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# **CONDITIONS REPORT & CONCEPTUAL DESIGN MEMORANDUM**

## **STEAM TUNNEL ASSESSMENT**

**ROOSEVELT ISLAND, NEW YORK**

*Prepared for:*

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**Attachments (refer to list provided)**



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## **INTRODUCTION**

This report has been prepared to present the results of our condition assessment of the Steam Tunnel structure that exists between the decommissioned power plant, located adjacent to the Roosevelt Island Ferry and Tram Station, and the NYC Health + Hospital/Coler Complex located on the north side of Roosevelt Island.

The Steam Tunnel structure consists of a Box Culvert supported by different foundation systems, dependent upon proximity to the bedrock. The structure was design to serve a dual purpose as a seawall to protect a large portion of Roosevelt Island form the East River and a utility corridor. The box culvert structure is 6,150-foot long, out of which, 4,150 feet functions as a seawall. In addition, the structure has been historically utilized as a conduit for the transmission of steam from the power plant to the hospital and other buildings, and as a service vault for various other utility services.

Prior to the decommissioning of the power plant, and with the understanding that the steam tunnel structure is an integral part of Roosevelt Island's shoreline protection system, the Roosevelt Island Operating Corporation (RIOCI) retained Langan to complete an engineering assessment of the structure to establish existing structural and functional conditions and to make engineering recommendations for the structure.

Our initial assessment was performed in 2014 prior to the NYC Health and Hospitals Corporation (HHC) disconnection of the steam pipes. The report has been updated per additional observations, which were completed on March 9<sup>th</sup> and April 9<sup>th</sup> 2018, to confirm and record the current conditions of the tunnel. The findings and conclusions of our observations summarized in this report are in general agreement with the conclusions outlined on the US ARMY CORPS of Engineers Roosevelt Island Seawall Study, Roosevelt Island, New York Report, dated June 2001, which evaluated the shoreline protection of the entire Island, including the steam tunnel structure.

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## EXECUTIVE SUMMARY

The Steam Tunnel structure consists of a Box Culvert supported by different foundation systems, dependent upon proximity to the bedrock. The box culvert structure is 6,150-foot long, out of which, 4,150 feet functions as a seawall. The Seawall section of the box culvert structure exists in an unbalanced loaded condition as one side acts as a river bulkhead (or seawall) and is subjected to hydrostatic and wave forces, while the other side functions as a retaining wall which sustains lateral soil/hydrostatic pressures.

The steam tunnel was stationed and mapped on topographic and aerial photographic backgrounds. The different box culvert geometries and conduit/pipe configurations were measured and indexed. Structural defects, both interior and exterior, were photographed, described and referenced by the tunnel stationing.

Extensive major defects that seriously compromise the tunnel structure, and which should be addressed as soon as possible, were identified. These areas of concern are the interior spalling condition (i.e. degradation of concrete and corrosion of existing reinforcement) on the land-side wall, the corrosion of roof slab reinforcement in the vicinity of the joints, the concrete haunch erosion at the seawall exterior base, the undermining of the tunnel floor slab (i.e. the loss of soil material below the tunnel slab), and deficient rip-rap rock levels on the shore-line.

Should these conditions not be addressed in the near term, the structural stability of the tunnel, seawall and promenade can be compromised. In the case of the interior spalling, and the corrosion of the roof slab reinforcement, the potential exists for a catastrophic failure should heavy traffic loads (HS-20 Truck Loads) be introduced above or adjacent to the tunnel. In the case of the exterior erosion, the concrete haunch will continue to deteriorate and the undermining will penetrate deeper beneath the tunnel slab, diminishing the load capacity of the tunnel and seawall and creating potentials for tunnel section rotation or deflection out of alignment. A failure in any form to the tunnel will lead to closure of the promenade and adjacent areas, loss of upland protection during storms, and considerable expense for demolition and replacement.

The tunnel appears to pose no flooding risk to the Coler Hospital basement, as we believe that the connecting door was intended as a water-tight bulkhead. Personnel at Coler Hospital have confirmed a lack of prior flood problems originating from the tunnel, and the water-tight door should be regularly inspected and maintained for this purpose.

Analyses were performed for the potential for ice formation and loads exerted. Our calculations suggest that significant ice formation to depths beyond the tunnel structural

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capacity is unlikely. In the event of a winter of sustained severity, a follow-up inspection is recommended to confirm absent or limited ice formation.

The presence of multiple utilities was researched and their function and responsible agency identified. The service distribution lines are by Verizon and Time-Warner Cable, and these utilities would wish to preserve service in the tunnels. Neither entity has an easement for placing their service distribution lines in the tunnels. In meetings and discussions, Verizon took the position that HHC should either provide power for electrical lighting and pumped drainage to facilitate maintenance of its service or should compensate Verizon for the considerable expense of service relocation.

Conceptual remedial construction designs were prepared and drawings are included herein, which present these designs. Both the interior and exterior work tasks have special challenges due to location and environment. In addition to the conceptual remedial designs presented in this report, we analyzed a series of alternatives scenarios, including no action, demolition/replacement, abandon/fill in place and partial demolition of the structure.

Note that we have termed the tunnel's major defects as serious, and that deterioration and structural failure can be expected under the worst combinations of loading conditions. We recommend that any decision regarding the tunnel be made with a commitment to initiate the recommended program of remedial repairs as soon as possible.

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## **SITE DESCRIPTION**

### Background

The Steam Tunnel is located on the east side of Roosevelt Island, generally running from the Power Plant to the two campuses of the Coler-Goldwater Hospital (note that the Goldwater Hospital has been demolished; our report refers to this building as "former-Goldwater," while referring to the north campus as "Coler"). The tunnel is approximately 6,150 feet in length as measured to the former-Goldwater property line. For approximately 4,150 feet, or just over 2/3 of this total length, the tunnel runs under the East River seawall promenade. We have attached to this report a series of Aerial Location Maps (see Figures VA-101 to VA-104), compiled from methods described below. The series of Aerial Location Maps show the tunnel alignment against a background of recent scaled aerial photography and upon which we have identified the Island major buildings and features.

### Available Design and Construction Records

According to our review of an incomplete set of record structural drawings dated 1949, the tunnel is a reinforced concrete box, built by HHC and/or the City of New York (NYC), for the most part designed to be structurally integral with an east-side concrete seawall (note that for the purposes of writing this report, the use of the term seawall refers only to the structurally-integral tunnel/seawall). This concrete seawall was constructed on the alignment of the former stone seawall, and is supported by different foundation systems, dependent upon proximity to the bedrock. These foundations systems consist of support directly on bedrock, support on short concrete piers where bedrock is at shallow depths, and support on deep timber pile foundations where bedrock is not proximate. Where founded on deep foundations, batter piles are also provided for lateral resistance.

The Seawall section of the box culvert structure exists in an unbalance load condition as one side acts as a river bulkhead (or seawall) and is subjected to hydrostatic and wave forces while the other side functions as a retaining wall which sustains lateral soil/hydrostatic pressures.

The tunnel floor is set at approximately elevation +5.0 feet (in Roosevelt Island or "Belmont Island" survey datum), which is a few inches below mean high water ("high tide") levels.

The drawings show that the two walls (seawall and land-side) and both the floor and ceiling slabs are generally 12 inches thick reinforced concrete. On all four sides the concrete reinforcement consists of two layers (top and bottom, or near and far face) of reinforcement.

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The seawall face is vulnerable to vessel-wake action and storm events of the East River environment. In addition, the ceiling slab serves directly as the east-side promenade walkway, and the land-side wall retains 8 feet of backfill, above which is the Island urban environment. Therefore on three sides the tunnel bears significant dead and/or live structural loads. The drawings also provide a cross-section of an inland tunnel segment, which is similar in design to seawall segment.

Prior the United States Army Corps of Engineers Investigation

In June 2001, the United States Army Corps of Engineers (USACE) issued a Seawall Study ("USACE Study") for Roosevelt Island on behalf of RIO, who has provided Langan with a report copy. In their study report, the USACE noted that the steam tunnel was structurally damaged in a number of areas, including walls and floors, and that a lack of rip-rap in certain areas might have resulted in undermining of existing piers, piles and caps. We will refer in more detail to the main concerns raised by USACE in our report below.

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## **OBSERVATIONS**

Our observations are presented in the paragraphs below.

### **Mapping and Recording Methods**

Our initial scope of investigation was completed over the course of four site visits, conducted in September and October of 2014. A new investigation was completed over two additional visits on March 9<sup>th</sup> and April 9<sup>th</sup> of 2018. The investigations included interior and exterior documentation of observable conditions. While our observations were generally planned to coincide with periods of low tide to allow for the greatest degree of accessibility within the tunnel, we also observed water infiltration conditions as the high tide receded.

#### Tunnel Interior Investigation

The tunnel was traversed by two Langan engineering personnel, and was stationed in a north to south direction using a measuring wheel. The measurements were compared with, and the data overlaid upon, the 1992 Island-wide Topometrics Survey electronic files, which RIOCC had provided from its records. Correlation of major features, such as the tunnel vent shafts, was also confirmed using scaled aerial photography.

The purpose of the stationing was to allow for systematic mapping of the tunnel cross-section geometries, concrete spalling locations, locations of differential settlement at seawall joints, and exterior conditions along the promenade and seawall. Extensive photographs and notes were taken to create a comprehensive record of impacted tunnel elements and materials.

#### Diver-Supported Investigation

As part of the tunnel assessment, an exterior inspection of the concrete seawall was performed along the rip-rap of the East River. This inspection was completed during low tide to allow for continuous inspection of the seawall and tunnel foundation conditions.

The inspection revealed four main issues that are addressed further in the report:

- Rip-rap deficiencies
- Erosion of haunch on seawall
- Undermining of tunnel floor-slab
- Spalling on face of seawall and at joints

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### Promenade Review

We walked the seawall promenade, other paved areas above the tunnel and the adjacent inland areas along the tunnel alignment. From the promenade railing, we observed and photographed seawall and construction joint conditions.

### Documentation

Our recorded site observations included documenting the following records:

- a dimensional/mapping study, as shown in the Aerial Location Maps (Drawings VA101 to VA104)
- interior conditions assessments (Drawings CS101 to CS104)
- exterior conditions assessments (Drawings CS201 to CS204)
- a piping inventory and layout for various tunnel geometries (Drawings XS-1 to XS-4)
- stationed photographs of defects are provided as Appendix A

All relevant observations are presented herein. A detailed list of observed conditions is provided in the Tables attached, with corresponding stationed mapping provided on interior and exterior conditions assessment drawings listed above.

The observations in these maps, drawings, photographs and annotations can be cross-referenced to each other by use of the assigned stationing (STA 0+00 at the Coler basement entrance, and increasing thru STA 61+50 at the former-Goldwater property line, for a total length of 6,150 feet).

### **General Description of Tunnel Interior**

Over its entire length, the tunnel interior consists of four different geometrical cross-sections, which we have measured and recorded on Drawings XS-1 through XS-4 attached. The primary function of the tunnel was to carry steam power and condensate return pipes. These pipes are supported on a continuous steel frame that rests upon the floor-slab and which occupies the easterly or seaward half of the tunnel. The different cross-sections appear to allow for various arrangement of the steam/condensate pipes and for storage space. Free walking passage is provided on the westerly half of the tunnel.

Access and ventilation to the tunnel is provided at either end and by louvered vent towers extending 3 feet above grade and which have interior metal ladder rungs. The combined tunnel and seawall concrete was cast in segments which ranged in size from approximately 30 to 60 feet long, at which intervals there exist alternatively construction and expansion joints, as shown on the original design drawings. Water was seen to enter the tunnel via

deteriorated joints. The tunnel floor drainage system consists of a shallow longitudinal gutter, set at the land-side wall base and which runs to pumps installed in sumps at each vent shaft. During our recent site observation, we found that none of the pumps were operational and all sump pits were filled with water. Lighting for the majority of the tunnel was also not operational.

## **Interior Observations of Steam Tunnel Conditions and Defects**

### Western (Land-side) Wall

Generally, spalling was observed throughout the length of the structure on the western (land-side) wall. The spalling typically extended from the wall base to an average height of 30 inches. In many cases, the spalled concrete was retained in place by a stapled conduit array, which prevented closer examination, but the loss of concrete surface integrity was nonetheless evident from deep cracking and partial displacement.

Where measurable, the spalling was generally 2-3 inches deep and was associated with exposure of wall reinforcement in almost all cases. This near-face layer of rebar on the land-side wall was universally severely corroded, and in many cases had completely disappeared. Slight bowing of the wall was apparent in the land-side wall in the northernmost seawall sections of the tunnel.

### Floor Slab

Differential “trip hazard” stepping at seawall joints was noted in a number of locations. The height of step varied up to 1 inch in height, and existed either due to spalled concrete edges or to an alignment differential in the tunnel sections. In the few cases where such an alignment existed, it was not possible to say if this was due to original mis-alignment or to slight movement of a section over time. In almost all cases, there was evidence of past floor-patching repairs, some of which had been uneven or frayed, and which made our observations difficult to interpret.

We did not find evidence of “lifting” of floor slabs near joints as the USACE had reported. We believe the USACE observation was a misinterpretation of the slab conditions. However, reference is made to the evaluation section of this document where shallow foundation and undermining conditions are discussed.

### Wall Joint Filler

Our observations of the tunnel wall joint filler showed that the great majority (more than 95%) were intact. There has been some loss of filler in the floor joints, which is to be



expected as these are most vulnerable to forces applied by tidal waters, and water was seen to enter the tunnel via some of these deteriorated joints. In a handful of cases in the southerly inland portion of the tunnel, bituminous ceiling joint filler was dislodged and suspended out of position. Joint filler in the land-side wall appeared to be intact. Seen from the inside, joint filler in the seawall appeared to be intact, although there has been some loss to erosion on the exterior.

### Roof Slab

Our observations of the tunnel roof slab revealed some evidence of corrosion near the expansion joints; this condition is likely to worsen due to the water leakage at each joint. A single area of concrete spalling with severely corroded rebar was observed in the tunnel extension leading to the former Goldwater Hospital.

### Concrete Sumps

We removed the gratings of a number of accessible sump stations during our initial assessment and observed that the concrete surfaces within revealed no signs of damage. During our recent site observation we found that none of the pumps were operational and all sump pits were filled with water. In addition to the standing water near the sump pump pits there was approximately 1 foot of standing water present in the tunnel from STA 0+00 to STA 2+00, approximately 2 feet of standing water present in the tunnel from STA 52+00 to STA 54+00, and approximately 1 foot of standing water present in the tunnel from STA 56+00 to STA 61+50.

### Stanchion Support Curb-Wall

For the inland sections of the tunnel between STA 49+50 to STA 55+12 there is a low concrete curb-wall which supports the metal outer stanchion of the pipe-rack. The concrete of the curb-wall has been subject to a chemical attack similar to the land-side spalling, and has largely disintegrated over time. Stop-gap supports have been provided to level up the pipe-rack.

### Piping Inventory

During our initial assessment, a piping inventory was completed within the steam tunnel, and is shown in the tunnel typical cross-sections (Drawings XS-1 to XS-4) attached. The inventory identified two steam pipes and condensation return pipes generally supported by a steel-frame stanchion occupying the east side of the tunnel. Power cable for electric service to pumps and lighting and fiber-optic cable reportedly for intra-hospital communications are supported along the ceiling. The communication cables (Verizon),

cable television fiber-optic, (Time-Warner Cable or "TWC"), and four abandoned alarm system conduits are generally affixed along the western wall. These conduits were identified by means of interview of the utility agencies and of HHC personnel.

In the course of obtaining field mark-out for our test-pit excavation program, we noted that both Con Edison and MCI Communications have conduit on the Island, however no service from either utility was marked out in the tunnel vicinity by their locator firms. In addition, in our interview of HHC personnel, they had not heard of PSE&G and MCI Communications having conduit in the tunnel. With the exception of the Verizon and TWC lines, the remainder of the piping and conduits are HHC's responsibility.

As part of the new re-assessment we contacted both Verizon and TWC to confirm our initial findings. Verizon declined to provide any records due to security concerns. TWC provided us the underrated maps as shown in Appendix D.

### **General Description of Tunnel/Seawall Exterior**

Within the scope of the study, the promenade concrete walkway is integral within the tunnel ceiling slab, and the concrete seawall is integral within the tunnel exterior wall. As such, the joints in the promenade walkway and seawall are the construction and expansion/contraction joints of the tunnel. On the seawall face, many of the joints are armored by vertical steel angles. As these steel angles were not indicated on the original drawings, and as the seawall spalling near these joints is worse than at other Island seawalls, it is likely that this armoring was added subsequent to the original construction.

At the base of the seawall, the reinforced concrete flares out as a haunch which serves to protect the edge of the tunnel floor-slab. The underside of tunnel floor-slab, which is effectively the seawall base, is set at approximately elev +4.0 ft which is high in the tidal range (elev +0.0 ft to elev +6.0ft is the range of most normal tides over a lunar cycle) atop former stone foundations. This base elevation is significantly higher than other Island seawalls, which are typically set at or below low water levels using tremie-concrete (in-water) pours, and appears to create potential for wave-driven erosion penetrate below the tunnel floor-slab.

A rip-rap revetment, consisting of large to massive rocks set in a stable configuration within and below the tidal zone, is general present along the East River shoreline which appears to be generally steep. Tunnel/seawall conditions to the north, where rip-rap is notably deficient, are discussed in the report.

Our observations sought to determine which sections of the tunnel structure have foundations systems consist of support directly on bedrock, support on short concrete

piers, or support on deep timber pile foundations, as shown on the original design drawings. Even where rip-rap is minimal, shoreline conditions limited observations of foundations. We were unable to observe any concrete piers or timber piles. We observed a total of just three pier-caps or pile-caps in close proximity to each other.

Therefore it is likely that sections of the tunnel floor-slab were actually founded on the former seawall stone foundation, contrary to the original design drawings. These tunnel sections are without pier or pile foundations that would transfer loads to underlying bedrock, but are instead shallow-founded on-grade.

### **Exterior Observations of Tunnel/Seawall Conditions and Defects**

#### Promenade

Our observations above and of the inland adjacent to the tunnel did not reveal evidence of serious underlying structural stress. We did notice a few tripping hazards at promenade construction joints, apparently typical of concrete sidewalk wear and tear in an urban environment. We also noticed tripping hazards caused by void spaces where the tunnel structure veers away in both south and north ends from the seawall alignment. These tripping hazards are visible to RIOC personnel, and we anticipate that they will be addressed on a priority basis by RIOC in the course of its public walkway maintenance programs.

The appearance of the tunnel vent shafts was generally satisfactory; however, the shaft roof within the southerly play-fields is unsightly due to multiple spalls likely caused by vandalism or construction traffic.

#### Rip-rap Revetment (at seawall)

A rip-rap revetment of rocks runs from the tunnel seawall face down to the river mud-line. The purpose of the rip-rap is to protect the structure in the intra-tidal zone from the erosive power of waves/tides and to prevent scouring of the subgrade from under the tunnel. The rip-rap can also serve to provide a working surface for maintenance and spot-repairs during low tide.

In many areas the rip-rap was in satisfactory condition along the majority of the seawall/tunnel, with rocks securely in place up to high tide levels and with stable cross-sectional profiles. However, for much of the northerly half of the seawall, as well as in short localized sections elsewhere, the rip-rap protection is substantially deficient. For the northerly deficient zone (STA 5+00 to STA 20+00 approximately) our survey shows that this absence is fairly uniform, with an average measured grades of elev +2.25' at the seawall

face and elev -0.75' at locations 10 feet from the seawall. As currents are strong at this location, it is possible that the rip-rap rocks have been leached out of position over time.

#### Erosion of Haunch on Seawall Base

In areas where rip-rap is deficient, we observed erosion of the concrete haunch was evident. This erosion varied from exposure of the rebar to sections where the concrete haunch was entirely missing. In addition, we observed that erosion had penetrated beneath the tunnel to create debris-filled voids. These areas are a concern since both tunnel concrete slab and underlying subgrade are vulnerable to further erosion and lateral undermining. The erosion of material under areas of the structural slab will also reduce bearing capacity of timber piles and expose the tunnel joints and piles to wave action which would cause damage to the piles and spalling of the concrete.

#### Spalling at Seawall Joints and Face

Numerous vertical construction joints between tunnel segments revealed evidence of concrete spalling. These conditions ranged in nature from minor spalling around steel plate-reinforced joints to extensive spalling with exposed/eroded rebar and deep missing portions of concrete measuring several square feet across the seawall face. (See Table 1).

It is apparent that the existence of the unreinforced joints presents exposed edges which are vulnerable to erosive wave action. In the severely eroded areas, it is possible that the deep concrete pours may not have been adequately vibrated to the formwork corners, resulting in localized weak edges once the forms were removed.

#### Settlement behind Tunnel Structure

Settlement in areas immediately behind the seawall section of the tunnel was observed during our investigation. The possible cause of the settlement is migration of fines under the tunnel structure caused by the loss of riprap protection on the waterside and high hydrostatic pressure on the landside.

### **Security Assessment Record**

Each of the tunnel access shafts was inspected by Langan personnel to evaluate security concerns. A photographic record was prepared and is attached hereto in Appendix B.

The assessment consisted of an evaluation of doors and louvered vents of the above-grade tunnel shafts from an accessibility perspective. Almost all of the access vents were locked and secure. However, the access panel on Air Vent #13 was open and was not lockable.

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The panel steel frame will need to be repaired or replaced such that the lock mechanism can be adequately secured. Minor repairs to some rungs and louvers are also needed.

### **Test-Pit Structural Investigation**

During the 2014 observations, five test pits were completed along the steam tunnel walls by Fleming and Sons, Inc. of Brooklyn, New York. The purpose of this investigation was to determine if there was evidence of horizontal cracking of the concrete structure and if so, whether water infiltration was occurring. Additionally, the investigation sought to determine any additional sources of water infiltration are present and to identify the presence/absence of waterproofing for the structure.

Generally, the exterior walls of the steam tunnel were in good condition at the time of the inspection. No evidence of structural cracking that would promote substantial water infiltration, or other evidence of water damage, were observed. However, waterproofing was not identified in any of the test pit excavations and it is conclusive that the bituminous coating shown in the original construction drawings was never installed.

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## **EVALUATION**

### **Overall Evaluation**

The tunnel and seawall are believed to have been constructed by HHC or NYC in one or two phases in the middle of the last century. Formwork, concrete finish and curing appear to have been of good quality. Possible design, construction or operational flaws may explain the spalling of the seawall face, the undermining of the tunnel floor-slab, and the extensive spalling to the interior land-side wall. Sections of the tunnel floor-slab appear to be shallow-founded directly on the former seawall stone base. Except where distressed by these conditions as described further below, the structure appears to be in fair condition.

The underside of tunnel floor-slab was set at approximately elev +4.0 ft which is high in the tidal range (elev +0.0 ft to elev +6.0ft is the range of most normal tides over a lunar cycle). This means that, especially where rip-rap is absent, there is a strong potential for wave and current action to progressively penetrate below the tunnel floor-slab and to leach out small-grain soils from the subgrade and from the upland area beyond the tunnel. In addition, the leading edge of the tunnel base, where the reinforced concrete haunch is formed, is vulnerable to erosive forces of the tidal "splash" zone, as we have noted.

The overall tunnel condition and the observed defects are discussed further below. We conclude that, should these defects be promptly addressed, the tunnel can continue to serve as a functional seawall well into the future.

### **Significant Defects**

The assessment identified major areas of concern, both interior and exterior. These include:

#### Interior Spalling:

Approximately 50% of the interior land-side wall of the tunnel is compromised by the concrete spalling condition. We believe that the cause of the spalling has been decalcification of the concrete arising from condensed steam flows over many years. We note that the steam pipe vents are oriented to discharge across the tunnel towards the land-side wall. The steam moisture is distilled water which can precipitate the calcium ions from the concrete, resulting in shallow brittle cracking. The conditions of extreme heat and constant presence of saltwater in contact with the land-side wall gutter may be contributing factors to the rebar corrosion.

Note that this is a serious condition as the wall has lost a significant amount of concrete and this significant loss, if not addressed could result in a compromise of the structural integrity

of the tunnel. The wall is designed to resist the weight of the adjacent soil and urban traffic. Should a significant traffic load be introduced above or adjacent to the tunnel, the applied load could result in catastrophic tunnel wall failure.

The slight bowing of the land-side wall observed at the northernmost end is a concern; however, it was not associated with major cracking that would indicate a failing condition.

Contrary to the USACE report, our test-pit observations indicate that stormwater infiltration through the wall from the exterior is at most a minor factor in the spalling condition. This implies that a repair of the concrete should be effective now that the flow of steam has been terminated.

### Roof Slab

Our observations of the roof slab revealed some evidence of corrosion near the expansion joints; this condition is likely caused by the water leakage from the expansion joint. Since it is not the intention to make the expansion joints water proof, it is likely that corrosion of the roof slab reinforcement will worsen in time compromising the structural stability of the tunnel near the expansion joints.

### Tunnel/Seawall Sub-Slab Voids and Rip-Rap Deficiency

The sections of the seawall where rip-rap protection is either not present or is inadequate are associated with erosion to the concrete haunch and creation of voids beneath the tunnel floor-slab. These debris-filled voids are a concern since the subgrade is vulnerable to erosion and lateral undermining. Evidence suggests that the tunnel in critical locations is not founded on bedrock using piles or piers per the original drawings, and instead the slab was placed directly on the grade of former stone seawall remnants. Any additional undermining of the tunnel subgrade could result in a deflection or rotation of a tunnel section out of alignment. Should this occur, the promenade would need to be closed due to the large tripping hazard, and it is possible that the tunnel section is likely to be severely cracked due to loss of uniform bearing. The reconstruction of these conditions would likely include demolition with replacement, and would be cost prohibitive.

Due to its relatively shallow bearing, loss of soils to the Island areas upland of the tunnel is also a strong possibility. This phenomenon is familiar to RIOC personnel in Lighthouse Park where the "bridging" effects of compacted surface pavements can conceal the penetrations of voids for months and even years. In addition, Langan has also investigated and designed repairs to large voids below and to the upland of Island seawalls in Octagon Park. Should these voids emerge upland of the tunnel, sink-holes would create safety hazards and would typically threaten trees, light-poles, curb-lines and travelled pavements.

As RIOG is aware, such sink-holes tend to be a chronic problem and are difficult and costly to rectify.

We note that the USACE Study had speculated that a few small differential steps between tunnel segments, seen both in the floor and on the promenade, may be indicative of ongoing settlement of the structure. Exacerbation of this surface differential does not appear to have occurred since the USACE inspections, and we did not find evidence for ongoing settlement. It is possible that a few tunnel segments may have settled or rotated moved slightly due to under-mining of the tunnel subgrade (as will be discussed later in this report) or due to flexure between points of uneven support.

#### Concrete Haunch Erosion

The on-going erosion of the haunch threatens the structural integrity of the seawall, which it was continuous with. It also threatens the structural integrity of the of the tunnel floor-slab which located immediately behind it. The erosion of material under the structural slab will also reduce bearing capacity of timber piles and expose the tunnel joints and piles to wave action, which could cause damage to the piles and spalling of the concrete.

#### Seawall Spalling

At the seawall joints where concrete spalling has exposed the wall reinforcement, the seawall is significantly weakened and vulnerable to further deterioration. Corrosion of the exposed rebar will typically result in expansion of the rusting metal as it oxidizes, which in turn will cause jacking and loss of the overlying concrete.

### **Structural Strength Analyses**

We performed capacity analyses to evaluate the ability of the main tunnel section to resist deformation due to unbalanced forces of the landside wall. We found that, with rebar intact on both faces, the tunnel wall has adequate capacity. However we also found that loss of the rebar on the interior face would reduce the factor of safety to close to 1.0 under combined hydrostatic and adjacent heavy truck traffic loads. This result implies that, for tunnel sections where the inner-face rebar has corroded away for a significant distance, the wall is threatened with failure under adverse load conditions, which refers to the unbalanced loading condition of the tunnel, as the island side of the tunnel is subjected to soil (dead load) and live load and the seawall side only subjected to wave force.

#### Thermal Evaluation of Tunnel Conditions



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At the time of the initial assessment, the steam transmission pipe was live and HHC had plans to terminate the system which had been terminated as of the most recent assessment. As such, as part of our structural analysis, calculations were performed based upon assuming freezing weather conditions to determine to what extent infiltrated water will freeze once the tunnel heating services are terminated.

Our analysis investigated infiltrating water that could theoretically freeze to a depth of approximately twelve inches (i.e. 1 foot) within the tunnel should ambient temperatures drop to the 10 degrees Fahrenheit mark and be sustained for one to two weeks. Our calculations show that it would take 134 hours (over 5.5 days) to initially freeze to a 1 foot depth followed by a sustained drop in the formed ice temperature to a uniform 20 degrees (temperature at which substantial ice expansion can occur).

Such a period would include several cycles of low tide, during which water would drain via the same existing joints through which it entered at high tide levels. This drainage is facilitated by the fact that ice develops from the top, and that water will remain liquid at floor-slab during the freezing process.

Based upon the foregoing, we conclude that the potential for significant ice formation appears low. This information has been confirmed by the absence of ice during our recent site observations.

#### Ice-Expansion Structural Capacity Calculations:

In the remote likelihood that significant solid ice formation could occur, we evaluated the capacities of both the tunnel seawall and land-side wall to withstand ice expansion. Our calculations demonstrate that expansive forces due to a twelve-inch layer of ice sitting on the tunnel floor would not exceed the structural capacity of the structure in its current condition.

#### Seismic Capacity

The tunnel was clearly not designed for seismic loading. Although a seismic loading analysis was beyond the scope of this study, we believe that it is unlikely that the tunnel structure could resist seismic loads to NYC Building Code or NYS Department of Transportation standards. Should a major earthquake occur, extensive damage is likely in the form of displacement, rotation and cracking of the tunnel structure towards the East River shoreline.

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## UTILITIES COORDINATION

Langan contacted Verizon and TWC, to confirm they have active services within the tunnel and to describe the planned shutdown. At the meetings, the possible future uses of the tunnel were explained, and that Langan's primary focus was in the tunnel's structural integrity for seawall and promenade purposes. HHC's main costs are believed to be electrical power for operation of the tunnel lighting and pumps, without which the tunnel would be dark and more prone to standing water.

Based upon our meetings and subsequent discussions with these agencies, we established the understanding described in the following paragraphs.

### TWC

TWC provided maps (copies are attached in an appendix herein) of their Island services, which show service within the tunnel. From the maps the TWC tunnel service appears to extend to the Fire Station, Coler and to Octagon Park Apartments. At the meeting, the TWC personnel could not confirm which buildings were served, and therefore could not confirm how much street installations would be needed if the tunnel conduits were removed. However, TWC believes that, if it was necessary to remove their conduits, existing TWC infrastructure exists within Main Street such that street pavement excavations for new conduit would be limited.

### Verizon

Citing security reasons, Verizon declined to provide any maps or diagrams showing their service within the tunnel, but stated that the sole function of the tunnel was to provide Coler with telecommunications service.

Verizon stated that lighting and pumps are needed to maintain its service. Should lighting and pumps be terminated, the cost to relocate these Verizon utilities elsewhere (street) would be considerable (cited \$400,000 just for conduit alone, and a considerable additional cost for technology and wiring).

Accordingly, Verizon's position is that, should removal of its service become necessary, HHC should pay the substantial capital cost for relocation so that the service can continue. Verizon's alternative position is that, in order to spare this capital expense, the lighting and pumps should be maintained indefinitely. It was noted that RIOC does not have control or ownership of the tunnel.

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Neither company has reported owning an easement or other agreement from HHC providing a right to maintain service; however, it would appear reasonable that both utilities continue to provide service within the tunnel. This can occur provided that a legal precedent or negotiation can establish responsibility for maintenance of the lighting and pumps.

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## **POST-SHUTDOWN OBJECTIVES**

As part of the initial assessment, our analyses reviewed alternate scenarios for an unheated tunnel. These scenarios included whether the electrical pumped drainage system would be retained or eliminated. If the pumps are retained, we believe it is unlikely that the sumps would freeze solid in winter, and therefore the pumps would remain operational. If the pumps were removed, it is unlikely that water flooding the tunnel in winter would freeze to a 12-inch depth. Based upon our analyses of the resultant ice-expansion forces, we do not believe that excessive loading would occur to either the tunnel land-side wall or the seawall.

In the current un-heated condition, over the longer term the cooler temperatures tend to cause contraction stresses in the concrete, leading to exacerbation of the existing spalling and cracking in both the land-side wall and seawall. The potential for worsening of these defects makes the need for the recommended repair program more immediate. Cooler conditions are also likely to cause more joint deterioration and to increase leakage. Given that the tunnel would be closed to routine maintenance, managing the joints conditions and related water ponding on a periodic basis should be acceptable.

The door to the Coler basement appears to have been designed as a water-tight bulkhead. We interviewed HHC personnel who affirmed that the tunnel itself has not been a source of flood problems to the basement. This tunnel access door should be regularly inspected and maintained for watertight performance. We note that flooding to levels at or above the "Sandy" mark may result in water filling the tunnel vent shafts via the louvered openings. We recommend that the current engineering study for Coler flood control should include a review of any such basement inundation potential arising at the project flood design levels.

---

## **RECOMMENDATIONS**

### **Interior Spalling Repair**

It is recommended that the reinforced concrete spalling be repaired in locations where damage was observed. We have provided a preliminary design for these repairs (refer to Drawing RR-1).

The work will generally consist of removal of loose concrete at spalled locations, removal of corroded rebar, and/or cleaning of exposed rebar where there is less than 60% section loss. The exposed surfaces of the concrete should be cleaned and prepared through the application of bonding agent and setting reinforcement of additional reinforcement. Standard 5,000 psi concrete can be pumped via the vent shafts to form the repair section.

### **Roof Slab Steel Frame**

To address the corrosion of the roof slab reinforcement near the expansion joints, we recommend the installation of a steel frame at each joint location. The reinforcement will consist of a simple steel frame bolted to the tunnel to connect the roof slab and walls. We have provided a preliminary design for the steel frame (refer to Drawing SF-1).

### **Concrete Repairs to fill Tunnel Sub-Slab Voids and to Eroded Haunch**

It is generally recommended that the reinforced concrete haunch be repaired in locations where defects were observed. Repairs should address, at a minimum, all areas where the haunch has spalled to expose rebar or where the tunnel floor-slab is undermined due to its exposed condition.

The repair program would include removal of loose concrete at spalling and erosion locations, cleaning of exposed rebar with removal where corrosion has caused section loss. An epoxy coating should then be applied to existing rebar and exposed surfaces of the concrete should be cleaned in preparation for the repair. A single vertical form should be adequate which will promote the concrete running under the haunch wherever voids have penetrated below the tunnel floor-slab. Dependent on contractor means-and-methods, a rough form may be adequate, supported and protected by stacked rip-rap rocks. The repair should then be implemented by the application of bonding agent, setting reinforcement, and pouring standard or "tremie" (under-water) 5,000 psi concrete for the repair. Refer to Drawings RR-3 for a typical design detail.

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### **Rip-Rap Replenishment**

It is recommended that rip-rap be placed in locations where it is inadequate. The primary need is in the area where large rock rip-rap is absent and where we have observed visible undermining. In these areas the rip-rap should be placed atop a 12" deep bedding stone layer, stabilized by a geotextile membrane in order to prevent settlement into the mud-line. The secondary need is in other areas where we have reported the rip-rap as deficient and where haunch erosion has occurred.

The slope of the rip-rap should have a maximum steepness of 1.5H to 1.0V and should have a stabilized toe by mechanical means as shown on Figure PR-1 attached to limit scour of bearing soils by the current. Because the rip-rap revetment will descend below low tide levels, a river-bed topography ("bathymetric") survey data should be conducted as part of the construction package design in order that the full scope of rip-rap volume and extent to be placed below tidal levels can be understood.

### **Seawall Spalling Repair**

We recommend that concrete spalling be repaired in locations where wall reinforcement is exposed, or in the few deep pockets which provide adequate bonding and allow a flush repair. The majority of the seawall spalls are minor, and many are in exposed locations such that the merits of a shallow repair are doubtful.

Repairs to the seawall spalls should consist of epoxy-based non-shrink mortar having properties of superior strength, rapid-cure, and chemical bonding to the existing concrete substrate. In general, additional reinforcement should not be needed. The epoxy mortar would typically be mixed on site, applied immediately and finished flush with the seawall.

To extend the life of the spalling repairs, and to address the continued corrosion at the expansion joints, we recommend the installation of stainless steel plates at each location. We have provided a preliminary design for the installation of these plates (refer to Drawing EJ-1).

### **Joints and Joint Filler**

We believe it is unlikely that the tunnel can be made waterproof by attempting to restore all joint filler material to an original condition. Furthermore, such repairs are likely to be vulnerable to water pressure from tidal action. Therefore, we recommend that joint filler repairs be limited to the few failed joints in ceilings and in walls which retain earth. A bituminous rubber compound product, manufactured for the purpose and sized appropriately, can be inserted securely within the joints.

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## **Hazardous Materials**

Assessment of hazardous materials, such as asbestos or lead-based paint, was not in the scope of the investigation. However, during our tunnel inspection program, we were informed that HHC was performing asbestos-abatement in a southern inland portion of the tunnel. Confirmation is needed that HHC has abated all asbestos insulation from the pipework. Due to the uncertainty about the presence of asbestos or other hazardous materials, we recommend that HHC should obtain written professional certification to the effect that no hazardous materials exist within, or form part of, the tunnel structure.

## **Steam Pipes and Pipe Insulation**

We understand that it is not yet known whether HHC will remove the steam and condensate pipework which has not been removed as of the 2018 assessment. It appears optional to remove or to keep the pipework in place. We note that extreme flooding events (such as Sandy) have been known to damage the pipe insulation, and we recommend removal of the insulation, at a minimum. As it is likely that the metal pipes have salvage value, their removal may be inexpensive or may at least partially off-set the cost of the insulation removal and disposal.

