Condition Assessment of Historic Properties and Associated Canal System

Lawrence Hydroelectric Project (FERC No. 2800)

May 6, 2025

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List of Acronyms

C.F.R.	Code of Federal Regulations
cfs	cubic feet per second
Essex	Essex Company, LLC (or Licensee)
FERC	Federal Energy Regulatory Commission (or Commission)
ft	feet
ILP	Integrated Licensing Process
MW	megawatt
NGVD 29	National Geodetic Vertical Datum 1929
NPS	National Park Service
Project	Lawrence Hydroelectric Project (or Lawrence Project)
RL	river left
RM	river mile
ROR	run-of-river
RR	river right
RSP	Revised Study Plan
SPD	Study Plan Determination

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1 Introduction and Background

Essex Company, LLC (Essex or Licensee) is the Licensee, owner, and operator of the 16.8-megawatt (MW) Lawrence Hydroelectric Project (Project or Lawrence Project) (FERC No. 2800). Essex operates and maintains the Project under a license from the Federal Energy Regulatory Commission (FERC or Commission). The Project's existing license expires on November 30, 2028. Essex is pursuing a new license for the Project using the Commission's Integrated Licensing Process (ILP) as defined in 18 Code of Federal Regulations (C.F.R.) Part 5.

In accordance with 18 Code of Federal Regulations (C.F.R.) § 5.15, Essex has conducted studies as provided in the study plan and schedule approved in the Commission's May 10, 2024 Study Plan Determination (SPD) for the Project. This report describes the methods and results of the approved Condition Assessment of Historic Properties and Associated Canal System conducted related to the North Canal and South Canal in support of a new license for the Project.

1.1 Project Description and Background

The Lawrence Project is located at river mile (RM) 31 on the Merrimack River in the City of Lawrence in Essex County, Massachusetts, with a headpond extending approximately 9.8 miles upstream. The existing Lawrence Project consists of:

1) A 900-foot-long, 33-foot-high rubble masonry gravity dam with a 5-foot-high Obermeyer crest gate system with a normal crest elevation of 44.17 feet (ft) National Geodetic Vertical Datum 1929 (NGVD 29);
2) A 655-acre headpond with a normal maximum water surface elevation of 44.17 ft NGVD 29;
3) A 2,750-foot-long existing South Canal, measuring approximately 35-feet-wide and 10-feet-deep and originating at the south abutment of the Essex Dam;
4) A 5,300-foot-long existing North Canal, measuring approximately 95-feet-wide and 15-feet-deep and originating at the north abutment of the Essex Dam;
5) A powerhouse containing two turbine-generator units with a total installed capacity of 16.8 MW;
6) A tailrace channel;
7) Upstream and downstream fish passage facilities including a fish elevator at the powerhouse, a downstream fish bypass, an eel ladder and an eel lift; and
8) Appurtenant facilities.

At the normal pond elevation of 44.17 ft NGVD 29[1] (crest of the pneumatic flashboards), the surface area of the headpond encompasses an area of approximately 655 acres. The gross storage capacity between the normal surface elevation of 44.17 ft and the minimum pond level is approximately 19,900 acre-ft. The Project operates essentially in a run-of-river (ROR) mode using automatic pond level control and has no usable storage capacity.

The Essex Company was formed in 1845 and designed the new town of Lawrence, laying out streets and using deed covenants to shape the new town's development. The company's primary infrastructure and means of development consisted of the Essex Dam, power canal, and machine shop. The Essex Company business plan consisted of contracting to build and equip mills along its canals for independent textile manufacturing corporations to use, then collecting yearly fees for waterpower delivery. The industry standard waterpower measurement unit consisted of the "mill power", which replaced the conventional horsepower. Mill owners typically purchased sufficient mill powers to run their existing mills, plus additional mill powers in reserve for future expansion.

Substantial build-out of the North Canal was achieved in 1864 and Essex reached its final development phase with construction of the South Canal in 1868. Each mill owner along the canals was responsible for construction and maintenance of its intake and headgate systems into the mills. Similarly, removal of unused intakes is the responsibility of the associated mill owner. As originally constructed, each intake system consisted of a set of tandem trash racks, headgates, hoists, and hoist enclosures. The mills and factories along the canals used water from the canals for the purpose of hydromechanical or hydroelectric power generation and discharged to the Merrimack River downstream of the Essex Dam.

2 Study Goals and Objectives

The goal of this study is to evaluate the potential effects of project operation on historic resources within the project's Area of Potential Effects (APE) in consultation with the Massachusetts State Historic Preservation Office (SHPO), Lawrence Historical Commission, and other interested parties. The specific objectives of this study are as follows:

- Determine the extent to which project operations, including water flow in the North and South Canals, have an effect on historic properties;
- Conduct a condition and structural assessment of the North and South Canals; and
- Identify potential impacts of current and proposed project operations on historic resources.

[1] Elevations throughout this study are reported or have been converted to the National Geodetic Vertical Datum 1929 (NGVD 29). The conversion from NGVD 29 to Essex Datum is NGVD 29 - 5.07 feet.

3 Study Area

In accordance with the Commission's SPD, the study area for the Condition Assessment of Historic Properties and Associated Canal System includes the Project's North Canal and South Canal systems. The study area starts at the North Canal Gatekeeper's House, Locks and Wasteway, and Great Stone (Essex) Dam and continues downstream of both canals to the North Canal discharge gate structure and the South Canal Wasteway. The study area is captured in Figure 3-1 and Figure 3-12.

Figure 3-1. Study Area for the Condition Assessment of Historic Properties and Associated Canal System

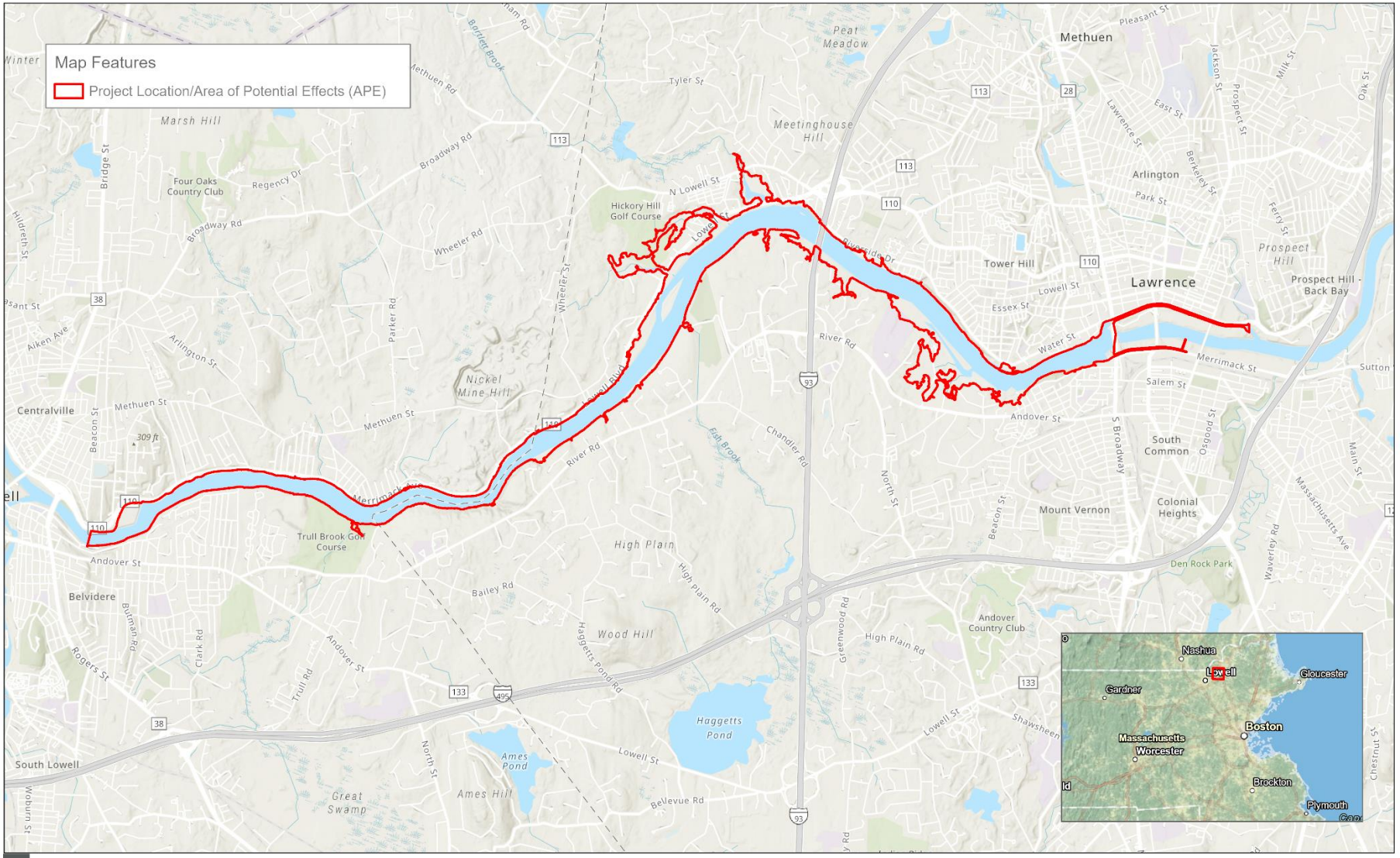
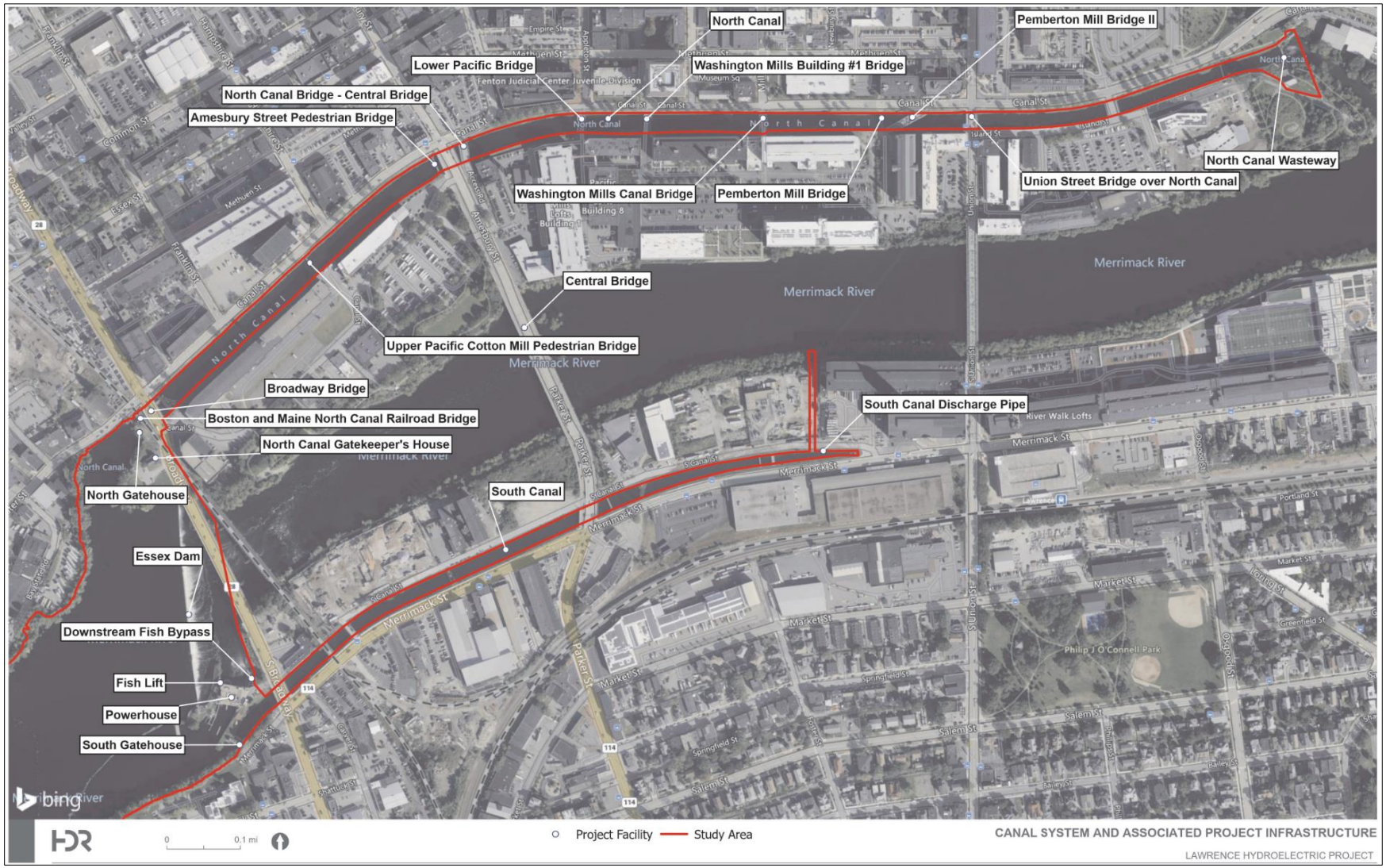


Figure 3-2. Canal System and Associated Project Infrastructure



4 Methodology

4.1 Document Review of Existing Conditions

To assist in performing the condition and structural assessment of the North and South Canals, HDR reviewed available engineering evaluations or discussions of historic canal structures available from Essex, including a condition assessment report of the North Canal dated May 2019, performed and written by Woodard & Curran. Based on this document review, HDR identified areas of previous concern and at higher risk of failure along the canal walls. These served as a basis for comparison with a site visit.

To assist in determining the extent to which project operations, including water flow in the North and South Canals, have an effect on historic properties and to identify potential impacts of current and proposed project operations on historic resources, HDR reviewed available operational data and engineering evaluations or discussions of historic canal structures. Based on this document review, HDR identified general impacts from past operations. These served as a basis for comparison with a site visit.

The site visit is discussed in the next sub-section of this report. Copies of the reviewed documents are included in Appendix A of this study report.

4.2 Site Visit to Document Existing Conditions

The approved Revised Study Plan (RSP) directed Essex (and HDR by extension) to conduct a site visit as part of a condition assessment to identify areas of deterioration and disrepair of the North and South canal walls that could lead to potential collapse or failure of the historic structures. As proposed by Essex, the intention of this field visit was to collect additional photographs and information on the canal walls.

Between October 22-24, 2024 HDR conducted a site visit to the historic canal structures to identify issues with the canal walls. On October 22, 2024, HDR started walking from the Broadway Street bridge along the south wall of the South Canal, heading east. Photographs were taken periodically of the south wall of the South Canal using a GoPro camera on a telescopic rod, matching the pace of the camera operator. Once the end of the South Canal was reached, HDR walked back along the south wall, photographing the north wall until reaching the Broadway Street bridge. This was due to limited public access on the north wall. On October 23, 2024, HDR repeated the same procedure for the North Canal; however, HDR walked along the north wall of the North Canal, as there was limited public access along the south wall. On October 24, 2024, HDR was escorted by Essex operations staff as they photographed and observed the portions of both the North and South Canals upstream of the Broadway Street bridge.

4.3 Assessment of Water Levels, Flows, and Project Effects

HDR compared the results of the document review of existing conditions and the qualitative operational history of water level, flow, and operational data from Essex. The results of this were used to identify potential Project-related effects on the historic canal system infrastructure. These results are discussed in the following section.

5 Study Results

5.1 Documentation Review of Existing Conditions

Pursuant to the approved study plan, HDR reviewed several source documents to better understand the known condition and potential structural issues. The following list includes those documents reviewed[2].

- Condition Assessment of Canal Walls Report, North Canal, Lawrence, MA. Woodard & Curran. City of Lawrence, MA. May 2019.
- Exhibit L, Sheet 4 & Sheet 5. Existing Canals – North Canal Wasteway Plans & Sections. Lawrence Hydroelectric Project. Essex Development Associates. June 28, 1977.
- Exhibit L, Sheet 4 . Existing Canals – Plans & Sections – South Canal Wasteway. Lawrence Hydroelectric Project. Essex Development, LLC. May 21, 2024.
- Existing Gate Details – Intake Gate Repairs. Essex Company, Lawrence, MA. May 11, 2007.
- Essex Company on the Merrimack at Lawrence, The. F. Morton Smith. The Newcomen Society of England – American Branch – New York. 1947.
- South Gate House Gate Replacement. ENEL North America, Inc. Lawrence Hydro. Methuen Construction Co., Inc. April 25, 2011.

HDR reviewed the above listed data to identify elevations, conditions, and other relevant information regarding historical structures that may be potentially affected by project operations related to water level fluctuations in the North Canal and South Canal. While many of these documents contain relevant information regarding the conditions of historic structures, there are few, if any details on the elevations of these structures in relation to water level fluctuation.

5.2 North Canal

5.2.1 Condition and Structural Assessment

Based on review of available documents and the site visit performed on October 22-24, 2024, it was observed that the condition of the north and south walls varies along the length of the North Canal. The canal walls are comprised of various materials and construction efforts ranging from dry-laid stone (without mortar), masonry (dry-laid stone with mortared connecting stones), various types of concrete, brick-and-mortar, and combinations of the aforementioned. The conditions observed are typical for walls of this age. Detailed

[2] Some documents referenced in this study report and included in this list are considered Critical Energy Infrastructure Information (CEII) by the FERC and are not for public distribution and are also not included in Appendix A of this study report.

information on the construction of the walls is limited. Most of the condition and structural assessment was limited to observations made of the exposed portions of the wall performed during the field visit. In general, extensive vegetative growth was observed along both the north and south walls of the North Canal; however, it was noted that most vegetative growth was limited to grassy plants and vines, with occasional woody growth that had been cut back or treated.

Wall sections were categorized based on the type of wall and corresponding condition traits. Wall section naming corresponds to having the first letter represent the associated canal (i.e., “N” for North Canal), the second letter representing the associated compass direction for the wall on that canal (i.e., “N” for north wall), and a numeral in sequence for that canal wall starting at the gatehouse and continuing downstream (i.e., the first wall section downstream of the corresponding gatehouse would be “1”).

Based on visual observations made of the condition of wall surfaces during the site visit, HDR has assigned a risk level category between 1 and 5, with 1 indicating structures that are heavily impacted and in a state of heavy disrepair and 5 indicating structures that are in great condition. Risk Levels 1 and 2 are generally reserved for conditions that impact stability, plumbness, or heavy deterioration/erosion. Risk Levels 3, 4, and 5 usually indicate the wall section is stable and generally plumb. Appendix B contains a reference plan of the various wall sections and their corresponding Risk Levels. Appendix C summarizes the results and observations of the field inspection. As indicated in Appendix B and C, most wall sections were rated at Risk Levels 3, 4, and 5. Wall sections that were categorized as Risk Levels 1 and 2 are described in further detail in the following tables.

Wall Section	Station	Risk Level
NN5	3+30 to 4+00	2
Observations		
This wall section is comprised of dry-laid stone. This wall section is noted to have large areas of missing stones in various locations. Additionally, the crest of the wall is uneven and does not appear to be plumb with the rest of the wall. This is caused by areas of overhanging stone along the crest that do not form a flush face with the rest of the wall section. Also, the wall section has woody vegetative growth between stones.		
Recommendations		
All voids should be replaced with similar stones. Mortar should be placed between the joints, where possible, to bind the stones together and to prevent seepage to/from the canal. Existing stones that are not flush with the wall surface should be repointed. All vegetation should be removed where possible. If removing the root structures would negatively impact the structural stability of the wall, then the vegetation should be treated instead to prevent future growth.		

Photos

Wall Section	Station	Risk Level
NN6	4+00 to 4+70	2

Observations

This wall section is comprised of dry-laid stone. This wall section is noted to have large areas of missing stones in various locations. Additionally, the crest of the wall is uneven and does not appear to be plumb with the rest of the wall. This is caused by areas of overhanging stone along the crest that do not form a flush face with the rest of the wall section. Also, the wall section has woody vegetative growth between stones.

Recommendations

All voids should be replaced with similar stones. Mortar should be placed between the joints, where possible, to bind the stones together and to prevent seepage to/from the canal. Existing stones that are not flush with the wall surface should be repointed. All vegetation should be removed where possible. If removing the root structures would negatively impact the structural stability of the wall, then the vegetation should be treated instead to prevent future growth.

Photos

Wall Section	Station	Risk Level
NN7	4+70 to 5+50	2
Observations		
This wall section is comprised of dry-laid stone. This wall section is noted to have large areas of missing stones in various locations. Additionally, the crest of the wall is uneven and does not appear to be plumb with the rest of the wall. This is caused by areas of overhanging stone along the crest that do not form a flush face with the rest of the wall section. Also, the wall section has woody vegetative growth between stones.		
Recommendations		
All voids should be replaced with similar stones. Mortar should be placed between the joints, where possible, to bind the stones together and to prevent seepage to/from the canal. Existing stones that are not flush with the wall surface should be repointed. All vegetation should be removed where possible. If removing the root structures would negatively impact the structural stability of the wall, then the vegetation should be treated instead to prevent future growth.		

Photos

Wall Section	Station	Risk Level
NN8	5+50 to 6+05	2
Observations		
This wall section is comprised of dry-laid stone. There are some minor areas with mortared joints, but this is limited to certain joints or locations rather than major portions of the wall section. This wall section is noted to have large areas of missing stones in various locations. Additionally, the crest of the wall is uneven and does not appear to be plumb with the rest of the wall. This is caused by areas of overhanging stone along the crest that do not form a flush face with the rest of the wall section. Also, the wall section has woody vegetative growth between stones.		
Recommendations		
All voids should be replaced with similar stones. Mortar should be placed between the joints, where possible, to bind the stones together and to prevent seepage to/from the canal. Existing stones that are not flush with the wall surface should be repointed. All vegetation should be removed where possible. If removing the root structures would negatively impact the structural stability of the wall, then the vegetation should be treated instead to prevent future growth.		

Photos

Wall Section	Station	Risk Level
NN11	6+80 to 10+50	2

Observations

This wall section is comprised of dry-laid stone. This wall section is noted to have large areas of missing stones in various locations. Additionally, the crest of the wall is uneven, likely from erosion of the soils topping the crest, and does not appear to be plumb with the rest of the wall. Also, the wall section has woody vegetative growth between stones.

Recommendations

All voids should be replaced with similar stones. Mortar should be placed between the joints, where possible, to bind the stones together and to prevent seepage to/from the canal. Existing stones that are not flush with the wall surface should be repointed. All vegetation should be removed where possible. If removing the root structures would negatively impact the structural stability of the wall, then the vegetation should be treated instead to prevent future growth.

Photos

Wall Section	Station	Risk Level
NN15	14+90 to 17+20	2
Observations		
This wall section is comprised of dry-laid stone. There are some minor areas with mortared joints, but this is limited to certain joints or locations rather than major portions of the wall section. This wall section is noted to have large areas of missing stones in various locations. Additionally, the crest of the wall is uneven and does not appear to be plumb with the rest of the wall. This appears to be due to erosion forces behind the crest stones. Also, the wall section has woody vegetative growth between stones and a large series of viny growth.		
Recommendations		
All voids should be replaced with similar stones. Mortar should be placed between the joints, where possible, to bind the stones together and to prevent seepage to/from the canal. Existing stones that are not flush with the wall surface should be repointed. All vegetation should be removed where possible. If removing the root structures would negatively impact the structural stability of the wall, then the vegetation should be treated instead to prevent future growth.		

Photos

Wall Section	Station	Risk Level
NN22	30+10 to 31+35	2

Observations

This wall section is comprised of dry-laid stone. There are some minor areas with mortared joints, but this is limited to certain joints or locations rather than major portions of the wall section. This wall section is noted to have large areas of missing stones in various locations, including the crest. This has led to the crest of the wall being uneven. Furthermore, the joints between cap stones are relatively large in areas which has led to heavy erosion of the soil materials on top of and behind the wall to fill voids with soil. Heavy erosion under the cap stones has led to voids and the face of the wall not being flush. Also, the wall section has slight woody vegetative growth between stones.

Recommendations

All voids should be replaced with similar stones. Mortar should be placed between the joints, where possible, to bind the stones together and to prevent seepage to/from the canal. Existing stones that are not flush with the wall surface should be repointed. All displaced soil should be removed from the capstone joints. If capstone joint openings are excessive, additional capstones should be added and the existing capstones shifted to have a limited joint opening. These joints should be mortared to prevent future surface erosion and vegetative growth through the joint. All vegetation should be removed where possible. If removing the root structures would negatively impact the structural stability of the wall, then the vegetation should be treated instead to prevent future growth.

Photos

Wall Section	Station	Risk Level
NN23	31+35 to 33+00	1
Observations		
This wall section is comprised of dry-laid stone. There are some minor areas with mortared joints, but this is limited to certain joints or locations rather than major portions of the wall section. The top of the wall section is covered by a large, concrete public observation deck with benches and a brick face. The crest and stones near the top of the wall appear to be leaning heavily into the canal, most likely caused by significant erosion of soils behind the canal wall and under the observation deck. It is noted there is no grass cover or material cover to prevent erosion under the observation deck. Additionally, this wall section is noted to have large areas of missing stones in various locations, including the crest.		
Recommendations		
The wall should be rebuilt with the same or similar materials and joints should be mortared to prevent erosion of soils from under the overhang. Essex is working with the Massachusetts Department of Conservation and Recreation and Lawrence Redevelopment Authority to coordinate repairs in 2026, which will require removal of the observation deck.		

Photos

Wall Section	Station	Risk Level
NN27	40+50 to 40+90	2
Observations		
This wall section is comprised of dry-laid stone. However, the wall section is positioned under the old Pemberton Mill Bridge, which is blocked from usage by concrete jersey barriers. The stones of the wall section do not appear stable or properly plumb. The stones appear to be shifting and do not have a flush face. Unlike many of the bridges on the Lawrence canal system, there does not appear to be a solid brick, concrete, or mortared-stone abutment for the bridge to rest on, instead resting directly on the dry-laid stone.		
Recommendations		
The wall section below the bridge should be rebuilt in-kind with similar stone. The stones should provide a flush, uniform face on the canal side and joints should be mortared to add stability and prevent erosion/seepage from the abutment.		

Photos

Wall Section	Station	Risk Level
NN35	46+50 to 47+20	1

Observations

This wall section is generally comprised of dry-laid stone (where visible) and an abandoned intake structure. A portion of the wall section is blocked from viewing due to an old intake structure. Of the visible portions of the wall section, the stones do not appear properly pointed, with no flush face. Portions of the visible stones do not appear plumb. Several stones have been weathered significantly. The crest of the wall section is non-uniform and appears to be partially collapsing into the intake structure where there are voids or erosion. Additionally, several stones along the crest have shifted or are missing entirely. The abandoned utility intake structure is in a state of heavy disrepair. The steel trashracks have corroded to near non-existence. The timber support structure is cracked and rotted. Steel bars supporting the structure are anchored to the stone wall section and pulling the stones with it as it leans into the canal. The entire intake structure and wall section are covered in vegetation.

Recommendations

The wall section should be rebuilt in-kind with similar stone. The stones should provide a flush, uniform face on the canal side and joints should be mortared to add stability and prevent erosion/seepage. The opening of the intake should be filled with stone and mortared to prevent seepage between the canal and the adjoining soil. The vegetation should be removed.

The abandoned intake structure should be repaired and regularly maintained by the associated mill owner. The mill owner should consider removal of the intake structure. Maintenance and removal of unused intakes is the responsibility of the associated mill owner.

Photos

Wall Section	Station	Risk Level
NS10	19+25 to 23+75	1
Observations		
This wall section is comprised of dry-laid stone. The wall appears to be unstable and is leaning into the canal. Some of the capstones have already collapsed into the canal. Additionally, there are various gaps and voids noted throughout this entire section.		
Recommendations		
The wall should be re-built in kind with similar stones. Stones should be mortared between joints.		

Photos


LCWCPA

Wall Section	Station	Risk Level
NS20	34+00 to 35+25	2
Observations		
This wall section is comprised of dry-laid stone. Additionally, portions of the wall section do not appear plumb. There are several voids that are moderate in size, and several stones have visible wear. An abandoned intake structure is in a state of disrepair. The wall section is covered in heavy vegetation, though the vegetation does not appear significantly woody or with deep root structures.		
Recommendations		
The wall should be re-built in kind with similar stones. The old intake structure should be left in place and either rehabilitated or preserved. Maintenance of unused intakes is the responsibility of the associated mill owner. The opening behind the gate structure should be filled with concrete if the gate structure is not planned to be opened.		

Photos

Wall Section	Station	Risk Level
NS23	38+95 to 39+35	1
Observations		
This wall section is comprised of dry-laid stone. The wall crest for a portion of the section has toppled over, and the remaining top stones are significantly leaning into the canal. Additionally, a portion of the wall about 5 feet in length has failed.		
Recommendations		
This wall section should be rebuilt in kind using similar stones. Joints should be mortared.		

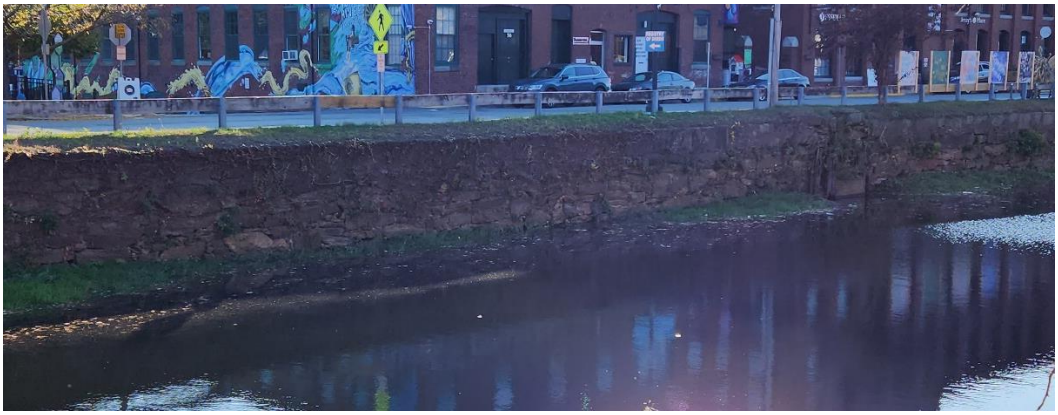
Photos

Wall Section	Station	Risk Level
NS28	48+10 to 48+30	1
Observations		
This wall section is comprised of dry-laid stone. Stones have shifted along this section. Stones along the crest have partially collapsed into the canal. The remaining stonework is leaning and does not appear stable. The wooden intake gate structure is significantly deteriorated.		
Recommendations		
The wall section should be rebuilt in kind using similar stones. Joints should be mortared. The intake structure should be preserved, rehabilitated, or restored. The opening behind the gate should be filled with similar stone to the wall and mortared, to prevent seepage through the gate structure.		

