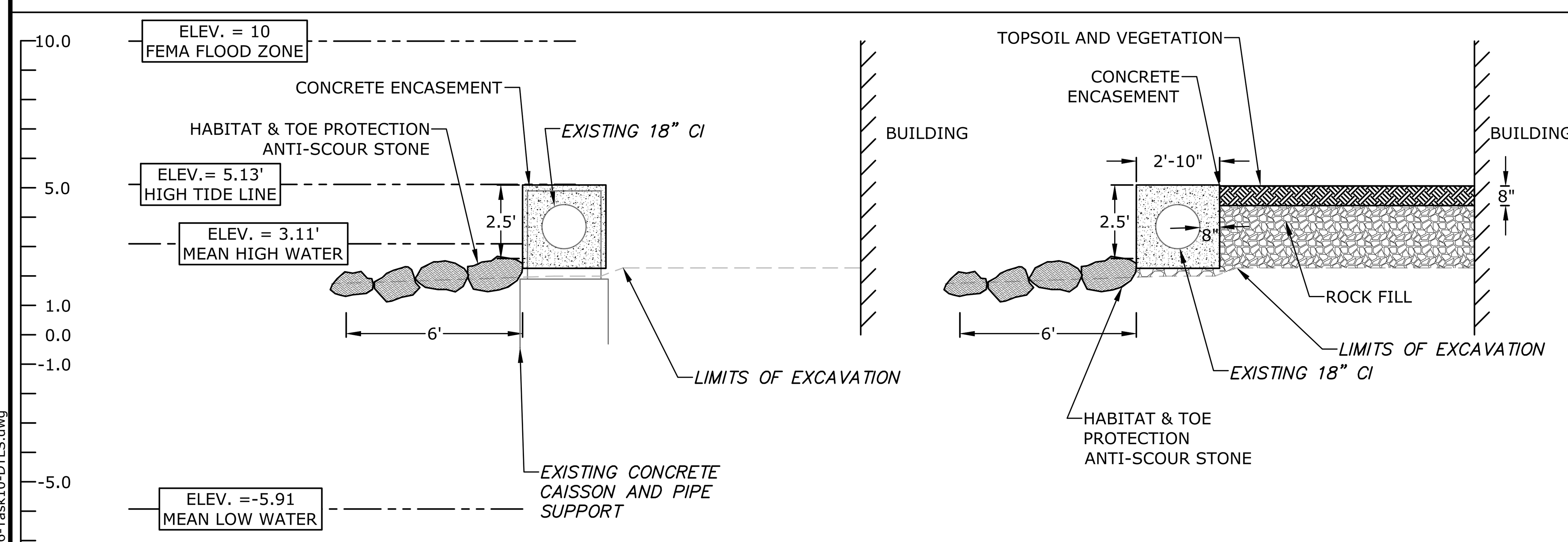
CONCRETE PEDESTAL #102 CROSS SECTION



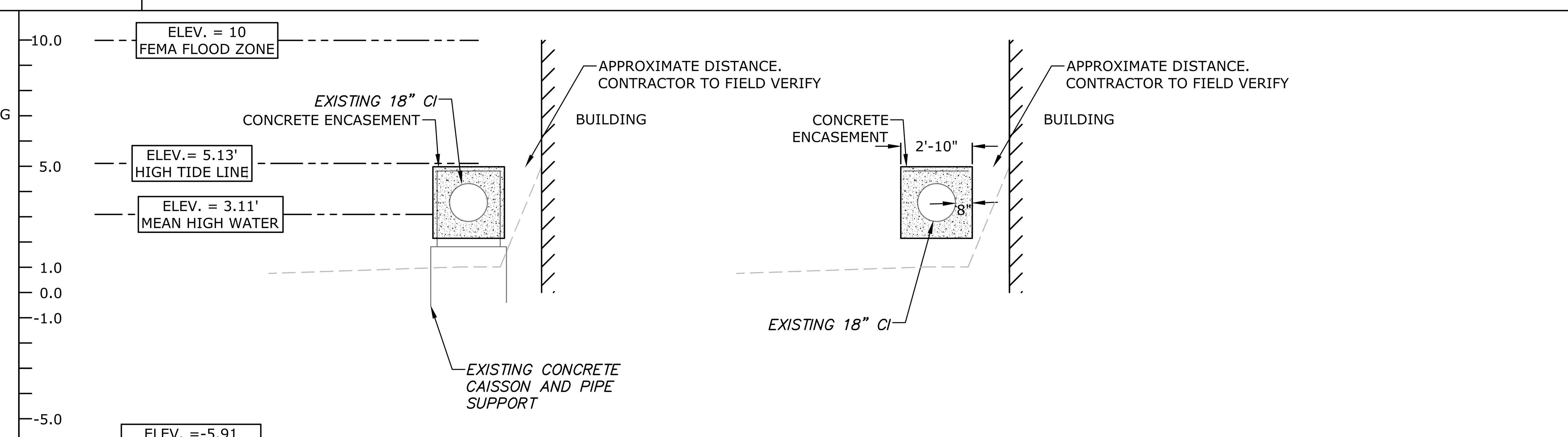
CONCRETE PEDESTAL #103 CROSS SECTION



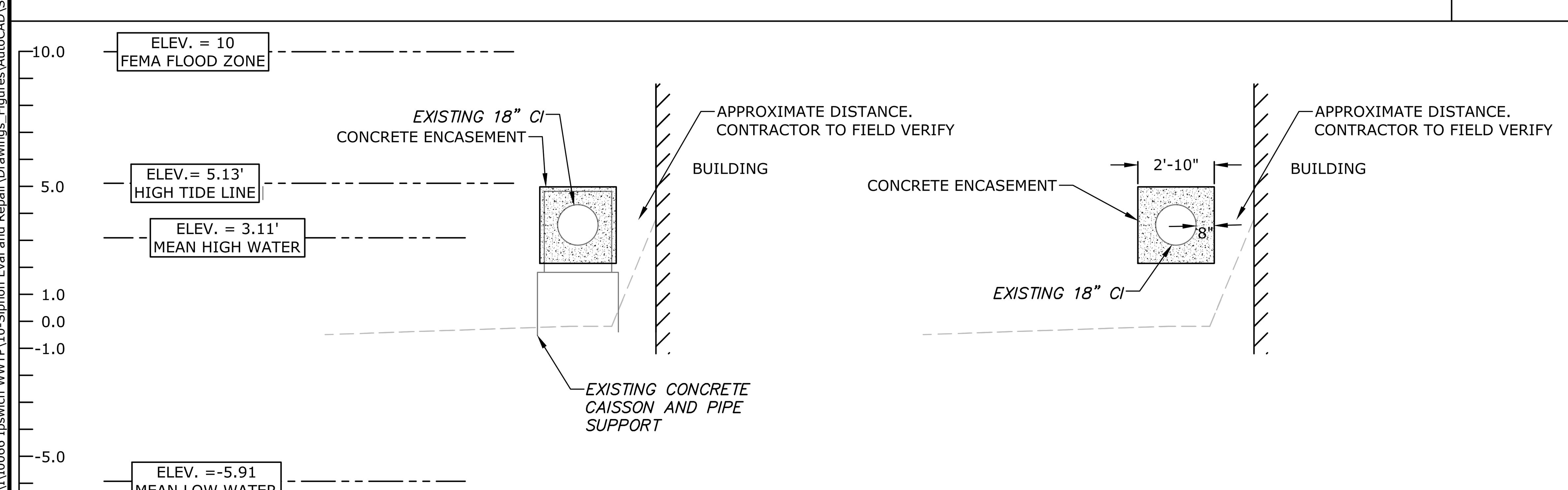
CONCRETE PEDESTAL #104 CROSS SECTION



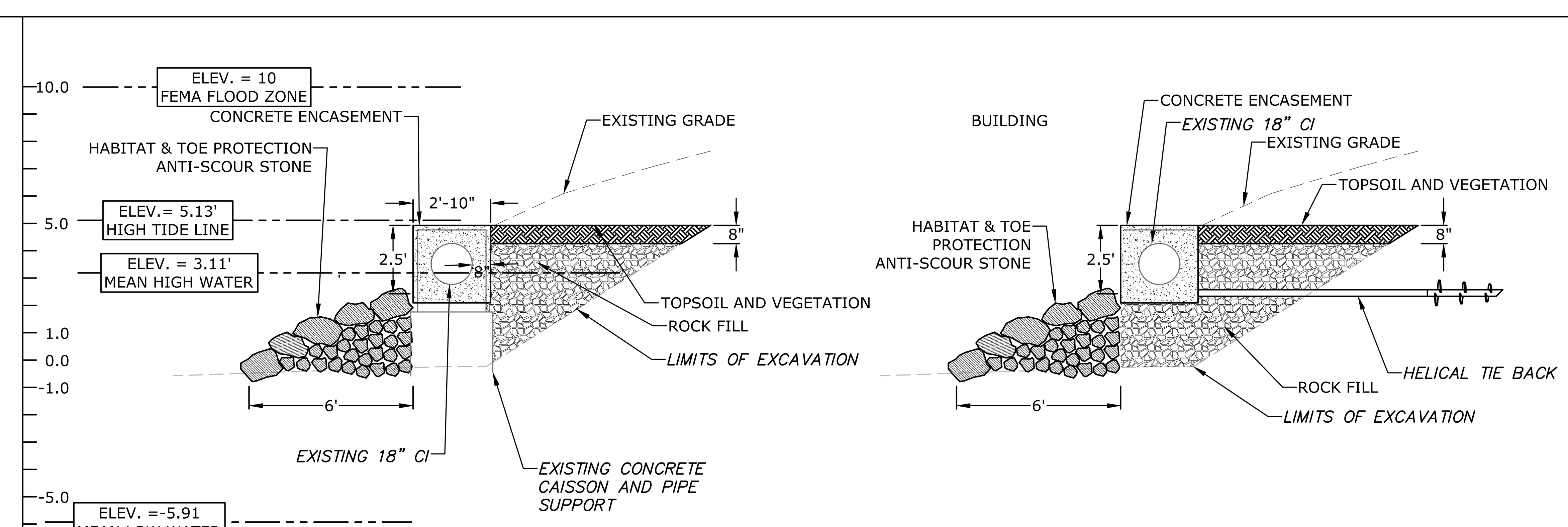
CONCRETE PEDESTAL #105 CROSS SECTION



CONCRETE PEDESTAL #106 CROSS SECTION (UNDER BRIDGE)



CONCRETE PEDESTAL #107 CROSS SECTION (UNDER BRIDGE)



CONCRETE PEDESTAL #108 CROSS SECTION

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

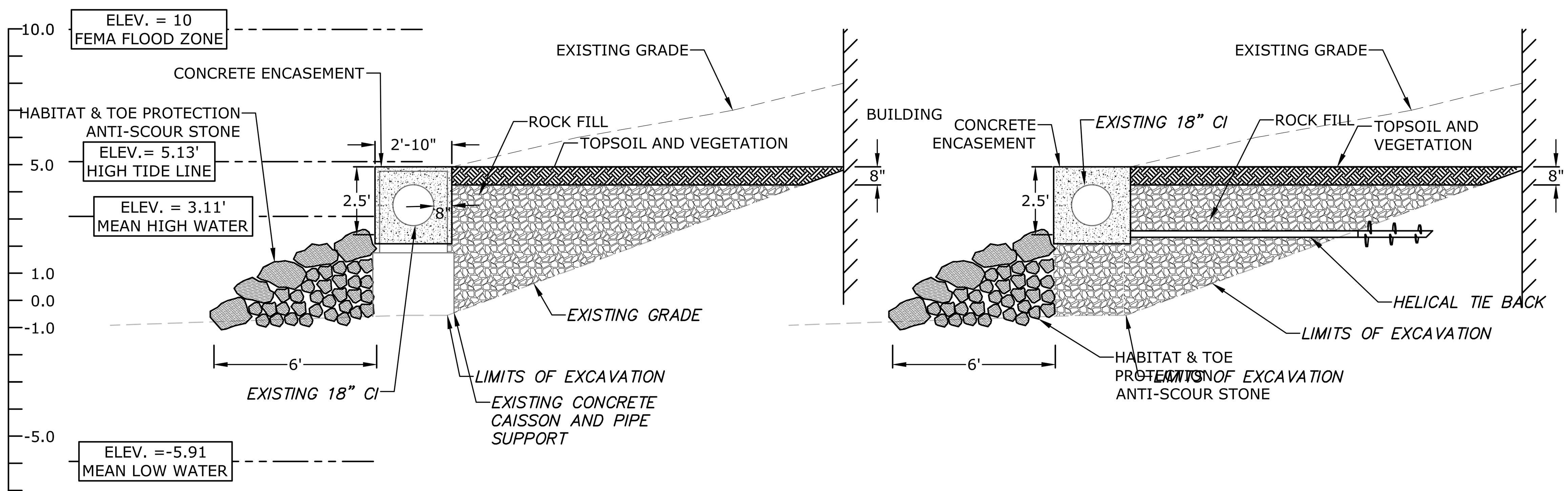
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK, SAT
CHECKED:	DCM
APPROVED:	SES

INTERCEPTOR REHABILITATION - DETAILS 1

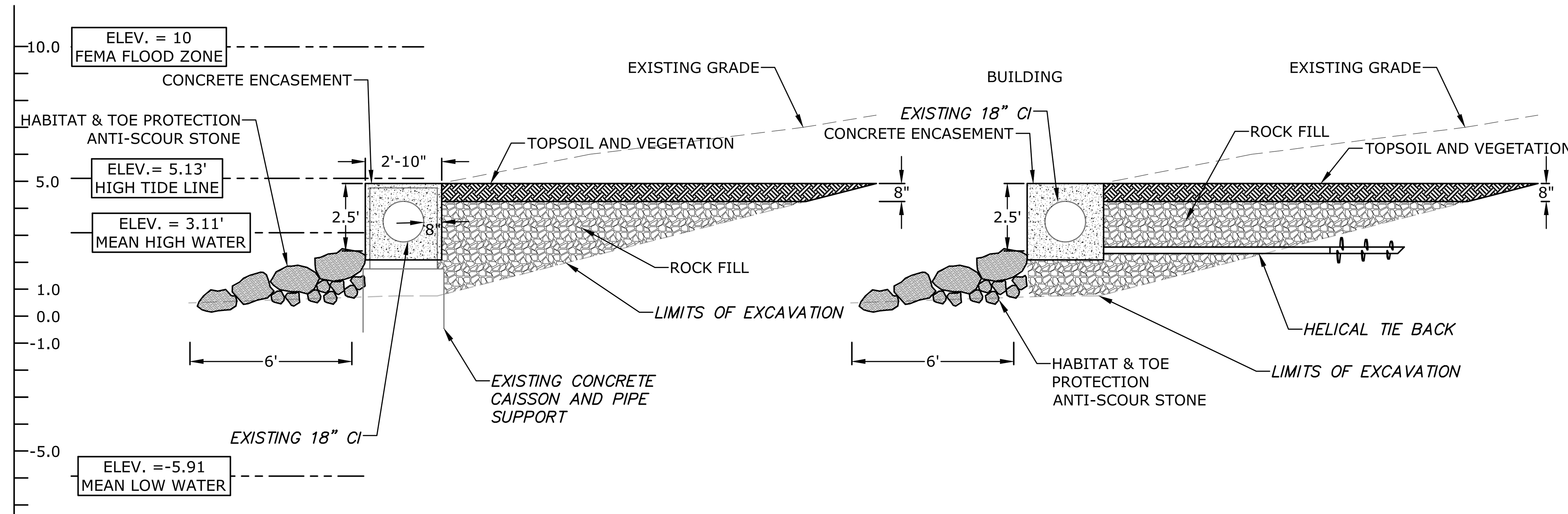
SCALE: 1/4" = 1'

SHEET 4

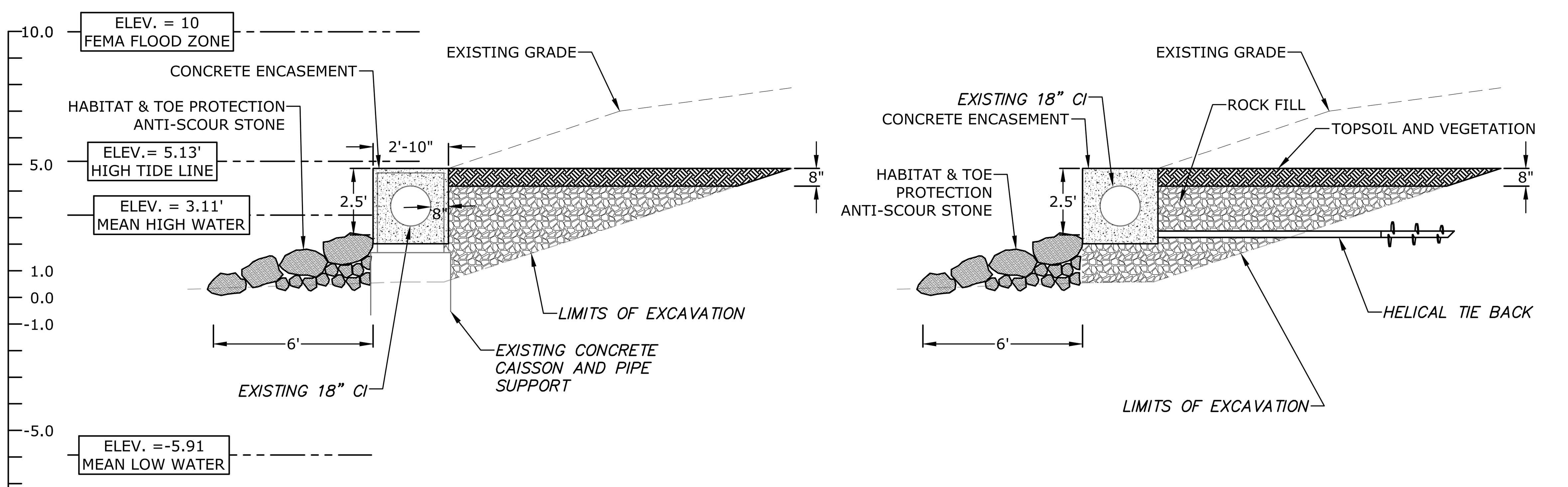
Last Saved: 4/17/2019
Plotted On:Apr 17, 2019-2:10pm By: SAT
Tighe & Bond:J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg



