Ipswich River Sewer Interceptor and Siphon Evaluation - FINAL

Prepared For:

Wastewater Department Ipswich, Massachusetts

March 2019

Tighe&Bond
Engineers | Environmental Specialists

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

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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.

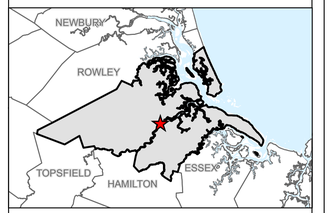
The Ipswich River Siphon has experienced overflows and backups. In order to minimize the potential for backups, the Town regularly cleans the siphon to remove material that has settled within the pipe.

FIGURE 1-1
PROJECT AREA

LEGEND

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

LOCUS MAP



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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

Tighe&Bond
Engineers | Environmental Specialists

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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.

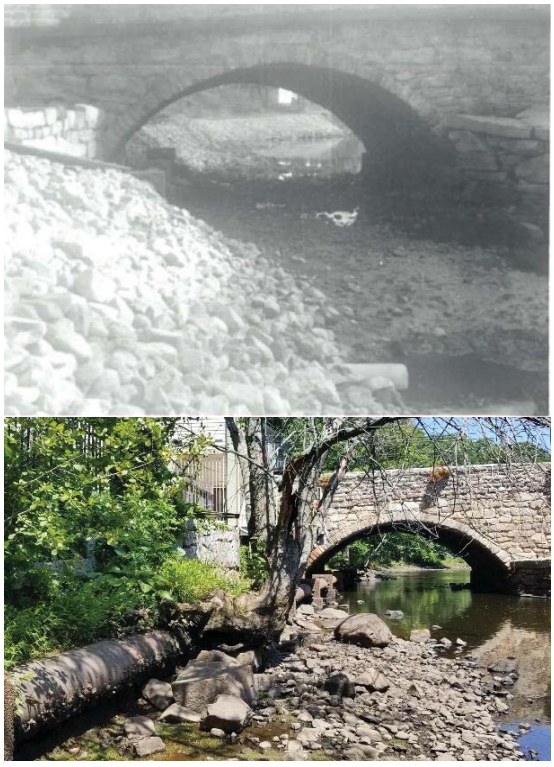


Figure 1-1. 1965 and 2018 Photos of Interceptor with and without revetment stone coverage.

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.

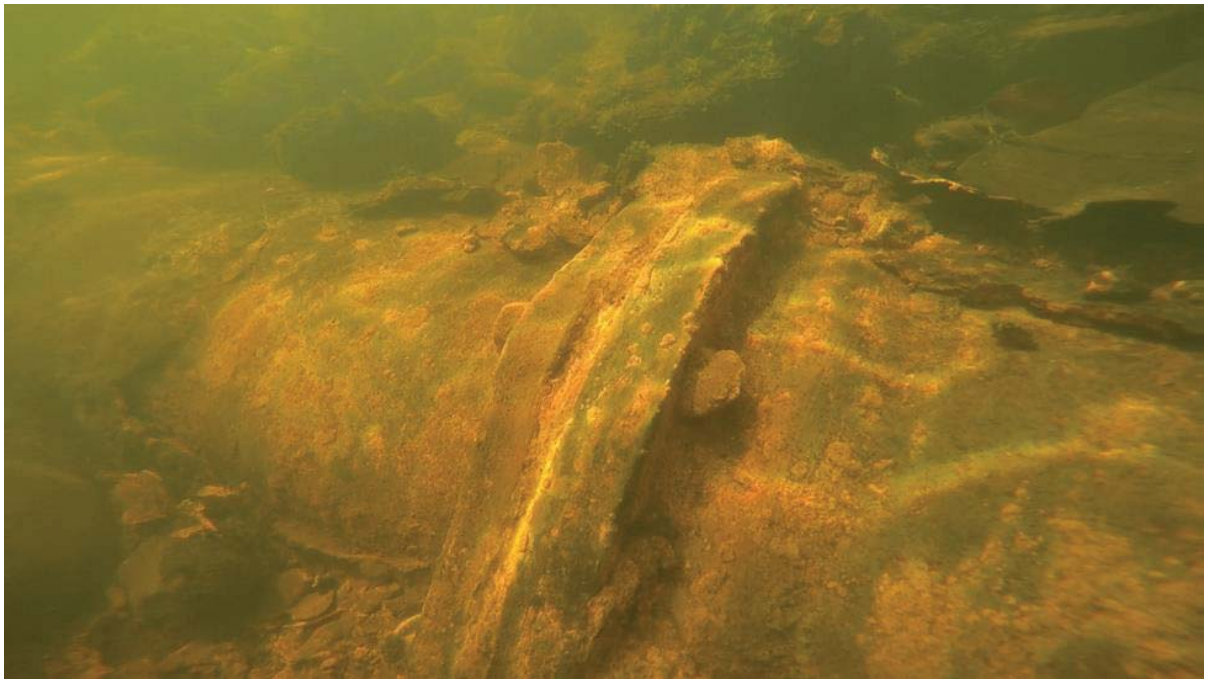


Photo 2-1.Bolted connection on exposed siphon pipe (after corrosion byproduct removal).

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.

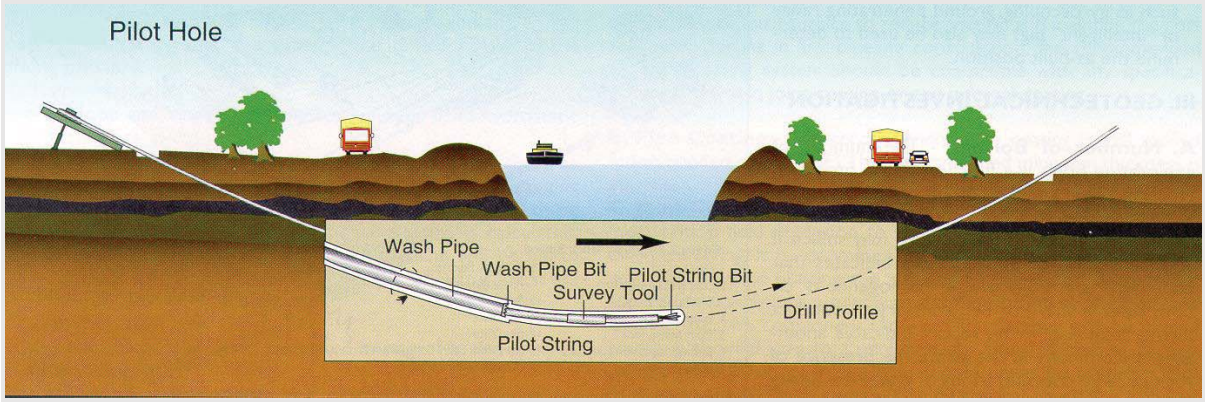
An HDD approach would prevent any temporary restrictions of flow in the Ipswich River, as well as prevent any risk of pollution or contamination from the active construction site. While this method does seem to be the most appealing from an environmental perspective. HDD installation at this site could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

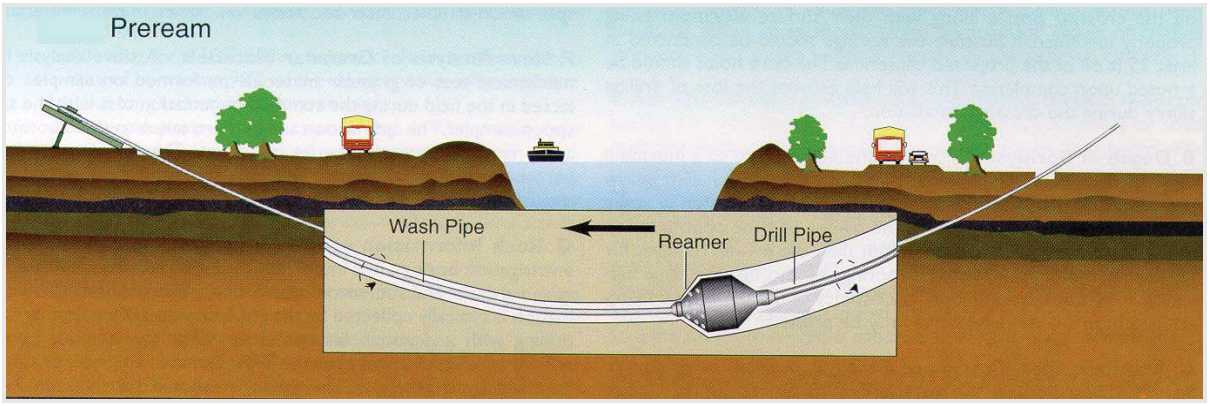
Drilling the Pilot Hole – A bore is launched from the surface, making a starting pit unnecessary. The drill bit is directed downward at an angle until the required depth is reached. From this point, the path of the bore is leveled and carefully guided towards its exit point, which is often the ground 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.



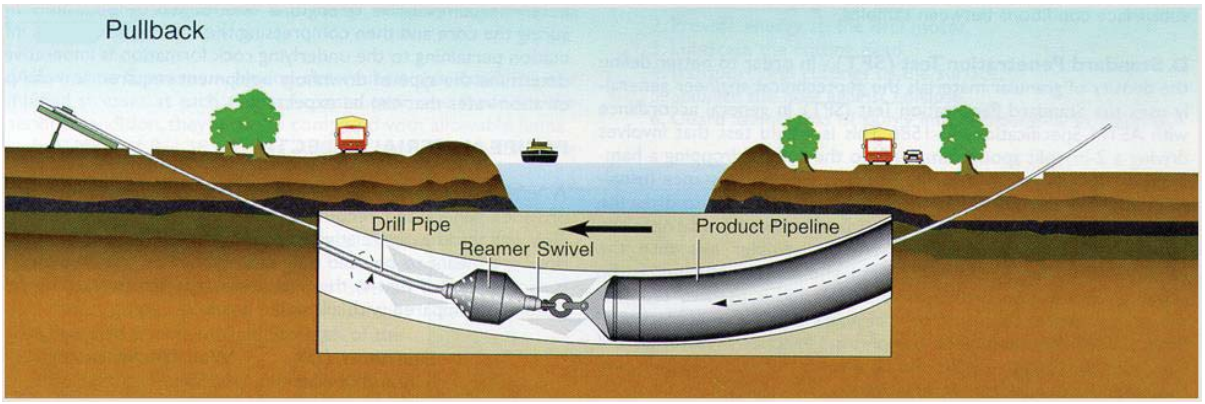
Source: Directional Crossing Contractors Association website

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.

