CONDITIONS REPORT & DESIGN MEMORANDUM

STEAM TUNNEL ASSESMENT

ROOSEVELT ISLAND, NEW YORK

Prepared for:

ROOSEVELT ISLAND OPERATING CORPORATION
591 MAIN STREET
ROOSEVELT ISLAND
NEW YORK, NEW YORK 10044

Prepared by:

Langan Engineering, Environmental, Surveying, and Landscape Architecture, D.P.C.
River Drive Center 1
Elmwood Park, New Jersey 07407

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RIOC

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INTRODUCTION

This report presents the results of our assessment of the Steam Tunnel structure that exists between the power plant and the Coler-Goldwater Hospital complex on Roosevelt Island. This structure has been historically utilized as a conduit for the transmission of steam from the plant to the hospitals and other Island buildings, and as a service vault for various other utility services.

We understand that it is currently anticipated that the power plant will be shut down and the tunnel will no longer be utilized by the NYC Health and Hospitals Corporation (HHC) in the near future. As almost the entire tunnel length is also an integral component of the Island's east-side East River seawall, it is anticipated that the structure will remain. As such, the Roosevelt Island Operating Corporation (RIOC) retained Langan to complete an engineering inspection report to establish existing structural and functional conditions and to make engineering recommendations for the structure.

EXECUTIVE SUMMARY

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

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.

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 concrete haunch erosion at the seawall exterior base, the under-mining of the tunnel floor-slab, and deficient rip-rap rock levels on the shore-line.

Should these conditions not be addressed in the near-term, dangers exist to the tunnel, seawall and promenade. In the case of the interior spalling, the potential exists for a catastrophic failure should heavy traffic 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 under-mining 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 affirmed 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 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.

Preliminary remedial construction designs are 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.

We recommend that any decision regarding the tunnel be made with a commitment to initiate the recommended program of remedial repairs. We believe that the steam heat can be terminated this winter, and that a follow-up inspection be conducted if cold weather conditions are persistently very severe.

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 at the time of writing this report, the south campus of Coler-Gold water had closed and demolition had recently commenced; 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 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.

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 Investigation

In June 2001 the United States Army Corps of Engineers (USACE) issued a Seawall Study ("USACE Study") for Roosevelt Island on behalf of RIOC, 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.

OBSERVATIONS

Our observations are presented in the paragraphs below.

Mapping and Recording Methods

Our scope of investigation was completed over the course of four site visits, conducted in September and October of this year, and included interior and exterior documentation of observable conditions. We had also accessed the tunnel interior in November 2013 and February 2014. While our inspections 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 RIOC 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

Promenade Review

We walked and 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 photographs 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 (Fig XX).
- 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 (Sta0+00 at the Coler basement entrance, and increasing thru Sta61+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 is 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 also 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 approximately 30 to 35 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.

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.

Tunnel Ceiling

Our observations of the tunnel ceiling revealed minimal evidence of structural distress. A single area of concrete spalling with severely corroded rebar was observed in the tunnel extension leading to the Goldwater Hospital.

Concrete Sumps

We removed the gratings of a number of accessible sump stations. Our observations of the concrete surfaces within revealed no signs of damage. We understand that, due to a recent HHC maintenance effort, all pumps are operational.

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 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 PSE&G 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.

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.

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.

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. 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

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.

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 once the flow of steam is terminated.

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 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 RIOC 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.

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.

Thermal Evaluation of Tunnel Conditions

It is our understanding that the steam transmission may be terminated by the end of the year. 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.

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 shore.

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 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.

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.

POST-SHUTDOWN OBJECTIVES

A critical issue is whether the tunnel can be left un-heated once the steam service is withdrawn. Due to the tunnel extreme length, sustaining heat inside would be an expensive operation to install, maintain, and fund energy needs.

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-inchdepth. 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.

Accordingly we believe that the tunnel heat can be terminated this winter. We recommend that, if a period of sustained extreme cold weather endures, that RIOC and Langan should perform a follow-up walkthrough to confirm the underlying assumptions and conclusions of our analyses.

In an un-heated condition, over the longer term the cooler temperatures will 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 two design options for these repairs (refer to Drawings RR-1 and RR-2). One design option includes insertion of a longitudinal pipe to allow for continued operation and maintenance of the floor drainage and pump system; whereas the other option makes no provisions for tunnel drainage.

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.

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.

Rip-Rap Placement

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 the areas In these areas the rip-rap should be placed atopa12" 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.

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.

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 is not yet known whether HHC will remove the steam and condensate pipework. 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.

Marine Permitting

The necessary ("tidal wetlands" and "open waters") permits have not been approved that would allow marine work to be done at the moment. Marine permit approvals should be sought and secured from NYS Department of Environmental Conservation (DEC) and the US Army Corps of Engineers.

We do not believe that these obtaining these permits should be onerous as repairing of bulkheads and shorelines without substantial modification is generally covered by broad-approval standing permits. However, as the DEC approval process can be lengthy we recommend early filing of the application so as to avoid later loss of time.

Near-Term Implementation

Based upon our review of conditions and our analyses performed, we believe that the tunnel steam heat can be terminated this winter. We recommend that, if a period of sustained extreme cold weather endures, that Langan should perform a follow-up walkthrough to confirm the underlying assumptions of our analyses. Observations of interest would be whether ice formation occurs to any depth and whether contraction of the tunnel segments results in grater inflow of water. If agreeable to all parties, these observations can be made both with and without the pumps in operation.

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 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.

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 RIOC HHC, 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, discussion of design objectives for the tunnel in a shut-down state, 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 (without drainage) – RR 1
2. Remedial Repair to Tunnel Interior (with drainage) – RR 2
3. Remedial Repair to Tunnel Exterior – RR 3
4. Placement of Rip-Rap Where Deficient – PR 1

Tables

Appendices

LEGEND

STEAM TUNNEL FOOT PRINT	
STEAM TUNNEL CENTER LINE	
AIR VENT	VENT

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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REVISIONS		

LANGAN
River Drive Center 1, 619 River Drive, Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA ABU DHABI ATHENS DOHA DUBAI ISTANBUL
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
Langan Holding Co. LLC
Langan International LLC
Collectively known as Langan
N.J. CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

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

Project No. 100444601	Drawing No. VA101
Date 9/29/2014	
Scale 1" = 50'	
Drawn By VP / Checked By JCO	
Submission Date	

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LEGEND

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STEAM TUNNEL CENTER LINE	
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T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
Langan C.T., Inc., LLC
Langan Engineering and Surveying, P.C.
Collectively known as Langan
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project

STEAM TUNNEL ASSESMENT

ROOSEVELT ISLAND

NEW YORK NEW YORK

Drawing Title

AERIAL LOCATION PLAN

(STA. 29+00 TO 46+00)

Project No. 100444601	Drawing No. VA102
Date 9/29/2014	
Scale 1" = 50'	
Drawn By VP / Checked By JCO	
Submission Date	

LEGEND

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River Drive Center 1, 619 River Drive, Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO
VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Surveying, P.C.
Langan Treadwell Rollo
Langan International LLC
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NJ CERTIFICATE OF AUTHORIZATION NO. 24GA27996400

Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
AERIAL LOCATION PLAN
(STA. 12+00 TO 29+00)

Project No.	100444601
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Scale	1" = 50'
Drawn By	VP
Checked By	JCO
Submission Date	
Drawing No.	VA103

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LEGEND

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NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO
VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
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NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project

STEAM TUNNEL ASSESMENT

ROOSEVELT ISLAND

NEW YORK NEW YORK

Drawing Title

AERIAL LOCATION PLAN

(STA. 00+00 TO 12+00)

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Drawn By VP / Checked By JCO	
Submission Date	

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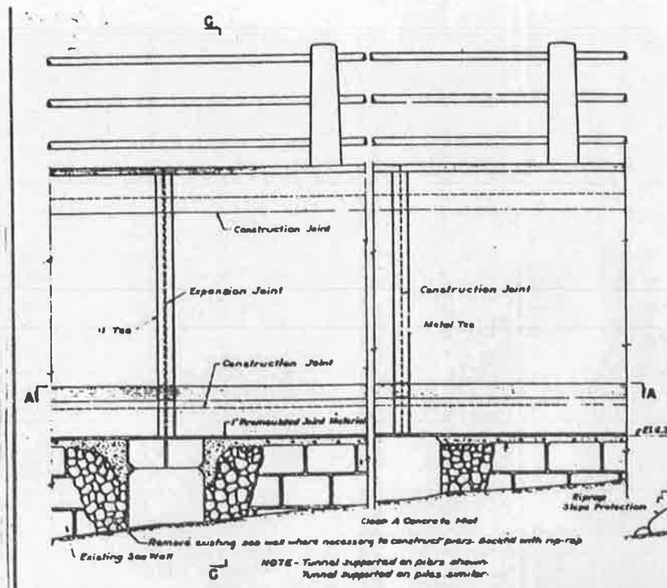
HISTORICAL DESIGN PLANS
(PARTIAL SET)

LANGAN

G & H NO. 2133C-3-067



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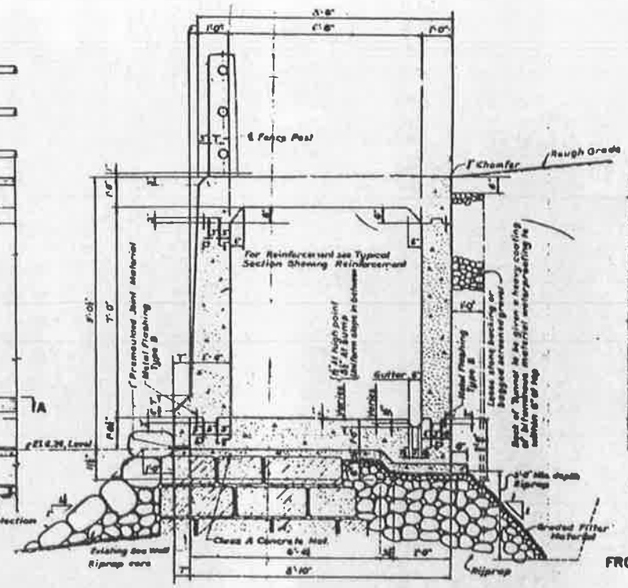

SECTION C-C

COMBINED STEAM TUNNEL AND SEA WALL
TUNNEL ON EXISTING SEA WALL

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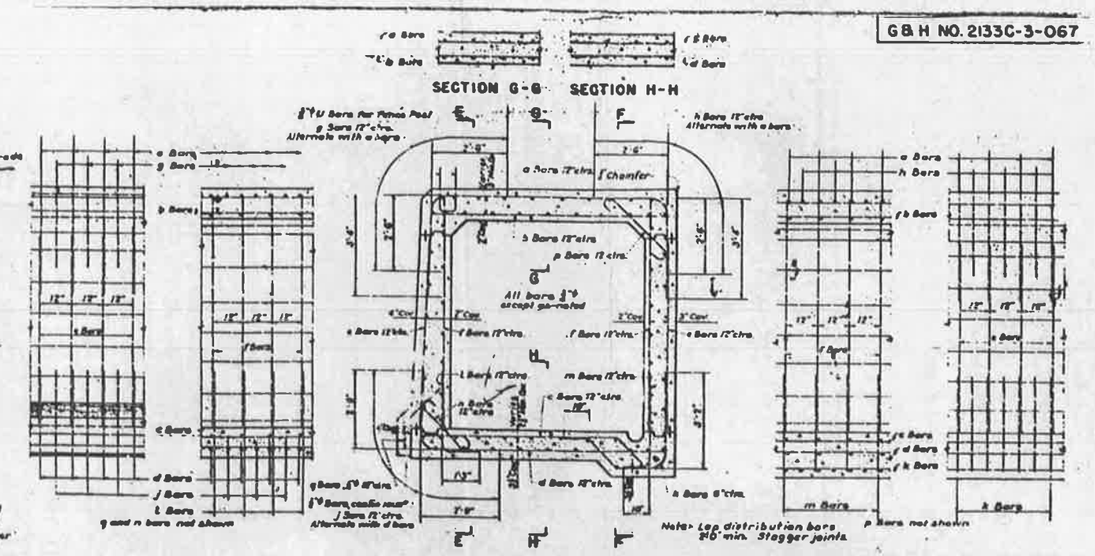