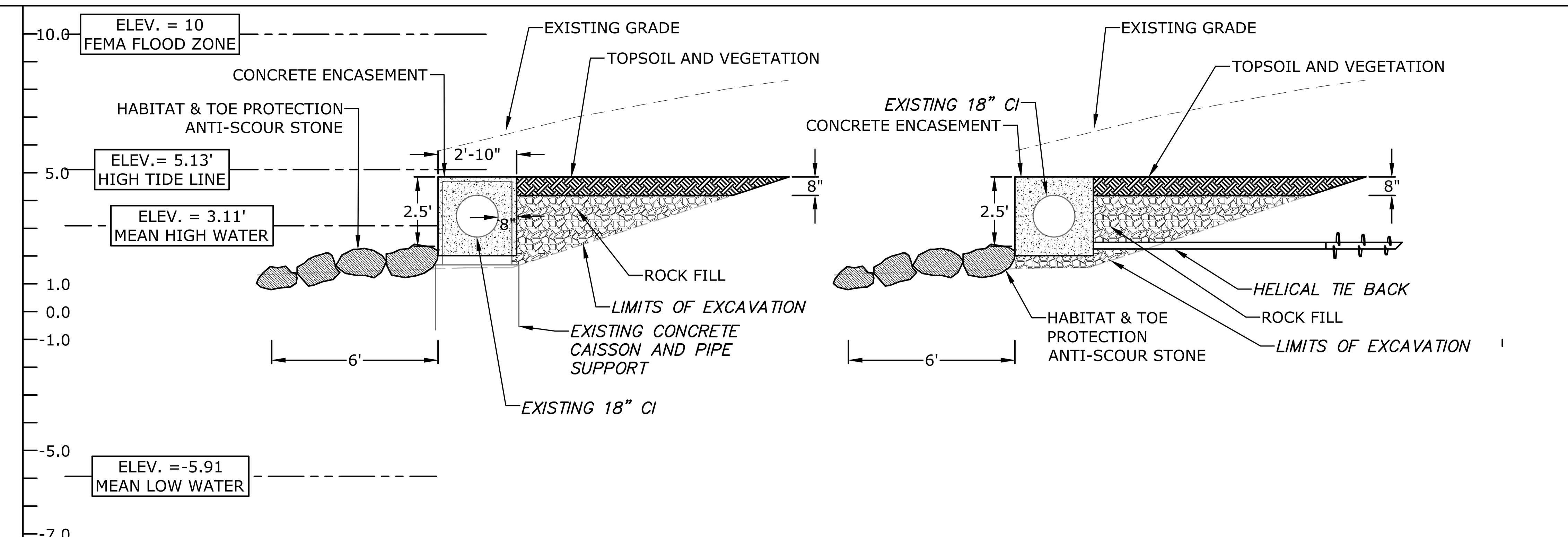
CONCRETE PEDESTAL #109 CROSS SECTION



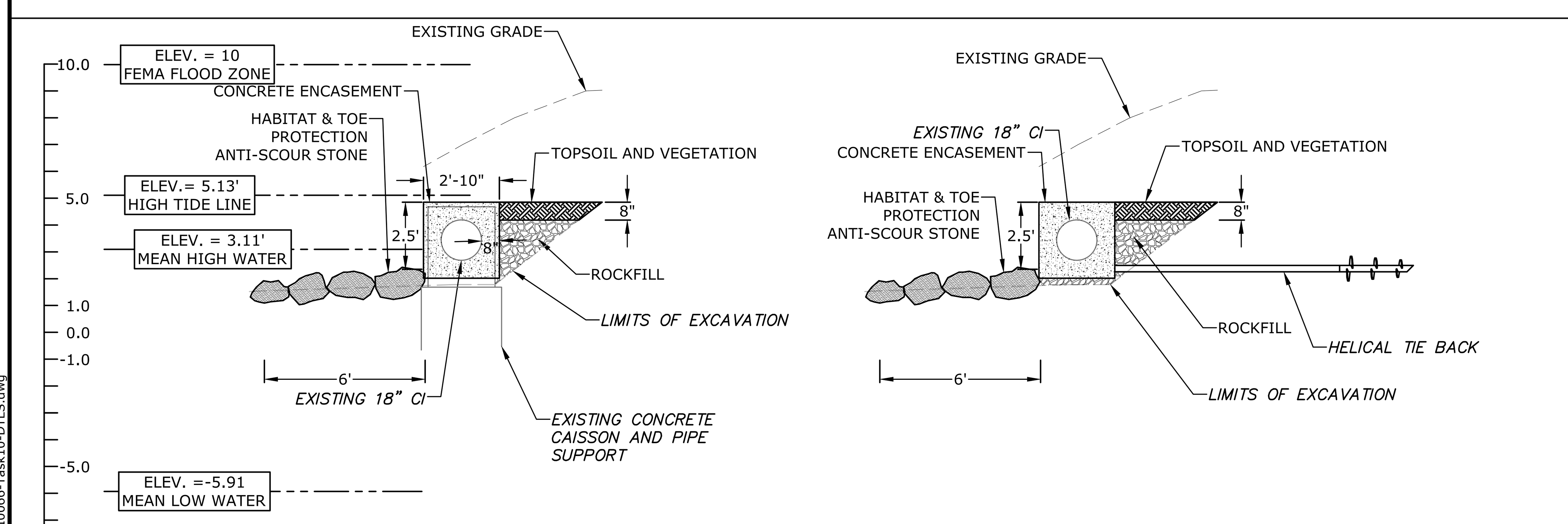
CONCRETE PEDESTAL #110 CROSS SECTION



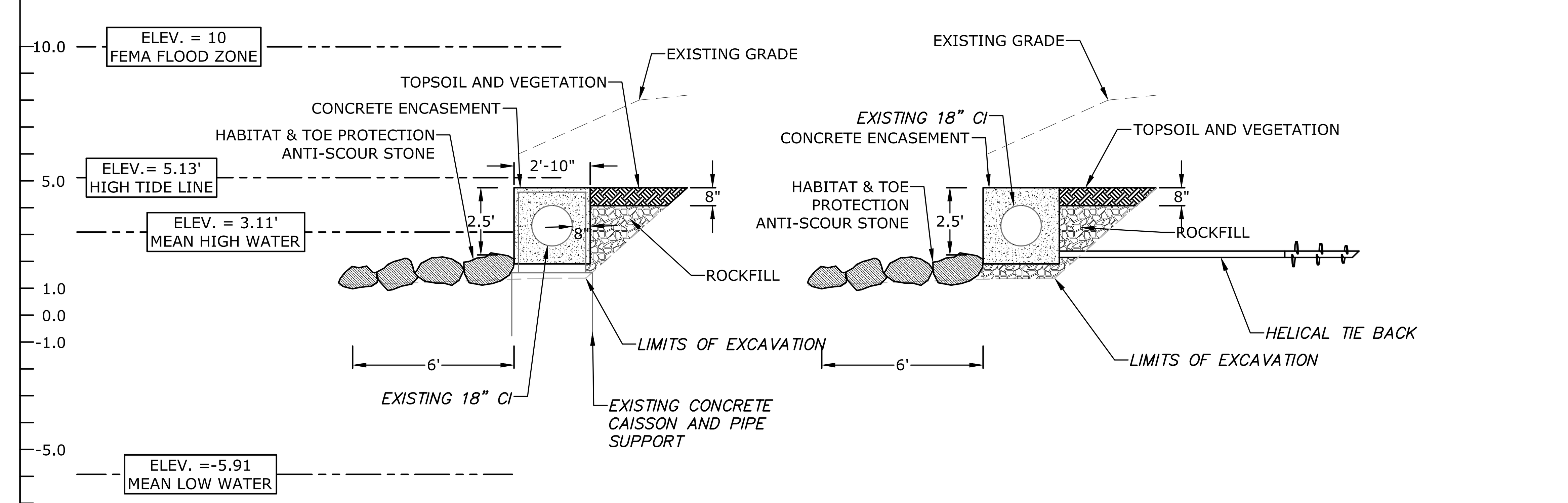
CONCRETE PEDESTAL #111 CROSS SECTION



CONCRETE PEDESTAL #112 CROSS SECTION



CONCRETE PEDESTAL #113 CROSS SECTION



CONCRETE PEDESTAL #114 CROSS SECTION

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

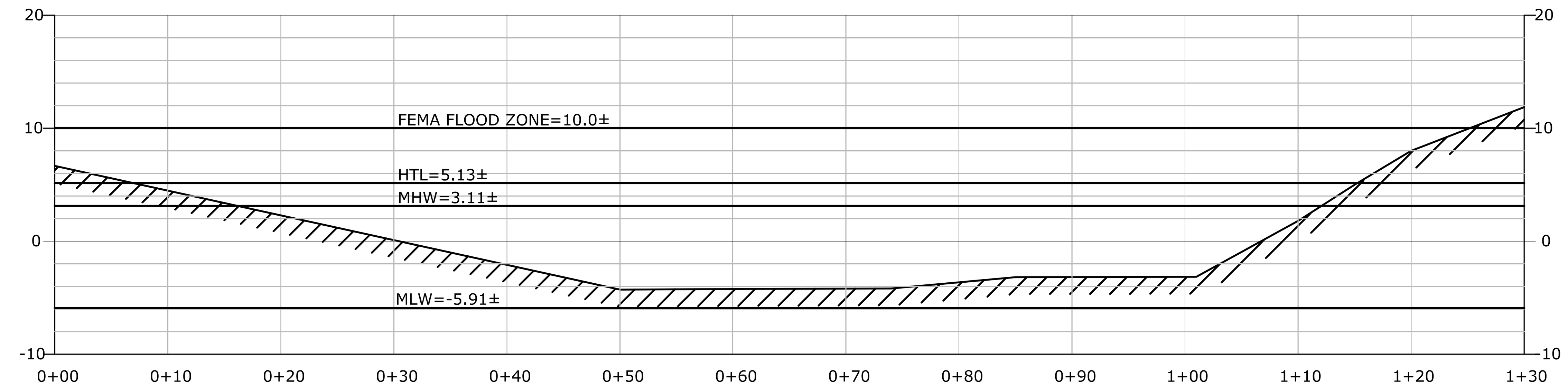
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK, SAT
CHECKED:	DCM
APPROVED:	SES

INTERCEPTOR REHABILITATION - DETAILS 2

SCALE: AS SHOWN

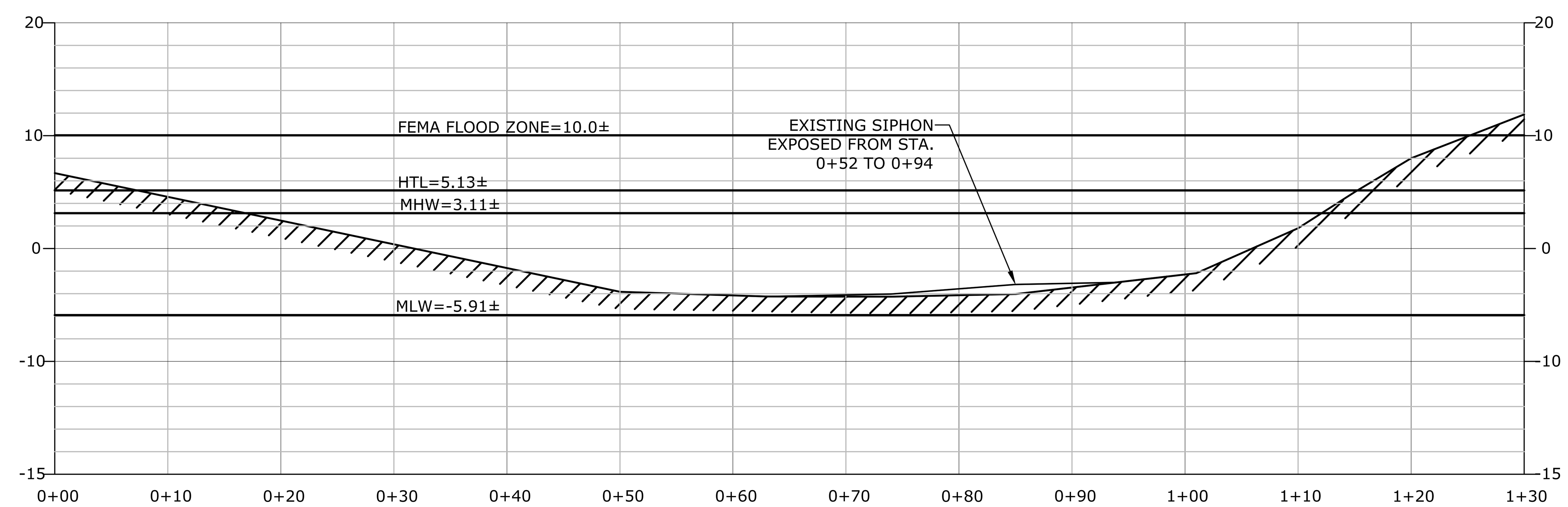
SHEET 5

Last Saved: 4/17/2019
Plotted On:Apr 17, 2019-1:19pm By: SAT
Tighe & Bond J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg



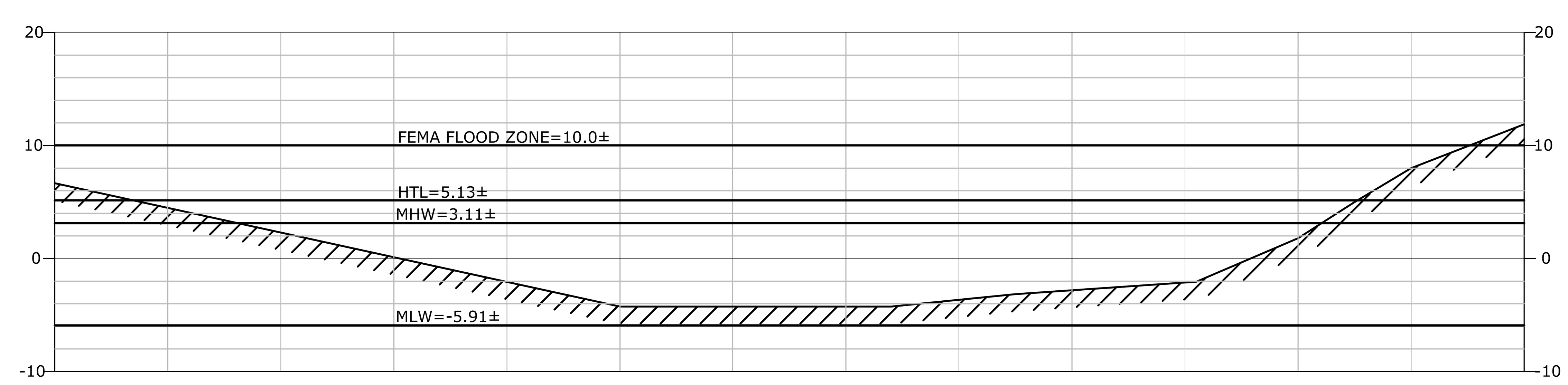
RIVER SECTION 10' UP RIVER OF SIPHON

SCALE IN FEET
0 10' 20'
GRAPHIC SCALE



RIVER SECTION AT SIPHON

SCALE IN FEET
0 10' 20'
GRAPHIC SCALE



RIVER SECTION 10' DOWN RIVER OF SIPHON

SCALE IN FEET
0 10' 20'
GRAPHIC SCALE

NOTES:
1. STATIONING & ELEVATIONS IN FEET WITH STA. 0+00 AT CENTER OF SMH 34 COVER.
2. ELEVATIONS TAKEN BY AUTO LEVEL, ROD AND STATIONING BY TAPE. VERTICAL DATUM BASED ON RIM ELEVATION OF SMH 34 ARCHIVE DATA IN NAVD88.
3. WATER ELEVATIONS VARY WITH RIVER FLOW & TIDES.

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

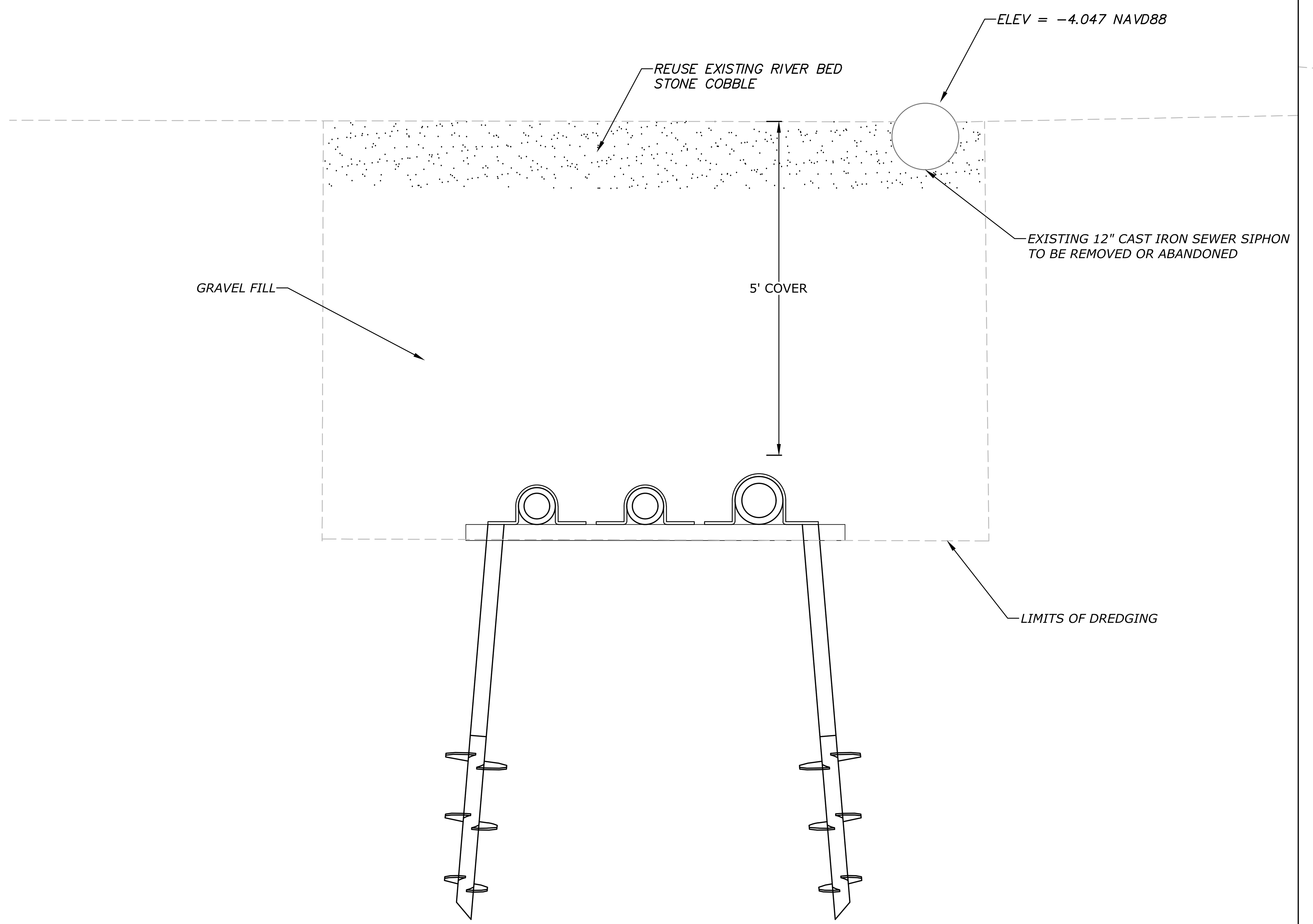
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK
CHECKED:	DCM
APPROVED:	SES

EXISTING SIPHON SECTIONS

SCALE: AS SHOWN

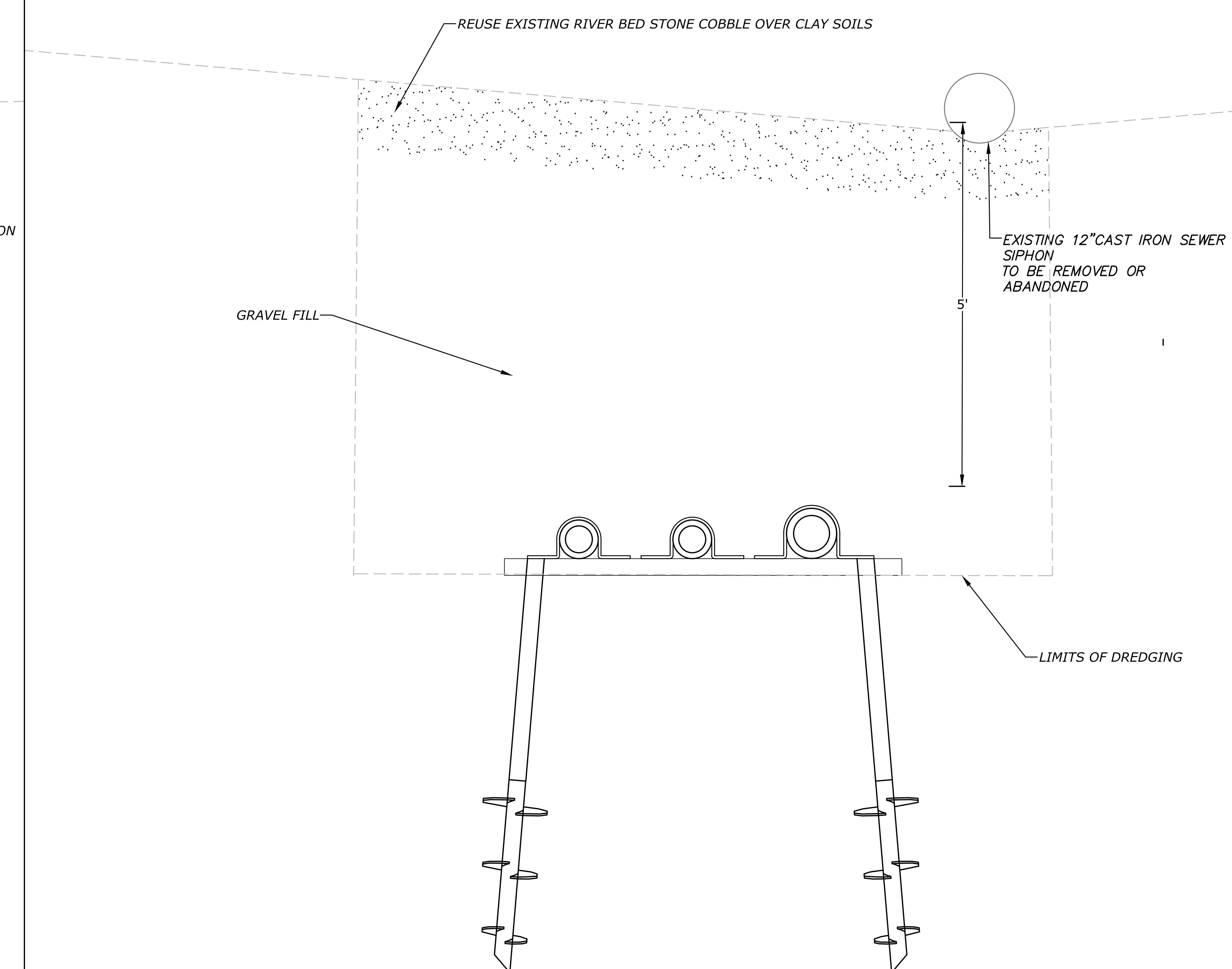
SHEET 6

Last Saved: 4/3/2019
Plotted On:Apr 03, 2019-3:59pm By: JAKallmerten
Tighe & Bond:J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg



SIPHON CROSS SECTION A-A STA. 0+74.00

0 1' 2' 3'
GRAPHIC SCALE



SIPHON CROSS SECTION B-B STA. 0+85.00

0 1' 2' 3'
GRAPHIC SCALE

Last Saved: 4/17/2019
Plotted On:Apr 17, 2019-2:22pm By: SAT
Tighe & Bond:J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg

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Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

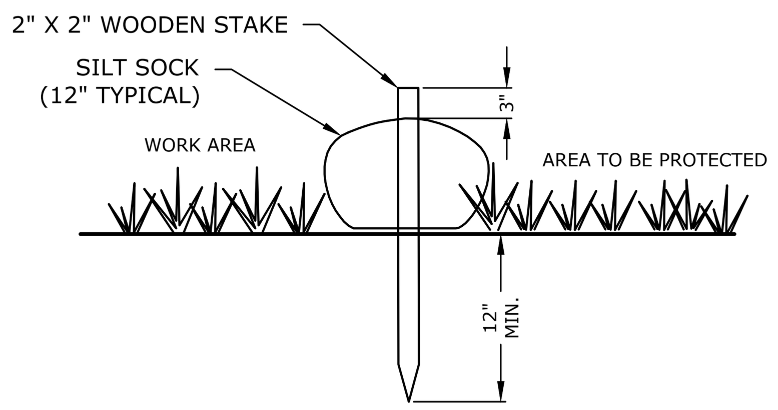
MARK	DATE	DESCRIPTION

PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK
CHECKED:	DCM
APPROVED:	SES

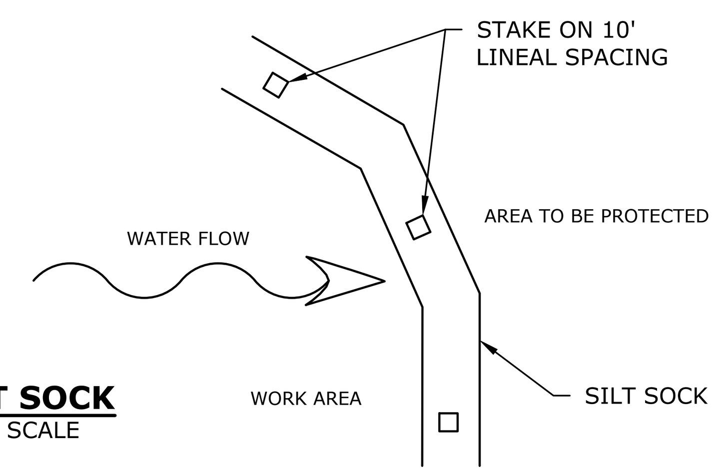
PROPOSED SIPHON SECTIONS

SCALE: AS SHOWN

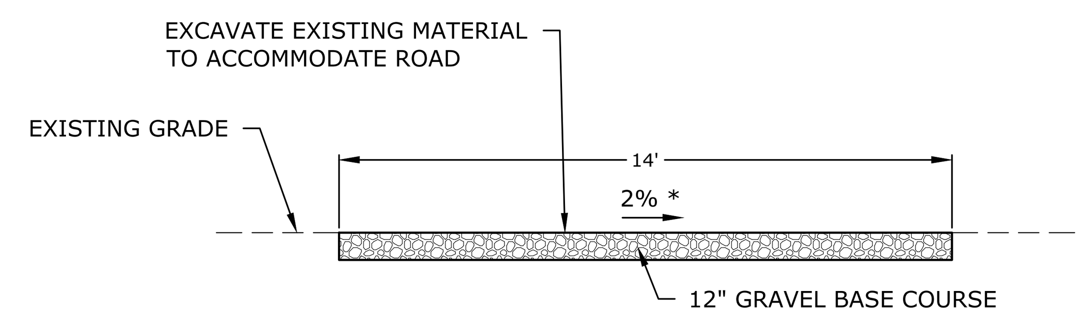
SHEET 7



NOTES:
1. SILT SOCK SHALL BE SILT SOXX BY FILTREXX OR APPROVED EQUAL.
2. SILT SOCK SHALL BE FILLED WITH FILTERMEDIA BY FILTREXX OR APPROVED EQUAL.
3. WHERE TWO SILT SOCKS ARE JOINED, A MINIMUM OF 2 FEET OF OVERLAP SHALL BE MAINTAINED.
4. SILT SOCKS SHALL BE INSTALLED IN ACCORDANCE WITH MANUFACTURER'S RECOMMENDATIONS.
5. CONTRACTOR TO INSTALL SILT SOCK IN J-HOOK OR SMILE CONFIGURATION TO LIMIT CONCENTRATION OF STORMWATER RUNOFF AT A SINGLE DISHCARGE POINT.