We recommend that the steam-pipe stanchion supports be kept in place, as a need for a non-grade dependent utility, such as electric, water, gas or AVAC extension, may emerge in future years. Installation within the tunnel could spare traffic disruption and provide major cost savings relative to a street excavation project. In the inland tunnel segment where the curb-wall support has disintegrated, a series of permanent supports should be installed.

## **Electrical Service to Pumps and Lighting**

An electrical engineer should be retained to establish options for the control switch and electrical service costs. Langan is not an electrical designer, and electrical service re-design is beyond the scope of this assessment.

## **Tunnel Access Door from Coler Basement**

The tunnel access door from the Coler basement should be regularly inspected and maintained for watertight performance. We note that flooding to levels at or above the "Sandy" mark may result in water filling the tunnel vent shafts via the louvered openings. We recommend that the current engineering study for Coler flood control should include a review of any such basement inundation potential arising at the project flood design levels.

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## **Air Vents Removal**

We understand that as part of the capital improvements RIOC is contemplating using the steam tunnel as part of a shared pedestrian-bicycle path which will require the removal of the existing 6 ft by 10 ft concrete air vent structures. Based on the review of the original constructions drawings we determined that the removal of the vent is feasible, and suggest using a steel framed concrete slab with an access manhole at each location. Refer to Drawing RS-1 for a typical design detail.

Eliminating the existing air vents will require the installation of mechanical ventilation system to maintain the air quality within the tunnel. A mechanical engineer should be retained to establish options and determine the cost of installation and operation of this system.

## **Marine Permitting**

Marine permits will need to be secured from NYS Department of Environmental Conservation (DEC) and the US Army Corps of Engineers to perform work within the limits of the East River. Marine work covered by the necessary ("tidal wetlands" and "nationwide") permits includes the replenishment of deficiencies in the rip-rap protection along the shoreline. The upland work and repairs to the Tunnel Seawall can be performed without these permits.

Obtaining these permits should not be onerous as repairing of bulkheads and shorelines without substantial modification is generally covered by broad-approval standing permits. Early submission of the permits applications to the NYS DEC and US Army Corps of Engineers is recommended as the technical review and approval process can take between 6 to 8 months.

## **Near-Term Implementation**

Note that we have termed the tunnel's major defects as serious, and that deterioration and structural failure can be expected under the worst combinations of loading conditions. We recommend that the repair program outlined in this report be implemented as soon as is possible.

## **Future Inspections and Maintenance**

The tunnel will continue to serve as the seawall and we have noted serious defects, including conditions of base slab undermining. We recommend a program of walk-through and shore-line engineering inspections be adopted as a safety measure in the years ahead



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in order to check for signs of significant deterioration. The degree of maintenance effort will depend upon a decision whether the electrical lighting and pumps will continue in operation.

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## CONCEPTUAL DESIGN ALTERNATIVES

We have analyzed the following alternative solutions to address the structural deficiencies of the tunnel and provide adequate shoreline protection to the island.

No Action – Our observations concluded that no action will result in further deterioration of the steam tunnel structure and possible failure.

Demolition/Replacement – We considered the demolition of the existing tunnel and replacement with a new seawall structure. This option far exceeds the tunnel's repair cost and is not economically feasible.

Abandon/Fill in Place – We explored the possibility of abandoning the tunnel and filling the void space. This option creates structural challenges and will increase loads on the existing foundations. According to record drawings, the tunnel functions as a continuous beam supported by timber pile caps spaced at 16-foot centers. Lightweight material will need to be used to minimize added loads, which will exponentially increase the cost.

Partial Demolition – We considered demolishing the roof slab and the landside wall, and salvaging the existing seawall and bottom slab. Without taking into account economic value, the design and constructability of this option will be extremely challenging. Existing deficiencies like the corroded dowels, coupled with the demolition of the other structural members, may weaken the seawall portion of the box. Lightweight fill will be required to minimize added loads on existing foundations.

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## LIMITATIONS

The observations, evaluations and recommendations offered in this report are based upon data recorded during the course of our investigation and based upon the information obtained from the documents provided to us by RIOCHHC, Verizon and TWC. In particular, complete design, construction and maintenance records for the steam tunnel and adjacent structures have not been provided.

Numerous conditions were observed and documented, while other conditions may remain concealed but may emerge at a point in the future. The conditions of this structure have deteriorated and repairs are warranted, most or all of which should be performed in the immediate future. Many defects are longstanding, and onset of deterioration may be imminent.

The drawings and figures attached to this report may serve as a basis for design, but are not to the level of construction documents. Further review, establishment of budget and preparation of technical specifications are necessary for design to advance to a level appropriate for bidding and construction. Marine permitting from environmental regulatory agencies must also be secured before a substantial portion of the work can proceed.

## **LIST OF ATTACHMENTS**

### **Figures**

#### Aerial Location Plans

1. Aerial Location Plan (STA. 46+00 TO 61+50) – VA101
2. Aerial Location Plan (STA. 29+00 TO 46+00) – VA102
3. Aerial Location Plan (STA. 12+00 TO 29+00) – VA103
4. Aerial Location Plan (STA. 00+00 TO 12+00) – VA104

#### Historical Design Plans (Partial Set of 4 Sheets)

### **Drawings**

#### Tunnel Cross-Sections

1. Typical Cross Sections (Sta. 00+00 to 49+00) – XS 1
2. Typical Cross Sections (Sta. 42+50 to 45+00) – XS 2
3. Typical Cross Sections (Sta. 49+00 to 57+20) – XS 3
4. Typical Cross Sections (Sta. 57+20 to 61+50) – XS 4

#### Interior Conditions Plans

1. Interior Conditions Plan – CS101
2. Interior Conditions Plan – CS102
3. Interior Conditions Plan – CS103
4. Interior Conditions Plan – CS104

#### Exterior Conditions Plans

1. Exterior Conditions Plan – CS201
2. Exterior Conditions Plan – CS202
3. Exterior Conditions Plan – CS203
4. Exterior Conditions Plan – CS204

#### Structural Remediation Plans

1. Remedial Repair to Tunnel Interior– RR 1
2. Steel Frame Cross Section – SF 1
3. Remedial Repair to Tunnel Exterior – RR 2
4. Expansion Joint Repair – EJ 1
5. Placement of Rip-Rap Where Deficient – PR 1
6. Roof Slab at Air Vent – RS 1

## **Tables**

### Defect Observations

1. Interior Defect Observations
2. Exterior Defect Observations

## **Appendices**

- A. Photographic Observations
  1. Interior Conditions
  2. Exterior Conditions
- B. Security Survey Photographs
- C. Excerpt of Relevant Material from 2001 USACE Study of RI Seawalls
- D. Available Interior Utility Maps
  1. TWC
- E. Thermal Modeling and Calculations for Ice Formation
- F. Calculations for Ice-Expansion Forces and Structural Capacity
- G. Test-Pit Logs

## **AERIAL LOCATION PLANS**



A

B

C

D

E

F

G



LEGEND

STEAM TUNNEL FOOT PRINT

STEAM TUNNEL CENTER LINE

AIR VENT

VENT

5/4/18	REVISED PER SITE INSPECTION ON 3/9/18 & 4/9/18	1.
Date	Description	No.

REVISIONS


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Langan Engineering LLC  
Contracting shown as Langan  
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project

STEAM TUNNEL ASSESSMENT  
ROOSEVELT ISLAND

NEW YORK

NEW YORK

Drawing Title

AERIAL LOCATION PLAN  
(STA. 46+00 TO 61+50)

Project No.  
100444601

Date  
9/29/2014

Scale  
1" = 50'

Drawn By  
VP

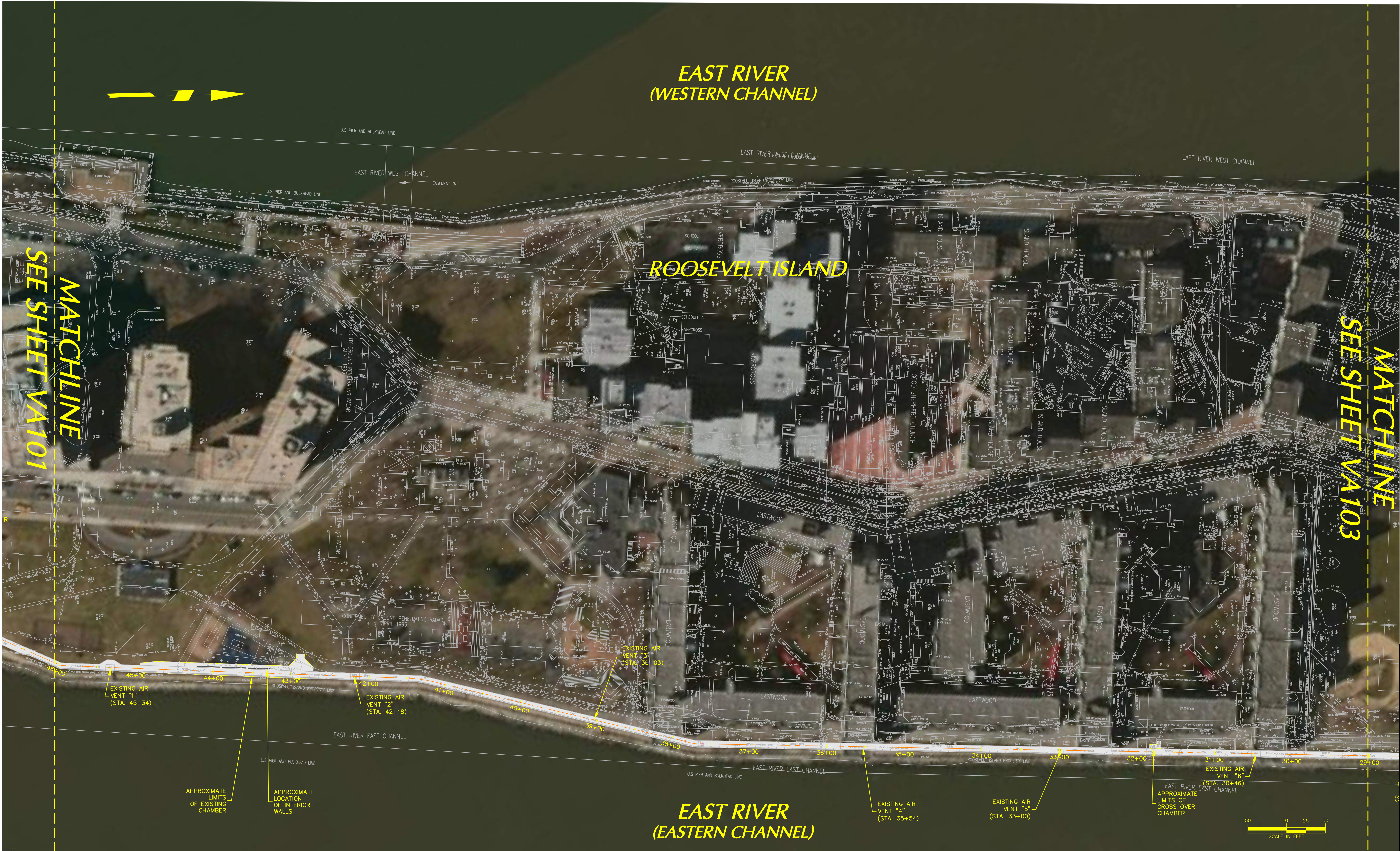
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Drawing No.

VA101

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LEGEND

STEAM TUNNEL FOOT PRINT

STEAM TUNNEL CENTER LINE

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Project

STEAM TUNNEL ASSESSMENT  
ROOSEVELT ISLAND

NEW YORK NEW YORK

Drawing Title

AERIAL LOCATION PLAN  
(STA. 29+00 TO 46+00)

Project No.  
100444601

Date  
9/29/2014

Scale  
1" = 50'

Drawn By  
VP

Checked By  
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Drawing No.  
VA102

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STEAM TUNNEL FOOT PRINT

STEAM TUNNEL CENTER LINE

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Project

STEAM TUNNEL  
ASSESMENT  
ROOSEVELT ISLAND

NEW YORKNEW YORK

Drawing Title

AERIAL LOCATION  
PLAN  
(STA. 00+00 TO 12+00)

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Drawn By	VP	Checked By	JCO

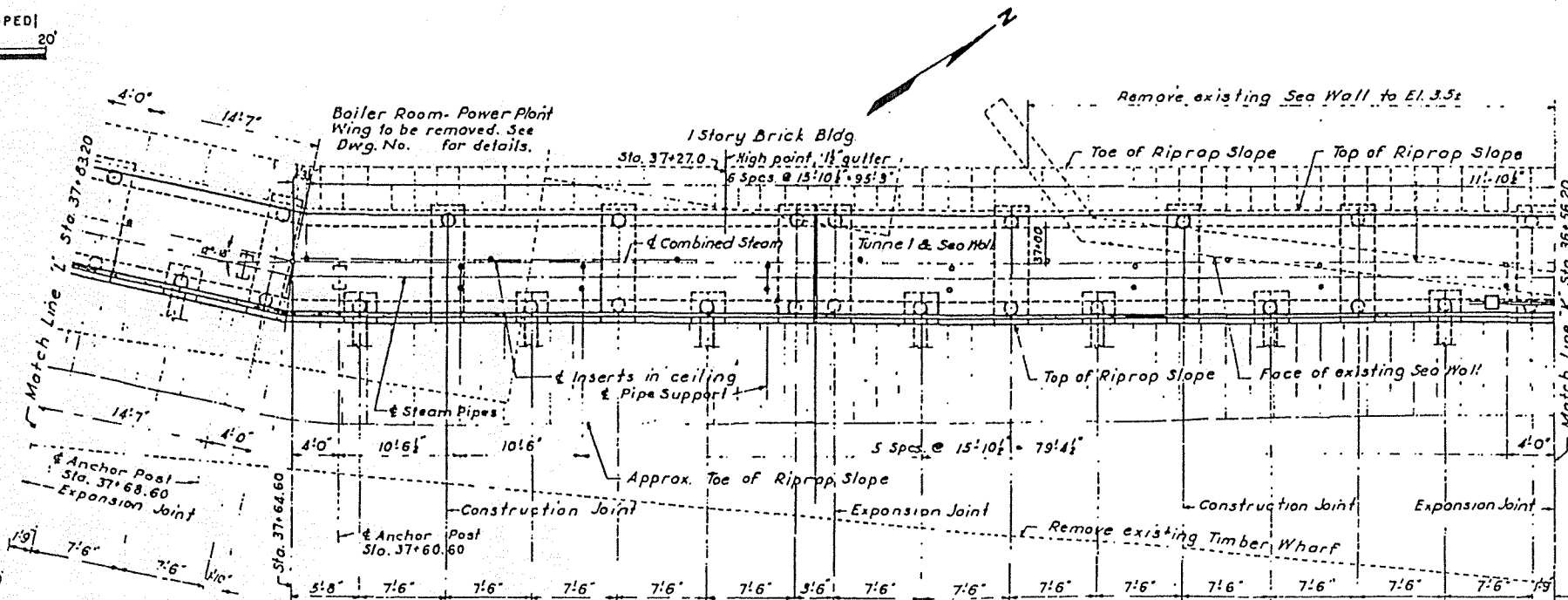
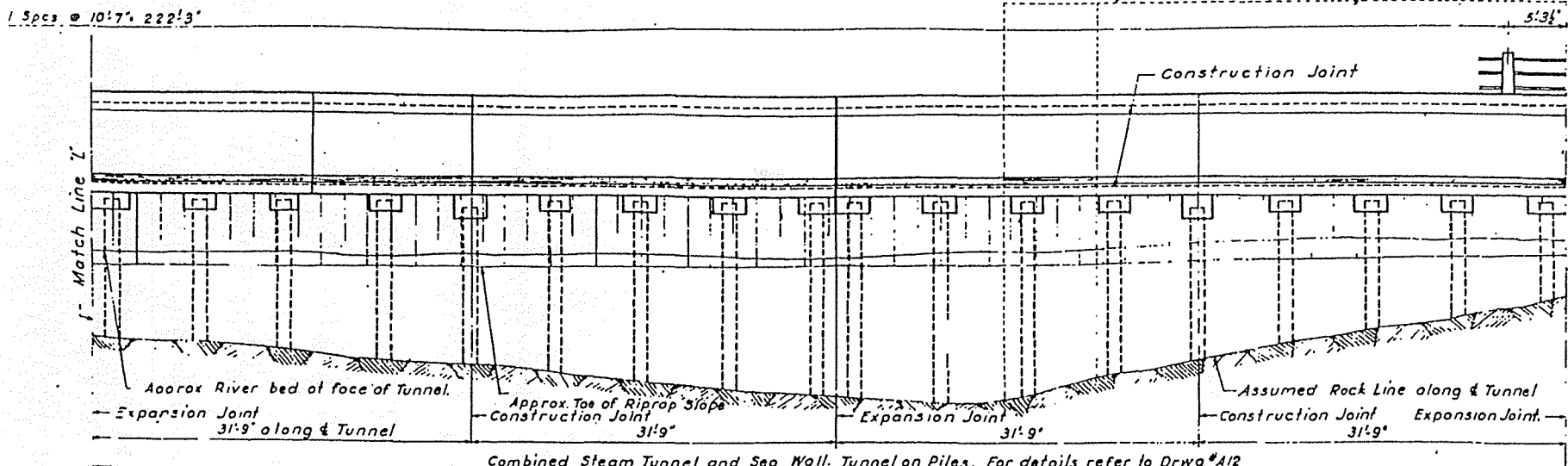


**HISTORICAL DESIGN PLANS  
(PARTIAL SET)**

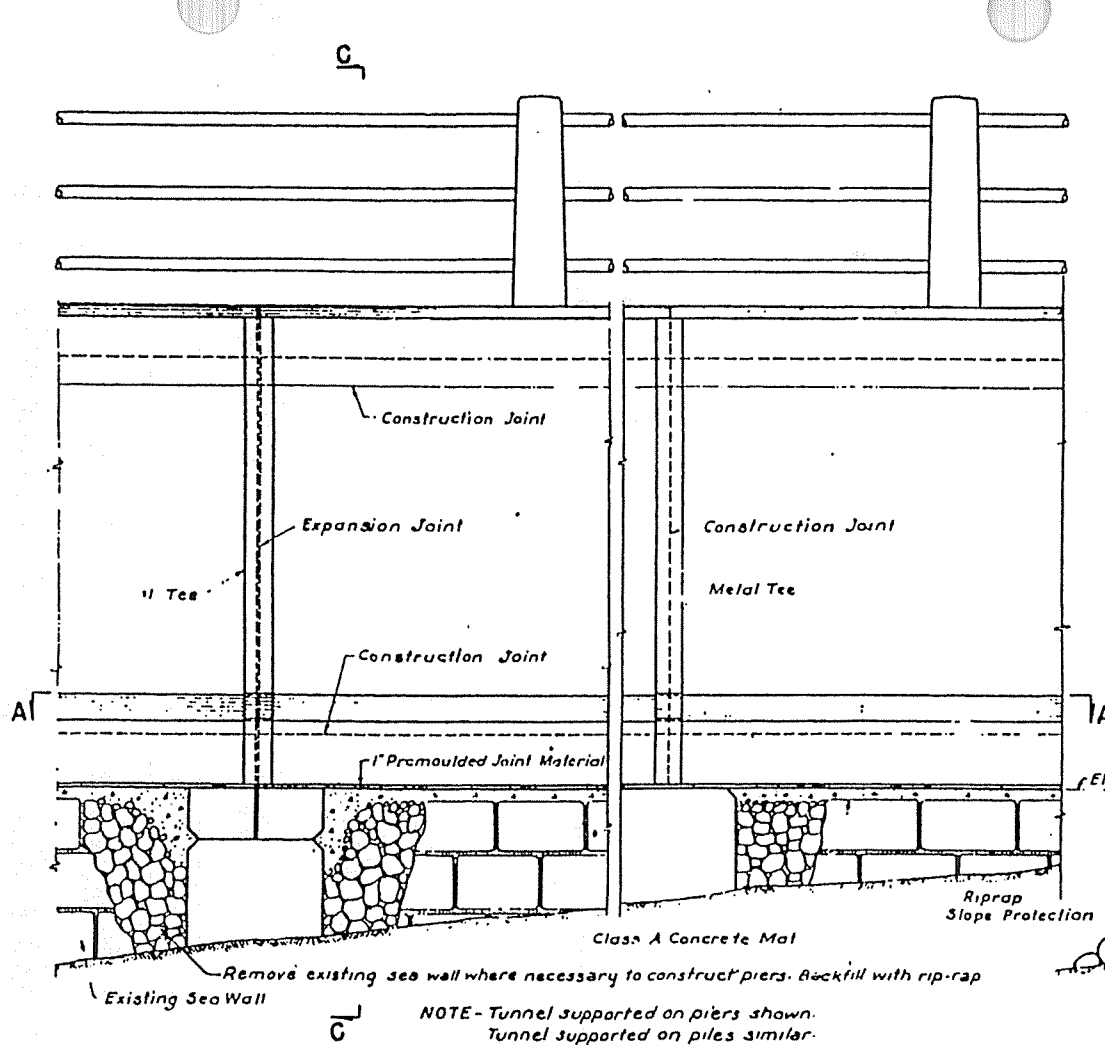








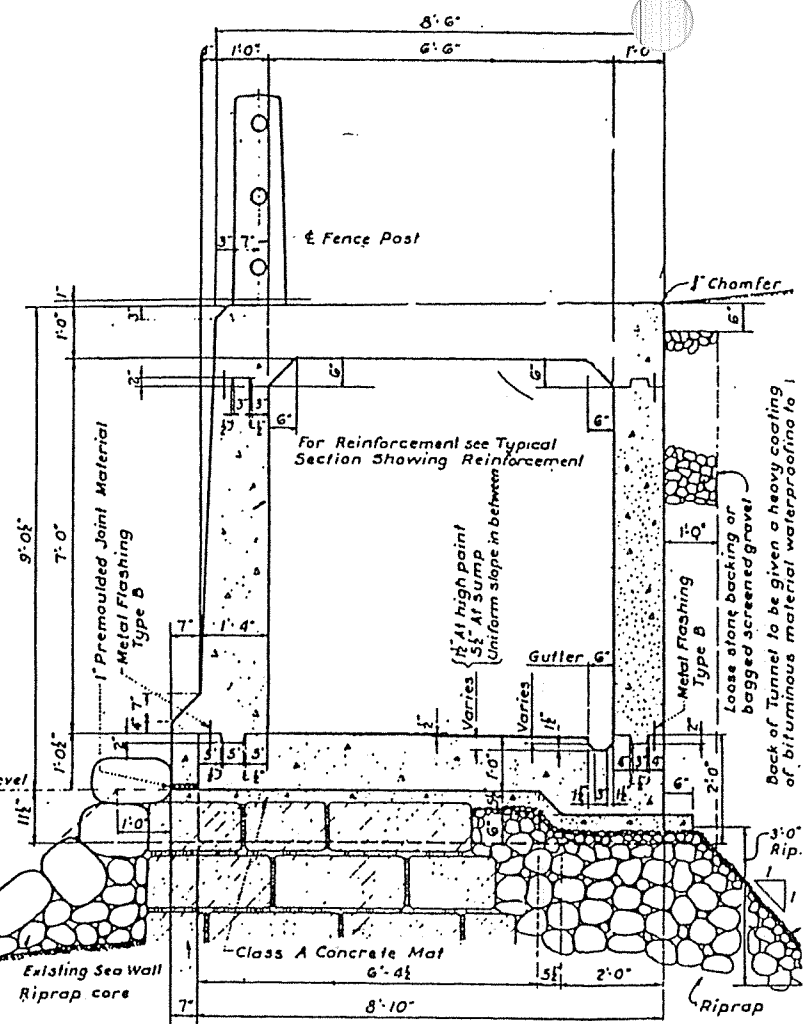
## APPENDIX C



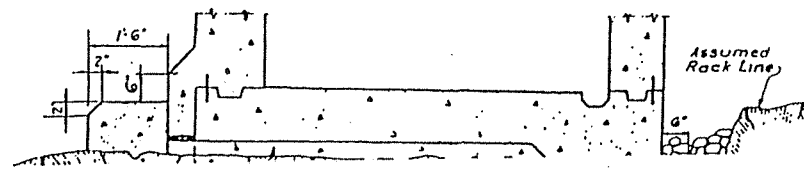
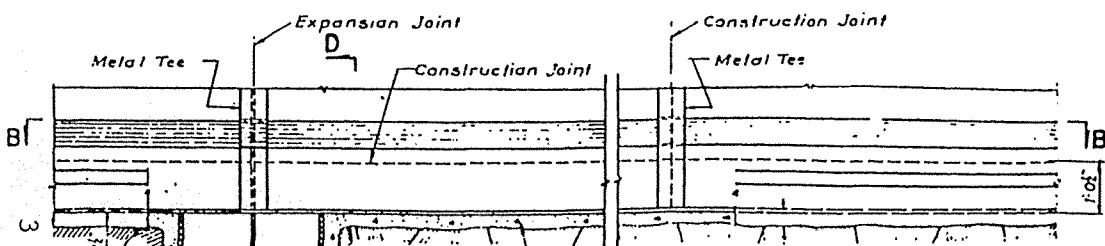
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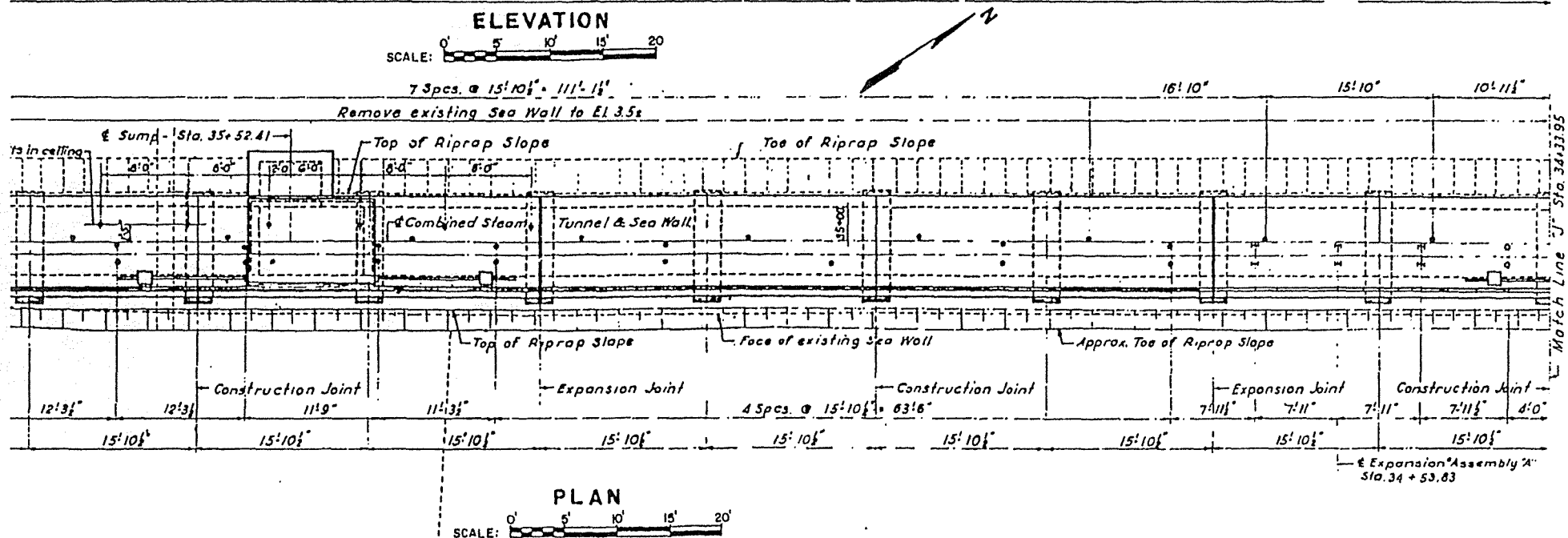
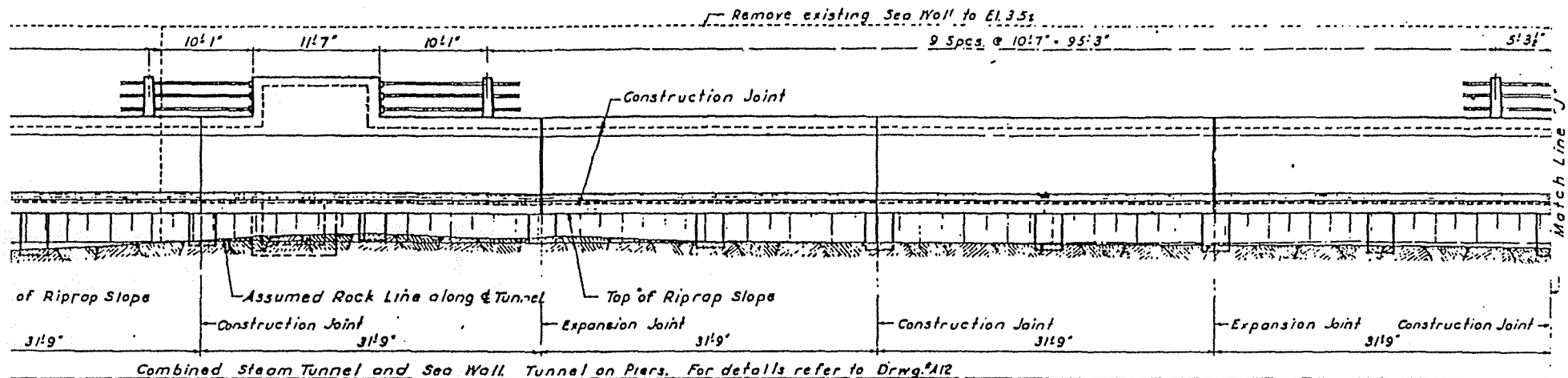
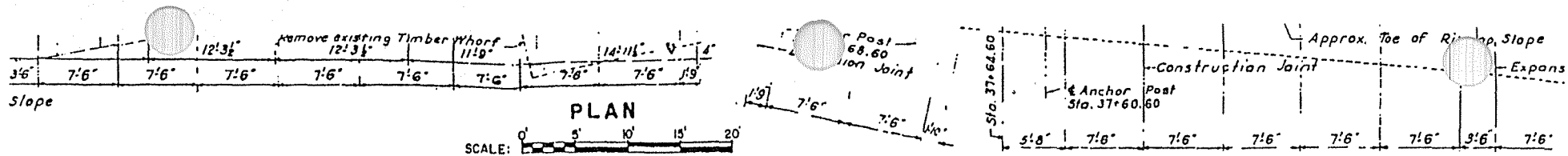
# COMBINED STEAM TUNNEL AND SEA WALL TUNNEL ON EXISTING SEA WALL

SCALE: 1" = 10'



SECTION C - C





# **DRAWINGS**

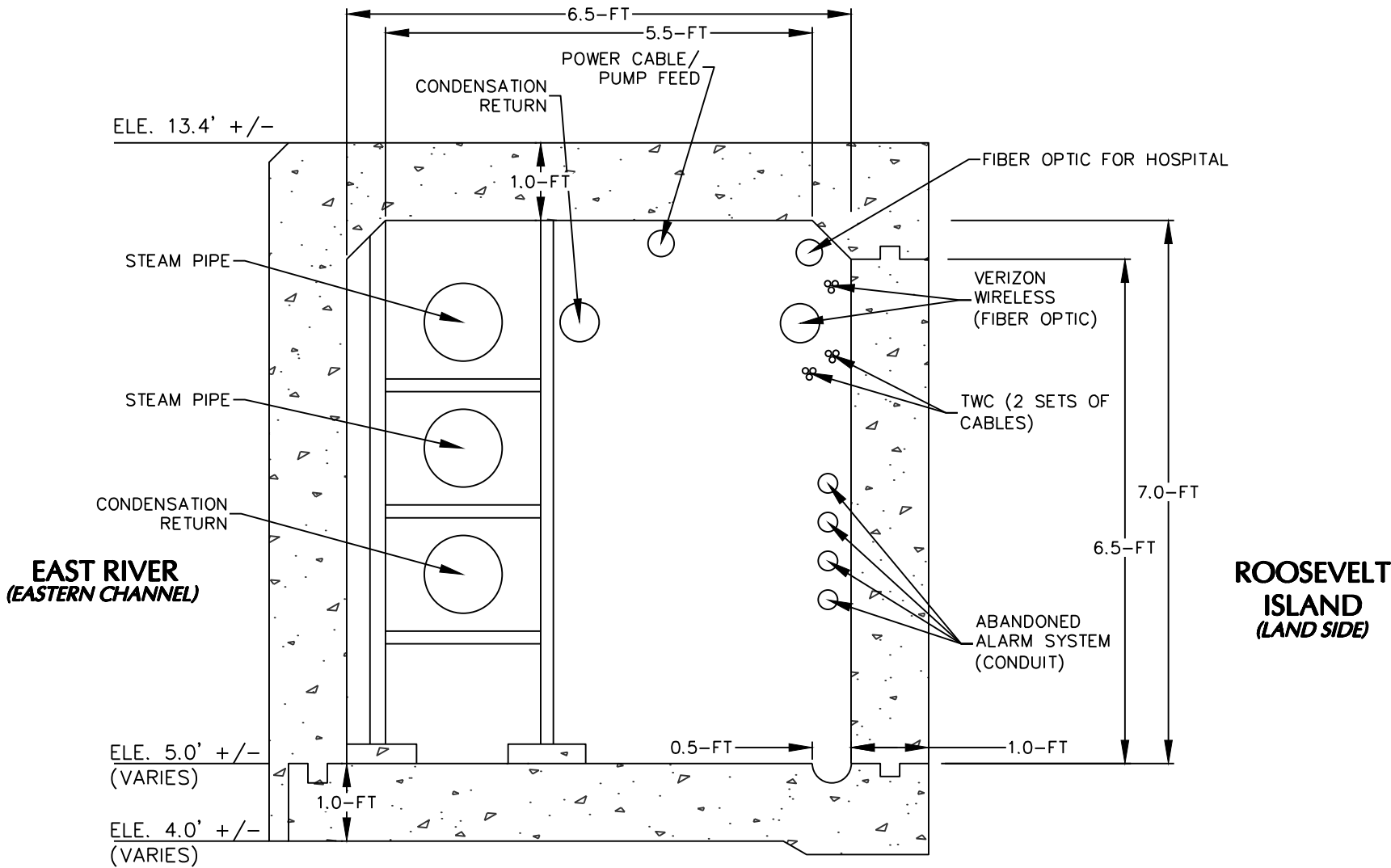


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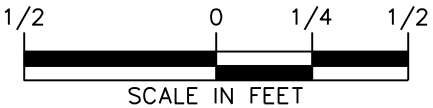
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M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±
NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.	

NOTE:

THIS SECTION DOES NOT SHOW ANY OF TUNNEL STRUCTURAL DEFECTS. SEE REPAIR SECTIONS FOR STRUCTURAL CONDITIONS AND REQUIRED REMEDIES.



TYPICAL CROSS SECTION STEAM TUNNEL  
STA. 0+00 TO 49+00



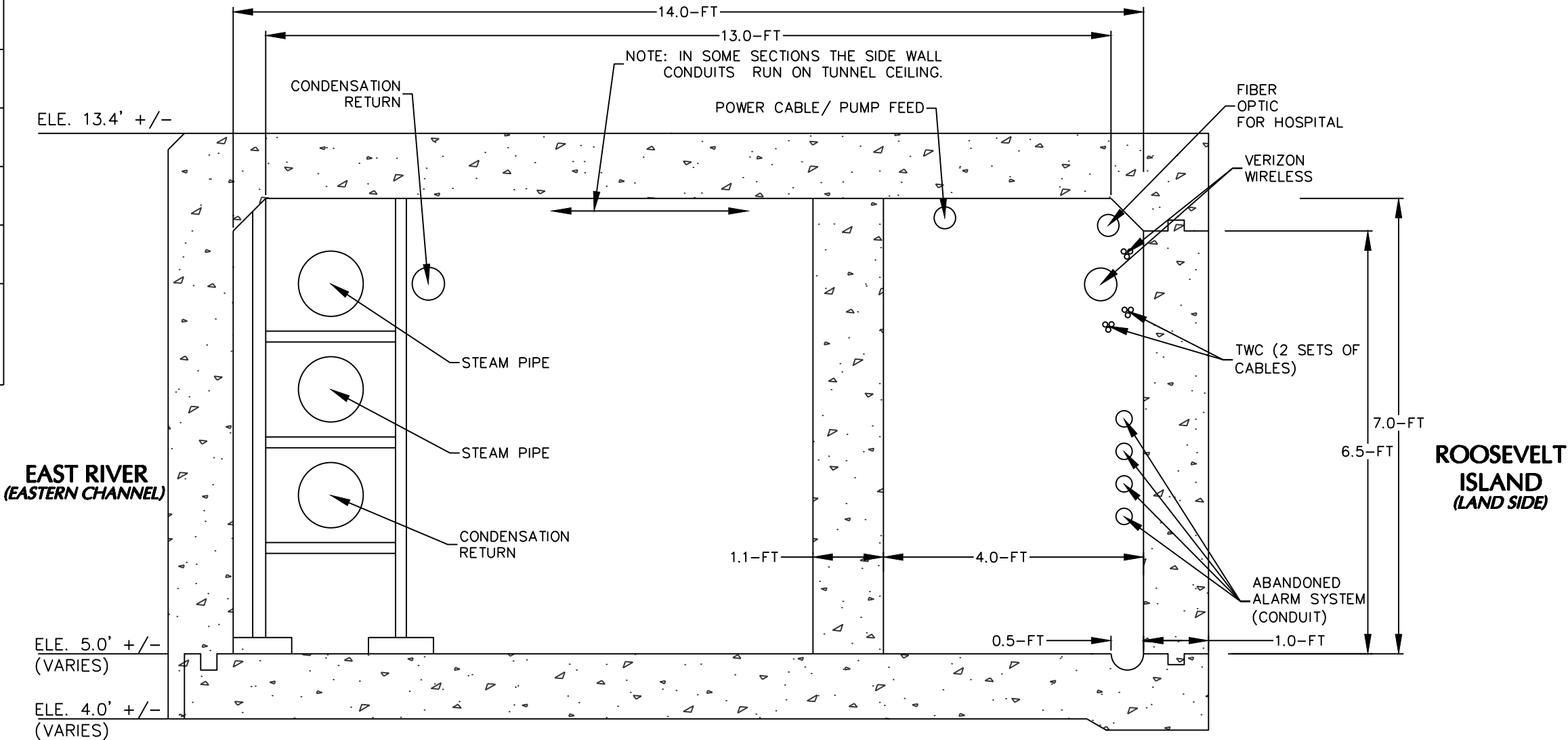
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- IDENTIFICATION OF SHOWN UTILITIES ARE BASED ON INFORMATION PROVIDED BY MAINTENANCE PERSONNEL ON THE FIELD.
  - ARRANGEMENT OF UTILITIES IS SCHEMATIC, CONDUITS ARE NOT SHOWN TO SCALE. ACTUAL LOCATION MAY VARY.