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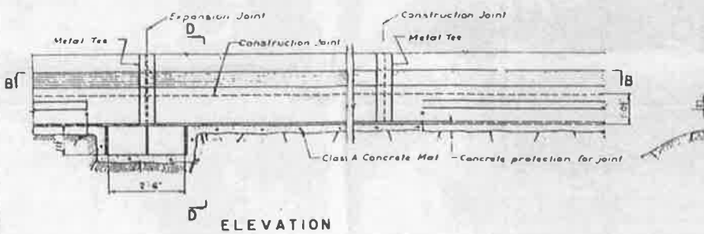

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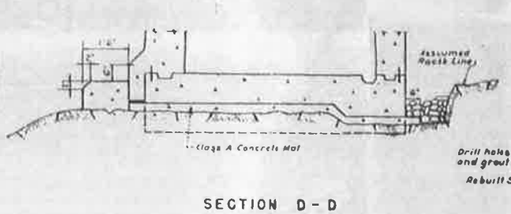

SECTION D-D

COMBINED STEAM TUNNEL AND SEA WALL
TUNNEL ON ROCK

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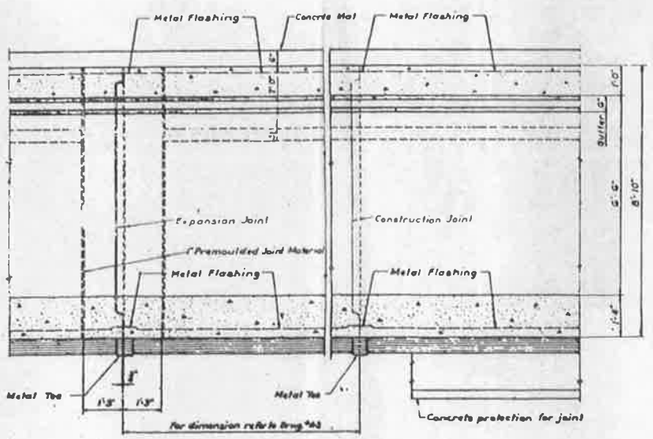
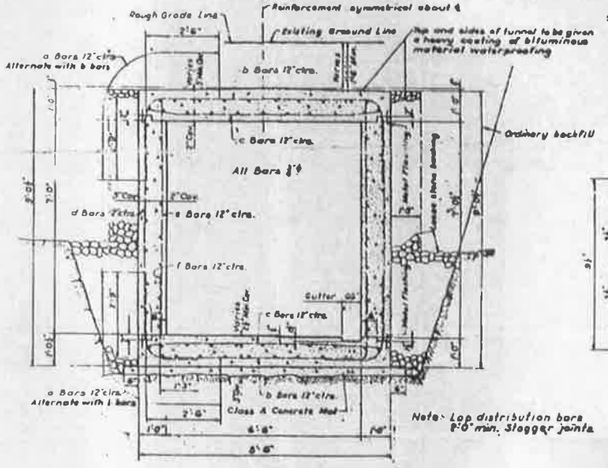
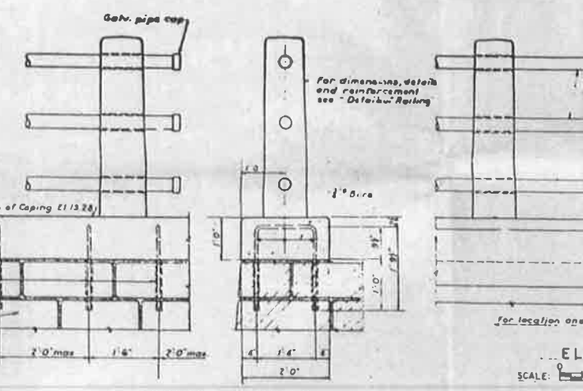


SECTION A-A
SECTION B-B SIMILAR



TYPICAL SECTION
INLAND TUNNEL



COPING DETAILS
AT JUNCTION OF INLAND TUNNEL WITH SEA WALL

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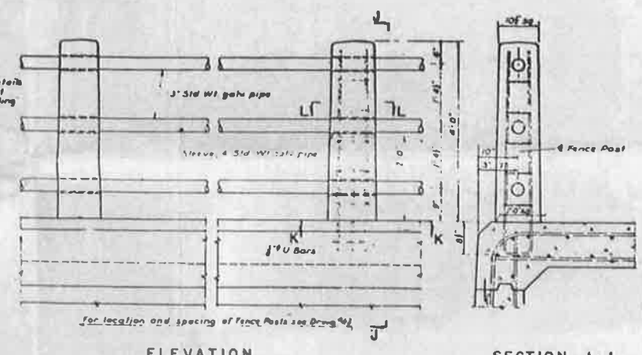
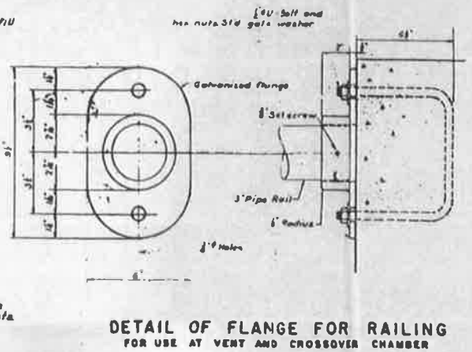


ELEVATION

SCALE:

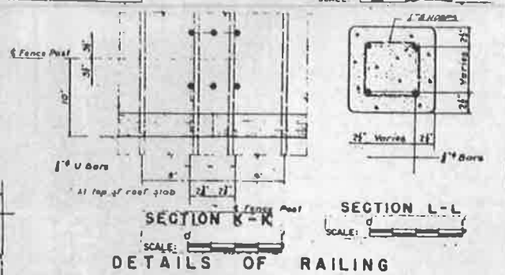
SECTION J-J

SCALE:



DETAIL OF FLANGE FOR RAILING
FOR USE AT VENT AND CROSSOVER CHAMBER

SCALE:



SCALE:

SCALE:

DETAILS OF RAILING

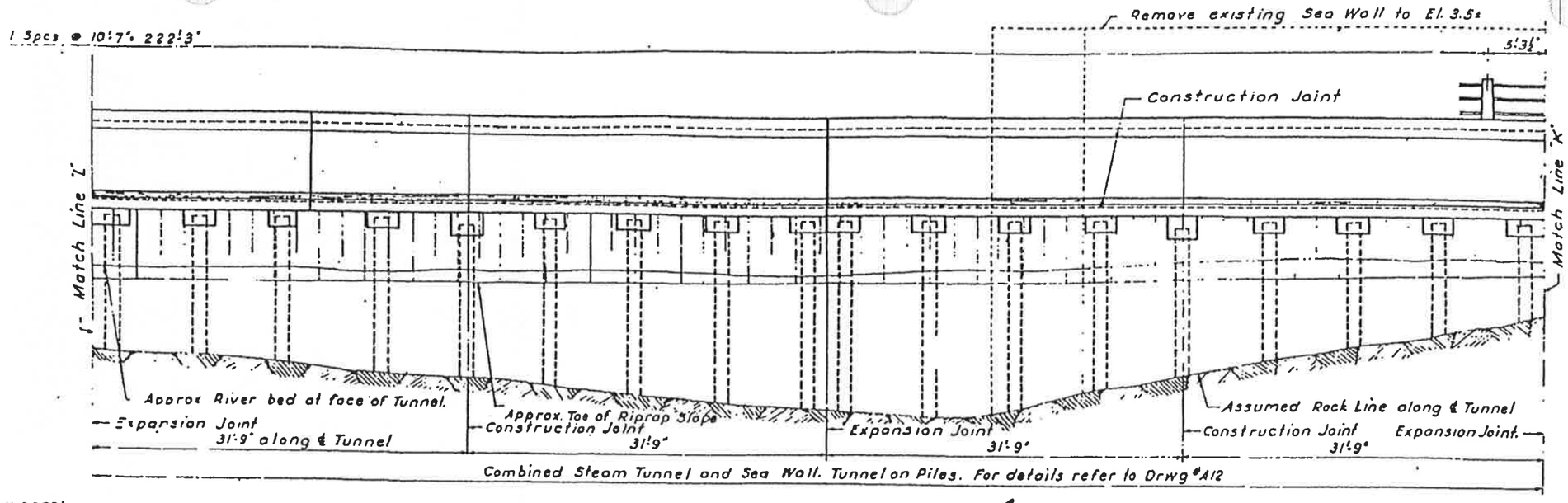
RECORD DRAWING
CITY OF NEW YORK
DEPARTMENT OF PUBLIC WORKS
DIVISION OF ENGINEERING AND ARCHITECTURE

POWER PLANT EXPANSION
PHASE "B" — COMBINED STEAM TUNNEL AND SEA WALL — STAGE ONE
WELFARE ISLAND BOROUGH OF MANHATTAN
FOR THE DEPARTMENT OF HOSPITALS

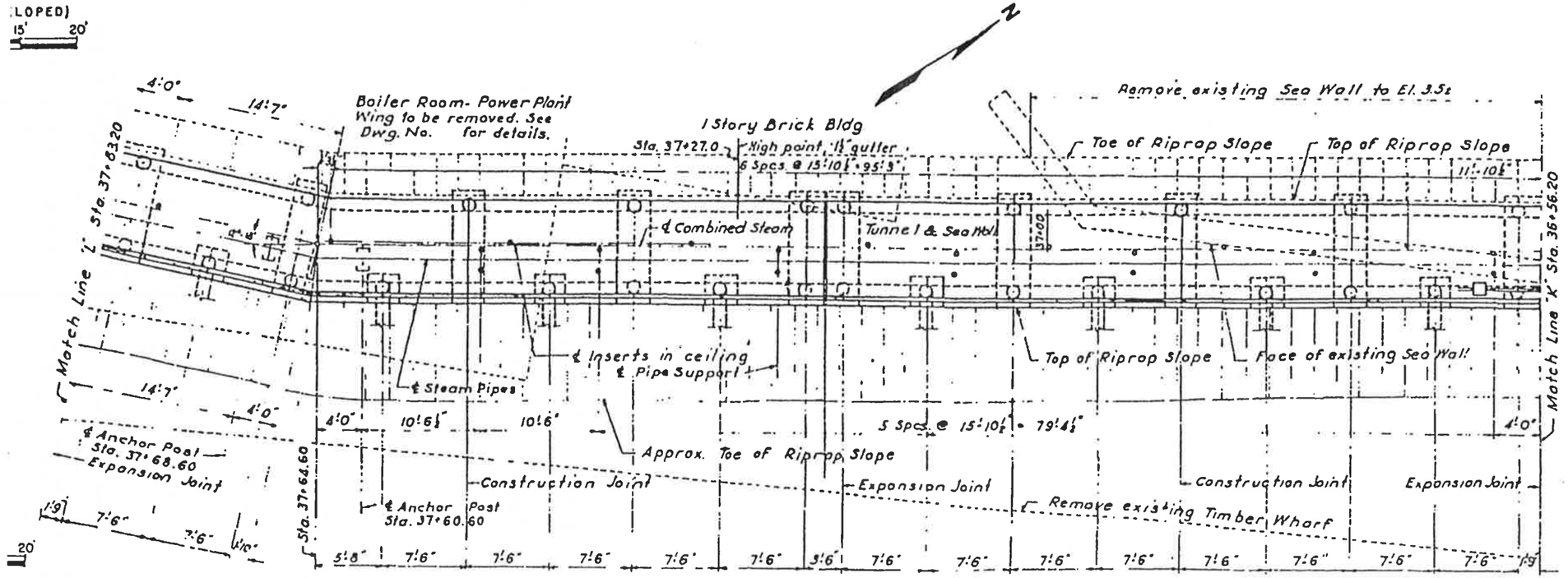
HENRY QUIST INC
L.I.C. N.Y.
MADE BY DATE
CHECKED BY