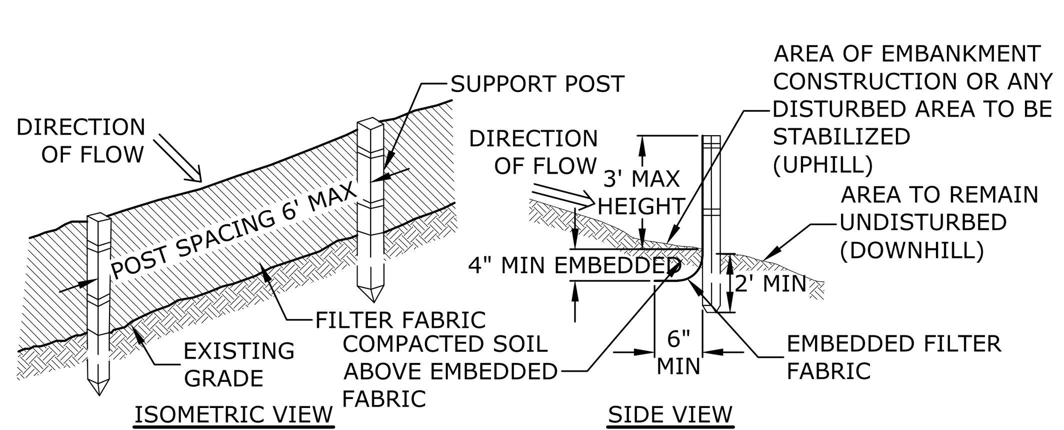
SILT SOCK
NO SCALE



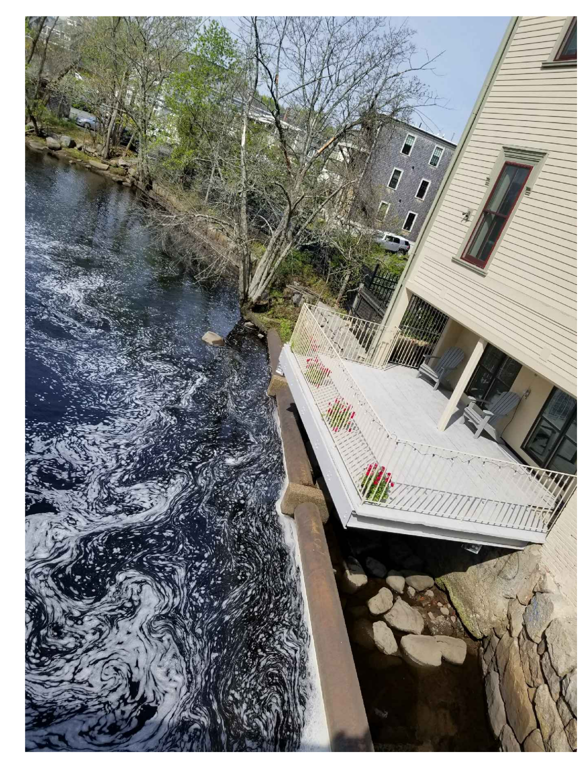
* SLOPE AS REQUIRED FOR DRAINAGE (2% MAX)

TYPICAL ACCESS ROAD SECTION
NO SCALE

NOTES:
1. SILT FENCE SHALL BE INSTALLED PER MANUFACTURER'S RECOMMENDATIONS.
2. ADJOINING SECTIONS OF THE FENCE SHALL BE OVERLAPPED BY 6 INCHES, FOLDED AND STAPLED TO A SUPPORT POST.
3. THE MAXIMUM CONTRIBUTING DRAINAGE AREA ABOVE THE FENCE SHOULD BE LESS THAN ¼ ACRE PER 100 LINEAR FEET OF FENCE;
4. THE MAXIMUM LENGTH OF SLOPE ABOVE THE FENCE SHOULD BE 100 FEET;
5. THE MAXIMUM SLOPE ABOVE THE FENCE SHOULD BE 2:1;
6. FENCES SHOULD BE INSTALLED FOLLOWING THE CONTOUR OF THE LAND AS CLOSELY AS POSSIBLE, AND
   a. THE ENDS OF THE FENCE SHOULD BE FLARED UPSLOPE;
   b. THE FABRIC SHOULD BE EMBEDDED A MINIMUM OF 4 INCHES IN DEPTH AND 4 INCHES IN WIDTH IN A TRENCH EXCAVATED INTO THE GROUND, OR IF SITE CONDITIONS INCLUDE FROZEN GROUND, LEDGE, OR THE PRESENCE OF HEAVY ROOTS, THE BASE OF THE FABRIC SHOULD BE EMBEDDED WITH A MINIMUM THICKNESS OF 8 INCHES OF ¾-INCH STONE;
   c. THE SOIL SHOULD BE COMPACTED OVER THE EMBEDDED FABRIC;
   d. SUPPORT POSTS SHOULD BE SIZED AND ANCHORED ACCORDING TO THE MANUFACTURER'S INSTRUCTIONS WITH MAXIMUM POST SPACING OF 6 FEET;
   e. ADJOINING SECTIONS OF THE FENCE SHOULD BE OVERLAPPED BY A MINIMUM OF 6 INCHES (24 INCHES IS PREFERRED), FOLDED AND STAPLED TO A SUPPORT POST. IF METAL POSTS ARE USED, FABRIC SHOULD BE WIRE-TIED DIRECTLY TO THE POSTS WITH THREE DIAGONAL TIES.
5. SILT FENCING SHOULD NOT BE STAPLED OR NAILED TO TREES.
6. THE FILTER FABRIC SHOULD BE A PERVIOUS SHEET OF PROPYLENE, NYLON, POLYESTER OR ETHYLENE YARN AND SHOULD BE CERTIFIED BY THE MANUFACTURER OR SUPPLIER.
7. THE FILTER FABRIC SHOULD CONTAIN ULTRAVIOLET RAY INHIBITORS AND STABILIZERS TO PROVIDE A MINIMUM OF 6 MONTHS OF EXPECTED USABLE CONSTRUCTION LIFE AT A TEMPERATURE RANGE OF 0 DEGREES FAHRENHEIT TO 120 DEGREES FAHRENHEIT.
8. POSTS FOR SILT FENCES SHOULD BE EITHER 4-INCH DIAMETER WOOD OR 1.33 POUNDS PER LINEAR FOOT STEEL WITH A MINIMUM LENGTH OF 5 FEET. STEEL POSTS SHOULD HAVE PROJECTIONS FOR FASTENING WIRE TO THEM. POSTS SHOULD BE PLACED ON THE DOWNSLOPE SIDE OF THE FABRIC.
9. THE HEIGHT OF A SILT FENCE SHOULD NOT EXCEED 36 INCHES AS HIGHER FENCES MAY IMPOUND VOLUMES OF WATER SUFFICIENT TO CAUSE FAILURE OF THE STRUCTURE.
10. THE FILTER FABRIC SHOULD BE PURCHASED IN A CONTINUOUS ROLL CUT TO THE LENGTH OF THE BARRIER TO AVOID THE USE OF JOINTS. WHEN JOINTS ARE NECESSARY, FILTER CLOTH SHOULD BE SPLICED TOGETHER ONLY AT SUPPORT POST, WITH A MINIMUM 6-INCH OVERLAP, AND SECURELY SEALED.
11. A MANUFACTURED SILT FENCE SYSTEM WITH INTEGRAL POSTS MAY BE USED.
12. POST SPACING SHOULD NOT EXCEED 6 FEET.
13. CONTRACTOR TO INSTALL SILT FENCE IN J-HOOK OR SMILE CONFIGURATION TO LIMIT CONCENTRATION OF STORMWATER RUNOFF AT A SINGLE DISHCARGE POINT.
14. A TRENCH SHOULD BE EXCAVATED APPROXIMATELY 4 INCHES WIDE AND 4 INCHES DEEP ALONG THE LINE OF POSTS AND UPGRADIENT FROM THE BARRIER.
15. THE STANDARD STRENGTH OF FILTER FABRIC SHOULD BE STAPLED OR WIRED TO THE POST, AND 8 INCHES OF THE FABRIC SHOULD BE EXTENDED INTO THE TRENCH. THE FABRIC SHOULD NOT EXTEND MORE THAN 36 INCHES ABOVE THE ORIGINAL GROUND SURFACE.
16. THE INSTALLATION TRENCH SHOULD BE BACKFILLED AND THE SOIL COMPACTED OVER THE FILTER FABRIC.
17. SILT FENCE MAY BE INSTALLED BY “SLICING” USING MECHANICAL EQUIPMENT SPECIFICALLY DESIGNED FOR THIS PROCEDURE. THE SLICING METHOD USES AN IMPLEMENT TOWED BEHIND A TRACTOR TO “PLOW” OR SLICE THE SILT FENCE MATERIAL INTO THE SOIL. THE SLICING METHOD MINIMALLY DISRUPTS THE SOIL UPWARD AND SLIGHTLY DISPLACES THE SOIL, MAINTAINING THE SOIL'S PROFILE AND CREATING AN OPTIMAL CONDITION FOR SUBSEQUENT MECHANICAL COMPACTION.
18. SILT FENCES SHOULD BE INSTALLED WITH “SMILES” OR “J-HOOKS” TO REDUCE THE DRAINAGE AREA THAT ANY SEGMENT WILL IMPOUND.
19. SILT FENCES PLACED AT THE TOE OF A SLOPE SHOULD BE SET AT LEAST 6 FEET FROM THE TOE TO ALLOW SPACE FOR SHALLOW PONDING AND TO ALLOW FOR MAINTENANCE ACCESS WITHOUT DISTURBING THE SLOPE.
20. SILT FENCES SHOULD BE REMOVED WHEN THEY HAVE SERVED THEIR USEFUL PURPOSE, BUT NOT BEFORE THE UPSLOPE AREAS HAVE BEEN PERMANENTLY STABILIZED.



SILT FENCE
NO SCALE



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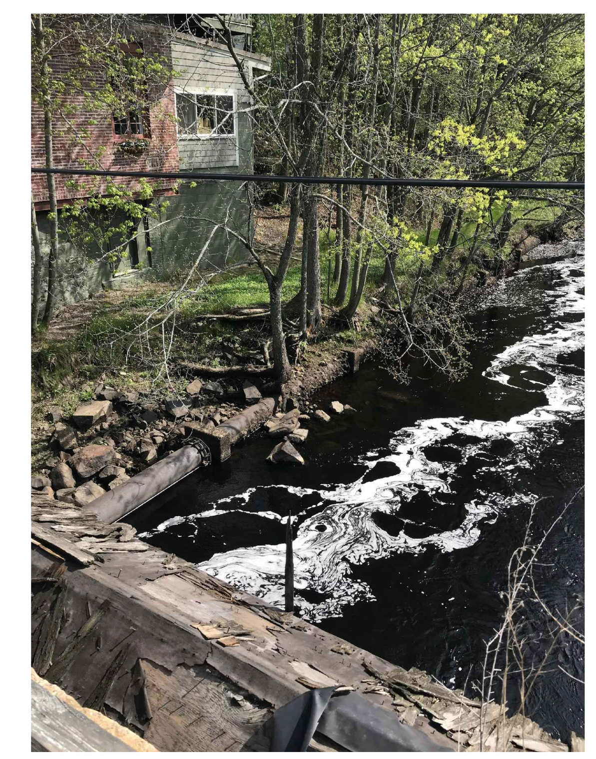
SHEET 2



2
SHEET 2

3
SHEET 2

4
SHEET 3

Tighe&Bond
www.tighebond.com

CONCEPTUAL DRAWINGS

NOT FOR CONSTRUCTION

Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

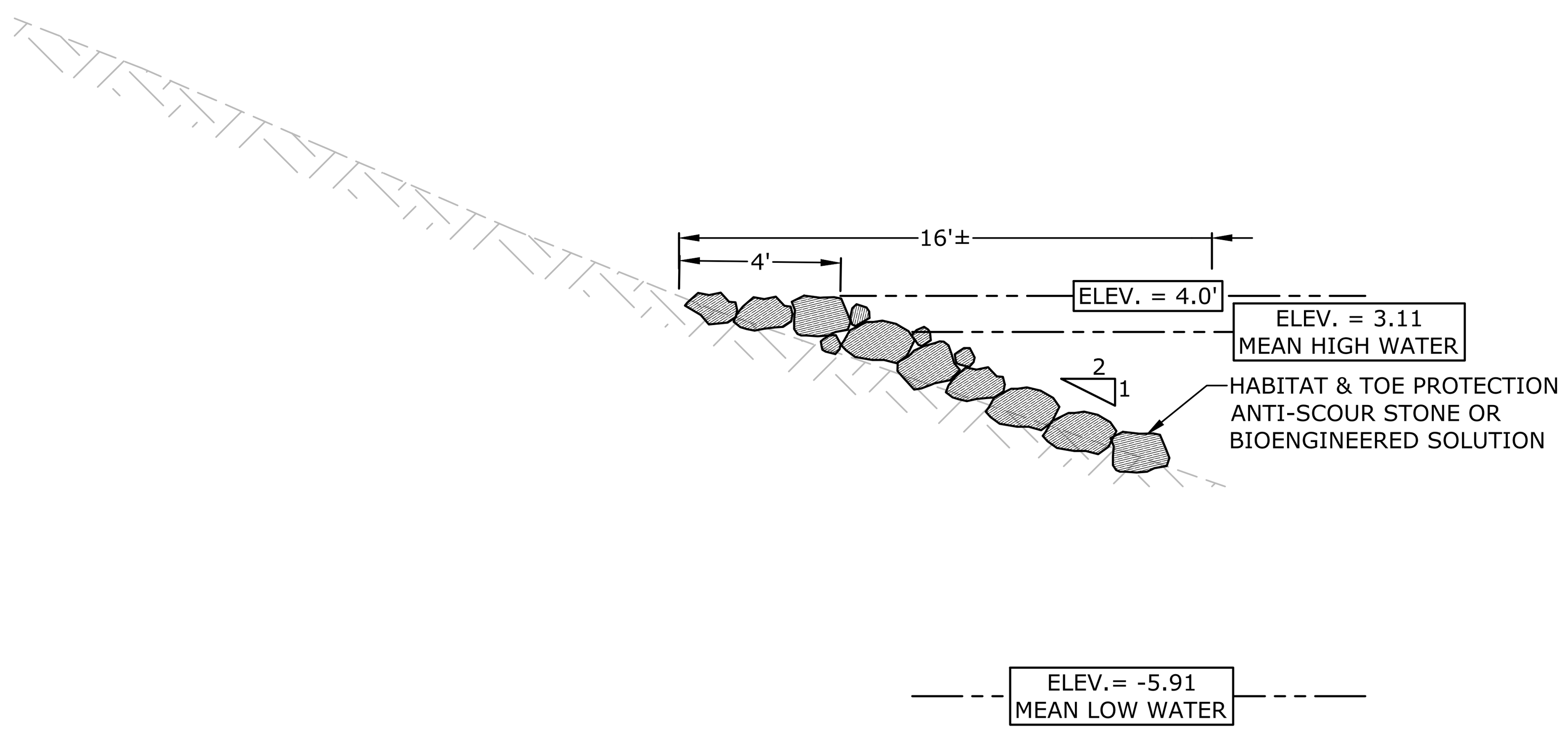
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK
CHECKED:	DCM
APPROVED:	SES

DETAILS

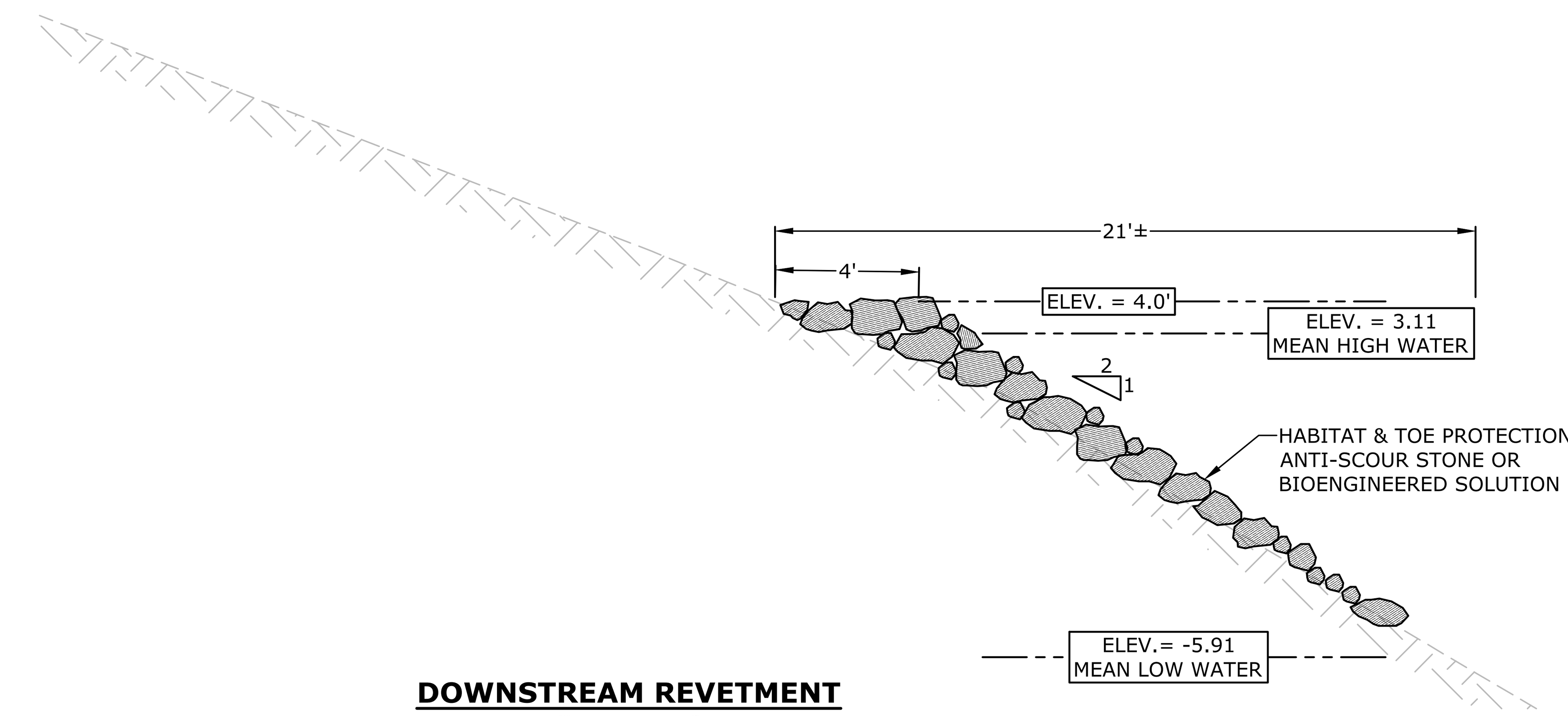
SCALE: AS SHOWN

SHEET 8

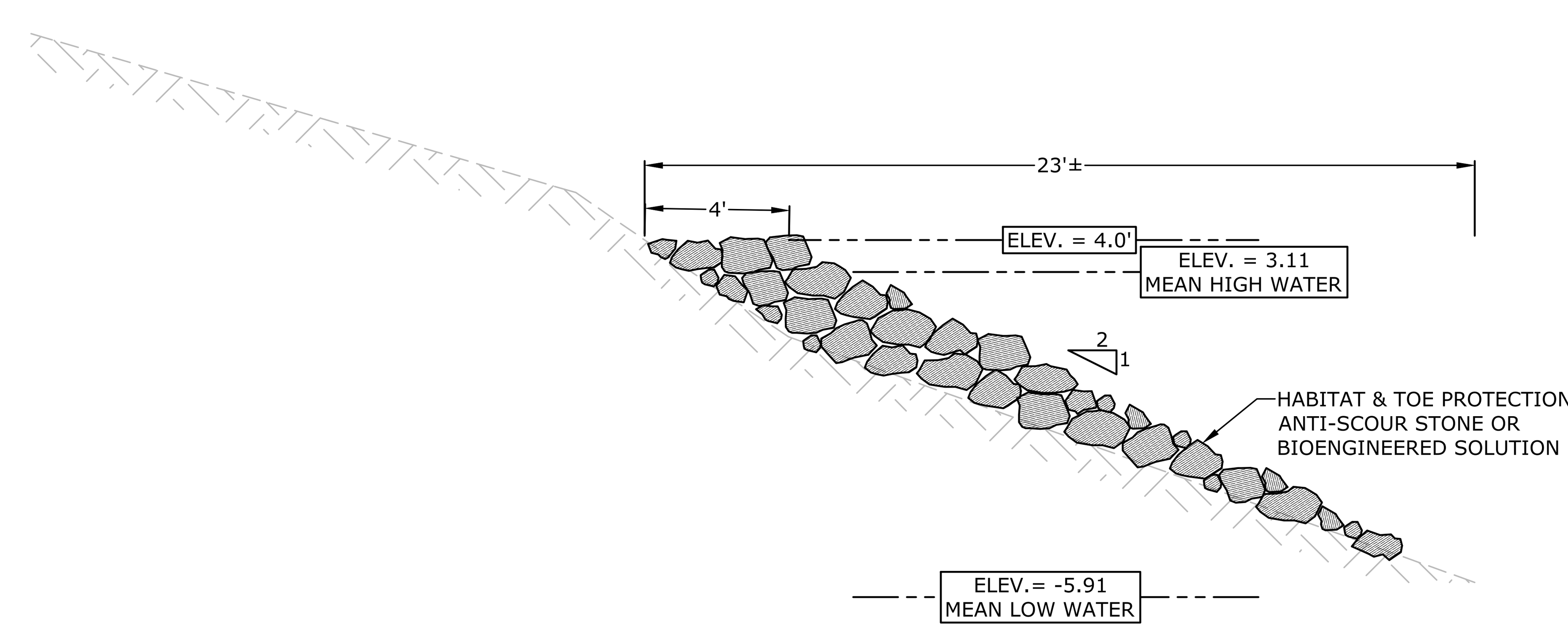
Last Saved: 4/17/2019
Plotted On:Apr 17, 2019-2:21pm By: SAT
Tighe & Bond:J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg



DOWNSTREAM REVETMENT
STA 0+00



DOWNSTREAM REVETMENT
STA 1+50



DOWNSTREAM REVETMENT
STA 3+62

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CONCEPTUAL DRAWINGS

NOT FOR CONSTRUCTION

Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK, SAT
CHECKED:	DCM
APPROVED:	SES

DOWNSTREAM REVETMENT DETAILS

SCALE: AS SHOWN

SHEET 9

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Plotted On:Apr 17, 2019-1:08pm By: SAT
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Appendix E
Ipswich River Interceptor
Sewer and Siphon
Emergency Action Plan

NEW ENGLAND CIVIL ENGINEERING CORP.