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			Scale 1" = 1/2'	
			Drawn By VP	
			Checked By JCO	
			Submission Date	

TIDAL DATUM LEGEND	
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M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±
NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.	

NOTE:  
THIS SECTION DOES NOT SHOW ANY OF TUNNEL STRUCTURAL DEFECTS. SEE REPAIR SECTIONS FOR STRUCTURAL CONDITIONS AND REQUIRED REMEDIES.



TYPICAL CROSS SECTION STEAM TUNNEL  
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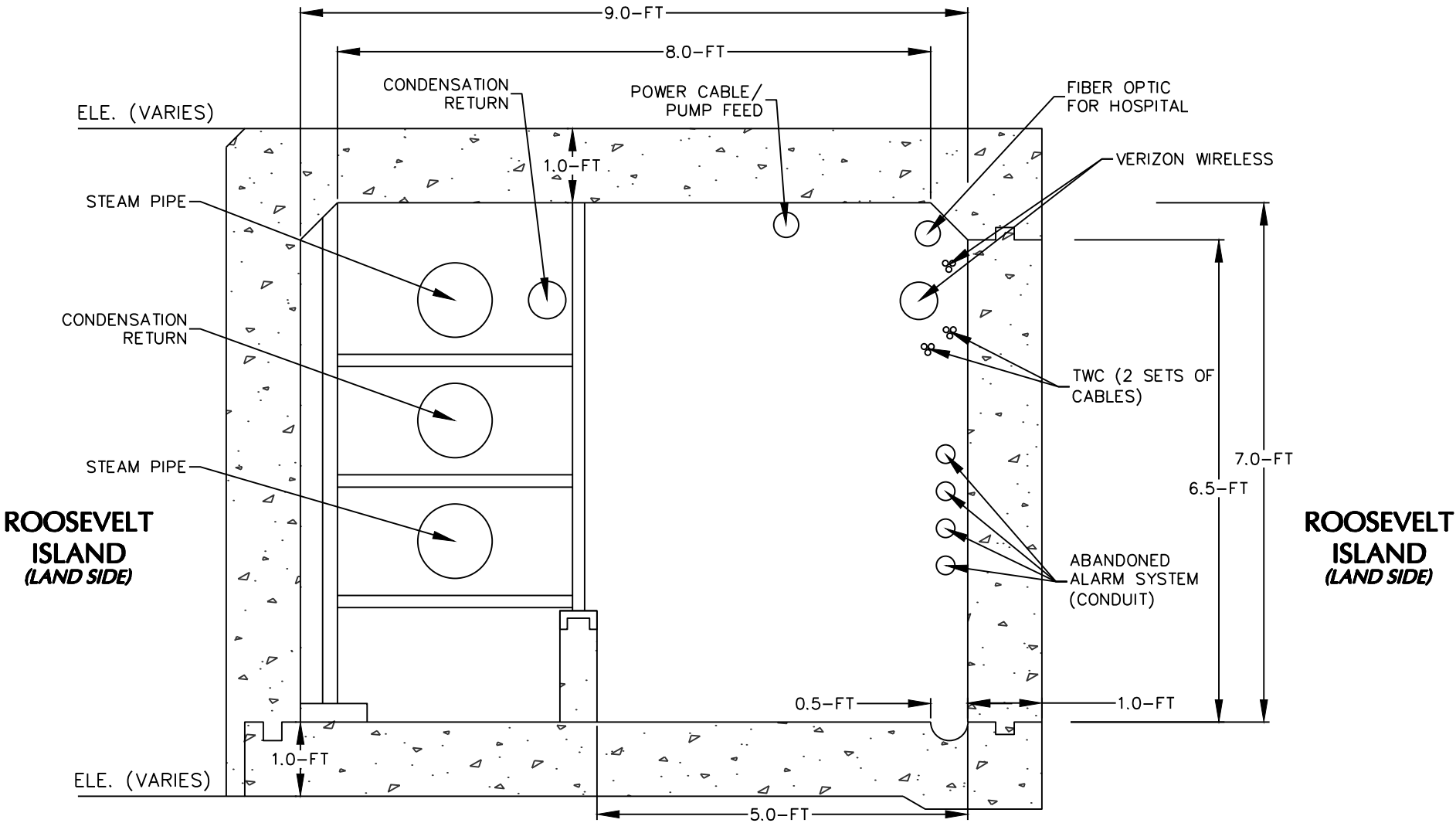
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  - ARRANGEMENT OF UTILITIES IS SCHEMATIC, CONDUITS ARE NOT SHOWN TO SCALE. ACTUAL LOCATION MAY VARY.

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			Date 10/31/2014 Scale 1" = 1/2' Drawn By VP Submission Date	

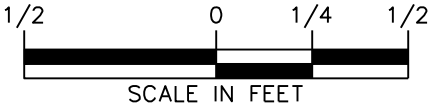
TIDAL DATUM LEGEND	
S.H.W. (SPRING)	+6.00±
M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±
NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.	

NOTE:  
THIS SECTION DOES NOT SHOW ANY OF TUNNEL STRUCTURAL DEFECTS. SEE REPAIR SECTIONS FOR STRUCTURAL CONDITIONS AND REQUIRED REMEDIES.



TYPICAL CROSS SECTION STEAM TUNNEL  
STA. 49+00 TO 57+20

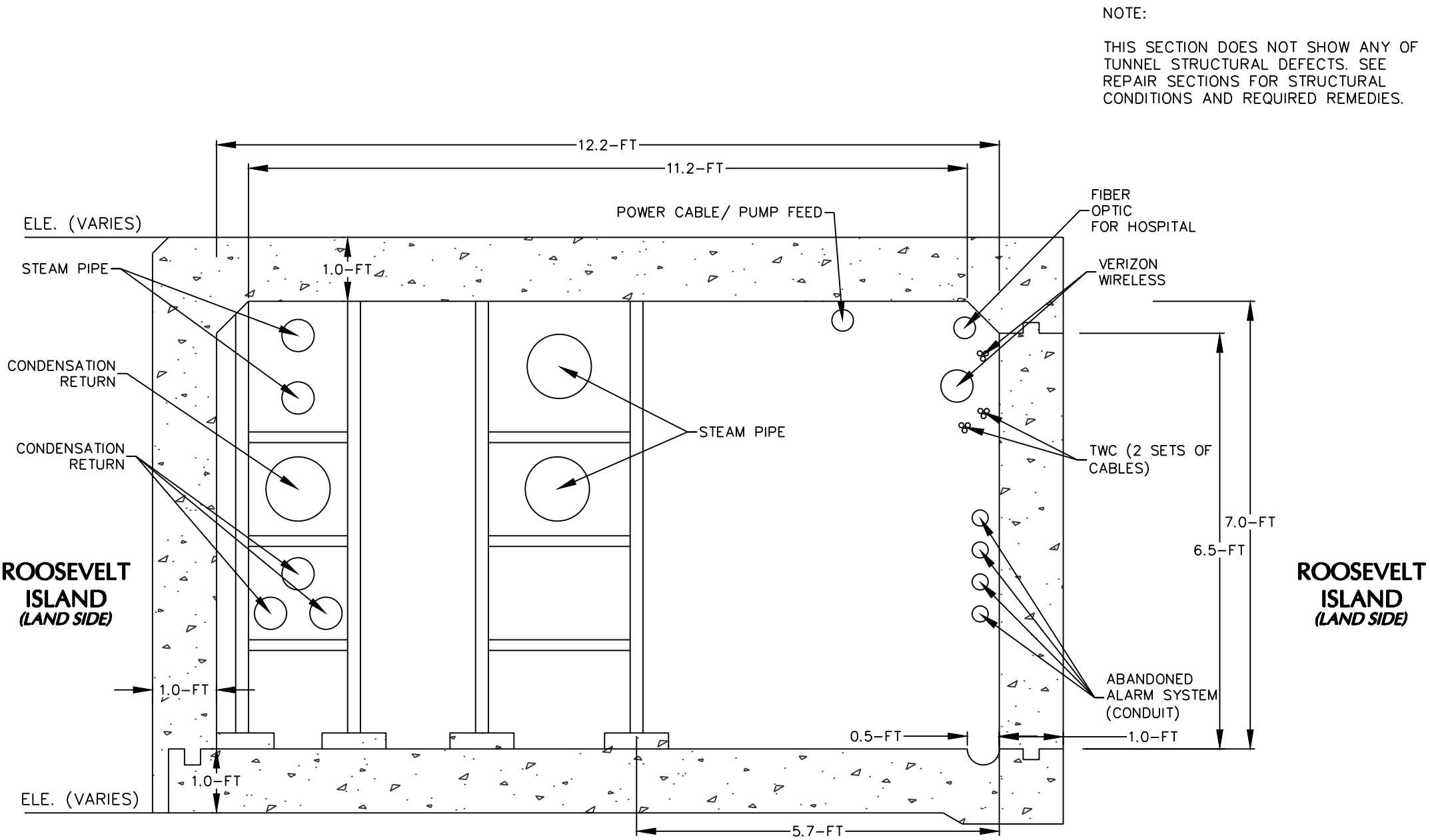
- NOTES:
- IDENTIFICATION OF SHOWN UTILITIES ARE BASED ON INFORMATION PROVIDED BY MAINTENANCE PERSONNEL ON THE FIELD.
  - ARRANGEMENT OF UTILITIES IS SCHEMATIC, CONDUITS ARE NOT SHOWN TO SCALE. ACTUAL LOCATION MAY VARY.



WARNING: IT IS A VIOLATION OF THE NYS EDUCATION LAW ARTICLE 145 FOR ANY PERSON, UNLESS HE IS ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN ANY WAY.

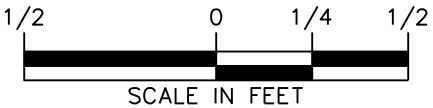
<b>LANGAN</b> 300 Kimball Drive Parsippany, NJ 07054 T: 973.560.4900 F: 973.560.4901 www.langan.com Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C. S.A. Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C. Langan Engineering and Environmental Services, Inc. Langan CT, Inc. Langan International LLC Collectively known as Langan NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400	Project <b>STEAM TUNNEL ASSESSMENT</b> <b>ROOSEVELT ISLAND</b> <b>NEW YORK</b>	Drawing Title <b>TYPICAL CROSS SECTION</b> STA. 49+00 TO 57+20 <b>NEW YORK</b>	Project No. 100444601	Drawing No. <b>XS 3</b>
			Date 10/31/2014 Scale 1" = 1/2' Drawn By VP Submission Date	

TIDAL DATUM LEGEND	
S.H.W. (SPRING)	+6.00±
M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±
NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.	



TYPICAL CROSS SECTION STEAM TUNNEL  
STA. 57+20 TO 61+50

- NOTES:
1. IDENTIFICATION OF SHOWN UTILITIES ARE BASED ON INFORMATION PROVIDED BY MAINTENANCE PERSONNEL ON THE FIELD.
  2. ARRANGEMENT OF UTILITIES IS SCHEMATIC, CONDUITS ARE NOT SHOWN TO SCALE. ACTUAL LOCATION MAY VARY.



WARNING: IT IS A VIOLATION OF THE NYS EDUCATION LAW ARTICLE 145 FOR ANY PERSON, UNLESS HE IS ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN ANY WAY.

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Langan CT, Inc.  
Langan International LLC  
Collectively known as Langan  
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

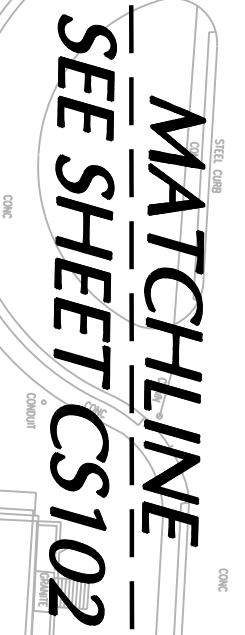
Project  
**STEAM TUNNEL  
ASSESSMENT**  
**ROOSEVELT ISLAND**  
**NEW YORK**

Drawing Title  
**TYPICAL CROSS  
SECTION**  
STA. 57+20 TO 61+50

Project No. 100444601	Drawing No. <b>XS 4</b>
Date 10/31/2014	
Scale 1" = 1/2'	
Drawn By VP	Checked By JCO
Submission Date	

# **INTERIOR CONDITIONS PLAN**





NEW YORK NEW YORK  
Drawing Title

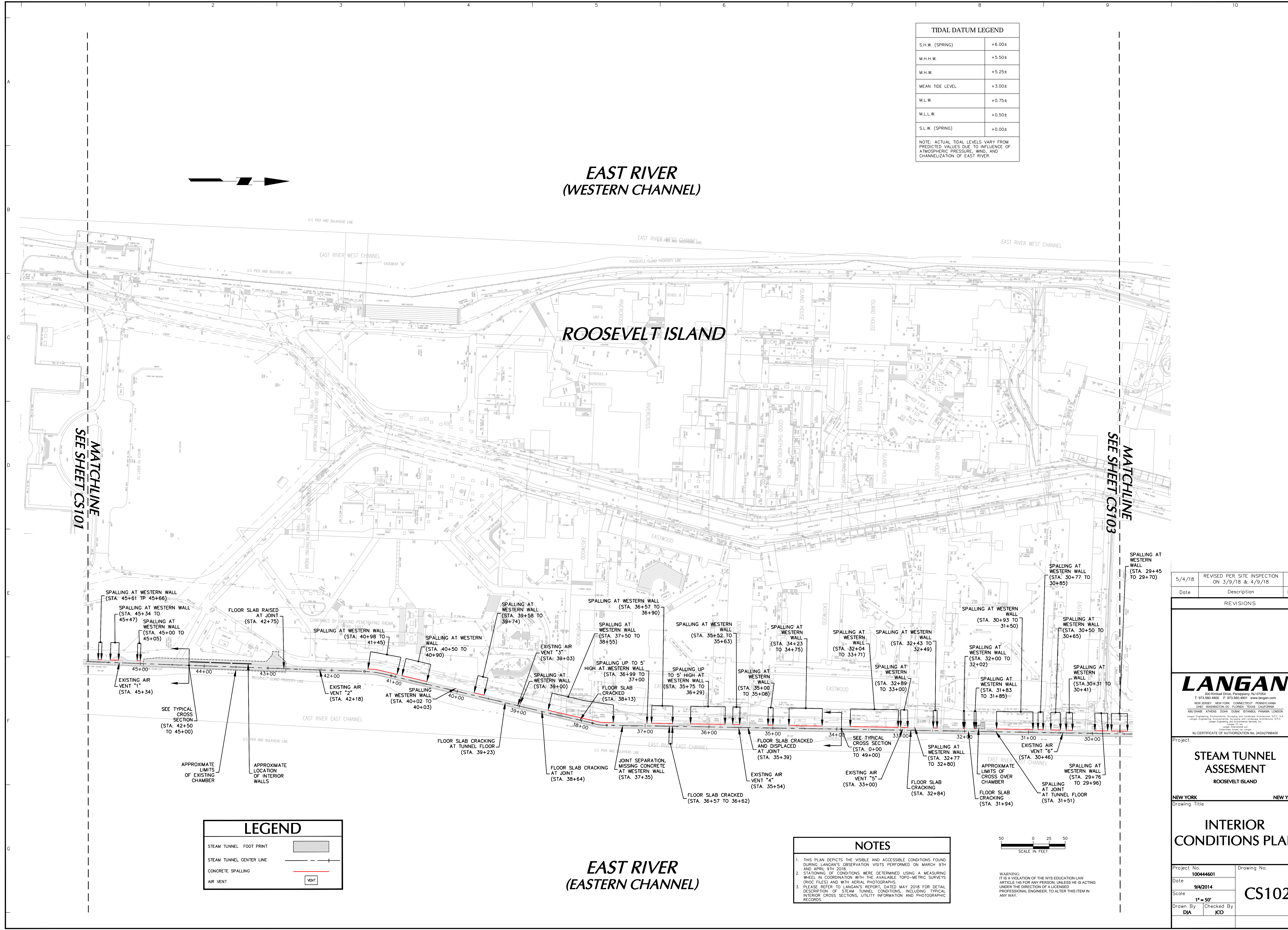
Project No. 100444601	Drawing No.
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Scale  
1" = 50'

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1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON MARCH 9TH AND APRIL 9TH 2018.
2. STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (RIOC FILES) AND WITH AERIAL PHOTOGRAPHS.
3. PLEASE REFER TO LANGAN'S REPORT, DATED MAY 2018 FOR DETAILED DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.

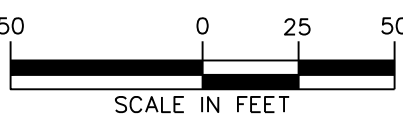




TIDAL DATUM LEGEND	
S.H.W. (SPRING)	+6.00±
M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±
NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.	

LEGEND	
STEAM TUNNEL FOOT PRINT	
STEAM TUNNEL CENTER LINE	
CONCRETE SPALLING	
AIR VENT	

NOTES	
1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON MARCH 5TH AND APRIL 9TH 2018.	
2. STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (R/C FILES) AND WITH AERIAL PHOTOGRAPHS.	
3. PLEASE REFER TO LANGAN'S REPORT, DATED MAY 2018 FOR DETAILED DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.	



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PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN  
ANY WAY.

5/4/18	REVISED PER SITE INSPECTION ON 3/9/18 & 4/9/18	1.
Date	Description	No.

REVISIONS

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Project  
**STEAM TUNNEL ASSESMENT**  
ROOSEVELT ISLAND

NEW YORK NEW YORK  
Drawing Title

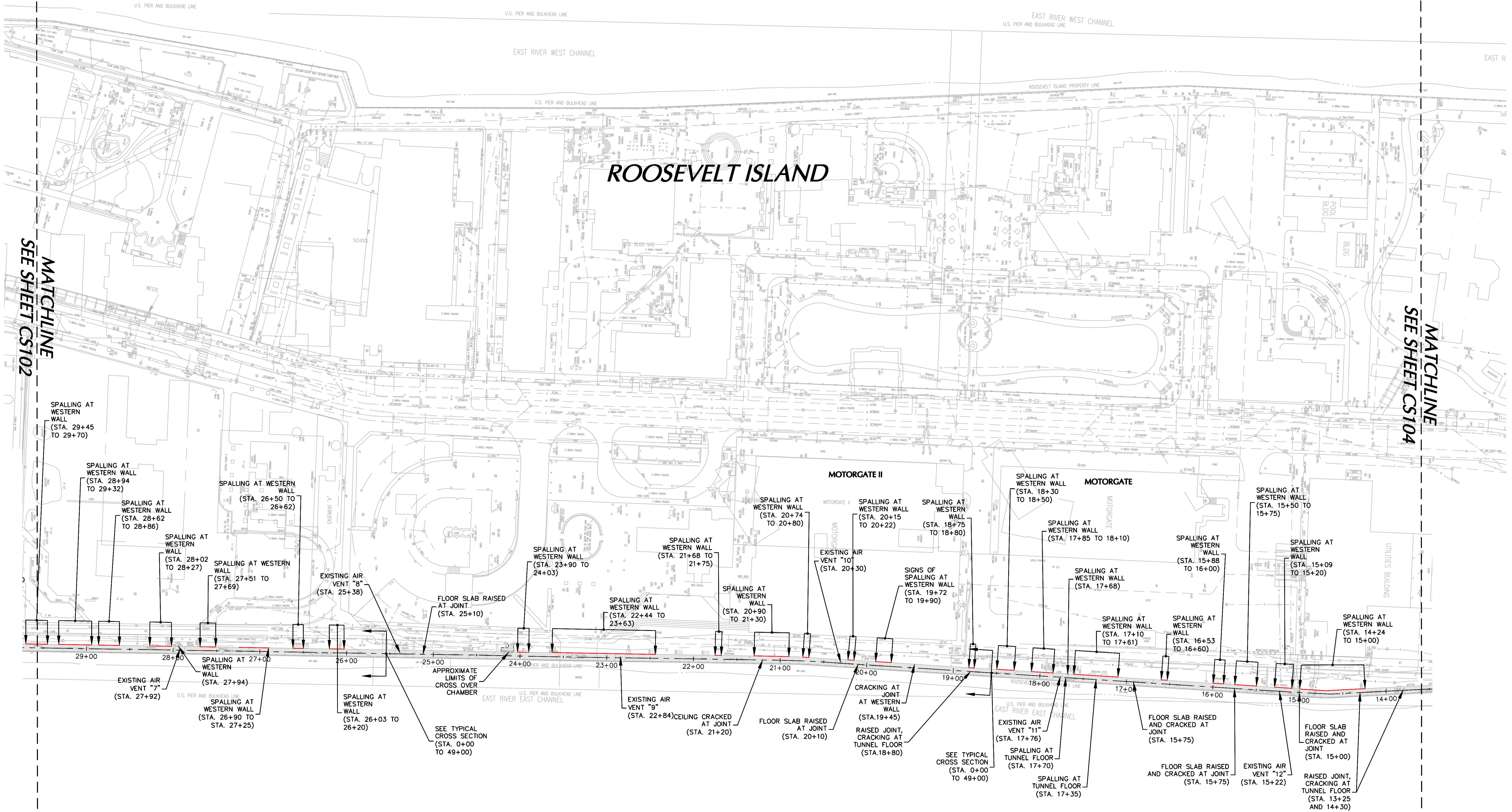
**INTERIOR CONDITIONS PLAN**

Project No.	100444601	Drawing No.	CS102
Date	9/4/2014		
Scale	1" = 50'		
Drawn By	DJA	Checked By	JCO



EAST RIVER  
(WESTERN CHANNEL)

TIDAL DATUM LEGEND	
S.H.W. (SPRING)	+6.00±
M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±
NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.	



LEGEND	
STEAM TUNNEL FOOT PRINT	
STEAM TUNNEL CENTER LINE	
CONCRETE SPALLING	
AIR VENT	

EAST RIVER  
(EASTERN CHANNEL)

- NOTES**
- THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON MARCH 9TH AND APRIL 9TH 2018.
  - STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (RIG FILES) AND WITH AERIAL PHOTOGRAPHS.
  - PLEASE REFER TO LANGAN'S REPORT, DATED MAY 2018 FOR DETAILED DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.

WARNING:  
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PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN  
ANY WAY.

5/4/18	REVISED PER SITE INSPECTION ON 3/9/18 & 4/9/18	1.	
Date	Description	No.	
REVISIONS			
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Project			
<b>STEAM TUNNEL ASSESSMENT</b> ROOSEVELT ISLAND			
NEW YORK NEW YORK			
Drawing Title			
<b>INTERIOR CONDITIONS PLAN</b>			
Project No. <b>100444601</b>		<b>CS103</b>	
Date <b>9/4/2014</b>			
Scale <b>1" = 50'</b>			
Drawn By <b>DJA</b>	Checked By <b>JCO</b>		



EAST RIVER  
(WESTERN CHANNEL)

TIDAL DATUM LEGEND	
S.H.W. (SPRING)	+6.00±
M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±
NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.	

ROOSEVELT ISLAND

OCTAGON BUILDING

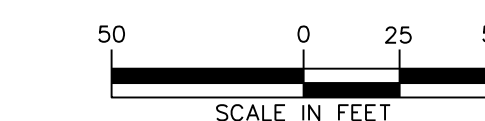
COLER GOLDWATER SPECIALTY  
HOSPITAL AND NURSING FACILITY

LEGEND

STEAM TUNNEL FOOT PRINT	
STEAM TUNNEL CENTER LINE	
CONCRETE SPALLING	
AIR VENT	VENT

NOTES

- THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON MARCH 8TH AND APRIL 9TH 2018.
- STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (ROC FILES) AND WITH AERIAL PHOTOGRAPHS.
- PLEASE REFER TO LANGAN'S REPORT, DATED MAY 2018 FOR DETAILED DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.



WARNING:  
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ARTICLE 145 FOR ANY PERSON, UNLESS HE IS ACTING  
UNDER THE DIRECTION OF A LICENSED  
PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN  
ANY WAY.

5/4/18	REVISED PER SITE INSPECTION ON 3/9/18 & 4/9/18	1.
Date	Description	No.

REVISIONS

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NJ CERTIFICATE OF AUTHORIZATION NO. 24GA2789400

Project  
**STEAM TUNNEL  
ASSESSMENT**  
ROOSEVELT ISLAND

NEW YORK NEW YORK  
Drawing Title

**INTERIOR  
CONDITIONS PLAN**

Project No. <b>100444601</b>	Drawing No. <b>CS104</b>
Date <b>9/4/2014</b>	
Scale <b>1" = 50'</b>	
Drawn By <b>DJA</b>	Checked By <b>JCO</b>



# **EXTERIOR CONDITIONS PLAN**











EAST RIVER  
(WESTERN CHANNEL)

LEGEND

STEAM TUNNEL FOOT PRINT	
STEAM TUNNEL CENTER LINE	
AIR VENT	

ROOSEVELT ISLAND

MOTORGATE II

MOTORGATE

NOTES

- THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON MARCH 9TH AND APRIL 9TH 2018.
- STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (RDC FILES) AND WITH AERIAL PHOTOGRAPHS.
- THE UNDERSIDE OF THE STEAM TUNNEL FLOOR SLAB WAS NOT ACCESSIBLE BY LANGAN'S DIVER.
- BASED ON RECORD DRAWINGS FROM THE 1950S, THE STEAM TUNNEL IS BELIEVED TO BE SUPPORTED AT VARIOUS POINTS ON BEDROCK, CONCRETE PIER AND TIMBER PILES, NEITHER THE RECORD DRAWINGS NOR THE LANGAN OBSERVATION VISIT REVEALED THE EXTENT OF THESE TYPES OF FOUNDATIONS.
- TEST PITS PERFORMED BY LANGAN ON OCTOBER 22ND, 2014 REVEALED NO STRUCTURAL DISTRESS OF THE OUTSIDE FACE OF THE WESTERN EXTERIOR WALL.
- PLEASE REFER TO LANGAN'S REPORT, DATED MAY 2018 FOR DETAIL DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.

TIDAL DATUM LEGEND

S.H.W. (SPRING)	+6.00±
M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±

NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.

EAST RIVER  
(EASTERN CHANNEL)

50 0 25 50  
SCALE IN FEET

WARNING:  
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PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN  
ANY WAY.

5/4/18	REVISED PER SITE INSPECTION ON 3/9/18 & 4/9/18	1.
Date	Description	No.

REVISIONS

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LANGAN ENGINEERING, ENVIRONMENTAL, SURVEYING AND LANDSCAPE ARCHITECTURE, D.P.C. S.A.  
NJ CERTIFICATE OF AUTHORIZATION No. 24GA2799400

Project  
**STEAM TUNNEL  
ASSESSMENT**  
ROOSEVELT ISLAND

NEW YORK NEW YORK  
Drawing Title

**EXTERIOR  
CONDITIONS PLAN**

Project No. <b>100444601</b>	Drawing No. <b>CS203</b>
Date <b>9/4/2014</b>	
Scale <b>1" = 50'</b>	
Drawn By <b>DJA</b>	Checked By <b>ICO</b>



## NOTES

1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON MARCH 9TH AND APRIL 9TH 2018.
2. STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (DOC FILES) AND WITH AERIAL PHOTOGRAPHS.
3. THE UNDERSIDE OF THE STEAM TUNNEL FLOOR SLAB WAS NOT ACCESSIBLE BY LANGAN'S DIVER.
4. BASED ON RECORD DRAWINGS FROM THE 1950S, THE STEAM TUNNEL IS BELIEVED TO BE SUPPORTED AT VARIOUS POINTS ON BEDROCK, CONCRETE PIER AND TOWER PILES. NEITHER THE RECORD DRAWINGS NOR THE LANGAN OBSERVATION VISIT REVEALED THE EXTENT OF THESE TYPES OF FOUNDATIONS.
5. TEST PITS PERFORMED BY LANGAN ON OCTOBER 22ND, 2014 REVEALED NO STRUCTURAL DISTRESS OF THE OUTSIDE FACE OF THE WESTERN EXTERIOR WALL.
6. PLEASE REFER TO LANGAN'S REPORT, DATED MAY 2018 FOR DETAIL DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.

## TIDAL DATUM LEGEND

S.H.W. (SPRING)	+6.00±
M.H.H.W.	+5.50±
M.H.W.	+5.25±
MEAN TIDE LEVEL	+3.00±
M.L.W.	+0.75±
M.L.L.W.	+0.50±
S.L.W. (SPRING)	+0.00±

NOTE: ACTUAL TIDAL LEVELS VARY FROM PREDICTED VALUES DUE TO INFLUENCE OF ATMOSPHERIC PRESSURE, WIND, AND CHANNELIZATION OF EAST RIVER.

EAST RIVER  
(WESTERN CHANNEL)

## LEGEND

STEAM TUNNEL FOOT PRINT

STEAM TUNNEL CENTER LINE

AIR VENT

VENT

## ROOSEVELT ISLAND

OCTAGON BUILDING

COLER GOLDWATER SPECIALTY  
HOSPITAL AND NURSING FACILITY

0+00'  
EXACT LOCATION AND GEOMETRY  
UNDER COLER GOLDWATER HOSPITAL  
CAN NOT BE DETERMINED.  
APPROXIMATE FOOTPRINT IS SHOWN  
FOR FUTURE CONSTRUCTION  
PROJECTS IN CLOSE PROXIMITY  
TO TUNNEL. THE PROJECT SURVEYORS  
SHALL ENTER THE TUNNEL AND  
SHALL PERFORM TEST PITS TO  
PRECISELY DETERMINE THE  
STRUCTURE LIMITS.

SEE TYPICAL  
CROSS SECTION  
(STA. 0+00 TO 49+00)EXISTING AIR  
VENT "17"  
(STA. 3+09)END OF SEAWALL  
(STA. 5+18)EXISTING AIR  
VENT "16"  
(STA. 6+16)MINOR SPALLING  
(STA. 7+68)TEST PIT 6  
(STA. 8+90)SPALLING, CRACKING, AND  
EXPOSED REINFORCEMENT  
AT HAUNCH  
(STA. 8+49)SPALLING, CRACKING, AND  
EXPOSED REINFORCEMENT  
AT HAUNCH  
(STA. 10+57)SEE TYPICAL  
CROSS SECTION  
(STA. 0+00  
TO 49+00)SPALLING WITH  
RE-BAR EXPOSED  
(STA. 12+68)SEAWALL SIDEWALK  
CRACKED AT JOINT  
(STA. 13+03)SPALLING WITH  
RE-BAR EXPOSED  
(STA. 13+10)SPALLING WITH  
RE-BAR  
EXPOSED  
(STA. 13+27)EAST RIVER  
(EASTERN CHANNEL)50 0 25 50  
SCALE IN FEET

WARNING:  
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ARTICLE 145 FOR ANY PERSON, UNLESS HE IS ACTING  
UNDER THE DIRECTION OF A LICENSED  
PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN  
ANY WAY.

5/4/18	REVISED PER SITE INSPECTION ON 3/9/18 & 4/9/18	1.
Date	Description	No.

## REVISIONS

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NJ CERTIFICATE OF AUTHORIZATION NO. 24GA2789400

Project

STEAM TUNNEL  
ASSESSMENT  
ROOSEVELT ISLAND

NEW YORK NEW YORK

Drawing Title

EXTERIOR  
CONDITIONS PLAN

Project No.

100444601

Date

9/4/2014

Scale

1" = 50'

Drawn By

DJA

Checked By

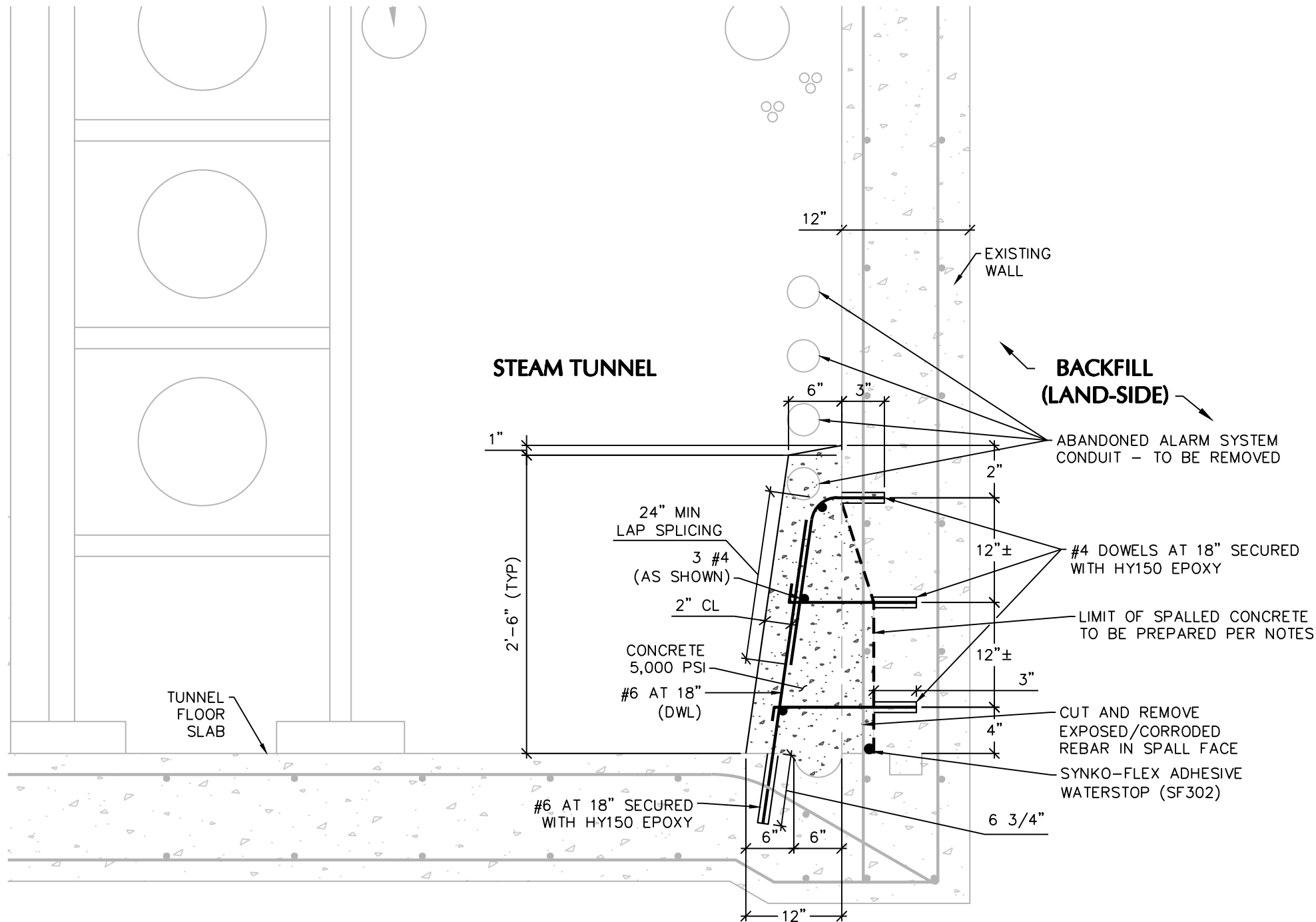
JCO

CS204



# **STRUCTURAL REMEDIATION PLANS**

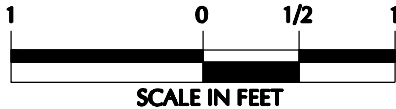




**CROSS SECTION**  
**SHOWING REMEDIAL STRUCTURAL REPAIR**  
**(INTERIOR FACE OF LAND-SIDE WALL)**

**SEQUENCE OF CONSTRUCTION**

1. REMOVE ALL LOOSE CONCRETE AT SPALL.
2. CLEAR OFF LOOSEN CORROSION OF REBARS. CUT OR REMOVE THE EXISTING REBARS IF THE REMAINING AREAS OF THE BARS ARE REDUCED MORE THAN 60% DUE TO CORROSION.
3. PRE-DRILL DIAMETER HOLES TO RECEIVE NEW DOWELS AS SHOWN.
4. CLEAN EXPOSED SURFACE OF CONCRETE WITH WATER BLASTING AS PREPARATION FOR REPAIR.
5. APPLY BONDING AGENT ONTO CLEANED CONCRETE SURFACE.
6. SET EPOXY COATED REINFORCEMENT AND FORMWORK FOR CONCRETE AS SHOWN.
7. POUR 5,000PSI CONCRETE TO CREATE REPAIR SECTION AS SHOWN.



WARNING: IT IS A VIOLATION OF THE NYS EDUCATION LAW ARTICLE 145 FOR ANY PERSON, UNLESS HE IS ACTING UNDER THE DIRECTION OF A LICENSED PROFESSIONAL ENGINEER, TO ALTER THIS ITEM IN ANY WAY.

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NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project

**STEAM TUNNEL  
ASSESSMENT**

**ROOSEVELT ISLAND**

**NEW YORK**

Drawing Title

**REMEDIAL REPAIR  
TO TUNNEL  
INTERIOR**

**NEW YORK**

Project No.