COMMISSIONER'S REPRESENTATIVE (RESIDENT ENGINEER) ARCH (PLUMBING INSPECTOR) DPW

TYPICAL DETAILS

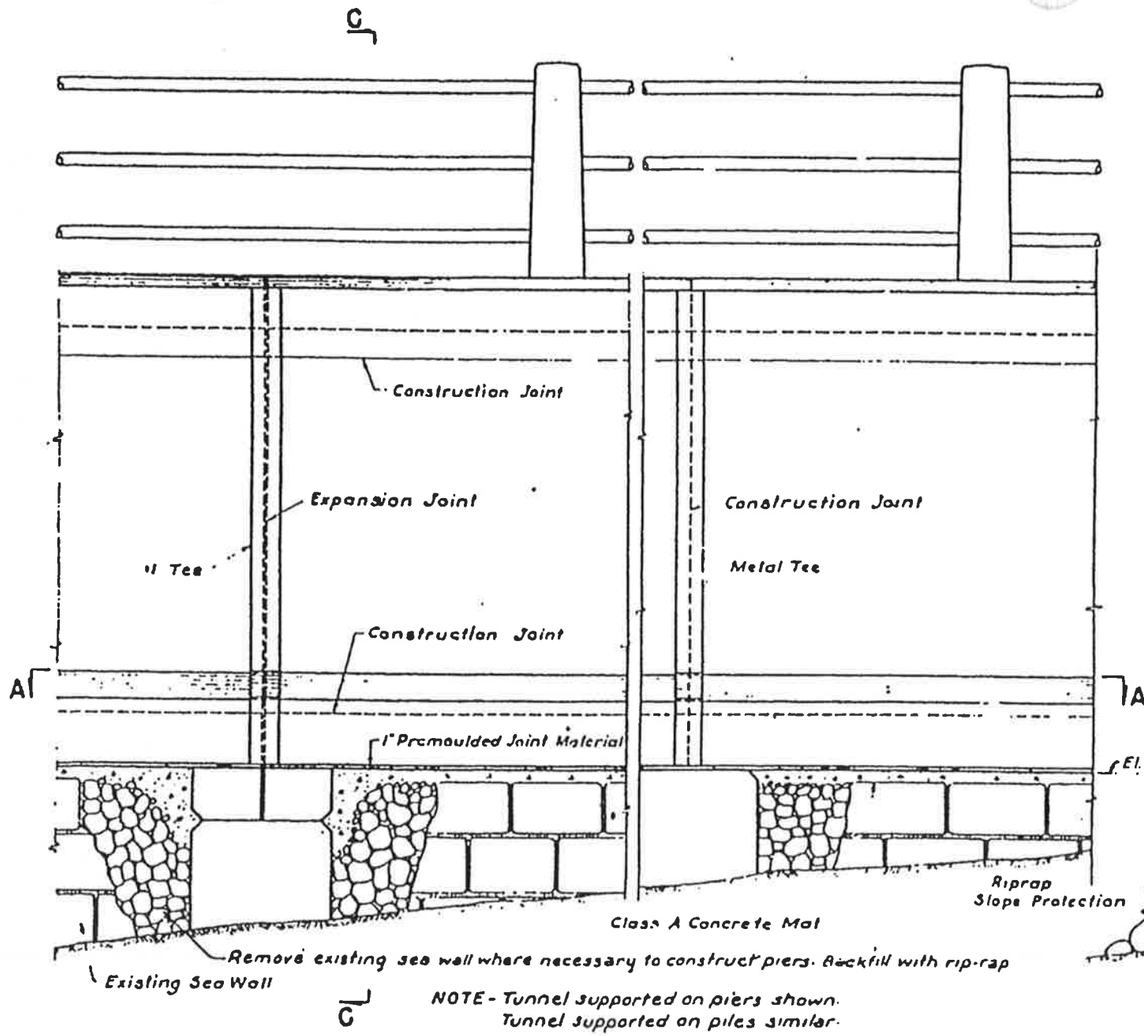


LOPED)
15' 20'

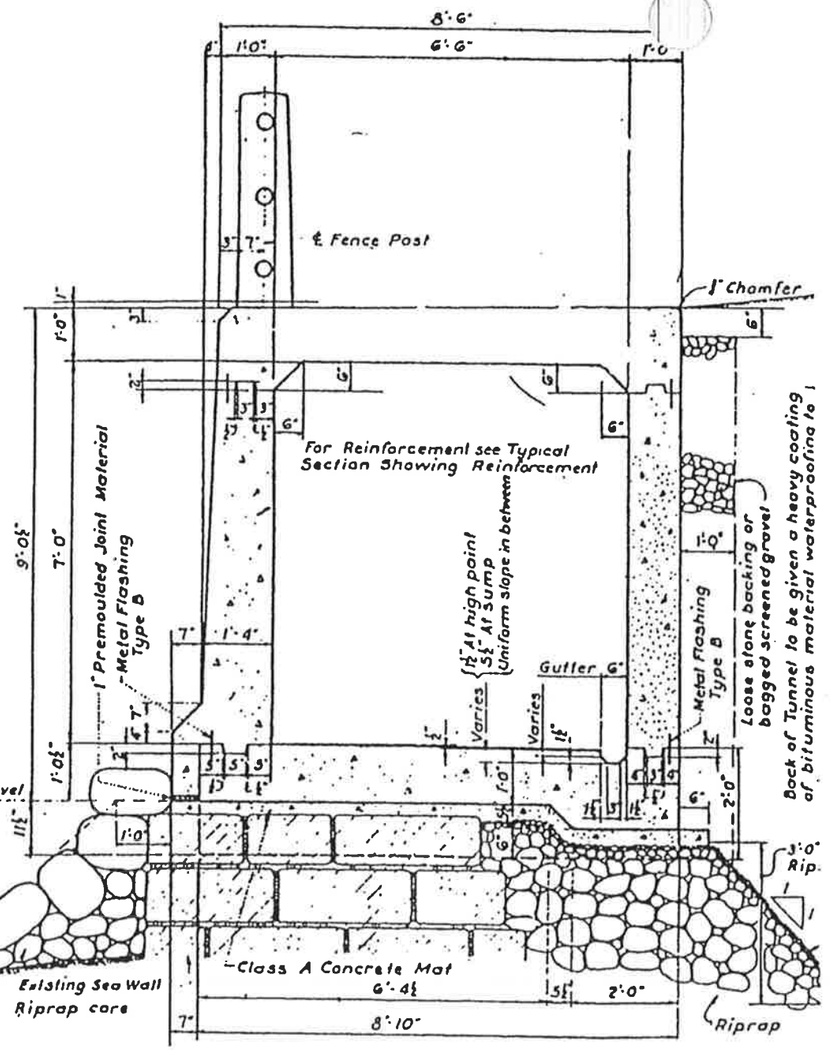


Remove existing Sea Wall to El. 3.5±

9 Spcs. @ 10'-7" = 95'-3" 5'-3½"



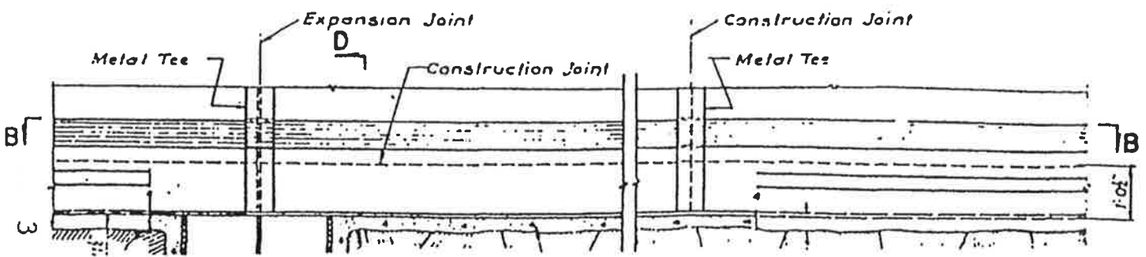
ELEVATION

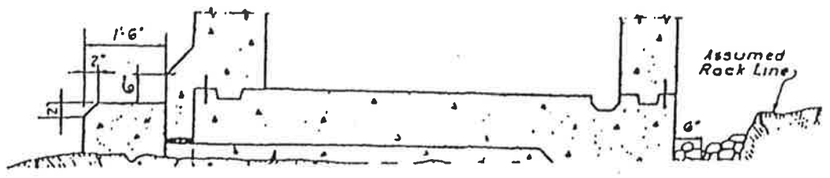


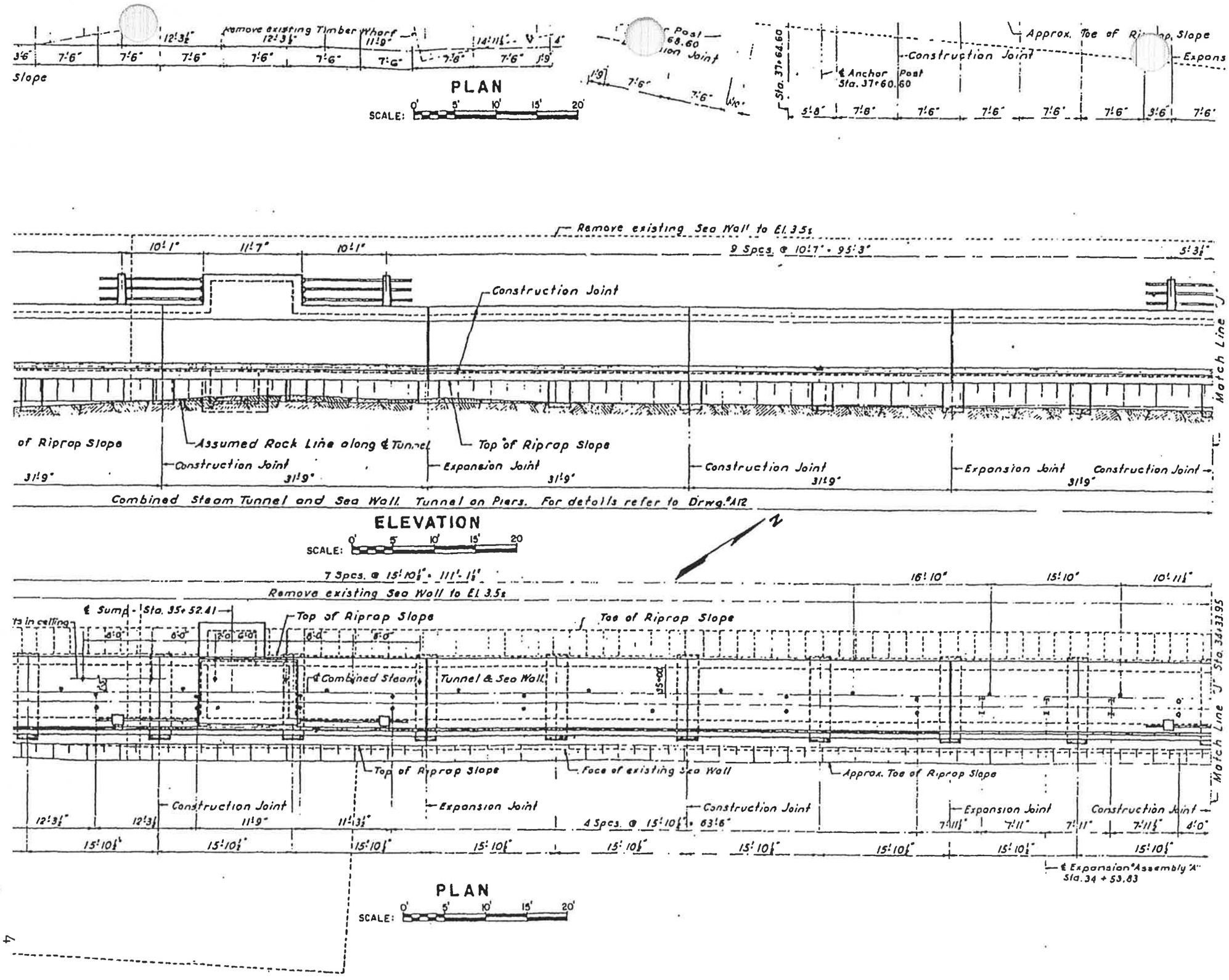
SECTION C - C

COMBINED STEAM TUNNEL AND SEA WALL TUNNEL ON EXISTING SEA WALL

SCALE: 0 1' 5'