Photos


Wall Section	Station	Risk Level
NS30	49+35 to 51+40	2
Observations		
This wall section is comprised of dry-laid stone. The wall section has several large voids and dislodged stones. The wall section appears to be leaning into the canal, as evidenced by the heavy erosion of soil and sod on top of the wall crest. A portion of the wall includes concrete. This abandoned concrete has significant undermining.		
Recommendations		
The wall section should be rebuilt in kind using similar stones. Joints should be mortared.		

Photos



Wall Section	Station	Risk Level
NS34	60+15 to 60+80	2
Observations		
This wall section is comprised of a sloped earthen embankment with a dry-laid stone cap. The earthen embankment is covered in minor grassy and weedy vegetation. The slope appears to generally be maintained. However, the rip-rap is not spread evenly and has gaps between stones. Additionally, the stone wall cap is out of plumb and does not appear stable.		
Recommendations		
The embankment slope should be monitored for any future deterioration. Its surface should be kept clear of vegetation growing between rip-rap stones, and the rip-rap should be evenly placed over its entire surface. Gaps within the rip-rap should be filled with stone. The stone wall cap should be repointed. New stones should be fitted where there are voids. All joints between the capstones should be mortared.		

Photos

5.2.2 Review of Project Operations' Effect on Historic Properties Along the North Canal

Under the current FERC license, Essex is not required to maintain a specific water level in either of the canals, or to allocate downstream flows between the canals and the main channel of the Merrimack River. In the past, the North Canal gatehouse was typically operated to maintain a steady state pool at a standard level of approximately two (2) feet below the top of the North Canal walls. Essex Company maintained inflows into the canals

to match observed outflows (e.g. withdrawals by the mills or leakage) or needs as reported by the mill power owners.

The North Canal houses six (6) sets of leaf gates that are split across three bays, two sets of leaf gates per bay. The leaf gates are comprised of four panels each, where the bottom panel lifts first and then engages each subsequent panel as it rises. Due to deterioration of the gate panels and the gate operators, stoplogs were placed along the left and right bays, rendering four sets of the gate panels inoperable. Currently, only two sets of leaf gates are available to pass flow, located in the central bay; however, these two sets of leaf gates are severely deteriorated as well and are only used for emergency scenarios. Each gate panel measures 9-feet, 9.75-inches wide by 3-feet, 3-inches tall and are configured in a manner where there is a 3-inch overlap of one panel with the next panel in succession so that the general openings before the next panel is raised is 3 feet. The bottom most gate panel has a sill elevation of approximately 28.1 feet NGVD 29; each subsequent sill elevation is 3 feet above the former. Each leaf gate set can discharge a total of 2,769 cubic feet per second (cfs) at the normal headpond level of 44.2 feet NGVD 29. As noted above, the headgates to the canals are cracked or closed as needed to maintain water levels in the canals in conjunction with the North Canal wasteway gates.

For periods of construction or inspection, the North Canal is drawn down using the North Canal Wasteway and limiting outflow from the North Canal gatehouse to leakage. Operations of the canal levels typically do not result in large changes in inflow or water surface elevation. Due to the disrepair of the North Canal gatehouse gates and repairs at the North Canal Wasteway, current operations correspond to limiting inflow into the North Canal to leakage only, since approximately 2010; because of this, the North Canal water surface levels have been typically limited to a maximum of the sill elevation of the North Canal wasteway weirs of 38.1 feet NGVD 29 (33.0 feet Essex datum). The wasteway discharge openings are at a sill elevation of 28.1 feet NGVD 29 (23.0 feet Essex datum) and measure 2.94-feet-high by 3.06-feet-high. The North Canal wasteway discharge gates were restored and are functional as of April 2025.

Effects on the canal walls and historic properties that were observed during the site visit appear consistent with long-term weathering, erosion, and corrosion associated with their age and long-term submergence and run-off/seepage from surrounding features. Project operations have had a limited effect on the historic properties along the North Canal. Typically, large changes in water surface elevations and flows have the most impact on structures; however, due to operations in recent years being limited to leakage through the North Canal gatehouse, large changes in either water surface elevation or flow have been limited to canal water level management.

Intake structures abandoned by their associated mill owners are typically in a state of disrepair. This can lead to canal wall sections partially collapsing into the intake structure or pulling stones with it as it leans into the canal. Maintenance and removal of unused intakes is the responsibility of the mill owner and is not associated with Project operations.

5.3 South Canal

5.3.1 Condition and Structural Assessment

Based on review of available documents and the site visit performed on October 22-24, 2024, it was observed that the condition of the north and south walls varies along the length of the South Canal. The canal walls are comprised of various materials and construction efforts ranging from dry-laid stone (without mortar), masonry (dry-laid stone with mortar connecting stones), various types of concrete, brick-and-mortar, and combinations of the aforementioned. The conditions observed are typical for walls of this age. Detailed information on the construction of the walls is limited. Most of the condition and structural assessment was limited to observations made of the exposed portions of the wall performed during the field visit. In general, extensive vegetative growth was noted along both the north and south walls of the South Canal; however, it was noted that most vegetative growth was limited to grassy plants and vines, with occasional woody growth that had been cut back or treated.

Wall sections were divided up based on the type of wall and corresponding condition traits. Wall section naming corresponds to having the first letter represent the associated canal (i.e., “S” for South Canal), the second letter representing the associated compass direction for the wall on that canal (i.e., “N” for north wall), and a numeral in sequence for that canal wall starting at the gatehouse and continuing downstream (i.e., the first wall section downstream of the corresponding gatehouse would be “1”).

Based on the observations made of the wall surfaces and condition during the site visit, HDR has assigned a risk level category between 1 and 5, with 1 indicating structures that are heavily impacted and in a state of heavy disrepair and 5 indicating structures that are in great condition. Risk Levels 1 and 2 are generally reserved for conditions that impact stability, plumbness, or heavy deterioration/erosion. Risk Levels 3, 4, and 5 usually indicate the wall section is stable and generally plumb. Appendix C summarizes the results and observations of the field inspection. As indicated in Appendix B and C, most wall sections were rated at Risk Levels 3, 4, and 5. Wall sections that were categorized as Risk Levels 1 and 2 are described in further detail in the following tables.

Wall Section	Station	Risk Level
SN5	5+90 to 7+40	2
Observations		
This wall section is generally comprised of dry-laid stone (though a portion of the wall has been repaired and re-mortared). Large voids of missing stone are noted sporadically along the length of the wall. This wall section also includes two old gate intake structures. Both structures are in a state of heavy disrepair. This disrepair has led to the surrounding wall section being affected by the steel anchors/bolts for the various structural components, pulling the stones from the wall. Additionally, the wall section has several areas of vegetative growth; the crest, in particularly, is covered in trees and shrubs, which may impact the structural stability of the wall due to root structures growing in cracks and voids between the stones. Portions of the wall face do not appear flush.		
Recommendations		

The wall section face should be repointed so that the face is flush and plumb. Any voids should be filled with similar stones and joints between stones should be mortared like the previous repair work. The two old gate structures should be restored, rehabilitated, or preserved. Any openings from the gate structures should be filled with stones and mortared to prevent seepage. Maintenance and removal of unused intakes is the responsibility of the associated mill owner. All woody vegetation on the surface of the wall and the crest should be removed including brush and trees.

Photos

Wall Section	Station	Risk Level
SS11	15+10 to 15+40	2
Observations		
The bottom portion of the wall section is dry-laid stone and is in relatively good shape, despite various small voids. The upper portion of the wall section is a brick-and-mortar frame surrounding a pipe exit, creating a hollow void approximately 2-feet-wide by 4-feet-high with the pipe at its center. The pipe exit has been stubbed and capped. Seepage is noted around the interior of the void. The brick frame has shifted over time and, rather than in line with the wall face, has rotated approximately 45 degrees on one side and about 10 degrees on the other. Additionally, there is a sizable number of lost bricks within the framing, and some of the mortar holding the remaining bricks in place also appears to be missing.		
Recommendations		
The existing brick framing should be repointed, re-mortared, and added to for support of the structure around the sealed pipe. The rest of the opening surrounding the pipe should be filled with similar stone to the rest of the wall and mortared to prevent erosion and leakage and to add stability to the rest of the wall section.		

Photos

Wall Section	Station	Risk Level
SS13	17+25 to 17+50	1

Observations

This wall section is comprised of dry-laid stone. The stone, however, has numerous voids in this vicinity. Additionally, the wall appears to have been retrofitted for a discharge pipe and supported by steel framing at the base of the wall. The dry-laid stone in this area has collapsed, creating a void of approximately 18 inches wide for almost the full wall height. Loose stone can be seen surrounding the discharge pipe and the steel frame along the base of the wall. The only functional portions of the wall at this location are the cap stones. The discharge pipe entrance is visible, indicating it has not been filled in. Its purpose and current usage status is unknown.

Recommendations

Determine functionality of discharge pipe. If pipe is no longer active, completely seal with concrete cap. Fill void in wall with similar stone and mortar joints to prevent leakage from pipe and groundwater seepage in old voids.

Photos

5.3.2 Review of Project Operations' Effect on Historic Properties Along the South Canal

Under the current FERC license, Essex is not required to maintain a specific water level in either of the canals, or to allocate downstream flows between the canals and the main channel of the Merrimack River. In the past, the South Canal gatehouse was typically operated to maintain a steady state pool at a standard level of approximately two (2) feet below the top of the South Canal walls. Essex Company maintained inflows into the canals to match observed outflows (e.g. withdrawals by the mills or leakage) or needs as reported by the mill power owners.

The South Canal houses four (4) sets of leaf gates that are split across two bays, two sets of leaf gates per bay. The leaf gates are comprised of four panels each, where the bottom panel lifts first and then engages each subsequent panel as it rises. Due to deterioration of the leaf panels and the gate operators, stoplogs were placed along both bays, rendering all of the gate panels inoperable, and unable to pass flows. Each leaf measures 9-feet, 9.75-inches wide by 3-feet, 3-inches tall and are configured in a manner where there is a 3-inch overlap of one leaf with the next leaf in succession so that the general openings before the next leaf is raised is 3 feet. The bottom most gate panel has a sill elevation of approximately 28.1 feet NGVD 29 (23.0 feet Essex Datum); each subsequent sill elevation is 3 feet above the former. Each leaf gate set can discharge a total of 2,769 cubic feet per second (cfs) at a normal headpond level of 44.2 NGVD29.

For periods of construction or inspection, the South Canal is drawn down using the South Canal Wasteway and limiting inflow from the South Canal gatehouse. Operations of the canal levels typically do not result in large changes in inflow or water surface elevation. Due to the disrepair of the South Canal gatehouse gates, current operations correspond to limiting inflow into the South Canal to purely leakage since approximately 2010; because of this, the South Canal water surface levels have been typically limited by the leakage of the South Canal Wasteway low level gate. The South Canal Wasteway's intake is approximately 26 feet wide in total. The intake is separated into four weir sections that measure approximately 5 feet wide each. Varying amounts of stoplogs are placed in these weir sections to control discharge elevations; the sill elevation of the weir sections is unknown. A vertical slide gate with unknown dimensions and a sill elevation of approximately 31.1 feet NGVD 29 (26.00 feet Essex Datum) is located at the base of the intake (below the weir sections). This gate is used to drain the South Canal below the weir heights when necessary. The South Canal Wasteway measures approximately 384.3 feet long with a slope of approximately 18H:1V, starting at invert elevation 29.6 feet NGVD 29 (24.5 feet Essex Datum) and ending below the normal water surface elevation of the Merrimack River at approximately invert elevation 7.9 feet NGVD 29 (2.8 feet Essex Datum). The pipe is constructed of steel on is exterior but was recently lined with a Spirolite High-Density Polyethylene (HDPE) liner; the exterior steel pipe with riveted joints has a 70-inch diameter while the Spirolite HDPE liner has a 66-inch internal diameter. The void between the previous steel pipe and the newer Spirolite HDPE liner was filled with low density cellular grout. Full capacity of the South Canal Wasteway is approximately 878 cfs.

Effects on the canal walls and historic properties that were observed during the site visit appear consistent with long-term weathering, erosion, and corrosion associated with age and long-term submergence and run-off/seepage from surrounding features. Project operations have had a limited effect on the historic properties along the South Canal. Typically, large changes in water surface elevations and flows have the most impact on structures; however, due to operations in recent years being limited to leakage through the South Canal gatehouse, large changes in either water surface elevation or flow have been limited to large storm events.

Intake structures abandoned by their associated mill owners are typically in a state of disrepair. This can lead to canal wall sections partially collapsing into the intake structure where there are voids or erosion. Intake structures anchored to the canal wall section can pull the stones with it as it leans into the canal. Maintenance and removal of unused intakes is the responsibility of the mill owner and is not associated with Project operations.

6 Analysis and Discussion

Wooden structural elements of the historic resources located along the North and South Canals appear most susceptible to damage from submergence, periodic inundation, and waterborne trash. Intake structures abandoned by their associated mill owners are typically in a state of disrepair. This can lead to canal wall sections partially collapsing into the intake structure. Maintenance and removal of unused intakes is the responsibility of the mill owner and is not associated with Project operations.

Canal water levels are controlled by gate structures which can be used to isolate the North and South Canal systems from the Merrimack River during high-water events. While the magnitude of fluctuation in the North and South Canals has been significantly reduced in recent years by generally limiting flows to leakage through the gates and stoplogs, the canals and Merrimack River still serve as run-off detention locations during stormwater events beyond Essex's control.

Above the North and South Canal Gatehouses, Merrimack River high flow events can also mobilize waterborne trash and debris that have the potential to damage wooden structural elements; however, neither high flow events nor the presence of waterborne trash and debris in the Merrimack River are attributable to Project operations. Past and present land use activities (e.g., industrialization, commercial development, etc.) will likely continue to contribute to the accumulation of waterborne trash within the Project's North and South Canals. Given the diversity of historical and current land use activities, tracing and identifying the sources of waterborne trash is complex. Waterborne trash consisted of common materials such as Styrofoam, plastic cups, plastic bottles, and organic debris. Roads, construction, recreation, and commercial and industrial developments all can contribute to the problem. Ongoing Project operation and maintenance has very little potential to cause and/or significantly contribute to the waterborne trash accumulation.

Effects on the canal walls and historic properties that were observed during the site visit appear consistent with long-term weathering, erosion, and corrosion associated with age

and long-term submergence and run-off/seepage from surrounding features. While normal Project operations do not appear to be adversely affecting the canal structures beyond normal wear, it should be noted that Project operations should be limited to smooth transitions in water surface levels and flows in the canals. During high water surface elevations, the soils behind the canal walls become saturated with water through the voids and empty mortar joints in the walls, leading to higher soil pressures against the wall. While the canals are fully watered, the water serves as a balancing force against the walls to hold them in place. Drawdowns remove that water pressure force on the walls from the canal side while the saturated soils behind them have increased pressure forces compared to their dry states. Additionally, fluctuations of water surface elevations can impact historic structures along the canals. Timbers that fluctuate between exposure to water and exposure to air more readily decompose. Similarly, steel and other metals tend to corrode faster during fluctuating water surface elevations due to the shifts in temperature between the water and air, the higher concentration of oxygen in air after the water has started the corrosion process, and the changes in flow rates during dewatering and rewatering of canals.

7 Variances from FERC-Approved Study Plan

The RSP indicated that the study area for the Condition Assessment of Historic Properties and Associated Canal System would include the Central Bridge. However, during the review of the various reference documents and the data available from the Massachusetts Cultural Resource Information Systems, the Central Bridge was noted to be outside of the APE. Therefore, potential impacts of historic, current, and proposed project operations on the Central Bridge were not included in this study.

8 Germane Consultation and Correspondence

A summary of germane correspondence and consultation related to the Condition Assessment of Historic Properties and Associated Canal System is presented in Table 8-1. Appendix D provides copies of relevant correspondence.

Table 8-1. Germane Consultation and Correspondence

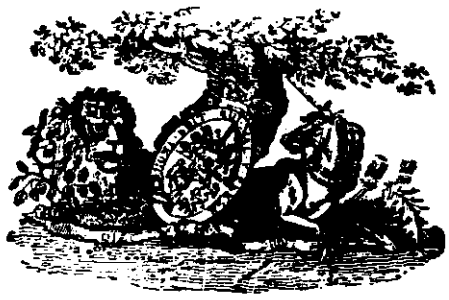
Date	Type	From	To	Subject
July 16, 2024	Letter	Essex/HDR	Lawrence Historical Commission	Initiating Consultation and Requesting Concurrence on the Area of Potential Effects for the Lawrence Hydroelectric Project
September 24, 2024	Letter	Essex/HDR	Massachusetts Historical Commission	Second Request Concurrence on the Area of Potential Effects for the Lawrence Hydroelectric Project

Appendix A - Documents Reviewed

The Essex Company

on the Merrimack at Lawrence

F. MORTON SMITH



"Were American Newcomen to do naught else, our work is well done if we succeed in sharing with America a strengthened inspiration to continue the struggle towards a nobler Civilization—through wider knowledge and understanding of the hopes, ambitions, and deeds of leaders in the past who have upheld Civilization's material progress. As we look backward, let us look forward."

—CHARLES PENROSE

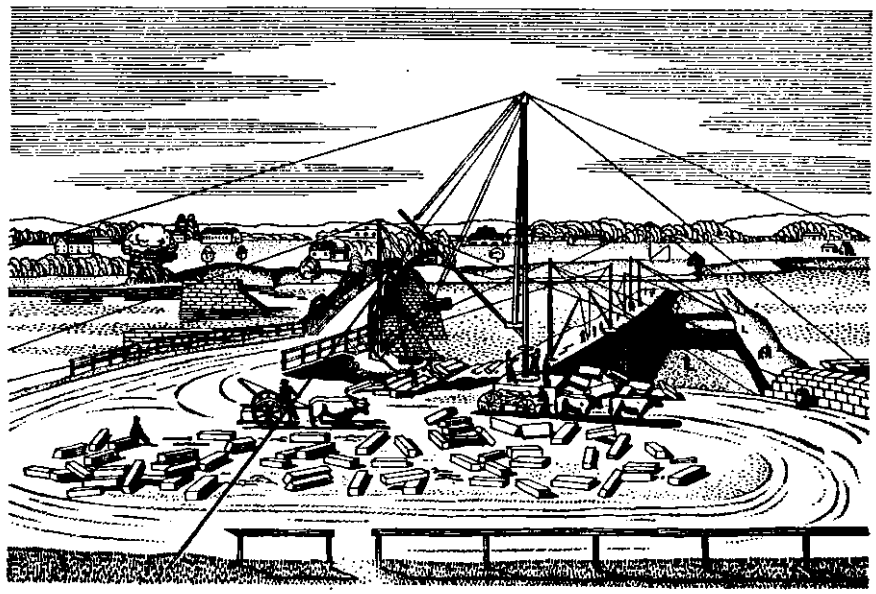
Senior Vice-President for North America
The Newcomen Society of England

This statement, crystallizing a broad purpose of the Society, was first read at the Newcomen Meeting at New York World's Fair on August 5, 1939, when American Newcomen were guests of The British Government

"Actorum Memores simul affectamus Agenda"

THE ESSEX COMPANY

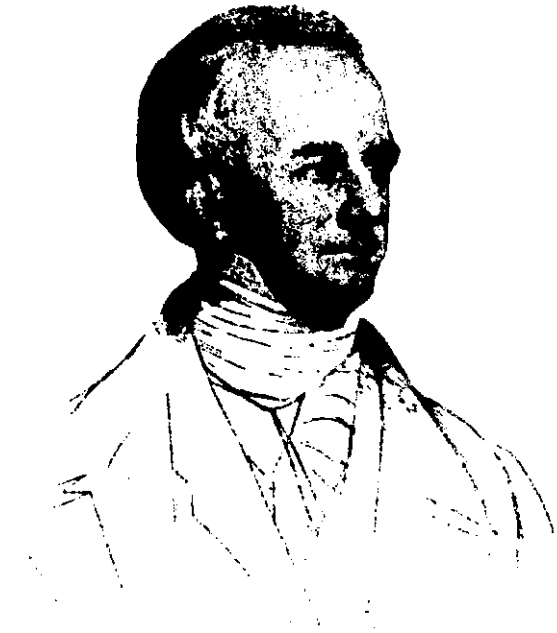
on the Merrimack at Lawrence



BUILDING THE GREAT DAM

At Lawrence, Massachusetts, U.S.A.

From a Water Color painted at the Site in June, 1847



Abbott Lawrence

The Essex Company
on the Merrimack at Lawrence

F. MORTON SMITH

MEMBER OF THE NEWCOMEN SOCIETY

TREASURER

THE ESSEX COMPANY

BOSTON

THE NEWCOMEN SOCIETY OF ENGLAND

AMERICAN BRANCH NEW YORK

1947

First Printing: March 1947

This Newcomen Address, dealing with early history of hydraulic works at Lawrence, Massachusetts, on the Merrimack River in New England, was delivered during the "1947 Boston Dinner" of The Newcomen Society of England, held in Georgian Room of the Hotel Statler, at Boston, Massachusetts, U.S.A., on March 13, 1947

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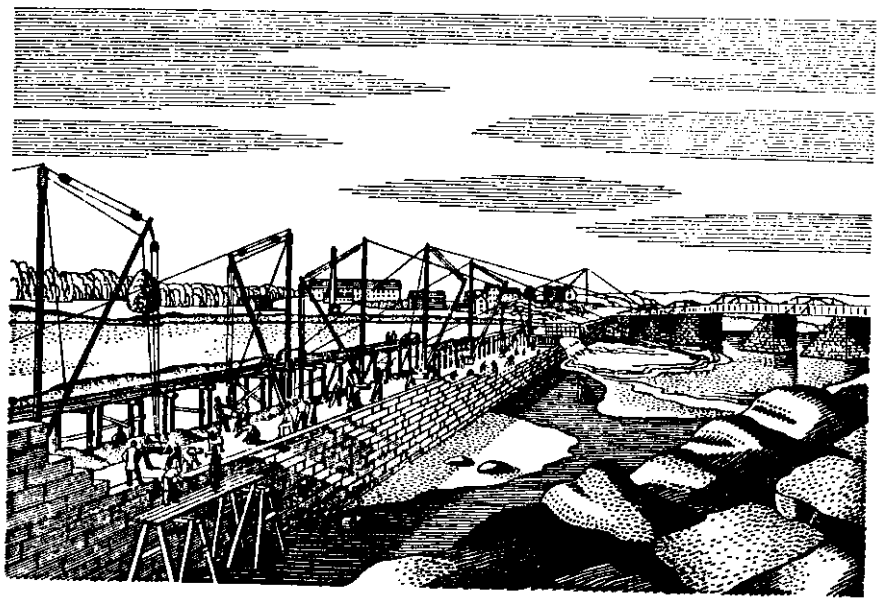

My fellow members of Newcomen:

A YOUNG woman stood in the door of the inner office. "Mr. Samuel H. Wolcott is on the telephone." The Treasurer of the Essex Company pushed aside a block of paper that he was writing a letter on and took up the instrument. "Hello, Sam," he said. "What can I do for you?"

"Have you some spare time?" asked Mr. Wolcott.

"Yes, I have," said the Treasurer. "A couple of hours. A quiet afternoon. A good rainfall up country. River full—all wheels turning."

"Well," continued the President, "there is a Dr. Penrose of Philadelphia here. He is interested in the early history of the Essex Company. He is the Senior Vice-President for North America in The Newcomen Society of England."

"I never heard of the Society," said the Treasurer. "Ask him to walk over to 50 State Street and I will tell him as much as I can remember of the Essex Company."

It was an old-fashioned office; there were models of ships, pic-

tures of Lewis Wharf, Peabody's Australian Packets, the Old Salt Houses on Long Wharf, and a network of spars of the sailing and early steam vessels tied up at Commercial Wharf. It was like so many other old Boston offices, with a baby jumbo desk, on which sat a model of a Merrimack River barge and catboat. There was a Santo Domingo mahogany stand-up desk with its high chair used in one of the clipper ship offices. Sometimes the Treasurer stood up and wrote on it. It rested his legs to stand up.

❦ ❦

The Treasurer of the Essex Company was also the Treasurer and Wharfinger of three Wharf Companies, and Long Wharf, about which Boston grew, was by far the oldest with its Royal Charter granted by George the III and a seal dated 1772.

Any Trustee's office that had the original dust of fifty years or more in the bottom drawers of its desks should have a charitable organizaton attached to it, and so the Treasurer of the Wharves and of the Essex Company, just as his father had been before him, was also Treasurer of the Boston Port and Seamen's Aid Society, called The Mariner's House, a home for seamen. Salt water and fresh water—salt to carry ships from the wharves to all parts of the world; fresh to turn the wheels that wove goods in Lawrence.

❦ ❦

"Good afternoon, Dr. Penrose," said the Treasurer. "I am very glad you have come to see me. Mr. Wolcott, who asked me to talk with you, is the President of the Essex Company. His grandfather, J. Huntington Wolcott, was President before him. Won't you sit down? I think you will find that old armchair comfortable. It came, as I recall it, from an early Bank Director's room. Now I am going to tell you, as I can remember it, *the history of the Essex Company*,—how it built a dam, founded a town, and developed that town into one of the greatest weaving centers of America.

"It is an interesting story, and I want you to stop me whenever you wish to ask questions."

"There was a farmer by the name of Daniel Saunders who lived not far from the town of Andover. Like so many other early men

of New England, he had a keen eye for the development of natural resources, and also for a little manufacturing, for he operated a small mill, carrying on cloth dressing and wool carding, which I suppose was only a few steps advanced from the early methods.

"Mr. Saunders was a man familiar with the Merrimack River. He had stood many times at a place called Bodwell's Falls and watched the water pour over the ledges. Saunders, being a man of ability and foresight, quietly had some surveys made of the river with the idea in the back of his mind that at these Falls a permanent dam could be built and a great water power developed.

"Mr. Saunders worked eagerly. He interested men with money and men who were anxious to go into the textile business. As a result of his work, in 1843 the Merrimack Water Power Associates was born, with Samuel Lawrence as its first President and Treasurer, and Daniel Saunders as its Agent.

"Samuel Lawrence at that time was a man of importance and wealth for he was Treasurer and Financial Agent of the Middlesex Mills. It was largely because of his enthusiasm and family position that in the year 1845 the Massachusetts Legislature granted a Charter of Rights to the Association under the name of the Essex Company. Samuel Lawrence, John Nesmith, Daniel Saunders and Edward Bartlett were the first incorporators."

"Let us go in our minds to the State House at Boston for a few minutes and imagine those men standing around a desk while Governor Briggs signed the Act. I don't think he used more than one pen, and I expect he put that one back on the bronze pen rack. Briggs undoubtedly wished the gentlemen success, for it meant much to Massachusetts. You don't recall, Dr. Penrose, the old Fitchburg Depot, (Oh, you do!) but here the gentlemen boarded a wooden coach for North Andover, where they got off and climbed into horse-drawn carriages to be driven to the Andover Bridge that crossed the Merrimack below Bodwell's Falls."

"I wish I had time to tell you a word about our early New England Proprietorships. You saw painted on the outside door of

this office, 'Proprietors of Boston Pier or the Long Wharf.' That was one of the earliest; and now in 1793 a group of men formed The Proprietors of the Andover Bridge, which built and owned the bridge. No, there were not shares of stock, but each Proprietor owned a certain proportion of the Company, according to what he put into it.

"I am going to refresh my memory, Penrose, from this book I have here, because I want to tell you the names of the men in that party. They are the early pioneers who built the dam and Lawrence.

"There were Abbott, William, and Samuel Lawrence, John and Francis Lowell, George and Theodore Lyman, Nathan Appleton, Patrick T. Jackson, Ignatius Sargent, William Sturgis, John Nesmith, Jonathan Tyler, James B. Francis, and Charles S. Storrow, men who were foremost in the development of Massachusetts, not only in commerce, but in science and learning. Francis, as the years went on, became one of the greatest hydraulic men of his time. Remind me to tell you about him later.

"These were the men whom Saunders led out into the old Andover Bridge, just below the Falls, and as they looked over the tumbling water, they must have stopped to admire the lovely flat flood-plains of the valley landscape and then been overwhelmed by the significance of the power of the river as it fell.

"Can't you imagine, Penrose, how Storrow, the engineer, hung out over the rail of the Bridge, peered down into the stream as the triangular cobblestone buttress split the current?

" 'Saunders,' he shouted above the roar, 'there is the spot to build the dam, with its canal gates. Anchor the end on the solid rock. There below our dam will grow a city with its mills alongside a canal that will furnish power to turn their wheels. There will be warehouses filled with woven goods, from whose doors railroad cars will be loaded with manufactured products to be hauled to Boston and sent to our young West, and by water from the docks of Boston around the Horn to Frisco, to Europe and South America.'