100444601

Date

11/13/2014

Scale

1" = 1'

Drawn By

PP

Checked By

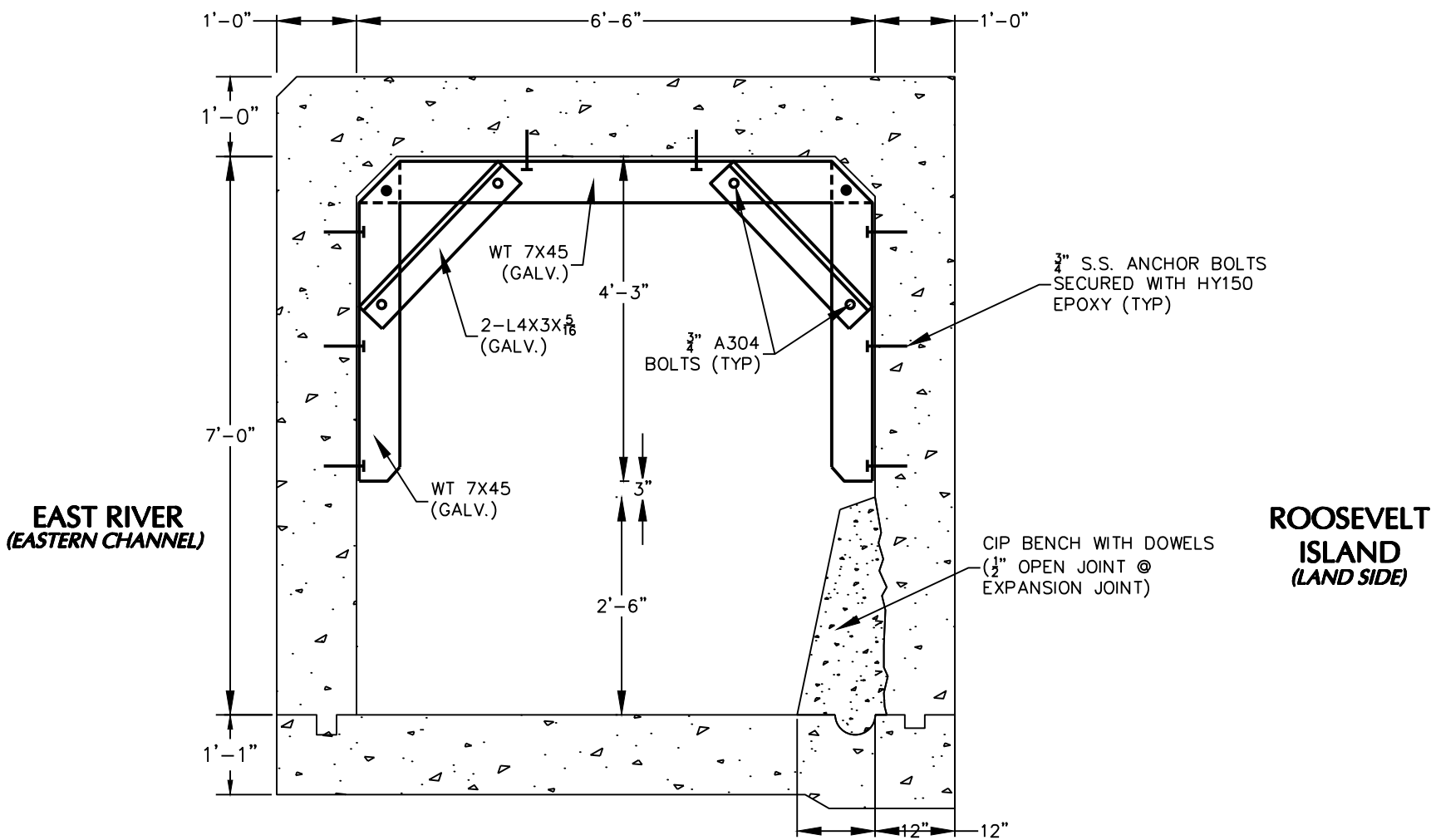
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Submission Date

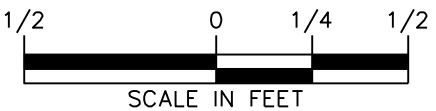
Drawing No.

**RR-1**

- NOTE:
1. THIS SECTION DOES NOT SHOW ANY OF TUNNEL STRUCTURAL DEFECTS. SEE REPAIR SECTIONS FOR STRUCTURAL CONDITIONS AND REQUIRED REMEDIES.
  2. THIS SECTION DOES NOT SHOW ANY OF THE EXISTING PIPES TO BE REMOVED FOR THE INSTALLATION OF THE STEEL FRAME.
  3. TWO STEEL FRAMES TO BE INSTALLED NEAR EACH EXPANSION JOINT.
  4. LOCATION OF FRAME SHALL BE FIELD DETERMINED BY THE DESIGN ENGINEER.



TYPICAL PROPOSED STEEL FRAME  
CROSS SECTION WITHIN STEAM TUNNEL



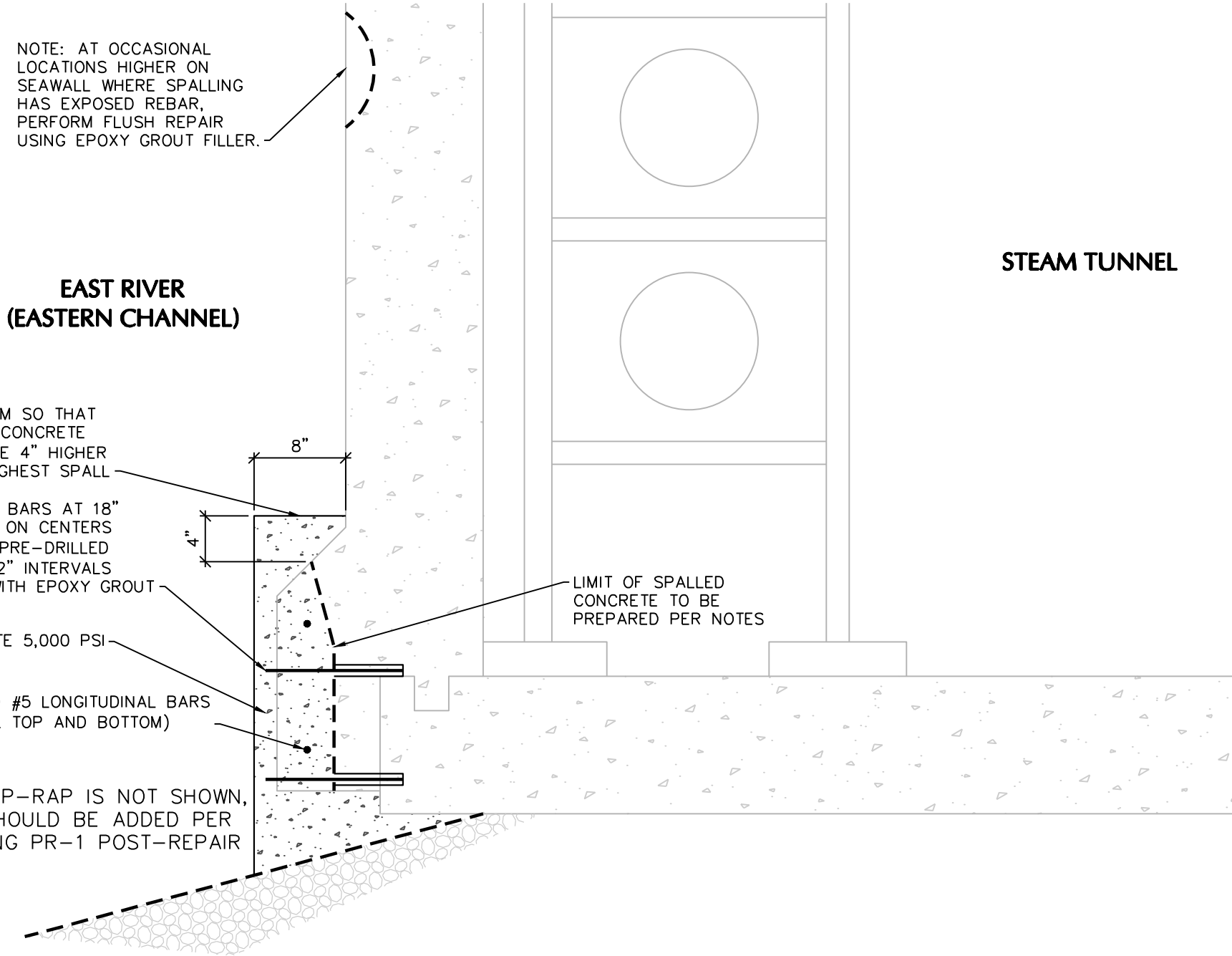
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Project  
**STEAM TUNNEL  
ASSESSMENT**  
**ROOSEVELT ISLAND**  
**NEW YORK NEW YORK**

Drawing Title  
**STEEL FRAME  
CROSS SECTION**

Project No. 100444601	Drawing No. <b>SF 1</b>
Date 10/31/2014	
Scale 1" = 1/2'	
Drawn By VP	Checked By JCO
Submission Date	

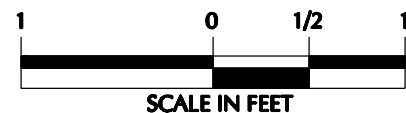


### SEQUENCE OF CONSTRUCTION

1. REMOVE ALL LOOSE CONCRETE AT SPALL.
2. CLEAN EXPOSED REBAR IN FACE OF SPALL. REMOVE PORTIONS IF CORROSION HAS CAUSED SECTION LOSS.
3. APPLY EPOXY PROTECTIVE COATING TO EXISTING REBAR.
4. PRE-DRILL ¾" DIAMETER HOLES 4" DEEP TO RECEIVE NEW REBAR AS SHOWN.
5. CLEAN EXPOSED SURFACE OF CONCRETE AS PREPARATION FOR REPAIR.
6. APPLY BONDING AGENT TO CLEANED CONCRETE SURFACE.
7. SET REINFORCEMENT AND FORMWORK FOR CONCRETE AS SHOWN.
8. PLACE 5,000PSI CONCRETE TO CREATE REPAIR SECTION AS SHOWN.

NOTE:

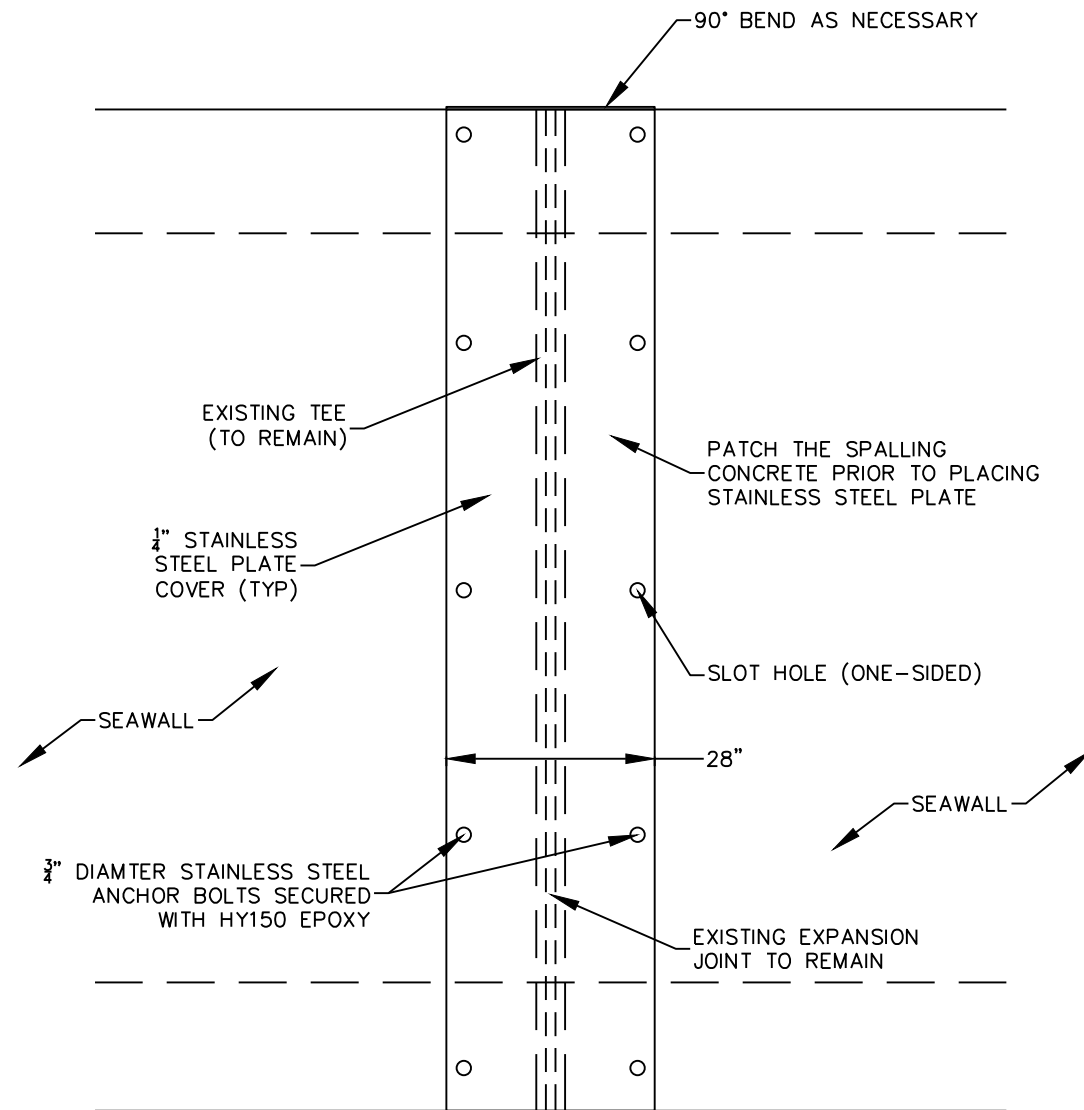
THIS DRAWING SHOWS A REPAIR SECTION FOR AREAS OF HAUNCH SPALLING WITH REBAR EXPOSURE AND UNDERMINING OF TUNNEL FLOOR-SLAB. WHERE SPALLING IS MINOR AND UNDERMINING IS NOT EVIDENT, MODIFY DETAIL TO EXCLUDE NEW REINFORCEMENT, OR PLACE RIP-RAP AS AN ALTERNATE TO PROTECT HAUNCH.



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## CROSS SECTION SHOWING REMEDIAL STRUCTURAL REPAIR (EXTERIOR FACE OF SEAWALL)

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	<div>STEAM TUNNEL ASSESSMENT</div> <div>ROOSEVELT ISLAND</div> <div>NEW YORKNEW YORK</div>	<div>REMEDIAL REPAIR TO TUNNEL SEAWALL FACE</div>	Date 11/13/2014	RR-2	
			Scale 1" = 1'		
			Drawn By PP		Checked By JCO
			Submission Date		



ELEVATION OF STAINLESS STEEL PLATE  
AT EXPANSION JOINT  
(ALONG THE EAST RIVER)



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NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project

**STEAM TUNNEL  
ASSESSMENT**

**ROOSEVELT ISLAND**

**NEW YORK**

Drawing Title

**EXPANSION  
JOINT REPAIR**

**NEW YORK**

Project No.  
100444601

Date  
10/31/2014

Scale  
1" = 1/2'

Drawn By  
VP

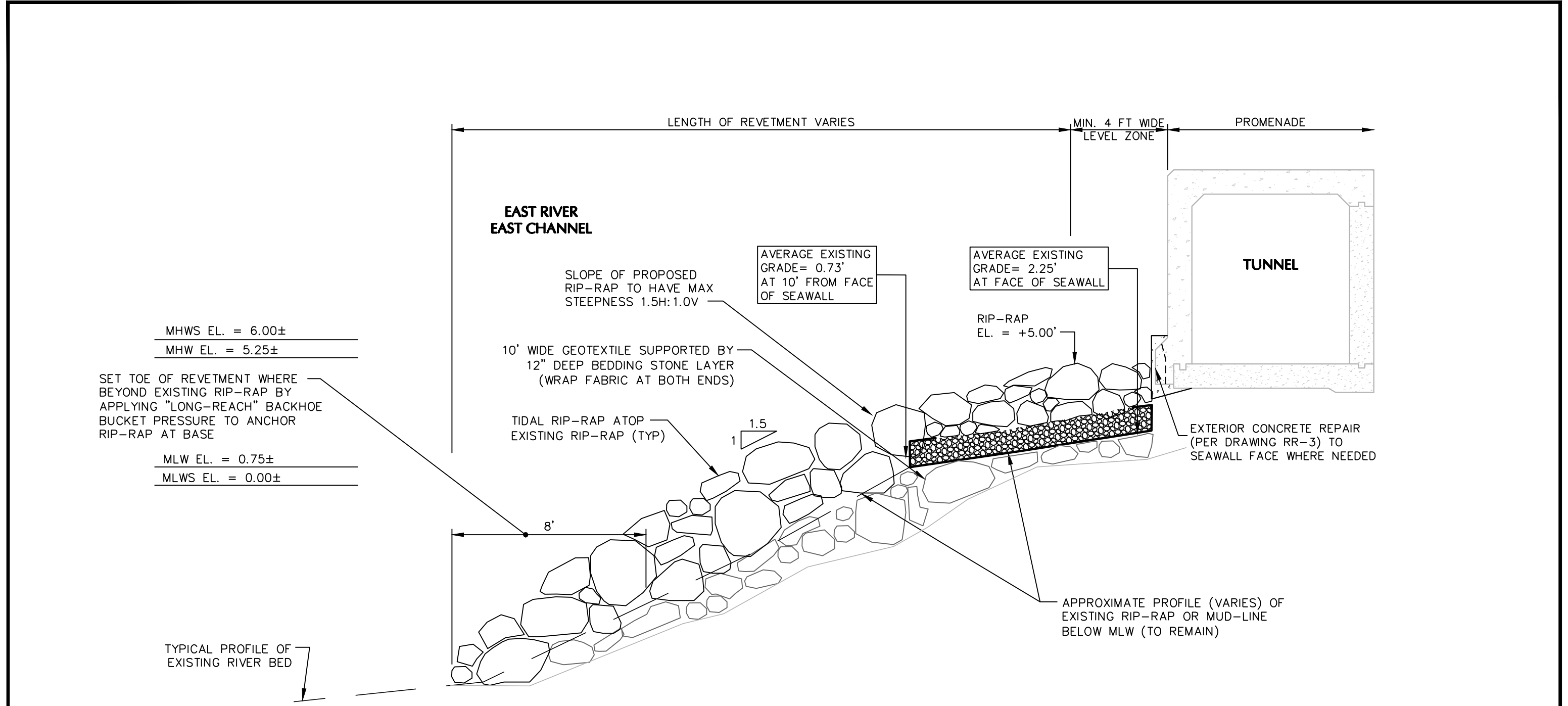
Checked By  
JCO

Submission Date

Drawing No.

**EJ 1**

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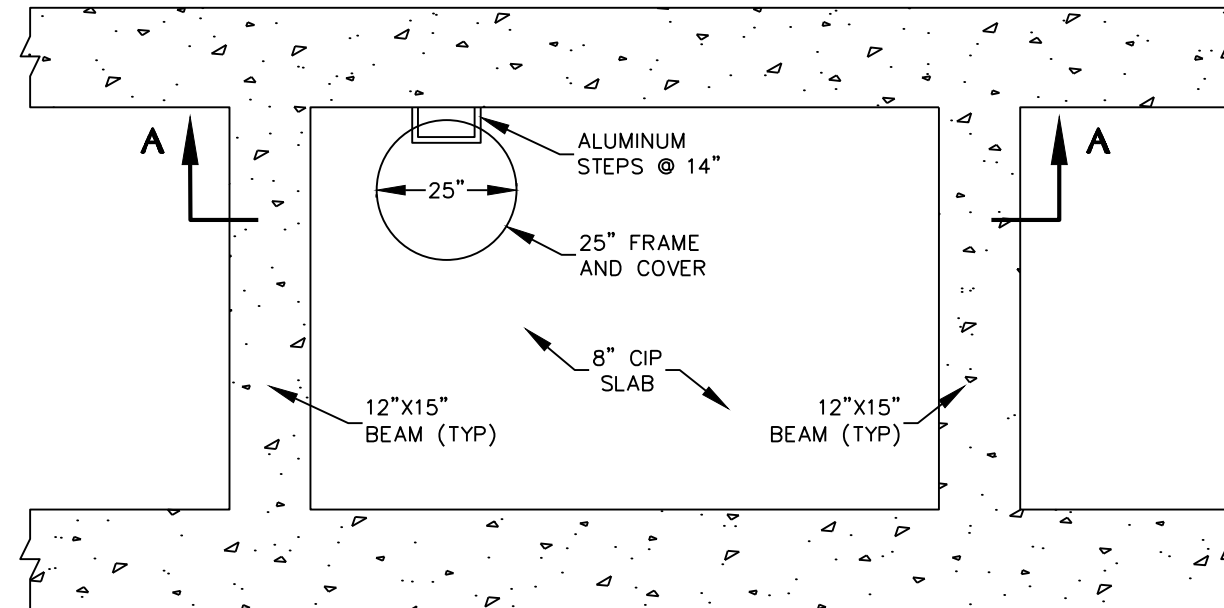


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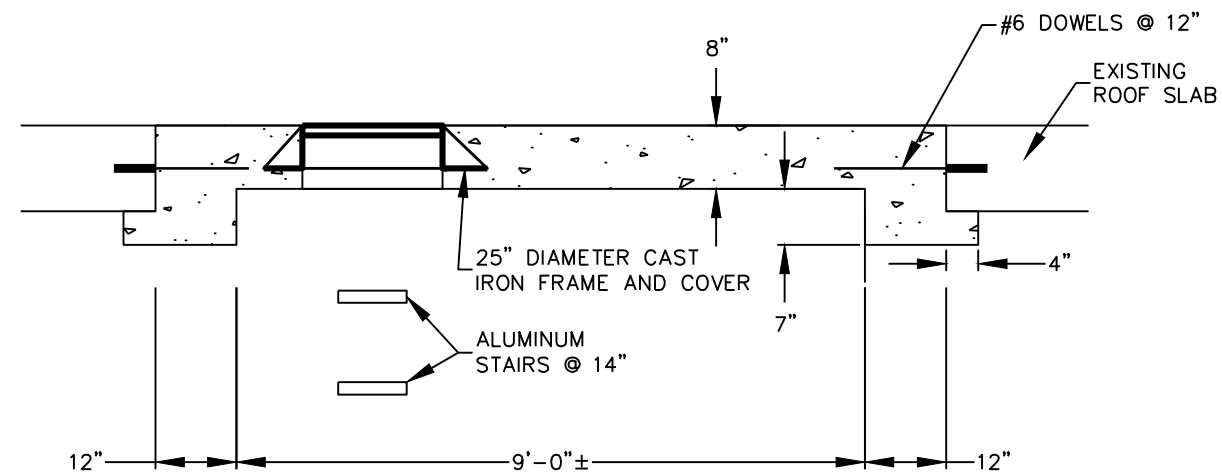
THIS DRAWING SHOWS PLACEMENT OF RIP- RAP WHERE ABSENT AND/OR WHERE THE TUNNEL FLOOR-SLAB EXPOSED TO UNDERMINING. IN AREAS WHERE RIP-RAP IS MODERATELY DEFICIENT, GEOTEXTILE AND STONE BEDDING IS NOT REQUIRED.

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	<b>STEAM TUNNEL ASSESSMENT</b>  ROOSEVELT ISLAND  NEW YORKNEW YORK	<b>PLACEMENT OF RIP-RAP WHERE DEFICIENT</b>  STA. 3+00 TO 6+00	100444601		<b>PR-1</b>
			Date		
			11/03/2014		
			Scale		
1/4"= 1'-0"		Drawn By	Checked By	Submission Date	
PP		JCO			



PLAN VIEW OF NEW ROOF SLAB AND  
CAST-IRON FRAME & COVER @ AIR VENT



PLAN VIEW OF NEW ROOF SLAB AND  
CAST-IRON FRAME & COVER @ AIR VENT



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Project

**STEAM TUNNEL  
ASSESSMENT**

**ROOSEVELT ISLAND**

**NEW YORK**

Drawing Title

**ROOF SLAB  
AT AIR VENT**

**NEW YORK**

Project No.  
100444601

Date  
10/31/2014

Scale  
1" = 1/2'

Drawn By  
VP

Checked By  
JCO

Submission Date

Drawing No.

**RS 1**

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## **TABLES**

## **DEFECT OBSERVATIONS**



# INTERIOR DEFECT OBSERVATIONS 4/9/2018

## STEAM TUNNEL

Station	Direction	Comments
0+36	Tunnel Floor	Floor Slab Cracking at Joint
1+56	Tunnel Floor	Floor Slab Cracking
1+95	Eastern Wall (Seawall)	Spalling, Loose Concrete, Exposed Rebar
1+95	Western Wall (In-Land)	Spalling, Loose Concrete, Exposed Rebar
2+60	Tunnel Floor	Raised Joint and Separation at Joint
3+09	Air Vent 17	Air Vent 17
3+50	Western Wall (In-Land)	Loose Concrete, Deteriorating Pipe and Brick
3+60	Western Wall (In-Land)	Concrete Spalling
4+50	Eastern Wall (Seawall)	Spalling, Re-Bar Exposed and Corroded
4+50 to 4+55	Western Wall (In-Land)	Spalling, Loose Concrete
4+50	Eastern Wall (Seawall)	Spalling, Re-Bar Exposed and Corroded
4+50 to 4+85	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
4+80 to 5+15	Eastern Wall (Seawall)	Concrete Spalling
4+50 to 4+85	Western Wall (In-Land)	Spalling, Loose Concrete
4+80 to 5+15	Eastern Wall (Seawall)	Concrete Spalling, Re-Bar Exposed and Corroded
5+08	Western Wall (In-Land)	Concrete Spalling
5+30	Tunnel Floor, Joint	Floor Slab Raised at Joint, Cracking, Loose Concrete
5+40	Eastern Wall (Seawall)/ Western Wall (In-Land)	Joint Leaking, Separated
5+45 to 5+55	Tunnel Floor	Floor Slab Cracking
5+90	Tunnel Floor	Raised Joint, Loose Concrete and Leaking at Seawall
6+16	Air Vent 16	Air Vent 16
6+16	Air Vent 16	Air Vent 16
6+16	Tunnel Floor	Sump Pump - Not Working
6+20 to 6+26	Tunnel Floor	Floor Slab Cracking and Spalling
6+30 to 6+47	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
6+56	Tunnel Floor	Raised Joint, Loose Concrete and Leaking at Seawall
6+90	Western Wall (In-Land)	Spalling, Loose Concrete
7+21	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
7+23 to 7+40	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
7+53	Western Wall (In-Land)	Concrete Spalling
7+75	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
8+47	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
8+72 to 8+88	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
9+09	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
9+21	Air Vent 15	Air Vent 15
9+21	Air Vent 15	Air Vent 15
9+21	Tunnel Floor	Sump Pump - Not Working
9+95 to 10+15	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
10+77	Air Vent 14	Air Vent 14
10+77	Air Vent 14	Air Vent 14
10+77	Tunnel Floor	Sump Pump - Not Working
11+18	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
11+29	Western Wall (In-Land)	Concrete Spalling
11+80	Western Wall (In-Land)	Joint Separation, Missing Concrete
11+85 +12+50	Western Wall (In-Land)	Concrete Spalling and Bowing of Wall
11+85 +12+50	Western Wall (In-Land)	Concrete Spalling and Bowing of Wall, Loose Concrete
12+53	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
12+65 to 12+85	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
12+84	Air Vent 13	Air Vent 13
12+84	Air Vent 13	Air Vent 13
12+84	Tunnel Floor	Sump Pump - Not Working
12+90 to 12+96	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
13+25	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
13+31	Western Wall (In-Land)	Spalling, Loose Concrete
13+70	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
14+30	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
14+24 to 15+00	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded

# INTERIOR DEFECT OBSERVATIONS 4/9/2018

## STEAM TUNNEL

Station	Direction	Comments
14+24 to 15+00	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded, Loose Concrete
14+24 to 15+00	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
14+24 to 15+00	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
15+00	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
15+09 to 15+20	Western Wall (In-Land)	Concrete Spalling
15+22	Air Vent 12	Air Vent 12
15+22	Air Vent 12	Air Vent 12
15+22	Tunnel Floor	Sump Pump - Not Working
15+50 to 15+75	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
15+75	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
15+88 to 16+00	Western Wall (In-Land)	Concrete Spalling
16+53 to 16+60	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
16+95	Tunnel Joint	Leaking at Seawall
17+35	Tunnel Floor	Concrete Spalling
17+10 to 17+61	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
17+10 to 17+61	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
17+70	Tunnel Floor	Concrete Spalling
17+68	Western Wall (In-Land)	Concrete Spalling
17+68	Western Wall (In-Land)	Concrete Spalling
17+76	Air Vent 11	Air Vent 11
17+76	Air Vent 11	Air Vent 11
17+76	Tunnel Floor	Sump Pump - Not Working
17+85 to 18+10	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
18+20	Tunnel Floor	Floor Slab Craking at Joint
18+30 to 18+50	Western Wall (In-Land)	Spalling, Loose Concrete
18+80	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
18+75	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
18+75 to 18+80	Western Wall (In-Land)	Concrete Spalling and Bowing of Wall, Loose Concrete, Re-Bar Exposed
19+45	Western Wall (In-Land)	Cracking at Joint, Concrete Missing
19+50 to 20+00	Tunnel Floor	Water Observed in the Tunnel
19+72 to 19+90	Western Wall (In-Land)	Concrete Spalling
20+10	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
20+15 to 20+22	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed
20+30	Tunnel Floor	Sump Pump - Not Working
20+30	Air Vent 10	Air Vent 10
20+30	Air Vent 10	Air Vent 10
20+74 to 20+80	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed
20+90 to 21+30	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
20+90 to 21+30	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
21+20	Tunnel Joint (Ceiling)	Tunnel Cracking at Joint
21+68 to 21+75	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed
22+70	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed
22+84	Tunnel Floor	Sump Pump - Not Working
22+84	Air Vent 9	Air Vent 9
22+84	Air Vent 9	Air Vent 9
23+44 to 23+63	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded, Loose Concrete
23+90 to 24+03	Western Wall (In-Land)	Spalling, Loose Concrete
25+10	Tunnel Floor	Floor Slab Raised at Joint
25+38	Air Vent 8	Air Vent 8
25+38	Air Vent 8	Air Vent 8
25+38	Tunnel Floor	Sump Pump

# INTERIOR DEFECT OBSERVATIONS 4/9/2018

## STEAM TUNNEL

Station	Direction	Comments
26+03 to 26+20	Western Wall (In-Land)/ Tunnel Floor	Concrete Spalling, Re-Bar Exposed and Corroded
26+50 to 26+62	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
26+90 to 27+25	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
27+25	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
27+51 to 27+69	Western Wall (In-Land)	Concrete Spalling
27+92	Air Vent 7	Air Vent 7
27+92	Air Vent 7	Air Vent 7
27+92	Tunnel Floor	Sump Pump
27+94	Western Wall (In-Land)	Concrete Spalling
28+02 to 28+27	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
28+62 to 28+86	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded, Loose Concrete
28+94 to 29+32	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
29+45 to 29+70	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded, Loose Concrete
29+76 to 29+96	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
30+31 to 30+41	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
30+46	Air Vent 6	Air Vent 6
30+46	Air Vent 6	Air Vent 6
30+46	Tunnel Floor	Sump Pump
30+50 to 30+65	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
30+77 to 30+85	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded, Loose Concrete
30+93 to 31+50	Western Wall (In-Land)	Concrete Spalling
31+83 to 31+85	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
31+94	Tunnel Floor	Floor Slab Cracking
32+00 to 32+02	Western Wall (In-Land)	Concrete Spalling
32+43 to 32+49	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
32+77 to 33+00	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
33+00	Air Vent 5	Air Vent 5
33+00	Air Vent 5	Air Vent 5
33+00	Tunnel Floor	Sump Pump
33+02	Western Wall (In-Land)	Concrete Spalling
33+04 to 33+71	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
34+23 to 34+75	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
34+23 to 34+75	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
35+00 to 35+08	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
35+39	Western Wall (In-Land)/ Tunnel Floor	Floor Slab Cracked and Displaced
35+52 to 35+63	Western Wall (In-Land)	Concrete Spalling
35+54	Air Vent 4	Air Vent 4
35+54	Air Vent 4	Air Vent 4
35+54	Tunnel Floor	Sump Pump
35+75 to 36+29	Western Wall (In-Land)	Concrete Spalling up to 5 feet Height
36+57 to 36+62	Tunnel Floor	Floor Slab Cracked
36+57 to 36+90	Western Wall (In-land)	Concrete Spalling
37+00	Western Wall (In-Land)	Concrete Spalling up to 5 feet Height
37+35	Tunnel Joint	Joint Separation, Missing Concrete
37+50 to 38+00	Western Wall (In-land)	Concrete Spalling
37+50 to 38+00	Western Wall (In-land)	Concrete Spalling
38+13	Tunnel Floor	Floor Slab Cracked
38+03 to 38+55	Western Wall (In-Land)	Concrete Spalling
38+64	Tunnel Floor	Floor Slab Cracking at Joint
39+00	Western Wall (In-Land)	Spalling, Loose Concrete
39+03	Air Vent 3	Air Vent 3
39+03	Air Vent 3	Air Vent 3
39+03	Tunnel Floor	Sump Pump
39+23	Tunnel Floor	Floor Slab Cracking

# **INTERIOR DEFECT OBSERVATIONS 4/9/2018** **STEAM TUNNEL**

Station	Direction	Comments
39+58 to 39+74	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
40+02 to 40+03	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
40+50 to 40+90	Western Wall (In-Land)	Concrete Spalling
40+98 to 41+45	Western Wall (In-Land)	Concrete Spalling
42+18	Air Vent 2	Air Vent 2
42+18	Air Vent 2	Air Vent 2
42+18	Tunnel Floor	Sump Pump
42+75	Tunnel Floor	Floor Slab Raised at Joint
45+00 to 45+05	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
45+34 to 45+47	Western Wall (In-Land)	Spalling, Loose Concrete
45+34	Air Vent 1	Air Vent 1
45+34	Air Vent 1	Air Vent 1
45+34	Air Vent 1	Sump Pump
45+61 to 45+66	Western Wall (In-Land)	Concrete Spalling
45+94	Tunnel Joint	Cracks
46+60	Tunnel Joint	Floor Slab Raised at Joint, Cracking, Loose Concrete
46+60	Tunnel Joint	Floor Slab Raised at Joint, Cracking, Loose Concrete
46+60	Tunnel Joint	Tunnel Displaced
49+09 to 49+23	Western Wall (In-Land)	Concrete Spalling
49+09	Eastern Wall	Wood Frame Support Structure
49+10 to 51+75	Tunnel Mid-Wall	Cracked, Missing Concrete on its Entirety
	Air Vent 2A	Air Vent 2A
	Air Vent 2A	Air Vent 2A
49+60	Western Wall (In-Land)	Concrete Spalling
49+17	Tunnel Floor	Joint Filler
53+50	Tunnel Mid-Wall (East Face)/ Tunnel Floor	Concrete Spalling
55+00	Tunnel Joint	Concrete Spalling, Corroded Utilities
	Air Vent 1B	Air Vent 1B
	Air Vent 1B	Air Vent 1B
55+52	Eastern Wall	1/8" Thick Crack running from the Floor to the roof of the Tunnel
55+65	Tunnel Floor	Concrete Spalling
56+00 to 58+50	Tunnel Floor	Water Observed in the Tunnel
58+53	Eastern Wall	Concrete Spalling around pipe opening
59+25	Western Wall	Re-Bar Exposed, Corroded
	Air Vent 1C	Air Vent 1C through building
61+50	Southern end of Tunnel	Brick Wall

## EXTERIOR DEFECT OBSERVATIONS 4/9/2018

### STEAM TUNNEL

Station	Direction	Comments
5+18	Northern Seawall Terminus	Gap Between Steam Tunnel and Seawall
5+18	Northern Seawall Terminus	Gap Between Steam Tunnel and Seawall
5+18	Northern Seawall Terminus	Tunnel Terminus from Inland
5+18	Northern Seawall Terminus	Spalling at Haunch
5+40	Seawall Joint	Concrete Spalling
5+60	Seawall	Concrete Spalling
5+94	Seawall	Concrete Cracks, Imbedded Wood Missing
6+16	Air Vent 16	Northern Face
6+16	Air Vent 16	Sothorn Face
6+60	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
6+60	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete
6+60	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete
6+96	Seawall	Missing Rip-Rap, Tunnel Undermined
7+26	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete
7+26	Seawall Sidewalk Joint	Concrete Spalling
7+68	Seawall	Exposed Re-Bar
7+86	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose
7+99	Seawall (Looking South)	Missing Rip-Rap, Tunnel Undermined
8+12	Seawall (Looking North)	Missing Rip-Rap, Tunnel Undermined, Exposed Re-Bar
8+28	Seawall	Missing Rip-Rap, Tunnel Undermined
8+37	Seawall (Looking North)	Spalling at Haunch, Missing Large Sections of Concrete, Exposed Re-Bar
8+49	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
8+49	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
8+80	Seawall Joint (Looking North)	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
8+94	Seawall	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
8+97	Seawall Joint	Missing Large Concrete Section, Tunnel has been Undermined
9+10	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose
9+21	Seawall	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
9+21	Air Vent 15	Northern Face
9+21	Air Vent 15	Western Face
9+21	Air Vent 15	Sothorn Face
9+37 to 10+10	Seawall	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
9+82	Seawall	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
10+43	Seawall	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined, Cap Beams Visible
10+43	Seawall	Tunnel has been Undermined
10+57	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose
10+57	Seawall	Tunnel has been Undermined
10+57	Seawall Sidewalk Joint	Concrete Spalling
10+57	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose
10+57	Seawall	Tunnel has been Undermined
10+63	Seawall	Tunnel has been Undermined
10+72	Seawall	Tunnel has been Undermined