Remove existing Timber Wharf
Slope
PLAN
SCALE: 0' 5' 10' 15' 20'
Construction Joint
Anchor Post
Sta. 37+60.60
Sta. 37+64.60
Approx. Toe of Riprap Slope
Expans
Remove existing Sea Wall to El 3.5±
9 Spcs. @ 10'-7" = 95'-3"
Construction Joint
Match Line
of Riprap Slope
Assumed Rock Line along ℄ Tunnel
Top of Riprap Slope
Construction Joint
Expansion Joint
Construction Joint
Expansion Joint
Construction Joint
Combined Steam Tunnel and Sea Wall. Tunnel on Piers. For details refer to Drwg.# A12
ELEVATION
SCALE: 0' 5' 10' 15' 20'
7 Spcs. @ 15'-10½" = 111'-1½"
Remove existing Sea Wall to El 3.5±
℄ Sump - Sta. 35+52.41
Top of Riprap Slope
Toe of Riprap Slope
℄ Combined Steam Tunnel & Sea Wall
Top of Riprap Slope
Face of existing Sea Wall
Approx. Toe of Riprap Slope
Construction Joint
Expansion Joint
Construction Joint
Expansion Joint
Construction Joint
4 Spcs. @ 15'-10½" = 63'-6"
℄ Expansion Assembly "A"
Sta. 34+53.83
Match Line "J" Sta. 34+33.95
PLAN
SCALE: 0' 5' 10' 15' 20'

DRAWINGS

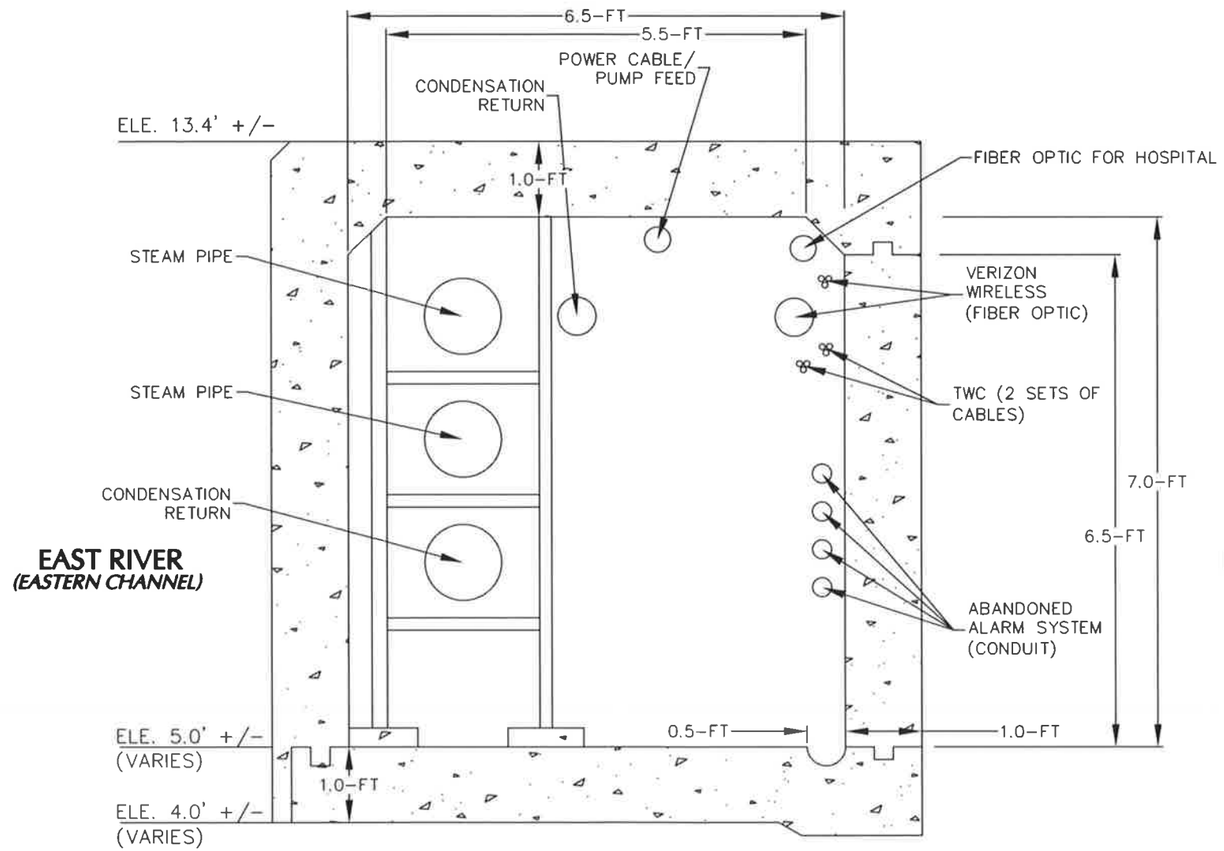
TUNNEL CROSS-SECTIONS

LANGAN

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.



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.

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

1/2 0 1/4 1/2
SCALE IN FEET

LANGAN
River Drive Center 1, 619 River Drive
Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
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
STEAM TUNNEL ASSESSMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
TYPICAL CROSS SECTION
STA. 0+00 TO 49+00

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

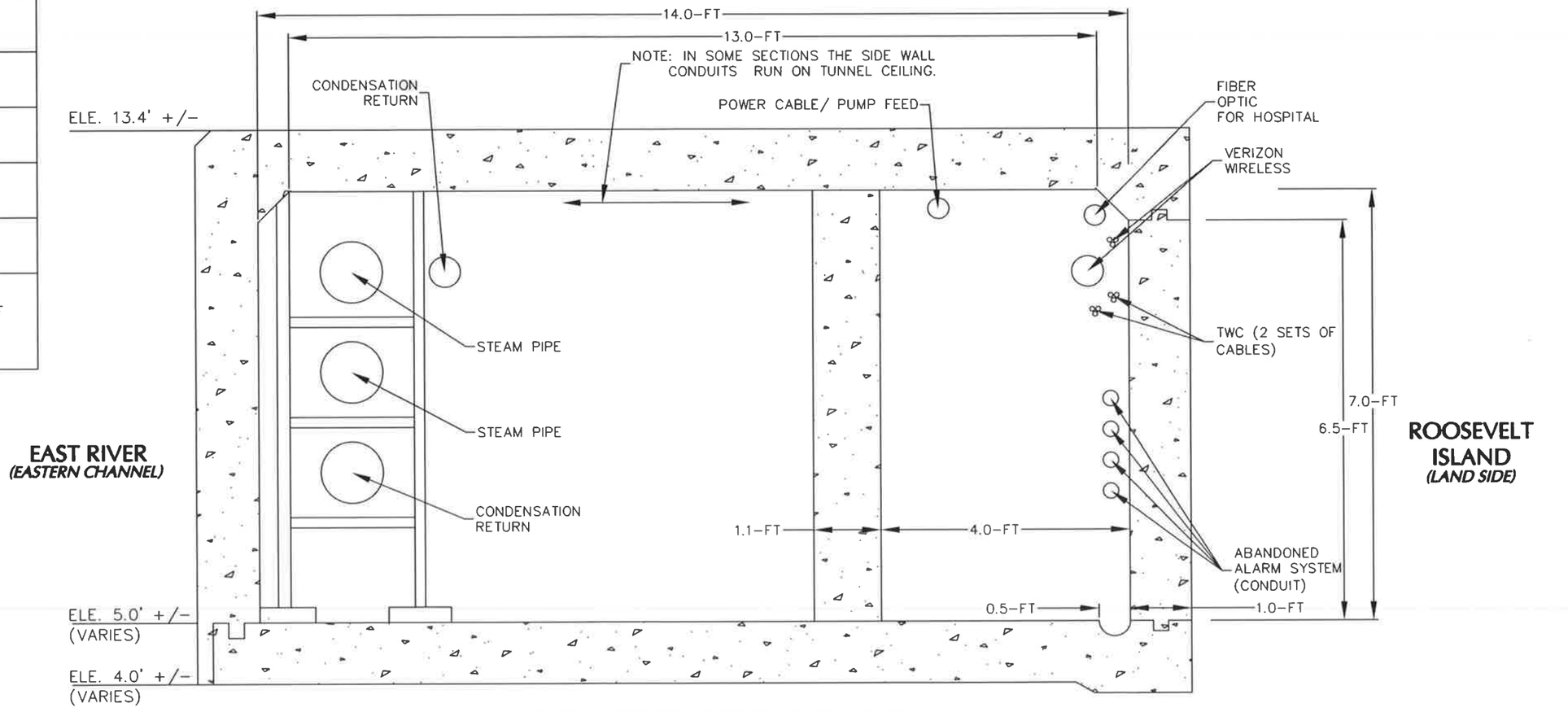
Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- XS 1.dwg Date: 11/10/2014 Time: 15:23 User: vipatel Style Table: Langan.stb Layout: XS 1

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. 42+50 TO 45+00 (APPROXIMATE)

1/2 0 1/4 1/2
SCALE IN FEET

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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River Drive Center 1, 619 River Drive
Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
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
STEAM TUNNEL ASSESSMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
TYPICAL CROSS SECTION
STA. 42+50 TO 45+00

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

Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- XS 2.dwg Date: 11/10/2014 Time: 15:22 User: vipatel Style Table: Langan.stb Layout: XS 2

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:

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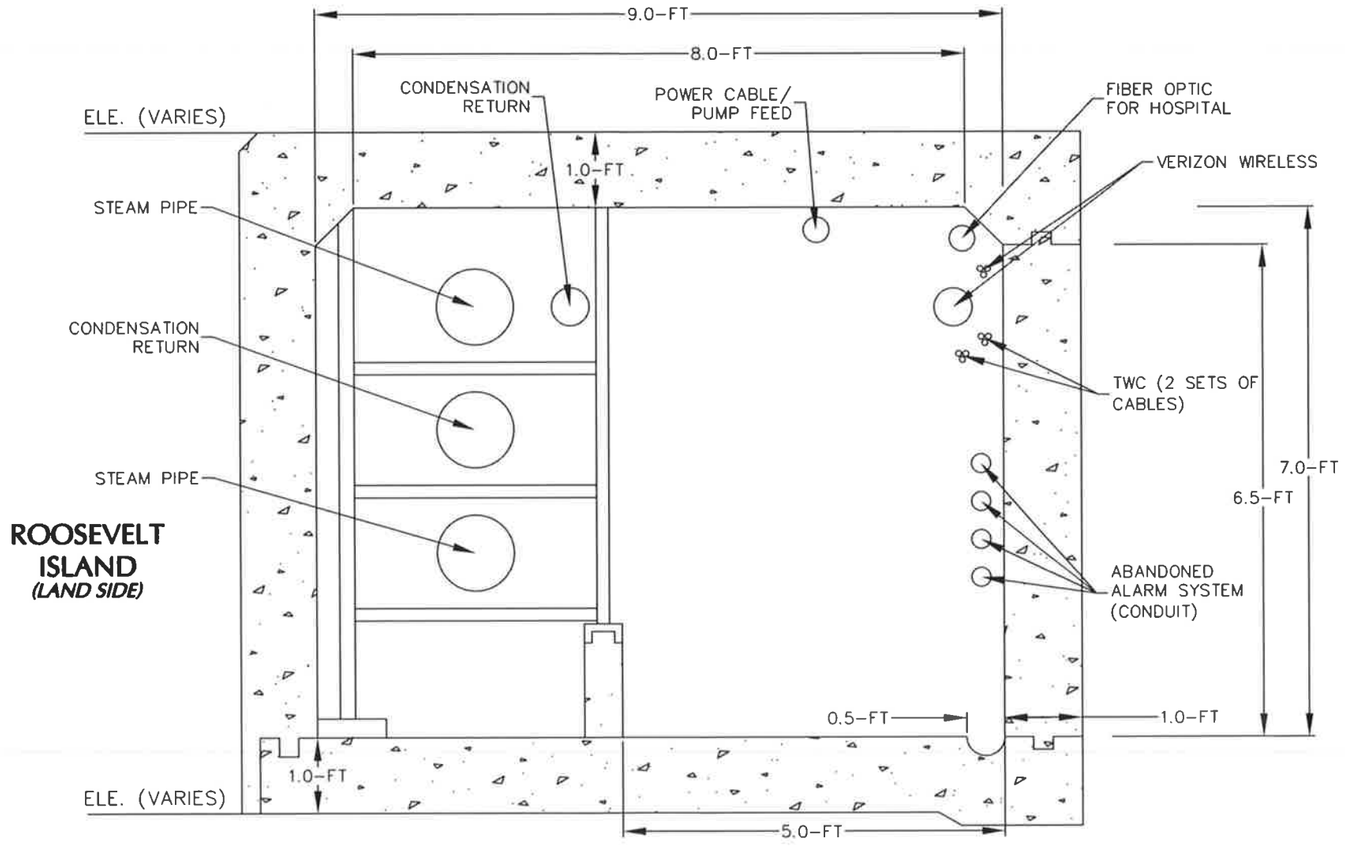