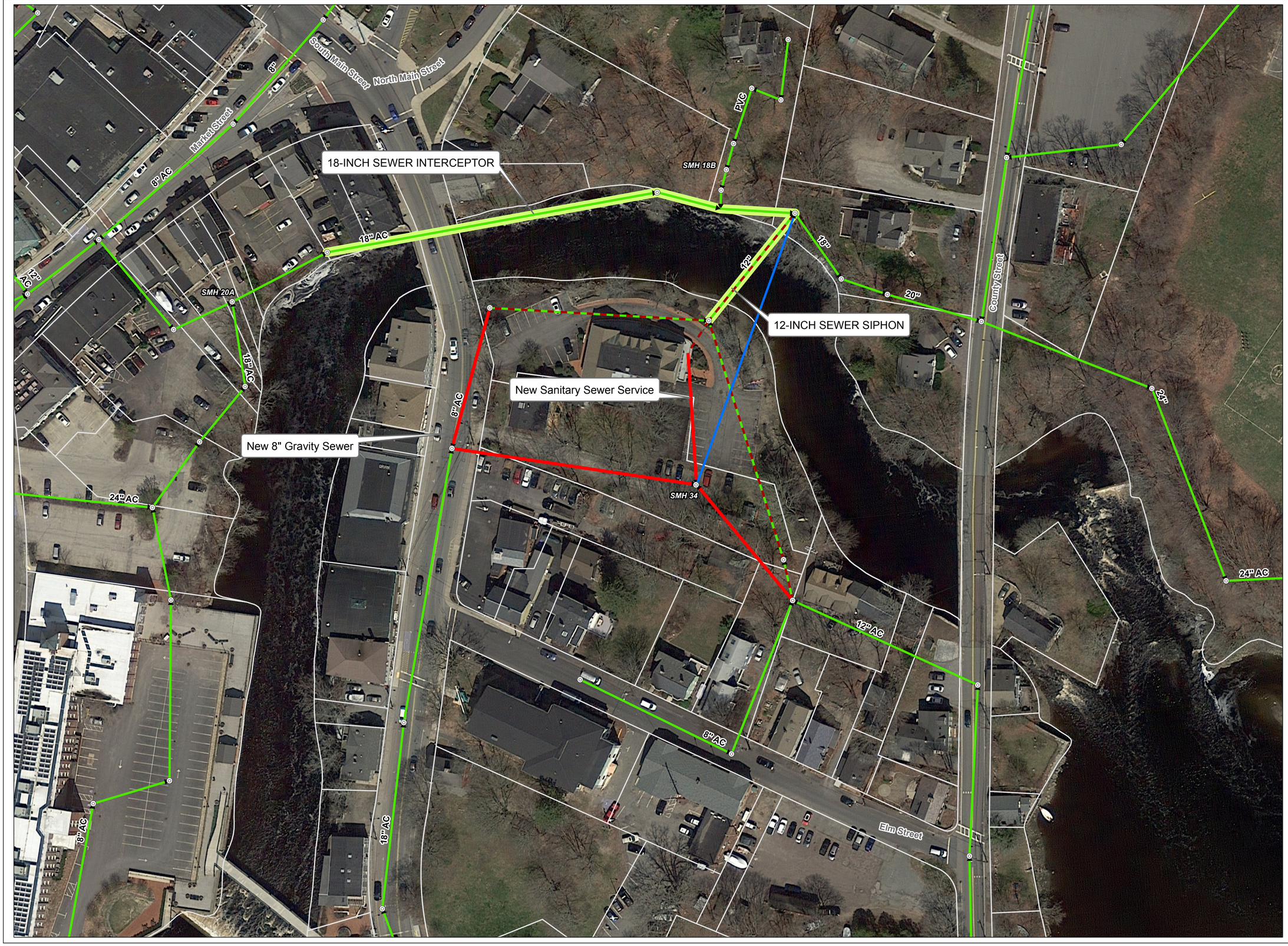
In Ipswich, the subsurface is clay. This was determined by an in-river investigation discussed earlier. One thing to note is that the extent of the in-river investigation found clay between 8' and 19'. The drilling contractors suggested a 10' pipe depth below the river. If, upon further investigation, 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.

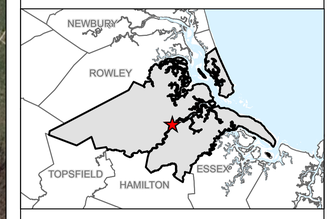
FIGURE 3-1
PROPOSED DIRECTIONAL DRILL SEWER OPTION



LEGEND

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

LOCUS MAP



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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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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.

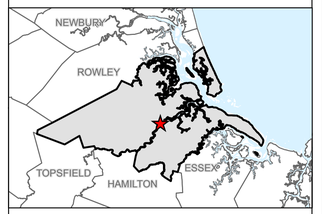
Please see diagram below for the layout of required land acquisition:

FIGURE 3-2
NECESSARY ACQUIRED LAND FOR NEW COLLECTION SYSTEM

LEGEND

- Necessary Acquired Land
- Approximate Parcel Boundary

LOCUS MAP



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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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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 parkling 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.

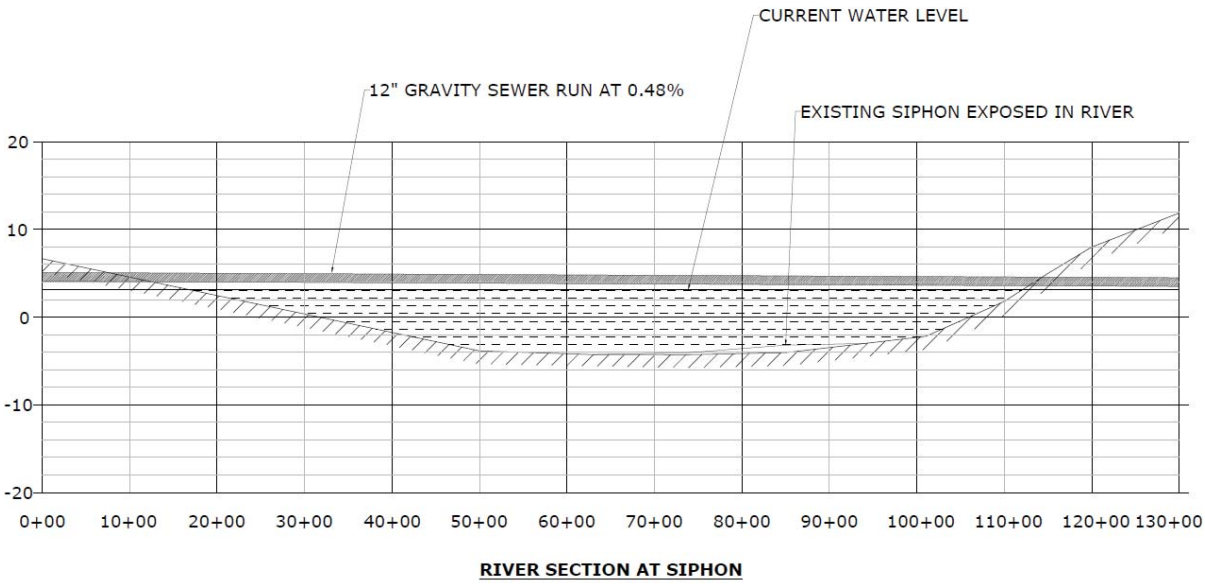


Figure 3-3. Profile View of Deep Gravity Sewer

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

18-INCH SEWER INTERCEPTOR

12-INCH SEWER SIPHON

PROPOSED 6" FORCE MAIN

SMH 18B

SMH 34

SMH 20A

South Main Street

North Main Street

Market Street

County Street

Elm Street

PS

8" AC

18" AC

12" AC

24" AC

PVC

12"

18"

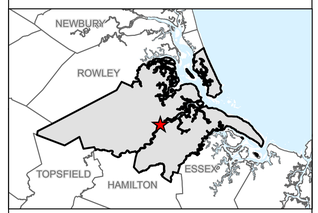
20"

24"

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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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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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.

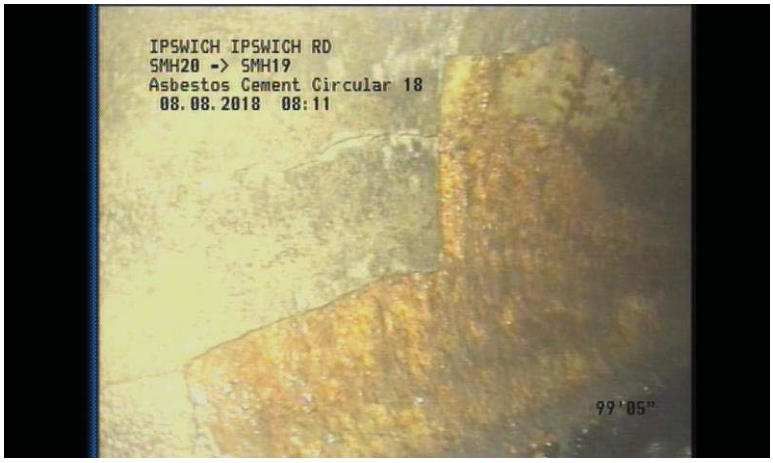

Photo 4-1. Multiple Cracks in Interceptor at 100 ft.

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.

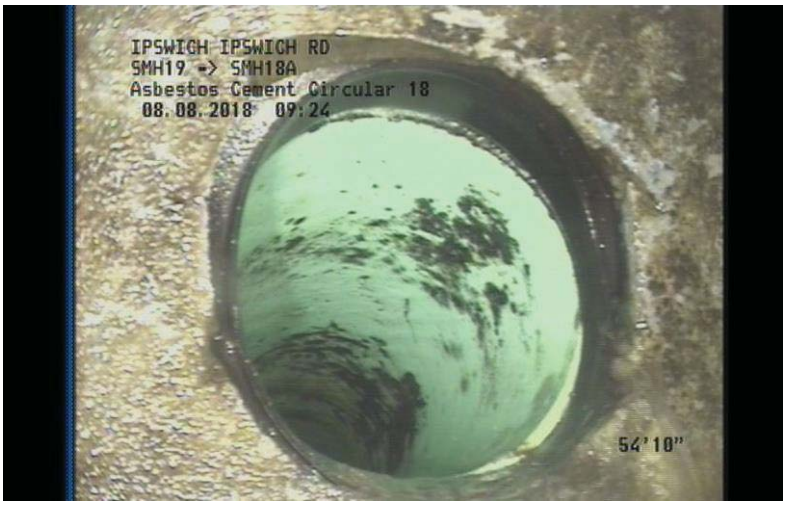

Photo 4-2. Defective Tap Break In

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 Low Voltage wire around MH	Yes
Interceptor (Western End)	SMH 20	Concrete Block	Good	Good	Ok	Ok	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.

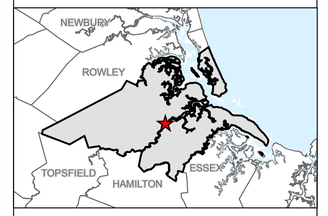
These flood zones conflict with the elevation of many structures in this area. Please see Table 2-7 and Figure 4-2 below displaying these results.

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.

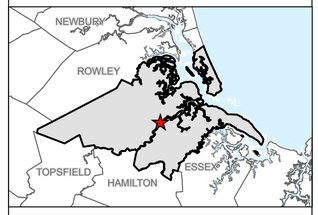
In order to provide access during construction, and to provide a means of access for future access to Interceptor and Siphon, it is recommended that a permanent gravel access road be constructed along with temporary work areas. It is recommended that a 14’ wide road mad of compacted processed gravel 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



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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

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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.

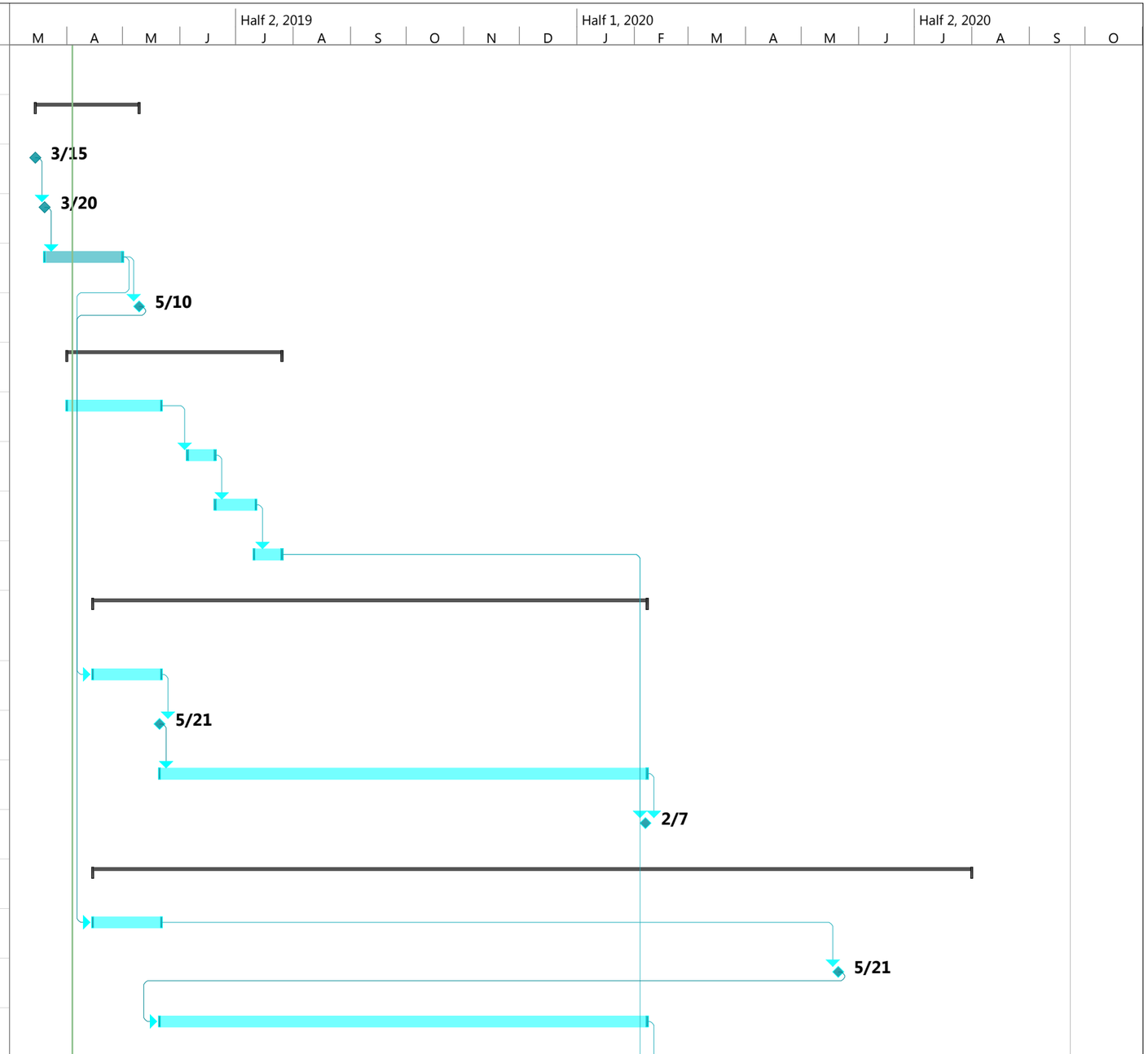
Corps Pre-Construction Notification - Corps authorization under Section 404 of the Federal Clean Water Act and Section 10 of the Rivers and Harbors Act is anticipated due to work within Waters of the United States (i.e., a tidal portion of the Ipswich River). Temporary and permanent impacts to wetlands 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.