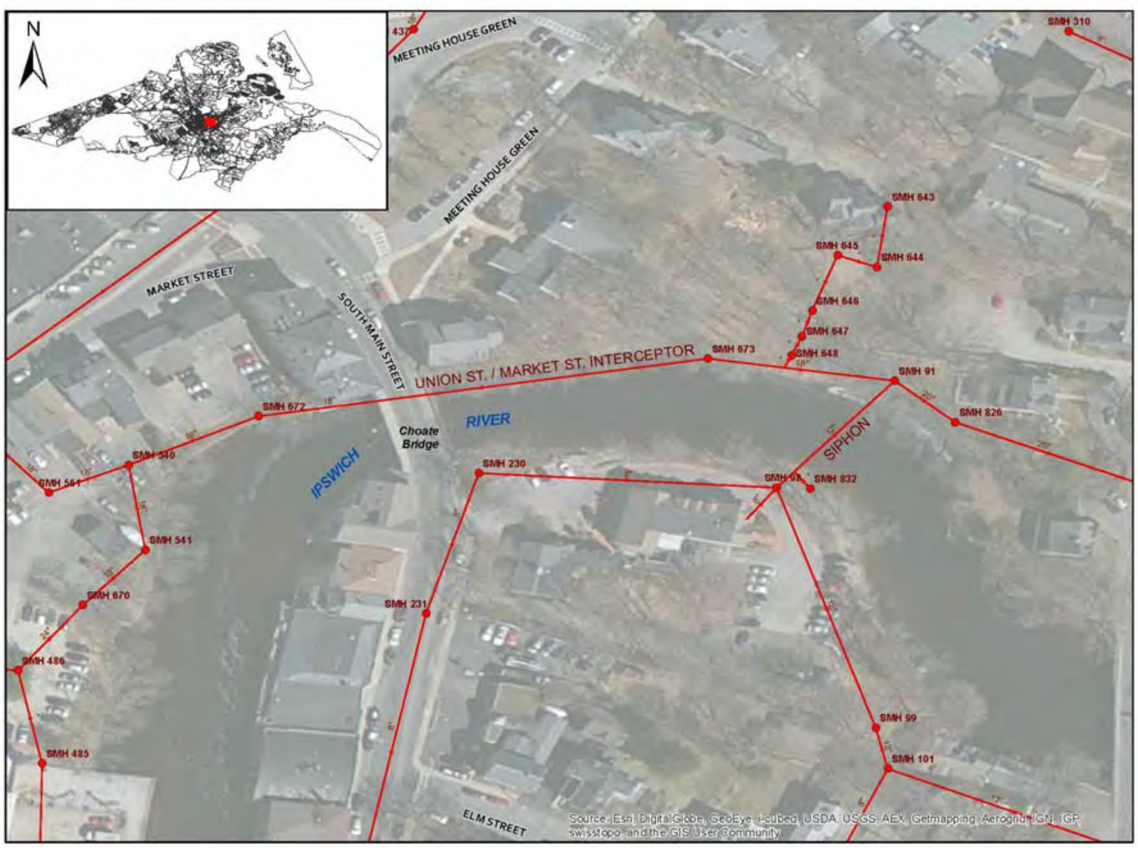
120 WASHINGTON STREET, SUITE 202E, P.O. BOX 3026, SALEM, MA 01970
PH: 978.741.7401 - FAX: 978.741.7402 – WWW.ENGINEERINGCORPORATION.COM

TOWN OF IPSWICH, MASSACHUSETTS

Ipswich River Interceptor Sewer and Siphon Emergency Action Plan

November 2017

Revised March 2018



WATER RESOURCES - BURIED INFRASTRUCTURE - PUBLIC WORKS - CONSTRUCTION ADMINISTRATION - LAND DEVELOPMENT

NEW ENGLAND CIVIL ENGINEERING CORP.
120 WASHINGTON STREET, SUITE 202E, P.O. BOX 3026, SALEM, MA 01970
PH: 978.741.7401 - FAX: 978.741.7402 – WWW.ENGINEERINGCORPORATION.COM

March 28, 2018

Ms. Vicki Halmen
Water and Wastewater Manager
Town of Ipswich
272 High Street
P.O. Box 151
Ipswich, MA 01938

Re: Final Report for Ipswich River interceptor sewer and siphon- Emergency Action Plan

Dear Vicki:

We are pleased to submit this Final letter report with revisions based on the discussion at the March 19, 2018 meeting. This report revises and replaces the draft report submitted under the cover letter dated November 20, 2017.

Revisions include adding sections Bypass Pump and Pipe Work Summary and Emergency Notification Protocol to facilitate equipment procurement and notification, along with the drawing titled, Sanitary Sewer Plan vicinity of South Main St. to County St. prepared by Graham Associates, Inc., dated March 14, 2018. Revisions to the Recommendations section identified work completed since the previous report submission. Maps 3 through 5 were also revised to show work completed and the inclusion of an additional bypass pipe route that may be feasible during low river stage (low flow) conditions.

If you have any questions or require additional information, please do not hesitate to contact me at any time on my cell phone at 978-767-5415 or at our Salem office at 978-741-7401. We thank you for the opportunity to work with the Town of Ipswich and look forward to building on our successful and rewarding partnership moving forward.

Sincerely,

William M. Ross, P.E.
Project Manager/Principal Engineer
New England Civil Engineering Corp.

attachments

TABLE OF CONTENTS

November 20, 2017

Ms. Vicki Halmen
Water and Wastewater Manager
Town of Ipswich
272 High Street
P.O. Box 151
Ipswich, MA 01938

Re: Ipswich River interceptor sewer and siphon- Emergency Action Plan

Dear Vicki:

I greatly appreciate the opportunity to meet with you on site on August 11, 2017 to observe the location of the sewer siphon in the vicinity of South Main and Elm Streets, and main interceptor sewer within the Ipswich River bank in the vicinity of Choate Bridge. We are pleased to submit this letter report to summarize the existing conditions of the main interceptor sewer and collector sewer siphon which are in the river bed in the vicinity of the Choate Bridge, and also provide preliminary scope of work and historical flow data for use in bypass pumping system design and emergency action planning.

Background and Project Understanding:
The Town of Ipswich Utilities Department (UD) owns and maintains the sanitary sewer collection system within Town streets, easements, and rights-of-way. The systems are old and require regular maintenance including cleaning, inspection, and failure repair. In the vicinity of the South Main Street crossing of the Ipswich River (across the Choate Bridge), the main interceptor sewer connects the collector sewers from Union Street and Market Street, passes under the bridge, and is installed along and within the Northern river bank exposed to the river flow and elements for a significant portion of the run. The sewer is constructed of cast iron pipe and is supported by concrete piles.

In the vicinity of Elm Street, a cross-country sewer connects the collector sewers from South Main Street and Elm Street and passes under the Ipswich River through a sewer siphon, and joins up with the main interceptor sewer on the Northern river embankment. This sewer siphon is also constructed of cast iron and connects to the Market Street/Union Street interceptor sewer in the Northern river bank. Infrequently in the past, blockages in the siphon have resulted in sanitary sewer overflows to the river from the upstream siphon inlet manhole, requiring jetting and cleaning of siphon by the UD.

Refer to Appendix C for copies of record drawings in plan and profile view dated 1960.

Observations:
Site visits and observations recorded in August 2017 identified several areas of concern and resulted in several recommendations for future investigations, and improvements to facilitate future maintenance and bypass pumping in the event emergency action is required.

Manholes
Field observations identified discrepancies between the record drawings and the structures observed in the field. On the North side of the river, SMH 540 was observed in the field but was not identified on the 1960 record drawings, this manhole connection was installed at a later date when Union Street collector sewer was connected to the interceptor sewer. Three sewer manholes (SMH 672, SMH 673, and SMH 826 were not observed and presumed to be buried and inaccessible.
On the South side of the river, SMH 832 (which is a siphon cleanout structure) was not observed and presumed to be buried and inaccessible.
Refer to Map 3 in Appendix A for more information.

Pipe
Interceptor Sewer - The main interceptor sewer was constructed on concrete piles along the Northern river embankment, completely exposed to river flow in the vicinity of the Choate Bridge, and then partially and fully encompassed in the Northern river bank (partially exposed) as it extends downstream to SMH 673.
The sewer is constructed with concrete pile supports, cast-in-place around the pipe near each pipe joint. Cast iron fittings at pipe joints are not encased in the concrete piles and are exposed to the elements and have evidence of corrosion on the bolts and hardware.
In some locations there appears to be a void beneath the upper concrete piles. Based on the record drawings it appears the concrete piles were constructed in two pours connected by reinforcing steel, with the lower concrete pile extending down to bedrock. It appears that erosion in the river bed has exposed the base of the upper concrete piers where they were they were previously buried in the river bed, but it is not clear if there is discontinuity between the upper piers and lower piers, or if the apparent void under the upper piers is a result of a concrete over-pour into the river bed that that has become exposed by erosion.
The section of sewer main partially encompassed by the Northern river embankment downstream of the Choate Bridge has experienced erosion beneath the exposed pipe. The pipe is exposed to the elements and river flow and appears to be bearing the weight of the river bank where the pipe and bank have been undermined by erosion, creating the risk of pipe failure in the event continued erosion causes bank slippage. There are also large trees growing in the vicinity of the pipe and river bank, adding to the potential risk to the pipe caused by future erosion and bank slippage.

Sewer Siphon - The sewer siphon crossing under the river is currently exposed and visible in the river bed. Record drawings identify the siphon as being buried under river bed with 2-feet of minimum cover, if the record drawings accurately represent the installed siphon configuration it appears that erosion of the river bed has significantly changed the cross-section of the river bed and exposed the pipe. The pipe is approximately half exposed to river flow (buried to the spring line) and is exposed to river flow and potential damage from boats or river born debris.

(As an example of river born debris, a large tree was observed in the river bed upstream of the siphon that presumably was washed downstream during high flows.)
Refer to photos in Appendix D (recorded in August of 2017) for additional information.

Recommendations: *(Revised March 2018)*

- Raise all castings for sewer manholes and structures to grade to facilitate observation and facilitate access for future maintenance and bypass pumping if required. (Refer to Map 3)
  Status = Complete as of March 2018

- Inspect exposed concrete piles for concerns with structural continuity between concrete pours in areas where erosion has exposed base of upper piles.

- Inspect pipe and joint fittings along Northern River bank for corrosion and evidence of leakage.

- Remove large trees in vicinity of sewer in Northern embankment, and evaluate alternatives to backfill and stabilize soil beneath pipe, and to stabilize the river bank along exposed sewer length between the Choate Bridge and SMH 673 to protect against erosion, bank slippage, and potential resulting pipe failure.

- Recommend completing level survey of exposed sewer siphon pipe and connecting manholes to compare against 1960 record drawing information relative to sewer profile.
  Status = Partially Complete as of March 2018, Survey is complete for interceptor sewer, elevation shots on siphon incomplete. Refer to Drawing 3 in Appendix C.

- Consider conducting soil borings along route of sewer siphon in river to evaluate alternatives to replace sewer siphon at deeper depth.

- Consider installing structural pipe liners to extend the life of the interceptor sewer and/or sewer siphon and provide some protection from failure.

Bypass Pumping, Emergency Action Plan:
In the event of pipe failure in the Union Street/Market Street interceptor sewer in the river bank, or the Choate Bridge sewer siphon exposed in the river bed, the pipe(s) should be plugged upstream and downstream of each failed pipe segment to prevent sewer discharge into the river, and prevent river flow from entering the pipe during high flows, and a bypass pump and piping system should be installed to convey the flows across the section of failed sewer.

Bypass Pumping Capacity:
The UD has collected flow data in the sanitary sewer collection system in the past including manholes downstream of each pipe segment to be bypassed. The data was collected in April of 2009 and again in April of 2011. The information is provided for reference in the attachments of this letter report, and provide information for average, minimum, and maximum anticipated flows to be handled by bypass pumping system in each location.

- Map 1 in Appendix A identifies the locations where the flow meter data was collected in 2009 and 2011.
- Map 2 identifies the approximate limits of the sewer catchment areas tributary to each pipe to be bypassed, and a schematic diagram of the flow metering.
- Graphs provided in Appendix B provide ranges of flow data collected during each metering period for each pipe to be bypassed, and meter installation logs prepared by the flow metering contractor.
- Map 3 identifies the approximate locations and depths of source and discharge manholes, and topographic contours for use in static head considerations by pumping contractor.

Bypass Piping:
Details of the bypass piping route (including pipe size and accommodation for pedestrian and vehicular traffic and safety) are not specified, but schematic potential bypass piping routes are provided for reference to facilitate the Town soliciting quotes from qualified vendors or pumping contractors.

- Map 4 identifies alternative locations for bypass pump source and discharge manholes, the number and approximate size of inflatable pipe plugs to be installed as part of the bypass pumping plan for the main interceptor sewer, and the schematic route of bypass piping to be installed to provide a pumping contractor with minimum length of pipe anticipated.

- Map 5 identifies alternative locations for bypass pump source and discharge manholes, the number and approximate size of inflatable pipe plugs to be installed as part of the bypass pumping plan for the Choate Bridge sewer siphon, and alternative schematic routes of bypass piping to be installed to provide a pumping contractor with minimum length of pipe anticipated.

Bypass Pump and Pipe Work Summary: *(Added March 2018)*

- Provide Dri-Prime diesel pumps (One for service and one on standby if required) with level transducer controls and wireless auto-dialer to relay alarm conditions.

- Bypass piping to be welded HDPE or approved equal. The diameter and route of bypass piping to be determined by Contractor. Bypass piping to be installed with ramps to facilitate vehicular and pedestrian traffic and/or installed below pavement in shallow saw-cut trench as directed by Town.

- Bypass pumps and pipes should be sized to efficiently handle following conditions:

Bypass Location	**Average Daily Flow** *(MGD)*	**Peak Flow** *(MGD)*	**Approximate Bypass Pipe Length*** *(Linear Feet)*	**Minimum Static Lift*** *(Vertical Feet)*
Union St. / Market St. Bypass	0.40 to 1.0	2.0	Low River Stage - 500 High River Stage - 700	Low River Stage - 13 High River Stage - 30
Siphon Bypass	0.10 to 0.20	0.35	Option One - 800 Option Two - 1,200	Option One - 30 Option Two - 20

* Bypass length and minimum static lift will be determined in the field by Contractor.

Emergency Notification Protocol: *(Added March 2018)*

Lisa Dallaire *MassDEP Environmental Engineer*	lisa.dallaire@state.ma.us	978-694-3238
Doug Koopman *EPA*	koopman.douglas@epa.gov	617-918-1747
Department of Marine Fisheries	shellfish.newburyport@state.ma.us	978-282-0308 ext. 160
Jack Schwartz *Division of Marine Fisheries*	jack.schwartz@state.ma.us	978-282-0308 ext. 122
Jeff Kennedy *Division of Marine Fisheries*	jeff.kennedy@state.ma.us	978-282-0308 ext. 165
Colleen Fermon *Ipswich Health Director*	colleenf@ipswich-ma.gov	978-356-6606
Alicia Geilen *Ipswich Conservation Agent*	aliciag@ipswich-ma.gov	978-356-6661
Scott LePreste *Ipswich Shellfish Constable*	scottshells9@yahoo.com	978-356-6671
Wayne Castonguay *Ipswich River Watershed Association Director*	wcastonguay@ipswichriver.org	978-412-9100

APPENDIX A
Maps

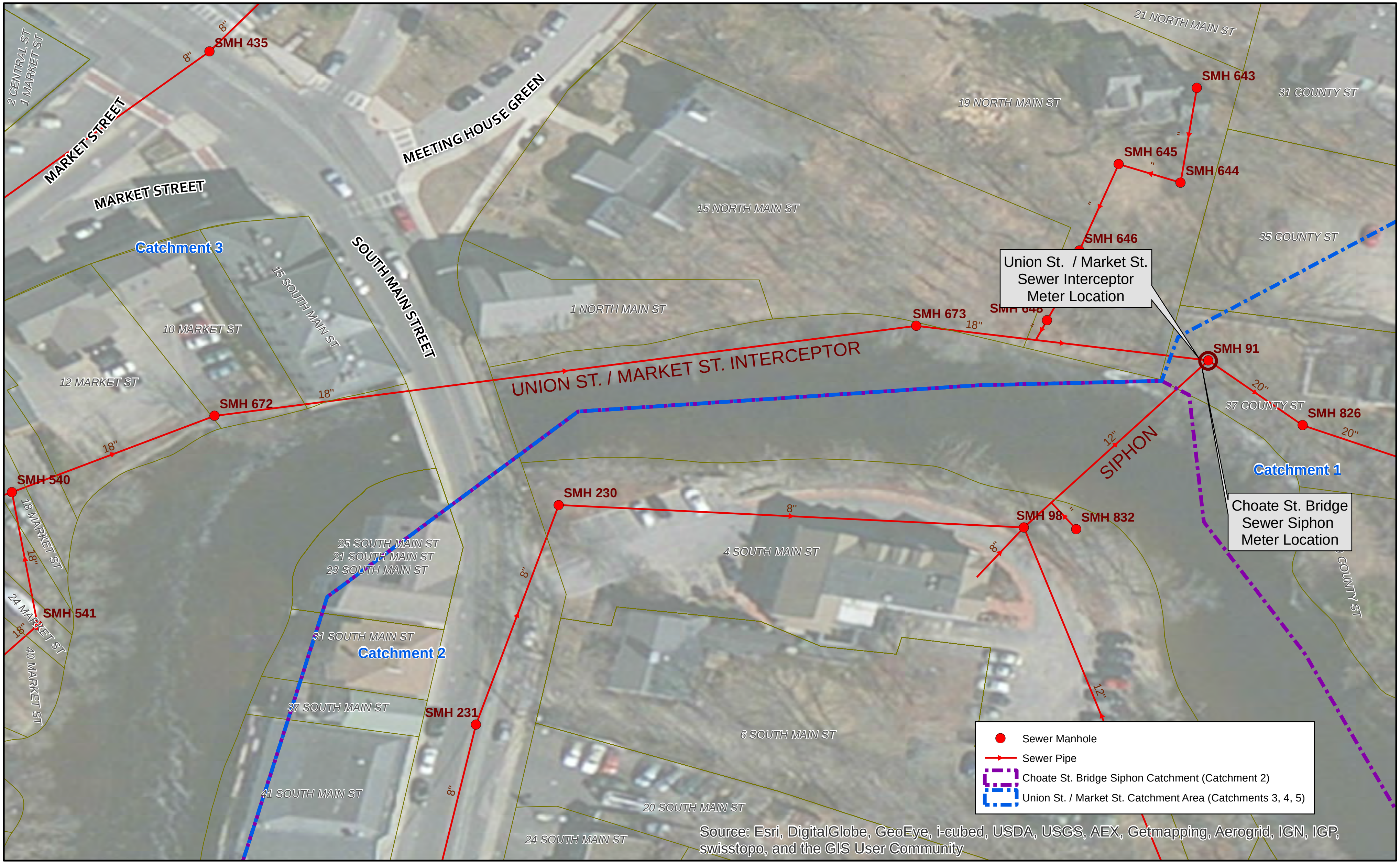
MAP 1: Sewer Flow Meter Locations for Choate Bridge Sewer Siphon and Union Street / Market Street Interceptor Sewer

MAP 2: Sewer System and Catchment Areas

MAP 3: Sewer Manhole Descriptions and Buried Structures to Raise

MAP 4: Potential Bypass Flow Handling for Union Street / Market Street Interceptor