TYPICAL CROSS SECTION STEAM TUNNEL STA. 49+00 TO 57+20

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.

1/2 0 1/4 1/2
SCALE IN FEET

LANGAN
River Drive Center 1, 619 River Drive
Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
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NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESSMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
TYPICAL CROSS SECTION
STA. 49+00 TO 57+20

Project No.	Drawing No.
100444601	XS 3
Date: 10/31/2014	
Scale: 1" = 1/2'	
Drawn By: VP / Checked By: JCO	
Submission Date	

Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- XS 3.dwg Date: 11/10/2014 Time: 15:20 User: vipatel Style Table: Langan.stb Layout: XS 3

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:

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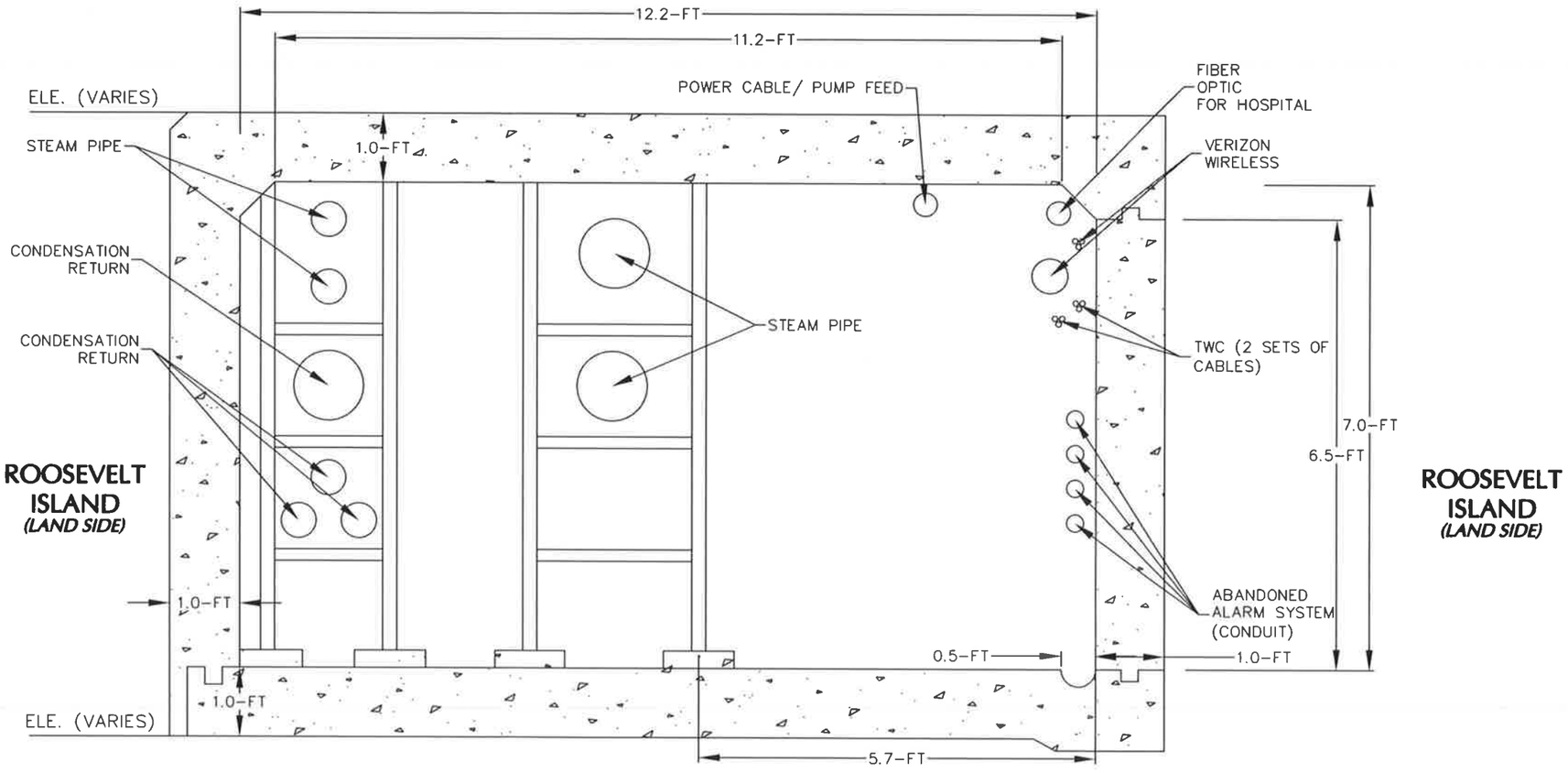

TYPICAL CROSS SECTION STEAM TUNNEL STA. 57+20 TO 61+50

NOTES:

1. IDENTIFICATION OF SHOWN UTILITIES ARE BASED ON INFORMATION PROVIDED BY MAINTENANCE PERSONNEL ON THE FIELD.
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1/2 0 1/4 1/2
SCALE IN FEET

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River Drive Center 1, 619 River Drive
Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
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NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESSMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

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

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

Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- XS 4.dwg Date: 11/10/2014 Time: 15:19 User: vipatel Style Table: Langan.stb Layout: XS 4

INTERIOR CONDITIONS PLAN

LANGAN

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)

ROOSEVELT ISLAND

EAST RIVER WEST CHANNEL

U.S. PIER AND BULKHEAD LINE

ROOSEVELT ISLAND PROPERTY LINE

TENNIS BUBBLE

GOLDWATER SPECIALITY HOSPITAL

TRAM BUILDING

CENTRAL NURSES RESIDENCE

GMH POWER PLANT

SEE TYPICAL CROSS SECTION (STA. 57+20 TO 61+50)

SPALLING AT WESTERN WALL (STA. 58+96)

CONCRETE SPALLING AROUND PIPE OPENING AT EASTERN WALL (STA. 58+54)

CONCRETE CRACKS AT EASTERN WALL (STA. 60+10)

OFFSET JOINT AT EASTERN WALL

SOUTHERN TUNNEL END BRICK WALL (STA. 61+50)

CONCRETE SPALLING PIPE OPENING AT EASTERN WALL (STA. 59+53)

FALLING JOINT SEALER AT TUNNEL JOINT (STA. 59+33)

SPALLING, RE-BAR EXPOSED AT TUNNEL ROOF (STA. 56+52 TO 56+55)

EXACT LOCATION AND GEOMETRY UNDER POWER PLANT BUILDING CAN NOT BE DETERMINED. APPROXIMATE FOOTPRINT IS SHOWN.FOR FUTURE CONSTRUCTION PROJECTS IN CLOSE PROXIMATELY TO TUNNEL, THE PROJECT SURVEYORS SHALL ENTER THE TUNNEL AND SHALL PERFORM TEST PITS TO PRECISELY DETERMINE THE STRUCTURE LIMITS.

CONCRETE CRACKING AT EASTERN WALL (STA. 55+84)

TUNNEL OFFSET AT TUNNEL ROOF (STA. 55+66)

CRACK FROM FLOOR TO ROOF AT EASTERN WALL (STA. 55+52)

SEE TYPICAL CROSS SECTION (STA. 49+00 TO 57+20)

EXISTING AIR VENT "1A"

MELTED JOINT FILLER AT TUNNEL FLOOR (STA. 50+06)

SPALLING AT WESTERN WALL (STA. 49+60 TO 49+62)

SPALLING AT WESTERN WALL (STA. 49+09 TO 49+23)

EXISTING AIR VENT "3A"

FLOOR SLAB RAISED LATERALLY 3" +/- AT EASTERN WALL (STA. 46+60)

TUNNEL DISPLACED

MELTED JOINT FILLER AT TUNNEL FLOOR (STA. 49+17)

EXISTING AIR VENT "2A"

ENTIRE LENGTH OF STANCHION SUPPORT CONCRETE HAUNCH IS CRACKED AND DETERIORATED. (STA. 49+50 TO 55+12)

SEE TYPICAL CROSS SECTION (STA. 0+00 TO 49+00)

CRACKS AT TUNNEL FLOOR (STA. 45+94)

61+50 61+00 60+00 59+00 58+00 57+00 56+00 55+00 54+00 53+00 52+00 51+00 50+00 49+00 48+00 47+00 46+00

EAST RIVER EAST CHANNEL

EAST RIVER
(EASTERN CHANNEL)

MATCHLINE SEE SHEET CS102

LEGEND

- STEAM TUNNEL FOOT PRINT
- STEAM TUNNEL CENTER LINE
- CONCRETE SPALLING
- AIR VENT (VENT)

NOTES

1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S WALK-THROUGH OF THE STEAM TUNNEL PERFORMED ON SEPTEMBER 9TH AND OCTOBER 6TH, 2014.
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 NOV 2014 FOR DETAILED DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.

50 0 25 50
SCALE IN FEET

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Date	Description	No.
REVISIONS		

LANGAN
River Drive Center 1, Exchange Place, Jersey City, NJ 07302
T: 201.798.6052 F: 201.798.6055 www.langan.com
NEW JERSEY · NEW YORK · CONNECTICUT · PENNSYLVANIA · WASHINGTON, DC · WEST VIRGINIA · FLORIDA · TEXAS · CALIFORNIA
ABU DHABI · ATHENS · DOHA · DUBAI · ISTANBUL
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Langan Engineering and Environmental Services, Inc.
Langan CT, Inc.
Langan International LLC
Collectively known as Langan.
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
INTERIOR CONDITIONS PLAN

Project No.	Drawing No.
100444601	CS101
Date: 9/4/2014	
Scale: 1" = 50'	
Drawn By: DJA / Checked By: JCO	
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.