## EXTERIOR DEFECT OBSERVATIONS 4/9/2018

### STEAM TUNNEL

Station	Direction	Comments
10+77	Air Vent 14	Northern Face
10+77	Air Vent 14	Western Face
10+77	Air Vent 14	Sothorn Face
11+06	Seawall	Tunnel has been Undermined
11+19	Seawall Joint	Remnant of Timber Formwork
11+19	Seawall Joint	Remnant of Timber Formwork
11+66	Seawall	Tunnel has been Undermined
11+83	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete
11+83	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete
12+68	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed. Tunnel has been Undermined. Missing Rip-Rap
12+84	Air Vent 13	Northern Face
12+84	Air Vent 13	Western Face
12+84	Air Vent 13	Sothorn Face
13+03	Seawall Sidewalk Joint	Concrete Spalling
13+10	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete
13+15	Seawall	Tunnel has been Undermined
13+27	Seawall Joint	Concrete Spalling
13+74	Seawall Joint	Concrete Spalling and Repair
14+37	Seawall Joint	Concrete Spalling, Loose Sections of Concrete
14+50	Seawall	Concrete Spalling
10+57	Seawall Sidewalk Joint	Concrete Cracks, Loose Sections of Concrete
15+06	Seawall Joint	Concrete Spalling, Loose Sections of Concrete, Tunnel has been Undermined.
15+06	Seawall Joint	Spalling along Joint and Haunch, Loose Concrete
15+06	Seawall Joint	Spalling along Joint and Haunch, Loose Concrete
15+22	Air Vent 12	Northern Face
15+22	Air Vent 12	Western Face
15+22	Air Vent 12	Southern Face
15+40	Seawall Joint	Concrete Spalling, Exposed Re-bar
15+63	Seawall Joint	Concrete Spalling, Exposed Re-bar
15+63	Seawall	Tunnel has been Undermined
16+00	Seawall	Concrete Spalling
16+23	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
16+37	Seawall Sidewalk Joint	Concrete Cracks
17+55 to 17+65	Seawall	Concrete Spalling
17+66	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
17+66	Seawall Sidewalk Joint	Concrete Spalling
17+76	Air Vent 11	Northern Face
17+76	Air Vent 11	Western Face
17+76	Air Vent 11	Southern Face
17+75 to 17+85	Seawall	Concrete Spalling
17+85	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
18+10	Seawall Sidewalk Joint	Concrete Cracks
18+82	Seawall Joint	Concrete Spalling, Exposed Re-bar, Cracks about 3-inches Deep
18+82	Seawall Joint	Concrete Spalling
20+09	Seawall Joint	Concrete Spalling
20+30	Air Vent 10	Northern Face
20+30	Air Vent 10	Western Face
20+30	Air Vent 10	Southern Face
20+45	Seawall	Exposed Re-Bar
20+73	Seawall Joint	Concrete Spalling and repair
21+23	Seawall	Exposed Re-Bar
21+33	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
21+33	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

## EXTERIOR DEFECT OBSERVATIONS 4/9/2018

### STEAM TUNNEL

Station	Direction	Comments
21+43	Seawall	Tunnel has been Undermined
22+64	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete
22+57	Seawall Sidewalk Joint	Concrete Cracks
22+84	Air Vent 9	Northern Face
22+84	Air Vent 9	Western Face
22+84	Air Vent 9	Southern Face
23+20	Seawall Sidewalk Joint	Concrete Cracks
23+88	Seawall Sidewalk Joint	Joint Repair
23+88	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete
23+78 to 24+00	Seawall	Tunnel has been Undermined
23+78 to 24+00	Seawall	Tunnel has been Undermined
24+10	Seawall	Exposed Re-Bar
24+00 to 24+20	Seawall	Tunnel has been Undermined
24+48	Seawall Sidewalk Joint	Concrete Cracks
24+53	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
25+10	Seawall Sidewalk Joint	Concrete Cracks
25+17	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed and Loose
25+17	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed and Loose
25+38	Air Vent 8	Northern Face
25+38	Air Vent 8	Western Face
25+38	Air Vent 8	Southern Face
25+82	Seawall Joint	Concrete Spalling
27+07	Seawall Sidewalk Joint	Concrete Cracks
27+07	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
27+92	Air Vent 7	Northern Face
27+92	Air Vent 7	Western Face
27+92	Air Vent 7	Southern Face
28+02	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
28+40 to 28+50	Seawall	Concrete Spalling
28+34	Seawall Sidewalk Joint	Concrete Cracks
28+34	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
28+34	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
28+91	Seawall Sidewalk Joint	Concrete Cracks, Attempt to Repair
29+62	Seawall Sidewalk Joint	Concrete Cracks
29+62	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
29+62	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
29+62	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
29+62	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
30+24	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
30+46	Air Vent 6	Northern Face
30+46	Air Vent 6	Western Face
30+46	Air Vent 6	Southern Face
31+52	Seawall Sidewalk Joint	Concrete Cracks
31+52	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
31+52	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
32+16	Seawall Joint	Concrete Spalling, Loose Section of Concrete, Re-Bar Exposed
32+16	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed and Loose
32+79	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
32+79	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
33+00	Air Vent 5	Northern Face
33+00	Air Vent 5	Western Face
33+00	Air Vent 5	Southern Face

# EXTERIOR DEFECT OBSERVATIONS 4/9/2018

## STEAM TUNNEL

Station	Direction	Comments
33+84	Seawall	Concrete Spalling
34+06	Seawall Sidewalk Joint	Concrete Cracks
34+06	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
34+30	Seawall	Re-Bar Exposed
34+70	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
34+70	Seawall Joint	Concrete Spalling, Loose Concrete
35+38	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
35+54	Air Vent 4	Northern Face
35+54	Air Vent 4	Western Face
35+54	Air Vent 4	Southern Face
35+93	Seawall	Exposed Re-Bar, Concrete Spalling
36+20	Seawall	Concrete Cracks
36+56	Seawall Sidewalk Joint	Concrete Cracks
37+22	Seawall Sidewalk Joint	Concrete Cracks
37+22	Seawall Joint	Concrete Spalling
37+40	Seawall	Concrete Cracks
38+44	Seawall Sidewalk	Concrete Cracks, Asphalt Repair
38+82	Seawall Joint	Concrete Spalling
39+03	Air Vent 3	Northern Face
39+03	Air Vent 3	Western Face
39+03	Air Vent 3	Southern Face
39+22	Seawall	Exposed Re-Bar
39+66	Seawall Sidewalk Joint	Concrete Cracks
39+70	Seawall	Exposed Re-Bar
40+00	Seawall Column	Concrete Spalling
40+39	Seawall Sidewalk Joint	Concrete Cracks
40+39	Seawall Joint	Concrete Spalling
40+61	Seawall Sidewalk Joint	Concrete Cracks
40+80	Seawall Joint	Concrete Spalling
41+22 to 41+54	Seawall Sidewalk	Concrete Cracks
41+31	Seawall Joint	Concrete Repair
41+50	Seawall	Missing Large Section of Concrete
41+97	Seawall	Concrete Repair
42+18	Air Vent 2	Northern Face
42+18	Air Vent 2	Western Face
42+18	Air Vent 2	Southern Face
42+22	Seawall Sidewalk	Concrete Cracks
42+39	Seawall Joint	Concrete Repair Over Metal Plate, Cracks
42+54	Seawall Sidewalk Joint	Concrete Cracks
43+04	Seawall	Tunnel has been Undermined
43+44	Seawall	Concrete Spalling, Exposed Re-bar
43+66	Seawall	Exposed Re-Bar
43+87	Seawall Joint	Spalling and Concrete Repairs
43+87	Seawall Joint	Spalling and Concrete Repairs
44+65	Seawall	Exposed Re-Bar
45+77	Seawall Joint	Concrete Spalling, Large Concrete Cracks
45+34	Air Vent 1	Northern Face
45+34	Air Vent 1	Western Face
45+34	Air Vent 1	Southern Face
45+77	Seawall Sidewalk Joint	Large Concrete Crack, Missing Concrete
45+77	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed
45+97	Seawall Sidewalk Joint at Terminus	Concrete Cracks
45+97	Southern Seawall Terminus	Spalling at Haunch
47+00	Southern Seawall Terminus	Start of Seawall



**APPENDIX A**

**PHOTOGRAPHIC OBSERVATIONS**

## **INTERIOR CONDITIONS**

Station 1+95



**Direction:** Eastern Wall (Seawall)

**Comments:** Spalling, Loose Concrete, Exposed Rebar

Station 1+95



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete, Exposed Rebar

Station 2+60



**Direction:** Tunnel Floor

**Comments:** Raised Joint and Separation at Joint

Station



**Direction:** Vent 17

**Comments:**



Station 3+50



**Direction:** Western Wall (In-Land)

**Comments:** Loose Concrete, Deteriorating Pipe and Brick

Station 3+60



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

**Station 4+50**



**Direction:** Eastern Wall (Seawall)

**Comments:** Spalling, Re-Bar Exposed and Corroded

**Station 4+50 to 4+55**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete

**Station 4+50**



**Direction:** Eastern Wall (Seawall)

**Comments:** Spalling, Re-Bar Exposed and Corroded

**Station 4+50 to 4+85**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

Station 4+80 to 5+15



**Direction:** Eastern Wall (Seawall)

**Comments:** Concrete Spalling

Station 4+50 to 4+85



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete



**Station 4+80 to 5+15**



**Direction:** Eastern Wall (Seawall)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

**Station 5+08**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 5+30



**Direction:** Tunnel Floor, Joint

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 5+40



**Direction:** Eastern Wall (Seawall)/ Western Wall (In-Land)

**Comments:** Joint Leaking, Separated

Station 5+45 to 5+55



**Direction:** Tunnel Floor

**Comments:** Floor Slab Cracking

Station 5+90



**Direction:** Tunnel Floor

**Comments:** Raised Joint, Loose Concrete and Leaking at Seawall



Station 6+16



**Direction:** Air Vent 16

**Comments:** Air Vent 16

Station 6+16



**Direction:** Air Vent 16

**Comments:** Air Vent 16



Station 6+16



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working

Station 6+20 to 6+26



**Direction:** Tunnel Floor

**Comments:** Floor Slab Cracking and Spalling

Station 6+30 to 6+47



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 6+56



**Direction:** Tunnel Floor

**Comments:** Raised Joint, Loose Concrete and Leaking at Seawall

Station 6+90



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete

Station 7+21



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 7+23 to 7+40



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

Station 7+53



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling



**Station 7+75**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

**Station 8+47**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 8+72 to 8+88



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

Station 9+09



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 9+21



**Direction:** Air Vent 15

**Comments:** Air Vent 15

Station 9+21



**Direction:** Air Vent 15

**Comments:** Air Vent 15

**Station 9+21**



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working

**Station 9+95 to 10+15**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded



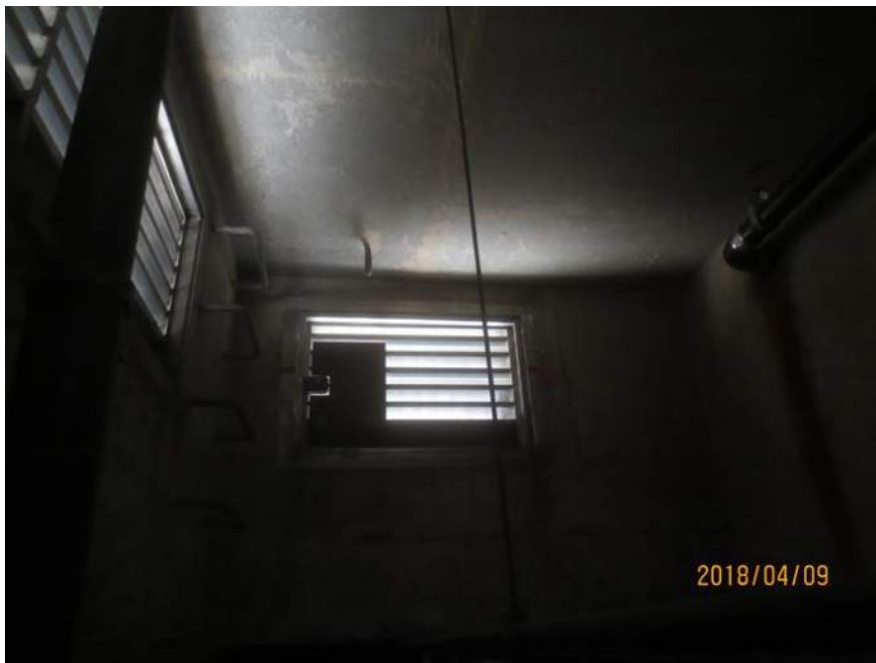
Station 10+77



**Direction:** Air Vent 14

**Comments:** Air Vent 14

Station 10+77



**Direction:** Air Vent 14

**Comments:** Air Vent 14

**Station 10+77**



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working

**Station 11+18**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 11+29



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 11+80



**Direction:** Western Wall (In-Land)

**Comments:** Joint Separation, Missing Concrete



Station 11+85 +12+50



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling and Bowing of Wall

Station 11+85 +12+50



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling and Bowing of Wall, Loose Concrete

**Station 12+53**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

**Station 12+65 to 12+85**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded



Station 12+84



**Direction:** Air Vent 13

**Comments:** Air Vent 13

Station 12+84



**Direction:** Air Vent 13

**Comments:** Air Vent 13

**Station 12+84**



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working

**Station 12+90 to 12+96**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded



**Station 13+25**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

**Station 13+31**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete

**Station 13+70**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

**Station 14+30**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete



Station 14+24 to 15+00



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 14+24 to 15+00



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded, Loose Concrete

Station 14+24 to 15+00



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

Station 14+24 to 15+00



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded



**Station 15+00**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

**Station 15+09 to 15+20**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 15+22



**Direction:** Air Vent 12

**Comments:** Air Vent 12

Station 15+22



**Direction:** Air Vent 12

**Comments:** Air Vent 12



Station 15+22



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working

Station 15+50 to 15+75



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

**Station 15+75**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

**Station 15+88 to 16+00**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

**Station 16+53 to 16+60**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

**Station 16+95**



**Direction:** Tunnel Joint

**Comments:** Leaking at Seawall



**Station 17+35**



**Direction:** Tunnel Floor

**Comments:** Concrete Spalling

**Station 17+10 to 17+61**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

Station 17+10 to 17+61



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded

Station 17+70



**Direction:** Tunnel Floor

**Comments:** Concrete Spalling

Station 17+68



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 17+68



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling



Station 17+76



**Direction:** Air Vent 11

**Comments:** Air Vent 11

Station 17+76



**Direction:** Air Vent 11

**Comments:** Air Vent 11

**Station 17+76**



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working

**Station 17+85 to 18+10**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

**Station 18+20**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Craking at Joint

**Station 18+30 to 18+50**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete



Station 18+80



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 18+75



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 18+75 to 18+80



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling and Bowing of Wall, Loose Concrete, Re-Bar Exposed

Station 19+45



**Direction:** Western Wall (In-Land)

**Comments:** Cracking at Joint, Concrete Missing

Station 19+50 to 20+00



**Direction:** Tunnel Floor

**Comments:** Water Observed in the Tunnel

Station 19+90 to 19+72



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling



**Station 20+10**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

**Station 20+15 to 20+22**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed

Station 20+30



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working

Station 20+30



**Direction:** Air Vent 10

**Comments:** Air Vent 10

**Station 20+30**



**Direction:** Air Vent 10

**Comments:** Air Vent 10

**Station 20+74 to 20+80**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed



Station 20+90 to 21+30



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 20+90 to 21+30



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

**Station 21+20**



**Direction:** Tunnel Joint (Ceiling)

**Comments:**

**Station 21+68 to 21+75**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed

Station 22+70



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed

Station 22+84



**Direction:** Tunnel Floor

**Comments:** Sump Pump - Not Working



Station 22+84



**Direction:** Air Vent 9

**Comments:** Air Vent 9

Station 22+84



**Direction:** Air Vent 9

**Comments:** Air Vent 9

Station 23+44 to 23+63



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded, Loose Concrete

Station 23+90 to 24+03



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete

Station 25+10



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint

Station 25+38



**Direction:** Air Vent 8

**Comments:** Air Vent 8



Station 25+38



**Direction:** Air Vent 8

**Comments:** Air Vent 8

Station 25+38



**Direction:** Tunnel Floor

**Comments:** Sump Pump

Station 26+03 to 26+20



**Direction:** Western Wall (In-Land)/ Tunnel Floor

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 26+50 to 26+62



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 26+90 to 27+25



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 27+25



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded



Station 27+51 to 27+69



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 27+92



**Direction:** Air Vent 7

**Comments:** Air Vent 7

Station 27+92



**Direction:** Air Vent 7

**Comments:** Air Vent 7

Station 27+92



**Direction:** Tunnel Floor

**Comments:** Sump Pump

**Station 27+94**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

**Station 28+02 to 28+27**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded



Station 28+62 to 28+86



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded, Loose Concrete

Station 28+94 to 29+32



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 29+45 to 29+70



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded, Loose Concrete

Station 29+76 to 29+96



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 30+31 to 30+41



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 30+46



**Direction:** Air Vent 6

**Comments:** Air Vent 6



Station 30+46



**Direction:** Air Vent 6

**Comments:** Air Vent 6

Station 30+46



**Direction:** Tunnel Floor

**Comments:** Sump Pump

**Station 30+50 to 30+65**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

**Station 30+77 to 30+85**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Re-Bar Exposed and Corroded, Loose Concrete

Station 30+93 to 31+50



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 31+83 to 31+85



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded



Station 31+94



**Direction:** Tunnel Floor

**Comments:** Floor Slab Cracking

Station 32+00 to 32+02



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 32+43 to 32+49



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 32+77 to 33+00



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 33+00



**Direction:** Air Vent 5

**Comments:** Air Vent 5

Station 33+00



**Direction:** Air Vent 5

**Comments:** Air Vent 5



Station 33+00



**Direction:** Tunnel Floor

**Comments:** Sump Pump

Station 33+02



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

**Station 33+04 to 33+71**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

**Station 34+23 to 34+75**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 34+23 to 34+75



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 35+00 to 35+08



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded



Station 35+39



**Direction:** Western Wall (In-Land)/ Tunnel Floor

**Comments:** Floor Slab Cracked and Displaced

Station 35+52 to 35+63



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 35+54



**Direction:** Air Vent 4

**Comments:** Air Vent 4

Station 35+54



**Direction:** Air Vent 4

**Comments:** Air Vent 4

Station 35+54



**Direction:** Tunnel Floor

**Comments:** Sump Pump

Station 35+75 to 36+29



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling up to 5 feet Height



Station 36+57 to 36+62



**Direction:** Tunnel Floor

**Comments:** Floor Slab Cracked

Station 36+57 to 36+90



**Direction:** Western Wall (In-land)

**Comments:** Concrete Spalling

**Station 37+00**



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling up to 5 feet Height

**Station 37+35**



**Direction:** Tunnel Joint

**Comments:** Joint Separation, Missing Concrete

Station 37+50 to 38+00



**Direction:** Western Wall (In-land)

**Comments:** Concrete Spalling

Station 37+50 to 38+00



**Direction:** Western Wall (In-land)

**Comments:** Concrete Spalling



Station 38+13



**Direction:** Tunnel Floor

**Comments:** Floor Slab Cracked

Station 38+03 to 38+55



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

**Station 38+64**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Cracking at Joint

**Station 39+00**



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete

Station 39+03



**Direction:** Air Vent 3

**Comments:** Air Vent 3

Station 39+03



**Direction:** Air Vent 3

**Comments:** Air Vent 3



**Station 39+03**



**Direction:** Tunnel Floor

**Comments:** Sump Pump

**Station 39+23**



**Direction:** Tunnel Floor

**Comments:** Floor Slab Cracking

Station 39+58 to 39+74



2018/04/09

**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 40+02 to 40+03



2018/04/09

**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 40+50 to 40+90



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 40+98 to 41+45



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling



Station 42+18



**Direction:** Air Vent 2

**Comments:** Air Vent 2

Station 42+18



**Direction:** Air Vent 2

**Comments:** Air Vent 2

Station 42+18



**Direction:** Tunnel Floor

**Comments:** Sump Pump

Station 42+75



**Direction:** Tunnel Floor

**Comments:** Floor Slab Raised at Joint

Station 45+00 to 45+05



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling, Re-Bar Exposed and Corroded

Station 45+34 to 45+47



**Direction:** Western Wall (In-Land)

**Comments:** Spalling, Loose Concrete



Station 45+34



**Direction:** Air Vent 1

**Comments:** Air Vent 1

Station 45+34



**Direction:** Air Vent 1

**Comments:** Air Vent 1

Station 45+34



**Direction:** Air Vent 1

**Comments:** Sump Pump

Station 45+61 to 45+66



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 45+94



**Direction:** Tunnel Joint

**Comments:** Cracks

Station 46+60



**Direction:** Tunnel Joint

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete



Station 46+60



**Direction:** Tunnel Joint

**Comments:** Floor Slab Raised at Joint, Cracking, Loose Concrete

Station 46+60



**Direction:** Tunnel Joint

**Comments:** Tunnel Displaced

Station 49+09 to 49+23



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

Station 49+09



**Direction:** Eastern Wall

**Comments:** Wood Frame Support Structure

Station 49+10 to 51+75



**Direction:** Tunnel Mid-Wall

**Comments:** Cracked, Missing Concrete on its Entirety

Station



**Direction:** Air Vent 2A

**Comments:** Air Vent 2A



Station



**Direction:** Air Vent 2A

**Comments:** Air Vent 2A

Station 49+60



**Direction:** Western Wall (In-Land)

**Comments:** Concrete Spalling

**Station 49+17**



**Direction:** Tunnel Floor

**Comments:** Joint Filler

**Station 53+50**



**Direction:** Tunnel Mid-Wall (East Face)/ Tunnel Floor

**Comments:** Concrete Spalling

**Station 55+00**



**Direction:** Tunnel Joint

**Comments:** Concrete Spalling, Corroded Utilities

**Station**



**Direction:** Air Vent 1B

**Comments:** Air Vent 1B



**Station**



**Direction:** Air Vent 1B

**Comments:** Air Vent 1B

**Station 55+52**



**Direction:** Eastern Wall

**Comments:** "1/8"" Thick Crack running from the Floor to the roof of the Tunnel"

**Station 55+65**



**Direction:** Tunnel Floor

**Comments:** Concrete Spalling

**Station 56+00 to 58+50**



**Direction:** Tunnel Floor

**Comments:** Water Observed in the Tunnel

**Station 58+53**



**Direction:** Eastern Wall

**Comments:** Concrete Spalling around pipe opening

**Station 59+25**



**Direction:** Western Wall

**Comments:** Re-Bar Exposed, Corroded



**Station**



**Direction:** Air Vent 1C

**Comments:** Air Vent 1C through building

**Station 61+50**



**Direction:** Southern end of Tunnel

**Comments:** Brick Wall

## **EXTERIOR CONDITIONS**

Station 5+18



**Direction:** Northern Seawall Terminus

**Comments:** Gap Between Steam Tunnel and Seawall

Station 5+18



**Direction:** Northern Seawall Terminus

**Comments:** Gap Between Steam Tunnel and Seawall



Station 5+18



**Direction:** Northern Seawall Terminus

**Comments:** Tunnel Terminus from Inland

Station 5+18



**Direction:** Northern Seawall Terminus

**Comments:** Spalling at Haunch

Station 5+40



**Direction:** Seawall Joint

**Comments:** Concrete Spalling

Station 5+60



**Direction:** Seawall

**Comments:** Concrete Spalling



**Station 5+94**



**Direction:** Seawall

**Comments:** Concrete Cracks, Imbedded Wood Missing

**Station 6+16**



**Direction:** Air Vent 16

**Comments:** Northern Face



**Station 6+16**



**Direction:** Air Vent 16

**Comments:** Sothern Face

**Station 6+60**



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined

Station 6+60



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete

Station 6+60



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete



**Station 6+96**



**Direction:** Seawall

**Comments:** Missing Rip-Rap, Tunnel Undermined

**Station 7+26**



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete



Station 7+26



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Spalling

Station 7+68



**Direction:** Seawall

**Comments:** Exposed Re-Bar

**Station 7+86**



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose

**Station 7+99**



**Direction:** Seawall (Looking South)

**Comments:** Missing Rip-Rap, Tunnel Undermined



**Station 8+12**



**Direction:** Seawall (Looking North)

**Comments:** Missing Rip-Rap, Tunnel Undermined, Exposed Re-Bar

**Station 8+28**



**Direction:** Seawall

**Comments:** Missing Rip-Rap, Tunnel Undermined



**Station 8+37**



**Direction:** Seawall (Looking North)

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Exposed Re-Bar

**Station 8+49**



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined

**Station 8+49**



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined

**Station 8+80**



**Direction:** Seawall Joint (Looking North)

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined



**Station 8+94**



**Direction:** Seawall

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined

**Station 8+97**



**Direction:** Seawall Joint

**Comments:** Missing Large Concrete Section, Tunnel has been Undermined



**Station 9+10**



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose

**Station 9+21**



**Direction:** Seawall

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined

Station 9+21



**Direction:** Air Vent 15

**Comments:** Northern Face

Station 9+21



**Direction:** Air Vent 15

**Comments:** Western Face



Station 9+21



**Direction:** Air Vent 15

**Comments:** Sothern Face

Station 9+82



**Direction:** Seawall

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined



Station 10+43



**Direction:** Seawall

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined, Cap Beams Visible

Station 10+43



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

Station 10+57



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose

Station 10+57



**Direction:** Seawall

**Comments:** Tunnel has been Undermined



Station 10+57



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Spalling

Station 10+57



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete, Metal Joint Covering Loose



**Station 10+57**



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

**Station 10+63**



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

**Station 10+72**



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

**Station 10+77**



**Direction:** Air Vent 14

**Comments:** Northern Face



Station 10+77



**Direction:** Air Vent 14

**Comments:** Western Face

Station 10+77



**Direction:** Air Vent 14

**Comments:** Southern Face



**Station 11+06**



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

**Station 11+19**



**Direction:** Seawall Joint

**Comments:** Remnant of Timber Formwork

**Station 11+19**



**Direction:** Seawall Joint

**Comments:** Remnant of Timber Formwork

**Station 11+66**



**Direction:** Seawall

**Comments:** Tunnel has been Undermined



Station 11+83



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete

Station 11+83



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete



Station 12+68



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed. Tunnel has been Undermined. Missing Rip-Rap

Station 12+84



**Direction:** Air Vent 13

**Comments:** Northern Face

Station 12+84



**Direction:** Air Vent 13

**Comments:** Western Face

Station 12+84



**Direction:** Air Vent 13

**Comments:** Southern Face



Station 13+03



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Spalling

Station 13+10



**Direction:** Seawall Joint

**Comments:** Spalling at Haunch, Missing Large Sections of Concrete



Station 13+15



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

Station 13+27



**Direction:** Seawall Joint

**Comments:** Concrete Spalling

Station 13+74



**Direction:** Seawall Joint

**Comments:** Concrete Spalling and Repair

Station 14+37



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Loose Sections of Concrete



**Station 14+50**



**Direction:** Seawall

**Comments:** Concrete Spalling

**Station 10+57**



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks, Loose Sections of Concrete



Station 15+06



**Direction:** Seawall Joint

**Comments:** "Concrete Spalling, Loose Sections of Concrete, Tunnel has been Undermined."

Station 15+06



**Direction:** Seawall Joint

**Comments:** Spalling along Joint and Haunch, Loose Concrete

**Station 15+06**



**Direction:** Seawall Joint

**Comments:** Spalling along Joint and Haunch, Loose Concrete

**Station 15+22**



**Direction:** Air Vent 12

**Comments:** Northern Face



Station 15+22



**Direction:** Air Vent 12

**Comments:** Western Face

Station 15+22



**Direction:** Air Vent 12

**Comments:** Southern Face



**Station 15+40**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Exposed Re-bar

**Station 15+63**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Exposed Re-bar

**Station 15+63**



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

**Station 16+00**



**Direction:** Seawall

**Comments:** Concrete Spalling



Station 16+23



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 16+37



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks



Station 17+55 to 17+65



**Direction:** Seawall

**Comments:** Concrete Spalling

Station 17+66



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 17+66



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Spalling

Station 17+76



**Direction:** Air Vent 11

**Comments:** Northern Face



**Station 17+76**



**Direction:** Air Vent 11

**Comments:** Western Face

**Station 17+76**



**Direction:** Air Vent 11

**Comments:** Southern Face



Station 17+75 to 17+85



**Direction:** Seawall

**Comments:** Concrete Spalling

Station 17+85



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 18+10



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 18+82

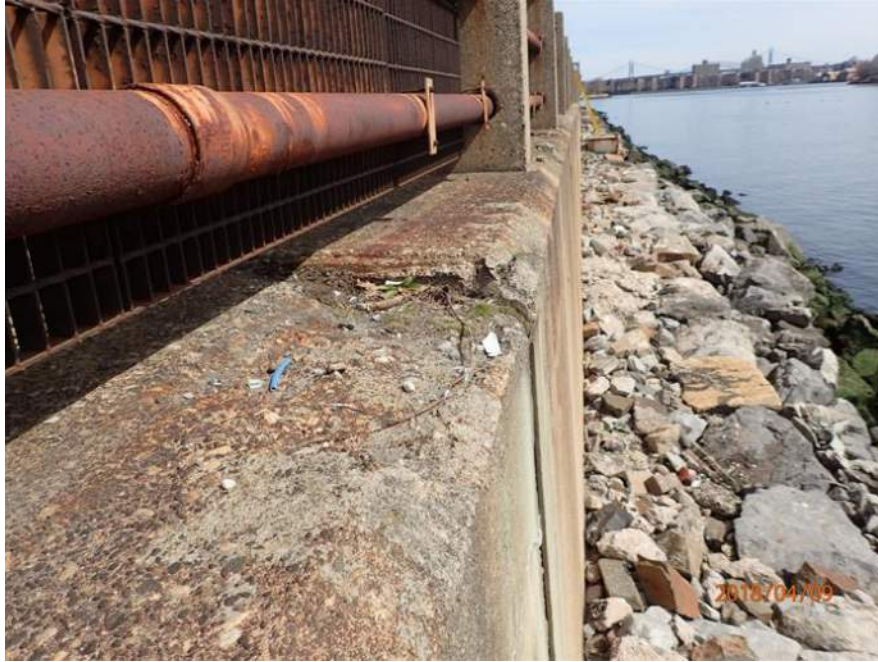


**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Exposed Re-bar, Cracks about 3-inches Deep



Station 18+82



**Direction:** Seawall Joint

**Comments:** Concrete Spalling

Station 20+09



**Direction:** Seawall Joint

**Comments:** Concrete Spalling



Station 20+30



**Direction:** Air Vent 10

**Comments:** Northern Face

Station 20+30



**Direction:** Air Vent 10

**Comments:** Western Face

Station 20+30



**Direction:** Air Vent 10

**Comments:** Southern Face

Station 20+45



**Direction:** Seawall

**Comments:** Exposed Re-Bar



Station 20+73



**Direction:** Seawall Joint

**Comments:** Concrete Spalling and repair

Station 21+23



**Direction:** Seawall

**Comments:** Exposed Re-Bar



Station 21+33



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 21+33



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 21+43



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

Station 22+64



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete



Station 22+57



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 22+84



**Direction:** Air Vent 9

**Comments:** Northern Face



Station 22+84



**Direction:** Air Vent 9

**Comments:** Western Face

Station 22+84



**Direction:** Air Vent 9

**Comments:** Southern Face

Station 23+20



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 23+88



**Direction:** Seawall Sidewalk Joint

**Comments:** Joint Repair



Station 23+88



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete

Station 23+78 to 24+00



**Direction:** Seawall

**Comments:** Tunnel has been Undermined



Station 23+78 to 24+00



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

Station 24+10



**Direction:** Seawall

**Comments:** Exposed Re-Bar

Station 24+00 to 24+20



**Direction:** Seawall

**Comments:** Tunnel has been Undermined

Station 24+48



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks



**Station 24+53**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

**Station 25+10**



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks



Station 25+17



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed and Loose

Station 25+17



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed and Loose

Station 25+38



**Direction:** Air Vent 8

**Comments:** Northern Face

Station 25+38



**Direction:** Air Vent 8

**Comments:** Western Face



Station 25+38



**Direction:** Air Vent 8

**Comments:** Southern Face

Station 25+82



**Direction:** Seawall Joint

**Comments:** Concrete Spalling



Station 27+07



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 27+07



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 27+92



**Direction:** Air Vent 7

**Comments:** Northern Face

Station 27+92



**Direction:** Air Vent 7

**Comments:** Western Face



**Station 27+92**



**Direction:** Air Vent 7

**Comments:** Southern Face

**Station 28+02**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed



Station 28+40 to 28+50



**Direction:** Seawall

**Comments:** Concrete Spalling

Station 28+34



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 28+34



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 28+34



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed



Station 28+91



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks, Attempt to Repair

Station 29+62



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks



Station 29+62



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 29+62



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 29+62



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 29+62



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed



Station 30+24



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 30+46



**Direction:** Air Vent 6

**Comments:** Northern Face



Station 30+46



**Direction:** Air Vent 6

**Comments:** Western Face

Station 30+46



**Direction:** Air Vent 6

**Comments:** Southern Face

Station 31+52



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 31+52



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed



**Station 31+52**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

**Station 32+16**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Loose Section of Concrete, Re-Bar Exposed



**Station 32+16**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed and Loose

**Station 32+79**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

**Station 32+79**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

**Station 33+00**



**Direction:** Air Vent 5

**Comments:** Northern Face



Station 33+00



**Direction:** Air Vent 5

**Comments:** Western Face

Station 33+00



**Direction:** Air Vent 5

**Comments:** Southern Face



Station 33+84



**Direction:** Seawall

**Comments:** Concrete Spalling

Station 34+06



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 34+06



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 34+30



**Direction:** Seawall

**Comments:** Re-Bar Exposed



Station 34+70



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 34+70



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Loose Concrete



Station 35+38



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 35+54



**Direction:** Air Vent 4

**Comments:** Northern Face

Station 35+54



**Direction:** Air Vent 4

**Comments:** Western Face

Station 35+54



**Direction:** Air Vent 4

**Comments:** Southern Face



Station 35+93



**Direction:** Seawall

**Comments:** Exposed Re-Bar, Concrete Spalling

Station 36+20



**Direction:** Seawall

**Comments:** Concrete Cracks



Station 36+56



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 37+22



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

**Station 37+22**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling

**Station 37+40**



**Direction:** Seawall

**Comments:** Concrete Cracks



Station 38+44



**Direction:** Seawall Sidewalk

**Comments:** Concrete Cracks, Asphalt Repair

Station 38+82



**Direction:** Seawall Joint

**Comments:** Concrete Spalling



Station 39+03



**Direction:** Air Vent 3

**Comments:** Northern Face

Station 39+03



**Direction:** Air Vent 3

**Comments:** Western Face

**Station 39+03**



**Direction:** Air Vent 3

**Comments:** Southern Face

**Station 39+22**



**Direction:** Seawall

**Comments:** Exposed Re-Bar



Station 39+66



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 39+70



**Direction:** Seawall

**Comments:** Exposed Re-Bar



Station 40+00



**Direction:** Seawall Column

**Comments:** Concrete Spalling

Station 40+39



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

Station 40+39



**Direction:** Seawall Joint

**Comments:** Concrete Spalling

Station 40+61



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks



Station 40+80



**Direction:** Seawall Joint

**Comments:** Concrete Spalling

Station 41+22 to 41+54



**Direction:** Seawall Sidewalk

**Comments:** Concrete Cracks



**Station 41+31**



**Direction:** Seawall Joint

**Comments:** Concrete Repair

**Station 41+50**



**Direction:** Seawall

**Comments:** Missing Large Section of Concrete

Station 41+97



**Direction:** Seawall

**Comments:** Concrete Repair

Station 42+18



**Direction:** Air Vent 2

**Comments:** Northern Face



Station 42+18



**Direction:** Air Vent 2

**Comments:** Western Face

Station 42+18



**Direction:** Air Vent 2

**Comments:** Southern Face



Station 42+22



**Direction:** Seawall Sidewalk

**Comments:** Concrete Cracks

Station 42+39



**Direction:** Seawall Joint

**Comments:** Concrete Repair Over Metal Plate, Cracks

**Station 42+54**



**Direction:** Seawall Sidewalk Joint

**Comments:** Concrete Cracks

**Station 43+04**



**Direction:** Seawall

**Comments:** Tunnel has been Undermined



**Station 43+44**



**Direction:** Seawall

**Comments:** Concrete Spalling, Exposed Re-bar

**Station 43+66**



**Direction:** Seawall

**Comments:** Exposed Re-Bar



Station 43+87



**Direction:** Seawall Joint

**Comments:** Spalling and Concrete Repairs

Station 43+87



**Direction:** Seawall Joint

**Comments:** Spalling and Concrete Repairs

**Station 44+65**



**Direction:** Seawall

**Comments:** Exposed Re-Bar

**Station 45+77**



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Large Concrete Cracks



Station 45+34



**Direction:** Air Vent 1

**Comments:** Northern Face

Station 45+34



**Direction:** Air Vent 1

**Comments:** Western Face



Station 45+34



**Direction:** Air Vent 1

**Comments:** Southern Face

Station 45+77



**Direction:** Seawall Sidewalk Joint

**Comments:** Large Concrete Crack, Missing Concrete

Station 45+77



**Direction:** Seawall Joint

**Comments:** Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 45+97



**Direction:** Seawall Sidewalk Joint at Terminus

**Comments:** Concrete Cracks



**Station 45+97**



**Direction:** Southern Seawall Terminus

**Comments:** Spalling at Haunch

**Station 47+00**



**Direction:** Southern Seawall Terminus

**Comments:** Start of Seawall



**APPENDIX B**

**SECURITY SURVEY**

Station 6+16



**Direction:** Air Vent 16

**Comments:** Northern Face

Station 6+16



**Direction:** Air Vent 16

**Comments:** Southern Face

**Station 9+21**



**Direction:** Air Vent 15

**Comments:** Northern Face

**Station 9+21**



**Direction:** Air Vent 15

**Comments:** Southern Face



**Station 10+77**



**Direction:** Air Vent 14

**Comments:** Northern Face

**Station 10+77**



**Direction:** Air Vent 14

**Comments:** Southern Face

Station 12+84



**Direction:** Air Vent 13

**Comments:** Northern Face Door Unlocked, Broken Lock

Station 12+84



**Direction:** Air Vent 13

**Comments:** Northern Face

**Station 12+84**



**Direction:** Air Vent 13

**Comments:** Sothern Face

**Station 15+22**



**Direction:** Air Vent 12

**Comments:** Northern Face



**Station 15+22**



**Direction:** Air Vent 12

**Comments:** Sothern Face

**Station 17+76**



**Direction:** Air Vent 11

**Comments:** Northern Face

**Station 17+76**



**Direction:** Air Vent 11

**Comments:** Sothern Face

**Station 20+30**



**Direction:** Air Vent 10

**Comments:** Northern Face

**Station 20+30**



**Direction:** Air Vent 10

**Comments:** Sothern Face

**Station 22+84**



**Direction:** Air Vent 9

**Comments:** Northern Face



Station 22+84



**Direction:** Air Vent 9

**Comments:** Sothern Face

Station 25+38



**Direction:** Air Vent 8

**Comments:** Northern Face

Station 25+38



**Direction:** Air Vent 8

**Comments:** Sothern Face

Station 27+92



**Direction:** Air Vent 7

**Comments:** Northern Face

**Station 27+92**



**Direction:** Air Vent 7

**Comments:** Sothern Face

**Station 30+46**



**Direction:** Air Vent 6

**Comments:** Northern Face



**Station 30+46**



**Direction:** Air Vent 6

**Comments:** Sothern Face

**Station 33+00**



**Direction:** Air Vent 5

**Comments:** Northern Face

**Station 33+00**



**Direction:** Air Vent 5

**Comments:** Sothern Face

**Station 35+54**



**Direction:** Air Vent 4

**Comments:** Northern Face

**Station 35+54**



**Direction:** Air Vent 4

**Comments:** Sothern Face

**Station 39+03**



**Direction:** Air Vent 3

**Comments:** Northern Face



**Station 39+03**



**Direction:** Air Vent 3

**Comments:** Sothern Face

**Station 42+18**



**Direction:** Air Vent 2

**Comments:** Northern Face

**Station 42+18**



**Direction:** Air Vent 2

**Comments:** Sothern Face

**Station 45+34**



**Direction:** Air Vent 1

**Comments:** Northern Face

Station 45+34



**Direction:** Air Vent 1

**Comments:** Sothern Face



## **APPENDIX C**

### **EXCERPT OF RELEVANT MATERIAL FROM 2001 USACE STUDY OF RI SEAWALLS**

## ROOSEVELT ISLAND APPENDIX V - PHASE II

### COMBINED STEAM TUNNEL / SEA WALL SURVEY

At the time of the interior tunnel inspection Roosevelt Island employees pointed out tunnel areas prone to leakage. They noted that during combinations of high tide and rainstorms the tunnel experiences greater water infiltration than that photographed during the time of this inspection. After inspecting the tunnel interior, the exterior was investigated both on shore and by boat. The draft of the boat limited approach to the tunnel wall. Further investigation is required. 1949 details shown in Appendix C point out that the tunnel has been built on piers and piles. According to the tunnel design, this system was to be protected by rip rap. Assuming the tunnel has been constructed as per the 1949 drawings, the piers, piles and their caps may have been undermined due to the lack of rip rap protection in many locations especially between vents 12 to 16.