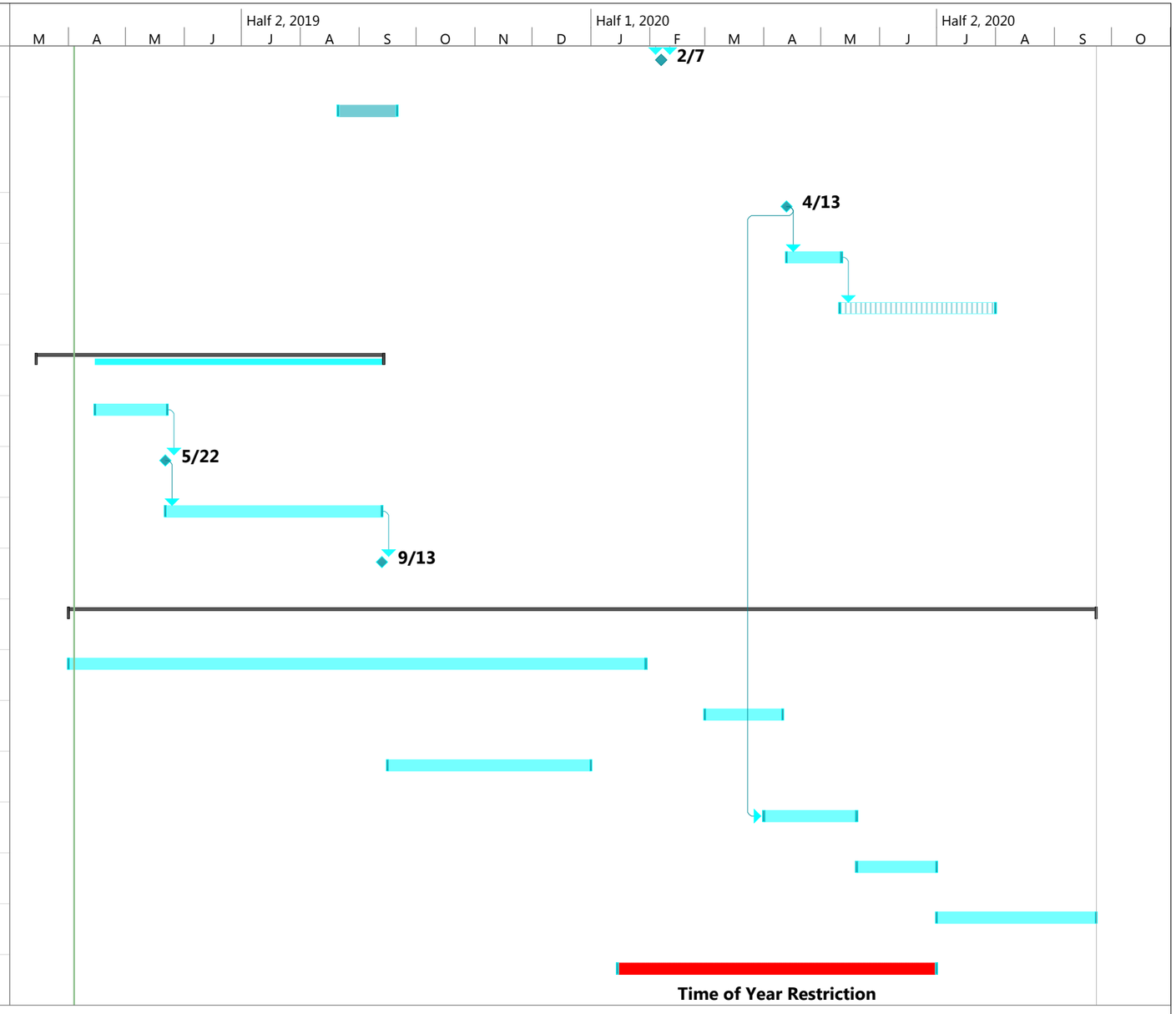
ID	Task Mode	Task Name	Duration	Start	Finish
1		**Permitting for Siphon & Interceptor Construction**			
2		**MEPA Env Notification Form & Site Visit**	**40 days**	**Fri 3/15/19**	**Fri 5/10/19**
3		Submit ENF	0 days	Fri 3/15/19	Fri 3/15/19
4		MEPA ENF Publication	0 days	Wed 3/20/19	Wed 3/20/19
5		MEPA 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

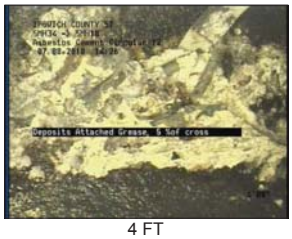
Date	P/O. No.	Weather	Surveyor's Name	Pipe Segment Reference	Section No.
8/7/2018		**Dry**	**BILL DEGROATE**		**1**
Certificate No.	**Survey Customer**	**System Owner**	**Date Cleaned**	**Pre-Cleaning**	**Sewer Category**
07007097			**8/7/2018**	**Heavy Cleaning**	

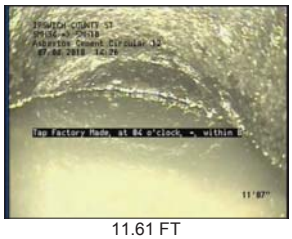
Street123	**COUNTY ST**	Use of Sewer	**Sanitary**	Upstream MH	**SMH34**
City	**IPSWICH**	Drainage Area		Dowstream MH	**SMH18**
Loc. details		Flow Control	**Bypassed**	Dir. of Survey	**Downstream**
Location Code	**Easement/Right of way**	Length surveyed	**127.70 ft**	Section Length	**127.70 ft**

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
127.70		AMH	Downstream Manhole, Survey Ends	
SMH18				


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**

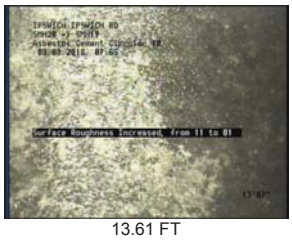
Purpose of Survey	**Maintenance Related**	Joint Length	
Year Laid		Dia./Height	**18 inch**
Year Rehabilitated		Material	**Asbestos Cement**
Tape / Media No.		Lining Method	

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

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 : **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	

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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
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
SMH19				
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**

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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

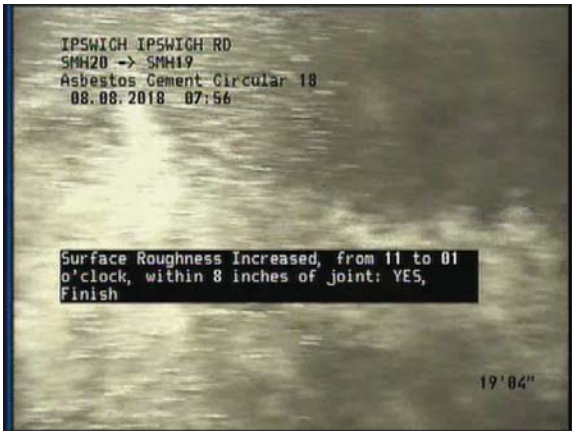

Photo: SMH20-SMH19-08202018-SRI-19.3148-160728.jpg
19.31FT, Surface Roughness Increased, from 11 to 01 o'clock, within 8 inches of joint: YES, Finish

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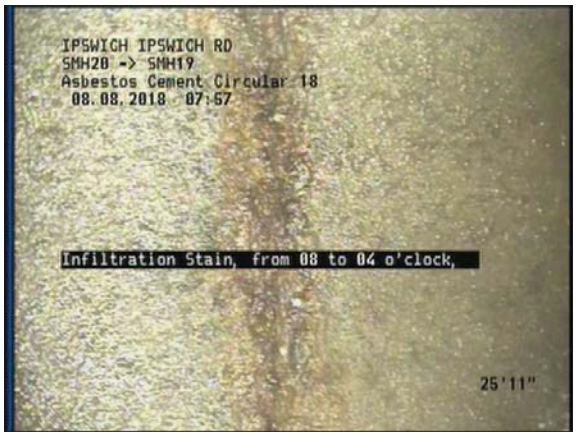

Photo: SMH20-SMH19-08202018-IS-25.9198-160828.jpg
25.92FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

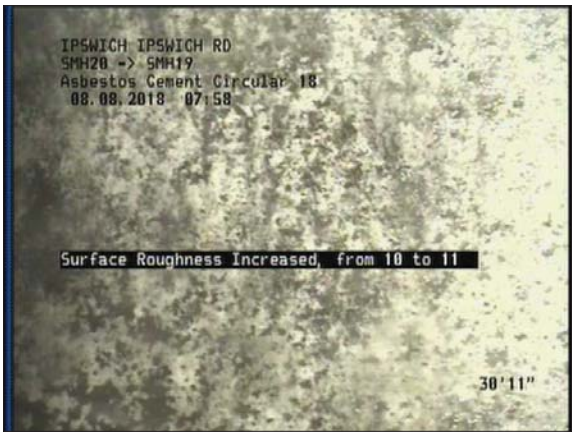

Photo: SMH20-SMH19-08202018-SRI-30.9237-160838.jpg
30.92FT, Surface Roughness Increased, from 10 to 11 o'clock, within 8 inches of joint: YES, Start

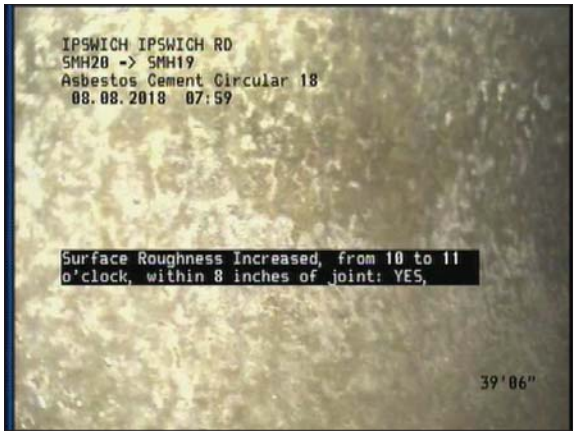

Photo: SMH20-SMH19-08202018-SRI-39.5303-160930.jpg
39.53FT, Surface Roughness Increased, from 10 to 11 o'clock, within 8 inches of joint: YES, Finish