MAP 5: Potential Bypass Flow Handling for Choate Bridge Sewer Siphon



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SALEM, MA

N

IPSWICH MASSACHUSETTS
THE BIRTHPLACE OF AMERICAN INDEPENDENCE 1687
INCORPORATED 1634

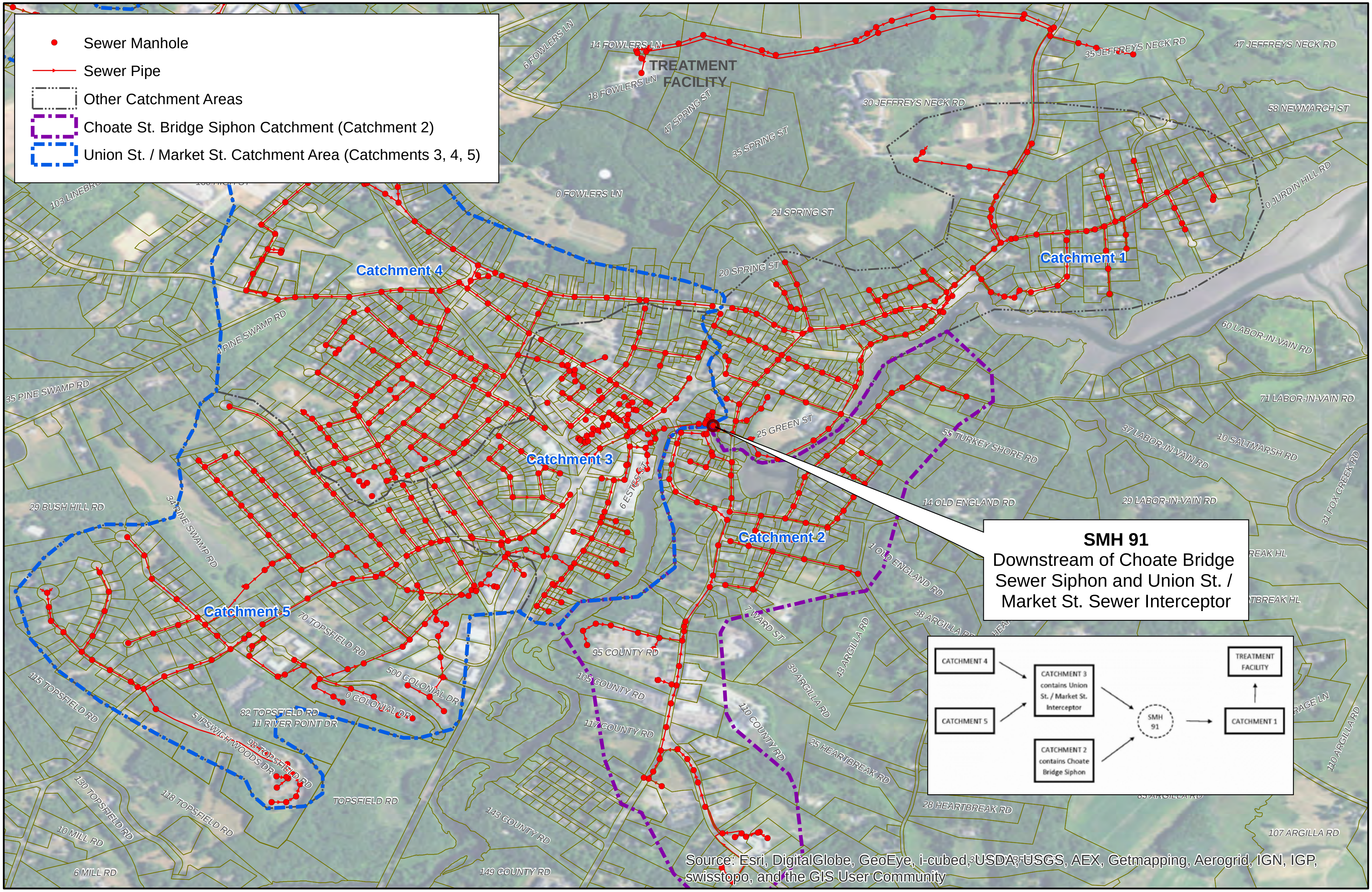
Town of Ipswich, Massachusetts

Sewer Flow Meter Locations for
Choate Bridge Siphon and Union St. / Market St. Interceptor

1 inch = 80 feet

0 20 40 80 Feet

MAP 1



Town of Ipswich, Massachusetts

Sewer System
and Catchment Areas

1 inch = 1,600 feet

0 400 800 1,600 Feet

N

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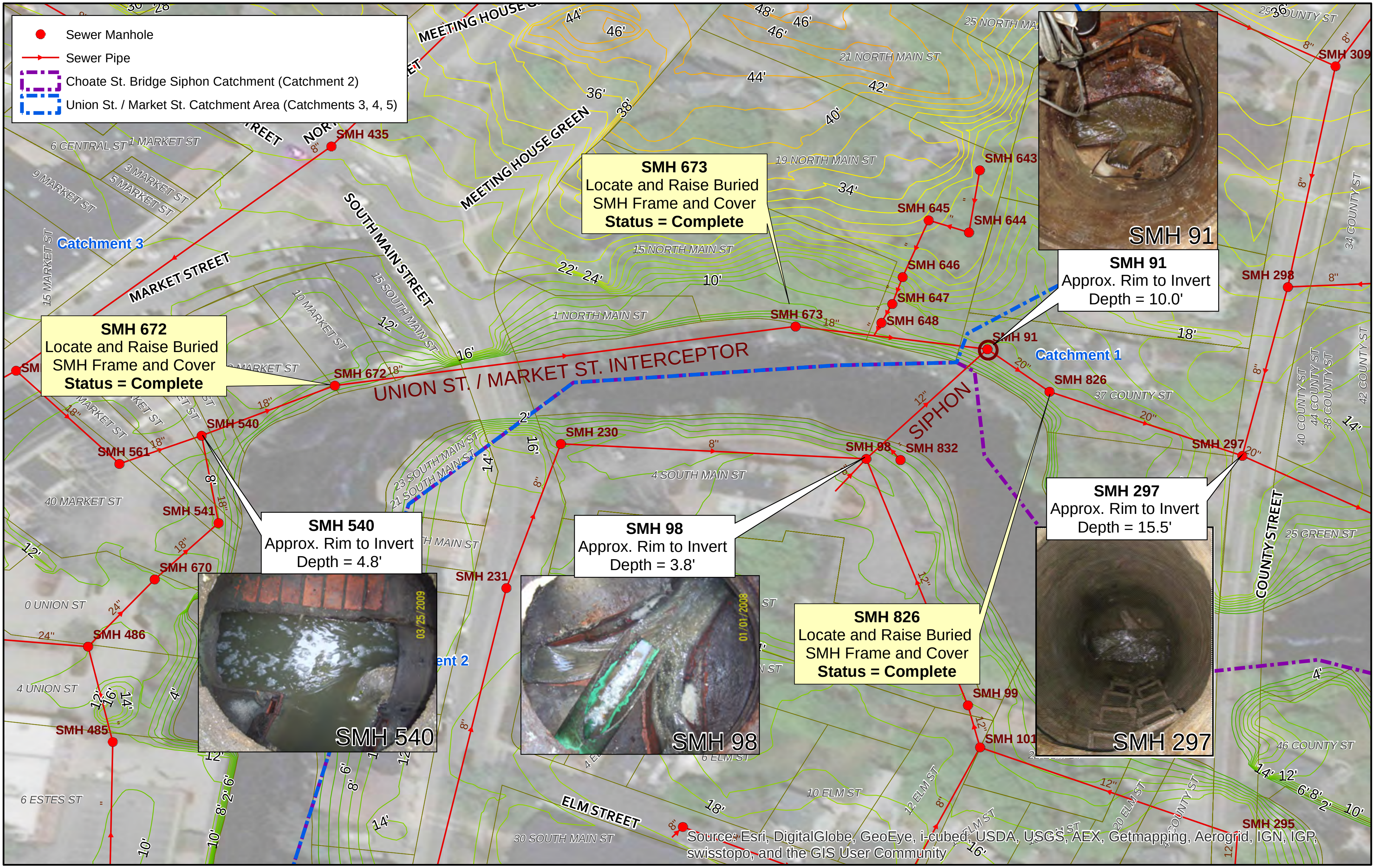
SALEM, MA

MAP 2



NECE
NEW ENGLAND CIVIL ENGINEERING
SALEM, MA

N

Town of Ipswich, Massachusetts

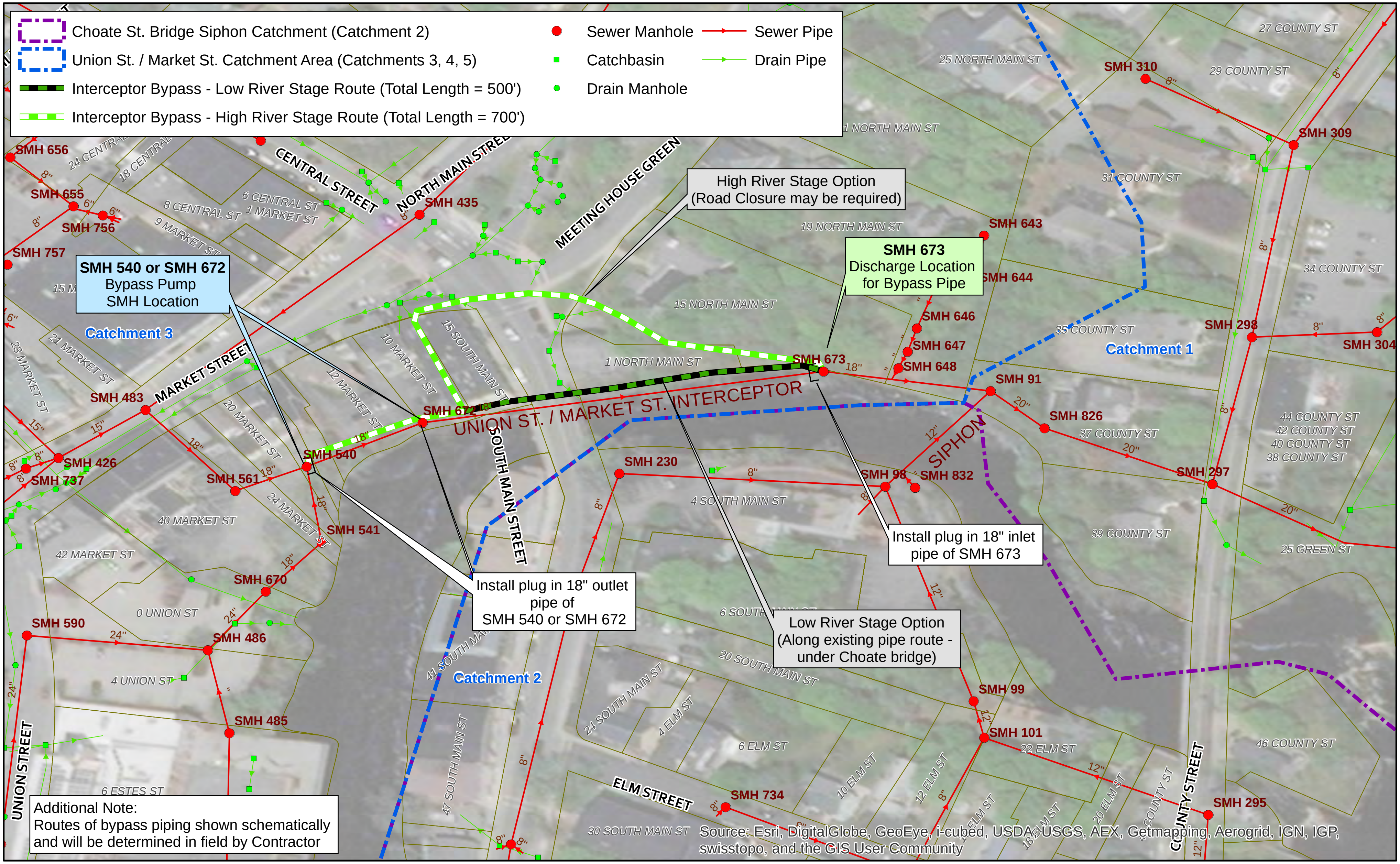
Sewer Manhole Descriptions and Buried Structures to Raise

Revised Map (Status = Complete, as of March 19, 2018)

1 inch = 120 feet

0 30 60 120 Feet

MAP 3

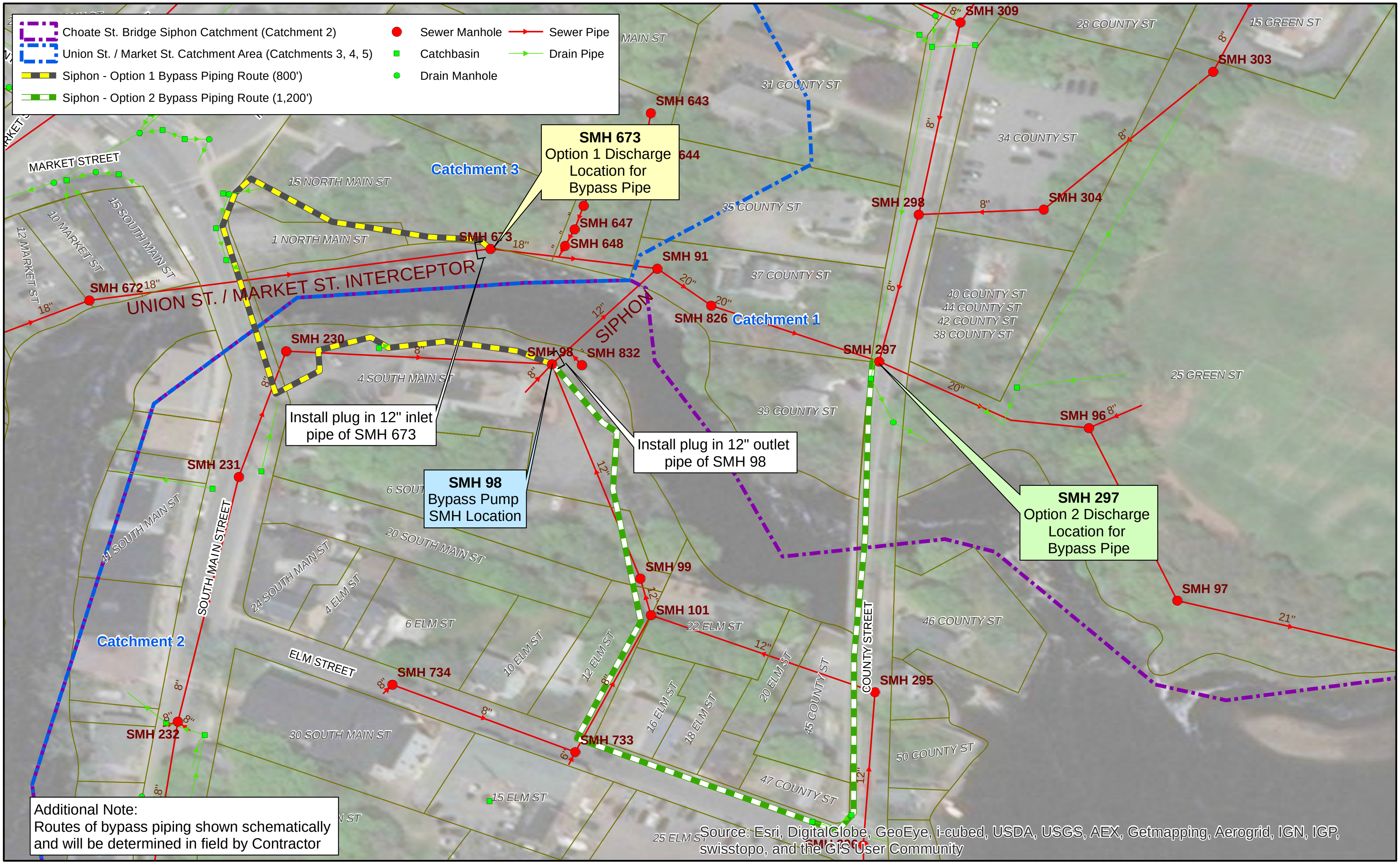


Town of Ipswich, Massachusetts

Potential Bypass Flow Handling for
Union St. / Market St. Interceptor

Revised Map as of March 19, 2018

MAP 4



NECE
NEW ENGLAND CIVIL ENGINEERING
SALEM, MA

N

Town of Ipswich, Massachusetts

Potential Bypass Flow Handling for Choate Bridge Sewer Siphon

Revised Map as of March 19, 2018

1 inch = 140 feet

0 35 70 140 Feet

MAP 5

APPENDIX B
Tables

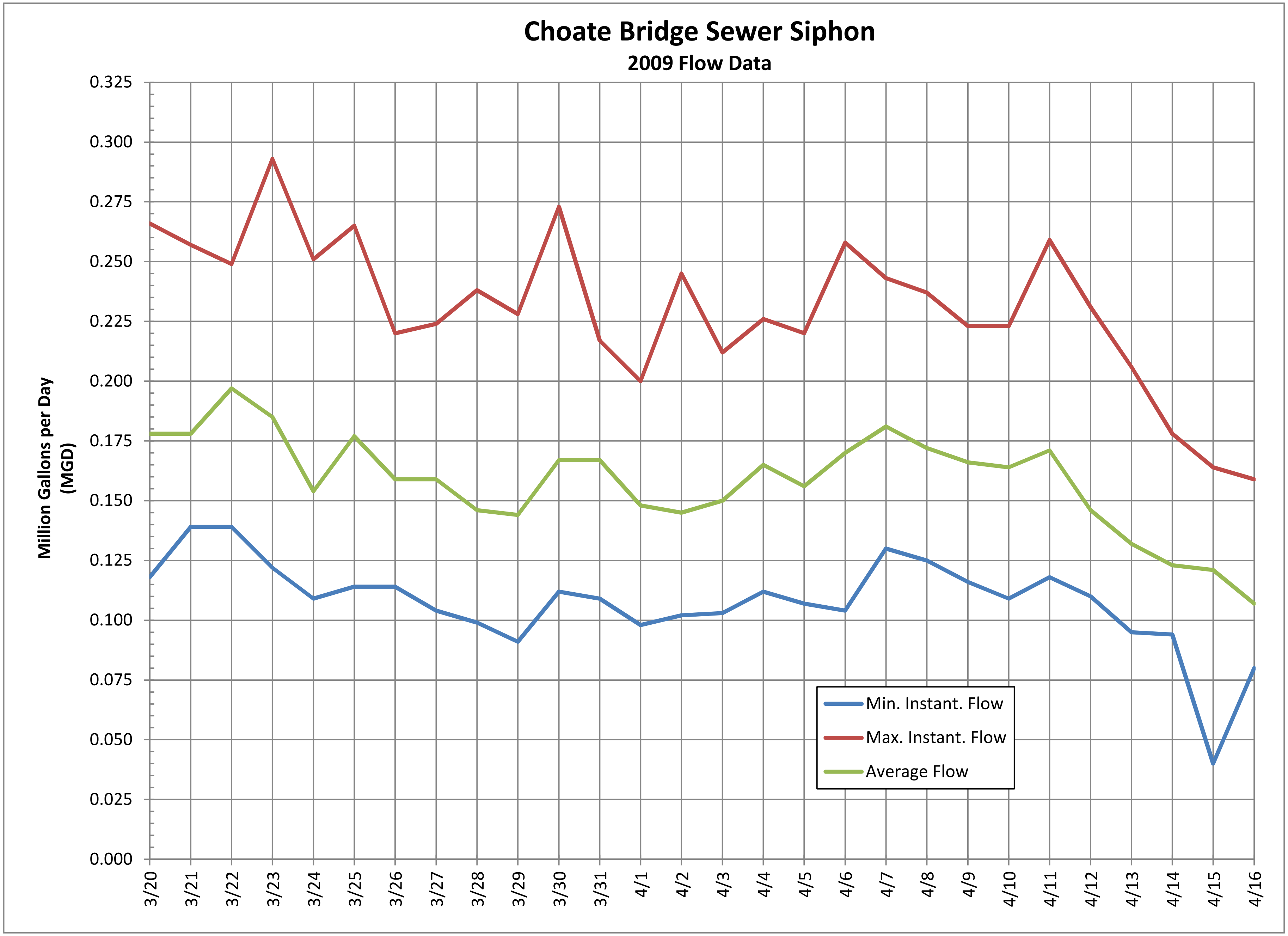
GRAPH 1: Choate Bridge Siphon 2009 Flow Data

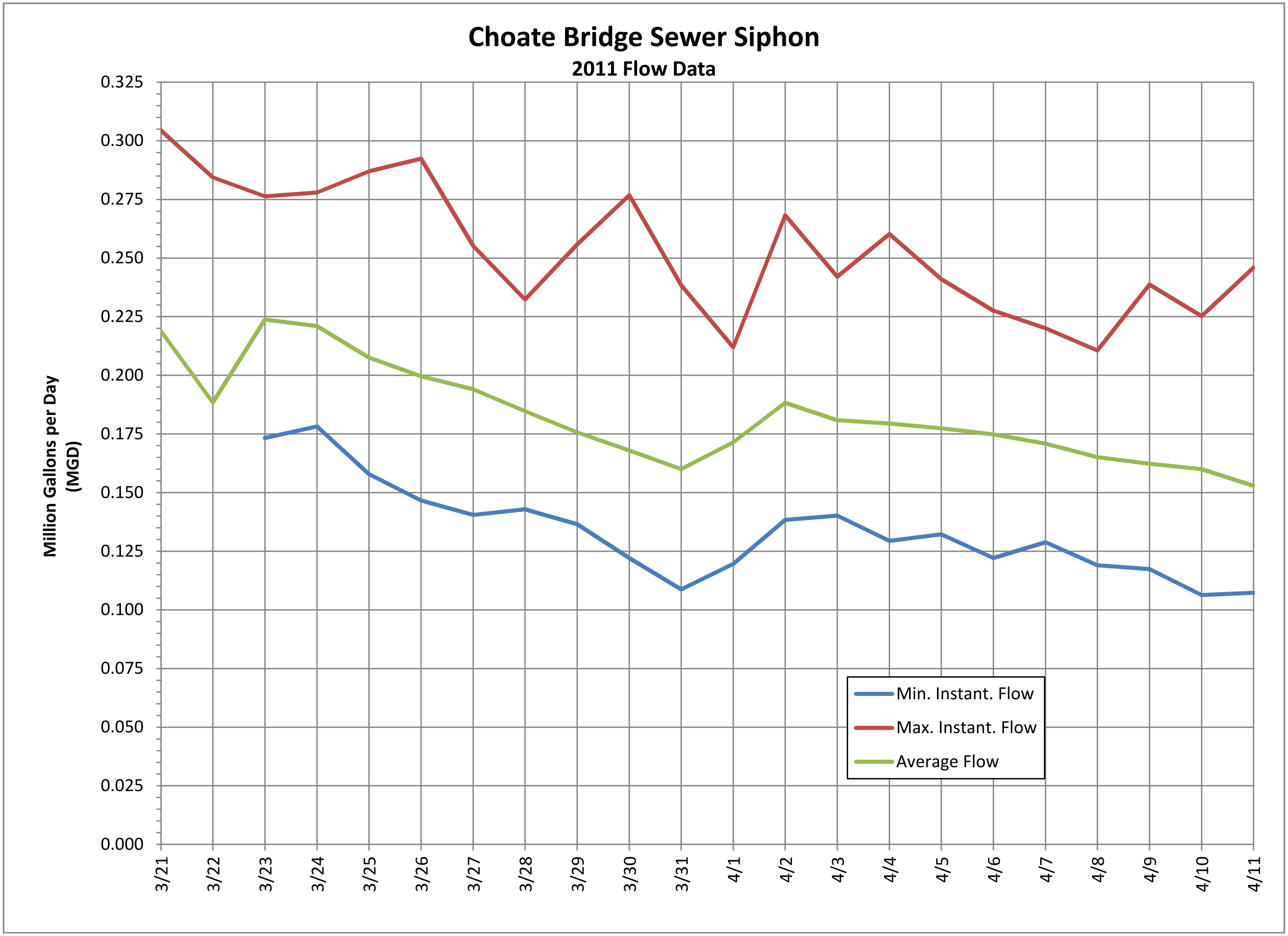
GRAPH 2: Choate Bridge Siphon 2011 Flow Data