It was found that although instances of both landside and seawall leakage occurs throughout the length of the tunnel, landside sources were prevalent within the Southern segment of the tunnel while leakage from the seawall due to a lack of rip rap was prevalent within the Northern Segment. The tunnel's leaking joints were scheduled to be repaired, but the work was never completed. In preparation for that project, asbestos was removed from pipes on either side of each tunnel joint. The joints still leak especially where additional rip rap is required. Joints throughout the length of the tunnel should be repaired as required. Interior renovations must take into account the presence of asbestos.

Landside sources of leakage include:

- a. tree roots along the interior tunnel wall;
- b. large grassed areas along the interior tunnel wall;
- c. lack of sewers for drainage on streets. Street drainage is often directed toward the tunnel wall over grassed areas with the intent for water to pass over the tunnel roof to the East River. The problem arises due to the fact that the tunnel roof is often higher than the eroded grassed area or sloped downward toward the grassed area from the East River edge causing the pooling of water at the landside tunnel wall.
- d. possible deterioration of waterproofing system at the interior wall. See detail for 1949 waterproofing design in Appendix C. (This should be checked.)
- e. New construction as for example the introduction of firehydrants & benches may have damaged the interior walls. The construction of new structures such as the parking garage along the interior tunnel wall has introduced different loading conditions at the wall. (See Appendix B, photo 3, pg. 7; photos 3, 4 pg. 8.)

Seawall sources of leakage include:

- a. lack of rip rap;
- b. damage to seawall joints.

APPENDIX A - locates the Combined Steam Tunnel and Sea Wall vents. The sea wall vents have been numbered 1 through 16. The map selected for Appendix A is captioned:

NEW YORK URBAN DEVELOPMENT CORPORATION  
WELFARE ISLAND DEVELOPMENT CORPORATION

Master Engineering Plan Parcelization, Horizontal Controls & Bench Marks South Town & Town Center  
by Gibbs & Hill, Inc., dated May 1971

This map was selected because drawings captioned:

CITY OF NEW YORK DEPARTMENT OF PUBLIC WORKS  
DIVISION OF ENGINEERING AND ARCHITECTURE  
Power Plant Expansion Phase B - Combined Steam Tunnel and Sea Wall - Stage Two  
by Rose and Rose Engineers, dated June 23, 1949

did not conform with existing dimensions between vents. It does not match existing conditions.

APPENDIX B - includes survey photographs. Photos have been organized according to vent locations.

APPENDIX C - includes 1949 details of the Combined Steam Tunnel and Sea Wall showing that it was constructed on piles and piers. It includes details of rip rap placement both at the sea wall and the land side of the tunnel. It also includes details of the landside waterproofing system. The 1949 details show the waterside base of the tunnel unprotected by rip rap. This has proved inadequate and a cause of deterioration at the base. Rip rap should be placed to protect the base of the tunnel as well.

See Phase I Report for further comments.

## **SOURCES OF TUNNEL LEAKAGE**

### **VENT SECTION 1 - 2**

#### **LOCATION OF PROBLEMS**

Leaks occur approximately 60 feet before Vent 1 at a bend. See Appendix B, photo 1, pg. 1..

#### **CONTRIBUTING SOURCE OF PROBLEMS**

Possible sources of leakage on either side of the bend are shown in photos 2, 3, 4, 6 and 7. These include the intersection between the steam tunnel and a cobblestone wall, a repair of the tunnel roof and expansion joint deterioration. A possible source of interior wall leakage is the 110' length of trees located at the interior wall of the tunnel starting approximately 140' from Vent 1. See Appendix B photo 5. Photo 8 shows a lack of rip rap at a section of the tunnel base.

#### **RECOMMENDATION**

Replace rip rap at location shown in photo 8. Replace cobblestone wall photo 6 at intersection of tunnel and sea wall. Check tree roots for possible tunnel wall damage. Check tunnel interior wall waterproofing system. See detail for 1949 waterproofing design in Appendix C. Waterproof as required. Repair expansion joints as required. Replace cobblestone wall.

### **VENT SECTION 2 - 3**

#### **LOCATION OF PROBLEMS**

Interior wall spalling occurs within this segment as shown in Appendix B, photo 1, pg. 2.

#### **CONTRIBUTING SOURCE OF PROBLEMS**

Tunnel roof and interior wall repairs are shown in photos 2, 3 and 4 on pg. 2. Existing damage may have been caused before these repairs were made. Photo 5 shows adequate rip rap placement. Landside problems appear to be the cause of leakage problems.

#### **RECOMMENDATION**

Check tunnel roof for additional crack repair requirements. Check tunnel interior wall waterproofing system. See detail for 1949 waterproofing design in Appendix C. Waterproof as required.



## **VENT SECTION 3 - 4**

### **LOCATION OF PROBLEMS**

There is a bulge in the landside wall within this section. See Appendix B, photo 1, page 3. Water is shown at the tunnel floor in photos 4 and 5. This occurs after the tunnel bend in the tree area.

### **CONTRIBUTING SOURCE OF PROBLEMS**

The bulge in the landside wall may be caused by a row of trees and grassed area at landside. See photos 2 and 3. Photo 6 shows adequate rip rap. Expansion joints appear to be a problem for the sea wall side.

### **RECOMMENDATION**

Check tree roots for possible wall damage. Check tunnel interior wall waterproofing system. See detail for 1949 waterproofing design in Appendix C. Waterproof as required. Repair expansion joints as required.

## **VENT SECTION 4 - 5; VENT SECTION 5 - 6; VENT SECTION 6 - 7**

### **LOCATION OF PROBLEMS**

General leakage.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Appendix B, photos 1, 2 and 4, pg. 4 illustrates damage at joints. It also shows adequate rip rap.

### **RECOMMENDATION**

Repair expansion joints as required. Photo 3 on pg. 4 within Vent Section 6 - 7 shows a broken stanchion in need of repair.

## **VENT SECTION 7 - 8**

### **LOCATION OF PROBLEMS**

Appendix B, photos 1 and 2, pg. 5 show general interior wall deterioration and spalling.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Photos 3 to 5 show a grassed area with trees along the interior wall. In addition to water infiltration from grassed areas and tree roots, street drainage is channeled toward the interior tunnel wall. The tunnel roof is situated at a higher level than the drainage channel, resulting in pooling of water at the interior tunnel wall. It appears that the street drainage design intended rain waters to flow through channels, over the tunnel roof and into the East River. This is not occurring. In addition, often these channels are cut into the grass without a concrete liner resulting in water infiltration behind the tunnel wall. Photo 6 shows adequate rip rap at the exterior sea wall. Water problems in this section appear to be landside problems.

### **RECOMMENDATION**

Correct street drainage. Repair seawall expansion joints as required. Check tree roots for possible wall damage. Check tunnel interior wall waterproofing system. See detail for 1949 waterproofing design in Appendix C. Waterproof as required.

## **VENT SECTION 8 - 9**

### **LOCATION OF PROBLEMS**

There is general interior wall spalling and deterioration in this vent section. See Appendix B, photo 1 pg. 6.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Photos 2 through 5 on pg. 6 again show street drainage, tree and grassed area problems similar to that shown for Vent Section 7 - 8. Photo 6 shows an exposed section of lower tunnel lacking rip rap.

### **RECOMMENDATION**

Same as for Vent Section 7 - 8. Add rip rap where required.

## **VENT SECTION 9 - 10**

### **LOCATION OF PROBLEMS**

There is general interior wall spalling and deterioration with exposed reinforcement in this vent section. See Appendix B, photos 1 and 2, pg. 7.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Again as in Vent Sections 7 - 8 and 8 - 9 drainage from the street is diverted to the interior tunnel wall. In addition, photo 3 shows that the tunnel roof is sloped down from the East River toward the street causing pooling at the interior wall. Photo 4 on pg. 7 shows adequate rip rap placement.

### **RECOMMENDATION**

Correct street drainage, repair seawall expansion joints as required. Check tunnel interior wall waterproofing system. See detail for 1949 waterproofing system design in Appendix C. Waterproof as required. Check installation of firehydrant at interior wall.

## **VENT SECTION 10 - 11**

### **LOCATION OF PROBLEMS**

There is general interior wall spalling and deterioration with exposed reinforcement in this vent section. See Appendix B, photos 1 and 2, pg. 8.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Again as in Vent Sections 7 - 8, 8 - 9 and 9 - 10 drainage from the street is diverted to the interior tunnel wall. In addition, photos 3 and 4 show that the tunnel roof is sloped down from the East River toward the street while the street is sloped toward the interior tunnel wall causing pooling at the interior wall. Photos 5 and 6 on pg. 8 show adequate rip rap placement but tunnel joints need repair. Differing site conditions exist with the construction of the parking garage which has introduced different loading conditions.

### **RECOMMENDATION**

Correct street drainage, repair seawall expansion joints as required. Check tunnel interior wall waterproofing system. See detail for 1949 waterproofing design in Appendix C. Waterproof as required. Verify that construction of parking garage has not compromised the interior tunnel wall.

## **VENT SECTION 11 - 12**

### **LOCATION OF PROBLEMS**

There is general interior wall spalling and deterioration with exposed reinforcement in this vent section. See Appendix B photos 1 and 2 pg. 9.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Photos 3 and 4 show a large grassed area along this tunnel section as well as damaged tunnel ceiling. Photos 5, 6 and 7 show adequate rip rap placement except for a small section. Joint covers are in place. Problems appear to be from the grassed area.

### **RECOMMENDATION**

Check tunnel interior wall for adequacy of waterproofing . See detail for 1949 waterproofing system design in Appendix C. Waterproof as required. Check that bench installation has not damaged tunnel wall, photo 3, pg. 9.

## **VENT SECTION 12 - 13**

### **LOCATION OF PROBLEMS**

Appendix B photos 2 and 4 pg. 10 show tunnel floor and wall damage. The tunnel floor is lifting. Water has accumulated on floor with evidence of salt indicating the presence of salt water.

### **CONTRIBUTING SOURCE OF PROBLEMS**

This section is experiencing water infiltration from both the land and water side due to cracks in the roof grassed areas, deteriorated wall joints and missing rip rap all as shown in photos 3, 5, 6, 7 and 8. Photo 5 shows moisture path on grassed area toward interior tunnel wall. Photo 1 shows a section of adequate rip rap.

### **RECOMMENDATION**

Check tunnel interior wall for adequacy of waterproofing . See detail for 1949 waterproofing system design in Appendix C. Waterproof as required. Replace rip rap as required. Repair tunnel roof cracks and expansion joints. Check tunnel piers, piles & caps for deterioration. Repair as required.

## **VENT SECTION 13 - 14**

### **LOCATION OF PROBLEMS**

Appendix B, photo 1, pg. 11 shows damage at lower tunnel.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Photo 1 pg. 11 shows missing rip rap which is contributing to the deterioration of the tunnel.

### **RECOMMENDATION**

Replace rip rap as required. Check tunnel piers, piles and caps for deterioration. Repair as required. Repair expansion joints.



## **VENT SECTION 14 - 15**

### **LOCATION OF PROBLEMS**

Appendix B, photos 2, 3, 4 & 5, pg. 11 show damage below vents 14 and 15 as well as the section between the vents.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Photos 2, 3, 4 & 5 pg. 11 show missing rip rap and deteriorated joints which are contributing to the deterioration of the tunnel.

### **RECOMMENDATION**

Replace rip rap as required. Repair expansion joints. Check tunnel piers, piles & caps for deterioration. Repair as required.

## **VENT SECTION 15 - 16**

### **LOCATION OF PROBLEMS**

Appendix B, photos 1 & 2, pg. 12 show damage to the tunnel floor. Water infiltrates through the floor.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Photos 3 & 5 show high grassed area and cracked tunnel ceiling. Photos 4, 6 & 7 show lack of rip rap resulting in damage to lower portion of the tunnel. These photos also indicate joint damage.

### **RECOMMENDATION**

Replace rip rap as required. Repair expansion joints. Check tunnel piers, piles & caps for deterioration. Repair as required.

## **VENT 16 - TO LAND VENT**

### **LOCATION OF PROBLEMS**

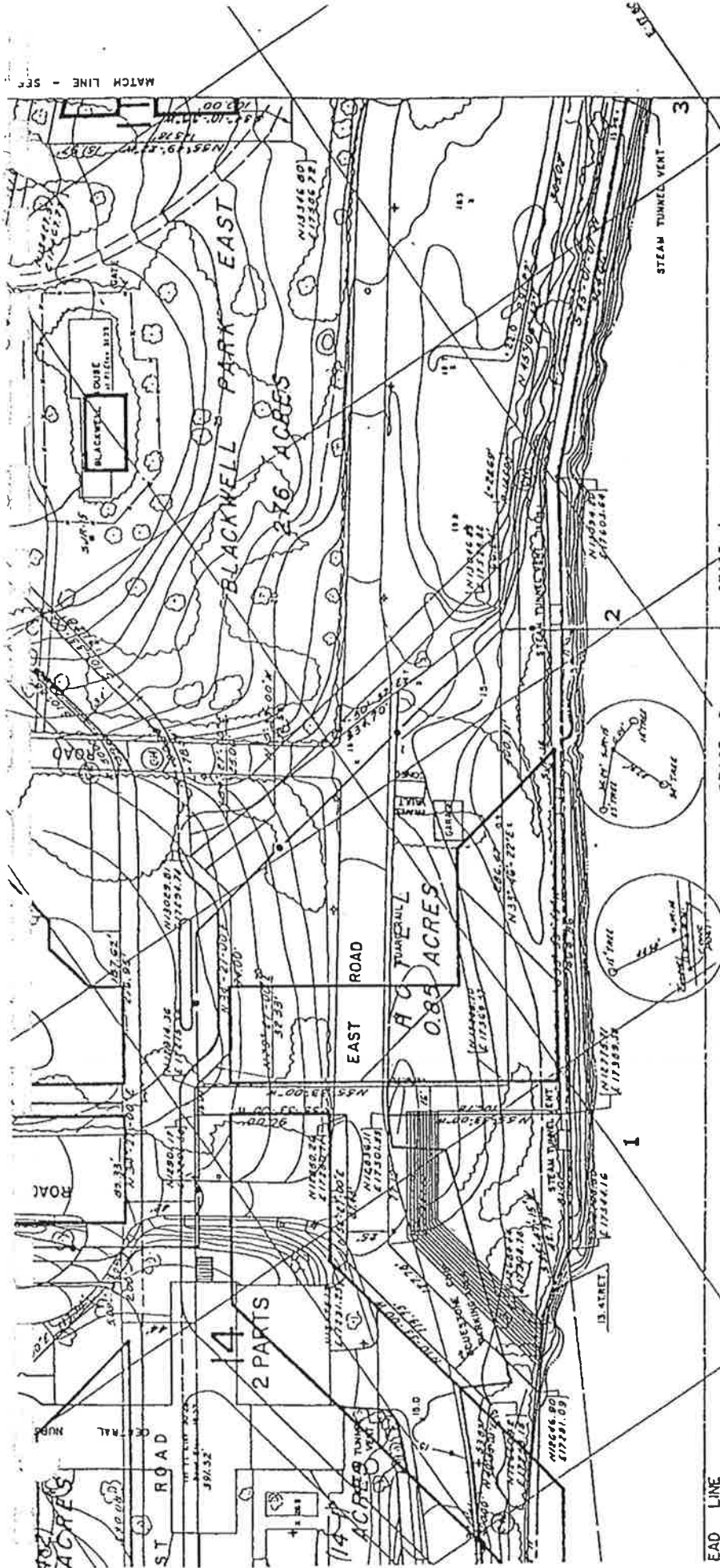
Photo 1 shows deterioration where steam tunnel meets adjoining sea wall. Photo 3 shows landside vent in the distance. Interior wall is bowing out in this section.

### **CONTRIBUTING SOURCE OF PROBLEMS**

Photos 2 and 3 show trees and grassed areas at interior wall side. Photo 1 shows lack of rip rap at location where steam tunnel meets adjoining sea wall.

### **RECOMMENDATION**

Check tunnel interior wall for adequacy of waterproofing. See detail for 1949 waterproofing system design in Appendix C. Waterproof as required. Check tree roots. Replace rip rap as required. Check and repair intersection of steam tunnel and adjoining sea wall.



LEAD LINE

**NOTES:**

ALL ELEVATIONS REFER TO M.L.W. ELEVATION AT BELMONT ISLAND, EL. 0.00. WHICH IS 2.365 FEET BELOW M.S.L. AT SANDY MOUL.

RETURNED ON N.W. CORNER OF QUELSTON BRIDGE PIER  
ON EASTERN BANK OF WELFARE ISLAND CL. 17.45H.

[illegible]

INFORMATION THAT HAS BEEN ADDED OR CHANGED FROM THAT SHOWN ON THE ORIGINAL KING & GAVARIS DRAWING IS THE RESPONSIBILITY OF GIBBS & HILL, INC., NEW YORK.

[illegible]

NEW YORK STATE

URBAN DEVELOPMENT CORPORATION  
WEI FARE IS AND DEVELOPMENT COE

# MASTER ENGINEERING PLAN

PARCELIZATION, HORIZONTAL CONTROLS & BENCH MARKS  
SOUTH TOWN & TOWN CENTER

<b>Gibbs &amp; Hill, Inc.</b> Structural, Electrical, Mechanical, Plumbing, Heating, Air Conditioning, and Sanitary Engineers 1000 York New York 17	SCALE	DATE	DWG. No.	SHEET
	AS SHOWN	MAY 1971	2133B M-ST3	3 OF SHEET

ΑΡΧΗΤΥΧ Α

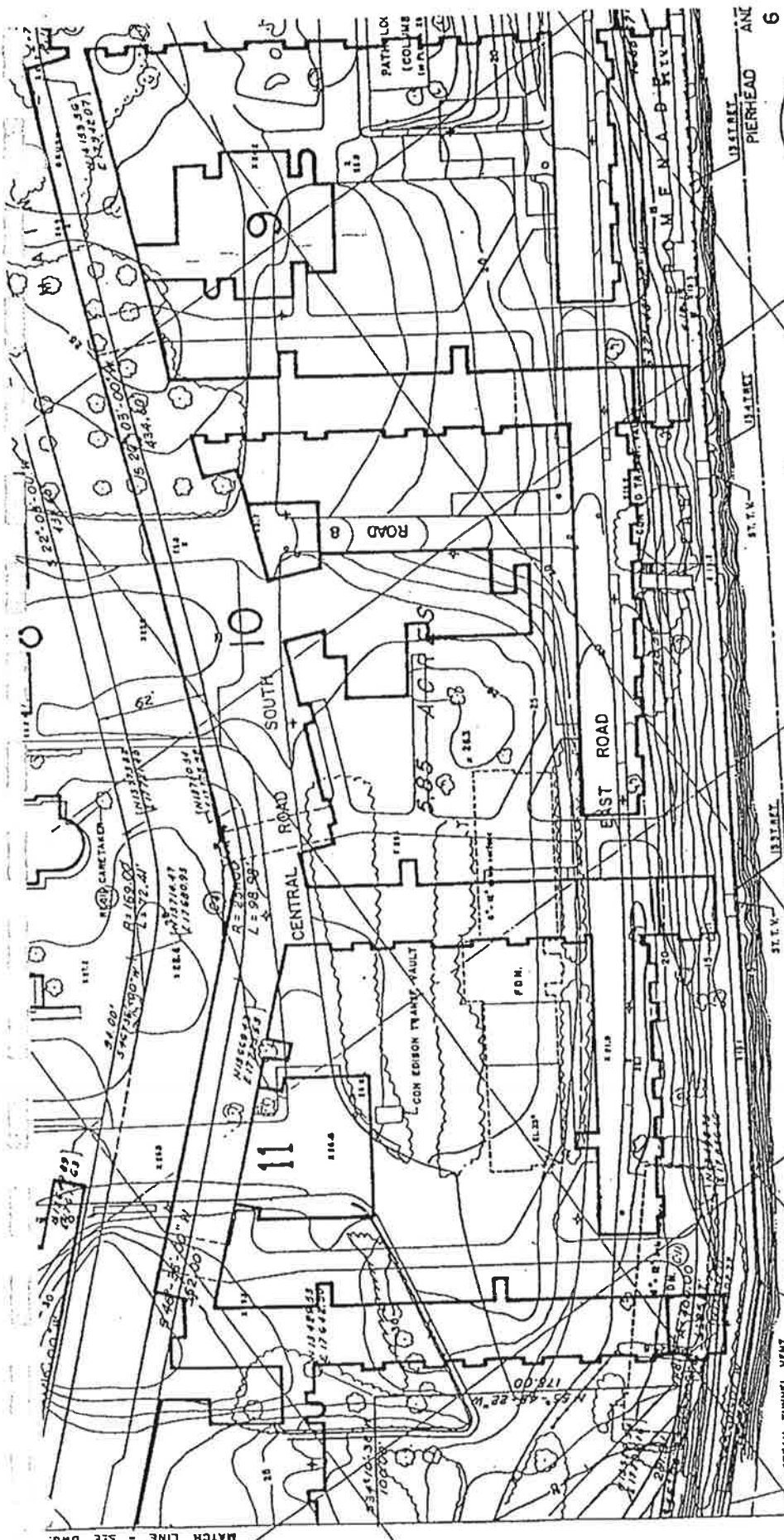
EAST CHANNEL



GRAPHIC SCALE

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502.19	MONUMENT	
551.10	MON. (S.M.)	61.15466
795.96		

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POINT NO.	COORDINATES		TYPE
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5UR-12	14515.42	18066.26	MONUMENT
5UR-13	13825.01	18162.29	MONUMENT
5UR-18	13737.38	17756.03	MONUMENT

EAST  
RIVER

GENERAL NOTES

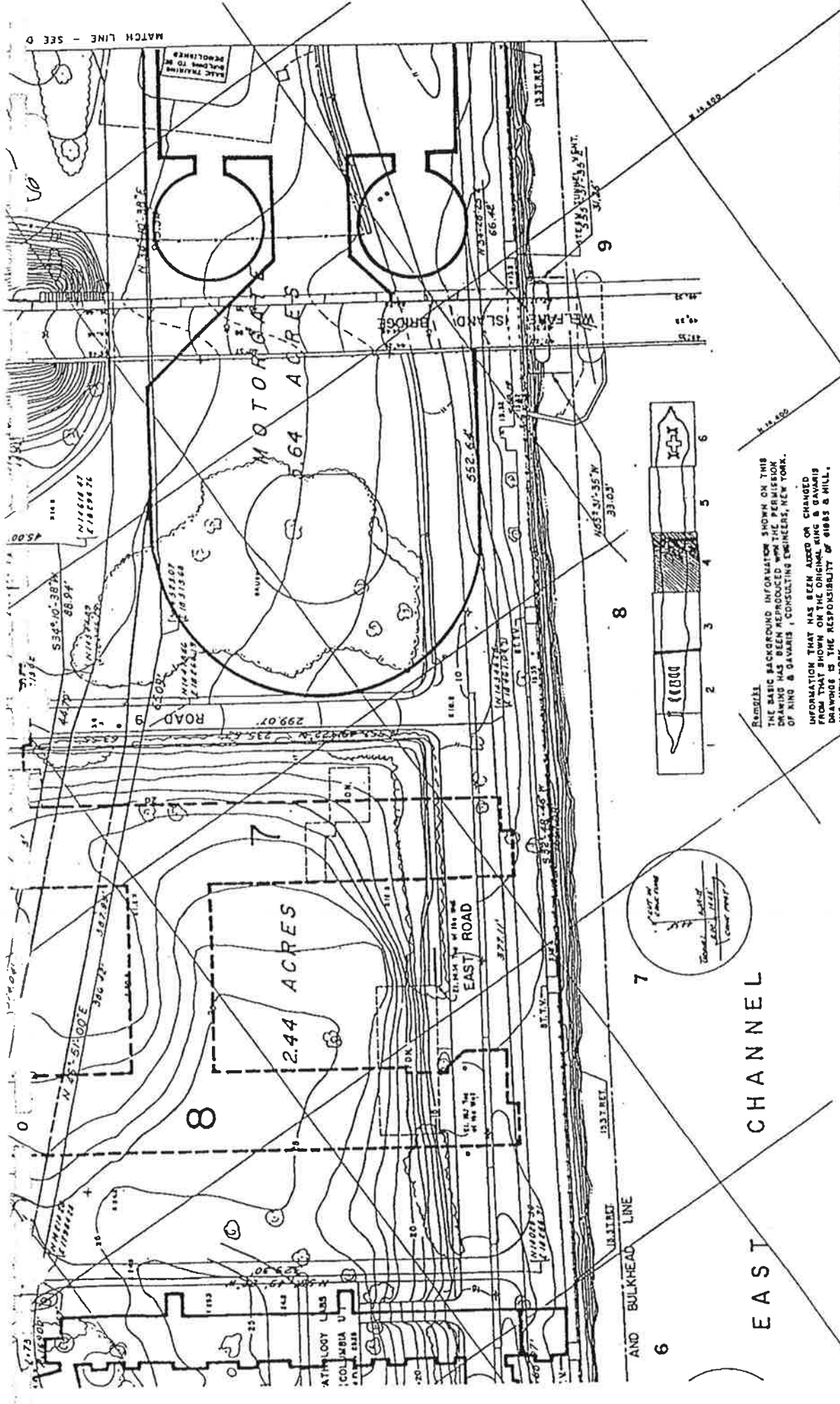
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2. THE RELATIVE POSITIONS OF ALL SIX BUILDINGS WITH RESPECT TO THE PARCEL LINES ARE SUBJECT TO ALTERATIONS BY THE ARCHITECTS.

LEGEND

_____	PRESENT LEASE LINE
_____	PROPOSED MODIFICATION TO LEASE LINE
_____	PARCEL LINE

INEL VENT  
N19161.97  
A17861.58





# NEW YORK STATE

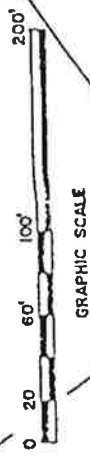
## URBAN DEVELOPMENT CORPORA'

### WELFARE ISLAND DEVELOPMENT

MASTER ENGINEERING PLAN  
PARCELIZATION, HORIZONTAL CONTROLS & BENC  
NORTH TOWN & MOTORWAY

<b>Gibbs &amp; Hill, Inc.</b> <small>INCORPORATED IN NEW YORK</small> <small>REGISTERED PROFESSIONAL ENGINEERS</small>	<b>SCALE</b> AS SHOWN	<b>DATE</b> MAY 1971	<b>DWG. No.</b> 21338	<b>DATE</b> MAY 1971
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**REMARKS:**  
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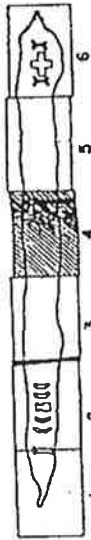
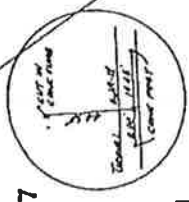
NO.	REVISION	DATE
1	MASTER ENGINEERING PLAN	

- NOTE:**
- ALL ELEVATIONS REFER TO M.L.W. ELEVATION AT BELMONT ISLAND, EL. 0.00, WHICH IS 2.265 FEET BELOW M.S.L. AT SANDY HOOK.
  - REMARKS ON E.W. CORNER OF OVERSHOULDER BRIDGE PIER ON EASTERN BANK OF WELFARE ISLAND EL. 17.456.
  - THE COORDINATE SYSTEM IS BASED UPON THE ONE ESTABLISHED BY THE U.S. ARMY ENGINEERS (DRAWING NO. S.D-276) AND THE FOLLOWING TRANSLATION WAS MADE:

TYPE	ELEVATION
MONUMENT	EL. 13.364
MONUMENT	EL. 13.364

U.S. COORDINATES	LEG COORDINATES
U.S. MON. 14	5 11,393.254
	6 812.168
	7 8 10,000.000
	8 15,000.000

EAST CHANNEL

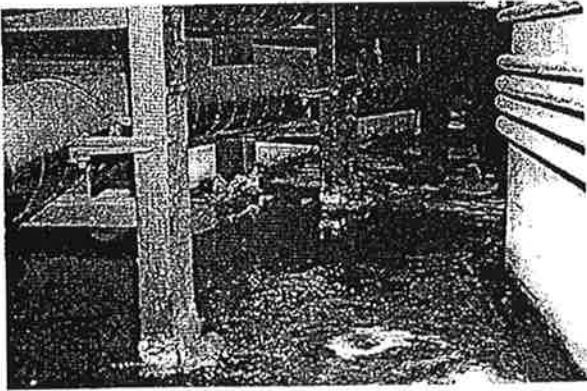




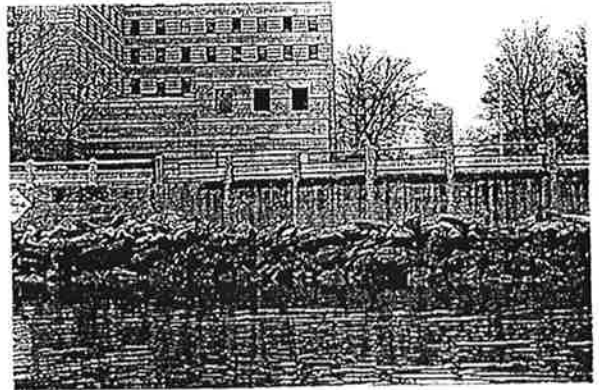




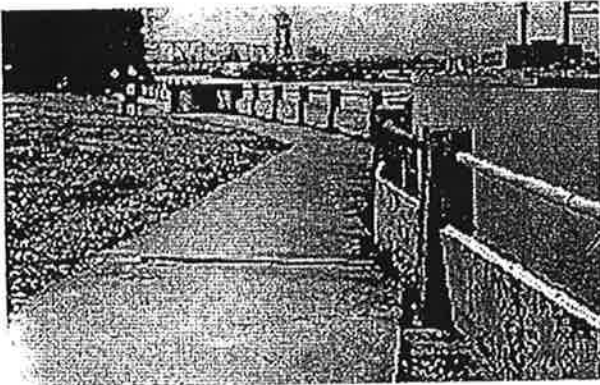
VENT 1 - VENT 2



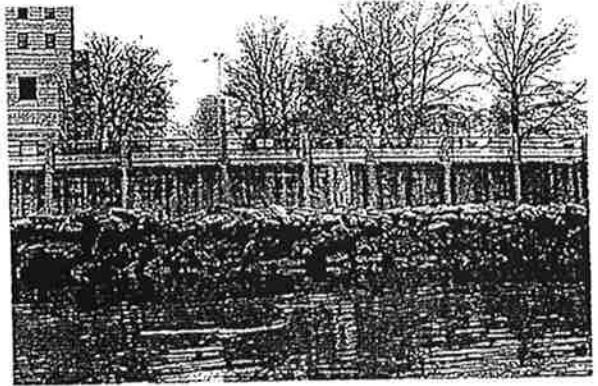
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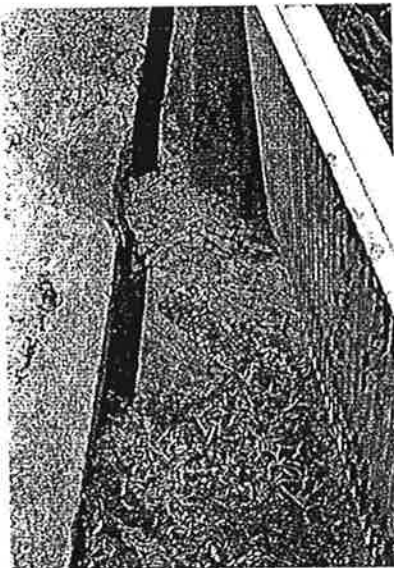
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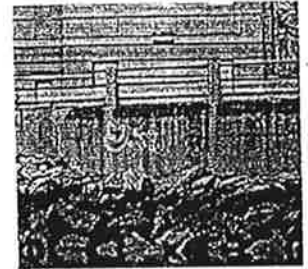
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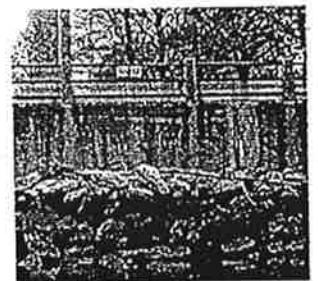
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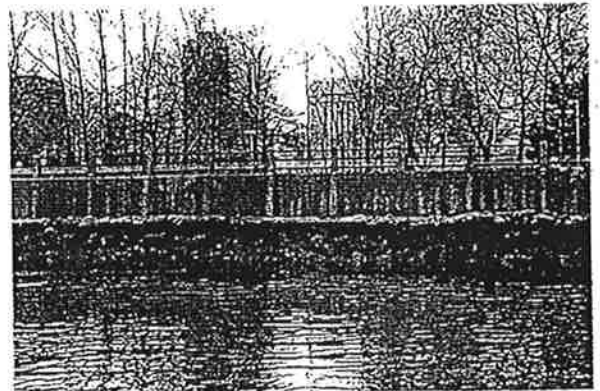
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7A



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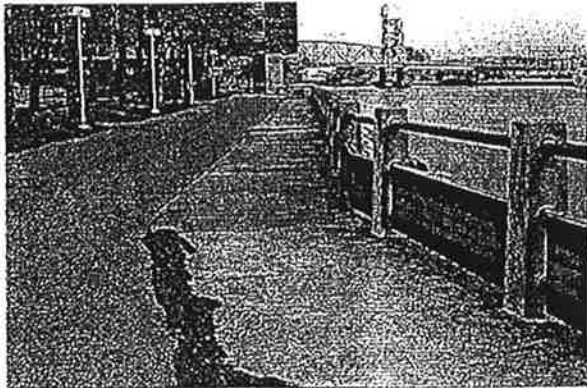


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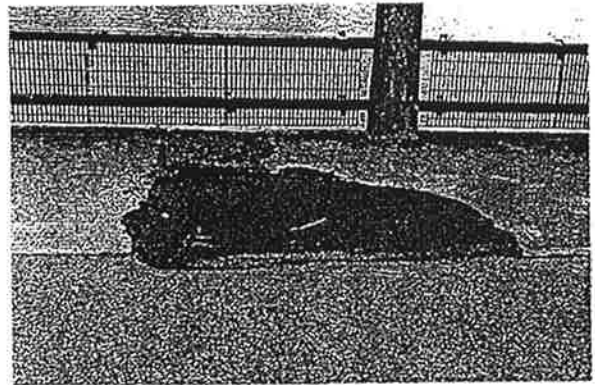
VENT 2 - VENT 3