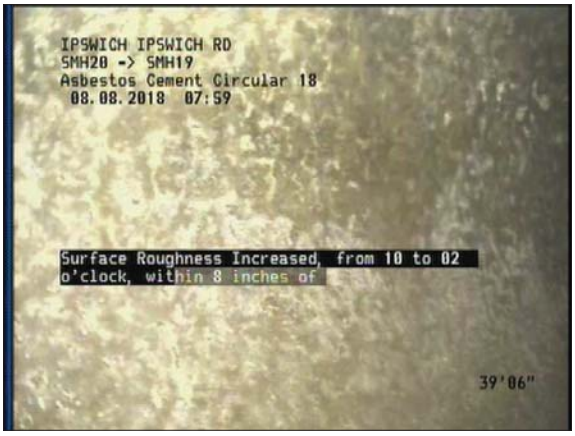

Photo: SMH20-SMH19-08202018-SRI-39.5303-160939.jpg
39.53FT, Surface Roughness Increased, from 10 to 02 o'clock, within 8 inches of joint: YES, Start

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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"

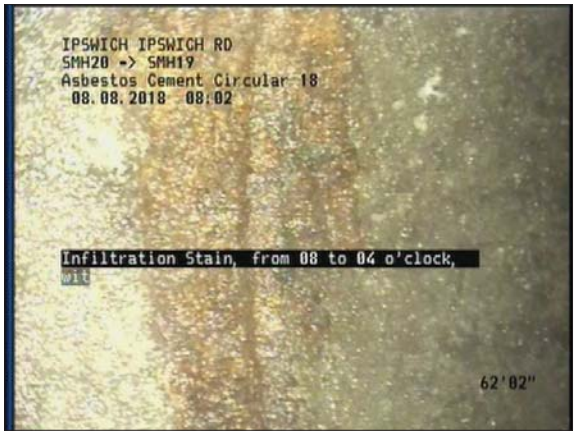

Photo: SMH20-SMH19-08202018-IS-62.1476-161049.jpg
62.15FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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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IPSWICH	**IPSWICH RD**			**2**

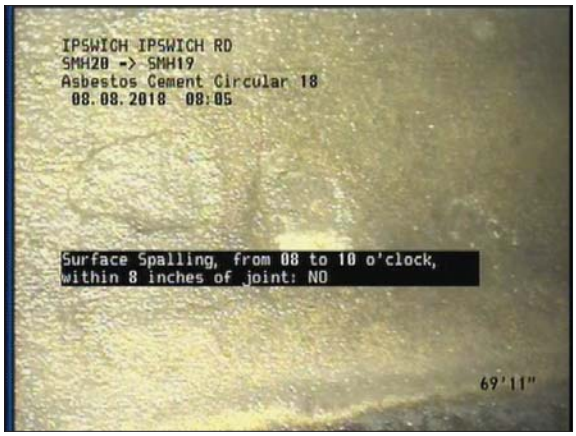

Photo: SMH20-SMH19-08202018-SSS-69.9536-161207.jpg 69.95FT, Surface Spalling, from 08 to 10 o'clock, within 8 inches of joint: NO

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

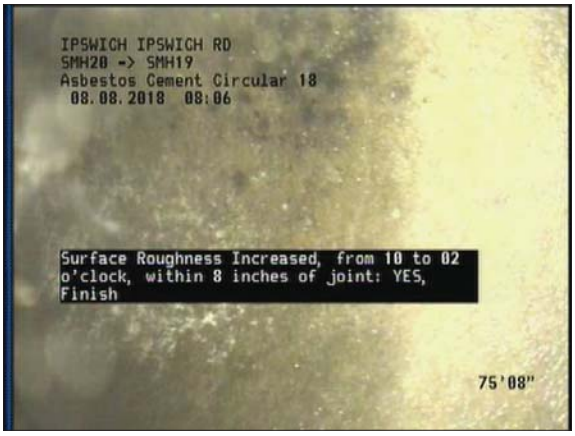

Photo: SMH20-SMH19-08202018-SRI-75.6579-161327.jpg 75.66FT, Surface Roughness Increased, from 10 to 02 o'clock, within 8 inches of joint: YES, Finish

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City :	Street :	Date :	Pipe Segment Reference :	Section No :
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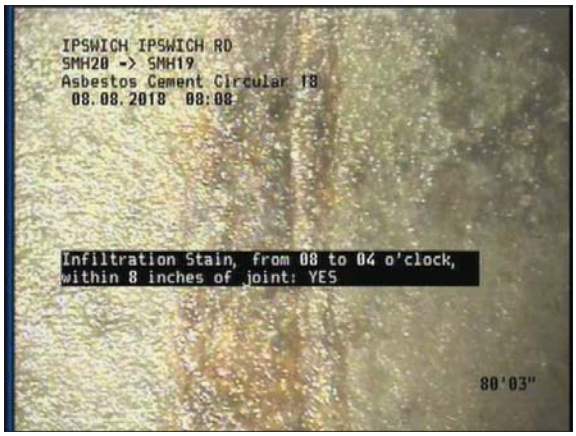

Photo: SMH20-SMH19-08202018-IS-80.2615-161523.jpg
80.26FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

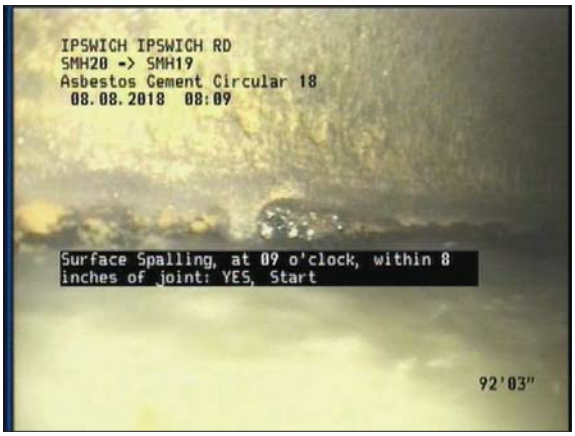

Photo: SMH20-SMH19-08202018-SSS-92.2707-161553.jpg
92.27FT, Surface Spalling, at 09 o'clock, within 8 inches of joint: YES, Start

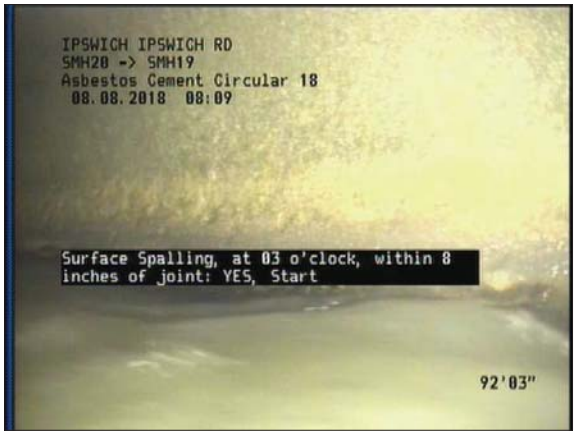

Photo: SMH20-SMH19-08202018-SSS-92.2707-161611.jpg
92.27FT, Surface Spalling, at 03 o'clock, within 8 inches of joint: YES, Start

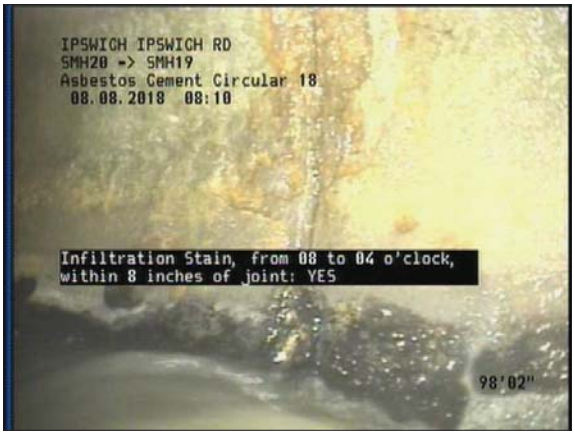

Photo: SMH20-SMH19-08202018-IS-98.1752-161803.jpg
98.18FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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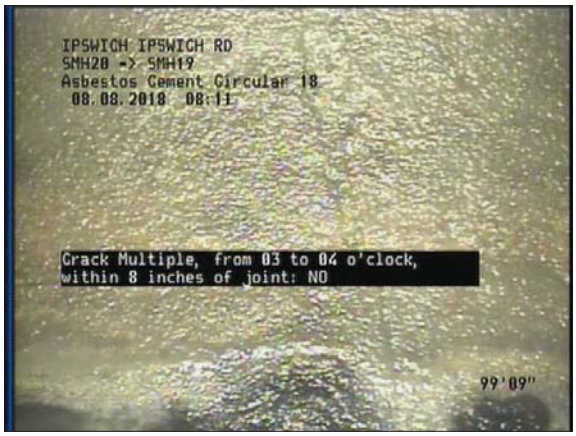

Photo: SMH20-SMH19-08202018-CM-99.7764-161705.jpg
99.78FT, Crack Multiple, from 03 to 04 o'clock, within 8 inches of joint: NO

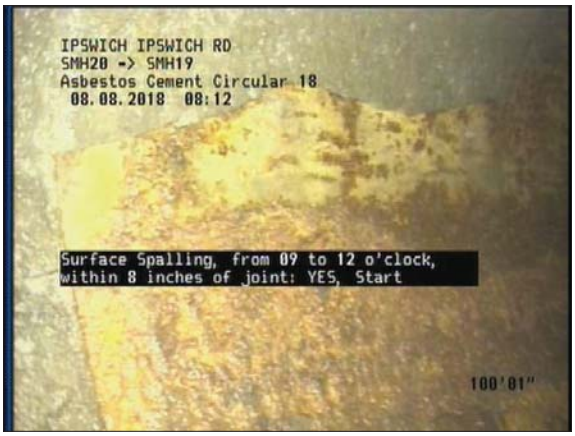

Photo: SMH20-SMH19-08202018-SSS-100.0766-161935.jpg
100.08FT, Surface Spalling, from 09 to 12 o'clock, within 8 inches of joint: YES, Start

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

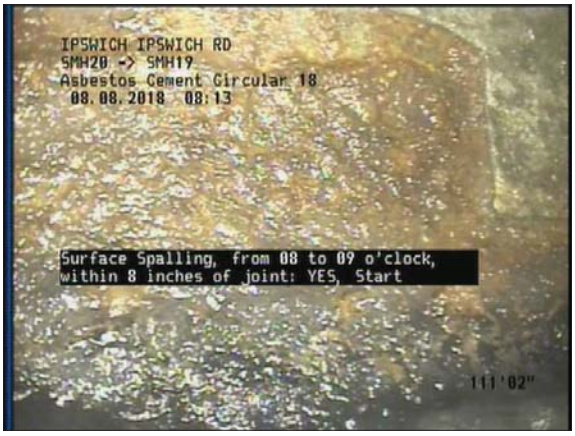

Photo: SMH20-SMH19-08202018-SSS-111.1851-162154.jpg
111.19FT, Surface Spalling, from 08 to 09 o'clock, within 8 inches of joint: YES, Start

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City :	Street :	Date :	Pipe Segment Reference :	Section No :
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Photo: SMH20-SMH19-08202018-SSS-111.1851-162033.jpg
111.19FT, Surface Spalling, at 09 o'clock, within 8 inches of joint: YES

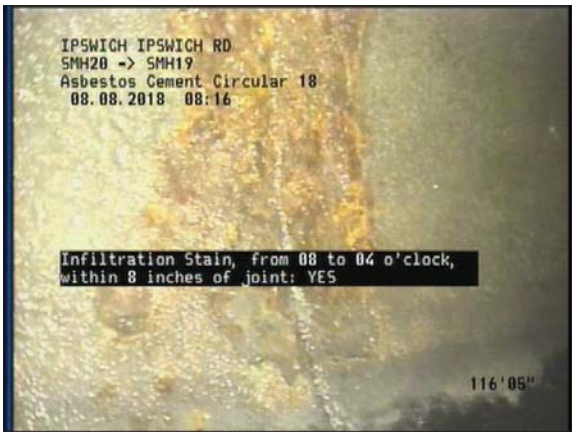

Photo: SMH20-SMH19-08202018-IS-116.3891-163428.jpg
116.39FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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