"Storrow stood apart from the group of men for a long time, his eye resting on the Falls and the farms below. 'Here,' he said to himself, 'here, instead of corn, will grow houses for people to live in; for men and women who will work in the mills, earn a living, and make for themselves a place in this coming industrial center of America.' "

"When they had finished looking at Bodwell's Falls, these men all climbed back into their carriages and drove back up the country road to the *Merrimack House* at Lowell. Saunders had told Landlord Larrabee to provide a dinner that was a dinner, for there were to be gentlemen from Boston to test his bill-of-fare.

"Once dinner was over, Storrow was chosen Secretary for the group and made his first entries in the record book. Then Samuel Lawrence and Saunders agreed to turn over the Merrimack Water Power Association with its water rights and land to a new corporation, the Essex Company, for Thirty Thousand Dollars.

"Abbott Lawrence looked, also, from the Andover Bridge into the future, for two days after the incorporation he subscribed $100,000 for a thousand shares of stock, and a million dollars was raised at once. Abbott Lawrence became the President and Charles S. Storrow the Treasurer. Some 2300 acres of land were acquired along each side of the river.

"Early in that same year, Mr. Storrow, the engineer, prepared plans for the great dam, its canals, mill sites, and the principal streets and squares of the town that he knew would become a city."

"I want to tell you, Penrose, a little more about Storrow. He was not only a railroad and civil engineer, trained in hydraulics, but he also had a splendid knowledge of city planning, and it was through his energy and influence that the beautiful Common in Lawrence exists as it does today, that the streets of the city are so scientifically laid out.

"You see, those men at that time had not only an engineering feat in harnessing the river to deal with, but they also had on their hands the beginning of what you might call civic planning.

They were actually doing in the same way what the Planning Boards in our cities, operating under the guidance of trained civic planners, are doing right now. There were Zoning Laws, only they were not called Zoning Laws; there were Building Laws, only they were not called Building Laws.

"When land was sold along Essex Street, intended to be the main business street of the town, restrictions were placed upon it. Buildings had to be built of brick, so many stories high. They had to have slate roofs for fire protection; there were set-backs; your store front had to be uniform with the next fellow's—and only business could be carried on which would not be detrimental to the textile industry and to the welfare of the town. Here was zoning. It was all written out in the deeds given to each purchaser.

"Abbott Lawrence was not only the big man of his town and city; he was a remarkable man in many other ways. One of the finest things he ever did was later to found the Lawrence Scientific School at Harvard College, where young men could be trained in all branches of engineering and science. I think it was in 1848 that he almost became Vice-President of the United States. His daring and absolute confidence in what he was doing saved the Essex Company more than once from financial difficulty. As President of the Pacific Mills, he guided that large enterprise to safety when, during an early depression, the mill's future hung in the balance."

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"Penrose, I know that you are an engineer and as such, if my guess is correct, you are interested in how the great dam was built, what sort of plan Mr. Storrow drew, and how he arranged to have the work carried out. No steam shovels; no electric drills in those days. No power cement mixers and automatic buckets to handle it. Every block of granite was cut, fitted, and put in place by hand.

"You must have sailed up Boston Harbor quite some few times in your life and you must have noticed the granite forts on the islands. Some of the forts—I can't tell you which—were constructed by a Captain Charles H. Bigelow. Mr. Storrow must have

known him and, recognizing his ability as an engineer, placed him in charge of the building of the dam.

"First, the foundation blocks of the dam were set in cement and bolted to the bed rock of the river bed.

"You have asked me how broad it was at the base. As near as I can remember, some thirty-five feet and tapers to some thirteen feet in width just below the top layer of blocks, which as you know was called the 'crest stone.' I think the greatest height of masonry from the bed rock of the river bed is forty feet, with an average of thirty-two feet.

"I wish, Penrose, that you would get up for a minute and stand in the doorway and look at the wall of the outer room. Thank you. You see over there a photograph of the Great Dam, running in a flat curve across the river, and the water plunging over it and falling in a beautiful arch to the river bottom. I have hardly ever seen a picture of a dam taken at low water. High-water pictures are the most dramatic, and who wants to see a dry river?

"Now, what do you guess the length of the dam to be from looking at the picture? You said between fifteen hundred and sixteen hundred feet? Well, you are pretty nearly on the bull's eye. It is actually 1629 feet long, and there is an unbroken fall of over nine hundred feet. These figures are interesting because they show the huge construction problem that Storrow and Bigelow had to face. Remember, it was all created *by hand.*

"Up in the Chief Engineer's office at Lawrence there are four water colors, painted during the Summer of 1847. They are fascinating. All the granite blocks were hauled by oxen and hewed into the exact size to fit. A coffer dam kept the river away from that portion of the wall being set on the bed rock. Wooden derricks, with pulley and tackles, lifted up the blocks as the hand winches wound up the rope, and when they were swung just right, the blocks settled into place amid the shouts of the workmen. As the work went on, one of the pictures shows a wooden trestle built of posts and timbers, and on this I expect a sort of flat car carried the blocks out to where they were to be lifted up and lowered in place. It must have been an imposing sight to watch this hand-

made wall of masonry progress foot by foot across the stream and grow higher and higher as it went."

❦ ❦

"There are two canals today with their gate houses which regulate the flow of water, and the dam develops approximately one hundred forty-four mill power of primary power, which, you know, means ten thousand horsepower. There is an actual installation of about twenty-two thousand horsepower, much of which is used when water conditions permit. A mere drop in the bucket today—a tremendous power in Saunders' and Storrow's day.

"Gilmore and Carpenter, contractors, started the excavations for the dam in August, 1845. The first stone was laid in the foundation on September 19, 1845, and *three years later to a day* the last stone was put in place. I have heard it said that once during the construction a freshet carried away a coffer dam, but not a single stone in the permanent structure moved nor has one moved *since.*

"There have been many floods on the Merrimack River. In the year 1852, the river rose and rushed over the top of the dam some ten feet deep, carrying away the fishway and parts of the old Andover Bridge."

❦ ❦

"Now I am going to tell you a story which has nothing to do with Lawrence. I think that it is fascinating, and will tell you about the foresight of that wise hydraulic engineer James B. Francis and the so-called '*safetyguard gate*' which in the 1936 flood saved the business section of Lowell from being inundated to a great depth.

"And here is the story, Penrose, as it was told to me in 1936. What parts of it are accurate—what parts of it are pure fiction—I don't know.

"A young man bent over his drawing in the drafting room of the Locks and Canals at Lowell. Before him were all the flood records of the Merrimack River that he could gather from talking with the farmers, from traces of high water upon the rocks and deposits of silt. His data were insufficient, largely legendary. He

had often watched the river in flood; he understood the force of the water. He had computed the maximum volume of a spring freshet caused by all the snows of the entire valley extending for miles into the mountains, every flake melting in a few days beneath a warm rain and rushing headlong at one time down the river.

"James B. Francis arose from his round stool and took his calculation to his superior in the company. He was told that the river could not rise that fast and that high.

"Francis looked out of the window at the town that was beginning to become a city—at walls of brick that were shaping themselves into mills, and throngs of workers pouring from their entrances.

" 'Look,' said Francis, 'there before us is the answer to the argument—absolute safety for the people, for the merchants.'

" 'I tell you,' repeated the other man, 'it is folly—rank folly; and yet it may make the storekeepers, our mill owners, the people, themselves, feel easier. Safety of life, safety of capital are always worth the striving for. You have permission to build your lock gate. If it is ever lowered it will close the canal that runs through the town and send the water out around it.'

"Carpenters and joiners constructed across the canal a huge gate of solid oak, a gate as heavy, massive, and strong as one in a medieval castle. It slid up and down in grooves cut into solid blocks of granite. It was suspended by a single wrought iron chain hanging from truss work and beams hewed from the largest pine trees that grew. Over it all was erected a building to keep the weather from rotting it. Men built well in those days, and under Francis' eye the workmanship was as perfect as that used in making the finest pieces of mahogany furniture. It was his idol—his masterpiece.

"The heavy gate was raised by scores of men with tackles and winches. The last link in the chain was welded in place and there it hung waiting for the water to rise so high that the canals would overflow and flood the town. Then the gate would be lowered and the flood diverted and the town saved.

"On the beam near the chain Francis placed a box, and in the box he put cold chisels and hammers to cut the link so that no time might be lost in looking for tools when a catastrophe was upon them and the gate must be lowered.

"That was in 1852—*eighty-four years* before the Spring of 1936.

"Francis became a renowned hydraulic engineer, but throughout his life he was known as a man who built a flood gate that had never been lowered—a gate called '*Francis' Folly.*' "

"There are some men today who, like Francis, sit in their offices behind their drafting boards and who hourly record the heights of water in the river. They know exactly the depth of snow in the valley—how much water had fallen when it rained a hundred miles north of them. The river to them is all-powerful, a whimsical old man, that must be humored and when in a rage controlled by their dams, canals, and flood gates.

"And so in March, 1936, the telephone rang in the company's office of Locks and Canals at Lowell. An elderly man answered it. The call was from Manchester, New Hampshire—up river. 'It is still raining,' he said quietly to his assistant. 'Temperature about 50 degrees; precipitation, three inches.' A chart was laid before him. He ran his eye over the past high-water levels of the river, and the flood dates. Then he made some hurried calculations.

" 'You will keep all your men on tonight,' he said. 'Tell every gate man to stand by. Notify every mill agent to move their goods from their basement—not to their first floors, but to their *second* floors.'

"Night wore on, the warm rain never ceased. At times the telephone rang. The elderly man in his chair smoked serenely, making notes on his pad. Men outside were loading thousands of sand bags into trucks. Gang after gang with their foremen moved out for designated danger spots. He checked them as they went.

"The assistant engineer took up the 'phone. 'Plymouth reports one inch of rain in an hour, temperature 52 degrees. Tyngsboro reports; Manchester reports the flood is fifteen feet over the crest

of the dam; our Gate House No. 1 reports water lapping over edges of canal, gates bulging.'

"The man took his pipe from his mouth and filled it. 'Advise Baldwin of the Essex below us at Lawrence—and in the bottom of the file labeled "Flood," you will find an old brown envelope marked "Francis' Folly." In it are his tables of possible high-water levels and a plan of his safety gate.' "

"He opened the envelope and spread out the dim calculations before him. 'Fifteen feet over the dam at Manchester means twenty feet at Lowell,' he read. 'It will reach us at seven in the morning. Seven feet above the record.'

"Carefully he folded up the plan, slipped it into his pocket, pulled on his rubber boots and rain coat.

"Searchlights flooded the truss work that held up the massive gate, Francis' Folly. Men with the cold chisels and hammers from the box cut on each side the iron link of the chain until it was nearly severed.

" 'Now, as I count, strike together!' shouted the man in the rain coat from below. 'Blow on blow, so that the link breaks evenly.'

" 'One, two, three, four.'

"The link snapped, with a roar and a jar that shook the building. Francis' Folly slid down the stone grooves without binding and settled into place.

"Outside a man shouted, 'She holds! The water is one foot from the top and dropping. It flows *the other way*.' "

"Many men that same morning had their breakfast and went down the Main Street of Lowell to their stores, little realizing that had there not been a gate of solid oak, the water would have been five feet deep where they stood and worked.

"The elderly man sat in his office; his paper had fallen on the floor; he slept in his chair; and spread out before him on his

drawing board was the plan of Francis' Folly—the plan made by James B. Francis, who with Storrow looked at Bodwell's Falls from the old Andover Bridge."

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"Let's go back, Penrose, to a few facts," said the Treasurer. "I hope that story did not tire you. You asked about the canals. Well, the North Canal is nearly a mile long and at least a hundred feet across, running parallel with the river some four hundred feet inland from its bank. On this canal are still located the Pacific Mills, Washington Mills, Pemberton Company, Lawrence Duck, and The Everett. Water flows from the canal into penstocks, then passes through the water wheels and flows by raceways back into the river bed. Each mill owns its own penstocks, wheels, and raceway. The amount of water used is measured by the Essex Company and paid for by the mills.

"When the land was sold by the Essex Company to a mill, an indenture or agreement was entered into, whereby the mill was forever to have so many mill powers attached to the land, and was to pay the Essex Company annually so many ounces of silver per mill power. This agreement is perpetual and is a covenant, as the lawyers say, running with the land. The value of a mill power was set on the North Canal in ounces of silver of a certain fineness.

"There were lots of contracts in New England about this time payable in metals; the founders of the Essex Company for some reason used silver. Holyoke Water Power used gold, but on the whole silver has stood the test—sometimes low, sometimes high, but never off the gold standard, as the World has been. These mill powers we call *permanent powers*. Look, Penrose, at that telephone. It costs so much a month to have it on my desk, and with it go a few hundred calls. That is like our permanent powers. Every time I call New York, or use more calls than I am allotted, the Telephone Company charges me for extras, and every time a mill uses more water than is allotted to it in its permanent powers, that is what we call *surplus power*, and we charge for it at a different rate.

"Now, you have asked me if there is a South Canal. Yes, there is. It is not as wide as the North Canal. It was built later. It ends

in a penstock which finally empties into the river, and on this Canal are located today a number of mills, with the huge Wood Mill of the American Woolen Company at its lower end. Here payments are estimated in dollars, not silver."

"The town of Lawrence was a great beehive in those early days. I expect very much like a growing mining camp in the Rockies. I notice you have a curious look in your eyes. You are saying to yourself, 'Why does this fellow talk so much about Lawrence, the city today, and not about the Essex Company that I came to ask him about?' Well, the reason is this: that the town and city were as much a part of the general plan to Saunders, Storrow, and Abbott Lawrence as the dam was. They were creating a tremendous source of natural power, and they were also building a city. Both had to be scientifically and properly planned. Both had to go hand in hand. There could be no separation.

"The whole world of the valley centered around the dam where stone cutters hewed the granite into blocks and hauled them to their places. There were temporary shops and quarters for the workers. You will still hear it said that a man named Timothy Osgood ran a famous boarding house with mountains of food and a heavy hand of discipline.

"The walls of the large mills went up one by one. Captain Bigelow, who had charge of the work on the dam, constructed a number of them. These mills were built by the Essex Company for their owners, and turned over to them ready to run. For the Essex Company was the Stone & Webster of its time. It sold the land, it sold the power, and it would build for a price a mill, flumes, penstocks, raceways, and all that was necessary. There were one-story buildings on Essex Street. There were plank walks; there were the problems of getting rid of mud holes and sewage. The town had to be lighted. The old Andover Bridge, a rough wooden structure, the main artery across the river, was not adequate. There must be a new bridge. There was a new bridge. Storrow and Bigelow solved one problem after another, with Abbott Lawrence always behind them.

"A town government was formed and gradually took charge of the town itself. Churches, schools, charities were organized, and a large foreign population began to pour in to take their places at the looms. The town grew and grew and in the year 1853, eight years after the company was incorporated, the legislature of the Commonwealth of Massachusetts again considered this manufacturing center and said, 'You are by charter now the *City of Lawrence.*'

"The Essex Company, always mindful of its youthful child, and as I have told you before, having a very clear idea of the necessities of city planning, gave to the new city its very civic heart—land for a public common, and those men who handled the affairs of the company very wisely said that no structure, building, or monument should ever be erected on that Common without the consent of the Essex Company, which consent has never been withheld, provided the use proposed conformed with a good city plan.

"There is a splendid park on Prospect Hill known as Storrow Park. A bit of land, The Amphitheatre, Union Park, Wolcott Park, Stockton Park—breathing spaces for the crowded city. And the people of a city must have breathing places and places where children can play.

"Early in 1850, the Essex Company and The Bay State Mills built a reservoir on the top of Prospect Hill, from which came water for drinking and fire purposes. I believe both companies together spent a hundred thousand dollars. The reservoir for fire purposes was abandoned some few years ago when a community main was installed to which the fire pumps at all the adjoining mills were connected to furnish adequate pressure; the drinking water now comes from a modern purification plant."

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"Any man who lived in the country as Saunders did, and any man like Storrow who had a love for the elm trees of Boston and our New England towns realized that a city should be more than bricks and mortar, that there should be trees, and so they planted trees along the sides of the streets and especially the Common, which is surrounded and shaded now by their elms.

"When Abbott Lawrence and Storrow needed money to build mills, they borrowed it from the stockholders by increasing the capital of the company; first one million, then a million four hundred thousand, and then even another million was borrowed elsewhere. Tremendous sums of money for those times, but the faith of the builders of the dam was richly repaid. The profits of the company were large. There were no taxes on profits. Gradually, the capital was reduced by payment of monies back to the stockholders until it now stands at five hundred thousand."

"Among the early ventures of the Essex Company was the Lawrence Machine Shop, which was built and owned by the company, and which in time was sold to a separate corporation known as The Lawrence Machine Company. The building was built of granite, for Captain Bigelow liked to work in stone. It still stands and is known as the Stone Mill—a part of the Everett Mills. Storrow saw the need of a machine shop in his expanding mill town. Machinery must be built—must be repaired. So the Machine Shop made everything in iron from a spindle to be used in weaving to a locomotive.

"Penrose, every now and then I get a catalogue from some dealer in Prints, telling about a fine cut of an early locomotive he has for sale, and people even go so far as to collect early timetables.

"Well, the Lawrence Machine Works' first locomotive was called '*The Essex*' and ran from Lawrence to Boston. Imagine the excitement of the crowd at the Old Depot when '*The Essex*' first left for its run to the Big City. Many a watch came out of a pocket to time to a second that run. Another engine ran from Lowell to Boston. '*The Wayland*' and '*Trent*' went to Ogdensburg, and others to the Erie Railroad. The Hoadley portable steam engine was built there, and it was at the drafting boards and at lathes of the Machine Shop that some of the best mechanics and manufacturing executives of America obtained their training.

"I understand, though I have no way to confirm my statement, that one of the men trained in that same shop produced one of the wonders of that age, the McKay Sewing Machine.

"Then came the great depression of 1857 and the business of the Machine Works shrunk to such a low level that the Stone Mill was sold to the Everett Mills, and was filled with cloth-producing machinery.

"Thus ended an industry, but not until it had left its mark on the mechanical world, and its young men had before them other fields of science to conquer."

"A town had to be lighted. I suppose that was first accomplished by the four-sided glass lanterns on posts in which sat oil lamps. You often see them today at the entrance to old houses which have been restored to their olden ways.

"Some time about 1849, not very many years after the dam was built, The Bay State Mills and the Essex Company officials decided that the town should be lighted *by gas*. So, at their expense, they built the Lawrence Gas Company, and there was an immediate demand for gas-lighting in the larger mills, on the main streets, and then in individual homes. Our Mr. Storrow became the first President of the company.

"There is in Lawrence, you know, besides weaving, a great deal of paper making, and it was not long after the great Machine Shop was built that the Essex Company constructed a building nearby for experimental work in building paper-making machinery. Several of the Essex Company directors were interested in it. The Carter Paper Company was organized. Thus the paper industry in Lawrence began, and the Russell Paper Company was formed. Today, the Munroe and Merrimack and The Champion-International still make paper, and water from the Merrimack turns the wheels."

"There was another side to the character of these early builders. They believed it necessary for the people of their town to go to church, and a year after the last cap-stone of the dam was laid, the company gave land for a Protestant Episcopal Chapel. It was built of wood and, of course, long since has been replaced by a stone structure. The other day, Mr. Prescott, our Cashier

at Lawrence, who has been with the company for over fifty years, telephoned me. It was about a church matter. Years ago, the company had given to one of the churches a piece of land on which to build a parish house, but it was to be occupied by the minister or people of the denomination connected with missionary work. If not so used, then the land came back to the Essex Company. The hand was always on the throttle. Now, years later, the Parish wished to sell the lot, no longer of use to them. The restrictions were removed, the lot sold, and the Parish today have the sales price in their pocket. The Company still must watch out for the welfare of its town."

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"Yes, and besides churches, the company, although not directly, was interested in libraries. No New England town can exist without a library. So in 1847, when there were still oil lamps on street posts, our Captain Charles H. Bigelow became the President of The Franklin Library, incorporated for the purpose of maintaining a library and reading room, advancing arts and sciences, and promoting public instruction by lectures. Abbott Lawrence reached into his own pocket and presented to the Library Association the sum of one thousand dollars. In those days, even in Boston today, the Trustees or Directors of an Association are at times called the 'Government,' and to the Government of the Library Lawrence wrote, 'Please invest in such scientific and other works as will tend to create good mechanics, good Christians, and good patriots.' The man who used his hands—that was all important. The age of the machine was just knocking at the door. The wonder age of atomic power is just now knocking at our door. The use of it rests in our hands."

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"I am not going to stop without saying a few words more about another man who was interested in the City of Lawrence, and who with the help of the Essex Company created what might be called 'a symposium'—Judge White, who was born in Lawrence, graduated from Harvard College in 1797, and was for many years Judge of the Essex County Probate Court. He lived, later on, in Salem and I think was the first President of the very famous

Essex Institute. There were about six acres of unoccupied land in the heart of the City of Lawrence which were controlled by the Judge and the Essex Company. It was a very valuable parcel of land. The Judge drove down to the Essex Company's office and had a talk with Mr. Storrow. Together they drew up an indenture whereby the land would be conveyed to certain Trustees who would sell it and invest the money in a fund to be known as '*The White Fund*,' which had as its purpose the establishment of an annual course of six lectures on 'Good Character' and the best means to promote intellectual and moral improvement. 'Yes,' said Judge White, 'you and I will die some day, Storrow, and we must always have able men as Trustees, men who will look into the future, so we will add one more clause, that each new Trustee, as time goes on, must be approved by the President of the Essex Company, for the President of the Essex Company will always act for the best interests of the city.' Those lectures are given in Lawrence today, and only a little while ago Mr. Wolcott, the President of Essex Company, has just approved the appointment of a new Trustee."

"Penrose," said the Treasurer, "it is four o'clock. Do you like China tea and cinnamon toast? I do. Let's walk up Park Street to the Union Club and while we have our tea, I will finish telling you the rest of the story."

So they sat at a little table in a room overlooking the old Granary Burying Ground.

"Have another cup, Penrose. Did you ever hear this bit of poetry?" said the Treasurer.

> "'*No earthquake shock, no portent wild,*
> *No blast of cannon, or scream of shell*
> *Gave hint or warning of coming doom*
> *When Pemberton fell!*'

"At five o'clock on a January evening, just as the Pemberton Mill was about to close, the building collapsed, and when I say 'collapsed,' I mean all the floors fell straight to the bottom, to the lowest level—a total wreck. The floors were saturated with

oil and while hundreds of people outside the mill were trying to pull out some five or six hundred injured and crushed,—a workman upset his lantern and flames swept the debris.

"A relief fund was immediately started, and we find our Charles S. Storrow and Daniel Saunders, Jr., the son of old Daniel, forming a committee.

"Philanthropic gentlemen in the office of the Massachusetts Hospital Life Insurance right across the hall from my office raised nineteen thousand dollars. Within thirteen days after the catastrophe, the relief fund had grown to $65,000, and then Mr. Storrow patiently heard and investigated the sufferings of each family in the calamity and disbursed aid as far as he was able to do so. I tell you all this, Penrose, because I want you to feel the tremendous responsibility that these early men such as Lawrence, Storrow, and the other Directors of the Company felt for the people who lived in the city they had created. It was their city; they had built it around a mighty water power that they had developed.

"Yes, of course they were interested in making money. That was their primary purpose when Daniel Saunders showed them Bodwell's Falls and they recognized the possibilities of the river as it fell over the ledges.

"However, even when they began to turn water into money, they never forgot their responsibility in laying out a city, in seeing that the city grew properly under their intelligent direction,—but they never allowed for one moment the spirit of patronage to exist. They were ready always to help—to build—to guide, but the city must stand on its own feet."

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"Penrose, if you have a river, if you have an expensive fishway, and if the Commonwealth of Massachusetts has a Department of Fisheries, then there must be fish in the Merrimack River—not little fish, but *big* fish worthy of a big river—and so I am going to repeat to you a story. I don't care whether you believe any of it or not. Nobody ever believed *a fish story*, but I did when this one was told to me.

"One summer evening as I sat on the side of the fishway at

Lawrence, swinging my feet over the edge, and heard the water gurgling down below me, a man came and sat beside me. This was what he said:

"'*Acipenser Sturio Linnaeus*—that means sturgeon—if you don't believe it, look it up in Volume I: "*Fish of the Gulf of Maine.*" On a bill-of-fare at the Waldorf, it means caviar at $2.50 an eighth of a cup. A girl-fish has been known by count to lay two million, four-hundred thousand eggs. How many $2.50 portions that would equal Jordan and Evermann, Research 1896 to 1900, do not compute. I expect the portions differ at various hotels, so it would be hard to estimate the difference in numerical quantities served between The Plaza and the Old Astor House. I ate —and I am sure you have eaten—caviar. Somebody bought mine for me—I washed it down on a cocktail. The caviar came in a small bowl. It looked like frog's eggs without the slime. You put a spoonful on a small hunk of hot toast, chew it, add alcohol to stimulate the taste, then let it slip away. Then you go right into your verbal ecstasy, along with a stuffed egg and your second Martini.

"'I am now quoting to you from statistics I have memorized carefully. In the year 1880, 12,500 pounds of sturgeon meat or 225 fish came up the Kennebec River in Maine, and in the early Massachusetts diaries there is a vital notation—

"'"All over the country, but the best catching of them be upon the Shoales of Cape Codde and in the River Merrimacke where much is taken, pickled and brought for England, some of these be 12, 14 and 18 foote long."'"

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"'"There is a pond that lies under a hill—where the threading roots of many trees . . ."

"'Let us bodily by geologic force transplant that unruffled bit of water, described by Miss Carson in "*The Odyssey of the Eel*" ("Anthology of a Naturalist"—Beebe, Knopf, typography and binding design by W. A. Dwiggins), let us transplant that one-hundred-thousand-odd cubic feet of water to Bodwell's Falls on the Merrimack at Lawrence, Massachusetts.

" 'Into that pool gazed Kan-ca-magus, the son of Nana-mo-co-muck, and as he gazed through the parted alders, *Acipenser Sturio*, ten feet long, swirled in and began to lay. When Kan-ca-magus became tired of beholding nature, he also swirled in, cupped his hands, took eight thousand eggs into them and swallowed the first American Caviar. He spat them out. He took a quiver-full home to his old man, Nana-mo-co-muck. He spat them out. So did his wife.

" 'Two hundred and fifty years ago, one little fingerling, one little sturgeon, swam down the Merrimack to the sea. She never came back. Her fingerlings never came back, but always there was a brain pattern in that sturgeon family of a quiet pool beside a water fall, with a kindly Indian spitting out caviar so that little sturgeons might live and swim down to the ocean abyss, where there was a perpetual blackout except for electric eels and skeletons of *Radiolaria* and dead *Rhizopoda*.

" 'Well, let's get away from this Hell Hole of Darkness and come back to our story of the great 1940 sturgeon who was known all over the Gulf of Maine as "*Long Nose Carrie*."

" 'Carrie was fed up with the Kennebec; the Penobscot was overcrowded with vulgar slinkey salmon; Heligoland on the North Sea had been too cold last summer.

" 'And so Carrie began dimly to recall what her great, great grandmother had told her grandmother about that little pond that lies under the hill and Carrie says to herself, "I might as well lay one million, five-hundred thousand caviars there as in the Black Sea."

" 'So up the Merrimack River comes Carrie. The water is warm. Carrie opened her mouth from time to time. The water was real tasty, even more so than in Boston Harbor off Moon Island. The water was not very deep. Carrie knew she was reaching a cataract; she could hear the roar. Carrie was in error. It was traffic over a highway bridge. Carrie was not used to traffic. Then Carrie ran aground.

" 'Carrie's submarine consciousness came to the surface. She

knew the pool was just ahead. Carrie gave a flip-flop; she rose in the air two feet; she came down with a wallop. Carrie lay in a rock pool, half out of water. Carrie was in Lawrence.

" 'Antonio Capoletta and Silver Cappucio hunted fresh-water mussels for pearls. They saw Carrie. François de Bois and Marie Rivières, hunting for driftwood below the Falls, saw Carrie. "*Un grand poisson!*" they yelled. "*Un diávolo d'un pésce!*" shouted Silver Capoletta. "*C'est le nôtre!* It is ours!" howled François. Carrie flapped her tail. Cappucio hugged the tail. François ran his fingers through Carrie's gills. Silver stuck a stick in Carrie's mouth. Carrie spanked all the water out of the pool. Ah, Marie Rivières, she was a man's woman; she understood men. Quick she take a little knife from Cappucio's hip pocket; quick she cut the wrist of Cappucio while he hold Carrie's tail; quick she stick the knife very gentle in Silver's ribs. Quick she throw the knife far away. *Le grand poisson* it is! Then Marie Rivières, she look up. There is a big traffic jam on the bridge—trucks; cars; men, women, children hang over the rail. They shout, "Big fish! Big fight! Kill'em, Frenchies! Kill'em, Wops!" Marie she hear. "Quick, François! We go quick! This way—the cops!"

" 'Patrick O'Hara and Matty Murphy climb down the bank. "You guys!" they shout. "You guys ain't got no fishing license. Come on up here."

" 'Cappucio, he wave his hands—he yell back. "You no need —what you call it? papers, to catch fish on land. Me catch by tail."

" 'Carrie opened her mouth; Carrie was dead. The flies settled on Carrie. Darkness came to Lawrence.

" 'Isadore Rosenguard was at heart a show man; Stanislaus was a Pole; Ivanovitch was a Russian.

" ' "For five dollars each," said Isadore, "you two boys take my Ford truck; you bring the big fish to Levine's Funeral Home. You lay it out on a board table. I'll borrow it from some Fraternal Club that has had its monthly feed. Then I give you five bucks each—not before. Levine, he can have funerals in the back room. We need the front."

" 'All day long people read the signs: "*Fresh Water Whale—*

560 pounds. Caught after terrific struggle in deep pool below Essex Company Dam. Admission, *ten cents*. Children, *five cents*."