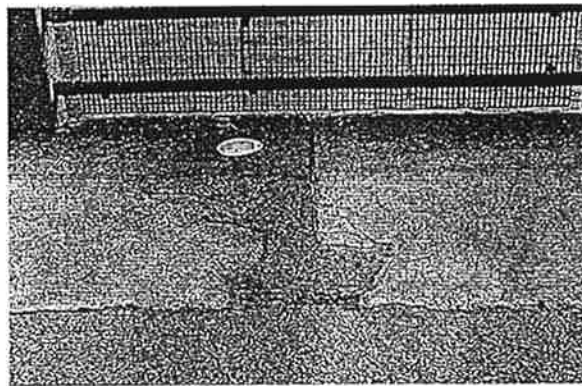
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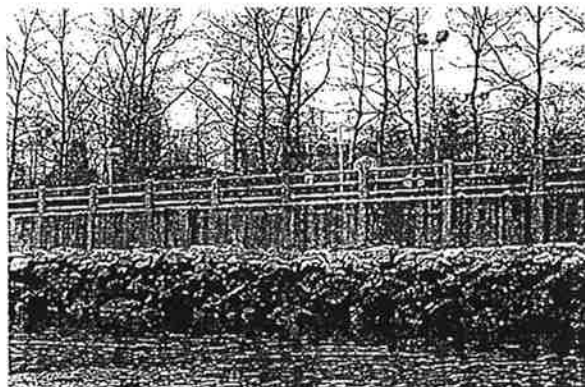
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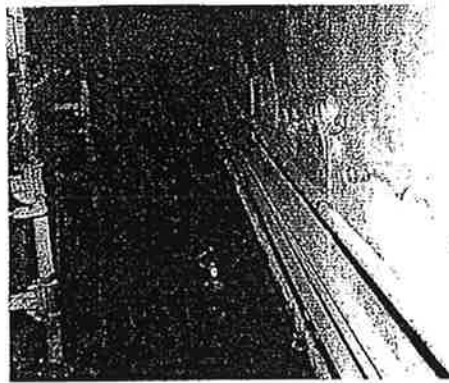


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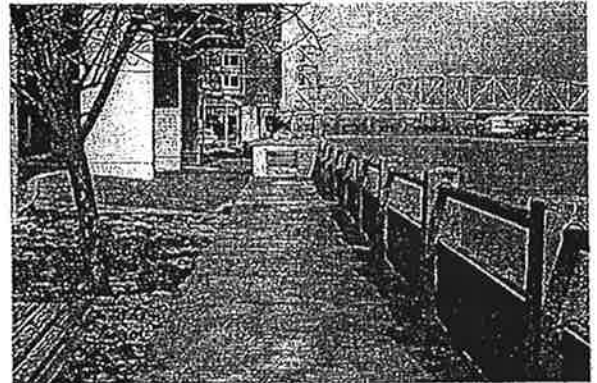
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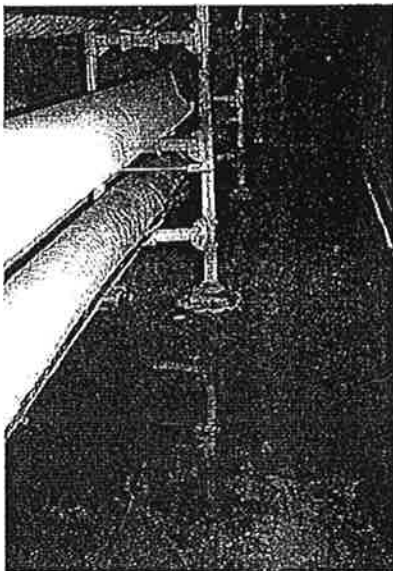
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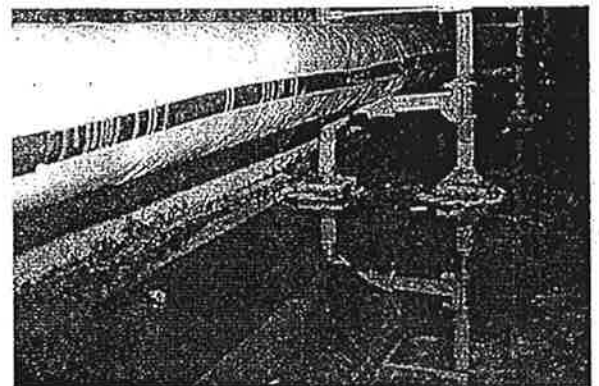
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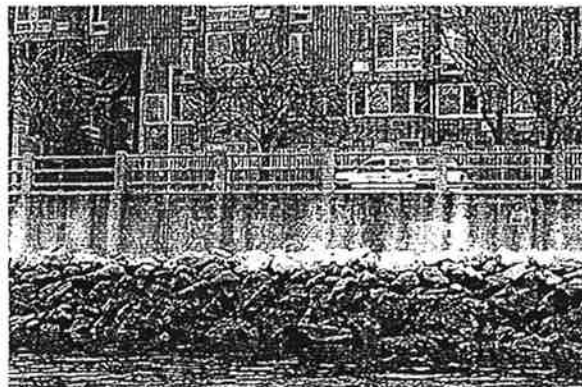
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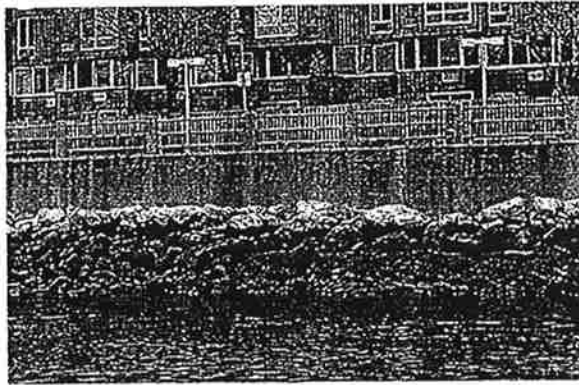
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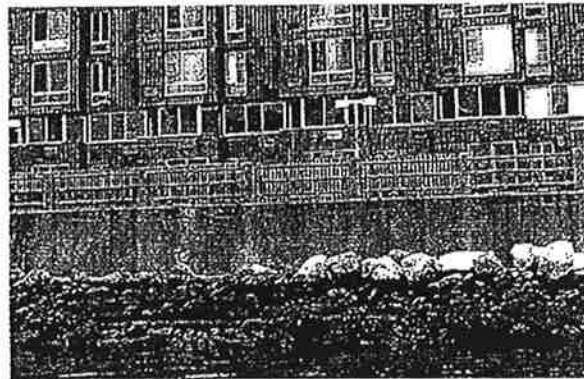


**VENT 4 - VENT 5**



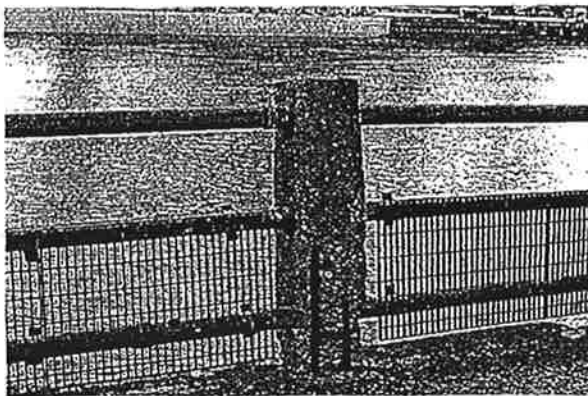
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**VENT 5 - VENT 6**

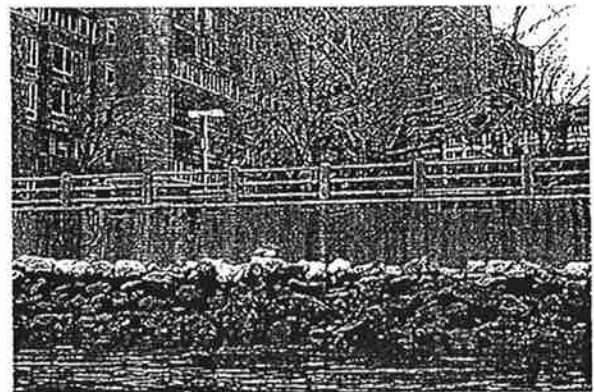


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**VENT 6 - VENT 7**



3

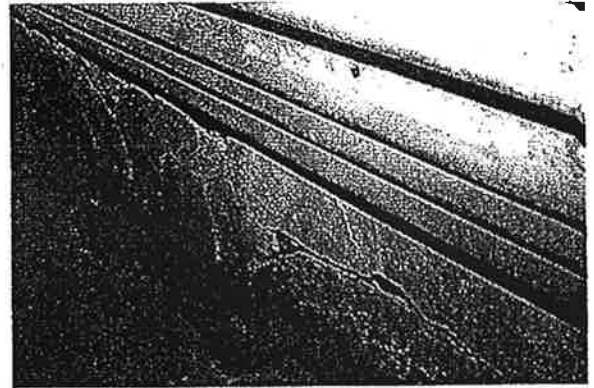


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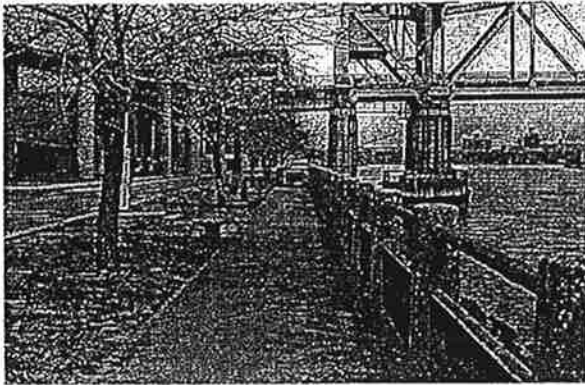
VENT 7 - VENT 8



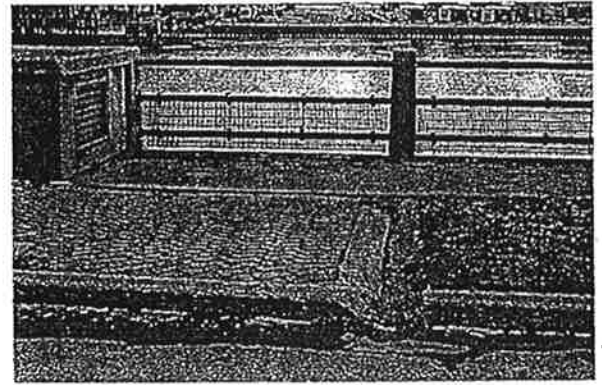
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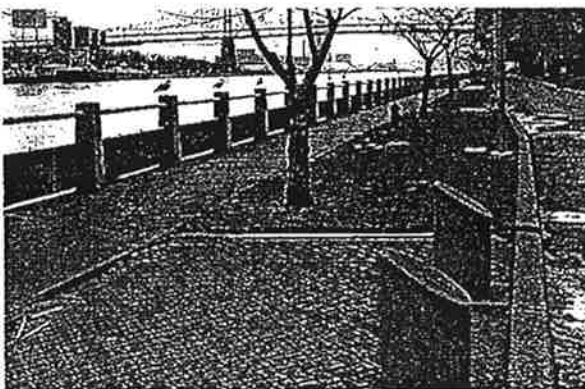
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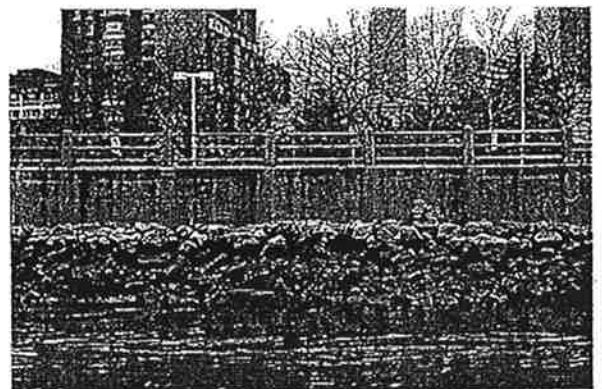
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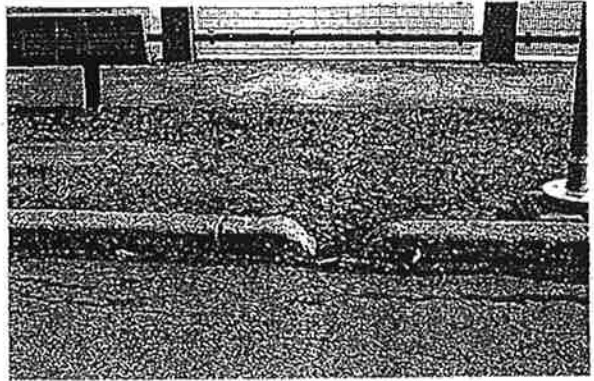


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VENT 8 - VENT 9



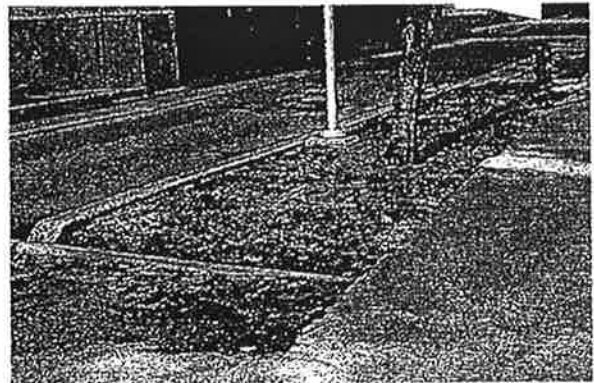
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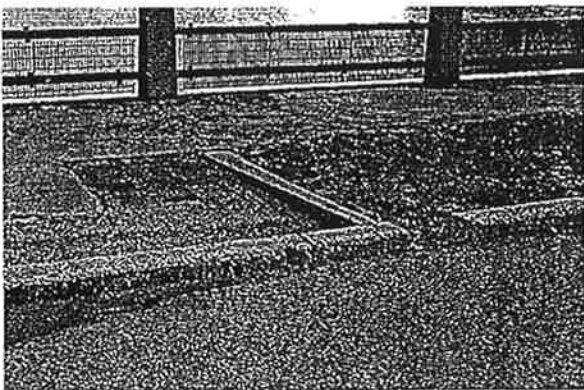
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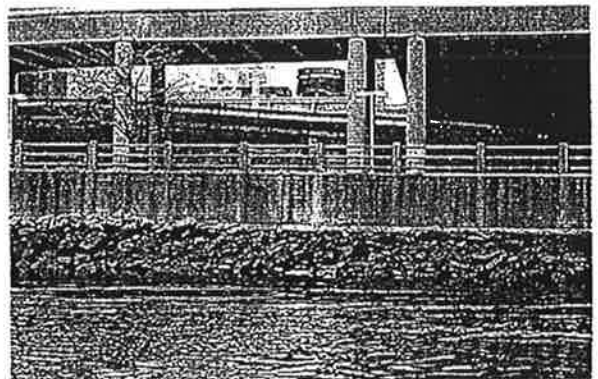
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5



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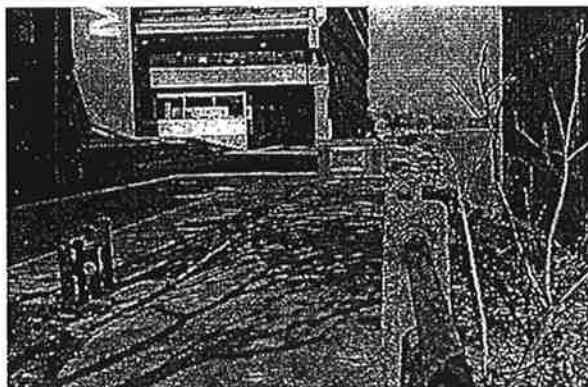
VENT 9 - VENT 10



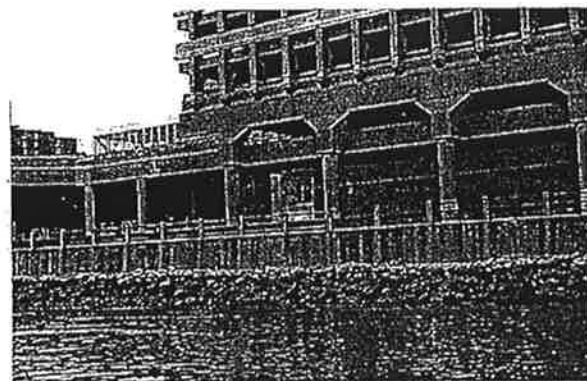
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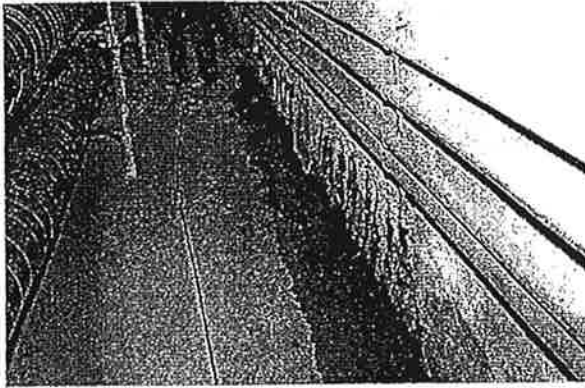


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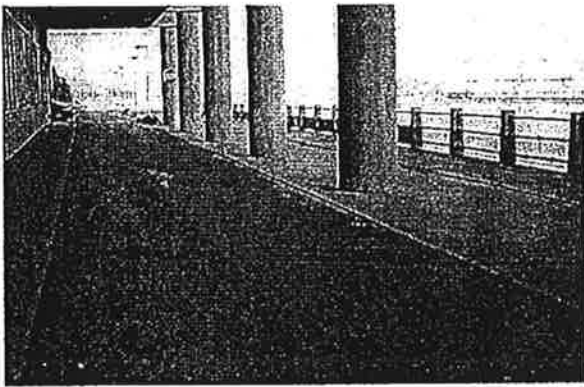
VENT 10 - VENT 11



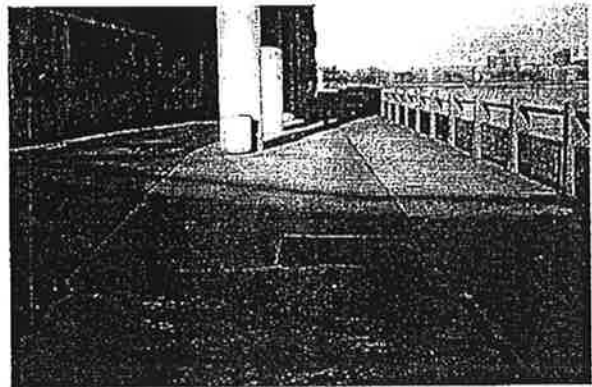
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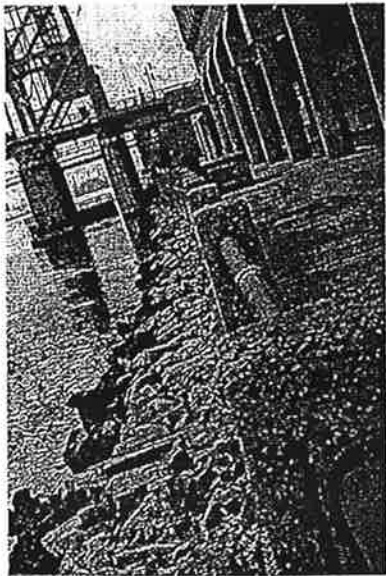
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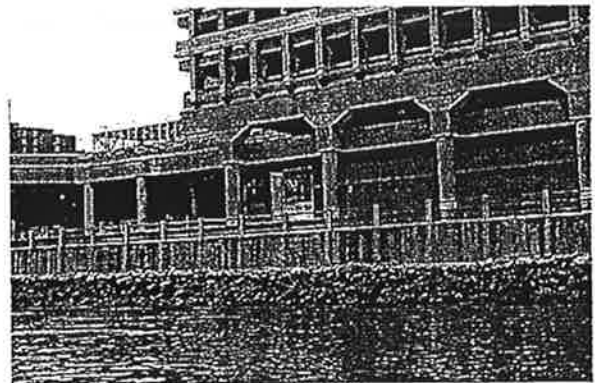
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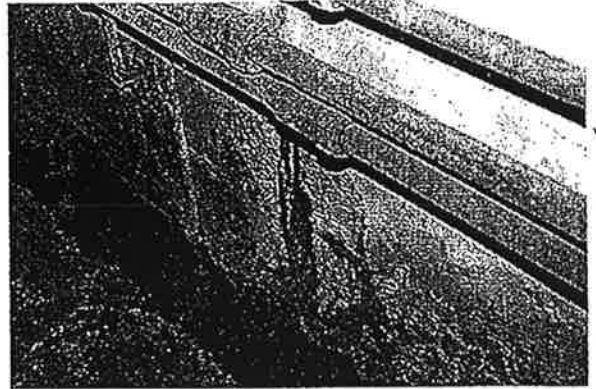


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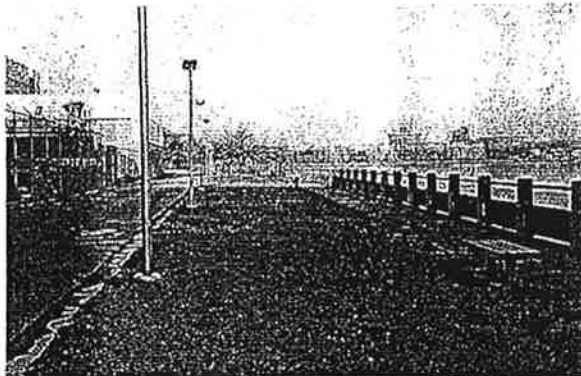
VENT 11 - VENT 12



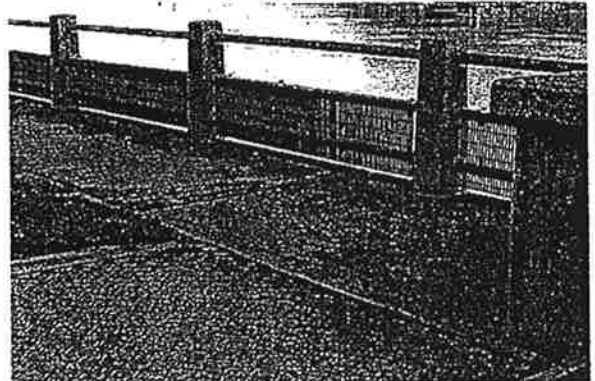
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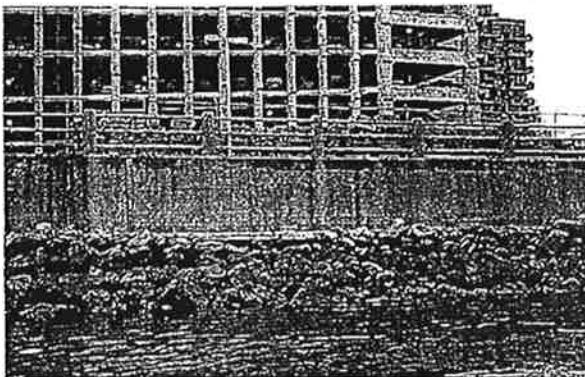
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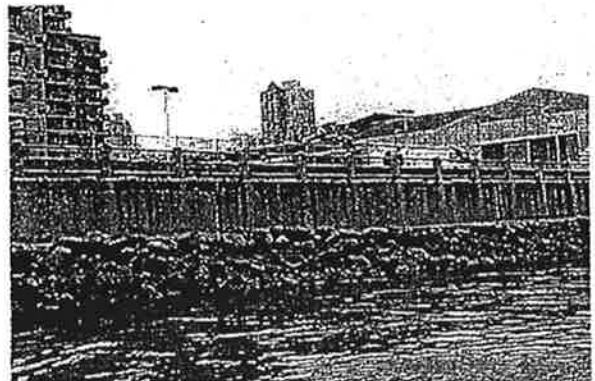
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5



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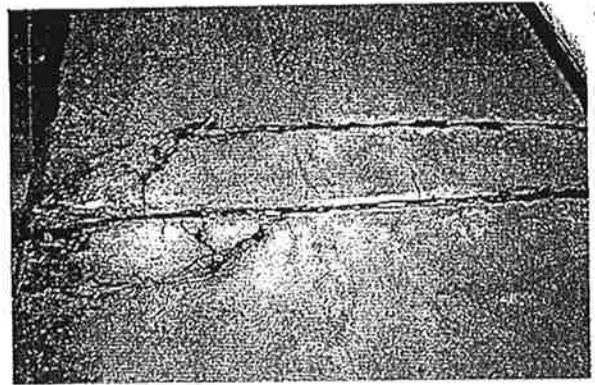
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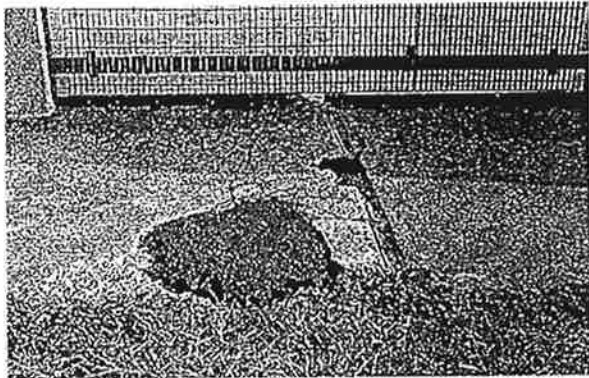
VENT 12 - VENT 13



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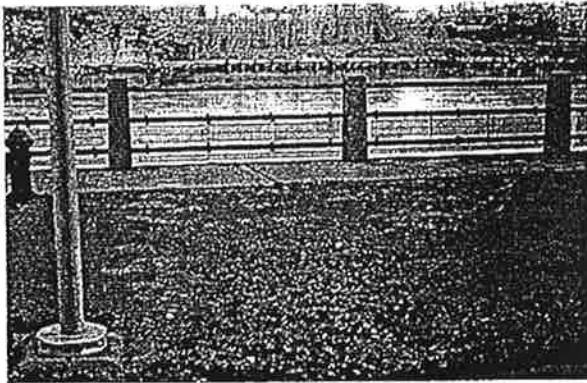
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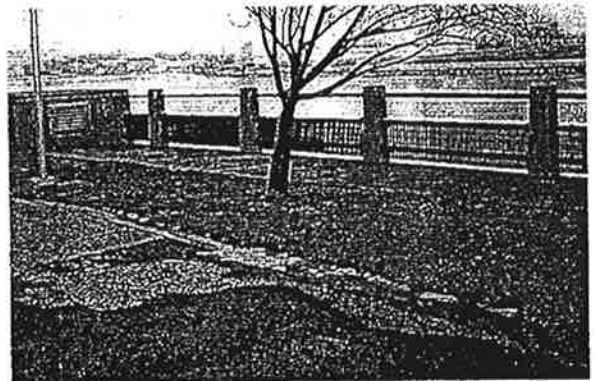
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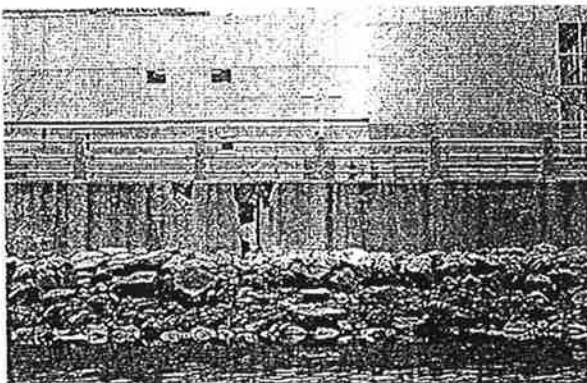
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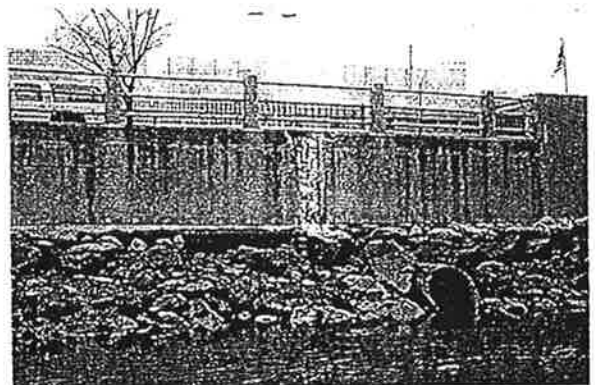
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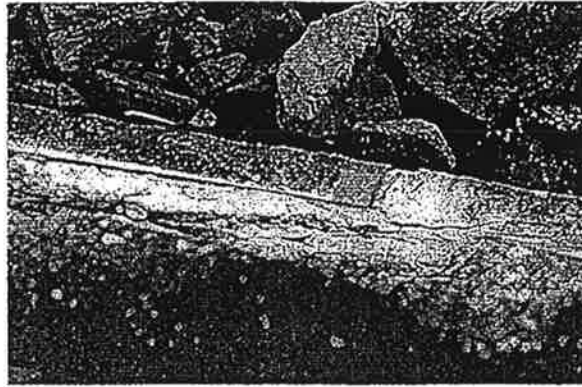


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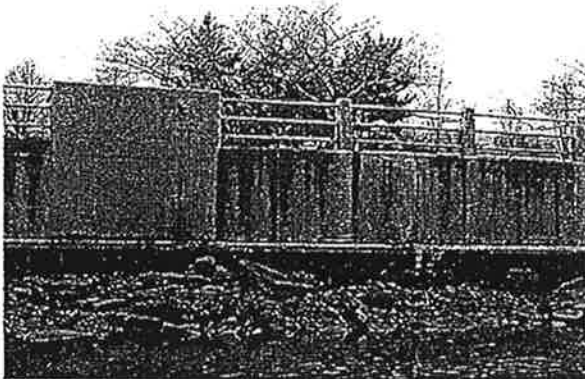
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**VENT 13 - VENT 14**

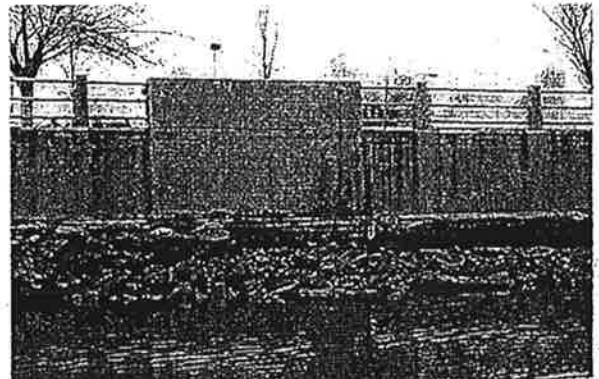


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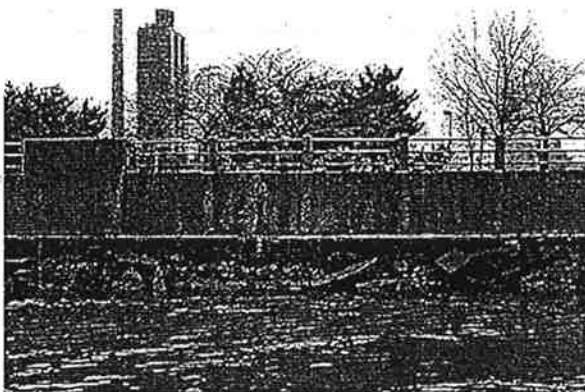
**VENT 14 - VENT 15**



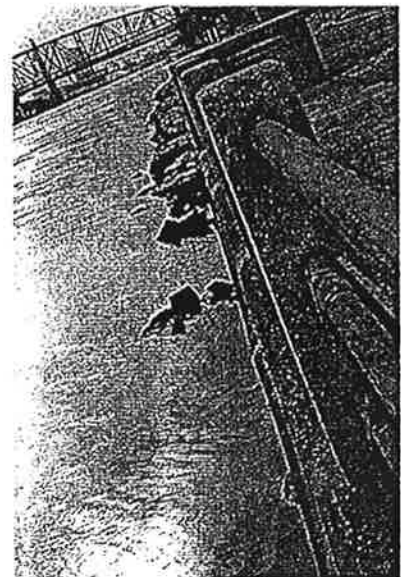
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**3**

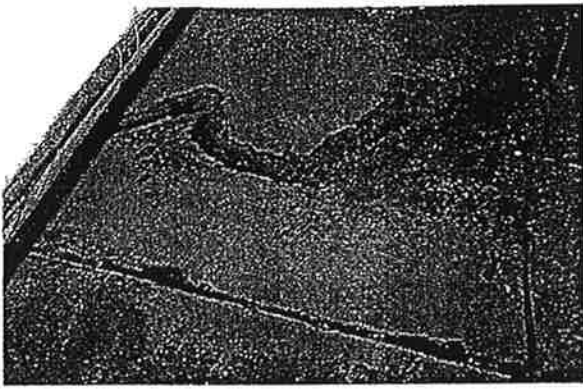


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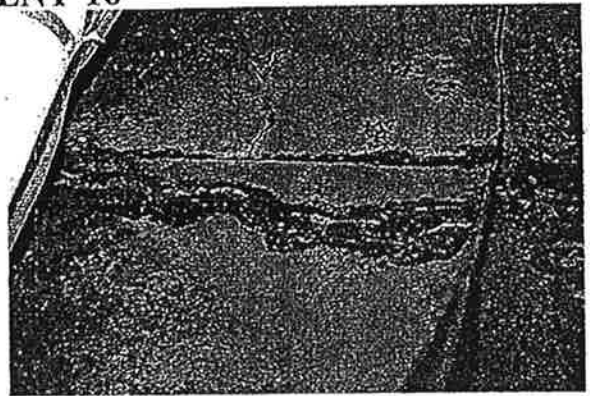