EAST RIVER
(WESTERN CHANNEL)

ROOSEVELT ISLAND

EAST RIVER
(EASTERN CHANNEL)

U.S PIER AND BULKHEAD LINE
EAST RIVER WEST CHANNEL
EASEMENT "M"
ROOSEVELT ISLAND PROPERTY LINE
EAST RIVER EAST CHANNEL
CONFIRMED BY GROUND PENETRATING RADAR, APRIL 1993
SCHED. B
SCHOOL
UNIT A
RIVERCROSS
SCHEDULE A
ISLAND HOUSE
GOOD SHEPHERD CHURCH
EASTWOOD

MATCHLINE SEE SHEET CS101

MATCHLINE SEE SHEET CS103

SPALLING AT WESTERN WALL (STA. 45+61 TP 45+66)
SPALLING AT WESTERN WALL (STA. 45+34 TO 45+47)
SPALLING AT WESTERN WALL (STA. 45+00 TO 45+05)
EXISTING AIR VENT "1" (STA. 45+34)
FLOOR SLAB RAISED AT JOINT (STA. 42+75)
SEE TYPICAL CROSS SECTION (STA. 42+50 TO 45+00)
APPROXIMATE LIMITS OF EXISTING CHAMBER
APPROXIMATE LOCATION OF INTERIOR WALLS
SPALLING AT WESTERN WALL (STA. 40+98 TO 41+40)
EXISTING AIR VENT "2" (STA. 42+18)
SPALLING AT WESTERN WALL (STA. 40+02 TO 40+03)
SPALLING AT WESTERN WALL (STA. 40+50 TO 40+90)
FLOOR SLAB CRACKING AT TUNNEL FLOOR (STA. 39+23)
SPALLING AT WESTERN WALL (STA. 39+58 TO 39+74)
EXISTING AIR VENT "3" (STA. 39+03)
SPALLING AT WESTERN WALL (STA. 39+00)
FLOOR SLAB CRACKING AT JOINT (STA. 38+64)
SPALLING AT WESTERN WALL (STA. 38+03 TO 38+55)
SPALLING UP TO 5' HIGH AT WESTERN WALL (STA. 36+99 TO 37+00)
FLOOR SLAB CRACKED (STA. 38+13)
JOINT SEPARATION, MISSING CONCRETE AT WESTERN WALL (STA. 37+35)
SPALLING AT WESTERN WALL (STA. 36+57 TO 36+90)
FLOOR SLAB CRACKED (STA. 36+57 TO 36+62)
SPALLING AT WESTERN WALL (STA. 35+52 TO 35+63)
SPALLING UP TO 5' HIGH AT WESTERN WALL (STA. 35+75 TO 36+29)
SPALLING AT WESTERN WALL (STA. 34+23 TO 34+75)
SPALLING AT WESTERN WALL (STA. 35+00 TO 35+08)
FLOOR SLAB CRACKED AND DISPLACED AT JOINT (STA. 35+39)
EXISTING AIR VENT "4" (STA. 35+54)
SPALLING AT WESTERN WALL (STA. 32+04 TO 33+71)
SEE TYPICAL CROSS SECTION (STA. 0+00 TO 49+00)
EXISTING AIR VENT "5" (STA. 33+00)
SPALLING AT WESTERN WALL (STA. 32+43 TO 32+49)
SPALLING AT WESTERN WALL (STA. 32+89 TO 33+00)
FLOOR SLAB CRACKING (STA. 32+84)
SPALLING AT WESTERN WALL (STA. 32+77 TO 32+80)
SPALLING AT WESTERN WALL (STA. 32+00 TO 32+02)
SPALLING AT WESTERN WALL (STA. 31+82 TO 31+85)
APPROXIMATE LIMITS OF CROSS OVER CHAMBER
FLOOR SLAB CRACKING (STA. 31+94)
SPALLING AT WESTERN WALL (STA. 30+93 TO 31+31)
SPALLING AT WESTERN WALL (STA. 30+77 TO 30+85)
SPALLING AT WESTERN WALL (STA. 30+50 TO 30+65)
SPALLING AT WESTERN WALL (STA. 30+31 TO 30+41)
EXISTING AIR VENT "6" (STA. 30+46)
SPALLING AT JOINT AT TUNNEL FLOOR (STA. 31+51)
SPALLING AT WESTERN WALL (STA. 29+76 TO 29+96)
SPALLING AT WESTERN WALL (STA. 29+45 TO 29+70)

45+00 44+00 43+00 42+00 41+00 40+00 39+00 38+00 37+00 36+00 35+00 34+00 33+00 32+00 31+00 30+00

LEGEND

- STEAM TUNNEL FOOT PRINT
- STEAM TUNNEL CENTER LINE
- CONCRETE SPALLING
- AIR VENT (VENT)

NOTES

1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S WALK-THROUGH OF THE STEAM TUNNEL PERFORMED ON SEPTEMBER 9TH AND OCTOBER 6TH, 2014.
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 NOV 2014 FOR DETAILED DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.

50 0 25 50
SCALE IN FEET

Date	Description	No.
REVISIONS		

LANGAN
River Drive Center 1, exit 16 River Drive, Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO
VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
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Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
INTERIOR CONDITIONS PLAN

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

Filename: \\langan.com\data\EP\data\5\100446015\Cadd Data - 100446015\xref files\100446015-CS102.dwg Date: 11/14/2014 Time: 15:15 User: vtpatel Style Table: Langan.stb Layout: CS102

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)

ROOSEVELT ISLAND

MATCHLINE
SEE SHEET CS102

MATCHLINE
SEE SHEET CS104

U.S. PIER AND BULKHEAD LINE

EAST RIVER WEST CHANNEL

ROOSEVELT ISLAND PROPERTY LINE

SPALLING AT WESTERN WALL (STA. 29+45 TO 29+70)

SPALLING AT WESTERN WALL (STA. 28+94 TO 29+32)

SPALLING AT WESTERN WALL (STA. 28+62 TO 28+86)

SPALLING AT WESTERN WALL (STA. 28+02 TO 28+27)

SPALLING AT WESTERN WALL (STA. 27+51 TO 27+69)

SPALLING AT WESTERN WALL (STA. 27+23)

SPALLING AT WESTERN WALL (STA. 26+90)

SPALLING AT WESTERN WALL (STA. 26+50 TO 26+62)

SPALLING AT WESTERN WALL (STA. 26+03 TO 26+20)

EXISTING AIR VENT "7" (STA. 27+92)

SPALLING AT 27+09 WESTERN WALL (STA. 27+94)

EXISTING AIR VENT "8" (STA. 25+38)

APPROXIMATE LIMITS OF CROSS OVER CHAMBER

SEE TYPICAL CROSS SECTION (STA. 0+00 TO 49+00)

SPALLING AT WESTERN WALL (STA. 23+90 TO 24+03)

SPALLING AT WESTERN WALL (STA. 22+44 TO 23+63)

EXISTING AIR VENT "9" (STA. 22+84)

SPALLING AT WESTERN WALL (STA. 21+68 TO 21+75)

SPALLING AT WESTERN WALL (STA. 20+90 TO 21+30)

SPALLING AT WESTERN WALL (STA. 20+74 TO 20+80)

MOTORGATE II

EXISTING AIR VENT "10" (STA. 20+30)

FLOOR SLAB RAISED AT JOINT (STA. 20+10)

SPALLING AT WESTERN WALL (STA. 20+15 TO 20+22)

SIGNS OF SPALLING AT WESTERN WALL (STA. 19+72 TO 19+90)

CRACKING AT JOINT AT WESTERN WALL (STA.19+45)

FLOOR SLAB RAISED AT JOINT (STA.18+80)

SEE TYPICAL CROSS SECTION (STA. 0+00 TO 49+00)

SPALLING AT WESTERN WALL (STA. 18+30 TO 18+50)

MOTORGATE

SPALLING AT WESTERN WALL (STA. 17+85 TO 18+10)

SPALLING AT WESTERN WALL (STA. 17+68)

SPALLING AT WESTERN WALL (STA. 17+10 TO 17+61)

EXISTING AIR VENT "11" (STA. 17+76)

SPALLING AT TUNNEL FLOOR (STA. 17+70)

SPALLING AT TUNNEL FLOOR (STA. 17+35)

SPALLING AT WESTERN WALL (STA. 15+88 TO 16+00)

SPALLING AT WESTERN WALL (STA. 16+53 TO 16+60)

FLOOR SLAB RAISED AND CRACKED AT JOINT (STA. 15+75)

EXISTING AIR VENT "12" (STA. 15+22)

SPALLING AT WESTERN WALL (STA. 15+50 TO 15+75)

SPALLING AT WESTERN WALL (STA. 15+09 TO 15+20)

FLOOR SLAB RAISED AND CRACKED AT JOINT (STA. 15+00)

RAISED JOINT, CRACKING AT TUNNEL FLOOR (STA. 14+30)

SPALLING AT WESTERN WALL (STA. 14+24 TO 15+00)

29+00 28+50 28+00 27+00 26+00 25+00 24+00 23+00 22+00 21+00 20+00 19+00 18+00 17+00 16+00 15+00 14+00

EAST RIVER
(EASTERN CHANNEL)

LEGEND

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

NOTES

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50 0 25 50
SCALE IN FEET

No.	Description	Date
	REVISIONS	

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Collectively known as Langan
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

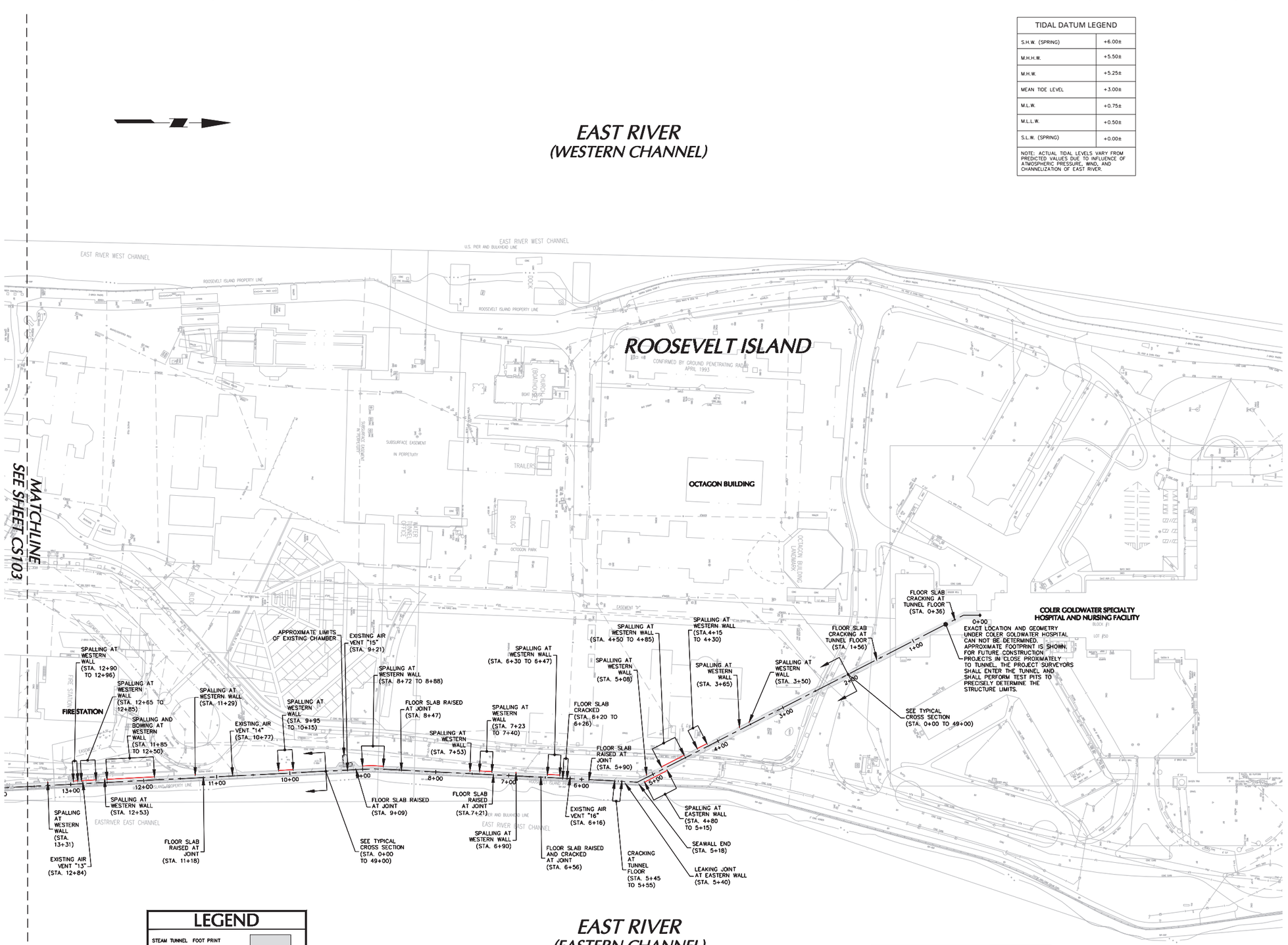
Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
INTERIOR CONDITIONS PLAN

Project No.	100444601
Date	9/4/2014
Scale	1" = 50'
Drawn By	DJA
Checked By	JCO
Submission Date	
Drawing No.	CS103

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 (VENT)

NOTES

1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S WALK-THROUGH OF THE STEAM TUNNEL PERFORMED ON SEPTEMBER 9TH AND OCTOBER 6TH, 2014.
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 NOV 2014 FOR DETAILED DESCRIPTION OF STEAM TUNNEL CONDITIONS, INCLUDING TYPICAL INTERIOR CROSS SECTIONS, UTILITY INFORMATION AND PHOTOGRAPHIC RECORDS.