" 'Capoletta did not come; Cappucio did not come. They were in the hospital. Marie, she come and look at Big *Poisson* all full of beautiful caviar. Marie, she sad—she say nothing.

" 'All day long people come. Two times Levine raise the rent on Isadore. Twice Isadore pay without a word.

" 'Eight thousand people see Carrie, the *Fresh Water Whale*.

" 'Then comes Pat O'Hara. Pat with a warrant in his pocket. Pat with a gleam in his eye. He walks in. "Get out of here, all of youse," he says. "No money back. The place stinks, stinks to high heaven. In the name of the Saints, do you think any Christian corpse would be resting where that rotting fish is?"

" ' "Isadore, I have a complaint for you. It's from the Board of Health. Marie Rivières says she cannot sleep for the stink."

" ' "How much is the day's take, Izzy? Well, now I tell ye. The garbage truck will be up this way in an hour. Smith, the driver, is a friend of mine. For ten bucks—no, for fifteen, Smith might take your hunk of carrion."

" 'Isadore went into the wash room and lost his sixty-cent lunch. Then he counted out the dough.

" 'Carrie on the table stank a little harder and seemed to wink an eye.' "

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"Penrose, there is one more chapter on the history of the Essex Company that I want to tell you about because it not only affected Lawrence, but also gave birth to a fundamental formula for the flow of water in pipes and conduits. That formula, I understand, is used today. Sometime when you are in your scientific library, look in '*The American Academy of Arts and Sciences*,' Volume 15, No. 2, '*Flow of Water in Pipes*'; there you will find at the beginning a historical and personal note about Hiram Mills, written by John R. Freeman, who was himself a great hydraulic engineer and a close friend of Hiram Mills and Richard Hale, both of the Essex Company. You used to know Richard Hale and John R. Freeman.

"I remember Hiram Mills when I first went to work for the company in its Boston Office. He used to come to Boston and talk with Mr. Howard Stockton, who was the second Treasurer, and strangely enough, I am the third Treasurer—hence I am assured of a long life.

"Mr. Mills, as I remember him, wore a black Prince Albert type of coat. His white hair, cut long, hung over the collar; he had a full beard; wore a round black hat with a low flat crown; and carried a gold-headed cane. A very venerable and impressive figure. I recall once he took me aside and asked my opinion whether or not the Merrimack could be deepened so that ocean-going ships of that time could navigate up as far as Lowell. I think he always cherished the idea that cotton bales could come from the South directly by water to docks at Lawrence and Lowell.

"Mr. Mills, Mr. Hale, and Mr. Stockton used to have long talks about hydraulic problems and about building new roads and grading vacant land, so that the city could expand as the population increased. This second generation of men, like the first, never lost sight of the fact that the purpose of the company was to create a water power and continually help create a larger city.

"Mr. Mills in 1872 began his experiments. He had in his early days been an assistant to the James B. Francis who was the famous hydraulician at Lowell, the man who stood on the Andover Bridge with Abbott Lawrence and Storrow while they looked at the water falling over the ledges at Bodwell's Falls.

"Mr. Mills, with the aid of the Essex Company, set up an outdoor laboratory at the Lower Locks. It consisted of a cast iron pipe three hundred and fifty feet long, inside of which were various instruments. This pipe was above the surface of the ground, set on piles, a roof was built over it to keep out the heat of the sun, and little buildings attached to it sheltered various pieces of apparatus and forms of Pitot tubes. Here hydraulic experiments were made in the pipe itself, and here the distribution of velocity and flow of water was determined. I told you at the beginning, Penrose, I am not an engineer, and the '*Flow of Water in Pipes*,' composed from Mills' data, as edited by Freeman after Mills' death, is an impossible book for me to comprehend.

"I was born in 1886 and in that same year Hiram Mills, along with his duties for the Essex Company, became the engineer member of the Massachusetts State Board of Health, for which he received no remuneration in dollars. His interest was awakened in the purification of water supplies and the prevention of river pollution. The Laboratory at the Lower Locks in Lawrence now became the experimental field laboratory of the State Board of Health, where world-important experiments on the filtration of sewage and the purification of water supplies were carried on.

"What may have been even more vital was Mills' enthusiasm, for many young men right from college came under his hard training, and later became leaders in hydraulics and water purification."

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"So you see, Penrose, that the second generation of the men of the Essex Company had gone one step further than the building of a city—they were now playing a major rôle in the sewage disposal and drinking water of the Nation.

"When Mr. Mills was about eighty, he retired from active work and came to live in the town I live in, Hingham, Massachusetts. It became necessary for him to have an elevater in the house he purchased. Would he have an electric elevator? Indeed, he would not. The machine he installed was hydraulic—operated on water. The only one in town, and I can well imagine Mr. Mills estimated out for the Water Company how much water it would use and how much to charge him. And so he died a very old man—working on his notes until the very last, but he still remembered what he had been taught as a young man by Abbott Lawrence, Storrow, and Francis, and so in his will he left his fortune to two Trustees, the income to be distributed equally to such charities in Lawrence and in Lowell as the Trustees should select. Ah, but he had not forgotten his lesson—and he further said:

" '*The President and the Directors of the Essex Company must approve of these Charities, because their judgment and approval will always be for the benefit of those men and women who work in the industries of Lowell and Lawrence.*' "

THE END

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"Actorum Memores simul
affectamus Agenda!"

THERE are two gentlemen whose knowledge of the history of Lawrence has aided me greatly, and to them I wish to express my sincere thanks:

First, to the late Hon. Robert H. Tewksbury, who wrote a magnificent chapter on Lawrence in "*The Standard History of Essex County*," published by C. F. Jewett & Co., Boston, 1878; and secondly, to Maurice B. Dorgan, Esq., whose "*History of Lawrence*," with war records, published in 1924 by the author, is a volume so readable, so well written, and so full of facts that every person who lives and works in Lawrence should read it. To Mr. James R. Baldwin, the Chief Engineer of the Essex Company today, and to Mr. Roland A. Prescott, the Cashier, I say: "Thank you for your aid."

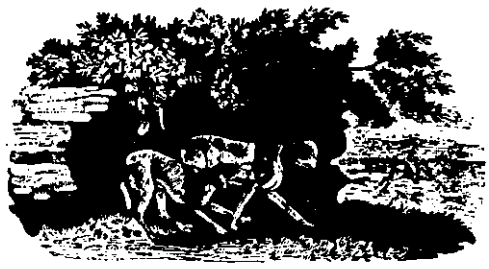
The story and characters in the "*Fish Story*," in this Newcomen address, are wholly imaginary and do not refer to anyone living or dead.

F.M.S.

Boston
March 1947

THIS NEWCOMEN ADDRESS, *based upon contemporary records of the early and colorful history of the Essex Company on the Merrimack River at Lawrence, Massachusetts, was delivered during the "1947 Boston Dinner" of The Newcomen Society of England, held in Georgian Room of the Hotel Statler, at Boston, Massachusetts, U.S.A., on March 13, 1947.* MR. SMITH, *the guest of honor, was introduced by* AUGUSTUS PEABODY LORING, JR. *of Boston, Chairman of the Board, Plymouth Cordage Company, President of The Peabody Marine Museum at Salem, and member of the New England Committee, in The Newcomen Society of England. The dinner was presided over by* DR. KARL T. COMPTON, *President, The Massachusetts Institute of Technology, and Chairman of the New England Committee in American Newcomen.*

THIS *Newcomen Address* has traced the beginnings and growth of a Massachusetts enterprise on the Merrimack River, started in the 1840's, which has contributed greatly to New England's industrial leadership.



THE NEWCOMEN SOCIETY OF ENGLAND

IN NORTH AMERICA

BROADLY, *this British Society has as its purposes: to increase an appreciation of American-British traditions and ideals in the Arts and Sciences, especially in that bond of sympathy for the cultural and spiritual forces which are common to the two countries; and, secondly, to serve as another link in the intimately friendly relations existing between Great Britain and the United States of America.*

The Newcomen Society centers its work in the history of Material Civilization, the history of: Industry, Invention, Engineering, Transportation, the Utilities, Communication, Mining, Agriculture, Finance, Banking, Economics, Education, and the Law—these and correlated historical fields. In short, the background of those factors which have contributed or are contributing to the progress of Mankind.

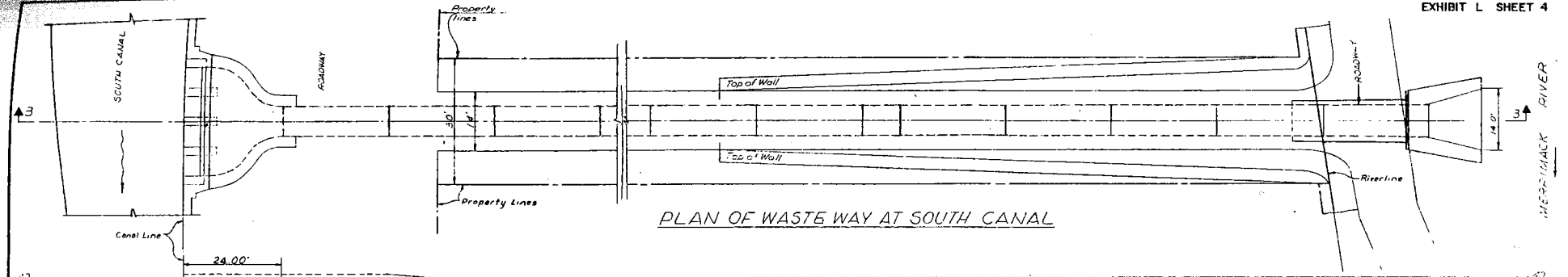
The best of British traditions, British scholarship, and British ideals stand back of this honorary society, whose headquarters are at London. Its name perpetuates the life and work of Thomas Newcomen (1663-1729), the British pioneer, whose valuable contributions in improvements to the newly invented Steam Engine brought him lasting fame in the field of the Mechanic Arts. The Newcomen Engines, whose period of use was from 1712 to 1775, paved a way for the Industrial Revolution. Newcomen's inventive genius preceded by more than 50 years the brilliant work in Steam by the world-famous James Watt.

"The roads you travel so briskly
lead out of dim antiquity,
and you study the past chiefly because
of its bearing on the living present
and its promise for the future."

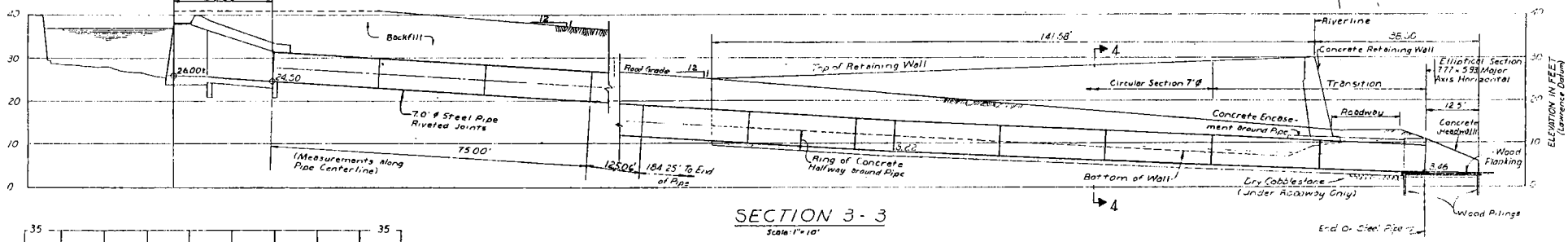
—LIEUTENANT GENERAL JAMES G. HARBORD,
K.C.M.G., D.S.M., LL.D., U.S. ARMY (RET.)

American Member of Council at London,
The Newcomen Society of England

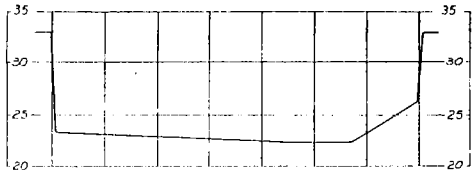
EXHIBIT L SHEET 4



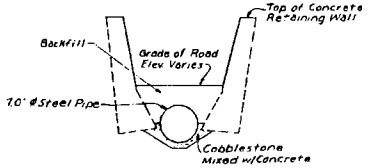
PLAN OF WASTE WAY AT SOUTH CANAL



SECTION 3 - 3
Scale: 1"=10'



SECTION 2-2



SECTION 4-4
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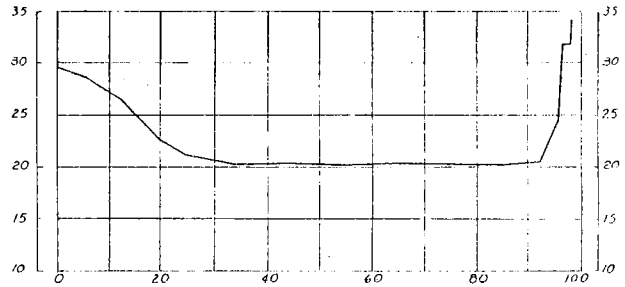
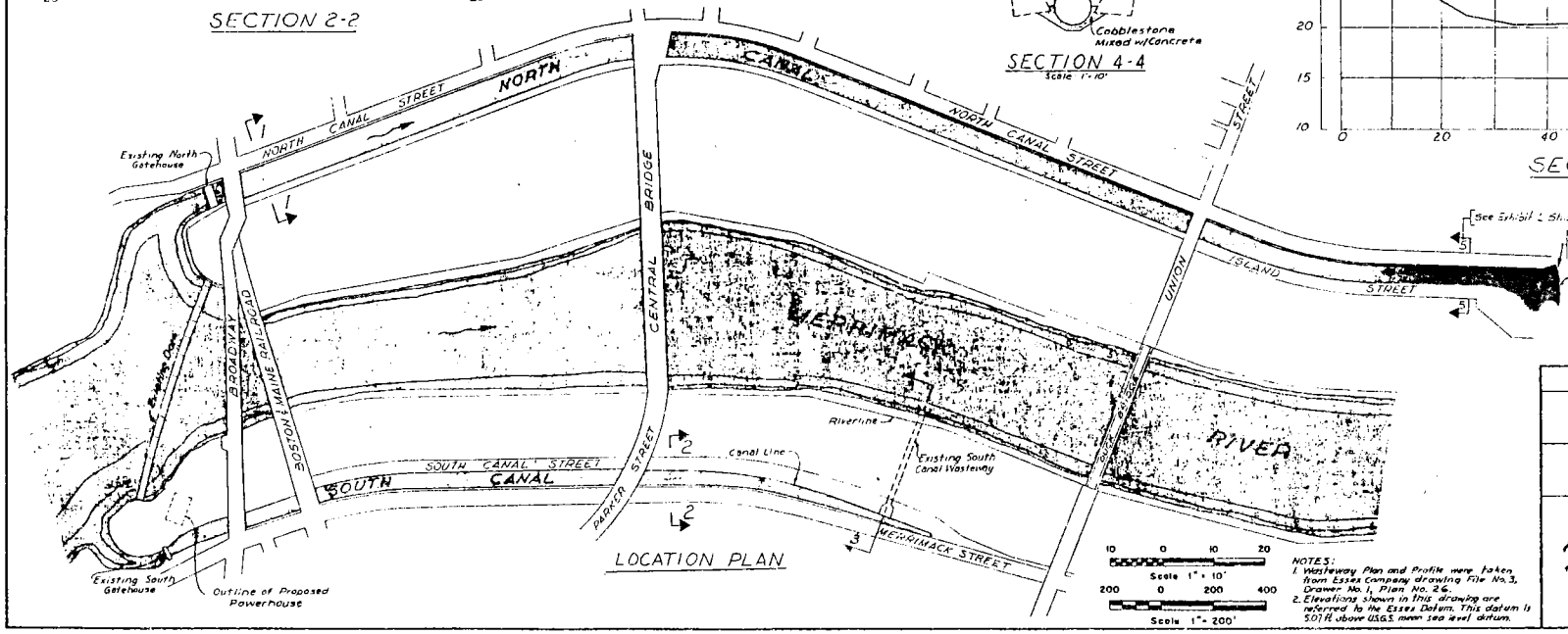


SECTION 1-1



LOCATION PLAN

Scale 1" = 10'
Scale 1" = 200'

NOTES:
1. Wasteway Plan and Profile were taken from Essex Company drawing File No. 3, Drawer No. 1, Plan No. 26.
2. Elevations shown in this drawing are referred to the Essex Datum. This datum is 5.01 ft. above U.S.G.S. mean sea level datum.

THIS DRAWING IS PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 28th DAY OF Dec. 1977

LAWRENCE HYDROELECTRIC ASSOCIATES

BY _____

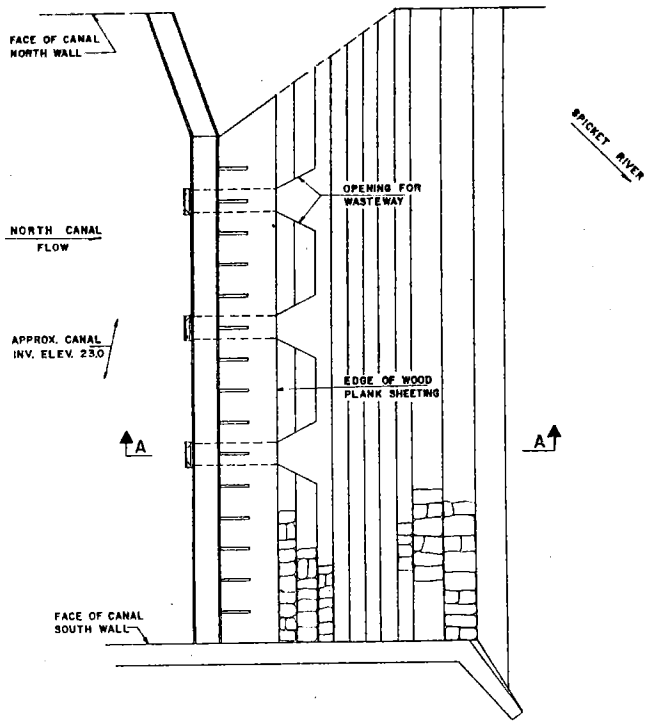
EXHIBIT L SHEET 4

EXISTING CANALS
NORTH CANAL WASTEWAY
PLANS & SECTIONS

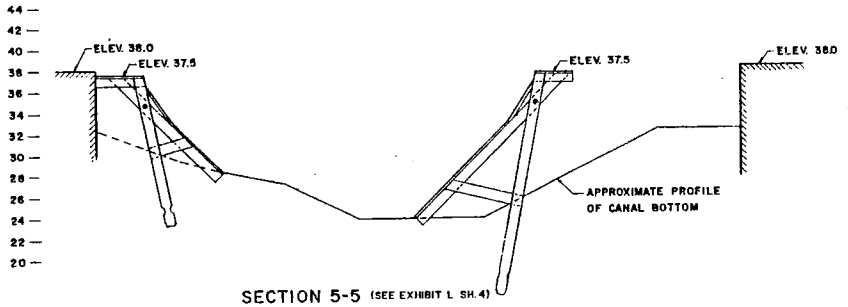
LAWRENCE HYDROELECTRIC PROJECT
ESSEX DEVELOPMENT ASSOCIATES
CHAS. T. MAIN, INC.

Exh. L-4

FERC NO. 2800-11

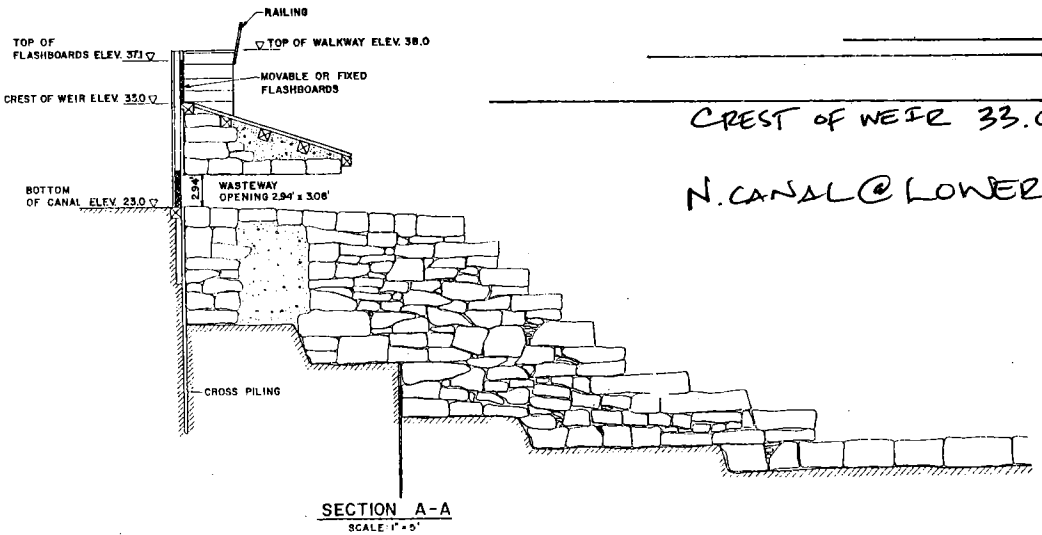


PLAN OF NORTH CANAL WASTEWAY
SCALE: 1" = 10'



SECTION 5-5 (SEE EXHIBIT L SH. 4)
SECTION OF NORTH CANAL
350 FEET UPSTREAM OF WASTEWAY (LOOKING UPSTREAM)
SCALE: 1" = 10'

NOTE
1. ELEVATIONS SHOWN ON THIS DRAWING ARE REFERRED TO THE ESSEX DATUM. THIS DATUM IS 5.07 FEET ABOVE THE U.S.G.S. MEAN SEA LEVEL DATUM.



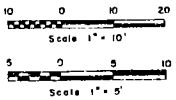
SECTION A-A
SCALE: 1" = 5'

TOP of WALKWAY 38.0'

CREST of FLASHBDS 37.1'

CREST of WEIR 33.0'

N. CANAL @ LOWER LOCKS.



THIS DRAWING IS A PART OF THE APPLICATION FOR A LICENSE MADE BY THE UNDERSIGNED THIS 28th DAY OF June, 1977

LAWRENCE HYDROELECTRIC ASSOCIATES
BY Geoffrey K. Mitchell
Its Gen. Partner

EXHIBIT L SHEET 5
EXISTING CANALS
NORTH CANAL WASTEWAY
PLAN & SECTIONS
LAWRENCE HYDROELECTRIC PROJECT
ESSEX DEVELOPMENT ASSOCIATES
CHAS. T. MAIN, INC.

Exh. L-5

CONDITION ASSESSMENT OF CANAL WALLS REPORT

North Canal
Lawrence, MA

40 Shattuck Road | Suite 110
Andover, Massachusetts 01810
866.702.6371

0228526.02
City of Lawrence, MA
May 2019

TABLE OF CONTENTS

APPENDICES

1. INTRODUCTION

Woodard & Curran Structural Engineer Jim Sturgis, P.E. conducted a visual condition assessment of the wall systems for the North Canal located in Lawrence, MA on May 1st & May 3rd, 2019. He was also accompanied on the first day by Woodard & Curran Structural Engineer Robert Njoroge, P.E. This visual assessment was conducted to evaluate the condition of the retaining walls that form the canal along the north and south borders.

The objective of this assessment was to make visual observations limited to only those surfaces visible as viewed from the top surface of the canal walls while canals were partially full of water. We identified signs of deterioration or instability such as out-of-plumbness, bulges, dislodged stones, missing stones, vegetation growth, mis-alignment along the face, mis-alignment along top of wall, open spaces or voids between stones, erosion, and differential settlement among other conditions. This assessment is a general overview of the condition of the canal wall system. A detailed close-up assessment in the canal, performed either by boat or in a drained accessible canal, would be required to provide a more concise and thorough evaluation of the canal system. This would include assessment of the underwater sections of the wall.

Access was very limited in some areas due to property being blocked off and the inability to safely assess wall conditions below bridge structures. All conditions were assessed from a distance on the opposite side of the canal, since we were not able to enter the canal. Photos are provided to accompany observations. This Memorandum will include the following sections:

- Memorandum (with photos provided for only the most high-risk conditions observed)
- Appendix A: North Canal Reference Plan (Google Map Showing all Stationing)
- Appendix B: North Canal Summary Table (with Observations & Recommendations by Station)

2. EXISTING CONSTRUCTION

The report provides a map and photos of observed conditions along the canal wall system and assigned a risk rating to the various conditions. The age, dimensional data, geometry, and design of the walls are unknown, as no existing record information was available during this task. As such, the characteristics of the wall structures were as observed on site. The total length of the North canal is approximately 5,400 feet based on a measurement taken from online maps. The canal flows west to east along Canal Street. The evaluation was performed by walking the length of the canal on both sides (where accessible), starting at the Broadway Street Bridge and ending at the canal discharge spillway.

Historic data suggests that the North Canal was completed in 1848 and consists of granite blocks laid on a bed of hydraulic cement. The wall system appears to be predominantly constructed of dry-laid stones of varying size and type. The appearance, stone type, method, quality, and workmanship of wall construction is inconsistent and variable along its length. Some sections were observed to have mortared joints, shotcrete facing, concrete facing, and conventional stone masonry. The function of the walls is to retain soil along each side of the canal. The height of the wall system varies and there are guardrails atop several walls that protect sidewalks and building frontage. The canal is bounded by a roadway, Canal Street, to the north and by an island with several large mill building structures to the south.

3. OBSERVATIONS

Observations were made along the entire length of both the north and south canal walls. A stationing system was developed to use for reference, starting with Station 0 + 00 at the Broadway Street Railroad Bridge to the west and ending with Station 54 + 05 at the canal discharge spillway to the east. Each section of canal wall was given a stationing range, given a condition description, then assigned a Risk Level from 1 (worst condition/highest risk level) to 5 (best condition/lowest risk level). Risk Levels 1 to 5 are further defined in Appendix B and are each designated by a unique color. An item number was assigned to each section of wall (N# for north wall and S# for south wall), where it appeared that the relative condition was observed to change. Note that this is difficult to differentiate (especially as viewed from a distance), but an attempt was made to do so in order to assign a relative Risk Level to each area and assist the owner with prioritization of future repairs.

A Google Map image was created for use as a reference plan (see Appendix A – North Canal Reference Plan), which included the following information:

- A colored Google Map image of the canal area for use as a background;
- Several named landmark stations were created along the canal to make it easier for someone to locate the stations in the field (labeled “A” through “Z”, then “AA” through “FF” and defined below the Google Map image);
- Colored Risk Levels were plotted with the five risk levels as defined in Appendix B; and
- Item numbers (N# and S#) were also plotted on this plan.

A summary document was created to summarize information pertaining to all item numbers in one place (see Appendix B – North Canal Summary Table). This summary table lists the following information:

- Item #, nearby landmark station points, start station, and end station;
- For each Item #: Type of wall; approximate height of wall above current canal water level, Observations, Recommendations, and Risk Level; and
- Definitions for Risk Levels 1 through 5, and a Legend with Abbreviations and Definitions.

4. RECOMMENDATIONS

In general, there are multiple and varying wall conditions along the length of the canal. The conditions observed are synonymous with signs of an aging wall system. In the absence of any as-built record information on the wall construction, it was difficult to ascertain whether the present conditions of the wall match the original intended geometry or what repairs have been done over time. We were only able to comment on the faces of the walls that are exposed to view. Extensive vegetation growth was observed along canal walls between stones, some of which were trees several inches in diameter. All vegetation growth can be destructive to the wall system and should be maintained and removed to prevent further damage. Refer to Appendix A and Appendix B for more detailed information about each area identified.

For all areas categorized as Risk Levels 3 through 5, it is recommended that condition and stability of areas should be monitored and re-inspected by a licensed structural engineer every 1 to 2 years to ensure that the observed conditions are not worsening. Some repairs may be required for these areas in the future.

Any wall sections that exhibit plumbness concerns, apparent instability, and/or deterioration have been categorized as Risk Levels 1 and 2. For these sections we recommend that the walls be rebuilt by an experienced contractor who specializes in building this type of rock wall system. It is difficult to assign a timetable to this without wall as-built record drawings, but it is recommended that walls be repaired within the next two to four years. However, given the nature of the wall construction, it should be understood that sections of wall could fail or collapse at any time. The following pages summarize the wall sections assigned to Risk Levels 1 and 2, presented in order of stationing first for the north wall then the south wall (with photos for each item number).

Wall Section: Item #N4; Station 1 + 90 to 3 + 80; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG (vegetation growth); top of wall uneven, potential differential settlement; appears unstable; out of plumb/top leaning into canal; large open joints and voids; missing stones; dislodged stones; overburden pushing top stones toward canal. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #N5; Station 3 + 80 to 5 + 30; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; top of wall uneven, potential differential settlement; appears unstable; out of plumb/top leaning significantly into canal; bowing; bulging; irregular and variable face; large open joints and voids; missing stones; dislodged stones; overburden pushing top stones towards canal. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #N6; Station 5 + 30 to 6 + 95; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; top of wall uneven, potential differential settlement; appears unstable; out of plumb/top leaning significantly into canal; bowing; bulging; irregular and variable face; large open joints and voids; missing stones; dislodged stones; overburden pushing top stones towards canal. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #N7; Station 6 + 95 to 8 + 05; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information.
Observations: VG; top of wall uneven, potential differential settlement; appears unstable; out of plumb/top leaning significantly into canal; bowing; bulging; irregular and variable face; large open joints and voids; missing stones; dislodged stones; overburden pushing top stones towards canal. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #N8; Station 8 + 05 to 9 + 95; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; top of wall uneven, potential differential settlement; appears unstable; out of plumb/top leaning significantly into canal; bowing; bulging; irregular and variable face; large open joints and voids; missing stones; dislodged stones; overburden pushing top stones towards canal. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #N17; Station 26 + 30 to 28 + 40; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: Heavy VG; out-of-plumb, leaning toward canal; appears unstable; major open joints and voids; dislodged stones. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #N18; Station 28 + 40 to 29 + 55; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; out-of-plumb leaning/bowing significantly into canal; unstable; many top stones pushing into canal; major open voids; large concrete public observation deck above wall with benches. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing (top portion is in the worst condition)

Wall Section: Item #N24; Station 41 + 50 to 42 + 70; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: Heavy VG; variable plumbness; questionable stability; poorly laid wall with variable stone sizes; many large open joints and voids; abandoned utility structure. See photos below.
Recommendations: Demolish existing abandoned utility structure; Rebuild this wall section with stone construction to match existing.