**5**

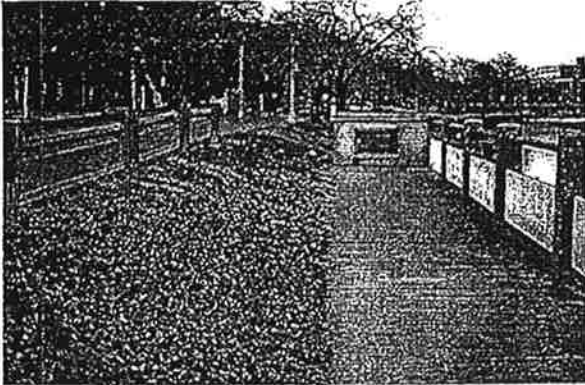
VENT 15 - VENT 16



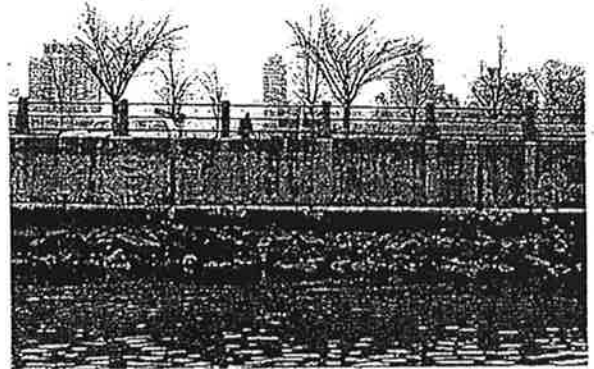
1



2



3



4



5



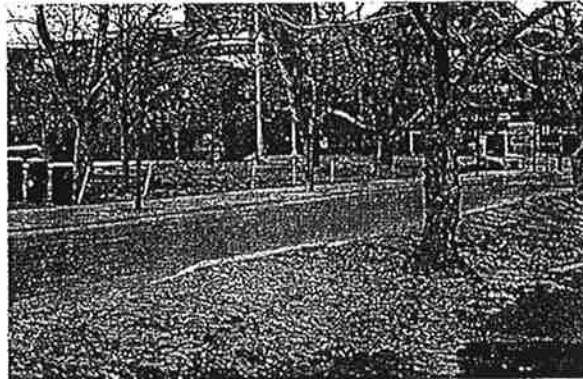
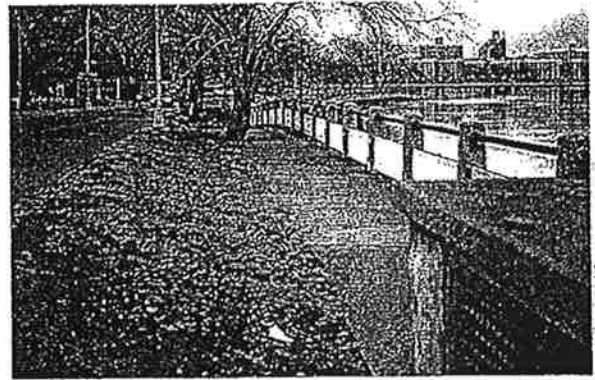
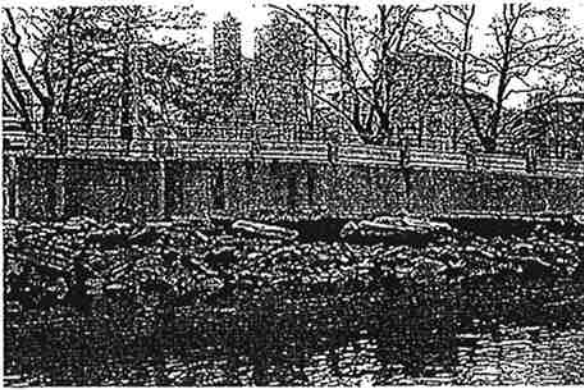
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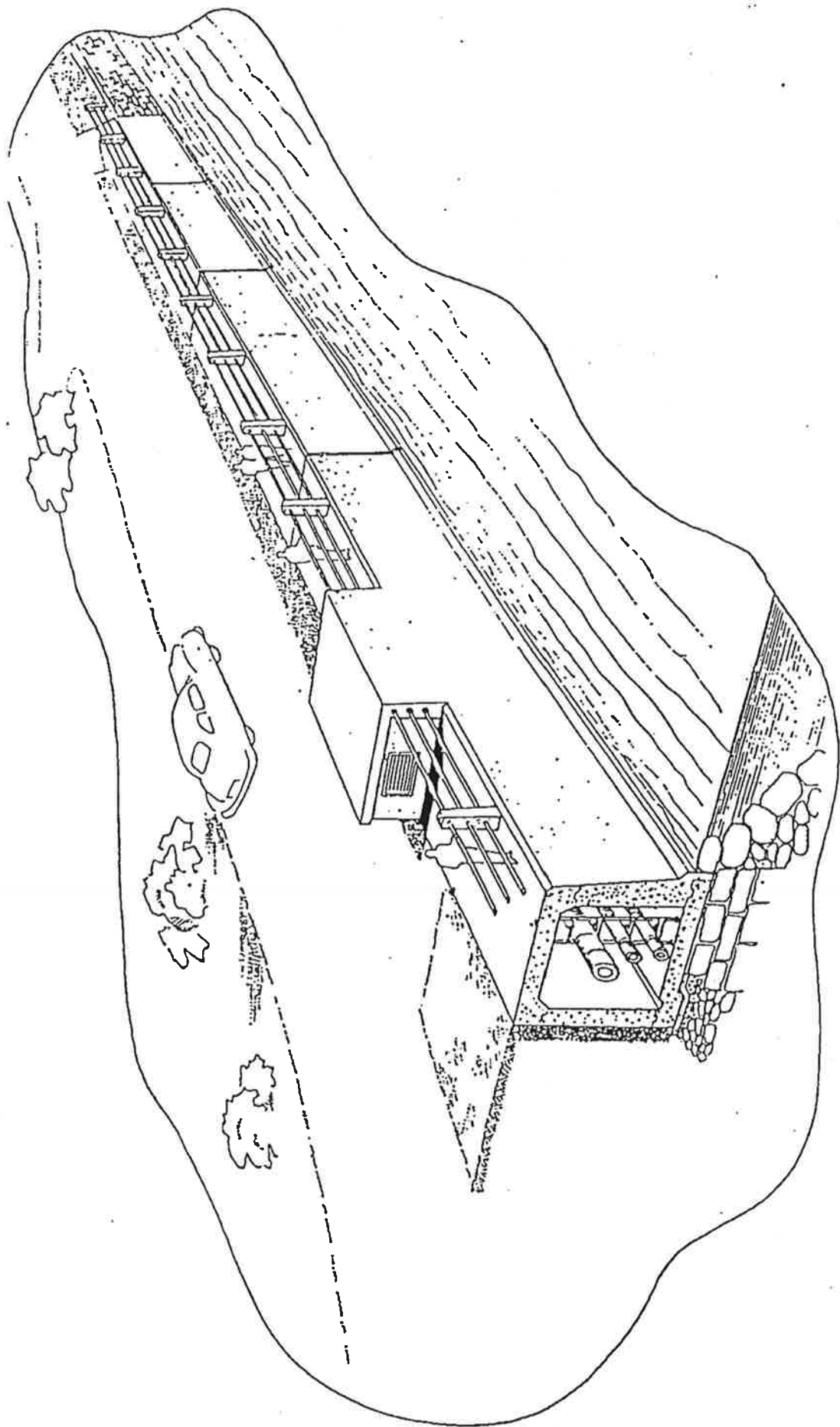
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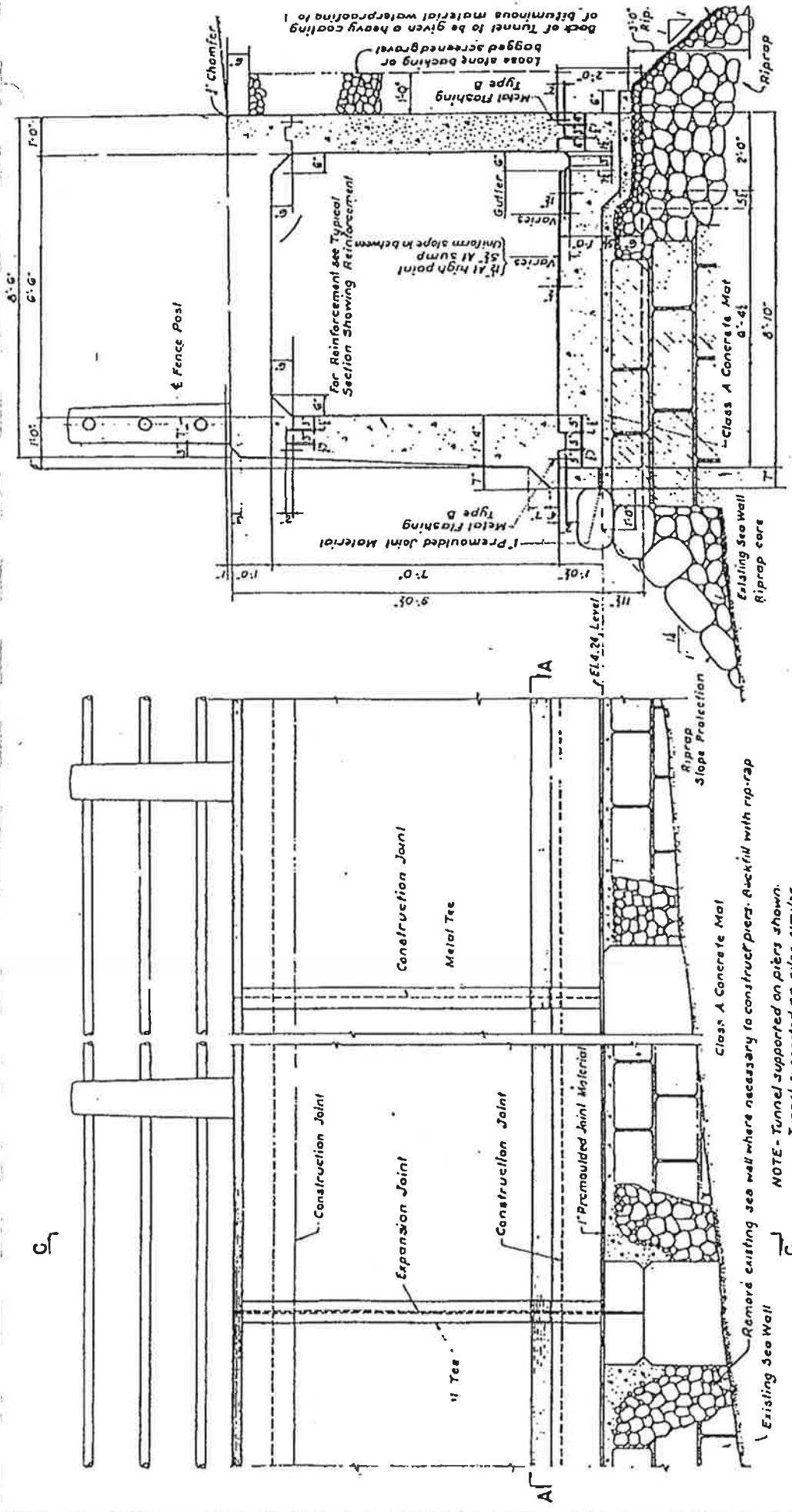
## VENT 16 - TO LAND VENT









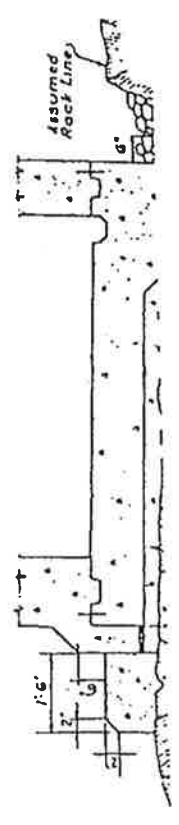
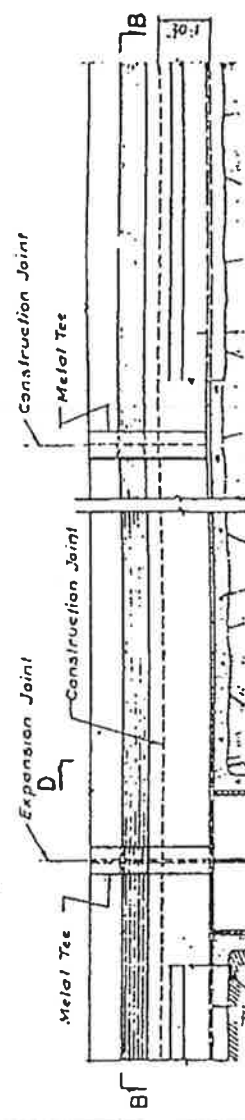


SECTION C - C

COMBINED STEAM TUNNEL AND SEA WALL  
TUNNEL ON EXISTING SEA WALL

SCALE: 1" = 10'

ELEVATION



NOTE - Tunnel supported on piles shown. Tunnel supported on piles similar.

Existing Sea Wall

Class A Concrete Mat

Riprap Slope Protection

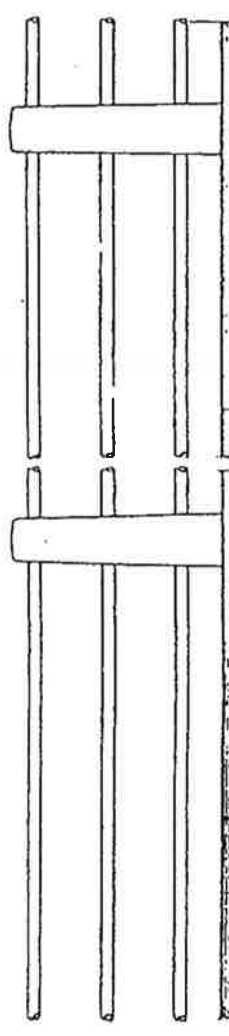
Back of Tunnel to be given a heavy coating of bituminous material waterproofing to 1' Chamfer.

For Reinforcement see Typical Section Showing Reinforcement

Loose stone backing or bogged screened gravel

1' Chamfer

Fence Post



1" Tee

Expansion Joint

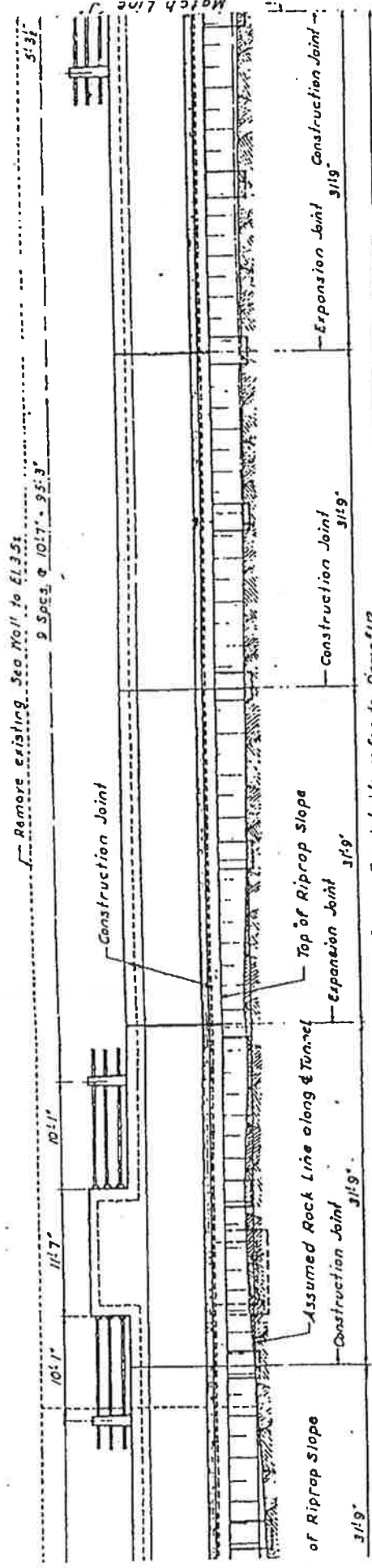
Construction Joint

Metal Tee

Construction Joint

A

B



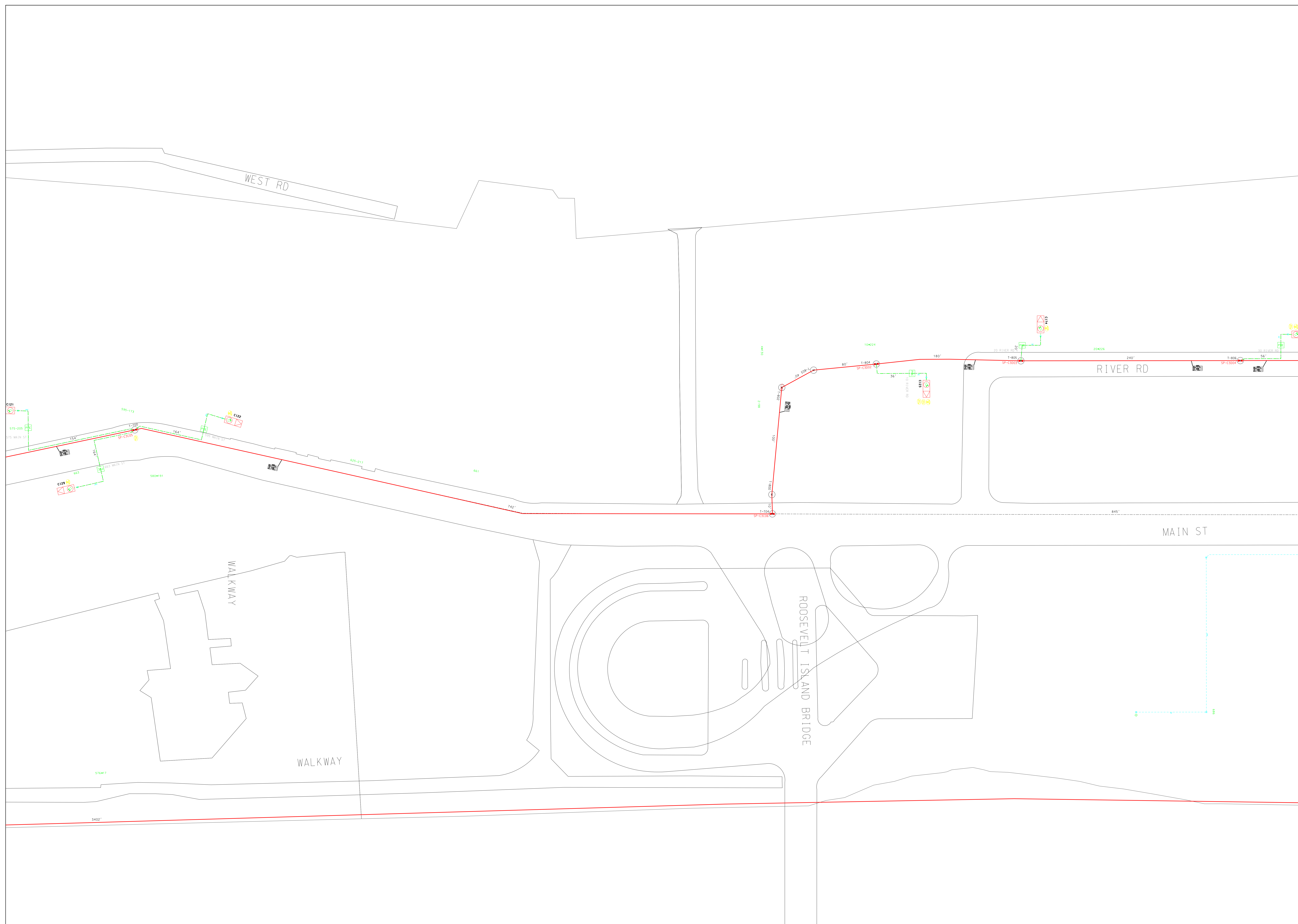
**APPENDIX D**

**AVAILABLE UTILITY MAPS**







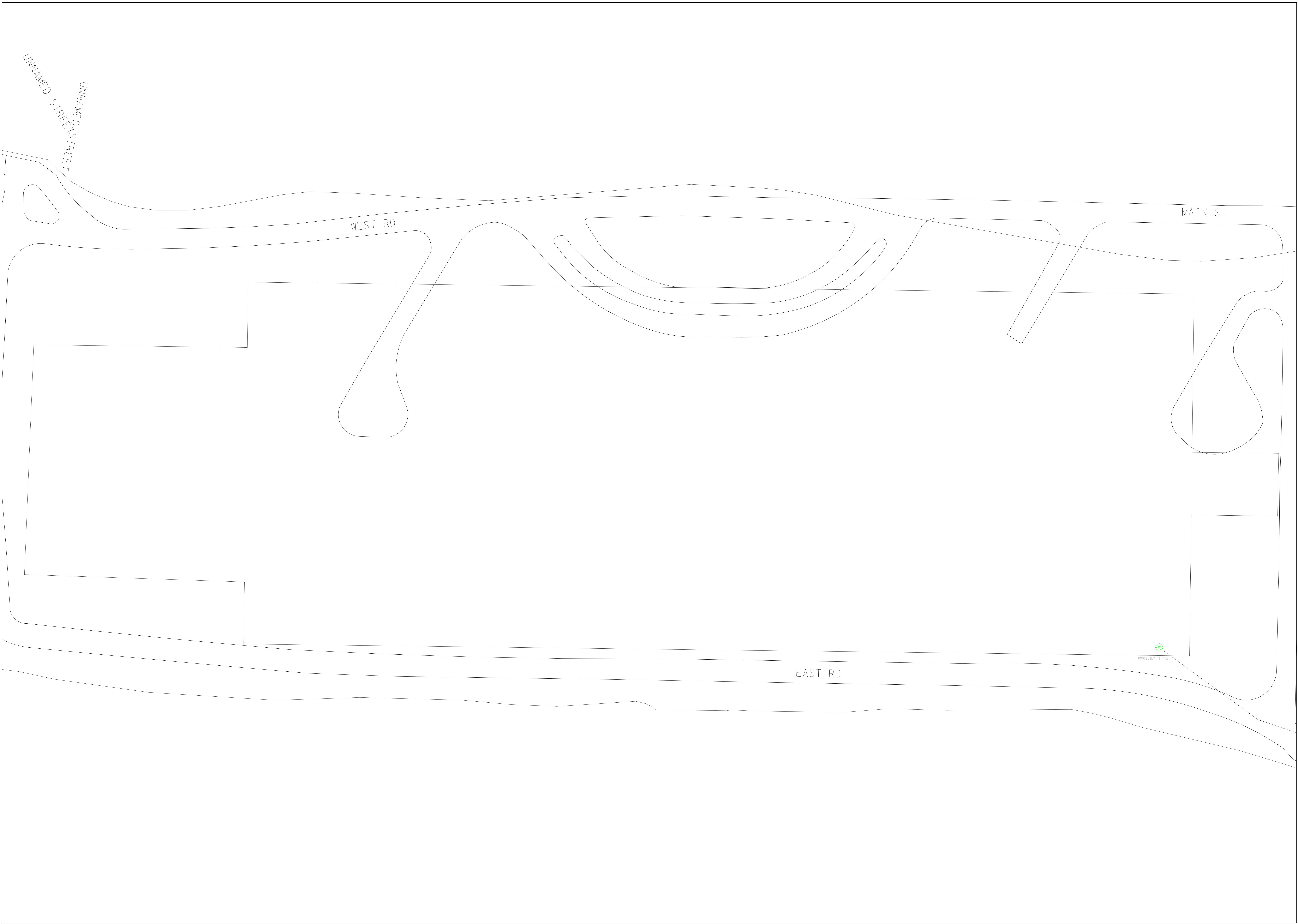




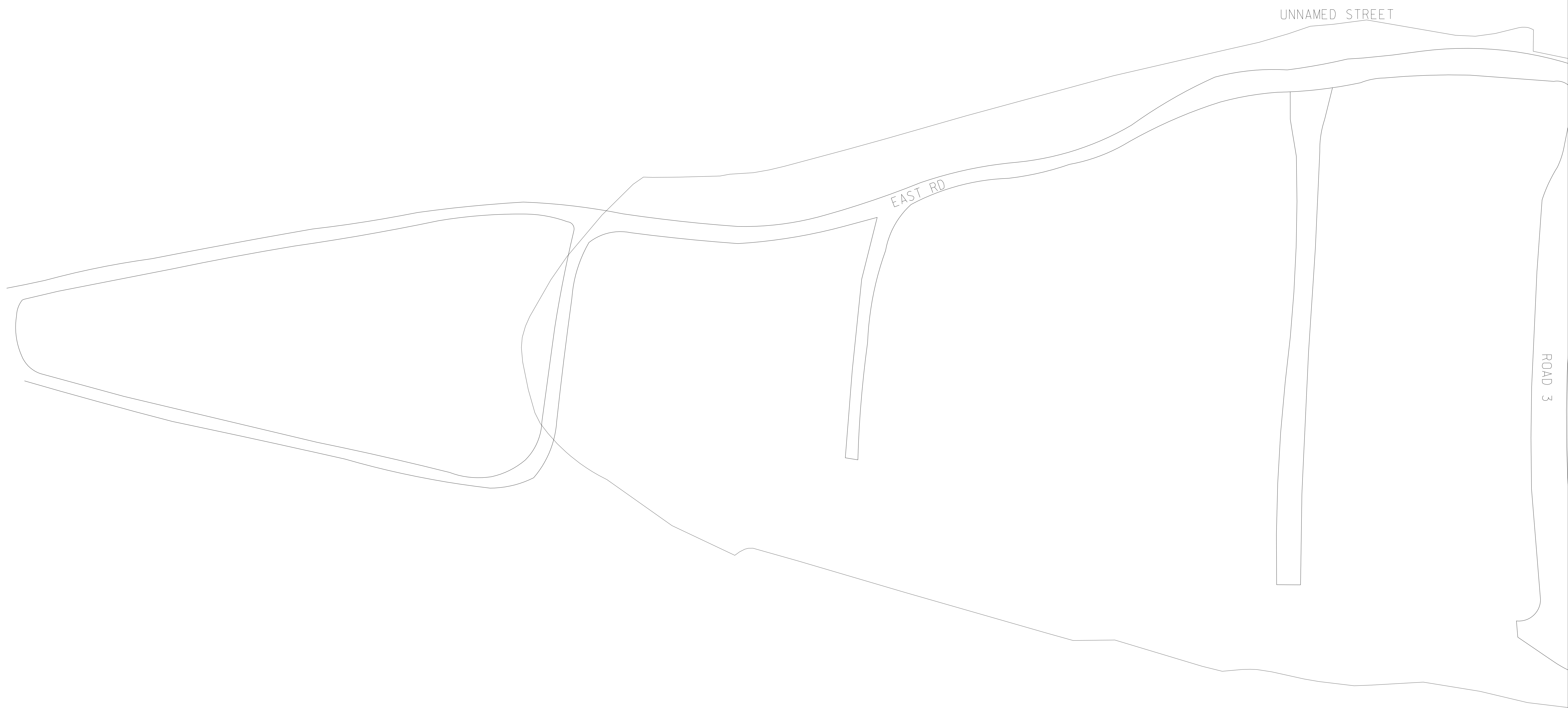












## **APPENDIX E**

# **THERMAL MODELING AND CALCULATIONS FOR FREEZE AND ICE-EXPANSION**

## Time to Freeze & Time to Expand

### Assumptions:

1. Starting condition, for weather is  $32^{\circ}\text{F}$  ( $0^{\circ}\text{C}$ ) and for water is  $32^{\circ}\text{F}$  ( $0^{\circ}\text{C}$ ).
2. Rapid temperature drop to  $10^{\circ}\text{F}$  ( $-12^{\circ}\text{C}$ ) occurs, cold temperature is sustained for at least one to two weeks.
3. Insulation of concrete and earth are ignored.
4. Conductivity of seawall ignored
5. Model is for 1 ft (0.31m) of standing water, infinite length, un-drained through joints.

### Time to Freeze

- Surface Area =  $2\text{m} \times 1\text{m} = 2\text{m}^2$
- Volume =  $2\text{m} \times 1\text{m} \times 0.31\text{m} = 0.62\text{m}^3$
- Weight =  $0.62\text{m}^3 \times 1000 \frac{\text{kg}}{\text{m}^3} = 620\text{kg}$
- Heat of Fusion (Water) =  $3.3 \times 10^3 \text{ J/kg}$

$$\Delta Q = 620 \text{ kg} \times 3.3 \times 10^3 \text{ J/kg}$$

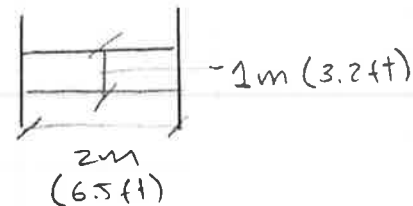
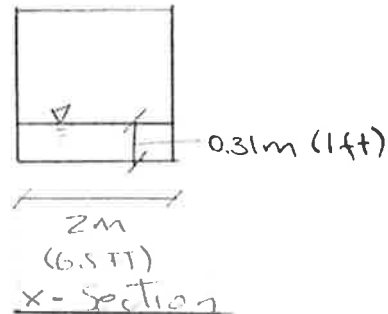
$$\Delta Q = 2.05 \times 10^6 \text{ J}$$

$$\text{Heat Flow} \Rightarrow q = \frac{KA \Delta T}{L}$$

$$K_{\text{air}} = 0.024 \text{ W/m}^{\circ}\text{C}$$

$$\Delta T = 0^{\circ} - (-12^{\circ}) = 12^{\circ}\text{C}$$

$$L = 0.001\text{m}$$



Steam Tunnel

Time to Freeze & Time to Expand.

BY \_\_\_\_\_ DATE \_\_\_\_\_

CHKD. \_\_\_\_\_ DATE \_\_\_\_\_

PROJ NO 100444601

SHEET 1 OF 2

**LANGAN**



### Time to Freeze Continuation

$$q = \frac{0.024 \frac{\text{W}}{\text{m}^{\circ}} (2 \text{ m}^2) (12^{\circ})}{0.001 \text{ m}} = 576 \text{ J/s}$$

$$t = \frac{2.05 \times 10^8 \text{ J}}{576 \text{ J/s}} = 355903 \cancel{s} \times \frac{1 \text{ hr}}{3600 \cancel{s}} = \underline{\underline{99 \text{ hrs}}}$$

### Time to Expand (0° to -6°)

• Specific Heat of Ice =  $2.1 \times 10^3 \frac{\text{J}}{\text{kg}^{\circ}}$

$$\Delta Q = 670 \cancel{\text{kg}} \times 2.1 \times 10^3 \frac{\text{J}}{\cancel{\text{kg}}^{\circ}} \times 6^{\circ} = 7.8 \times 10^6 \text{ J}$$

$$K_{\text{ice}} = 1.6 \frac{\text{W}}{\text{m}^{\circ}}$$

$$q = \frac{1.6 \frac{\text{W}}{\text{m}^{\circ}} (2 \text{ m}^2) (6^{\circ})}{0.31 \text{ m}} = 62 \text{ J/s}$$

$$t = \frac{7.8 \times 10^6 \text{ J}}{62 \text{ J/s}} = 126000 \cancel{s} \times \frac{1 \text{ hr}}{3600 \cancel{s}} = \underline{\underline{35 \text{ hrs.}}}$$

### Total time to Freeze and Expand

$$99 \text{ hrs} + 35 \text{ hrs} = \underline{\underline{134 \text{ hrs}}}$$

$$134 \text{ hrs} \times \frac{1 \text{ day}}{24 \text{ hrs}} = \underline{\underline{5.6 \text{ days}}}$$

Steam Tunnel

Time to Freeze & Time to Expand

BY \_\_\_\_\_ DATE \_\_\_\_\_

CKD. \_\_\_\_\_ DATE \_\_\_\_\_

PROJ NO. 100444601

SHEET 2 OF 2

**LANGAN**

## **APPENDIX F**

### **CALCULATIONS FOR ICE-EXPANSION FORCES AND STRUCTURAL CAPACITY**

# 1. Check Seawall

## (1) Shear taken by Keyway

Assume there will be 12" thick ice, the lateral ice thrust

$$P_s = 5 \text{ k/ft}; \quad P_u = 5 \times 1.6 = 8.0 \text{ k/ft}$$

Assume the Keyway as shown

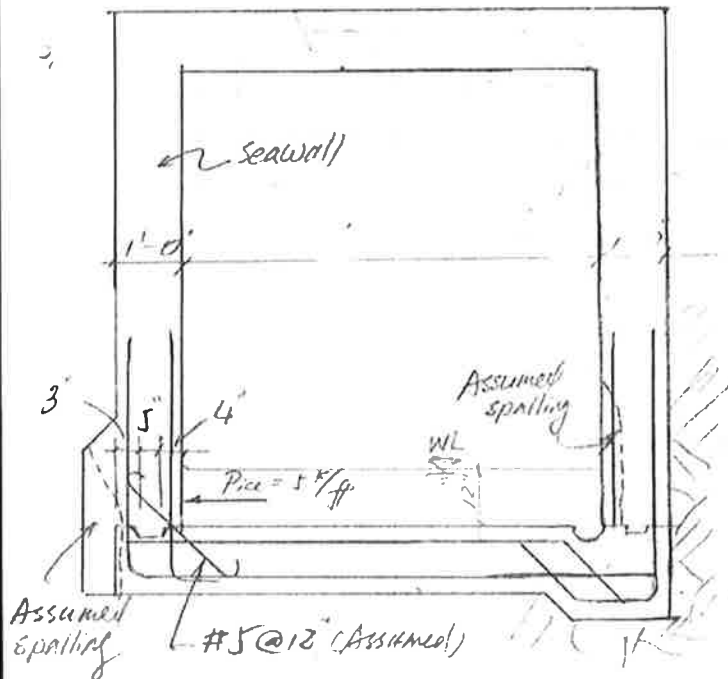
the outer width  $b = 2$ ,

$$f_c' = 2000 \text{ psi},$$

shear resistance = 70% of regular shear key due to the trapezoidal shape

$$\therefore \phi V_c = 0.75 \times 2 \sqrt{2000} \times 2 \times 12 \times 0.70$$

$$= 1.127 \text{ k/ft}$$



## (2) Shear taken by Dowels

$$\phi V_d = \phi A_v f_y M$$

$$\text{where, } A_v = 0.31 \text{ in}^2/\text{ft},$$

$$f_y = 40.0 \text{ ksi}$$

$M = 0.80$  due to low strength of concrete,

$$\phi V_d = 0.75 \times 0.31 \times 40 \times 0.80$$

$$= 7.44 \text{ k/ft}$$

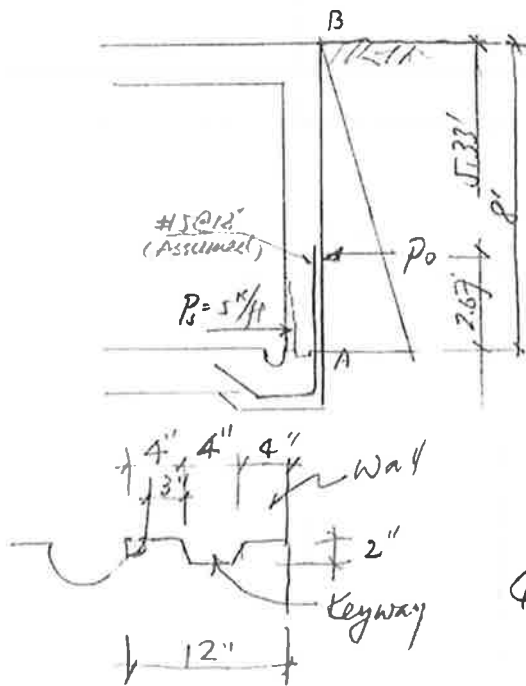
$$\phi V_d + \phi V_c = 7.44 + 1.127 = 8.567 \text{ k/ft} > P_u = 8.0 \text{ k}$$

$\therefore$  OK!

BY <u>gjs</u>	DATE <u>11/4/14</u>	PROJ. NO. _____
CKD. _____	DATE _____	SHEET _____ OF _____



## 2. Cheek Landside Wall



Use  $K_0 = 1 - \sin 33^\circ = 0.45$ ,  $\gamma = 120 \text{ pcf}$

$$\therefore P_0 = \frac{\gamma^2}{2} \times 0.12 \times 0.45$$

$$= 1.747 \text{ k/ft}$$

$$V_{A_0} \times 7.5 = P_0 \times (5.33 - 0.5)$$

$$V_{A_0} = \frac{1.747 \times 4.83}{7.5}$$

$$= 1.126 \text{ k/ft} \text{ --- Shear Resist. by Soil Pressure}$$

Assume the shear key as shown

$$\phi V_c = 0.75 \times 2 \sqrt{2000} \times 3 \times 12 \times 0.70$$

$$= 1.69 \text{ k/ft} \text{ --- Shear Resist. by Keyway}$$

$$\phi V_{sf} = \phi A_{sf} f_s \cdot u$$

$$= 0.75 \times 0.31 \times 40 \times 0.80$$

$$= 7.44 \text{ k/ft}$$

$$\Sigma \phi V = 7.44 + 1.69 + 1.126 = 10.41 \text{ k/ft} > P_u = 8.0 \text{ k/ft} \therefore \text{OK!}$$

BY \_\_\_\_\_ DATE \_\_\_\_\_

PROJ. NO. \_\_\_\_\_

CKD \_\_\_\_\_ DATE \_\_\_\_\_

SHEET \_\_\_\_\_ OF \_\_\_\_\_

**LANGAN**

**APPENDIX G**

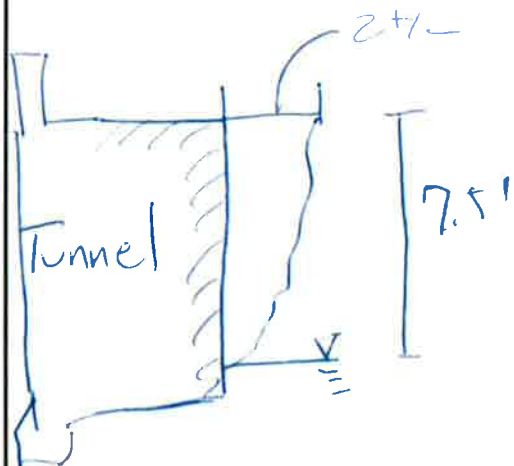
**TEST-PIT LOGS**

## DAILY FIELD REPORT

Project No. 10044601	Client: RIOCC	Date: October 23, 2014
Project Steam Tunnel		Weather: Rain - 55 Degrees
Location Roosevelt Island, NY		Time: 7:30 am - 1:30 pm
Contractor & Equipment: Fleming & Sons, Backhoe		Present At Site: Martin Fleming, 3 Laborers, Juan C. Osorio (Langan)

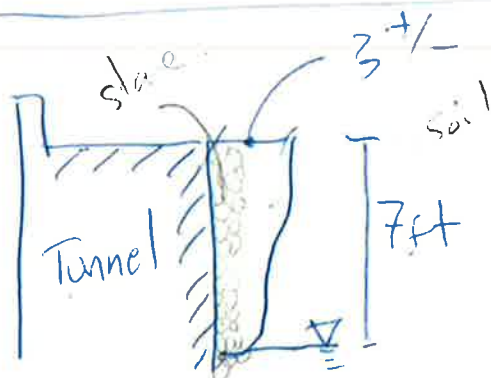
### Observations, Discussions, Test Results, Etc.

The contractor completed a total of 5 test pits along the steam tunnel. The locations had previously marked by Langan Engineering based on the test pit location plans provided to the RIOCC.



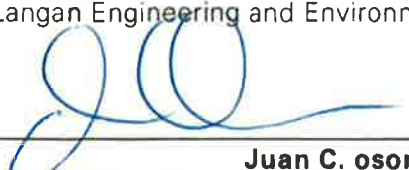
- Wall in good condition, no cracks visible
- No water proofing
- No stone

Test Pit 6 - STA: ~~8+92~~ 8+92



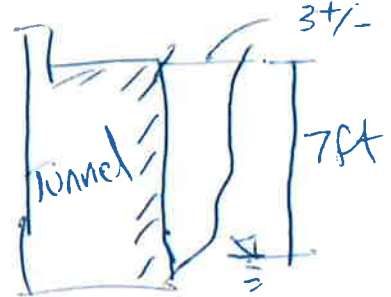
- wall in good condition, no cracks visible
- No water proofing
- Crushed stone in the first foot along the wall

Test Pit 5 - STA: 11+99

CC:	By: Langan Engineering and Environmental Services
	
	Juan C. osorio

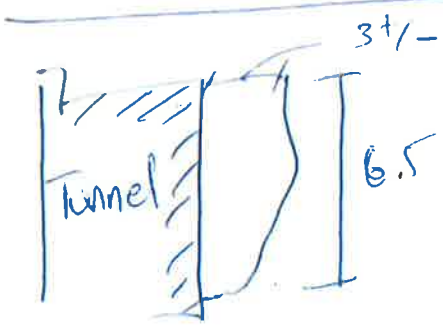


Observations, Discussions, Test Results, Etc. (Continued)



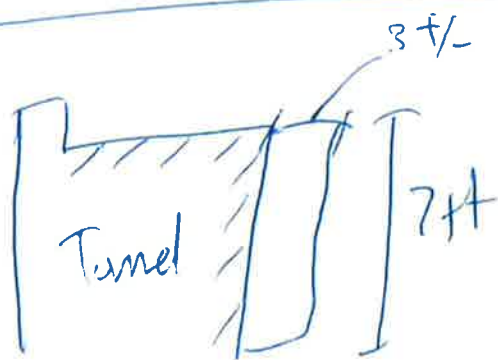
- wall in good condition, no cracks visible
- No water proofing
- Crushed stone.

Test Pit 4 STA: 17+13



- Wall in good condition, no cracks visible.
- No water proofing
- Crushed stone.

Test Pit 3 STA: 25+90



- Wall in good condition, no visible cracks
- No water proofing
- No stone.

Test Pit 1 STA: 45+60



Test Pit 6 – Steam Tunnel exterior wall in good condition



Test Pit 5 – Steam Tunnel exterior wall in good condition



Test Pit 4 – Steam Tunnel exterior wall in good condition



Test Pit 3 – Steam Tunnel exterior wall in good condition



Test Pit 1 – Steam Tunnel exterior wall in good condition