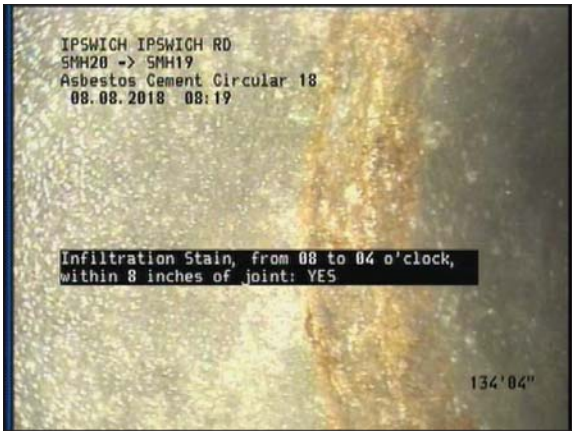

Photo: SMH20-SMH19-08202018-IS-134.3028-163451.jpg
134.3FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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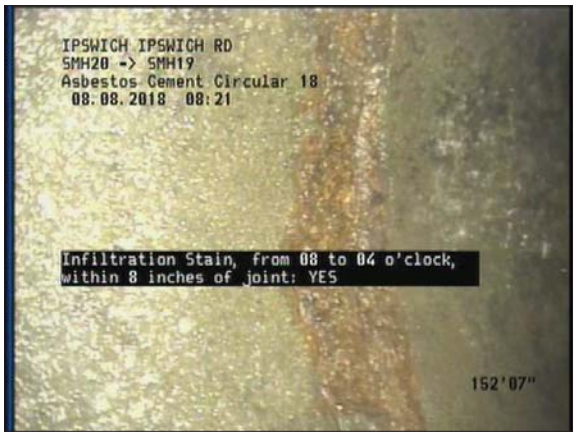

Photo: SMH20-SMH19-08202018-IS-152.6169-163510.jpg
152.62FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

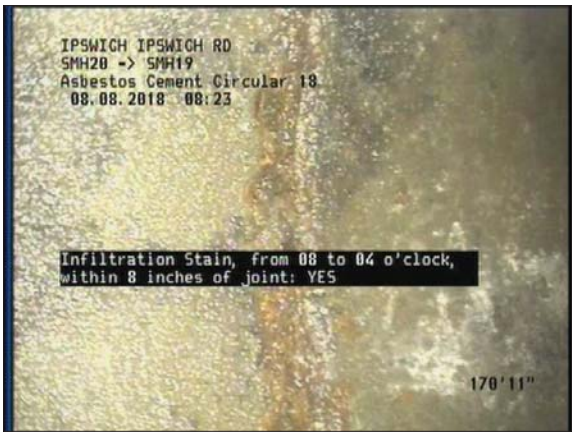

Photo: SMH20-SMH19-08202018-IS-170.9309-163611.jpg
170.93FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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"

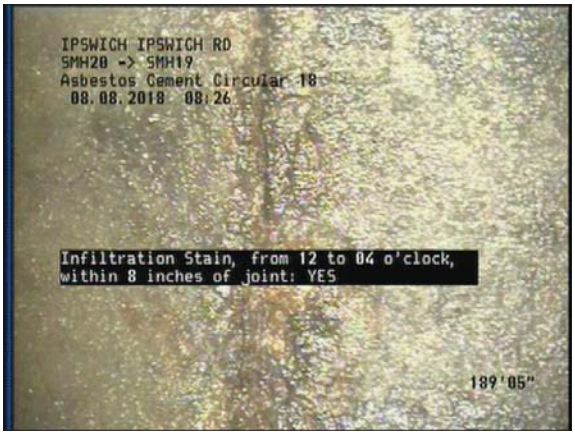

Photo: SMH20-SMH19-08202018-IS-189.4451-163713.jpg
189.45FT, Infiltration Stain, from 12 to 04 o'clock, within 8 inches of joint: YES

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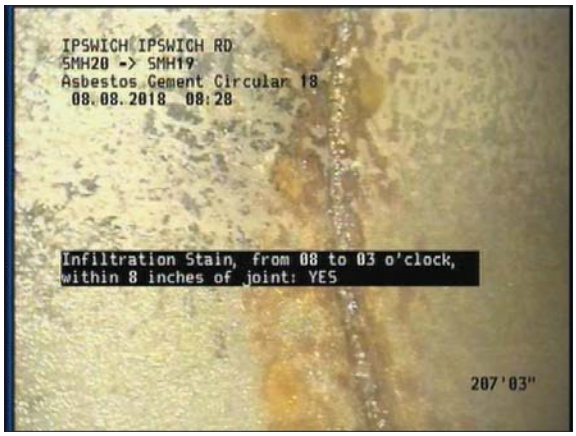

Photo: SMH20-SMH19-08202018-IS-207.2587-163744.jpg
207.26FT, Infiltration Stain, from 08 to 03 o'clock, within 8 inches of joint: YES

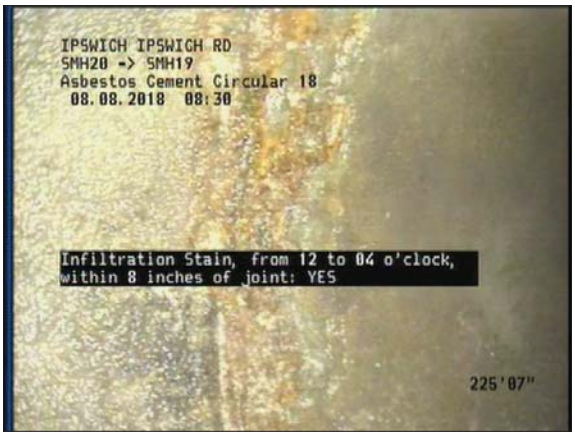

Photo: SMH20-SMH19-08202018-IS-225.5727-163758.jpg
225.57FT, Infiltration Stain, from 12 to 04 o'clock, within 8 inches of joint: YES

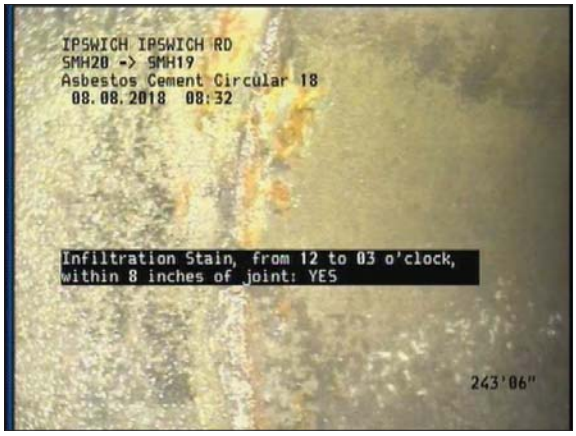

Photo: SMH20-SMH19-08202018-IS-243.4865-163818.jpg
243.49FT, Infiltration Stain, from 12 to 03 o'clock, within 8 inches of joint: YES

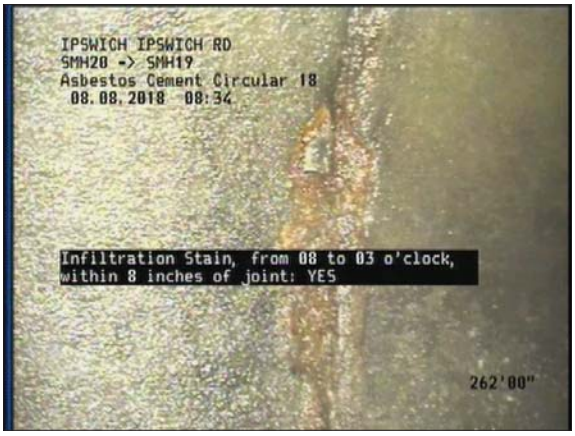

Photo: SMH20-SMH19-08202018-IS-262.0006-163859.jpg
262FT, Infiltration Stain, from 08 to 03 o'clock, within 8 inches of joint: YES

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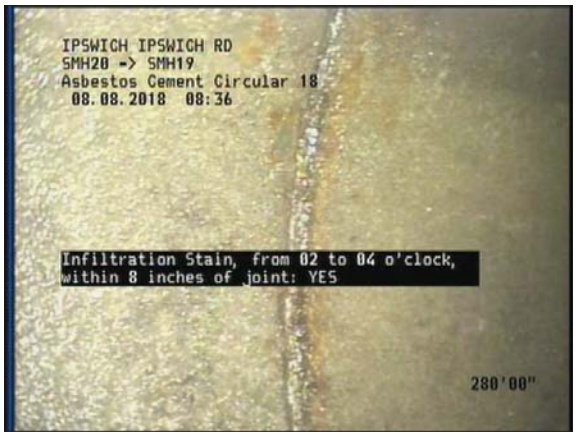

Photo: SMH20-SMH19-08202018-IS-280.0144-164005.jpg
280.01FT, Infiltration Stain, from 02 to 04 o'clock, within 8 inches of joint: YES

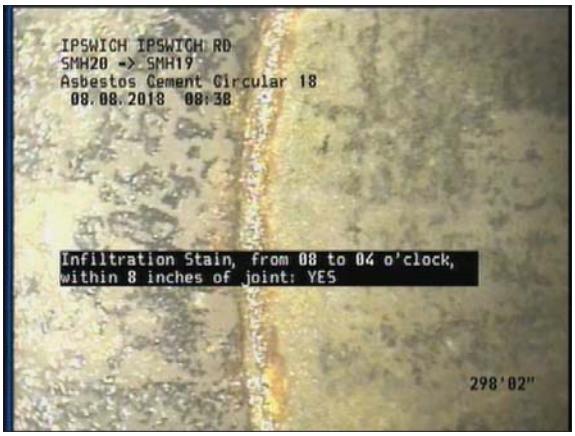

Photo: SMH20-SMH19-08202018-IS-298.1283-164037.jpg
298.13FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

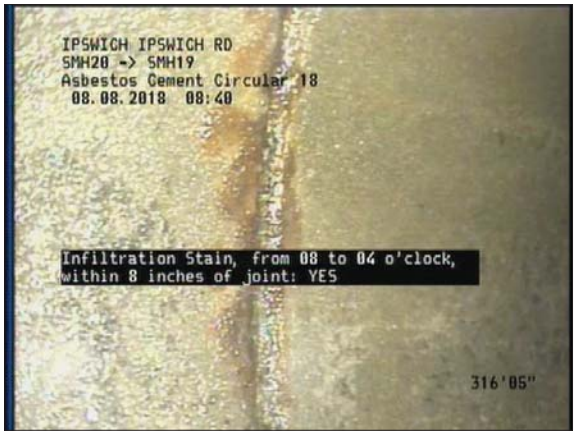

Photo: SMH20-SMH19-08202018-IS-316.4423-164129.jpg
316.44FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

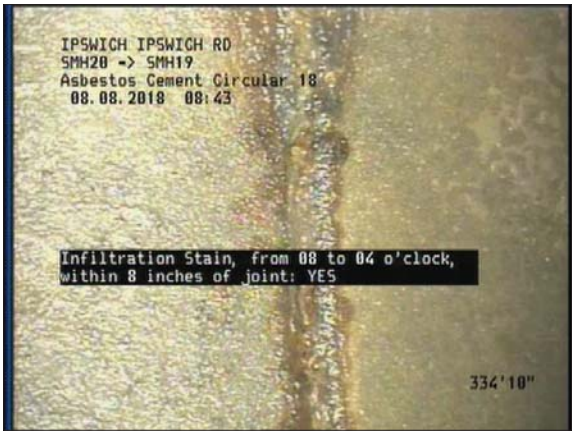

Photo: SMH20-SMH19-08202018-IS-334.8564-164153.jpg
334.86FT, Infiltration Stain, from 08 to 04 o'clock, within 8 inches of joint: YES

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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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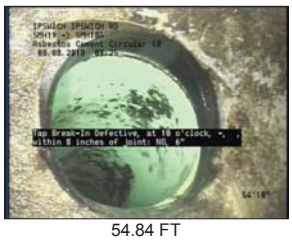
Inspection Report