Wall Section: Item #S15; Station 10 + 10 to 10 + 25; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; plumb; questionable stability; large open voids near base of wall at old, deteriorated gate structure. See photos below.
Recommendations: Demolish existing abandoned gate structure; Rebuild this wall section with stone construction to match existing.

Wall Section: Item #S23; Station 18 + 90 to 22 + 10; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: Heavy VG; some areas out-of-plumb and leaning outward into canal; appears unstable; erosion along base and top of wall; many dislodged and missing stones. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #S25; Station 22 + 75 to 23 + 45; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information.
Observations: VG; 50 LF of wall to face of bridge appears unstable and is out-of-plumb with top leaning significantly into canal. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #S26; Station 23 + 45 to 26 + 30; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information.
Observations: Heavy VG; out-of-plumb and leaning into canal; appears unstable; wall is wavy along its length; major open joints and large voids; dislodged stones pushed outward in many locations, especially along top. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #S27; Station 26 + 30 to 27 + 80; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; out-of-plumb and top half of wall is pushed out and leaning into canal; appears unstable; past shotcrete repair is failing; missing stones; dislodged stones. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

Wall Section: Item #S28; Station 27 + 80 to 28 + 40; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: Section of concrete wall is in very poor condition – especially the lower half – with severe deterioration and undermining at its base; past shotcrete repair is failing; pronounced lean into canal; appears unstable. See photos below.
Recommendations: Demolish concrete wall and rebuild this wall section with stone construction to match existing.

Wall Section: Item #S31; Station 29 + 70 to 31 + 25; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: Heavy VG; out-of-plumb leaning into canal; large open joints and voids; failing mortar in joints; missing stones; old gate structure; appears unstable. See photos below.
Recommendations: Demolish old gate structure and rebuild this wall section with stone construction to match existing.

Wall Section: Item #S32; Station 31 + 25 to 31 + 65; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: This entry is for 25 LF of wall starting at face of bridge; VG; out of-plumb with major leaning into canal; **appears unstable with vehicles currently parked close to face of wall;** earth and VG along base of wall. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing. **Prohibit parking of vehicles along this wall to minimize future surcharge loading.**

Wall Section: Item #S34; Station 33 + 25 to 34 + 05; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: DLSW appears to have been repaired using formed concrete on exterior face; this concrete facing is cracked, deteriorated, and severely undermined along its base; questionable plumbness; questionable stability. See photos below.
Recommendations: Demolish existing cracked, deteriorated concrete and rebuild this wall section with stone construction to match existing.

Wall Section: Item #S36; Station 35 + 10 to 35 + 70; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; out-of-plumb and leaning into canal; appears unstable with areas that have partial and total collapse; large open joints and voids; missing stones. See photos below.
Recommendations: Rebuild this wall section with stone construction to match existing.

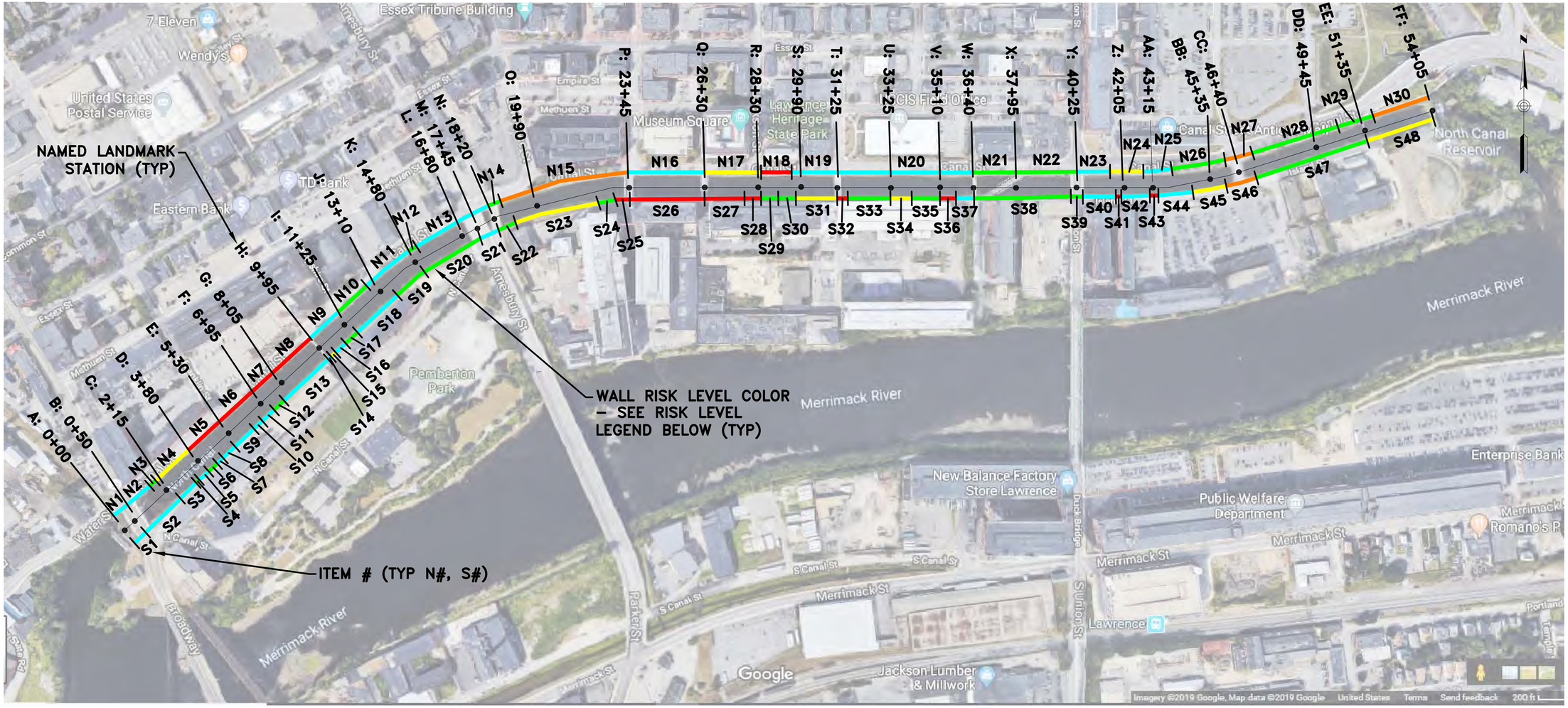
Wall Section: Item #S41; Station 41 + 80 to 41 + 95; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: DLSW combined with rotten wood framework; abandoned utility structure; heavy VG; appears unstable; partial collapse for top portion; major open joints and voids; missing stones; erosion. See photos below.
Recommendations: Demo wooden utility structure and rebuild this wall section with stone construction to match existing.

Wall Section: Item #S43; Station 43 + 00 to 43 + 20; Risk Level 1 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: DLSW combined with rotten wood framework; abandoned utility structure; heavy VG; appears unstable; partial collapse for top portion; major open joints and voids; missing stones; erosion. See photos below.
Recommendations: Demo wooden utility structure and rebuild this wall section with stone construction to match existing.

Wall Section: Item #S45; Station 44 + 50 to 45 + 90; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; out-of-plume and leaning into canal; appears unstable; major open joints and gaps; dislodged stones; abandoned concrete post foundation atop unstable DLSW stones; erosion along top supporting sidewalk and street. See photos below.
Recommendations: Demo concrete post-foundation structure and rebuild this wall section with stone construction to match existing.

Wall Section: Item #S48; Station 51 + 35 to 54 + 05; Risk Level 2 Refer to Appendix A – North Canal Reference Plan and Appendix B – North Canal Summary Table for further information
Observations: VG; out-of-plumb and top stones are leaning into canal; appears unstable; poorly-built wall with variable and irregular surface; large open joints and voids; dislodged stones; last portion of wall was previously replaced with riprap stone, likely due to a wall collapse; wall ends near canal outlet which is located at Station 54 + 05. See photos below.
Recommendations: Demo concrete post foundation structure and rebuild this wall section with stone construction to match existing.

APPENDIX A: NORTH CANAL REFERENCE PLAN



APPENDIX A: NORTH CANAL REFERENCE PLAN

A : RAILROAD BRIDGE ADJACENT WEST OF BROADWAY
B : BROADWAY BRIDGE
C : DRIVEWAY BETWEEN TWO BRICK BUILDINGS
D : CENTER OF LORENZO BUILDING (AT DOOR)
E : FRANKLIN STREET
F : 90 DEGREE BEND IN CHAINLINK FENCE
G : EDGE OF BRICK BUILDING
H : PEDESTRIAN BRIDGE
I : HAMPSHIRE STREET
J : EDGE OF BRICK BUILDING
K : EDGE OF BRICK BUILDING
L : PEDESTRIAN BRIDGE WITH NO RAILINGS
M : AMESBURY STREET BRIDGE
N : BRIDGE DIRECTLY EAST OF AMESBURY STREET
O : LAWRENCE STREET
P : BRIDGE ACROSS FROM APPLETON STREET
Q : BRIDGE ACROSS FROM WHITE MUSEUM BUILDING
R : JACKSON STREET
S : DRIVEWAY BETWEEN TWO BRICK BUILDINGS
T : BRIDGE ACROSS FROM MILL STREET
U : DOORWAY OF BRICK BUILDING
V : EDGE OF BRICK BUILDING
W : PEDESTRIAN BRIDGE
X : END OF TRUSS BRIDGE AT BOLLARDS
Y : UNION STREET BRIDGE
Z : EDGE OF BRICK BUILDING
AA : DOORWAY OF BRICK BUILDING
BB : EDGE OF BRICK BUILDING
CC : BRIDGE ACROSS FROM PARKING LOT DRIVEWAY
DD : PARKING LOT DRIVEWAY
EE : BEAMS CROSSING THE CANAL
FF : CANAL SPILLWAY

RISK LEVEL LEGEND

- RISK LEVEL 1
- RISK LEVEL 2
- RISK LEVEL 3
- RISK LEVEL 4
- RISK LEVEL 5

BAR SCALE
200' 0 200' 400'
1" = 200'
CHECK GRAPHIC SCALE BEFORE USING

NOTES:

1. ALL STATIONING IS APPROXIMATE AND SHALL BE USED FOR REFERENCE ONLY.
2. REFER TO APPENDIX B – NORTH CANAL SUMMARY TABLE FOR STATIONING RISK LEVEL INFORMATION AND FOR OBSERVATIONS.
3. REFER TO MEMO OBSERVATIONS SECTION FOR PHOTOS FOR RISK LEVELS 1 & 2.

40 Shattuck Road, Suite 110
Andover, Massachusetts 01810
866.702.6371 | www.woodardcurran.com

COMMITMENT & INTEGRITY DRIVE RESULTS

WOODARD & CURRAN

REV.	DESCRIPTION	DATE
DESIGNED BY: JPS / ZRB	CHECKED BY: JPS	
DRAWN BY: ZRB		

APPENDIX A: NORTH CANAL REFERENCE PLAN

TOWN OF LAWRENCE, MA

NORTH CANAL REPAIR PLAN

JOB NO.: 0228526.02
DATE: 05/07/19
SCALE: AS NOTED
SHEET: 1 OF 1

APPENDIX: A

APPENDIX B: NORTH CANAL SUMMARY TABLE

Appendix B - North Canal Summary Table (see Legend & Abbreviations below for further descriptions)

#	NEAR POINTS	START LOC'N	END LOC'N	TYPE	H	OBSERVATIONS	RECOMMENDATIONS	RL 1-5
N1	A - B	0 + 00	0 + 50	DLSW	9'	Canal entrance; VG; plumb; appears stable; minor open joints; very limited access/visibility below railroad crossing	RV; further inspect walls below railroad deck area	4*
N2	B - C	0 + 50	1 + 60	DLSW	9'	VG; plumb; appears stable; minor open joints; very limited access/visibility below Broadway bridge	RV; further inspect walls below bridge area	4*
N3	B - C	1 + 60	1 + 90	DLSW	5'	VG; questionable plumbness; appears stable; sag in top of wall, potential local settlement; minor open joints; very limited access/visibility since south side locked	RV; monitor	3**
N4	B - D	1 + 90	3 + 80	DLSW	5'	VG; top of wall uneven, potential differential settlement; appears unstable; out of plumb/top leaning into canal; large open joints & voids; missing stones; dislodged stones; overburden pushing top stones toward canal	Rebuild wall	2**
N5	D - E	3 + 80	5 + 30	DLSW	5'	VG; top of wall uneven, potential differential settlement; appears unstable; out of plumb/top leaning significantly into canal; bowing; bulging; irregular and variable face; large open joints & voids; missing stones; dislodged stones; overburden pushing top stones towards canal	Rebuild wall	1**
N6	E - F	5 + 30	6 + 95	DLSW	5'	Observations similar to Item #N5	Rebuild wall	1**
N7	F - G	6 + 95	8 + 05	DLSW	5'	Observations similar to Item #N5	Rebuild wall	1**
N8	G - H	8 + 05	9 + 95	DLSW	5'	Observations similar to Item #N5	Rebuild wall	1**
N9	H - I	9 + 95	11 + 25	DLSW	7'	VG; plumb; appears stable; moderate open joints & voids	RV; monitor	4
N10	I - J	11 + 25	12 + 80	DLSW	5'	VG; plumb; appears stable; moderate open joints; several top stones are dislodged	RV; monitor	3
N11	I - K	12 + 80	14 + 80	DLSW	5'	VG; plumb; appears stable; moderate open joints;	RV; monitor	4
N12	K - L	14 + 80	15 + 15	DLSW	7'	Heavy VG; small trees growing between stones; questionable plumbness; appears stable; moderate open joints; dislodged stones; top of wall is uneven with stones pushing into canal	RV; monitor	3
N13	K - N	15 + 15	18 + 20	DLSW, CONC	6'	VG; plumb; appears stable; minor open joints; top of wall is concrete near Reference Points L & M	RV; monitor	4
N14	N - O	18 + 20	18 + 70	DLSW, CONC	7'	VG; plumb; appears stable; some large voids in stone below concrete (20 LF)	RV; large voids below concrete cap wall; monitor	3
N15	N - P	18 + 70	23 + 45	DLSW, MSW	7'	VG; plumb; appears stable; minor open joints; MSW on top portion; DLSW on bottom portion	RV; monitor	5
N16	P - Q	23 + 45	26 + 30	DLSW	6'	VG; plumb; appears stable; minor open joints	RV; monitor	4
N17	Q - R	26 + 30	28 + 40	DLSW	4'	Heavy VG; out-of-plumb, leaning toward canal; appears unstable; major open joints & voids; dislodged stones	Rebuild wall	2
N18	R - S	28 + 40	29 + 55	DLSW	4'	VG; out-of-plumb leaning/bowing significantly into canal; appears unstable; many top stones pushing into canal; major open voids; large concrete public observation deck above wall with benches;	Rebuild wall, at least the top portion.	1
N19	R - T	29 + 55	31 + 25	DLSW	5'	Heavy VG; appears stable; plumb; moderate open joints	RV; monitor	4
N20	T - W	31 + 25	36 + 40	DLSW	7'	VG; appears stable; plumb; moderate open joints; some small stones dislodged with voids in places; earth & VG along base	RV; monitor; reset any loose, dislodged stones	4
N21	W - X	36 + 40	37 + 95	DLSW, MSW, CONC	7'	VG; appears stable; plumb; moderate open joints & voids; deteriorated concrete near diagonal walking bridge; top half of wall has mortared joints	RV; monitor; repair 20 LF of deteriorated concrete	3
N22	X - Y	37 + 95	40 + 25	DLSW, MSW, CONC	7'/11'	VG; appears stable; fairly plumb; moderate open joints; many dislodged stones; lower DLSW with upper MSW or CONC	RV; monitor; reset any loose, dislodged stones	3
N23	Y - Z	40 + 25	41 + 50	DLSW, MSW, CONC	7'/11'	VG; appears stable; plumb; minor open joints; lower DLSW with upper MSW or CONC	RV; monitor	4
N24	Y - AA	41 + 50	42 + 70	DLSW	5'	Heavy VG; variable plumbness; questionable stability; poorly laid wall with variable stone sizes; many large open joints & voids; abandoned utility structure	Rebuild wall	2
N25	Z - BB	42 + 70	43 + 75	DLSW	5'	VG; plumb; appears stable; moderate open joints	RV; monitor	4
N26	AA - CC	43 + 75	46 + 05	DLSW	4'-6'	VG; out-of-plumb; appears unstable; poorly laid wall with variable stone sizes; many large open joints & voids; abandoned utility structure	RV; monitor	3
N27	BB - DD	46 + 05	47 + 05	MSW	6'-8'	Mortared stone masonry wall below and in vicinity of vehicle & pedestrian bridges in good condition	No work required	5
N28	CC - EE	47 + 05	51 + 00	DLSW	5'	VG; fairly plumb; appears stable; poorly laid wall with variable/irregular stone sizes and profile; many large open joints & voids; dislodged stones	RV; monitor	3
N29	DD - FF	51 + 00	51 + 85	DLSW, CONC	5'	Abandoned intake structure has assortment of DLSW and CONC walls, with corroded steel framework	Demo steel framework & re-inspect wall in more detail	3
N30	EE - FF	51 + 85	54 + 05	EARTH	8'	Sloped, vegetated earthen embankment which ends near canal outlet located at Station 54 + 05	No work required	5
S1	A - B	0 + 00	0 + 50	DLSW, CONC	12'	Could not inspect – concealed by railroad bridge	Re-inspect from below with safety precautions in place	4
S2	B - D	0 + 50	2 + 30	DLSW	12'	VG; plumb; appears stable; minor open joints; old steel bridge beams bear on wall	RV; monitor	4**
S3	C - D	2 + 30	3 + 55	DLSW, CONC	12'	VG; plumb; appears stable; minor open joints; upper sections are poured concrete	RV; monitor	4**
S4	C - D	3 + 55	3 + 65	DLSW	12'	VG; questionable plumbness; appears stable; localized vertical strip with missing stones, large voids, and major erosion	RV; rebuild localized area (5 LF wide); monitor	3**
S5	C - E	3 + 65	3 + 90	DLSW	12'	VG; appears stable; plumb; minor open joints	RV; monitor	4**
S6	D - E	3 + 90	4 + 35	BRICK	12'	Brick drainage gate structure with 4 pipes and wooden gates below water; brick fair condition; wood poor condition; plumb; appears stable	RV; monitor	3**
S7	D - E	4 + 35	4 + 55	DLSW	12'	VG; appears stable; plumb; minor open joints	RV; monitor	4**
S8	D - E	4 + 55	4 + 95	DLSW	11'	VG; appears stable; plumb; moderate open joints & some large voids	RV; monitor	4**
S9	D - F	4 + 95	6 + 15	DLSW	11'	VG; appears stable; plumb; minor open joints	RV; monitor	4**
S10	E - F	6 + 15	6 + 55	DLSW	11'	VG; appears stable; plumb; moderate open joints & some large voids	RV; monitor	4**
S11	E - F	6 + 55	7 + 25	DLSW	11'	VG; appears stable; plumb; minor open joints	RV; monitor	4**

Appendix B - North Canal Summary Table (see Legend & Abbreviations below for further descriptions)

#	NEAR POINTS	START LOC'N	END LOC'N	TYPE	H	OBSERVATIONS	RECOMMENDATIONS	RL 1-5
S12	F - G	7 + 25	7 + 75	BRICK	10'	Brick drainage gate structure with 4 pipes and wooden gates below water; brick fair to poor condition; wood very poor condition; plumb; appears stable	RV; monitor; repair crumbling brick	3**
S13	F - H	7 + 75	9 + 95	DLSW	8'	VG; plumb; appears stable; moderate open joints & some large voids;	RV; monitor	4**
S14	H - I	9 + 95	10 + 10	DLSW, MSW	9'	VG; plumb; appears stable; moderate open joints	RV; monitor	4
S15	H - I	10 + 10	10 + 25	DLSW	8'	VG; plumb; questionable stability; large open voids near base of wall at old, deteriorated gate structure;	Rebuild approx. 15 LF of wall	2
S16	H - I	10 + 25	10 + 75	DLSW	8'	VG; plumb; appears stable; moderate open joints & some large voids	RV; monitor	4
S17	H - I	10 + 75	11 + 35	DLSW	6'	VG; out-of-plumb; questionable stability; top of wall has outward bowing into canal (former railroad rails adjacent to wall, potential past rail surcharge); moderate open joints & some large voids	RV; monitor	3
S18	I - K	11 + 35	13 + 60	DLSW	6'	VG; plumb; appears stable; moderate open joints	RV; monitor	4
S19	J - L	13 + 60	15 + 00	DLSW, SHCT	6'	VG; plumb; appears stable; evidence of various past repairs to wall; face of wall was coated with shotcrete that is now flaking off; lower portion is faced with concrete that has cracks/deterioration that is beginning to fail;	RV; monitor	3
S20	K - M	15 + 00	17 + 45	DLSW	6'	Heavy VG; fairly plumb; questionable stability; evidence of past repair with granite blocks and crushed stone where wall presumably collapsed; missing & dislodged stones; major open joints & large open voids; some areas crumbling	RV; monitor	3
S21	M - N	17 + 45	18 + 20	DLSW, CONC	6'	Bridge area: could not gain access or visibility to inspect.	RV; monitor; further inspect walls below bridge area	4
S22	N - O	18 + 20	18 + 90	DLSW, MSW	6'	VG; plumb; appears stable; moderate open joints; previously-mortared joints are failing	RV; monitor	3
S23	N - P	18 + 90	22 + 10	DLSW	6'	Heavy VG; some areas out-of-plumb and leaning outward into canal; appears unstable; erosion along base & top of wall; many dislodged & missing stones;	Rebuild wall	2
S24	O - P	22 + 10	22 + 75	CONC, MTL	7'	Abandoned metal & concrete intake structure; metal is corroded and conceals concrete wall; could not access for inspection	Demo steel framing items and conduct wall inspection	3
S25	O - P	22 + 75	23 + 45	DLSW	7'	VG; 50 LF of wall to face of bridge appears unstable & out-of-plumb with top leaning significantly into canal	Rebuild wall	1
S26	P - Q	23 + 45	26 + 30	DLSW	6'	Heavy VG; out-of-plumb and leaning into canal; appears unstable; wall is wavy along its length; major open joints & large voids; dislodged stones pushed outward in many locations, especially along top	Rebuild wall	1
S27	Q - R	26 + 30	27 + 80	DLSW, SHCT	7'	VG; out-of-plumb and top half of wall is pushed out and leaning into canal; appears unstable; past shotcrete repair is failing; missing stones; dislodged stones	Rebuild wall	1
S28	Q - S	27 + 80	28 + 40	CONC	8'	Section of concrete wall is in very poor condition – especially the lower half – with severe deterioration and undermining at its base; past shotcrete repair is failing; pronounced lean into canal; appears unstable	Rebuild wall	1
S29	R - S	28 + 40	29 + 50	DLSW, SHCT	7'	DLSW concealed by past shotcrete repair that is flaking off; appears stable; plumb; one large void in wall	RV; monitor; infill one large hole	3
S30	R -S	29 + 50	29 + 70	DLGWR	7'	Dry laid granite block wall repair with combination of granite blocks and crushed stone; assumed that this section of DLSW previously collapsed; alignment is poor; variable plumbness and appears stable	RV; monitor	3
S31	S - T	29 + 70	31 + 25	DLSW, MSW	7'	Heavy VG; out-of-plumb leaning into canal; large open joints & voids; failing mortar in joints; missing stones; old gate structure	Rebuild wall; demo gate structure	2
S32	T - U	31 + 25	31 + 65	DLSW	8'	This entry is for 25 LF of wall starting at face of bridge; VG; out of-plumb with major leaning into canal; **appears unstable with vehicles currently parked close to face of wall;** earth & VG along base of wall	Rebuild wall**; consider prohibiting parking next to this wall**	1
S33	T - U	31 +65	33 + 25	DLSW, MSW	7'	Heavy VG; DLSW with failing mortar joints for upper areas; out-of-plumb with top stones pushed into canal; questionable stability; earth & VG along base of wall	RV; monitor; reset any dislodged top stones	3
S34	U - V	33 + 25	34 + 05	CONC-FCD DLSW	7'	DLSW appears to have been repaired using formed concrete on exterior face; this concrete facing is cracked, deteriorated, and severely undermined along its base; fairly plumb; questionable stability	Rebuild wall (impractical to repair)	2
S35	U - V	34 + 05	35 + 10	CONC	7'	Concrete wall along abandoned intake structure; wall appears plumb & stable but is concealed by intake structure framework	Demo intake structure & conduct closer inspection of wall	3
S36	V - W	35 + 10	35 + 70	DLSW	7'	VG; out-of-plumb and leaning into canal; appears unstable with areas that have partial & total collapse; large open joints & voids; missing stones	Rebuild wall	1
S37	U - W	35 + 70	36 + 40	DLSW	7'	VG; plumb; appears stable; minor open joints	RV; monitor	4
S38	W - Y	36 + 40	40 + 00	DLSW, MSW, CONC	7'/11'	VG; plumb; appears stable; major open joints & large voids; DLSW lower wall and MSW/CONC upper wall	RV; monitor	3
S39	Y	40 + 00	40 + 50	CONC BRIDGE	7'	Union Street Bridge (1939 construction) has major concrete deterioration and exposed rebar on each face, railings, and abutments	Conduct detailed structural condition assessment and repair all deteriorated concrete	3
S40	Y - Z	40 + 50	41 + 80	DLSW, MSW, CONC	7'/11'	VG; plumb; appears stable; moderate open joints; some dislodged stones; DLSW lower wall and MSW/CONC upper wall	RV; monitor	4
S41	Y - Z	41 + 80	41 + 95	DLSW, WOOD	7'	DLSW combined with rotten wood framework; abandoned utility structure; heavy VG; appears unstable; partial collapse for top portion; major open joints & voids; missing stones; erosion	Rebuild wall; demo wooden utility structure	1
S42	Y - AA	41 + 95	43 + 00	DLSW	7'	VG; plumb; appears stable; moderate open joints & gaps; DLSW lower wall and MSW/CONC upper wall	RV; monitor	4
S43	AA	43 + 00	43 + 20	DLSW, WOOD	7'	DLSW combined with rotten wood framework; abandoned utility structure; heavy VG; appears unstable; partial collapse for top portion; major open joints & voids; missing stones; erosion	Rebuild wall; demo wooden utility structure	1
S44	AA - BB	43 + 20	44 + 50	DLSW, MSW	8'	VG; plumb; appears stable; major open joints & gaps	RV; monitor	4

Appendix B - North Canal Summary Table (see Legend & Abbreviations below for further descriptions)

#	NEAR POINTS	START LOC'N	END LOC'N	TYPE	H	OBSERVATIONS	RECOMMENDATIONS	RL 1-5
S45	AA - CC	44 + 50	45 + 90	DLSW	5'	VG; out-of-plume and leaning into canal; appears unstable; major open joints & gaps; dislodged stones; abandoned concrete post foundation atop DLSW stones which appear to be unstable; erosion along top supporting sidewalk and street	Rebuild wall	2
S46	BB - DD	45 + 90	47 + 00	MSW	6-8'	Modern stone masonry wall below and in vicinity of bridge at Station Point CC is in good condition	No work required	5
S47	CC - EE	47 + 00	51 + 35	DLSW	5'	VG; appears plumb & stable; poorly-built wall with variable & irregular surface; large open joints & voids; dislodged stones	RV; monitor	3
S48	EE - FF	51 + 35	54 + 05	DLSW	5'	VG; out-of-plumb and top stones are leaning into canal; appears unstable; poorly-built wall with variable & irregular surface; large open joints & voids; dislodged stones; last portion of wall was previously replaced with riprap stone, likely due to a wall collapse; wall ends near canal outlet which is located at Station 54 + 05	Rebuild wall	2

***** The access and visibility was very limited for the rock walls below Point A Station 0 + 00 (Railroad Bridge) and below Point B Station 0 + 50 (Broadway Street Bridge); these areas were fully concealed by the bridge construction and should be further inspected from below at a future date with the proper safety protocol in place.

****** The stretch of canal between Station Points B through H had very limited access and visibility. The entire south side of the canal that borders the Cardinal Shoe property was blocked off with security gates near Points B and H. This greatly inhibited our ability to view the top of the south wall and get opposite canal views of the north wall along this stretch. Though a reasonable opinion of condition was achieved looking with binoculars from Points B and H, visibility would be greatly improved if access past the security fences could be arranged.