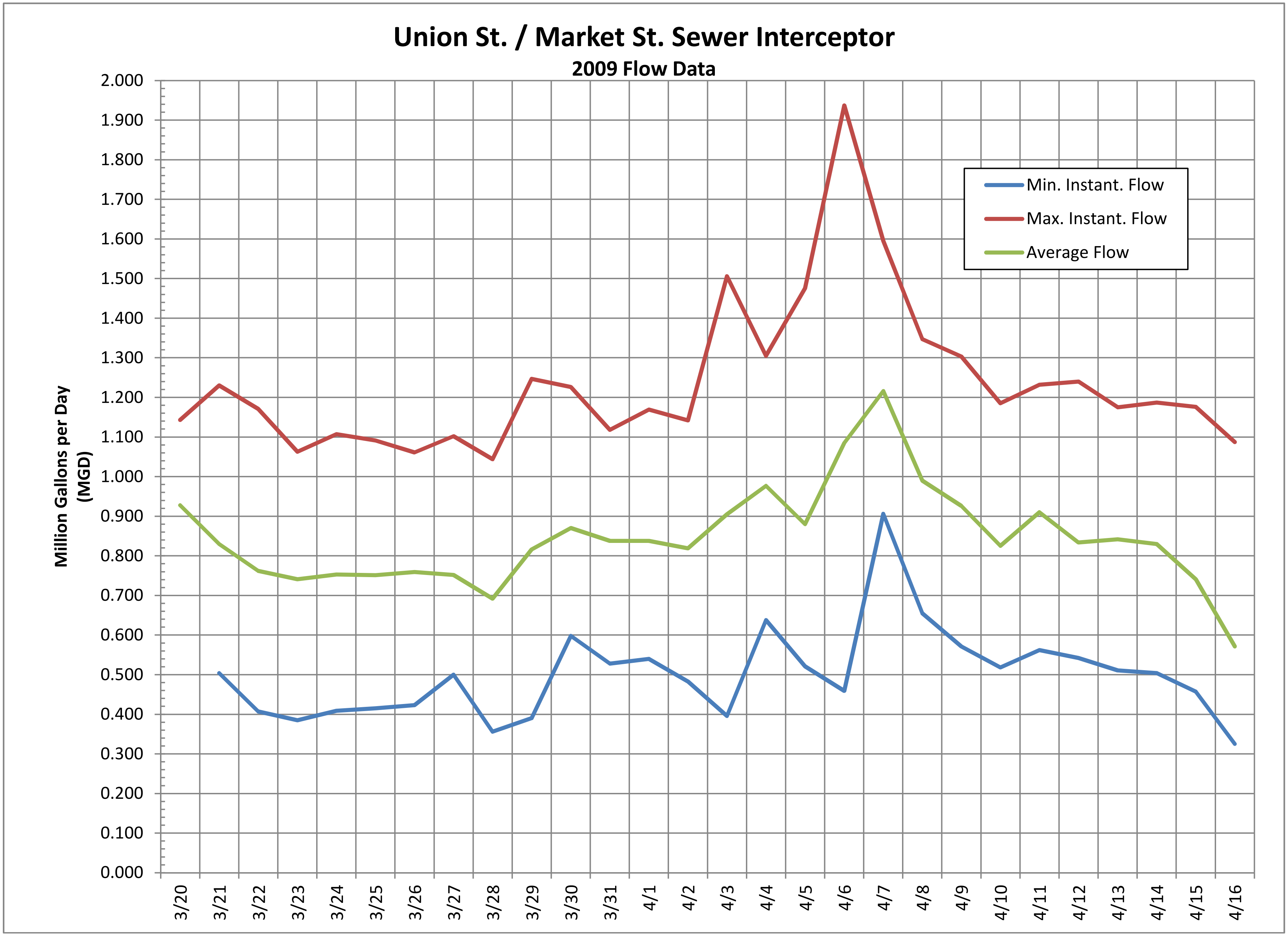
GRAPH 3: Union St. / Market St. Interceptor 2009 Flow Data

GRAPH 4: Union St. / Market St. Interceptor 2009 Flow Data

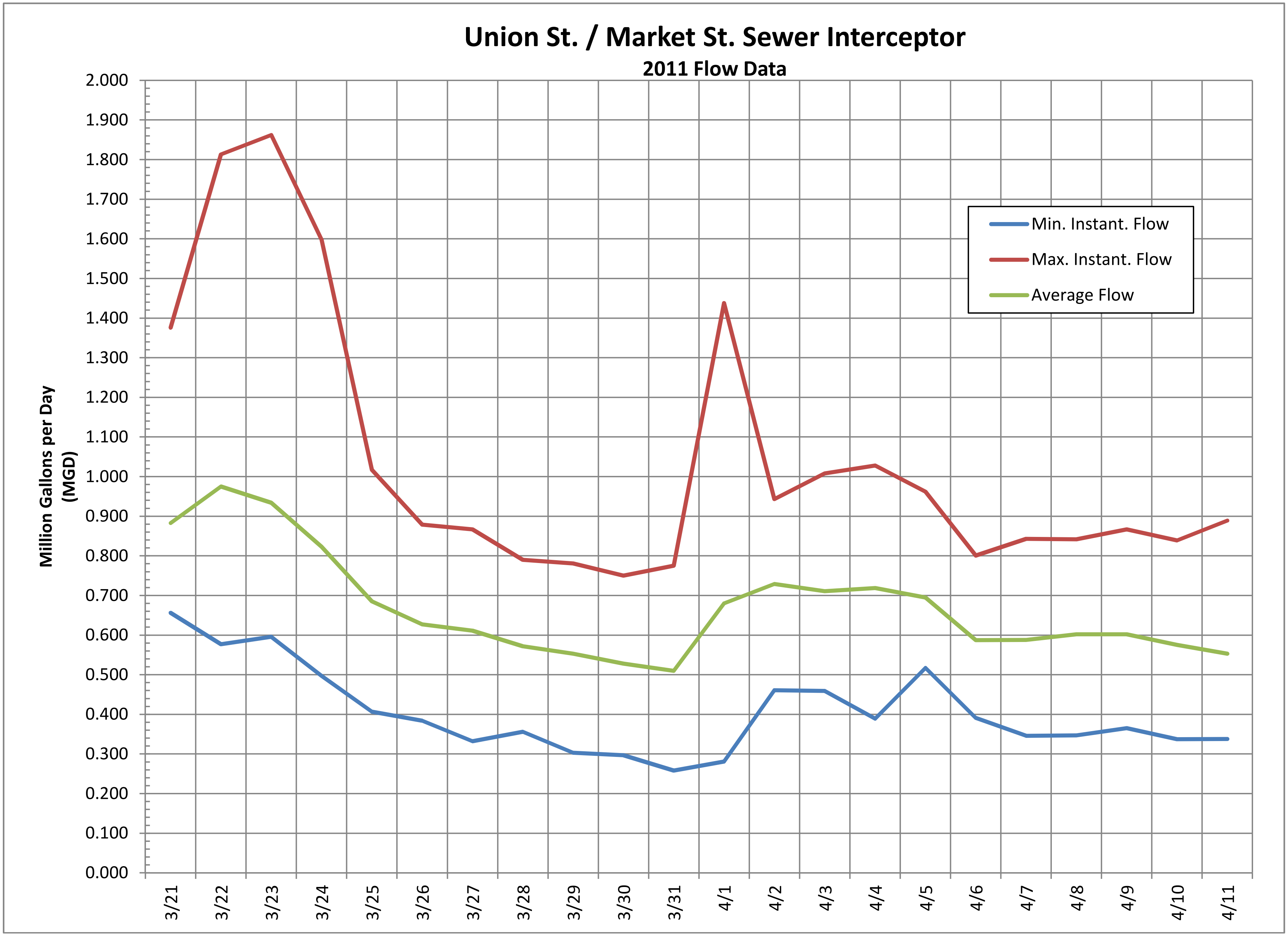
EST METER 2 Inspection Log


Choate Bridge Sewer Siphon
2009 Flow Data
Million Gallons per Day (MGD)
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
3/20
3/21
3/22
3/23
3/24
3/25
3/26
3/27
3/28
3/29
3/30
3/31
4/1
4/2
4/3
4/4
4/5
4/6
4/7
4/8
4/9
4/10
4/11
4/12
4/13
4/14
4/15
4/16
Min. Instant. Flow
Max. Instant. Flow
Average Flow


Choate Bridge Sewer Siphon
2011 Flow Data
Million Gallons per Day
(MGD)
0.325
0.300
0.275
0.250
0.225
0.200
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
3/21
3/22
3/23
3/24
3/25
3/26
3/27
3/28
3/29
3/30
3/31
4/1
4/2
4/3
4/4
4/5
4/6
4/7
4/8
4/9
4/10
4/11
Min. Instant. Flow
Max. Instant. Flow
Average Flow



Union St. / Market St. Sewer Interceptor
2009 Flow Data
Million Gallons per Day (MGD)
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
3/20
3/21
3/22
3/23
3/24
3/25
3/26
3/27
3/28
3/29
3/30
3/31
4/1
4/2
4/3
4/4
4/5
4/6
4/7
4/8
4/9
4/10
4/11
4/12
4/13
4/14
4/15
4/16
Min. Instant. Flow
Max. Instant. Flow
Average Flow


Union St. / Market St. Sewer Interceptor
2011 Flow Data
Million Gallons per Day (MGD)
2.000
1.900
1.800
1.700
1.600
1.500
1.400
1.300
1.200
1.100
1.000
0.900
0.800
0.700
0.600
0.500
0.400
0.300
0.200
0.100
0.000
3/21
3/22
3/23
3/24
3/25
3/26
3/27
3/28
3/29
3/30
3/31
4/1
4/2
4/3
4/4
4/5
4/6
4/7
4/8
4/9
4/10
4/11
Min. Instant. Flow
Max. Instant. Flow
Average Flow

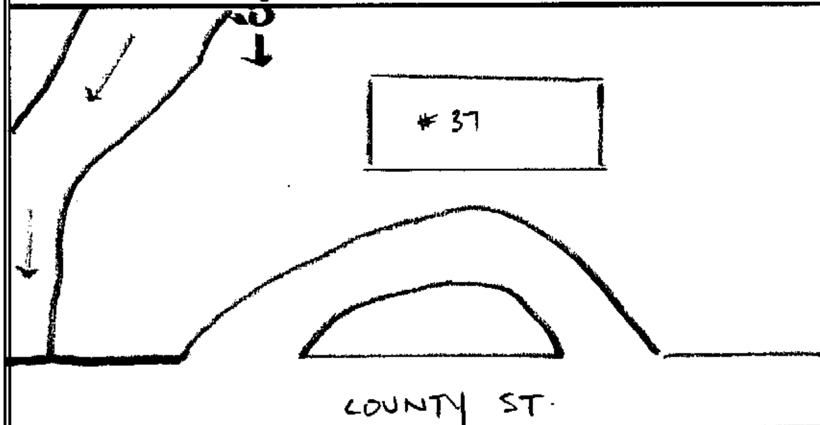
2 meters

EST Associates, Inc.

51 Fremont Street Needham MA, 02494
tel: 781-455-0003 fax: 781-455-8336

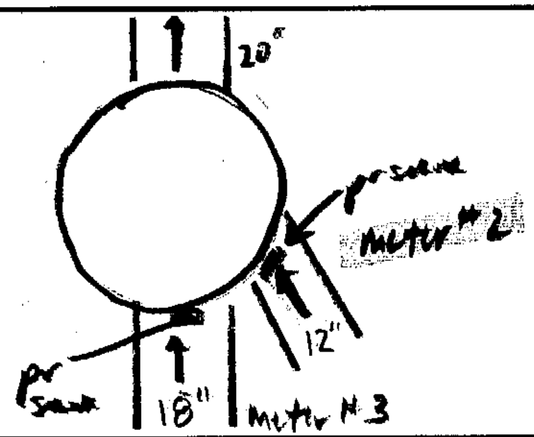
SITE INVESTIGATION

SITE LOCATION



Project:	IPSWICH, MA
Location:	37 COUNTY ST.
MH#	Meter 02
Map #	
Date:	3/20/09
Time:	0950
Regulator#	

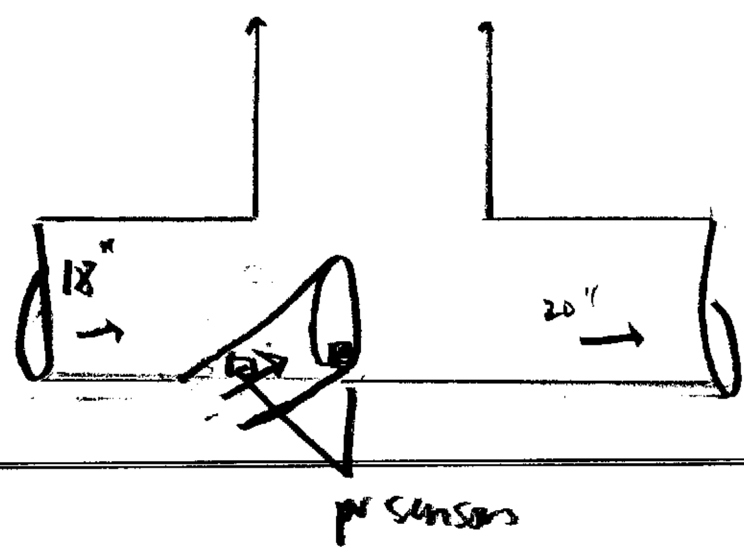
PLAN VIEW



LINE DESCRIPTIONS

	Incoming (IN)	~~Outgoing~~ (IN)	~~Overflow~~ (out)
Size	12"	18"	20"
Material	VCP	VCP	VCP
Debris	NO	NO	NO
Shape	CIRC	CIRC	CIRC
Depth	9'3"	9'10"	6'2"

PROFILE VIEW



WEIR/FLUME

Length ________

Width ________

Level Yes/No N/A

Height Above Weir ________

Overflow Occurs @ ________

Meter programmed to measure zero:

- [ ] 1. invert to pipe
- [ ] 2. top of weir wall
- [ ] 3. other : ________

EST
Associates, Inc.

FLOW MONITORING

DATE: 3-25-09
TIME: 9:05

INSPECTORS' INITIALS: JG/SS/MS

SITE NAME: IPSWICH METER 02
ADDRESS: 37 COUNTY ST.

METER SERIAL NUMBER: P9K

SERVICES/ACTIONS PERFORMED:

- ☒ Sensor Cleaning
- ☒ Calibration Check
- ☒ Data Downloaded
- ☐ Other ____________________

Data Downloaded? (Y / N) — Y circled

- ☐ By Modem: [date:__________]
- ☐ To DTU: [file number:__________]
- ☒ To Laptop (Y / N) [SN: #2]

Replace Batteries? (Y / N) — N circled

Existing volts: 5.4

New volts:__________

Dessicant Status: GOOD

Replaced dessicant? (Y / N) — N circled

Meter Running? (Y / N) — Y circled

METER READINGS

Level Readings	Actual 4.4 (in)	Metered: 4.361 (in)	Recalibrated to:__________(in)
Velocity Readings	Actual__________(ft/s)	Metered: 1.28 (ft/s)	

Telltale in place? (Y / N) **Replaced telltale? (Y / N)**

Errors recorded: ____________________

Work to be performed/Additional Comments/Observations: METER RUNNING GOOD GRAPH LOOKS OK - SOME RAGGING MAY OCCUR AFFECTING VELOCITIES PERIODICALLY

EST
Associates, Inc.

FLOW MONITORING

DATE: 4-1-09
TIME: 9:45

INSPECTORS' INITIALS: JG/GB

SITE NAME: IPSWICH METER 02
ADDRESS: 37 COUNTY STREET

METER SERIAL NUMBER: P9K

SERVICES/ACTIONS PERFORMED:

- [x] Sensor Cleaning
- [x] Calibration Check
- [x] Data Downloaded
- [ ] Other ____________

Data Downloaded? ((Y) / N)

- [ ] By Modem: [date:____________]
- [ ] To DTU: [file number:____________]
- [x] To Laptop (Y / N) [SN: #1]

Replace Batteries? (Y / (N))

Existing volts: 5.3
New volts: —

Dessicant Status: GOOD

Replaced dessicant? (Y / (N))

Meter Running? ((Y) / N)

METER READINGS

Level Readings Actual 3.9 (in) Metered: 3.859 (in) Recalibrated to:____________(in)

Velocity Readings Actual — (ft/s) Metered: 1.41 (ft/s)

Telltale in place? (Y / N) **Replaced telltale? (Y / N)**

Errors recorded: ____________

Work to be performed/Additional Comments/Observations: GRAPH LOOKS LEVEL HAS DROPPED SOMEWHAT IN LAST WEEK, HOWEVER READINGS APPEAR NORMAL. LIKELY SOME RAGGING OCCURING AFFECTING VELOCITIES ON OCCASION

EST
Associates, Inc.

FLOW MONITORING

DATE: 4-8-09
TIME: 12:00

INSPECTORS' INITIALS: JG/MR

SITE NAME: IPSWICH METER 02
ADDRESS: 37 COUNTY STREET

METER SERIAL NUMBER: P9K

SERVICES/ACTIONS PERFORMED:

- ☒ Sensor Cleaning
- ☒ Calibration Check
- ☒ Data Downloaded
- ☐ Other ______

Data Downloaded? (Y / N) — Y circled

- ☐ By Modem: [date:______]
- ☐ To DTU: [file number:______]
- ☒ To Laptop (Y / N) [SN: #1]

Replace Batteries? (Y / N) — N circled

Existing volts: 5.4

New volts: —

Dessicant Status: GOOD

Replaced dessicant? (Y / N) — N circled

Meter Running? (Y / N) — Y circled

METER READINGS

Level Readings Actual 3.4 (in) Metered: 3.387 (in) Recalibrated to: ______ (in)

Velocity Readings Actual — (ft/s) Metered: 1.26 (ft/s)

Telltale in place? (Y / N) **Replaced telltale? (Y / N)**

Errors recorded: ______

Work to be performed/Additional Comments/Observations: GRAPH LOOKS CONSISTANT

EST
Associates, Inc.

FLOW MONITORING

DATE: 4/16/09 INSPECTORS' INITIALS: GB/GG/MR
TIME: 8:30

SITE NAME: IPSWICH METER 02 METER SERIAL NUMBER: P9K
ADDRESS: 37 COUNTY STREET

SERVICES/ACTIONS PERFORMED:

- ☐ Sensor Cleaning
- ☑ Calibration Check
- ☑ Data Downloaded
- ☑ Other REMOVED METER

Data Downloaded? (Y / N) — Y circled

- ☐ By Modem: [date:________]
- ☐ To DTU: [file number:________]
- ☑ To Laptop (Y / N) [SN: #1] — Y circled

Replace Batteries? (Y / N) — N circled

Existing volts: 4.7

New volts:________

Dessicant Status: GOOD

Replaced dessicant? (Y / N) — N circled

Meter Running? (Y / N) — Y circled

METER READINGS

Level Readings Actual 3.25 (in) Metered: 3.21 (in) Recalibrated to:________(in)

Velocity Readings Actual 1.30 (ft/s) Metered: 1.34 (ft/s)

Telltale in place? (Y / N) **Replaced telltale? (Y / N)**

Errors recorded:

Work to be performed/Additional Comments/Observations:

SMH 91 Meter Manhole Location

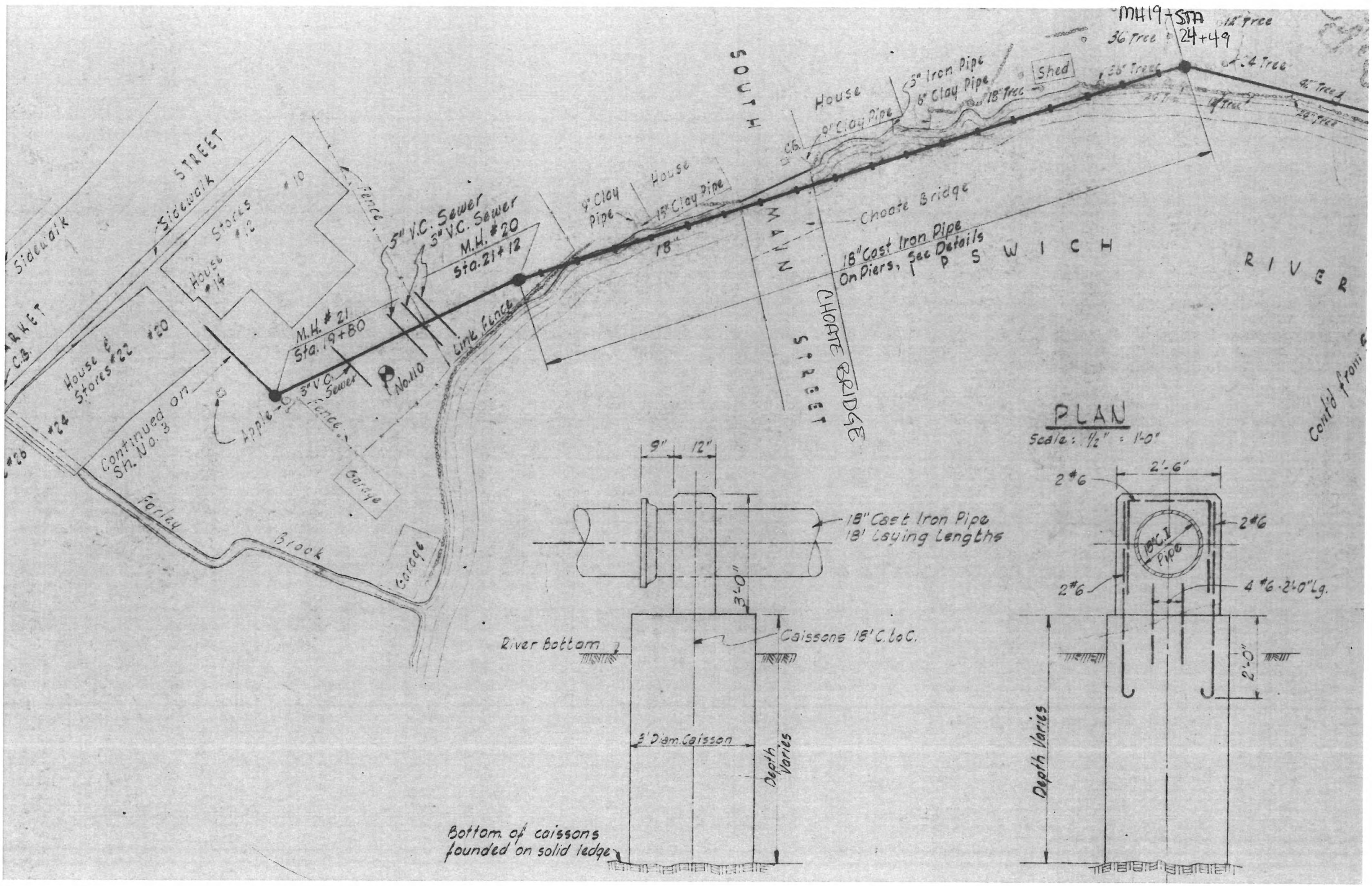
SMH 91 Meter Manhole Interior View

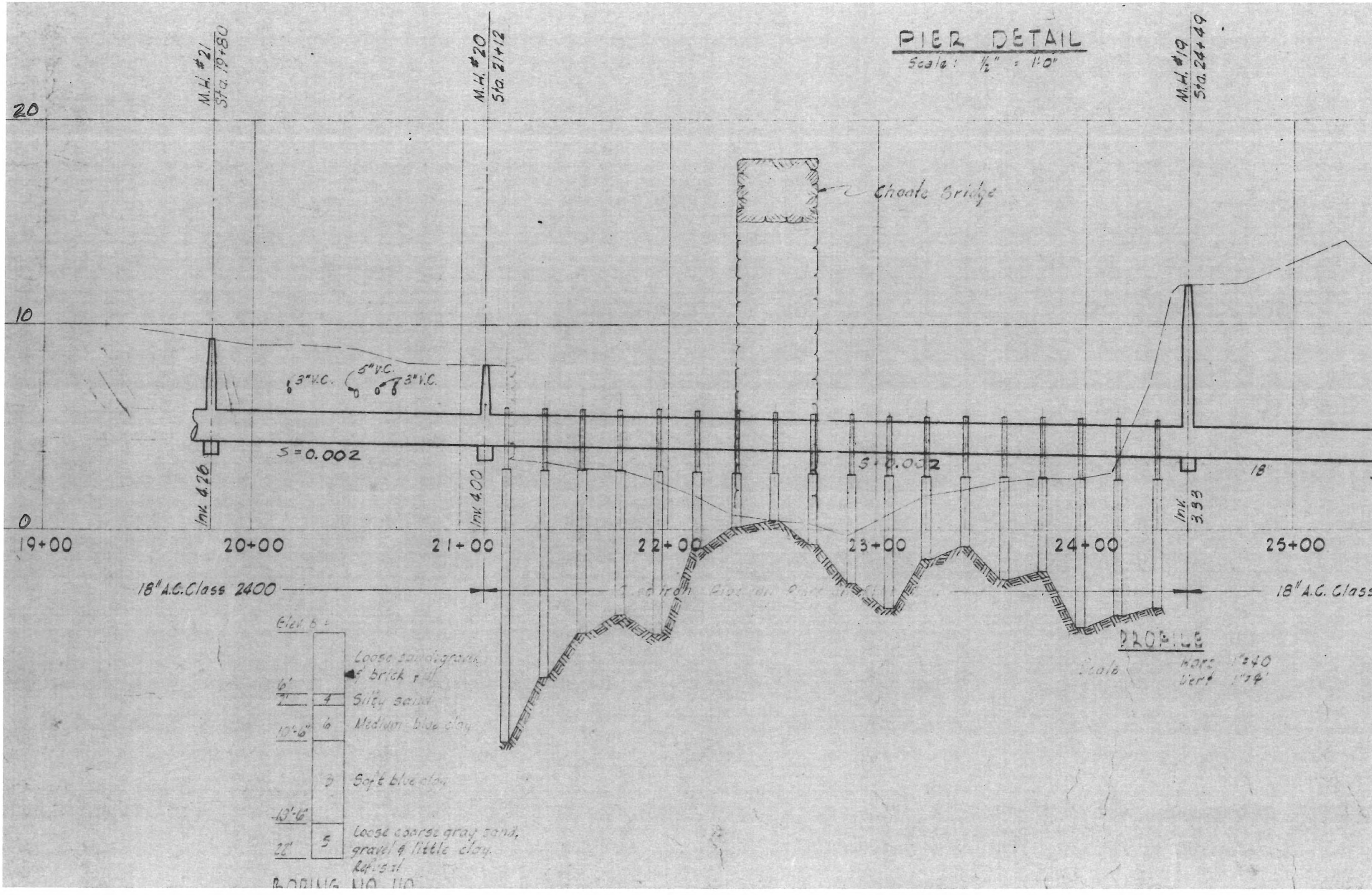
APPENDIX C
As-Built Drawings

DRAWING 1: Siphon As-Built Drawing

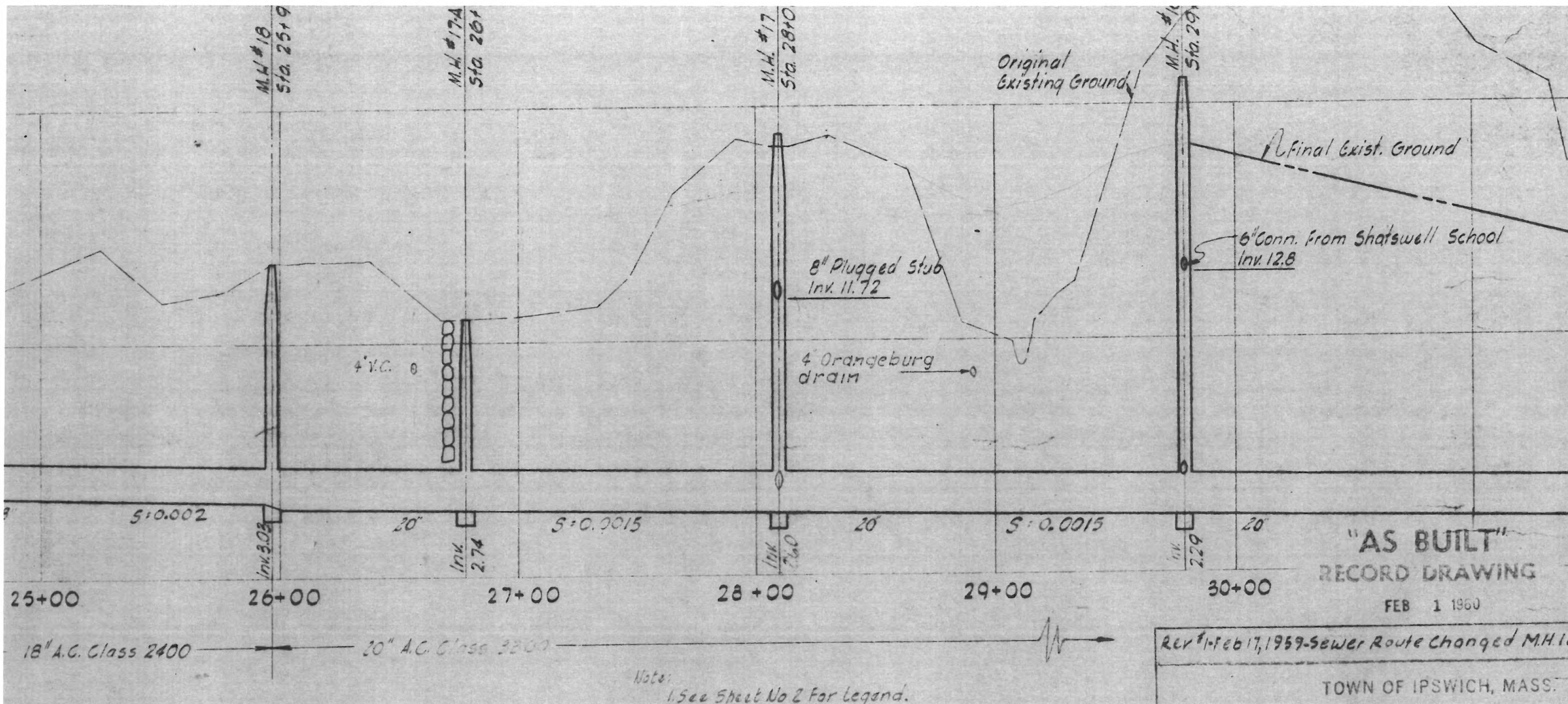
DRAWING 2: Interceptor As-Built Drawing

DRAWING 3: Sanitary Sewer Plan, Graham Associates, Inc.
March 14, 2018


MH19-STA 24+49
12" Tree
36 Tree
4 Tree
Shed
5" Iron Pipe
6" Clay Pipe
18" Tree
36" Tree
House
9" Clay Pipe
C.B.
SOUTH
MAIN
STREET
Choate Bridge
CHOATE BRIDGE
IPSWICH RIVER
18" Cast Iron Pipe
On Piers, See Details
House
15" Clay Pipe
9" Clay Pipe
18"
STREET
Sidewalk
Stores #10 #12
House #14
Fence
5" V.C. Sewer
5" V.C. Sewer
M.H. #20
Sta. 21+12
M.H. #21
Sta. 19+80
Link Fence
No. 110
3" V.C. Sewer
Fence
Apple
Continued on Sh. No. 3
House & Stores #22 #20
#24
#26
MARKET
C.B.
Farley Brook
Garage
Garage
PLAN
Scale: 1/2" = 1'-0"
9"
12"
18" Cast Iron Pipe
18' Laying Lengths
3'-0"
River Bottom
Caissons 18' C. to C.
3' Diam. Caisson
Depth Varies
Bottom of caissons
founded on solid ledge
2'-6"
2 #6
2 #6
2 #6
18" C.I. Pipe
4 #6 - 2'-0" Lg.
2'-0"
Depth Varies



PIER DETAIL
Scale: 1/2" = 1'-0"
M.H. #21
Sta. 19+80
M.H. #20
Sta. 21+12
M.H. #19
Sta. 24+49
20
10
0
Choate Bridge
3" V.C.
5" V.C.
3" V.C.
S=0.002
S=0.002
Inv. 4.26
Inv. 4.00
Inv. 3.33
18"
19+00
20+00
21+00
22+00
23+00
24+00
25+00
18" A.C. Class 2400
18" A.C. Class
Elev. 6 ±
Loose sand, gravel & brick fill
6'
7'
4
Silty sand
6
Medium blue clay
10'-6"
3
Soft blue clay
13'-6"
5
Loose coarse gray sand, gravel & little clay.
22'
Refusal
BORING NO. 110
PROFILE
Scale
Horz. 1"=40'
Vert. 1"=4'



Note:
1. See Sheet No 2 For Legend.

"AS BUILT"
RECORD DRAWING
FEB 1 1960

Rev #1-Feb 17, 1959-Sewer Route Changed M.H. 18

TOWN OF IPSWICH, MASS.

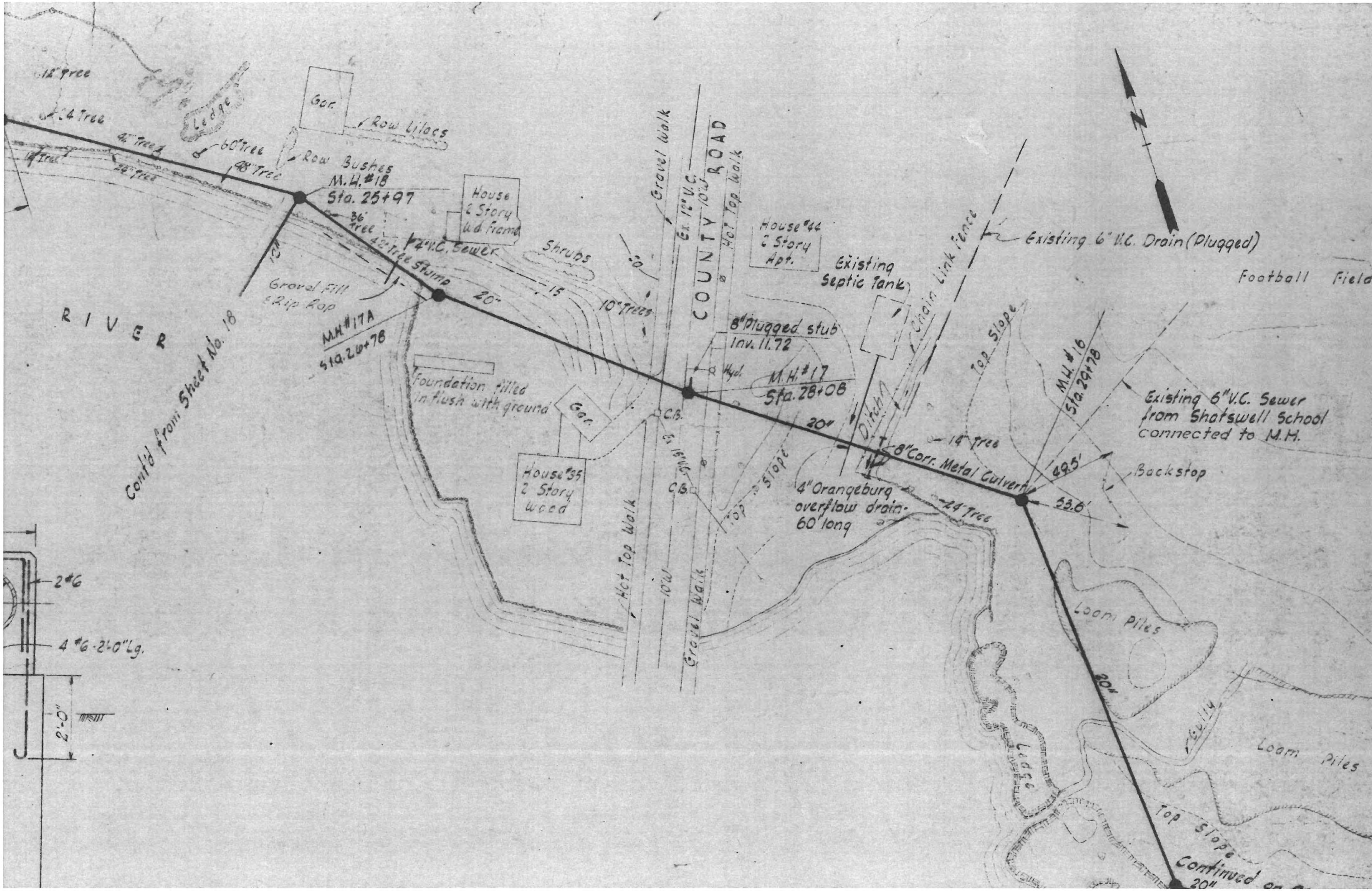
SEWERS & FORCE MAIN

IPSWICH RIVER TRUNK S

STA 19+80 TO 31+82

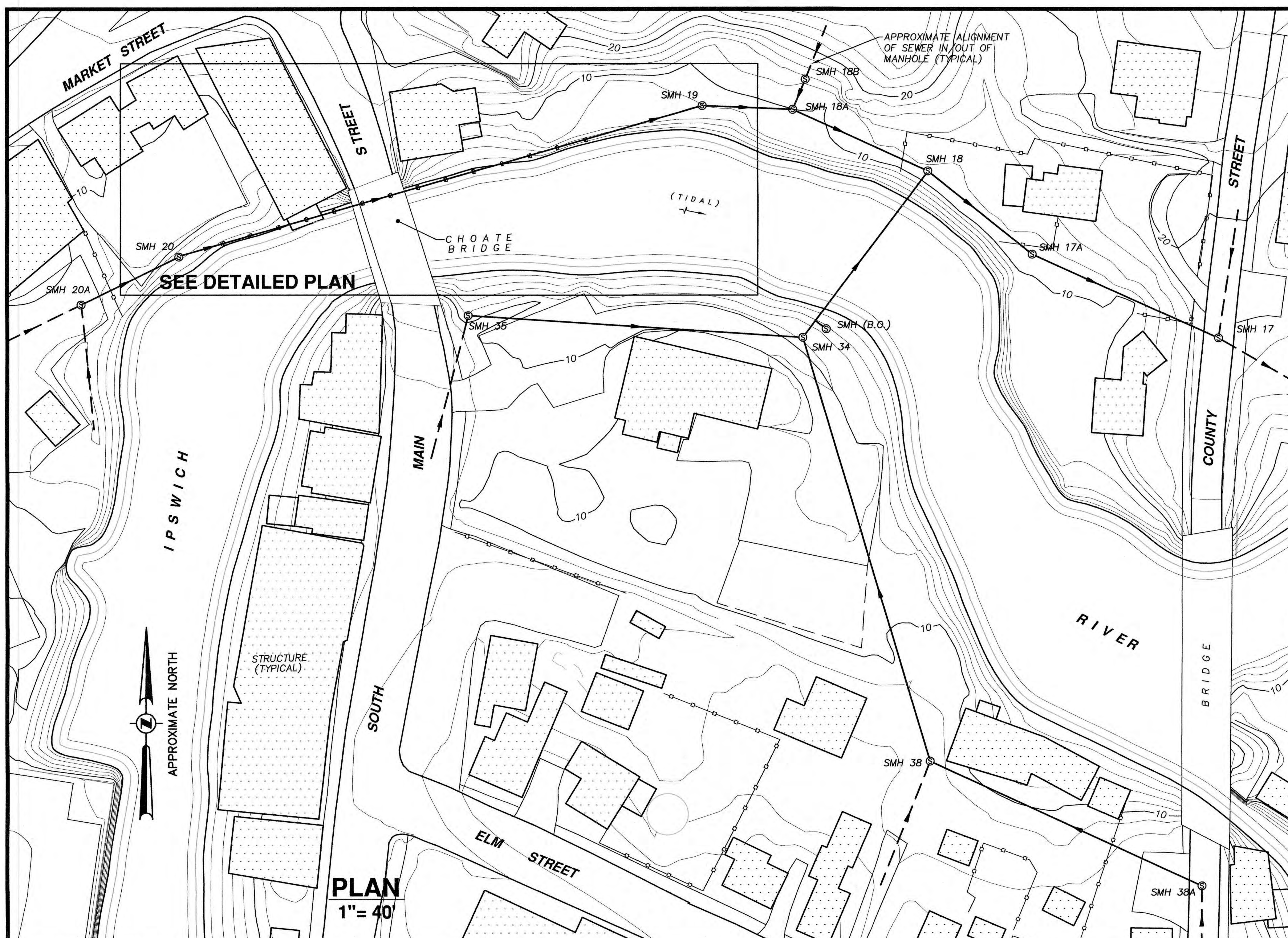
HAYDEN, HARDING & BUCHANA
CONSULTING ENGINEERS
BOSTON, MASS.