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 FT
0.00	MWL	Water Level, 30 %of cross sectional area		0 FT
10.31	TF	Tap Factory Made, at 12 o'clock, -, within 8 inches of joint: YES, 4"		10.31 FT
54.84	TBD	Tap Break-In Defective, at 10 o'clock, -, , within 8 inches of joint: NO, 6"	M 3	 54.84 FT
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"		54.94 FT
146.41	AMH	Downstream Manhole, Survey Ends		
SMH18				

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

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**			**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

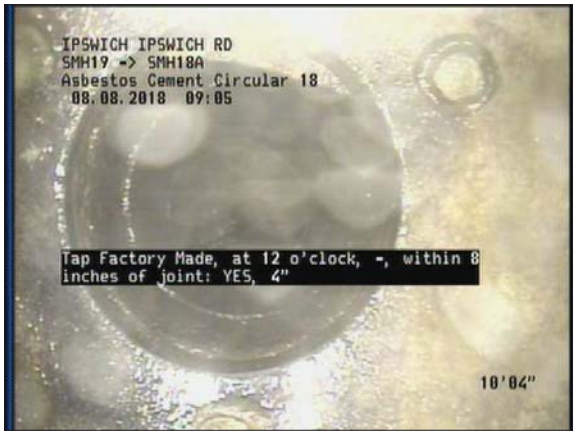


Photo: SMH19-SMH18-08202018-TF-10.3079-164420.jpg
10.31FT, Tap Factory Made, at 12 o'clock, -, within 8 inches of joint: YES, 4"

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"

The Environmental Protection Specialists

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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**			**3**

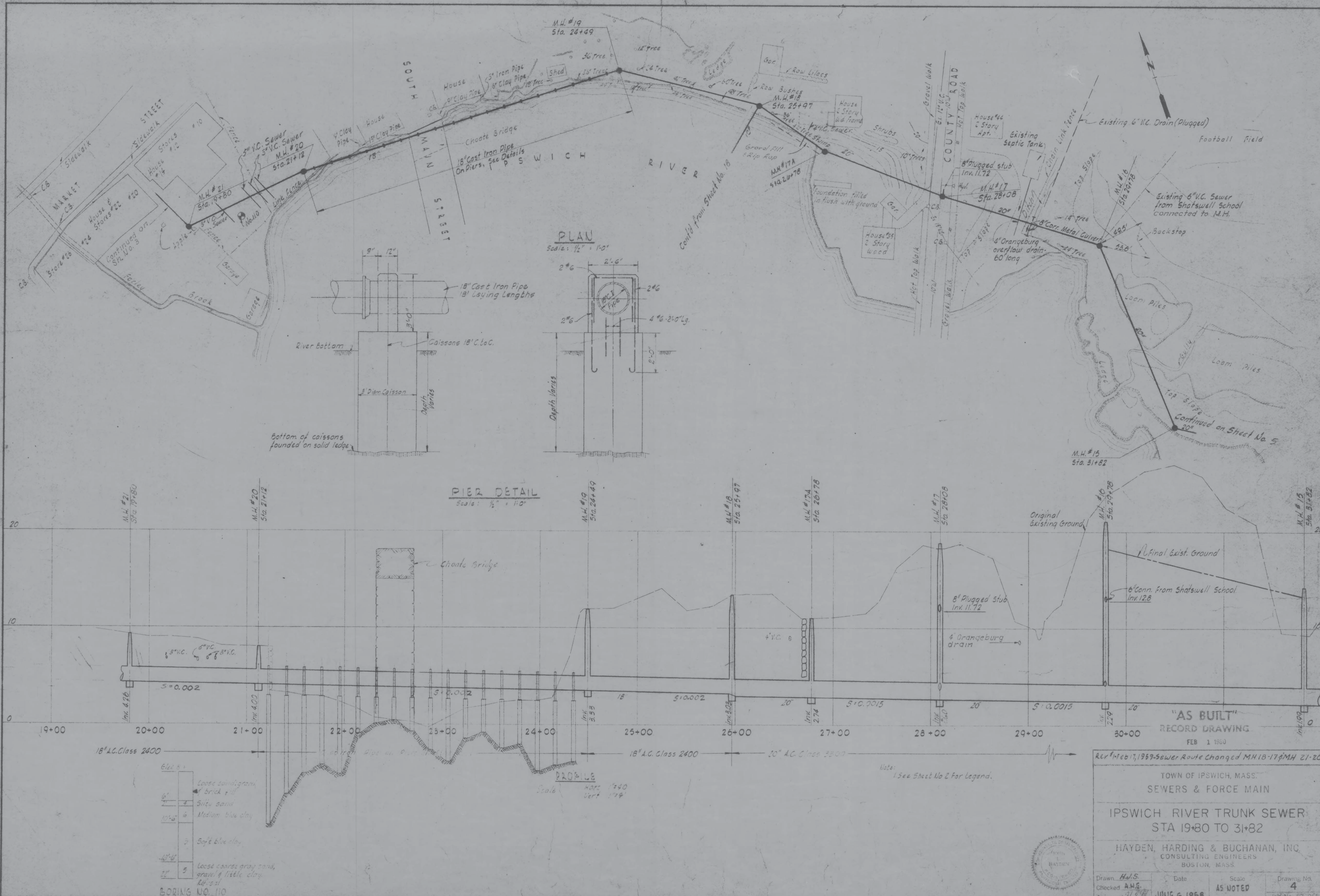
Photo: SMH19-SMH18-08202018-IG-54.9421-164511.jpg
54.94FT, Infiltration Gusher, at 10 o'clock, within 8 inches of joint: NO

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. #17A
Sta. 26+78
M.H. #17
Sta. 28+08
M.H. #16
Sta. 29+78
M.H. #15
Sta. 31+82
M.H. #20
Sta. 21+12
M.H. #21
Sta. 19+80
SOUTH MAIN STREET
MARKET STREET
COUNTY ROAD
IPSWICH RIVER
Choate Bridge
18" Cast Iron Pipe On Piers, See Details
Football Field
Existing 6" V.C. Drain (Plugged)
Existing 6" V.C. Sewer from Shatswell School connected to M.H.
Existing Septic Tank
8" Plugged stub Inv. 11.72
4" Orangeburg overflow drain 60' long
8" Corr. Metal Culvert
Backstop
Loam Piles
Continued on Sheet No. 5
Contd from Sheet No. 18
Continued on Sh. No. 3
Foundation filled in flush with ground
PLAN
Scale: 1/2" = 1'-0"
PIER DETAIL
Scale: 1/2" = 1'-0"
18" Cast Iron Pipe 18' Laying Lengths
River Bottom
Caissons 18" C.L.C.
Depth Varies
Bottom of caissons founded on solid ledge
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
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 #1 - Feb 17, 1959 - Sewer Route Changed M.H. 18-17 & M.H. 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
Job No. 57-065

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
2-4" V.C. Sewer Drains
County Road Connection
Sta. 25+97 Trunk Sewer Continued on Sheet No. 4
M.H.#18
Sta. 0-20
Blow-off M.H.
6" Gate Valve
M.H.#34
Sta. 1+20
IPSWICH RIVER
Continuation Sheet No. 4
Bldg.
Gas Station
ELM STREET
Town Hall
Existing sewer
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
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
2-4" V.C. Sewers
1-6" V.C. Sewers
S = 0.004
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
SOUTH MAIN STREET
8" A.C., Class 1500
PROFILE
Scale: Hor. 1" = 40'
Vert. 1" = 4'
Note:
See Sheet No. 2 for Legend
Existing Ground
2-4" V.C. Sewer Drains
12" Plugged stub for connection to future sewer from County Road
S = 0.003
COUNTY ROAD CONNECTION
12" A.C., Class 1500
"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 D.W.D.
Checked A.H.G.
Date JUNE 6, 1958
Scale AS NOTED
Drawing No. 18
Job No. 57-065

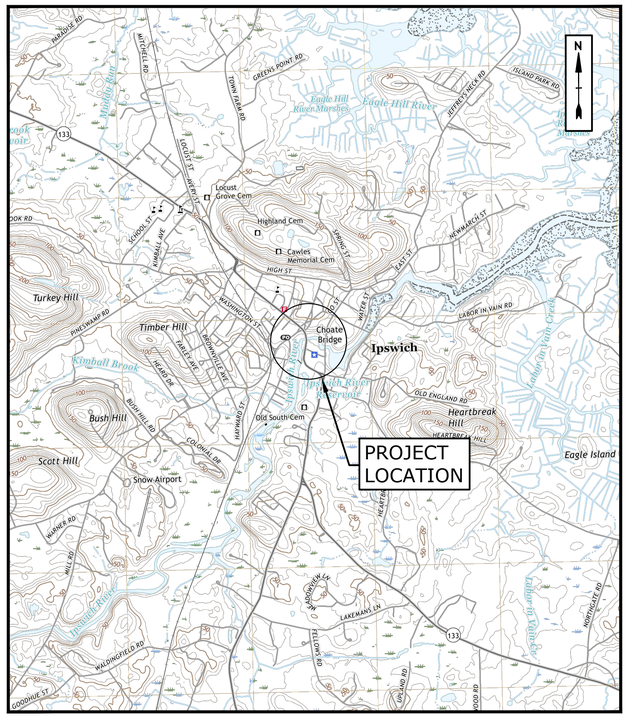
Appendix D
Design Drawings

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:

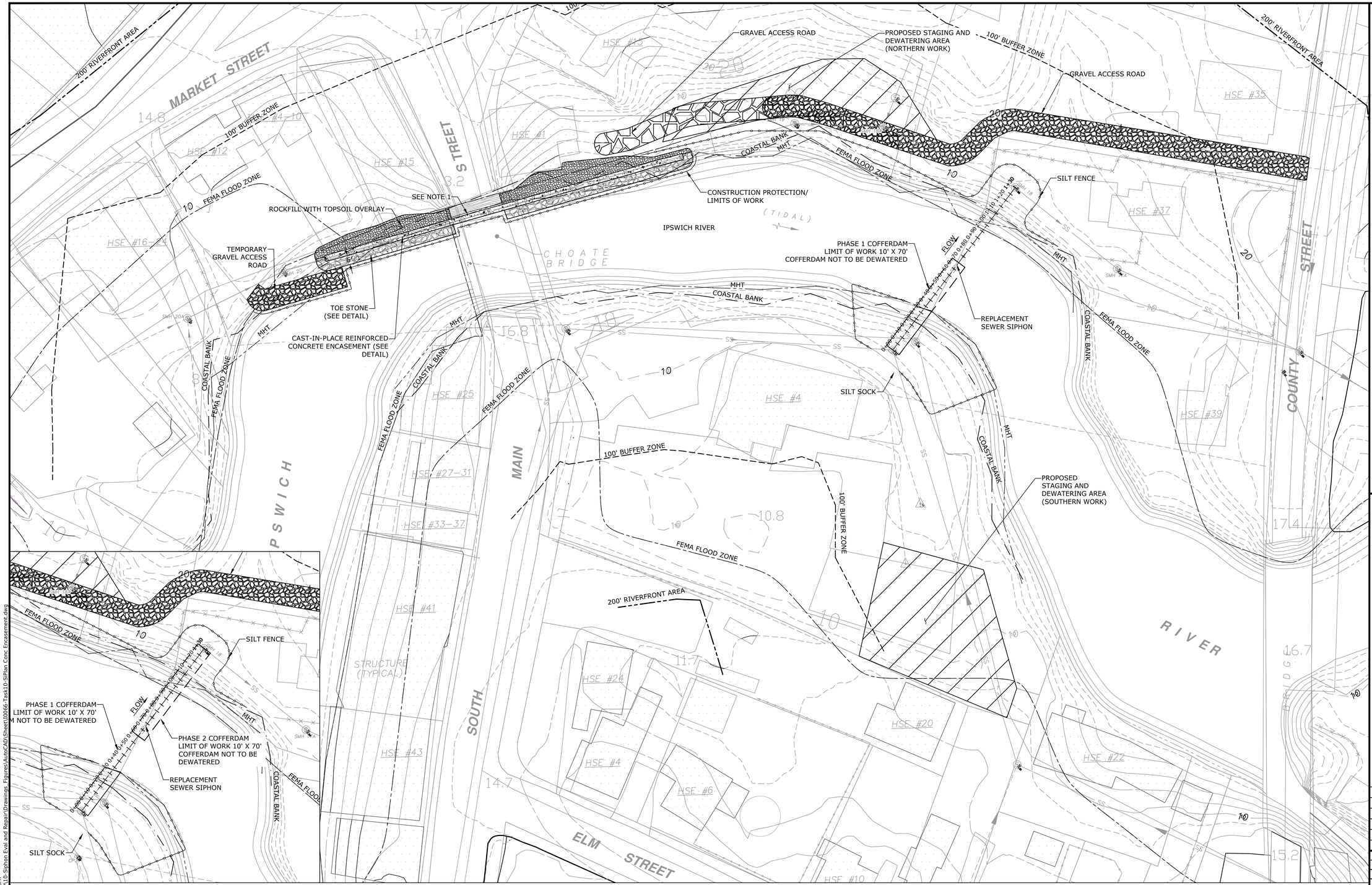
TOWN OF IPSWICH

WATER & WASTEWATER DIRECTOR, VICKI HALMEN

TOWN MANAGER, ANTHONY MARINO

CONCEPTUAL DRAWINGS
NOT FOR CONSTRUCTION

Last Saved: 2/28/2019
Plotted: Mar 28, 2019 - 1:14pm By: SAT
Tighe & Bond J:\1\100066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings, Figures\AutoCAD\Xref\100066-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.