LEGEND & ABBREVIATIONS:

- Table Heading Title Abbreviations: # = Reference # (N# or S#); NEAR POINT = Station Letter Locations on Reference Plan for quick reference; START LOC'N = station point at start of area; END LOC'N = station point at end of area; TYPE = wall construction type; H = rough approximation of wall height above current canal water level at time of inspection (actual canal depth was variable and not determined); RL 1-5 = Risk Level # as defined below:
  - *Risk Level 1: Very poor condition with several problem areas – high risk of failure*
  - *Risk Level 2: Poor condition with several problem areas – moderate to high risk of failure*
  - *Risk Level 3: Poor to fair condition with some problem areas – moderate risk of failure*
  - *Risk Level 4: Fair condition with some problem areas – low to moderate risk of failure*
  - *Risk Level 5: Fair to good condition with minimal problem areas – low risk of failure*
- Additional Abbreviations: N# = Wall reference on North side of wall; S# = Item reference # on South side of wall; VG = vegetation growth; RV = remove/treat vegetation growth; DLSW = dry-laid stone wall; MSW = mortared stone wall; CONC = concrete wall; CONC FCD = formed concrete patch wall installed against dry-laid stone wall; BRICK = brick wall; WOOD = wood wall components; EARTH = earthen embankment; MTL = metal wall components; SHCT = shotcrete (sprayed concrete) facing over stone; DLGWR = dry laid granite block repair to wall;
- Clarifications of terms used: "plumb" = wall is generally plumb as viewed from a distance; "out-of-plumb" = wall is not plumb and appears to be leaning toward the canal as viewed from a distance; "stable or unstable" = general impression that the wall appears to be stable/unstable as viewed from a distance, but this shall not be interpreted as a statement that the wall is not at risk for failure.
- Definitions:
  - Monitor = monitor condition and stability of this wall section over time; future repairs will likely be necessary to maintain the integrity of the wall system.
  - Rebuild wall = excavating behind wall (shoring adjacent construction as needed to protect existing structures or roadways), disassembling wall, then rebuilding it with existing stones and/or additional stones to match existing appearance. This work should be performed by a skilled rock wall contractor with experience restoring historic rock walls similar to that which exists in the North Canal.
- Photos: Refer to Memorandum Observations section for photos of each Item # listed in Risk Levels 1 & 2. Photos are not provided for item #'s listed in Risk Levels 3, 4, & 5.

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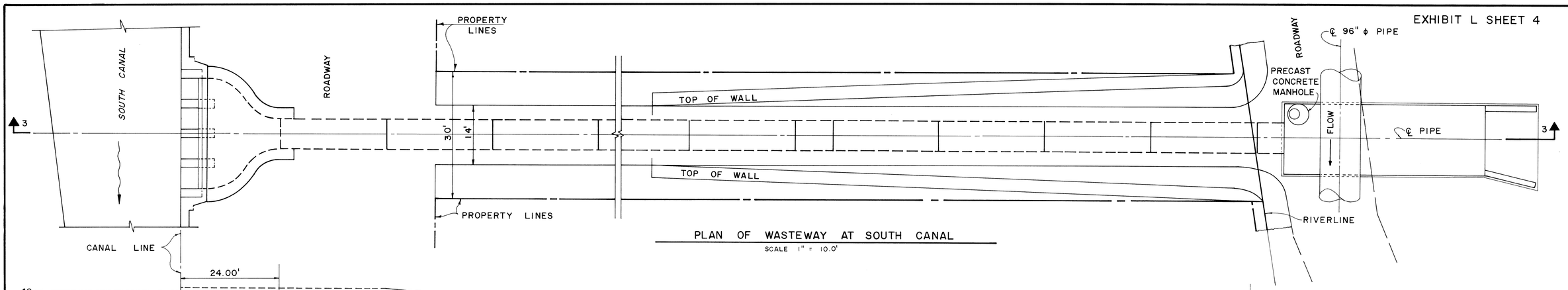
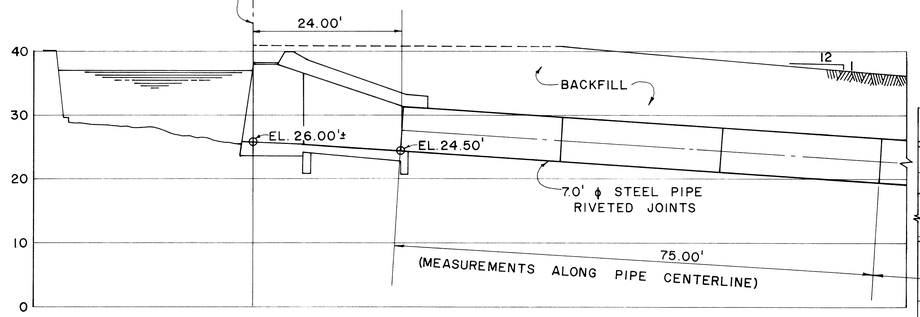
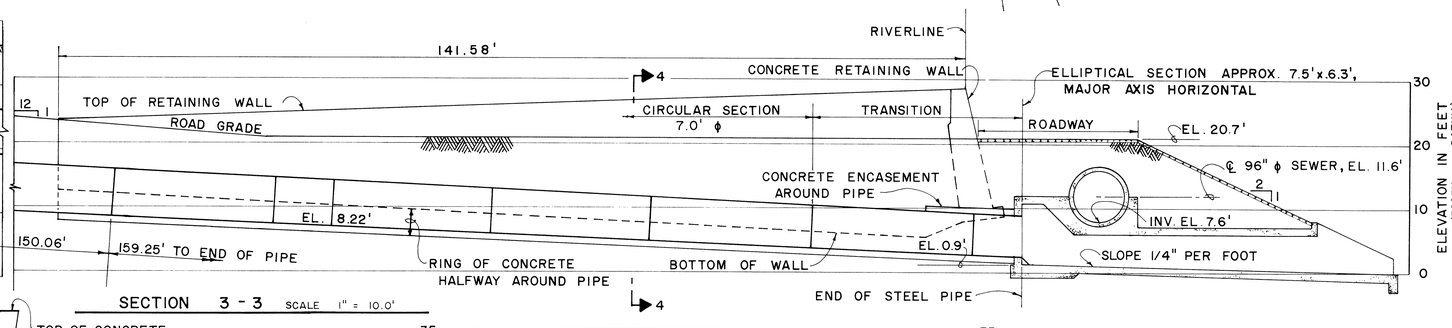
COMMITMENT & INTEGRITY DRIVE RESULTS

EXHIBIT L SHEET 4

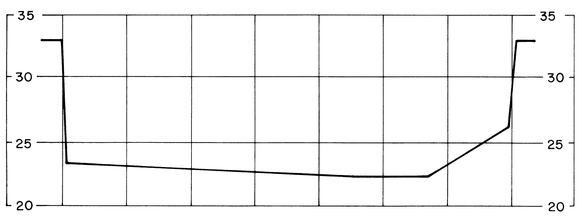


PLAN OF WASTEWAY AT SOUTH CANAL
SCALE 1" = 10.0'

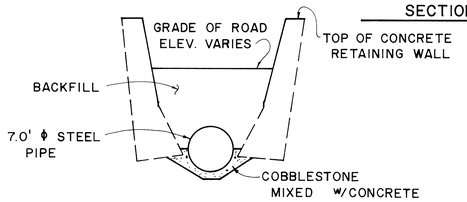




SECTION 3 - 3 SCALE 1" = 10.0'



SECTION 2-2



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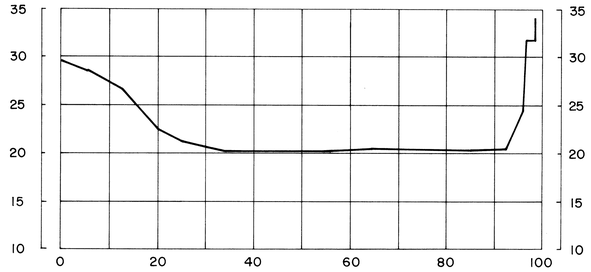
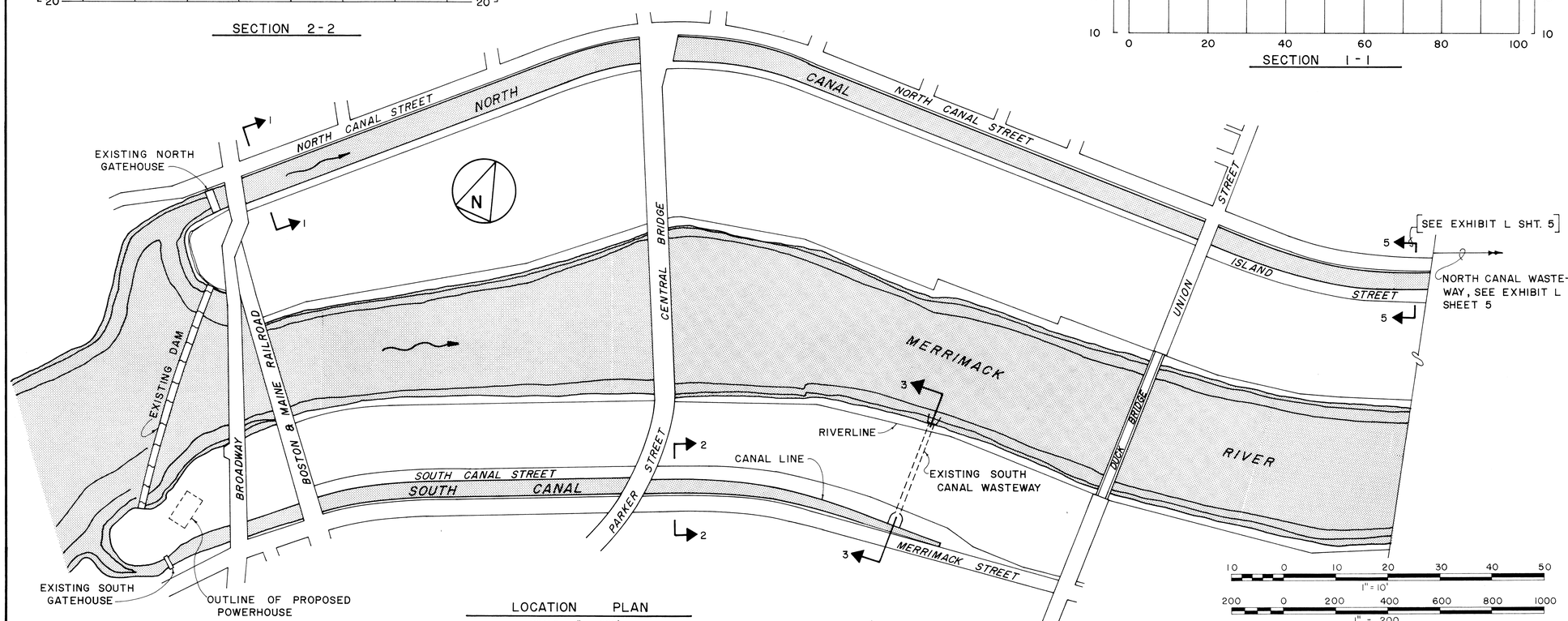


SECTION 1 - 1



LOCATION PLAN
SCALE 1" = 200'

NOTES:

1- WASTEWAY PLAN AND PROFILE WERE TAKEN FROM ESSEX COMPANY DRAWING FILE NO. 3, DRAWER NO. 1, PLAN NO. 26. WITH RIVER OUTLET REVISIONS FROM GREATER LAWRENCE SANITARY DISTRICT, CONTRACT NO. 4, SHEET 19.

2- ELEVATIONS SHOWN ON THIS DRAWING ARE REFERRED TO THE ESSEX DATUM THIS DATUM IS ELEVATION +5.07 U.S.G.S. MEAN SEA LEVEL.

THIS DRAWING IS A PART OF THE APPLICATION FOR AN AMENDMENT TO LICENSE FOR PROJECT NO. 2800 MADE BY THE UNDERSIGNED.
THIS 29th DAY OF March 1979

LAWRENCE HYDROELECTRIC ASSOCIATES
BY Geoffrey K Mitchell

EXHIBIT L SHEET 4

EXISTING CANALS - PLANS & SECTIONS SOUTH CANAL WASTEWAY

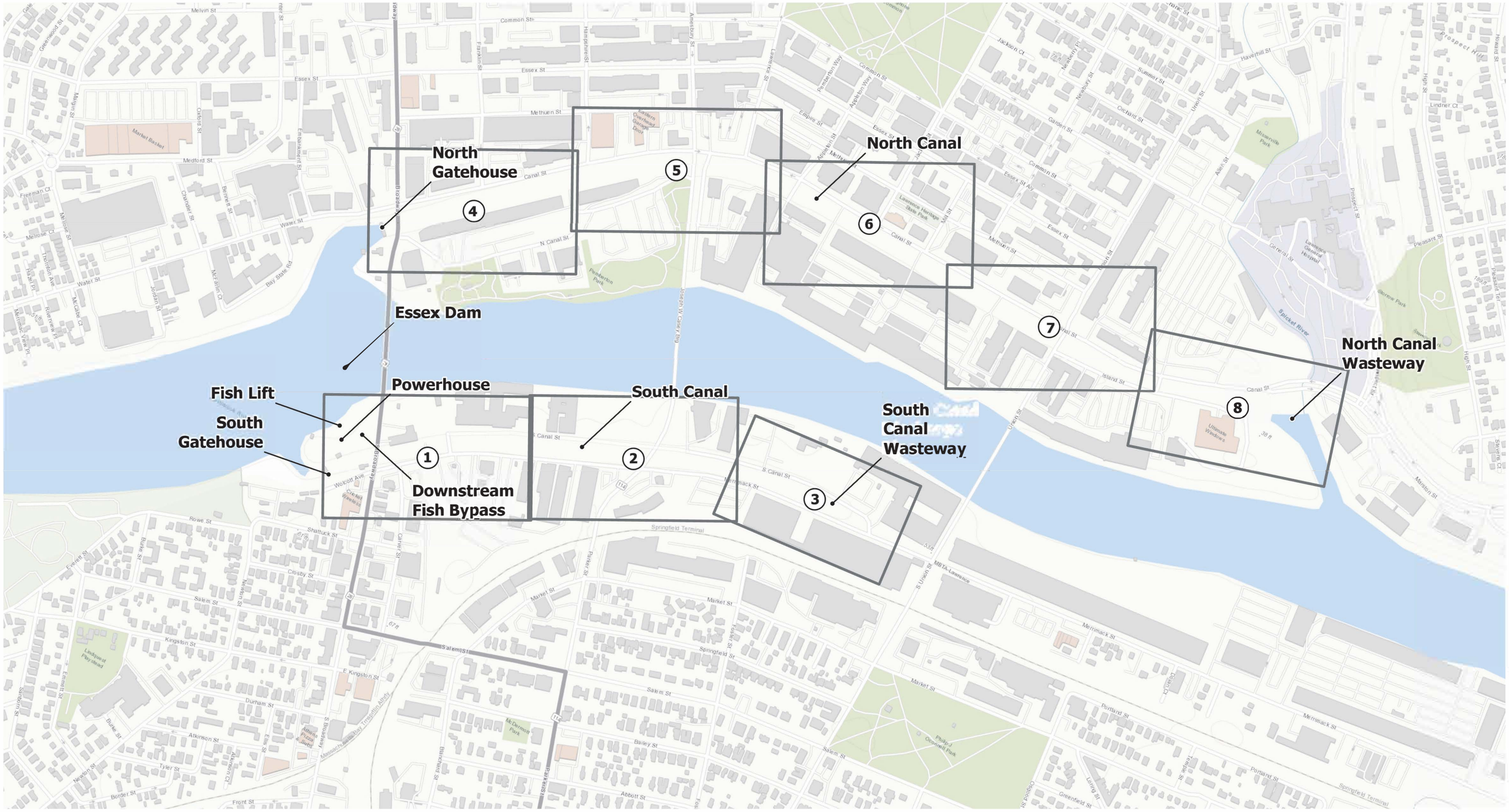
SCALES: 1" = 10' & 1" = 200'

LAWRENCE HYDROELECTRIC PROJECT

LAWRENCE HYDROELECTRIC, ASSOCIATES
W. R. HOLWAY & ASSOCIATES

FERC NO. 2800-11 REV.

Appendix B - Canal Condition Assessment Reference Plan



NOTES: ALL STATIONING IS APPROXIMATE AND SHALL BE USED FOR REFERENCE ONLY.REFER TO SECTIONS 5 AND 6 FOR STATIONING RISK LEVEL INFORMATION AND FOR OBSERVATIONS. REFER TO SECTION 5 FOR PHOTOS FOR RISK LEVELS 1 & 2.

0 1,000 Feet

INDEX SHEET
CANAL CONDITION ASSESSMENT REFERENCE PLAN
CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

\\SYR-SRV01\GIS\PROJECTS\CENTRAL_RIVERS_POWER\10358652_LAWRENCERELICENSING\7.2_WIP\MAP_DOCS\CRP_LAWRENCEPROJECT1.APRX DATE: 3/13/2025

LAWRENCE HYDROELECTRIC PROJECT

RISK LEVEL 2 RISK LEVEL 3 RISK LEVEL 4 RISK LEVEL 5

NOTES: ALL STATIONING IS APPROXIMATE AND SHALL BE USED FOR REFERENCE ONLY.REFER TO SECTIONS 5 AND 6 FOR STATIONING RISK LEVEL INFORMATION AND FOR OBSERVATIONS. REFER TO SECTION 5 FOR PHOTOS FOR RISK LEVELS 1 & 2.

0 200 Feet

SHEET 1
CANAL CONDITION ASSESSMENT REFERENCE PLAN
CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

\\SYR-SRV01\GIS\PROJECTS\CENTRAL_RIVERS_POWER\10358652_LAWRENCERELICENSING\7.2_WIP\MAP_DOCS\CRP_LAWRENCEPROJECT1.APRX DATE: 3/4/2025

LAWRENCE HYDROELECTRIC PROJECT

RISK LEVEL 1 RISK LEVEL 2 RISK LEVEL 3 RISK LEVEL 4 RISK LEVEL 5

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HDR

0 200 Feet

SHEET 2
CANAL CONDITION ASSESSMENT REFERENCE PLAN
CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

\\SYR-SRV01\GIS\PROJECTS\CENTRAL_RIVERS_POWER\10358652_LAWRENCERELICENSING\7.2_WIP\MAP_DOCS\CRP_LAWRENCEPROJECT1.APRX DATE: 3/4/2025

LAWRENCE HYDROELECTRIC PROJECT

RISK LEVEL 3 RISK LEVEL 4 RISK LEVEL 5

NOTES: ALL STATIONING IS APPROXIMATE AND SHALL BE USED FOR REFERENCE ONLY.REFER TO SECTIONS 5 AND 6 FOR STATIONING RISK LEVEL INFORMATION AND FOR OBSERVATIONS. REFER TO SECTION 5 FOR PHOTOS FOR RISK LEVELS 1 & 2.

0 200 Feet

SHEET 3
CANAL CONDITION ASSESSMENT REFERENCE PLAN
CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

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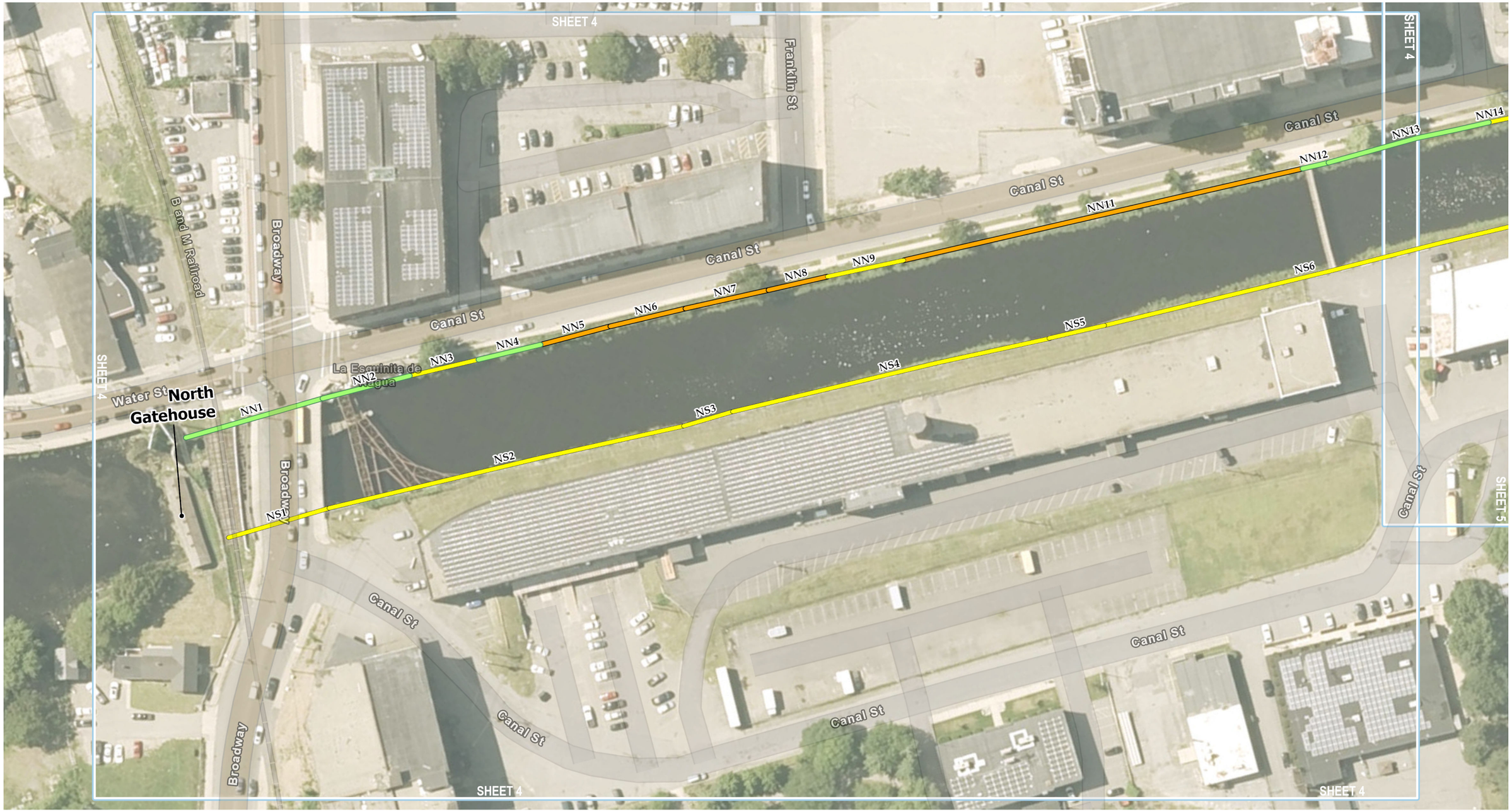
LAWRENCE HYDROELECTRIC PROJECT



RISK LEVEL 1 RISK LEVEL 2 RISK LEVEL 3 RISK LEVEL 4

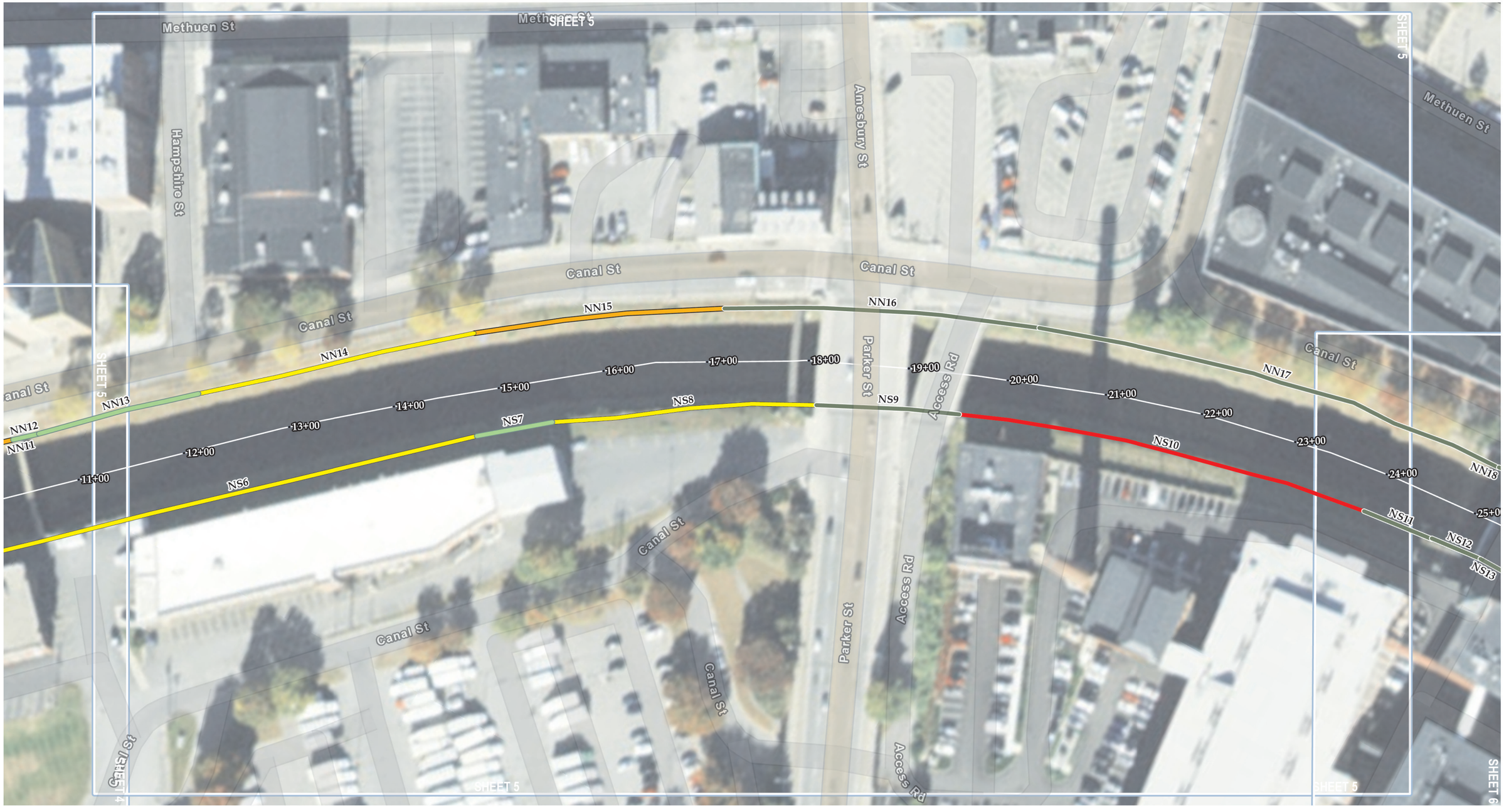
NOTES: ALL STATIONING IS APPROXIMATE AND SHALL BE USED FOR REFERENCE ONLY.REFER TO SECTIONS 5 AND 6 FOR STATIONING RISK LEVEL INFORMATION AND FOR OBSERVATIONS. REFER TO SECTION 5 FOR PHOTOS FOR RISK LEVELS 1 & 2.

0 200 Feet

SHEET 4
CANAL CONDITION ASSESSMENT REFERENCE PLAN
CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

\\SYR-SRV01\GIS\PROJECTS\CENTRAL_RIVERS_POWER\10358652_LAWRENCERELICENSING\7.2_WIP\MAP_DOCS\CRP_LAWRENCEPROJECT1.APRX DATE: 5/5/2025

LAWRENCE HYDROELECTRIC PROJECT



RISK LEVEL 1 RISK LEVEL 2 RISK LEVEL 3 RISK LEVEL 4 RISK LEVEL 5

NOTES: ALL STATIONING IS APPROXIMATE AND SHALL BE USED FOR REFERENCE ONLY.REFER TO SECTIONS 5 AND 6 FOR STATIONING RISK LEVEL INFORMATION AND FOR OBSERVATIONS. REFER TO SECTION 5 FOR PHOTOS FOR RISK LEVELS 1 & 2.