Drawn H.J.S. Checked A.H.G. Approved H.J.H.	Date JUNE 6, 1958	Scale AS NOTED

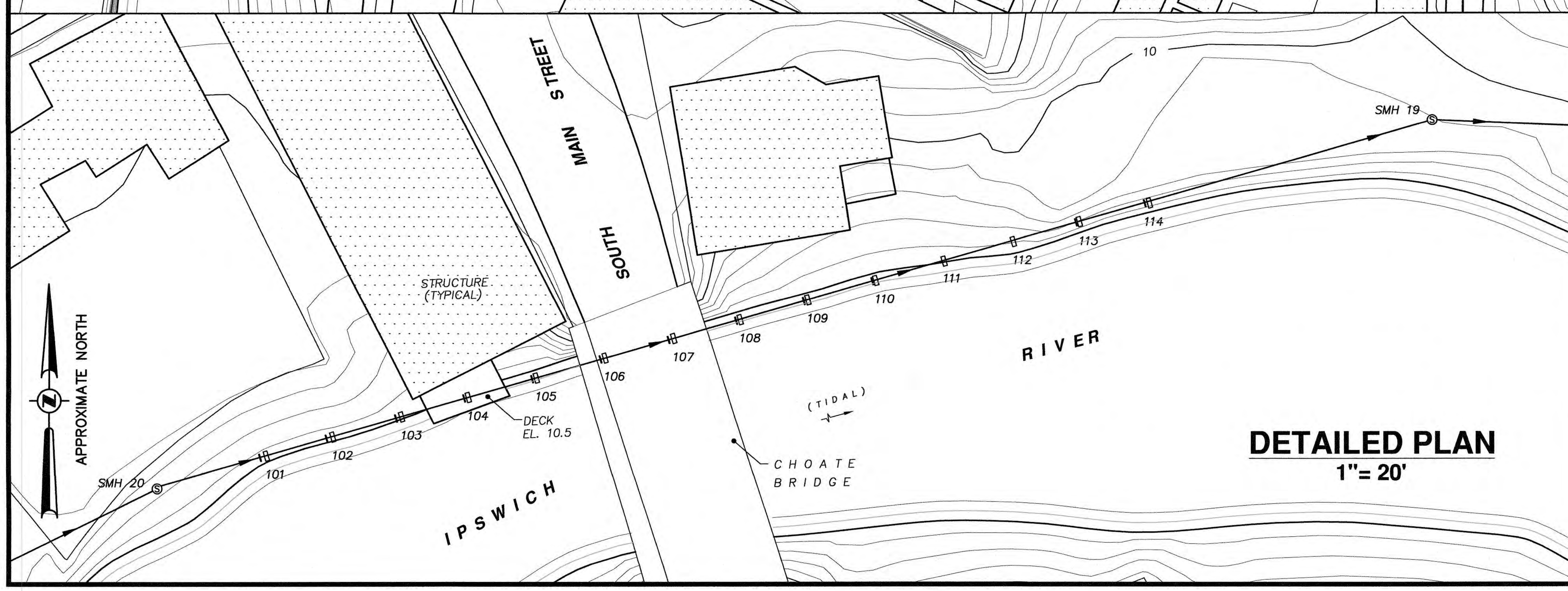


12" Tree
4 Tree
Ledge
Gar.
Row Lilacs
4" Tree
60" Tree
Row Bushes
48" Tree
24" Tree
M.H. #18
Sta. 25+97
House
2 Story
Wd. Frame
36' Tree
42" Tree Stump
4" V.C. Sewer
Shrubs
Gravel Fill & Rip Rap
20"
15
10" Trees
RIVER
M.H. #17A
Sta. 26+78
Cont'd from Sheet No. 18
Foundation filled in flush with ground
Gar.
House #35
2 Story
Wood
Gravel Walk
Ex. 12" V.C.
COUNTY ROAD
Hot Top Walk
House #44
2 Story
Apt.
Existing Septic Tank
Chain Link Fence
Existing 6" V.C. Drain (Plugged)
Football Field
8" Plugged stub
Inv. 11.72
Hyd.
M.H. #17
Sta. 28+08
C.B.
20"
Ditch
14" Tree
8" Corr. Metal Culvert
4" Orangeburg overflow drain 60' long
24" Tree
Top Slope
M.H. #16
Sta. 29+78
Existing 6" V.C. Sewer from Shotswell School connected to M.H.
49.5'
53.6'
Backstop
Loam Piles
Ledge
Gully
Loam Piles
20"
Top Slope
Continued on
2 #6
4 #6 - 2'-0" Lg.
2'-0"
N


12" Plugged stub for connection to future sewer from County Road
M.H.#38 - Sta.2+78 Existing Sewer Connected into M.H.
IPSWICH RIVER
Sta.26+97 Trunk Sewer Contract on Sheet No. 4
M.H.#18 Sta.0-20
Continued on Sheet No. 4
Blow-off M.H. 6" Gate Valve
County Road Connection
M.H.#34 Sta.1+20
2-4" V.C. Sewer Drains
Garage
Exist. Sewer
Exist. Septic Tank
Water & Light Dept.
Sheet Metal Shop
Bldg.
Gas Station
ELM STREET
Town Hall
Existing sewer
8" Sewer Connection from Town Hall into M.H.#37
M.H.#37 Sta.7+35
8" Plugged stub
M.H.#36 Sta.4+69
M.H.#35 Sta.3+31
10" V.C. Storm Drain
Boring No.112
SOUTH MAIN STREET
Plugged
BRIDGE
Ford Co.
Chevrolet Co.
PLAN
Scale 1" = 40'
Elev. 9.0±
Loose dirty yellow sand & Gravel fill
Firm sand, gravel & brick fill
Medium yellow clay
Ground water level fluctuates with the tide
BORING NO 112
Existing Ground
12" Plugged stub for connection to future sewer from County Road
12"
S = 0.003
COUNTY ROAD CONNECTION
12" A.C. Class 1500
Existing ground
2-4" V.C. Sewers
1-6" V.C. Sewers
Stone wall
S = 0.004
2'-0" Min Cover
22½° Bend
12" C.I. Blow-off Branch
SOUTH MAIN STREET
8" A.C. Class 1500
PROFILE
Note: See Sheet No. 2 for Legend
"AS BUILT" RECORD DRAWING
FEB 1 1960
OPTION No. II
TOWN OF IPSWICH, MASS.
SEWERS & FORCE MAIN
SOUTH MAIN ST. SEWER
STA 0-20 TO 7+35
COUNTY ROAD CONNECTION
STA 0+00 TO 2+78
HAYDEN, HARDING & BUCHANAN, INC.
CONSULTING ENGINEERS
BOSTON, MASS.
AS NOTED
18



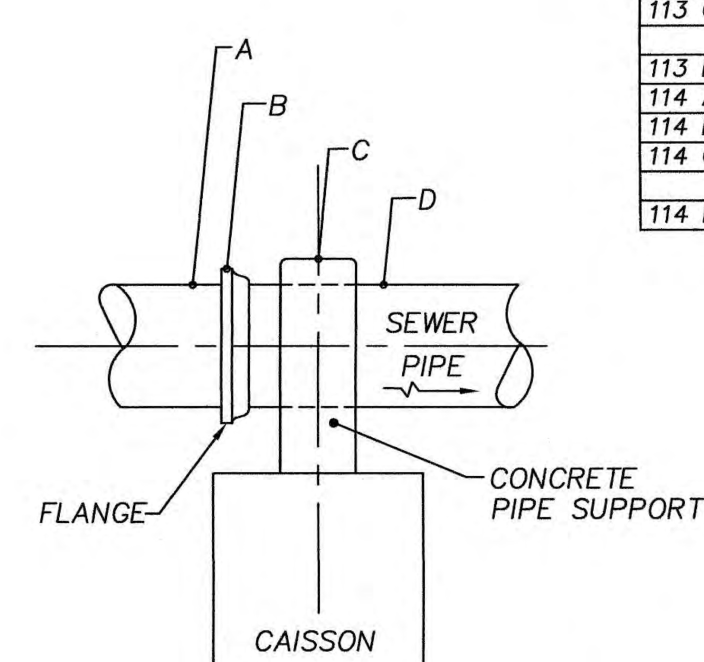
PLAN
1"= 40'



DETAILED PLAN
1"= 20'

PLAN REFERENCE	DESCRIPTION	COORDINATES (NAD 83) NORTHING	EASTING	ELEVATION (NAVD 1988)
SMH 20	MANHOLE COVER	3073327.69	834286.53	7.18
SMH 20A	MANHOLE COVER	3073297.71	834225.44	7.87
SMH 19	MANHOLE COVER	3073422.35	834613.83	8.17
SMH 18A	MANHOLE COVER	3073420.04	834670.38	9.41
SMH 18B	MANHOLE COVER	073438.85	834678.18	13.99
SMH 18	MANHOLE COVER	3073381.38	834754.88	11.88
SMH 17A	MANHOLE COVER	3073329.35	834820.07	10.68
SMH 17	MANHOLE COVER	3073276.81	834936.45	17.55
SMH 34	MANHOLE COVER	3073277.38	834676.56	6.67
SMH (B.O.)	MANHOLE COVER	3073282.67	834691.19	5.52
SMH 35	MANHOLE COVER	3073291.06	834467.39	11.63
SMH 38	MANHOLE COVER	3073012.21	834756.09	11.81
SMH 38A	MANHOLE COVER	3072934.21	834926.03	14.12
101 A	TOP CENTER PIPE	3073335.55	834311.65	4.57
101 B	TOP FLANGE	3073335.78	834313.00	4.86
101 C	TOP CONC. PIPE SUPPORT	3073336.15	834314.61	5.03
	(AT CENTER OVER PIPE)			
101 D	TOP CENTER PIPE	3073336.57	834316.33	4.56
102 A	TOP CENTER PIPE *	BURIED		
102 B	TOP FLANGE *	BURIED		
102 C	TOP CONC. PIPE SUPPORT	3073341.01	834331.68	5.03
	(AT CENTER OVER PIPE)			
102 D	TOP CENTER PIPE	3073341.62	834332.95	4.55
103 A	TOP CENTER PIPE	3073345.36	834346.56	4.48
103 B	TOP FLANGE	3073345.85	834347.89	4.81
103 C	TOP CONC. PIPE SUPPORT	3073346.17	834349.34	4.97
	(AT CENTER OVER PIPE)			
103 D	TOP CENTER PIPE	3073346.54	834350.69	4.49
104 A	TOP CENTER PIPE	3073350.37	834363.90	4.42
104 B	TOP FLANGE	3073350.81	834365.34	4.76
104 C	TOP CONC. PIPE SUPPORT	3073351.15	834366.40	4.91
	(AT CENTER OVER PIPE)			
104 D	TOP CENTER PIPE	3073351.52	834368.10	4.41
105 A	TOP CENTER PIPE	3073355.59	834381.73	4.39
105 B	TOP FLANGE	3073355.90	834382.77	4.75
105 C	TOP CONC. PIPE SUPPORT	3073356.16	834383.82	4.91
	(AT CENTER OVER PIPE)			
105 D	TOP CENTER PIPE	3073356.54	834385.07	4.38
106 A	TOP CENTER PIPE	3073360.49	834398.76	4.37
106 B	TOP FLANGE	3073360.93	834400.30	4.66
106 C	TOP CONC. PIPE SUPPORT	3073361.29	834401.48	4.85
	(AT CENTER OVER PIPE)			
106 D	TOP CENTER PIPE	3073361.67	834402.75	4.36
107 A	TOP CENTER PIPE	3073365.57	834416.40	4.35
107 B	TOP FLANGE	3073365.94	834417.73	4.68
107 C	TOP CONC. PIPE SUPPORT	3073366.30	834419.07	4.83
	(AT CENTER OVER PIPE)			
107 D	TOP CENTER PIPE	3073366.72	834420.29	4.35
108 A	TOP CENTER PIPE	3073370.55	834433.86	4.31
108 B	TOP FLANGE	3073370.84	834435.17	4.62
108 C	TOP CONC. PIPE SUPPORT	3073371.12	834436.19	4.78
	(AT CENTER OVER PIPE)			
108 D	TOP CENTER PIPE	3073371.56	834437.37	4.31
109 A	TOP CENTER PIPE	3073375.66	834451.44	4.24
109 B	TOP FLANGE	3073375.92	834452.58	4.55
109 C	TOP CONC. PIPE SUPPORT	3073376.18	834453.59	4.77
	(AT CENTER OVER PIPE)			
109 D	TOP CENTER PIPE	3073376.54	834454.72	4.25
110 A	TOP CENTER PIPE	3073380.72	834468.99	4.27
110 B	TOP FLANGE	3073381.00	834470.13	4.59
110 C	TOP CONC. PIPE SUPPORT	3073381.15	834471.00	4.73
	(AT CENTER OVER PIPE)			
110 D	TOP CENTER PIPE	3073381.67	834472.33	4.30
111 A	TOP CENTER PIPE *	BURIED		
111 B	TOP FLANGE *	BURIED		
111 C	TOP CONC. PIPE SUPPORT	3073384.93	834488.91	4.66
	(AT CENTER S.E. END)			
111 D	TOP CENTER PIPE *	BURIED		
112 A	TOP CENTER PIPE	3073390.62	834503.93	4.27
112 B	TOP FLANGE	3073390.79	834505.05	4.48
112 C	TOP CONC. PIPE SUPPORT	3073391.12	834506.33	4.64
	(AT CENTER OVER PIPE)			
112 D	TOP CENTER PIPE	3073391.56	834507.95	4.20
113 A	TOP CENTER PIPE	3073395.78	834521.52	4.17
113 B	TOP FLANGE	3073395.90	834522.45	4.46
113 C	TOP CONC. PIPE SUPPORT	3073395.02	834523.65	4.69
	(AT CENTER S.E. END)			
113 D	TOP CENTER PIPE	3073397.02	834525.25	4.14
114 A	TOP CENTER PIPE	3073400.69	834538.89	4.11
114 B	TOP FLANGE	3073400.98	834540.06	4.39
114 C	TOP CONC. PIPE SUPPORT	3073399.83	834541.60	4.55
	(AT CENTER S.E. END)			
114 D	TOP CENTER PIPE *	BURIED		

* **NOTE:** SURVEY LOCATIONS BURIED



SKETCH of SURVEY LOCATIONS
(101 A,B,C,D TO 114 A,B,C,D)

SANITARY SEWER PLAN
vicinity of
SOUTH MAIN STREET TO COUNTY STREET

IPSWICH MA

GRAHAM ASSOCIATES, INC.
CIVIL ENGINEERS
TWO CENTRAL STREET, IPSWICH, MA 01938 (978) 356-2756

DRAWN BY: JC	CHECKED BY: HLG	PROJECT NO.: 17-1725
DATE: MARCH 14, 2018	SCALE: AS SHOWN	SHEET 1 OF 1

APPENDIX D
Photos

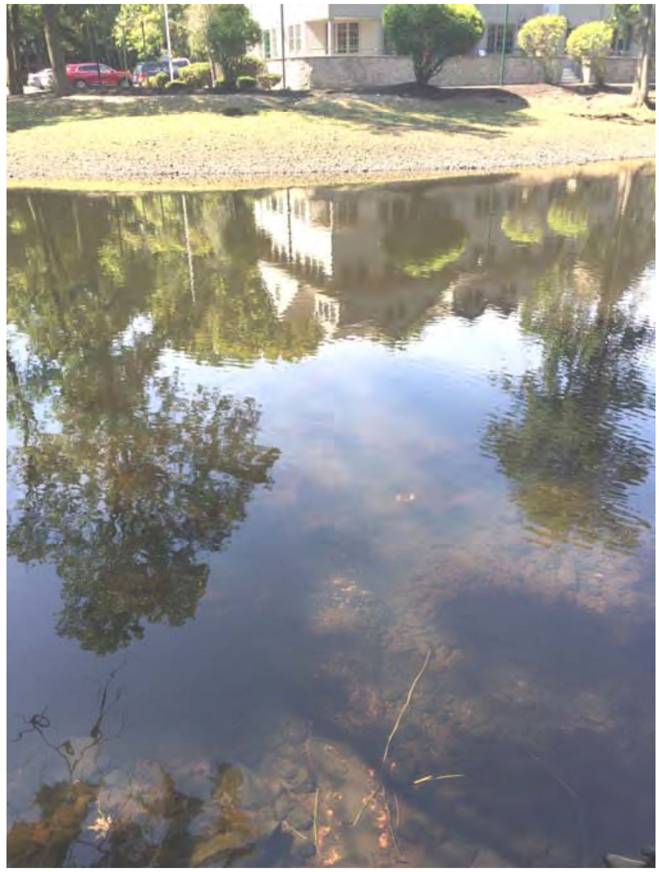
August 2017 Union Street / Market Street Interceptor Sewer - Photos

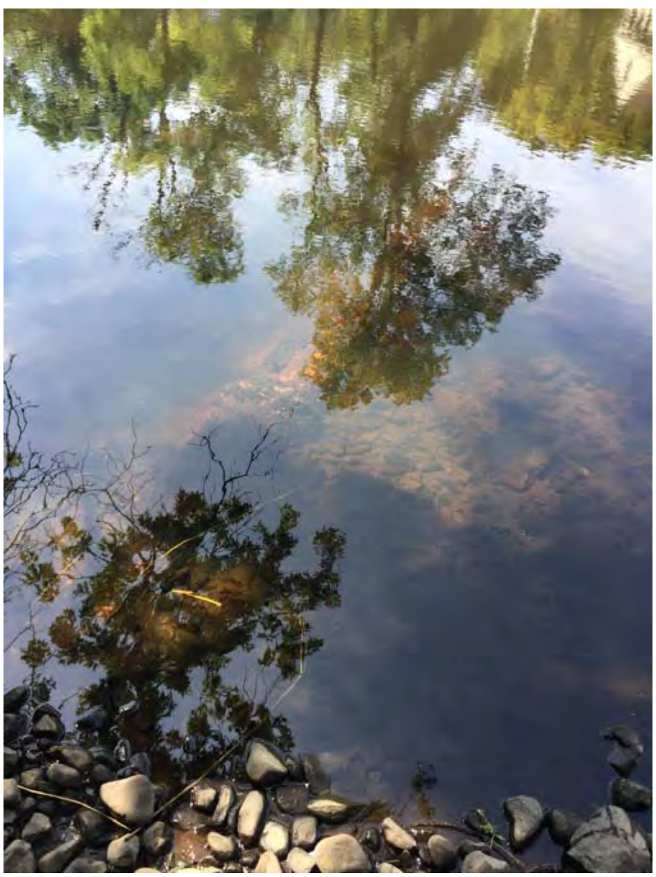
August 2017 Union Street / Market Street Interceptor Sewer - Photos

August 2017 Union Street / Market Street Interceptor Sewer - Photos

August 2017 Union Street / Market Street Interceptor Sewer - Photos

August 2017 Choate Bridge Sewer Siphon - Photos





Appendix F
Boring Logs

Tighe&Bond
Engineers | Environmental Specialists

Boring No. **B-1**
Page 1 of 1
File No. I-0066
Checked by:

Project: Ipswich Siphon and Sewer Design
Location: Ipswich River near South Main Street, Ipswich
Client: Town of Ipswich

Drilling Co. New England Boring Contractors
Foreman: W. Hoeckele
T&B Rep.: J. Libby
Date Start: 8/15/18 End: 8/15/18
Location See Exploration Location Plan
GS. Elev. Datum:

	Casing	Sampler
Type	Casing	Split Spoon
I.D./O.D.	4"/4.5"	1-3/8"/2"
Hammer Wt.	140#	140#
Hammer Fall	30"	30"
Rig Make/Model	Track Rig	

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
See Note 1				

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes	Well Construction
		S1/6	0-2	2-2		S1:Loose, brown, fine to medium SAND, some Silt, trace Gravel, dry	**SAND**		
				5-6					
		S2/5	2-4	4-2		S2:Loose, brown, fine to coarse SAND, little Gravel, little Silt, dry			
				2-2			4'		
		S3/3	4-6	3-2		S3:Loose, brown GRAVEL, some fine to coarse SAND, trace Silt, wet	**GRAVEL**	1	
5	31			6-18			6'		
	47	S4/4	6-8	9-5		S4:Loose, brown, fine to coarse SAND, some Silt, little Gravel, wet	**SAND**		
	48			5-8			8'	2	
	Push	S5/20	8-10	2-5		S5:Stiff, grey CLAY, wet			
	Push			6-7			**CLAY**		
10	Push	S6/24	10-12	10-7		S6:Stiff, grey CLAY, wet			
	Push			6-7			12'		
	Push	S7/24	12-14	1-3		S7:Medium, grey, Silty CLAY, wet			
	Push			4-4					
	Push	S8/24	14-16	1-1		S8:Soft, grey, Silty CLAY, wet	**Silty CLAY**		No Well Installed
15	Push			2-2					
	Push	S9/28	16-18	1-3		S9:Medium, grey, Silty CLAY, wet; some Gravel at tip			
	Push			2-13			18'	3	
	Push	S10/11	18-20	6-10		S10:Medium Dense, grey Gravel, some Silt, little Clay, trace fine to coarse SAND, wet	**Gravel**		
	64			11-13			20'		
20	52	S11/4	20-22	7-8		S11:Medium Dense, grey, fine to coarse SAND, some Gravel, little Silt, trace Clay, wet			
	32			9-10					
	53								
	52								
	53	S12/6	24-26	14-14		S12:Medium Dense, grey, fine to coarse SAND, some Gravel, little Silt, trace Clay, wet	**SAND**		
25				14-14					
		S13/5	27-29	18-8		S11:Medium Dense, grey, fine to coarse SAND, some Gravel, little Silt, trace Clay, wet			
				11-45			29'		
30						**End of Exploration at 29 ft**			

Notes:
1. Groundwater encountered at approximately 4 ft BGS, based on sample wetness.
2. Based on drillers observations, clay started at approximately 7.5ft BGS.
3. Based on drillers observations, gravel started at approximately 17.5 ft BGS.
4. During casing recovery the bottom casing (4ft), threads, and 1ft of the second to bottom casing sheared off at approximately 19ft BGS.

Proportions Used

TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	

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Boring No. **B-2**

File No. I-0066
Checked by:

Project: Ipswich Siphon and Sewer Design
Location: Ipswich River near County Street, Ipswich
Client: Town of Ipswich

Drilling Co. S.W. Cole Explorations
Foreman: S. Hollabaugh
T&B Rep.: E. Larkin
Date Start: 12/12/18 End: 12/12/18
Location See Exploration Location Plan
GS. Elev. Datum:

	Casing	Sampler
Type	HSA 0-14'	Split Spoon
I.D./O.D.		1-3/8"/2"
Hammer Wt.		140#
Hammer Fall		30"
Rig Make/Model	Track Rig	Auto Hammer

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
See Note 1				

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes	Well Construction
		S1/4	0-2	4-8 6-8		Stiff, brown, SILT, some Gravel, little Sand, little Wood, dry	**TOPSOIL** 2'		No Well Installed
		S2/5	2-4	5-5 6-6		Medium dense, brown, fine to medium SAND, some Silt, little Gravel, dry	**GLACIAL TILL**		
5		S3/0	4-6	12-8 7-4		No Recovery			
		S4/6	6-8	4-8 4-2		Medium dense, brown, fine to medium SAND, some Silt, little Gravel, trace Peat, wet	8'	1	
		S5/2	8-10	4-5 3-5		Loose, gray, GRAVEL, trace Silt, wet	**WEATHERED BEDROCK**		
10		S6/10	10-12	16-49 50/4		Very dense, GRAVEL and SILT, little fine to coarse Sand, wet	12'		
						End of Exploration at 13 ft			
15									
20									
25									
30									

Notes:
1. Groundwater encountered at approximately 6 ft BGS, based on sample wetness.

Proportions Used

TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	>30

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Boring No. **B-3**
Page 1 of 1
File No. I-0066
Checked by:

Project: Ipswich Siphon and Sewer Design
Location: Ipswich River near County Street, Ipswich
Client: Town of Ipswich

Drilling Co. S.W. Cole Explorations
Foreman: S. Hollabaugh
T&B Rep.: E. Larkin
Date Start: 12/12/18 End: 12/12/18
Location See Exploration Location Plan
GS. Elev. Datum:

	Casing	Sampler
Type	HSA 0-14'	Split Spoon
I.D./O.D.		1-3/8"/2"
Hammer Wt.		140#
Hammer Fall		30"
Rig Make/Model	Track Rig	Auto Hammer

Groundwater Readings

Date	Time	Depth	Casing	Sta. Time
See Note 1				

Depth (ft.)	Casing Blows Per Ft.	Sample No. / Rec.(in)	Sample Depth (ft.)	Blows Per 6"	PID Reading (ppm)	Sample Description	General Stratigraphy	Notes	Well Construction
0-8						No Samples Collected			
5									
		S1/9	8-10	8-6		Medium Dense, Gray, CLAY and SILT, some Gravel, wet	**GLACIAL TILL**		
				10-10					
10		S2/7	10-12	10-50/3		Very dense, Gray Brown CLAY and SILT, little Gravel, little fine to coarse Sand, wet	12'		
						End of Exploration at 13 ft			No Well Installed
15									
20									
25									
30									

Notes:

Proportions Used

TRACE (TR.)	0 - <10%
LITTLE (LI.)	10 - <20%
SOME (SO.)	20 - <35%
AND	35 - <50%

Density/Consistency

VERY LOOSE	0-4	VERY SOFT	<2
LOOSE	4-10	SOFT	2-4
MEDIUM DENSE	10-30	MEDIUM	4-8
DENSE	30-50	STIFF	8-15
VERY DENSE	>50	VERY STIFF	15-30
		HARD	>30