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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

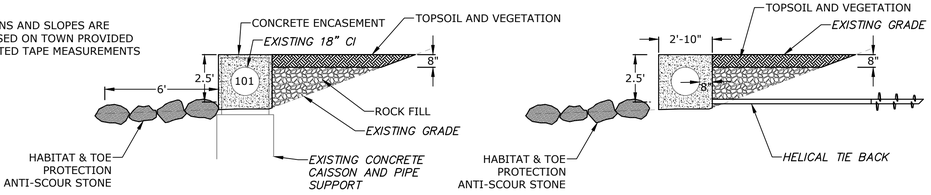
INTERCEPTOR REHABILITATION SITE PLAN

SCALE: 1"=30'

SHEET 2

Last Saved: 3/4/2019
Plotted On: Mar 04, 2019-11:50am By: SAT
T:\Projects\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings Figures\AutoCAD\Sheet\I0066-Task10-SiPlan Conc Encasement.dwg

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



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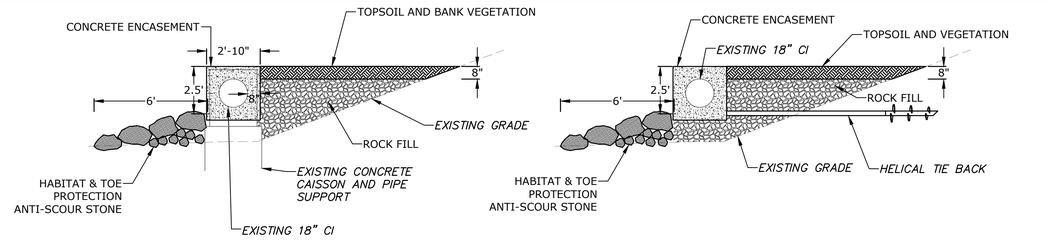

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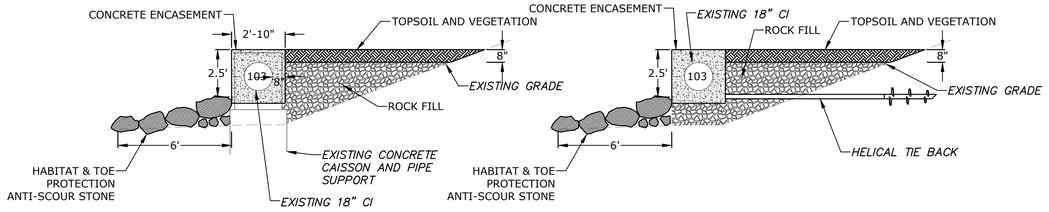

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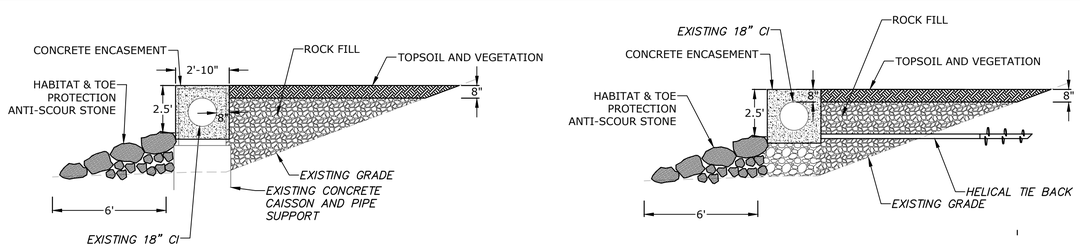

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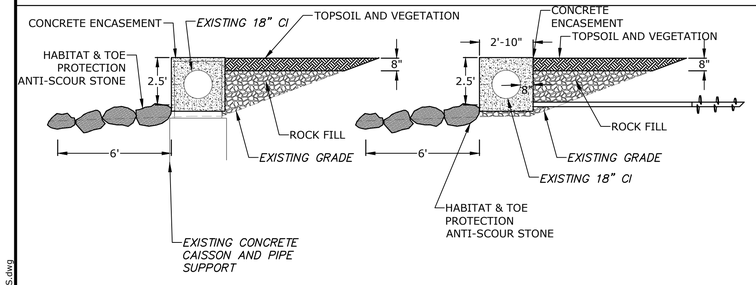

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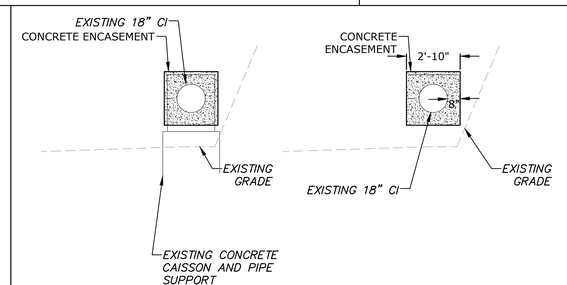

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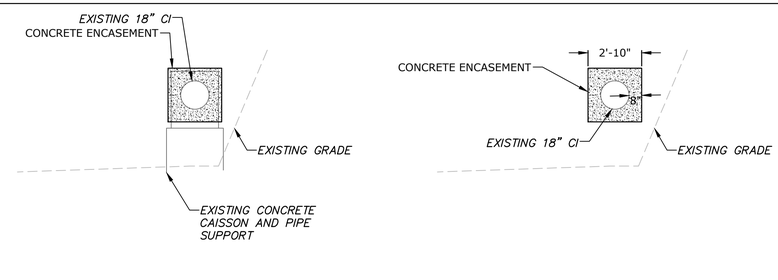

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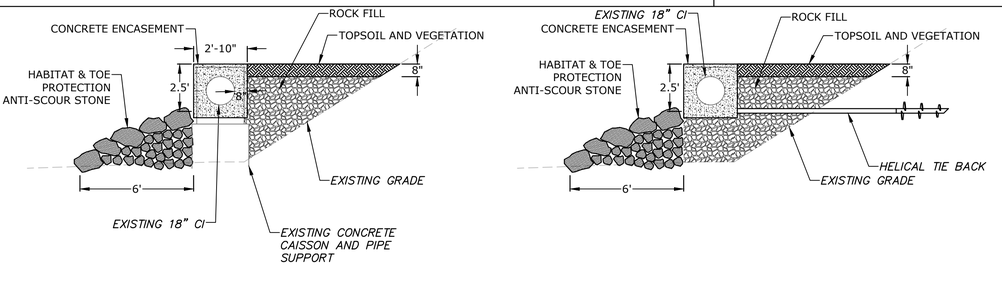

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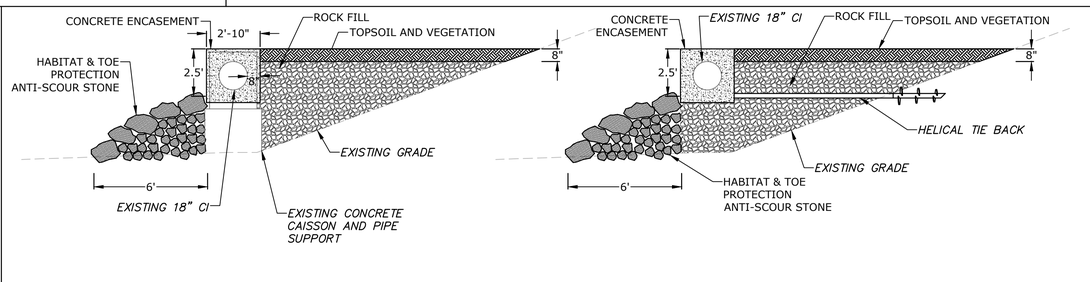

CONCRETE PEDESTAL #109 CROSS SECTION

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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: AS SHOWN

SHEET 3

Last Saved: 2/27/2019
Plotted: Feb 28, 2019 1:30pm By: SAT
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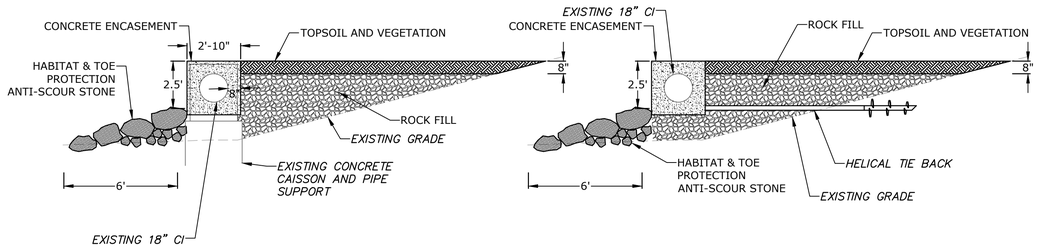

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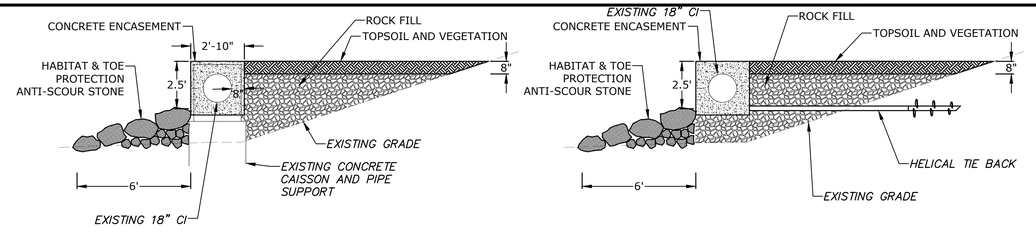

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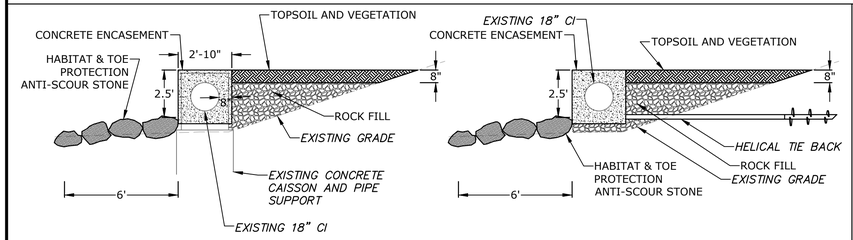

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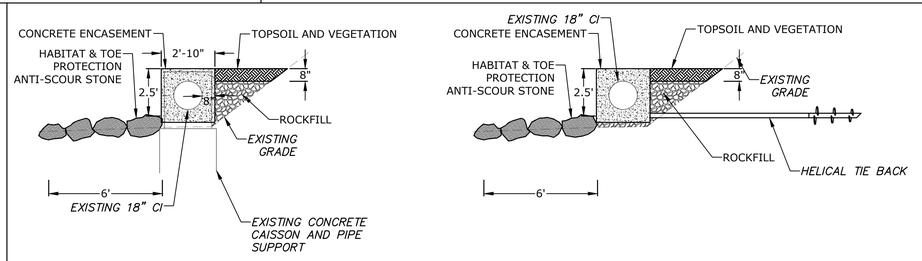