0 200 Feet

SHEET 5
CANAL CONDITION ASSESSMENT REFERENCE PLAN
CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

RISK LEVEL 1 RISK LEVEL 2 RISK LEVEL 3 RISK LEVEL 4 RISK LEVEL 5

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SHEET 6
CANAL CONDITION ASSESSMENT REFERENCE PLAN
CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

\\SYR-SRV01\GIS\PROJECTS\CENTRAL_RIVERS_POWER\10358652_LAWRENCERELICENSING\7.2_WIP\MAP_DOCS\CRP_LAWRENCEPROJECT1.APRX DATE: 3/4/2025

LAWRENCE HYDROELECTRIC PROJECT

RISK LEVEL 1 RISK LEVEL 2 RISK LEVEL 3 RISK LEVEL 4 RISK LEVEL 5

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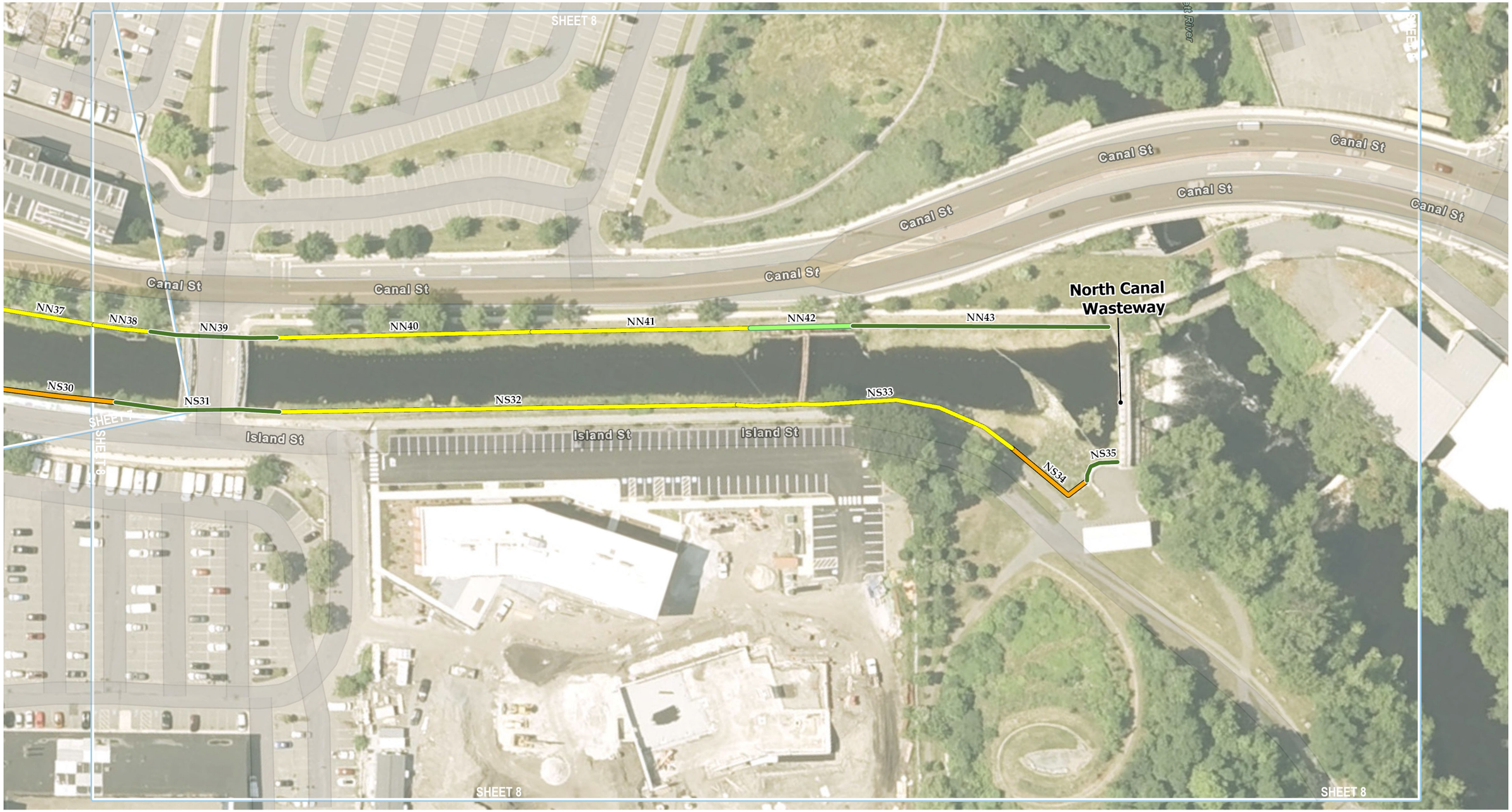
SHEET 7

CANAL CONDITION ASSESSMENT REFERENCE PLAN

CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

\\SYR-SRV01\GIS\PROJECTS\CENTRAL_RIVERS_POWER\10358652_LAWRENCERELICENSING\7.2_WIP\MAP_DOCS\CRP_LAWRENCEPROJECT1.APRX DATE: 5/5/2025

LAWRENCE HYDROELECTRIC PROJECT



RISK LEVEL 2 RISK LEVEL 3 RISK LEVEL 4 RISK LEVEL 5

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SHEET 8

CANAL CONDITION ASSESSMENT REFERENCE PLAN

CONDITION ASSESSMENT OF HISTORIC PROPERTIES AND ASSOCIATED CANAL SYSTEM

\\SYR-SRV01\GIS\PROJECTS\CENTRAL_RIVERS_POWER\10358652_LAWRENCERELICENSING\7.2_WIP\MAP_DOCS\CRP_LAWRENCEPROJECT1.APRX DATE: 5/5/2025

LAWRENCE HYDROELECTRIC PROJECT

Appendix C - Canal Condition Assessment Summary Table

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
NN1	0+00	1+30	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
NN2	1+30	2+10	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
NN3	2+10	2+75	Dry-Laid Stone Wall	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones and the presence of woody vegetation between several joints. There are some voids of 0.5 sq. ft. or greater.	Remove/treat vegetative growth. Fill voids with stones and repoint stones that have shifted angles. Monitor for future movement or stone loss.	3
NN4	2+75	3+30	Masonry Stone Wall	Top of wall is uneven, as is the thickness of the overall wall, creating a shelf. However, overall wall appears in fair condition with areas of missing mortar and most of wall appearing plumb.	Monitor wall section for movement or changes.	4
NN5	3+30	4+00	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. The crest of the wall is uneven and does not appear plumb. Areas of overhang of stone along crest, instead of flush with face of wall.	Repoint wall, replace missing stones, and mortar between joints where possible. Remove/treat vegetation.	2
NN6	4+00	4+70	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. The crest of the wall is uneven and does not appear plumb. Areas of overhang of stone along crest, instead of flush with face of wall.	Repoint wall, replace missing stones, and mortar between joints where possible. Remove/treat vegetation.	2
NN7	4+70	5+50	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. The crest of the wall is uneven and does not appear plumb. Areas of overhang of stone along crest, instead of flush with face of wall.	Repoint wall, replace missing stones, and mortar between joints where possible.	2
NN8	5+50	6+05	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. The crest of the wall is uneven and does not appear plumb. Areas of overhang of stone along crest, instead of flush with face of wall.	Repoint wall, replace missing stones, and mortar between joints where possible.	2
NN9	6+05	6+60	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones.	Repoint wall, replace missing stones, and mortar between joints where possible.	3
NN10	6+60	6+80	Dry-Laid Stone Wall/Masonry Stone Wall	Portions of the upper wall have mortared joints and appear to be re-pointed. Overall wall in good condition; however, some vegetation and missing stones were noted.	Monitor wall section for movement or changes.	4
NN11	6+80	10+50	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. The crest of the wall is uneven and does not appear plumb. Areas of overhang of stone along crest or missing stone altogether, instead of flush with face of wall.	Repoint wall, replace missing stones, and mortar between joints where possible.	2

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
NN12	10+50	10+75	Dry-Laid Stone Wall/Masonry Cap	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
NN13	10+75	12+25	Dry-Laid Stone Wall	Traces of mortar were noted between the joints of smaller stones. Pointing appeared in relatively good shape and only small voids were noted. An old pipe was noted to daylight through the wall. However, its joints are mortared, and the steel cap is also encapsulated in concrete.	Monitor wall section for movement or changes.	4
NN14	12+25	14+90	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. Some mortar is noted but sporadic. Alignment of face appears skewed, with overhanging cap stones. However, alignment is not severe and does not appear in a state of toppling.	Repoint wall, replace missing stones, and mortar between joints where possible.	3
NN15	14+90	17+20	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. Some mortar is noted but sporadic. Alignment of face appears skewed, with overhanging cap stones. However, alignment is not severe and does not appear in a state of toppling.	Repoint wall, replace missing stones, and mortar between joints where possible.	2
NN16	17+20	20+20	Dry-Laid Stone Wall/Concrete Wall Cap	Wall appears in great condition. Minor areas noted of vegetative growth and minor missing stone.	Continue monitoring for potential deterioration over time.	5
NN17	20+20	25+05	Dry-Laid Stone Wall/Masonry Stone Wall	Wall appears in great condition. Minor areas noted of vegetative growth and minor missing stone. Top of wall has recent mortared joints that appear in good condition. Bottom of wall has missing mortar but appears stable and solidly built.	Continue monitoring for potential deterioration over time.	5
NN18	25+05	25+90	Dry-Laid Stone Wall/Concrete Wall Cap	Wall appears in relatively good condition. Minor areas of missing stone noted.	Continue monitoring for potential deterioration over time.	5
NN19	25+90	28+40	Masonry Stone Wall	Wall appears in great condition. Minor areas noted of vegetative growth. Overall mortar looks to be in good shape with only minor areas of missing mortar.	Continue monitoring for potential deterioration over time.	5
NN20	28+40	29+00	Concrete Wall	Wall appears brand new under the two bridges.	Continue monitoring for potential deterioration over time.	5
NN21	29+00	30+10	Dry-Laid Stone Wall	Traces of mortar were noted between the joints of smaller stones. Voids of missing stone were noted and areas of erosion below cap stones was strongly noted.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate.	3
NN22	30+10	31+35	Dry-Laid Stone Wall	Traces of mortar were noted between the joints of smaller stones. Voids of missing stone were noted and areas of erosion below cap stones was strongly noted. Large voids below the capstones can result in toppling of the crest of the wall. Several capstones are already missing based on these voids.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate. Repoint and plumb wall.	2

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
NN23	31+35	33+00	Dry-Laid Stone Wall	Large concrete public observation deck above wall with benches and brick face. The crest and stones near the top of the wall appear to be leaning heavily into the canal, most likely caused by significant erosion of soils behind the canal wall and under the observation deck. Several leaning stones appear to bow into canal. Many capstones are eroded. Does not appear plumb or stable. However, historically noted to appear similar in 2019 inspection. Sediment movement on top of stones shows heavy erosion from stormwater.	Rebuild wall below concrete patio. Essex is working with Department of Conservation and Recreation and Lawrence Redevelopment Authority to coordinate repairs in 2026.	1
NN24	33+00	34+30	Dry-Laid Stone Wall	Large areas of missing stone. Woody vegetative growth between stones. Wall is covered in vegetation, mostly vines.	Repoint wall, replace missing stones, and mortar between joints where possible. Remove vegetation.	3
NN25	34+30	34+90	Dry-Laid Stone Wall, Brick and Concrete Cap	Pointing of overall wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints. Additionally, the brick pointing is not flush, with a number of angled bricks and missing bricks.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting. Repoint stones and bricks that are out of alignment.	3
NN26	34+90	40+50	Dry-Laid Stone Wall/Masonry Stone Wall	The wall is covered in large amounts of vine and grassy vegetation. However, the wall appears generally stable and plumb. There are some minor areas of voids with missing stones and missing mortar; however, most of the wall is flush and well-mortared.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate.	4
NN27	40+50	40+90	Dry-Laid Stone Wall	Stones do not appear stable or plumb. Bridge above is closed to pedestrian and vehicle access. Areas of seepage noted. Several large voids are noted.	Rebuild wall below bridge abutment in kind. Mortar joints for added stability and to prevent erosion/seepage from abutment.	2
NN28	40+90	41+80	Dry-Laid Stone Wall/Masonry Stone Wall	The wall is covered in large amounts of vine and grassy vegetation. However, the wall appears generally stable and plumb. There are some minor areas of voids with missing stones and missing mortar; however, most of the wall is flush and well-mortared.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate.	4
NN29	41+80	42+25	Dry-Laid Stone Wall with Concrete Cap	Concrete surface is weathered but does not appear to have widespread spalling. Stone sections appear to be missing a series of stones and mortar but appear relatively stable and plumb. Minor vegetation in wall cracks.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate.	4
NN30	42+25	43+05	Concrete Wall	Concrete surface appears in good condition. Minor efflorescence on surface.	Monitor for future deterioration.	5
NN31	43+05	43+35	Dry-Laid Stone Wall with Concrete Cap	Concrete surface is weathered but does not appear to have widespread spalling. Stone sections appear to be missing a series of stones and mortar but appear relatively stable and plumb. Minor vegetation in wall cracks.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate.	4

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
NN32	43+35	44+90	Dry-Laid Stone Wall/Masonry Stone Wall	Traces of mortar were noted between the joints of smaller stones. Voids of missing stone were noted and areas of erosion below cap stones was strongly noted. Large voids below the capstones can result in toppling of the crest of the wall. Several capstones are already missing based on these voids. Several voids appear due to old pipe entrances, which may still serve as erosion paths. Bottom is not mortared while capstones are.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate. Repoint and plumb wall.	3
NN33	44+90	45+60	Dry-Laid Stone Wall with Concrete Cap	Concrete surface is weathered but does not appear to have widespread spalling. Stone sections appear to be missing a series of stones and mortar but appear relatively stable and plumb. Minor vegetation in wall cracks.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate.	4
NN34	45+60	46+50	Masonry Stone Wall	Stones appear stable and plumb and most of the mortar is still in place. Some minor spots of missing mortar or missing smaller stones.	Monitor wall section for movement or changes. Replace missing stones and fill voids. Mortar as appropriate.	4
NN35	46+50	47+20	Dry-Laid Stone Wall	Stones do not appear properly pointed. Portions do not appear plumb. Voids are moderate in size and several stones have visible wear. Additionally, the abandoned utility structure is in a state of disrepair and is impacting the wall. The crest of the wall is non-uniform and has missing or shifted stones. The wall is covered in heavy vegetation.	Replace wall in-kind around the abandoned intake structure. Fill holes in the intake structure with stone and mortar to prevent leakage.	1
NN36	47+20	48+95	Dry-Laid Stone Wall	There are some large areas of missing stones. Pointing of stones does not appear uniform with a flush surface. However, wall appears stable. There appears to be vegetation between stones.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3
NN37	48+95	51+25	Dry-Laid Stone Wall	There are some large areas of missing stones. Pointing of stones does not appear uniform with a flush surface. However, wall appears stable. There appears vegetation between stones.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3
NN38	51+25	51+75	Dry-Laid Stone Wall	Stones do not appear properly pointed. Portions do not appear plumb. Voids are moderate in size and several stones have visible wear. Additionally, the abandoned utility structure is in a state of disrepair and is impacting the wall. The crest of wall is non-uniform and has missing or shifted stones. Wall is covered in heavy vegetation.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3
NN39	51+75	53+05	Masonry Stone Wall	Wall appears in good condition.	Monitor for future deterioration.	5
NN40	53+05	55+50	Dry-Laid Stone Wall	There are some large areas of missing stones. Pointing of stones does not appear uniform with a flush surface. However, the wall appears stable. There appears to be vegetation in between stones.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
NN41	55+50	57+55	Dry-Laid Stone Wall	There are some large areas of missing stones. Pointing of stones does not appear uniform with a flush surface. However, wall appears stable. There appears to be vegetation in between stones.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3
NN42	57+55	58+55	Dry-Laid Stone Wall/Concrete Wall	Abandoned intake structure composed of concrete walls, dry-laid stone walls, and a corroded steel framework. Surfaces are generally eroded but appear in good condition. Stable and plumb.	Monitor for future deterioration. Rehabilitate, restore, or preserve the intake structure.	4
NN43	58+55	61+25	Earthen Embankment	Sloped earthen embankment with minor vegetation. Slope appears maintained.	Monitor for future deterioration.	5
NS1	0+00	1+00	Dry-Laid Stone Wall/Concrete Wall	The wall appears stable; however, many of the stones are displaced and at angles without a smooth surface. A number of stones are missing or dislodged. Vegetation is present between stones along the entire length. The concrete wall below Broadway St. bridge appears in relatively good condition.	Replace missing stones and repoint stones to provide smooth surface. Remove/treat vegetation. Monitor for future shifting or void formations.	3
NS2	1+00	4+40	Dry-Laid Stone Wall	The wall appears stable; however, many of the stones are displaced and at angles without a smooth surface. A number of stones are missing or dislodged. Vegetation is present between stones along the entire length. Concrete structures are periodically built into the wall and appear in relatively stable condition.	Replace missing stones and repoint stones to provide smooth surface. Remove/treat vegetation. Monitor for future shifting or void formations.	3
NS3	4+40	4+85	Brick Wall with Concrete Capstone and Concrete Bulkheads	Old intakes framed in brick. The intake pipes have been filled with concrete. The top of the wall has a concrete cap stone. Wood framing for intake is heavily deteriorated and much of the surface mortar for the brick has been eroded. The concrete cap stones have spalling and erosion, and the uneven surface of the intake has a large amount of vegetation.	Remove/treat vegetation. Add mortar to brick joints that may be missing them. Restore, rehabilitate, or preserve the old intakes.	3
NS4	4+85	7+85	Dry-Laid Stone Wall	Wall appears stable; however, many of the stones are displaced and at angles without a smooth surface. A number of stones are missing or dislodged. Vegetation is present between stones along entire length.	Replace missing stones and repoint stones to provide smooth surface. Remove/treat vegetation. Monitor for future shifting or void formations.	3
NS5	7+85	8+30	Brick Wall with Concrete Capstone and Concrete Bulkheads	Old intakes framed in brick. The intake pipes have been filled with concrete. Top of wall has a concrete cap stone. Wood framing for intake is heavily deteriorated and much of the surface mortar for the brick has been eroded. The concrete cap stones have spalling and erosion, and the uneven surface of the intake has a large amount of vegetation.	Remove/treat vegetation. Add mortar to brick joints that may be missing them. Restore, rehabilitate, or preserve the old intakes.	3
NS6	8+30	14+50	Dry-Laid Stone Wall	Wall appears stable; however, many of the stones are displaced and at angles without a smooth surface. A number of stones are missing or dislodged. Vegetation is present between stones along entire length.	Replace missing stones and repoint stones to provide smooth surface. Remove/treat vegetation. Monitor for future shifting or void formations.	3
NS7	14+50	15+25	Dry-Laid Stone Wall with Shotcrete Overlay/Concrete Wall	Top of wall is dry-laid stone wall with shotcrete overlaid on its surface. Bottom of wall is old concrete. Shotcrete appears in stable condition but has cracks. Concrete wall has a series of large vertical cracks. Vegetation is present along the entire wall length.	Monitor concrete/shotcrete for scaling/large cracks. Repair, as necessary. Remove/treat vegetation.	4
NS8	15+25	18+00	Dry-Laid Stone Wall	There are some large areas of missing stones. Pointing of stones does not appear uniform with a flush surface. However, wall appears stable and generally plumb. There appears vegetation between stones.	Monitor for future deterioration. Remove/treat vegetation. Repoint shifted stones. Fill voids/gaps with new stones.	3

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
NS9	18+00	19+25	Concrete Wall	Wall appears to be in good condition. No major or minor issues noted.	Monitor for future deterioration.	5
NS10	19+25	23+75	Dry-Laid Stone Wall	Wall appears to be unstable and leaning into the canal. Some top stones appear to have already collapsed into the canal. There are various gaps and voids noted. A large number of stones are displaced.	Replace wall in kind with dry-laid stone and mortar.	1
NS11	23+75	24+40	Concrete Wall/Steel Intake	Wall appears to be in good condition. No major or minor issues noted.	Monitor for future deterioration.	5
NS12	24+40	25+25	Masonry Stone Wall	Wall appears to be in good condition. No major or minor issues noted.	Monitor for future deterioration.	5
NS13	25+25	25+55	Concrete Wall	Wall appears to be in good condition. No major or minor issues noted.	Monitor for future deterioration.	5
NS14	25+55	28+35	Dry-Laid Stone Wall	The wall appears to have the upper stones in the wall shifting outwards compared to the bottom stones. The crest of the wall is heavily eroded as evidenced by the sod and soil. Minor voids and displaced stones throughout.	Monitor for future deterioration. Remove/treat vegetation. Repoint shifted stones.	3
NS15	28+35	29+00	Concrete Wall	Wall appears to be relatively new and in good condition. No major or minor issues noted.	Monitor for future deterioration.	5
NS16	29+00	29+50	Dry-Laid Stone Wall	The wall appears to be stable and generally plumb; however, the crest of the wall is heavily eroded. Some mortar is seen in certain locations. Some minor shifting of stones and some minor gaps.	Monitor for future deterioration. Remove/treat vegetation. Repoint shifted stones.	3
NS17	29+50	31+75	Dry-Laid Stone Wall with Concrete Surface Overlay	Portions of the concrete overlay have cracked off and exposed the stone below. Bottom is missing stones. Some areas of the crest have settled or shifted, leaning inwards.	Repoint stones and fill voids. Resurface with concrete once formed to be plumb and with a consistent crest elevation.	3
NS18	31+75	32+35	Dry-Laid Stone Wall	There are a number of missing stones and cracks in some of the existing stones. However, wall appears generally stable and plumb. The surface is uneven. There is some vegetative growth in the cracks.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3
NS19	32+35	34+00	Masonry Stone Wall	The wall appears generally stable and plumb. However, there is evidence of erosion of vegetation and sod on top of crest. Minor cracks and missing stones appear throughout.	Monitor for future deterioration. Remove/treat vegetation to prevent crest erosion.	4
NS20	34+00	35+25	Dry-Laid Stone Wall	Stones do not appear properly pointed. Portions do not appear plumb. Voids are moderate in size and several stones have visible wear. Additionally, the abandoned utility structure is in a state of disrepair. The crest of wall is non-uniform and has missing or shifted stones. Wall is covered in heavy vegetation.	Replace wall. Fill the abandoned intake structure opening with concrete, if planned to keep the gate remaining closed, or fill with stones and mortar joints if the gate will be opened at times, to maintain its historic value while preventing seepage.	2
NS21	35+25	37+80	Dry-Laid Stone Wall with Concrete Surface Overlay	Portions of the concrete overlay have cracked off and exposed the stone below. The top of the wall is leaning slightly, and the bottom is missing stones. Some areas of the crest have settled.	Repoint stones and fill voids. Resurface with concrete once formed to be plumb and with a consistent crest elevation.	3
NS22	37+80	38+95	Concrete Wall	The concrete is heavily eroded along its crest and has a number of cracks along the old intake structure.	Repair top of wall and monitor for future deterioration.	3

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
NS23	38+95	39+35	Dry-Laid Stone Wall	The wall crest has toppled over, and the remaining top stones are significantly leaning. Portions of the wall are heavily eroded and have failed onto a sediment deposit in the canal.	Replace wall section in kind.	1
NS24	39+35	42+30	Dry-Laid Stone Wall	The wall appears to be stable and generally plumb; however, the crest of the wall is heavily eroded. Some mortar is seen in certain locations. Some minor shifting of stones and some minor gaps.	Monitor for future deterioration. Remove/treat vegetation. Repoint shifted stones.	3
NS25	42+30	42+60	Concrete Wall	The wall has minor cracking and appears pitted in some locations. However, the wall appears stable, plumb, and generally uniform.	Monitor for future deterioration.	5
NS26	42+60	44+60	Dry-Laid Stone Wall	The wall appears to be stable and generally plumb; however, the crest of the wall is heavily eroded. Some mortar is seen in certain locations. Some minor shifting of stones and some minor gaps.	Monitor for future deterioration. Remove/treat vegetation. Repoint shifted stones. Restore, rehabilitate, or preserve the old intakes.	3
NS27	44+60	48+10	Dry-Laid Stone Wall	The wall appears to be stable and generally plumb. Some minor shifting of stones and some minor gaps. Surface generally appears uniform.	Monitor for future deterioration. Remove/treat vegetation.	4
NS28	48+10	48+30	Dry-Laid Stone Wall	Wooden gate structure appears significantly deteriorated. Wall stones have shifted and partially collapsed at crest. Remaining stonework is leaning and does not appear stable.	Rebuild wall in kind. Fill the opening behind the intake gate with similar stone and mortar joints. Rehabilitate, restore, or preserve the intake structure.	1
NS29	48+30	49+35	Dry-Laid Stone Wall	The wall appears to be stable and generally plumb. Some minor shifting of stones and some minor gaps. Surface generally appears uniform.	Monitor for future deterioration. Remove/treat vegetation.	4
NS30	49+35	51+40	Dry-Laid Stone Wall	The wall has several large voids and dislodged stones. The wall appears to be slightly leaning, as evidenced by the heavy erosion of soil and sod on top of the wall crest. Abandoned concrete has significant undermining.	Rebuild wall.	2
NS31	51+40	53+05	Masonry Stone Wall	The wall appears to be in good condition with no major missing stones or mortar noted. There does not appear to be any vegetation between stones. Surface appears slightly uneven but does not appear to affect its plumbness or stability.	Monitor for future deterioration.	5
NS32	53+05	57+45	Dry-Laid Stone Wall	There are some large areas of missing stones. Pointing of stones does not appear uniform with a flush surface. However, wall appears stable and generally plumb. There appears vegetation between stones.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3
NS33	57+45	60+15	Dry-Laid Stone Wall	There are some large areas of missing stones. Pointing of stones does not appear uniform with a flush surface. However, wall appears stable and generally plumb. There appears vegetation between stones.	Remove/treat vegetation. Repoint stones that are out of placement. Replace missing stones and fill voids.	3
NS34	60+15	60+80	Earthen Embankment with riprap and Dry-Laid Stone Wall cap	Sloped earthen embankment with minor vegetation. Slope appears maintained. Rip-rap is not spread evenly. Stone wall cap is out-of-plumb and does not appear stable.	Monitor embankment for future deterioration. Add additional riprap for reinforcing. Repoint and mortar stone wall cap, filling voids with new stones.	2
NS35	60+80	61+25	Concrete Wall	The wall is in good condition with no signs of major deterioration. Wall appears stable and plumb.	Monitor for future deterioration.	5
SN1	0+00	0+50	Dry-Laid Stone Wall (with some mortar)	Pointing of wall looks in great condition. Surface is smooth and flush and well-maintained.	Monitor for future deterioration.	5
SN2	0+50	3+25	Dry-Laid Stone Wall (with some mortar)	Pointing of wall has some irregularities in the stones. However, structure of wall appears stable and generally plumb.	Monitor for future deterioration. Monitor for shifting of stones.	4

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
SN3	3+25	5+25	Dry-Laid Stone Wall with Concrete Cap	The wall appears stable. However, the face of the wall does not appear uniform, indicating shifting of stones. No major voids noted. Minor vegetation in wall cracks and minor voids.	Remove and treat vegetation. Monitor for developing voids or larger shifts in stonework.	4
SN4	5+25	5+90	Dry-Laid Stone Wall with Concrete Cap	The wall appears stable. However, the face of the wall does not appear uniform, indicating shifting of stones. No major voids noted. Minor vegetation in wall cracks and minor voids. Wooden stoplogs are in place over a portion of the wall for a release structure. No seepage or major deterioration noted.	Remove and treat vegetation. Monitor for developing voids or larger shifts in stonework.	4
SN5	5+90	7+40	Dry-Laid Stone Wall/Masonry Stone Wall	The wall appears to be missing a number of stones and wall face does not appear flush in locations. Some portions appear to have been repaired and re-mortared. Old gate structure appears in a state of heavy disrepair and has impacted the stone structure. This wall section is heavily vegetated both on the wall and on its crest.	Replace wall or repoint, fill voids, and re-mortar wall (with the exception of the wall portion that was already repaired). Remove the two old gate structures if not deemed to still be in usage or historic. Remove vegetation.	2
SN6	7+40	8+80	Dry-Laid Stone Wall	The wall appears to be missing a number of stones, and some stones appear protruded from surface. However, wall appears stable. Minor vegetation is noted in the cracks between stones.	Remove and treat vegetation. Monitor for developing voids or larger shifts in stonework.	3
SN7	8+80	10+25	Dry-Laid Stone Wall	The wall appears to be missing a number of stones, and some stones appear protruded from surface. However, the wall appears stable. Minor vegetation is noted in the cracks between stones. Two old intakes are hosted at this wall section. While the intakes themselves appear in poor condition for their steel and wood components, they do not appear to have heavily impacted the canal wall.	Remove and treat vegetation. Repoint stones and fill voids with stones and mortar.	3
SN8	10+25	11+50	Masonry Stone Wall	The wall appears to be stable and plumb with all joints mortared and an old outlet filled and mortared.	Monitor for any future deterioration.	5
SN9	11+50	13+50	Dry-Laid Stone Wall	The wall appears stable. However, the face of the wall does not appear uniform, indicating shifting of stones. No major voids noted. Minor vegetation in wall cracks and minor voids.	Remove and treat vegetation. Monitor for developing voids or larger shifts in stonework.	4
SN10	13+50	18+60	Dry-Laid Stone Wall	The wall appears stable. However, the face of the wall does not appear uniform, indicating shifting of stones. No major voids noted. Minor vegetation in wall cracks and minor voids. Small intake gate appears in	Remove and treat vegetation. Monitor for developing voids or larger shifts in stonework.	4
SN11	18+60	21+10	Dry-Laid Stone Wall with Concrete Cap	The wall appears stable. However, the face of the wall does not appear uniform, indicating shifting of stones. No major voids noted. Minor vegetation in wall cracks and minor voids. Wooden stoplogs are in place over a portion of the wall for an old release structure. No seepage or major deterioration of the boards noted. Rest of release structure is in poor condition.	Remove and treat vegetation. Monitor for developing voids or larger shifts in stonework. Remove abandoned structure if not deemed historically significant.	3
SN12	21+10	23+60	Dry-Laid Stone Wall	The wall appears to be missing a number of stones, and some stones appear protruded from surface. However, wall appears stable. Minor vegetation is noted in the cracks between stones.	Remove and treat vegetation. Monitor for developing voids or larger shifts in stonework.	4
SN13	23+60	24+00	Masonry Stone Wall (with Concrete Bulkhead)	The wall appears stable and plumb. Stones are held together with masonry. An old intake is filled with a concrete bulkhead. Stones and concrete look slightly weathered but overall in good condition.	Monitor for any future deterioration.	5

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
SN14	24+00	25+00	Dry-Laid Stone Wall	The wall appears to be missing a number of stones, and some stones appear protruded from surface. However, the wall appears stable. Minor vegetation is noted in the cracks between stones. There are some areas with large chunks of stones missing and areas where old (removed) pipes daylight.	Remove and treat vegetation. Fill voids and mortar areas around old pipe inlets. Monitor for developing voids or larger shifts in stonework.	3
SN15	25+00	27+60	Masonry Stone Wall (with Concrete Bulkhead)	The wall appears stable and plumb. Stones are held together with masonry. An old intake is filled with a concrete bulkhead. Stones and concrete look slightly weathered but overall in good condition.	Monitor for any future deterioration.	5
SN16	27+60	28+75	Masonry Stone Wall	The wall appears stable and plumb. Stones are held together with masonry. There are two areas with larger missing stones that appear to be from an old structure that was removed. Otherwise, the wall is in good condition.	Monitor for any future deterioration. Observe areas of missing stone for any shifting or further deterioration.	4
SN17	28+75	30+25	Dry-Laid Stone Wall	The wall appears to be missing a number of stones, and some stones appear protruded from surface. However, wall appears stable. Minor vegetation is noted in the cracks between stones. There are some areas with large chunks of stones missing and areas where old intakes have been bulkheaded with concrete.	Remove and treat vegetation. Fill voids and mortar areas around old intakes. Monitor for developing voids or larger shifts in stonework.	3
SN18	30+25	31+75	Dry-Laid Stone Wall/Masonry Stone Wall	The wall appears to be missing a number of stones, and some stones appear protruded from the surface. However, the wall appears stable. Minor vegetation is noted in the cracks between stones. There are some areas with large chunks of stones missing and areas where old intakes have been bulkheaded with concrete.	Remove and treat vegetation. Fill voids and mortar areas around old intakes. Monitor for developing voids or larger shifts in stonework.	3
SN19	31+75	34+00	Dry-Laid Stone Wall/Masonry Stone Wall	Some stones appear missing and/or protruded from surface. However, the wall appears stable and plumb. Minor vegetation is noted in the cracks between stones. Intakes appear in relatively good condition. The entrance to the South Canal Wasteway appears to be well-maintained.	Remove and treat vegetation. Fill voids and mortar areas around old intakes. Monitor for developing voids or larger shifts in stonework.	4
SN20	34+00	34+00	Dry-Laid Stone Wall (with Concrete Bulkhead)	End of South Canal. The wall appears to be stable. A concrete bulkhead is in place for an old discharge channel/pipe. Does not appear to have been used in a long time.	Monitor for future deterioration. Remove old pipe stem, if determined to not be historically remarkable.	4
SS1	0+00	0+25	Masonry Stone Wall	The wall looks stable and plumb. Masonry was noted in all joints. Wall is well-maintained.	Monitor for future deterioration.	5
SS2	0+25	1+50	Bedrock Face	This portion of the South Canal is maintained by a bedrock outcropping.	Monitor for future deterioration.	5
SS3	1+50	3+10	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS4	3+10	5+20	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS5	5+20	6+20	Dry-Laid Stone Wall	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones and the presence of woody vegetation between several joints. The surface block contacts are highly eroded. Presence of seepage noted in some joints.	Remove/treat vegetative growth. Replace missing stones and mortar joints around bridge. Add mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS6	6+20	7+35	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
SS7	7+35	10+50	Dry-Laid Stone Wall	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones and the presence of woody vegetation between several joints. The surface block contacts are highly eroded. Presence of seepage noted in some joints.	Remove/treat vegetative growth. Replace missing stones and mortar joints around new stone placement. Add mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS8	10+50	12+25	Dry-Laid Stone Wall	Areas of shifting of stones has occurred. There are missing and dislodged stones, including several stones close to 18-24" in length and the presence of woody vegetation between several joints. The surface block contacts are highly eroded.	Remove/treat vegetative growth. Replace missing stones and mortar joints around new stone placement. Add mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS9	12+25	13+00	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS10	13+00	15+10	Dry-Laid Stone Wall	Areas of shifting of stones has occurred. There are missing and dislodged stones, including several capstones 12"+ in length and the presence of woody vegetation between several joints. The surface block contacts are highly eroded. Minor seepage is noted in some locations.	Remove/treat vegetative growth. Replace missing stones and mortar joints around new stone placement. Add mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS11	15+10	15+40	Dry-Laid Stone Wall/Brick-and-Mortar	The general wall in this area is dry-laid stone wall; however, the upper portion is composed of a brick-and-mortar frame over a pipe exit. Seepage is noted along this brick framing and pipe exit, which is capped and stubbed. Brick is no longer properly pointed, mortar is missing, and stone is missing in the rest of the wall.	Replace brick framing around opening and fill rest of opening with either brick or dry-laid stone wall to prevent erosion and large amounts of seepage.	2
SS12	15+40	17+25	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS13	17+25	17+50	Dry-Laid Stone Wall	A discharge pipe is seen coming into the wall. However, almost all stone is missing for an 18" wide section	Replace wall.	1
SS14	17+50	18+50	Dry-Laid Stone Wall	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones and the presence of woody vegetation between several joints. The surface block contacts are highly eroded. Presence of seepage noted in some joints.	Remove/treat vegetative growth. Replace missing stones and mortar joints around bridge. Add mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS15	18+50	19+15	Dry-Laid Stone Wall	Pointing of the wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS16	19+15	20+15	Dry-Laid Stone Wall/Concrete	The upper portion of the wall below the bridge deck is concrete, although quite worn, with exposed portions of the aggregate. The dry-laid stone portion below is in relatively good condition, though has some missing and dislodged stones.	Monitor condition of concrete and stones for any further deterioration or exposure.	4
SS17	20+15	20+90	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints. Some missing stones are relatively large in size (approximately 0.5 sq. ft or larger on the surface of wall).	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting. Replace missing stones in larger voids.	3

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
SS18	20+90	21+00	Dry-Laid Stone Wall/Concrete	The upper portion of the wall below the bridge deck includes a concrete overlay. The dry-laid stone portion below is in relatively good condition, though has some missing and dislodged stones.	Monitor condition of concrete and stones for any further deterioration or exposure.	4
SS19	21+00	21+40	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS20	21+40	21+85	Dry-Laid Stone Wall	Pointing of the wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints, primarily woody vegetation in the cap. The top of the wall is missing a number of large stones, causing jutting of the surrounding stones from a lack of uniformity. One area of complete vertical missing stone about three (3) inches wide.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting. Replace missing stones in larger voids.	3
SS21	21+85	23+50	Dry-Laid Stone Wall	Pointing of the wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints. The stone below the old railroad bridge is slightly more deteriorated than rest of the section but in stable condition.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS22	23+50	24+75	Dry-Laid Stone Wall	Pointing of the wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints, primarily woody vegetation in the cap. One area of complete vertical missing stone about three (3) inches wide.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting. Replace missing stones in larger voids.	3
SS23	24+75	26+10	Dry-Laid Stone Wall	Pointing of the wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS24	26+10	27+10	Dry-Laid Stone Wall	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones and the presence of woody vegetation between several joints. The surface block contacts are highly eroded.	Remove/treat vegetative growth. Add stone and mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS25	27+10	28+20	Dry-Laid Stone Wall	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS26	28+20	28+50	Dry-Laid Stone Wall	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones and the presence of woody vegetation between several joints. The surface block contacts are highly eroded.	Remove/treat vegetative growth. Add stone and mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS27	28+50	29+95	Dry-Laid Stone Wall	Pointing of the wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4
SS28	29+95	30+55	Dry-Laid Stone Wall (with some mortar at certain locations)	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones and the presence of woody vegetation between several joints. The surface block contacts are highly eroded.	Remove/treat vegetative growth. Add stone and mortar between joints of capstones to prevent erosion of topping soil. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS29	30+55	31+75	Dry-Laid Stone Wall (with some mortar at certain locations)	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4

I.D. No.	Start Stationing	End Stationing	Type of Wall	Observations	Recommendations	Risk Level
SS30	31+75	32+40	Dry-Laid Stone Wall (with some mortar at certain locations)	Overall pointing appears stable but areas of shifting of stones has occurred. There are missing and dislodged stones, including some areas with stones of 12"+ in height or greater missing or askew.	Remove/treat vegetative growth. Add stone and mortar where stones are missing. Monitor wall section for continuing loss of stones or any continued shifting.	3
SS31	32+40	34+00	Dry-Laid Stone Wall (with some mortar at certain locations)	Pointing of wall appears stable; however, there are missing and dislodged stones and the presence of vegetation between several joints.	Remove/treat vegetative growth. Monitor wall section for continuing loss of stones or any shifting.	4

Appendix D - Germane Consultation and Correspondence

July 16, 2024

Jonas Stundžia
Chairman
Lawrence Historical Commission
200 Common Street
3rd Floor
Lawrence, MA 01840

Subject: **Initiating Consultation and Requesting Concurrence on the Area of Potential Effects for the Lawrence Hydroelectric Project, FERC Project Number 2800; Essex County, Massachusetts.**

Dear Jonas Stundžia:

Essex Company, LLC (Essex), a subsidiary of Patriot Hydro, LLC, is the Licensee, owner, and operator of the Lawrence Hydroelectric Project (FERC No. 2800) (Project or Lawrence Project). The Project was licensed by the Federal Energy Regulatory Commission (FERC or Commission) on December 4, 1978 (with an effective date of December 1, 1978), and the license expires on November 30, 2028. The Lawrence Project is located on the Merrimack River in the City of Lawrence in Essex County, Massachusetts. Essex has initiated a licensing process for the Project with the Federal Energy Regulatory Commission (FERC). The issuance of a license by FERC to Essex is a federal undertaking subject to compliance with relevant federal historic preservation laws. In particular, as the lead federal agency for the undertaking, FERC must comply with Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended (54 U.S.C. § 300101 et seq.), which requires federal agencies to take into account the effects of their undertakings on historic properties.[1]

FERC issued a Notice of Notice of Intent (NOI) to File License Application and Filing of Pre-Application Document on August 15, 2023. This issuance designated Essex as the non-federal representative in accordance with Title 36 Code of Federal Regulations (CFR) Section 800.2(c)(4) for purposes of consultation under Section 106 of the NHPA (see Attachment 2).[2] On behalf of Essex under the authority of the FERC, HDR Engineering, Inc. (HDR) initiated consultation with the Massachusetts State Historic Preservation Officer (SHPO) per 36 CFR Section 800.3 for the Project and in accordance with 36 CFR

[1] "Historic property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places [NRHP] maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria" (36 CFR Section 800.16(l)(1).
[2] FERC issued the Notice of Notice of Intent to File License Application and Filing of Pre-Application Document on August 15, 2023.

800.4(a)(1), requested concurrence on the appropriateness of the area of potential effects (APE) for the proposed undertaking. Additionally, Essex is seeking your concurrence with with the APE for the proposed undertaking.

Project Description

The Lawrence Hydroelectric Project is located along the Merrimack River in Lawrence, Massachusetts, and the Project consists of facilities including the Essex Dam, or the Great Stone Dam, the Project impoundment, intake canal, powerhouse, turbines and generators, the North Canal the South Canal and their respective gatehouses, tailrace, fish passage structures, transmission line, and recreational facilities. The Project is the first dam on the Merrimack River, approximately 29 river miles (RM) from the Atlantic Ocean and is located approximately 11 RM downstream of the Lowell Hydroelectric Project (FERC No. 2790).

FERC regulations require that a licensed hydroelectric project include a defined Project Boundary that includes "only those lands necessary for operation and maintenance of the project and for other project purposes, such as recreation, shoreline control, or protection of environmental resources." The Project Boundary encompasses approximately 1,092 acres.

Area of Potential Effects Description

Project operation and maintenance has the potential to affect historic properties. As defined in the applicable regulations found at 36 CFR 800.16(d), the APE is "...the geographic area or areas within which an undertaking may directly or indirectly cause changes in the character or use of historical properties, if any such properties exist." Because the Project Boundary encompasses all lands that are necessary for Project purposes, all Project-related operations, potential enhancement measures, and routine maintenance activities associated with the implementation of a license issued by the Commission are expected to take place within the Project Boundary. The proposed APE is consistent with the potential scope of Project effects and the manner in which the Commission has defined the APEs for other hydroelectric relicensings.

During the licensing process, Essex will conduct a Condition Assessment of Historic Properties and Associated Canal System Study in accordance with the *Condition Assessment of Historic Properties and Associated Canal System Study Plan, Lawrence Hydroelectric Project (FERC No. 2800)* (Study Plan), dated April 10, 2024.

Because it is not possible to determine all of the effects of various activities that may occur over the course of a license, Essex plans to develop a Historic Properties Management Plan (HPMP) in consultation with consulting parties to manage potential effects on historic properties throughout the term of a license issued by FERC. FERC typically completes

Section 106 by entering into a Programmatic Agreement (PA) or Memorandum of Agreement (MOA) with the licensee, the Advisory Council on Historic Preservation (ACHP), if they choose to participate, and the SHPO that requires the licensee to develop and implement an HPMP in consultation with Section 106 consulting parties.

Essex will prepare a report at the conclusion of the Condition Assessment of Historic Properties and Associated Canal System Study that will contain sensitive, confidential, and privileged information and will work with FERC, SHPO, and tribes to ensure that confidential information is shared with consulting parties appropriately. Essex will seek SHPO concurrence on any NRHP eligibility determinations. The study report may be filed with FERC with a designation as "privileged." Essex will also provide a summary of findings for purposes of the public licensing process that excludes sensitive, confidential, and privileged information.

Essex requests your concurrence on the appropriateness of the APE for the proposed undertaking. We look forward to receiving your response within 30 days of your receipt of this submittal given field work associated with the Condition Assessment of Historic Properties and Associated Canal System Study is scheduled to begin in this fall of 2024 (mid-September to October).

If you have any questions or require additional information regarding the attachments or any other aspect of this transmittal, please do not hesitate to contact me at (717) 515-8994 or Kimberly.smith@hdrinc.com. Thank you for your assistance with this undertaking.

Respectfully submitted,

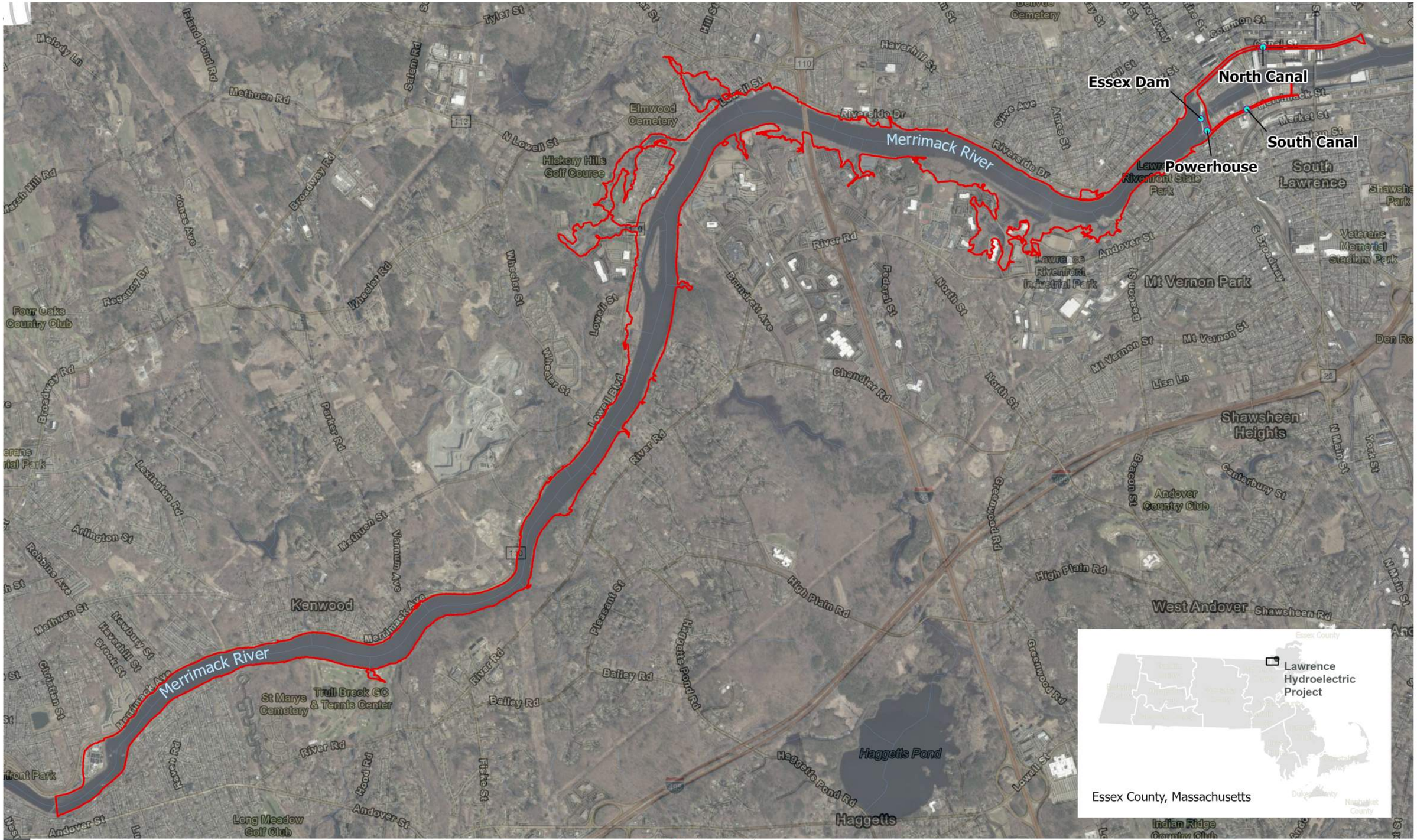
Kimberly Smith, MA, RPA
Senior Cultural Resources Specialist
HDR

cc:

Attachments: 1) Project Boundary Map
2) FERC Notice of Intent to File License Application, Filing of Pre-Application Document

Attachment 1

Project Boundary Map



AREA OF INTEREST
ESSEX DAM AND FACILITIES

PROJECT FACILITIES
ESSEX COUNTY, MASSACHUSETTS

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LAWRENCE HYDROELECTRIC PROJECT

Initiating Consultation and Requesting Concurrence on the APE for the Lawrence Hydroelectric Project, FERC Project Number 2800; Essex County, Massachusetts.

Attachment 2

FERC NOI and designation of Essex as non-federal representative for purposes of Section 106 consultation during licensing

UNITED STATES OF AMERICA
FEDERAL ENERGY REGULATORY COMMISSION

Essex Company, LLC Project No. 2800-054

NOTICE OF INTENT TO FILE LICENSE APPLICATION, FILING OF PRE-APPLICATION DOCUMENT (PAD), COMMENCEMENT OF PRE-FILING PROCESS, AND SCOPING; REQUEST FOR COMMENTS ON THE PAD AND SCOPING DOCUMENT, AND IDENTIFICATION OF ISSUES AND ASSOCIATED STUDY REQUESTS

(August 15, 2023)

a. Type of Filing: Notice of Intent to File License Application for a New License and Commencing Pre-filing Process

b. Project No.: 2800-054

c. Dated Filed: June 16, 2023

d. Submitted By: Essex Company, LLC (Essex)

e. Name of Project: Lawrence Hydroelectric Project (Lawrence Project)

f. Location: The project is located on the Merrimack River in the City of Lawrence in Essex County, Massachusetts.

g. Filed Pursuant to: 18 C.F.R. Part 5 of the Commission's Regulations

h. Applicant Contact: Kevin Webb, Hydro Licensing Manager, Essex Company, 670 N. Commercial Street, Suite 204, Manchester, NH 03101; (978) 935-6039; kwebb@patriothydro.com.

i. FERC Contact: Bill Connelly at (202) 502-8587 or e-mail at william.connelly@ferc.gov.

j. Cooperating agencies: Federal, state, local, and tribal agencies with jurisdiction and/or special expertise with respect to environmental issues that wish to cooperate in the preparation of the environmental document should follow the instructions for filing such requests described in item o below. Cooperating agencies should note the Commission's policy that agencies that cooperate in the preparation of the environmental document cannot also intervene. *See* 94 FERC ¶ 61,076 (2001).

k. With this notice, we are initiating informal consultation with: (a) the U.S. Fish and Wildlife Service and/or the National Oceanic and Atmospheric Administration Fisheries under section 7 of the Endangered Species Act and the joint agency regulations thereunder at 50 C.F.R., Part 402; and (b) the State Historic Preservation Office, as required by section 106, National Historic Preservation Act, and the implementing regulations of the Advisory Council on Historic Preservation at 36 C.F.R. § 800.2.

l. With this notice, we are designating Essex as the Commission's non-federal representative for carrying out informal consultation, pursuant to section 7 of the Endangered Species Act and section 106 of the National Historic Preservation Act.

m. Essex filed with the Commission a Pre-Application Document (PAD), including a proposed process plan and schedule, pursuant to 18 C.F.R. § 5.6 of the Commission's regulations.

n. A copy of the PAD may be viewed on the Commission's website (http://www.ferc.gov) using the "eLibrary" link. Enter the docket number, excluding the last three digits in the docket number field, to access the document. For assistance, contact FERC at FERCOnlineSupport@ferc.gov or call toll-free, (866) 208-3676 or TYY, (202) 502-8659.

   You may register online at https://ferconline.ferc.gov/FERCOnline.aspx to be notified via email of new filings and issuances related to these or other pending projects. For assistance, contact FERC Online Support.

o. With this notice, we are soliciting comments on the PAD and Commission staff's Scoping Document 1 (SD1), as well as study requests. All comments on the PAD and SD1, and study requests should be sent to the address above in paragraph h. In addition, all comments on the PAD and SD1, study requests, requests for cooperating agency status, and all communications to and from staff related to the merits of the potential application must be filed with the Commission.

   The Commission strongly encourages electronic filing. Please file all documents using the Commission's eFiling system at https://ferconline.ferc.gov/FERC Online.aspx. Commenters can submit brief comments up to 6,000 characters, without prior registration, using the eComment system at https://ferconline. ferc.gov/QuickComment.aspx. You must include your name and contact information at the end of your comments. For assistance, please contact FERC Support at FERCOnlineSupport@ferc.gov. In lieu of electronic filing, you may submit a paper copy. Submissions sent via the U.S. Postal Service must be addressed to: Kimberly D. Bose, Secretary, Federal Energy Regulatory

Commission, 888 First Street NE, Room 1A, Washington, DC 20426. Submissions sent via any other carrier must be addressed to: Kimberly D. Bose, Secretary, Federal Energy Regulatory Commission, 12225 Wilkins Avenue, Rockville, Maryland 20852. The first page of any filing should include docket number **P-2800-054.**

All filings with the Commission must bear the appropriate heading: "Comments on Pre-Application Document," "Study Requests," "Comments on Scoping Document 1," "Request for Cooperating Agency Status," or "Communications to and from Commission Staff." Any individual or entity interested in submitting study requests, commenting on the PAD or SD1, and any agency requesting cooperating status must do so by **October 14, 2023.**[1]

p. The Commission's Office of Public Participation (OPP) supports meaningful public engagement and participation in Commission proceedings. OPP can help members of the public, including landowners, environmental justice communities, Tribal members and others, access publicly available information and navigate Commission processes. For public inquiries and assistance with making filings such as interventions, comments, or requests for rehearing, the public is encouraged to contact OPP at (202) 502-6595 or OPP@ferc.gov.

q. The Commission's scoping process will help determine the required level of analysis and satisfy the National Environmental Policy Act (NEPA) scoping requirements, irrespective of whether the Commission prepares an environmental assessment or environmental impact statement.

Scoping Meetings

Commission staff will hold two scoping meetings for the project to receive input on the scope of the NEPA document. An evening meeting will be held at 7:00 p.m. on September 13, 2023, at the Elk's Lodge #65 in Lawrence, Massachusetts, and will focus on receiving input from the public. A daytime meeting will be held at 10:00 a.m. on September 14, 2023, at Lawrence Public Library in Lawrence, Massachusetts, and will focus on the concerns of resource agencies, non-governmental organizations (NGOs), and Indian Tribes. We invite all interested agencies, Indian Tribes, non-governmental organizations, and

[1] The Commission's Rules of Practice and Procedure provide that if a filing deadline falls on a Saturday, Sunday, holiday, or other day when the Commission is closed for business, the filing deadline does not end until the close of business on the next business day. 18 C.F.R. § 385.2007(a)(2) (2022). Because the filing deadline falls on a Saturday (*i.e.*, September 2, 2023), the filing deadline is extended until the close of business on Monday, October 16, 2023.

individuals to attend one or both meetings. **Spanish-English translation services will be provided**. If a significant number of people are interested in providing oral comments, a time limit of 3 minutes may need to be implemented for each commentor.

The times and locations of these meetings are as follows:

Evening Scoping Meeting

DATE: Wednesday, September 13, 2023
TIME: 7:00 p.m. (EDT)
PLACE: Elks Lodge #65
ADDRESS: 652 Andover Street, Lawrence, MA 01843
PHONE: (978) 687-7274

Daytime Scoping Meeting

DATE: Thursday, September 14, 2023
TIME: 10:00 a.m. (EDT)
PLACE: Lawrence Public Library, Sargent Auditorium
ADDRESS: 51 Lawrence Street, Lawrence, MA 01841
PHONE: (978) 620-3600

SD1, which outlines the subject areas to be addressed in the environmental document, was mailed to the individuals and entities on the Commission's mailing list and Essex's distribution list. Copies of SD1 may be viewed on the web at http://www.ferc.gov, using the "eLibrary" link. Follow the directions for accessing information in paragraph n. Based on all oral and written comments, a Scoping Document 2 (SD2) may be issued. SD2 may include a revised process plan and schedule, as well as a list of issues, identified through the scoping process.

Environmental Site Review

The applicant and Commission staff will conduct an environmental site review of the project. All interested individuals, agencies, tribes, and NGOs are invited to attend. Please RSVP via email to Mkinney@patriothydro.com or notify Miley Kinney at (603) 732-8162 on or before September 5, 2023 if you plan to attend the environmental site review. The time and location of the environmental site review is as follows:

Lawrence Project

DATE: Wednesday, September 13, 2023

TIME: 9:00 a.m. (EDT)
PLACE: Lawrence Gateway parking lot
ADDRESS: 70 General Street, Lawrence, MA 01840

Participants will meet at the Lawrence Gateway parking lot and depart to the Lawrence at 9:15 a.m (EDT). Essex will provide transportation to the project facilities. All participants are responsible for their own transportation to the Lawrence Gateway parking lot.

All persons attending the environmental site review must wear sturdy, closed-toe shoes or boots. The applicant will provide hard hats to attendees for entry into low-overhead areas, if needed; however, participants who have their own hardhats should bring them.

Meeting Objectives

At the scoping meetings, Commission staff will: (1) initiate scoping of the issues; (2) review and discuss existing conditions; (3) review and discuss existing information and identify preliminary information and study needs; (4) review and discuss the process plan and schedule for pre-filing activity that incorporates the time frames provided for in Part 5 of the Commission's regulations and, to the extent possible, maximizes coordination of federal, state, and tribal permitting and certification processes; and (5) discuss the potential of any federal or state agency or Indian tribe to act as a cooperating agency for development of an environmental document.

Meeting participants should come prepared to discuss their issues and/or concerns. Please review the PAD in preparation for the scoping meetings. Directions on how to obtain a copy of the PAD and SD1 are included in item n of this document.

Meeting Procedures

Commission staff are moderating the scoping meetings. The meetings are recorded by an independent stenographer and become part of the formal record of the Commission proceeding on the project. Individuals, NGOs, Indian Tribes, and agencies with environmental expertise and concerns are encouraged to attend the meeting and to assist the staff in defining and clarifying the issues to be addressed in the NEPA document.

Kimberly D. Bose,
Secretary.

HDR

CONCURRENCE Brona Simon RC.14254
11/4/24 BRONA SIMON
STATE HISTORIC
PRESERVATION OFFICER
MASSACHUSETTS
HISTORICAL COMMISSION

September 24, 2024

Brona Simon
Massachusetts Historical Commission
State Historic Preservation Officer 220
William T Morrissey Blvd
Boston, Massachusetts 02125

Subject: **Second Request Concurrence on the Area of Potential Effects under Section 106 of the NHPA for the Lawrence Hydroelectric Project, FERC Project Number 2800; Essex County, Massachusetts.**

Dear Brona Simon:

Essex Company, LLC (Essex), a subsidiary of Patriot Hydro, LLC, is the Licensee, owner, and operator of the Lawrence Hydroelectric Project (FERC No. 2800) (Project or Lawrence Project). The Project was licensed by the Federal Energy Regulatory Commission (FERC or Commission) on December 4, 1978 (with an effective date of December 1, 1978), and the license expires on November 30, 2028. The Lawrence Project is located on the Merrimack River in the City of Lawrence in Essex County, Massachusetts. Essex has initiated a licensing process for the Project with the Federal Energy Regulatory Commission (FERC). The licensing of the Lawrence Hydroelectric Project requires FERC to comply with relevant federal historic preservation laws. Specifically, Section 106 of the National Historic Preservation Act (NHPA) of 1966, as amended (54 U.S.C. § 300101 et seq.), requires federal agencies to consider the effects of their undertakings on historic properties.[1]

On August 15, 2023, FERC issued a Notice of Intent (NOI) to File License Application for a New License and Commencing Pre-filing Process, which designated Essex as the non-federal representative in accordance with Title 36 Code of Federal Regulations (CFR) Section 800.2(c)(4) for carrying out consultation with the State Historic Preservation Office (SHPO) under Section 106 of NHPA. HDR Engineering, Inc. (HDR) has been retained by Essex in support of performing the Historically Significant Waterpower Equipment Study and Condition Assessment of Historic Properties and Associated Canal System Study (Studies).

On July 16, 2024, HDR sent letters by mail initiating consultation with SHPO (per 36 CFR Section 800.3) and requesting concurrence on the appropriateness of Area of Potential Effect (APE) in accordance with 36 CFR 800.4(a)(1). Essex is proposing the FERC Project Boundary as the APE. Essex is seeking concurrence from SHPO on the APEs for the Studies.

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[1] "Historic property means any prehistoric or historic district, site, building, structure, or object included in, or eligible for inclusion in, the National Register of Historic Places [NRHP] maintained by the Secretary of the Interior. This term includes artifacts, records, and remains that are related to and located within such properties. The term includes properties of traditional religious and cultural importance to an Indian tribe or Native Hawaiian organization and that meet the National Register criteria" (36 CFR Section 800.16(l)(1)

Additionally, Essex is notifying you that the field assessments for the Studies are scheduled to be initiated during the week of **October 21, 2024**. If the SHPO would like to attend the field assessments, please notify Kelsey Iffert at the contact information below.

If you have any questions or require additional information regarding any other aspect of this letter, please do not hesitate to contact me at (315) 414-2206 or Kelsey.iffert@hdrinc.com. HDR and Essex appreciate your participation in the Studies.

Thank you for your assistance with this request.

Sincerely,

Kelsey Iffert

Kelsey Iffert, MS
Environmental/Regulatory Section Lead
HDR