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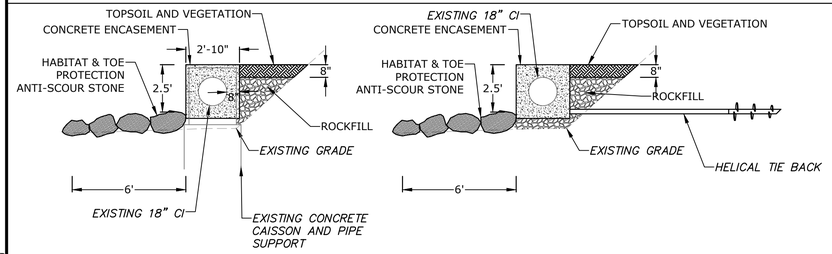

CONCRETE PEDESTAL #114 CROSS SECTION

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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: 03/06/2019 1:31pm By: SAT
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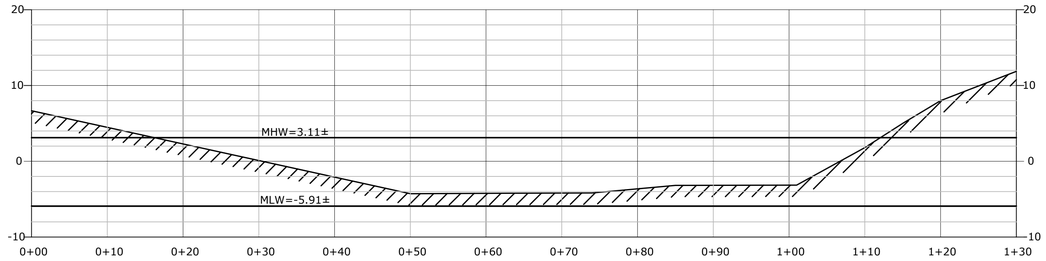
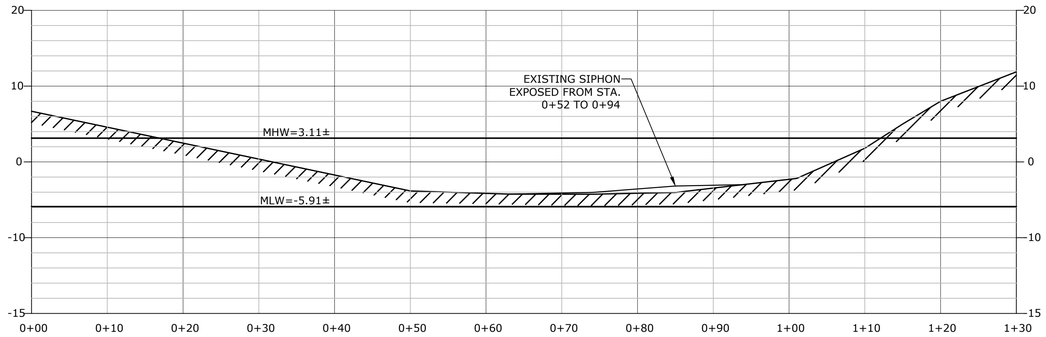


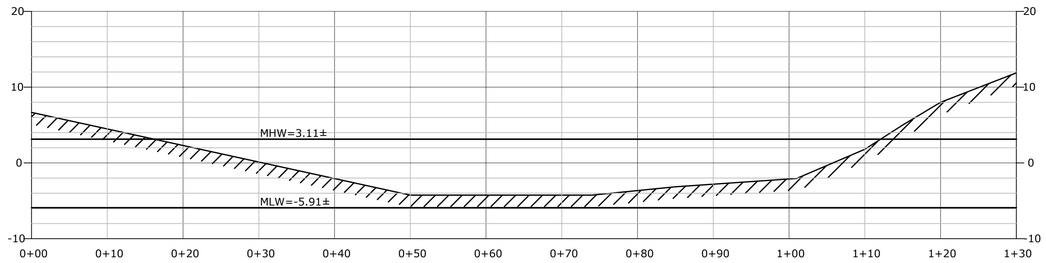
RIVER SECTION 10' UP RIVER OF SIPHON

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

Last Saved: 2/27/2019
Plotted: Feb 27, 2019 - 4:02pm By: SAT
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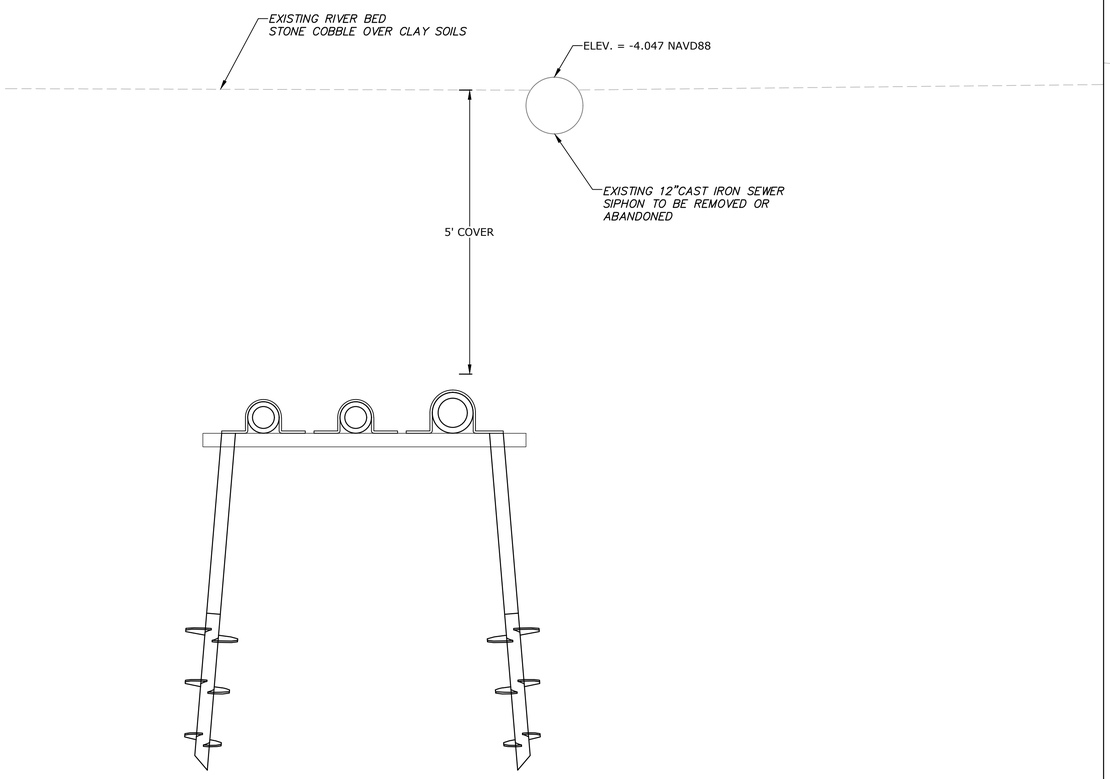
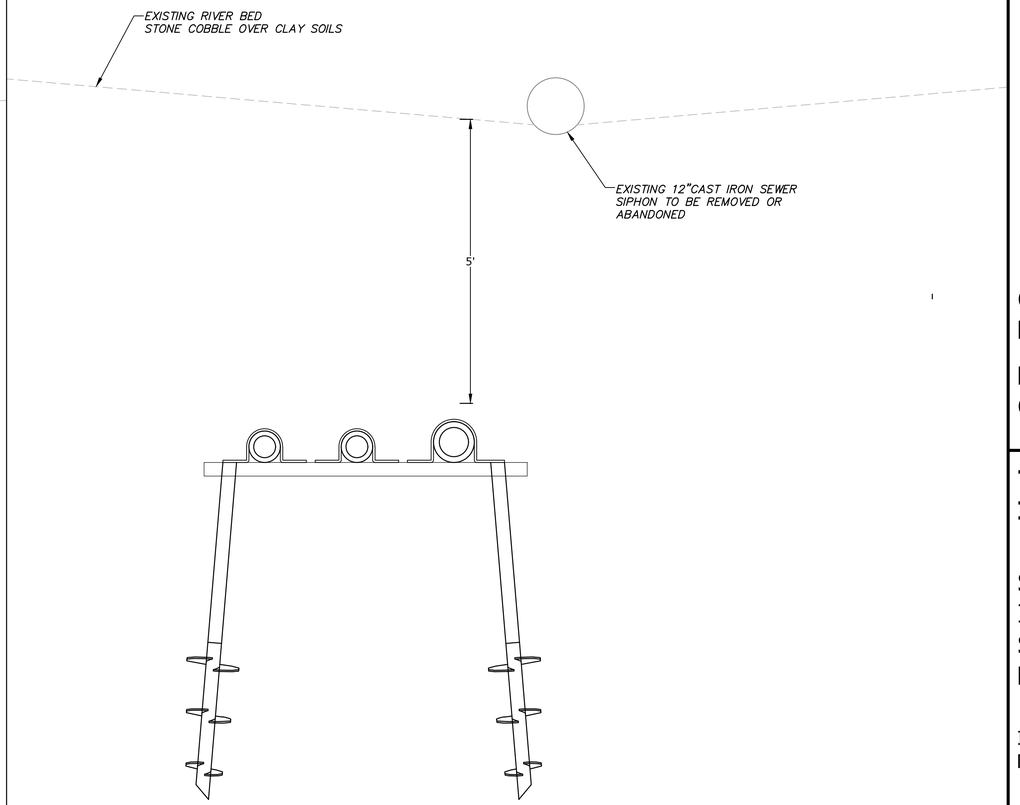


SIPHON CROSS SECTION A-A STA. 0+74.00

0 1' 2' 3'
GRAPHIC SCALE



SIPHON CROSS SECTION B-B STA. 0+85.00

0 1' 2' 3'
GRAPHIC SCALE

Tighe&Bond
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CONCEPTUAL DRAWINGS

NOT FOR CONSTRUCTION

Town of Ipswich

Sewer Interceptor and Siphon Rehabiitation

Ipswich, Massachusetts

MARK	DATE	DESCRIPTION

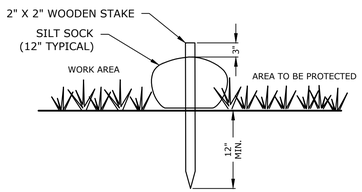
PROJECT NO:	I0066/10
DATE:	03/2019
FILE: I0066-Task10-DTLS.dwg	
DRAWN BY:	JAK
CHECKED:	DCM
APPROVED:	SES

PROPOSED SIPHON SECTIONS

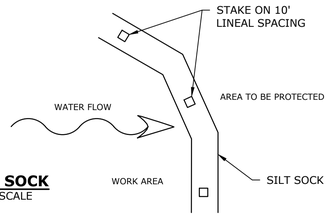
SCALE: AS SHOWN

SHEET 6

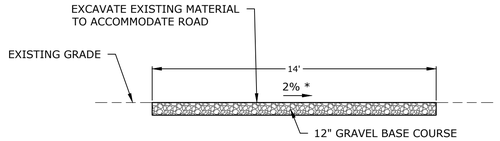
Last Saved: 2/27/2019
Plotted: 03/06/2019 4:09pm By: SAT
Tighe & Bond: J:\I\I0066 Ipswich WWTP\10-Siphon Eval and Repair\Drawings_Figures\AutoCAD\Sheet\I0066-Task10-DTLS.dwg



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.



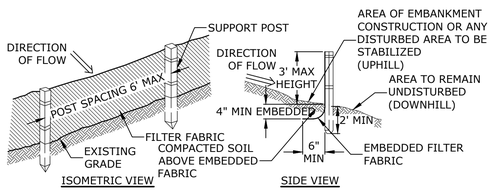
SILT SOCK
NO SCALE



* 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

Last Saved: 2/27/2019
Plotted On: Feb 27, 2019 - 4:11pm By: SAT
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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			
				5-6			**SAND**		
		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	