50 0 25 50
SCALE IN FEET

Date	Description	No.
REVISIONS		

LANGAN
River Drive Center 1, 619 River Drive, Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO
VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL
Langan Engineering, Environmental, Surveying, and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
Langan IMM China Ltd.
Collectively known as Langan
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

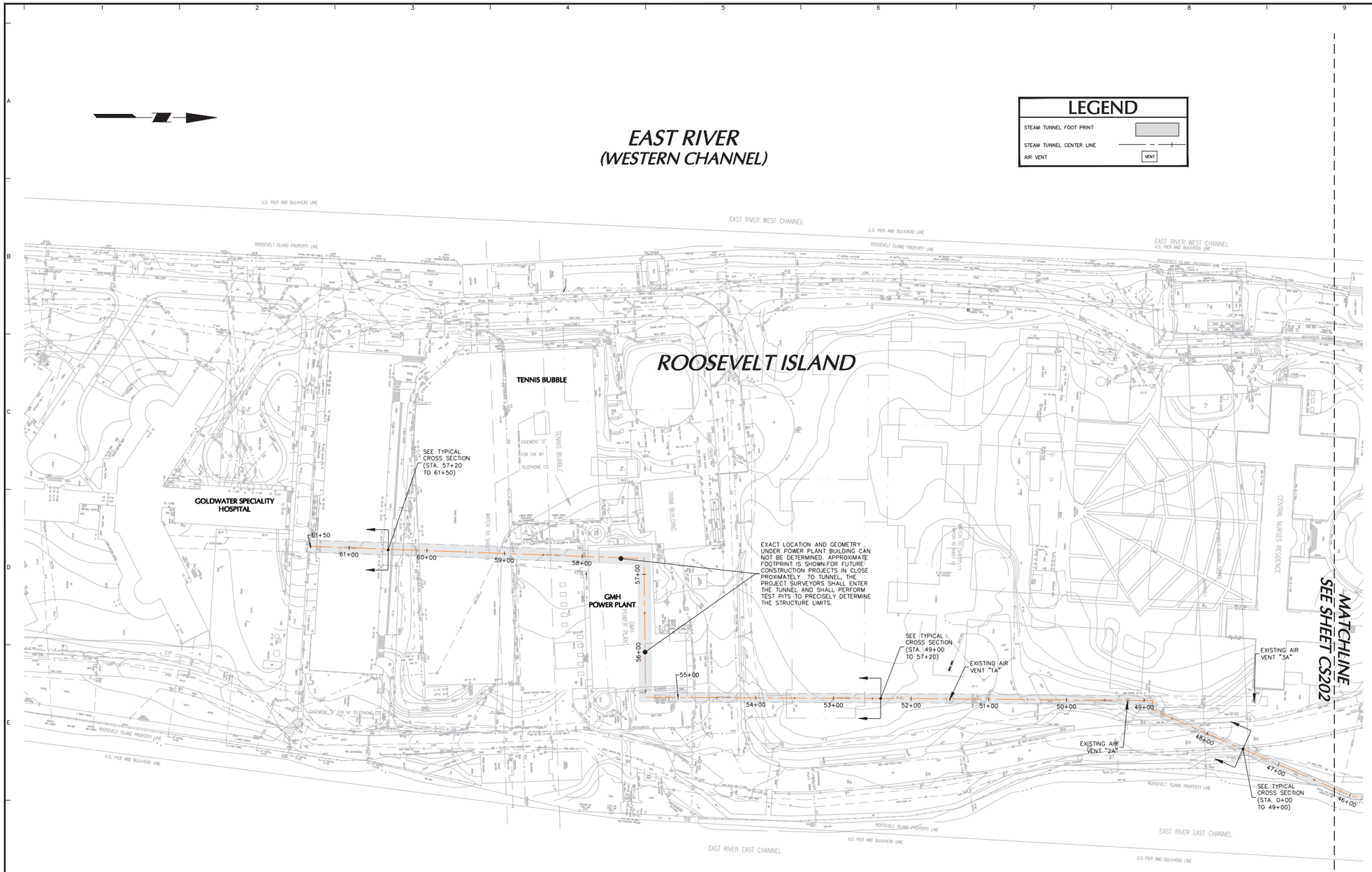
Drawing Title
INTERIOR CONDITIONS PLAN

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

Filename: \\langan.com\data\EP\data5\100446\01\Cadd Data - 100446001\Sheet files\100446001 - CS104.dwg Date: 11/14/2014 Time: 15:17 User: vkpatel Style Table: Langan.stb Layout: CS104

EXTERIOR CONDITIONS PLAN

LANGAN



NOTES

1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON SEPTEMBER 9TH, OCTOBER 6TH AND 22ND, 2014.
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. 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 TIMBER PILES; NEITHER THE RECORD DRAWINGS NOR THE LANGAN OBSERVATION VISIT REVEALED THE EXTEND 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 NOV 2014 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.

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.

Date	Description	No.
REVISIONS		

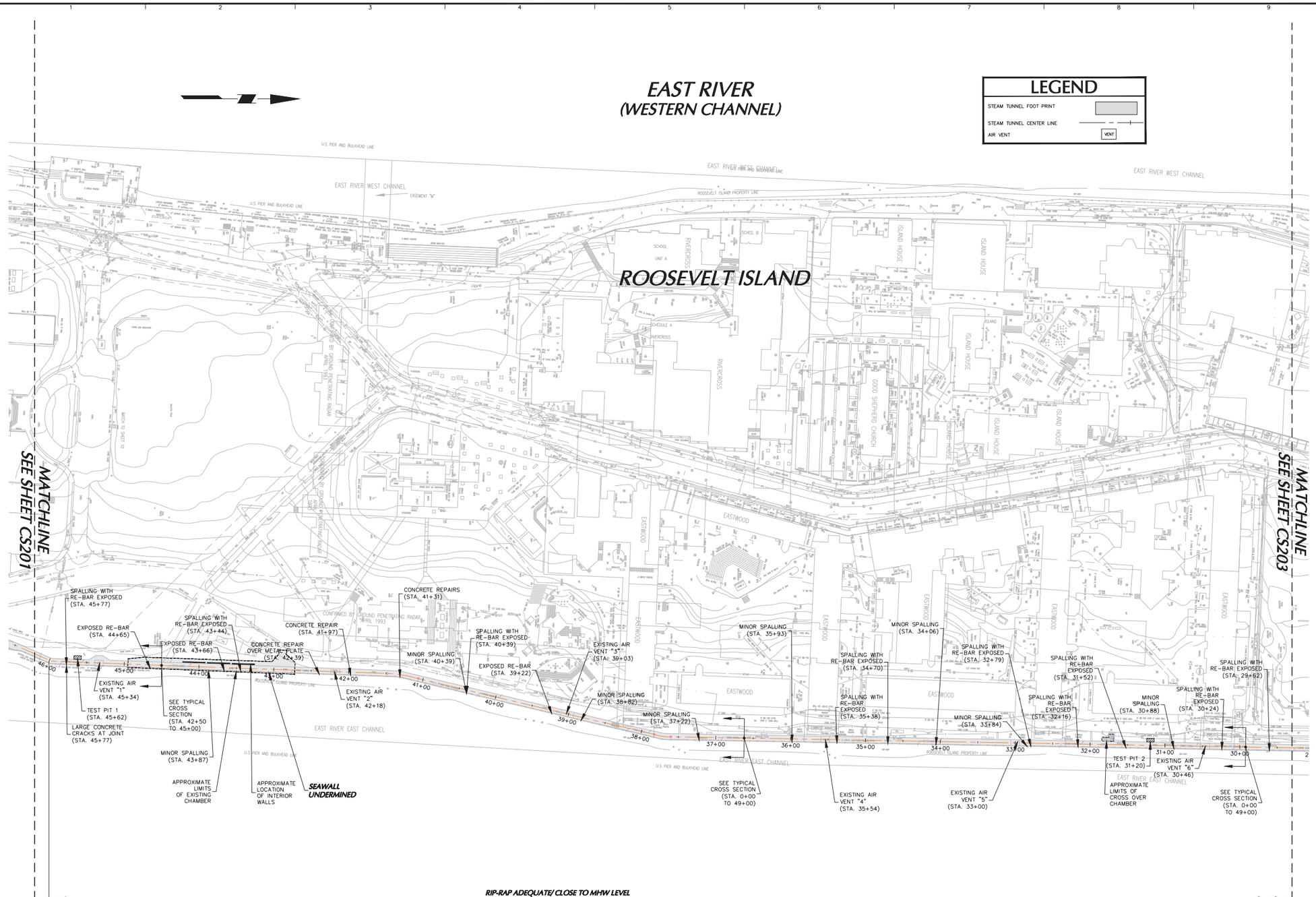
LANGAN
River Drive Center 1, Exchange Place, Jersey City, NJ 07302
T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY · NEW YORK · CONNECTICUT · PENNSYLVANIA · WASHINGTON, DC · FLORIDA · TEXAS · OHIO · VIRGINIA · WASHINGTON · WEST VIRGINIA · NORTH DAKOTA · CALIFORNIA
ABU DHABI · ATHENS · DOHA · DUBAI · ISTANBUL
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
Langan International LLC
Collectively known as Langan
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESMENT
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
Submission Date	
Drawing No.	CS201

Filename: I:\langan.com\data\EPData\69-100444601\Cadd Data - 100444601\2-xref files\100444601-CS201.dwg Date: 11/10/2014 Time: 10:59 User: vtpatel StyleTable: Langan.stb Layout: CS201



NOTES

1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON SEPTEMBER 9TH, OCTOBER 6TH AND 22ND, 2014.
2. STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (ROC FILES) AND WITH AERIAL PHOTOGRAPHS.
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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 NOV. 2014 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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Date	Description	No.
REVISIONS		

LANGAN
River Drive Center 1, 619 River Drive, Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0080 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO
VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL
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NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND

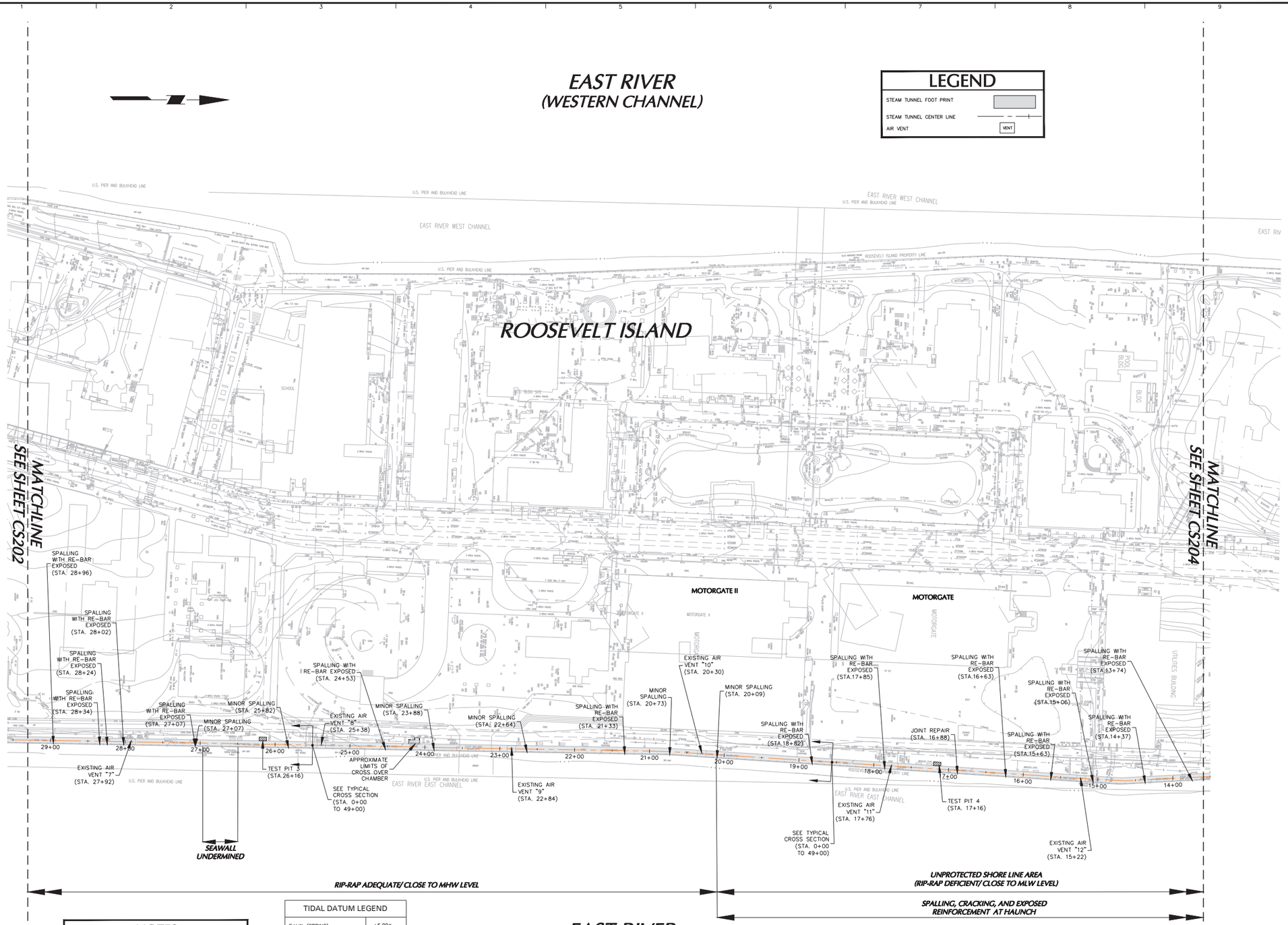
NEW YORK NEW YORK

Drawing Title
EXTERIOR CONDITIONS PLAN

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

Drawing No.
CS202

File name: I:\langan.com\data\EP\data8\100444\601\Cadd Data - 100444601\Sheet files\100444601 - CS202.dwg Date: 11/14/2014 Time: 15:19 User: vipatel Style Table: Langan.stb Layout: CS202



NOTES

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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.

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Date	Description	No.
REVISIONS		

LANGAN
River Drive Center 1, 619 River Drive, Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Surveying, P.C.
Langan Services, Inc.
Langan International LLC
Collectively known as Langan
NJ CERTIFICATE OF AUTHORIZATION NO. 24GA27996400

Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
EXTERIOR CONDITIONS PLAN

Project No. 100444601	Drawing No. CS203
Date 9/4/2014	
Scale 1" = 50'	
Drawn By DA / Checked By JCO	
Submission Date	

NOTES

1. THIS PLAN DEPICTS THE VISIBLE AND ACCESSIBLE CONDITIONS FOUND DURING LANGAN'S OBSERVATION VISITS PERFORMED ON SEPTEMBER 9TH, OCTOBER 6TH AND 22ND, 2014.
2. STATIONING OF CONDITIONS WERE DETERMINED USING A MEASURING WHEEL IN COORDINATION WITH THE AVAILABLE TOPO-METRIC SURVEYS (RIOC FILES) AND WITH AERIAL PHOTOGRAPHS.
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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
- AIR VENT (VENT)

EAST RIVER
(WESTERN CHANNEL)

ROOSEVELT ISLAND

EAST RIVER WEST CHANNEL

EAST RIVER WEST CHANNEL
U.S. PIER AND BULKHEAD LINE

ROOSEVELT ISLAND PROPERTY LINE

DOCK

CHURCH (BAPTIST)

BOAT HOUSE

CONFIRMED BY GROUND PENETRATING RADAR APRIL 1993

SUBSURFACE EASEMENT IN PERPETUITY

TRAILERS

OCTAGON BUILDING

OCTAGON BUILDING LANDMARK

BDG

OCTAGON PARK

EASEMENT

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 PROXIMATELY 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)

SPALLING WITH RE-BAR EXPOSED (STA.13+27)

SPALLING WITH RE-BAR EXPOSED (STA.13+10)

FIRE STATION

SPALLING WITH RE-BAR EXPOSED (STA.12+68)

SPALLING WITH RE-BAR EXPOSED (STA.12+51)

SEE TYPICAL CROSS SECTION (STA. 0+00 TO 49+00)

APPROXIMATE LIMITS OF EXISTING CHAMBER

EXISTING AIR VENT "15" (STA. 9+21)

MINOR SPALLING (STA. 9+96)

MINOR SPALLING (STA. 8+97)

MINOR SPALLING (STA. 7+26)

MINOR SPALLING (STA. 5+94)

MINOR SPALLING (STA. 5+61)

MINOR SPALLING (STA. 6+60)

MINOR SPALLING (STA. 7+68)

EXISTING AIR VENT "14" (STA. 10+77)

TEST PIT 5 (STA. 12+16)

TEST PIT 6 (STA. 8+90)

EXISTING AIR VENT "16" (STA. 6+16)

END OF SEAWALL (STA. 5+18)

EXISTING AIR VENT "13" (STA. 12+84)

0+00 1+00 2+00 3+00 4+00 5+00 6+00 7+00 8+00 9+00 10+00 11+00 12+00 13+00

EASTRIVER EAST CHANNEL

U.S. PIER AND BULKHEAD LINE
EAST RIVER EAST CHANNEL

SEAWALL UNDERMINED

UNPROTECTED SHORE LINE AREA (RIP-RAP DEFICIENT/ CLOSE TO MLW LEVEL)

SPALLING, CRACKING, AND EXPOSED REINFORCEMENT AT HAUNCH

EAST RIVER
(EASTERN CHANNEL)

MATCHLINE SEE SHEET CS203

50 0 25 50
SCALE IN FEET

WARNING:
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Date	Description	No.
REVISIONS		

LANGAN
River Drive Center 1, 619 River Drive, Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
NEW JERSEY NEW YORK CONNECTICUT PENNSYLVANIA OHIO VIRGINIA WASHINGTON DC FLORIDA NORTH DAKOTA CALIFORNIA
ABU DHABI ATHENS DOHA DUBAI ISTANBUL
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
Langan International LLC
Collectively known as Langan
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

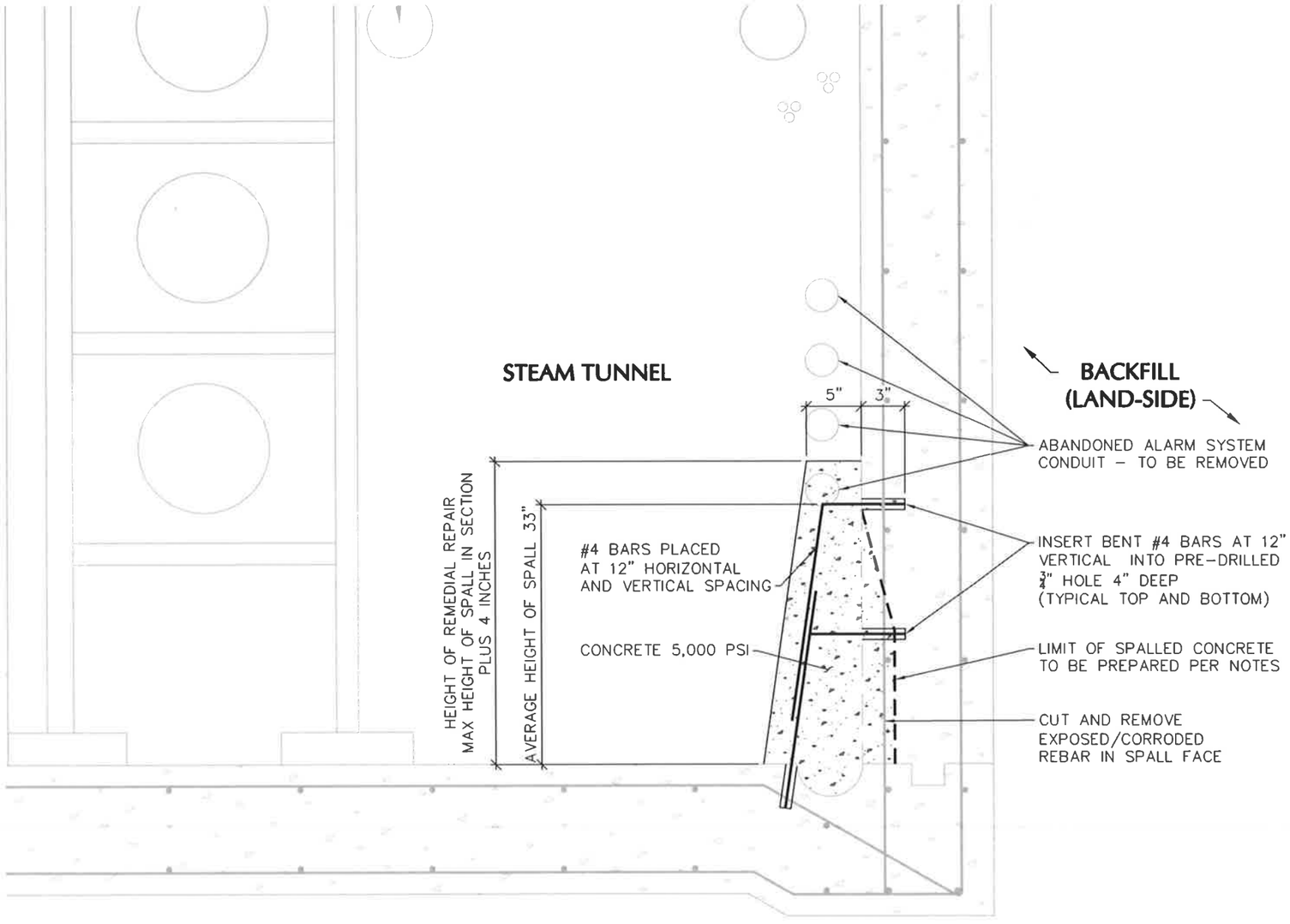
Project
STEAM TUNNEL ASSESMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
EXTERIOR CONDITIONS PLAN

Project No. 100444601	Drawing No. CS204
Date 9/4/2014	
Scale 1" = 50'	
Drawn By DJA / Checked By JCO	
Submission Date	

STRUCTURAL REMEDIATION PLANS

LANGAN



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 ¾" DIAMETER HOLES 3" DEEP TO RECEIVE NEW REBAR TOP AND BOTTOM.
4. CLEAN EXPOSED SURFACE OF CONCRETE AS PREPARATION FOR REPAIR.
5. APPLY BONDING AGENT TO CLEANED CONCRETE SURFACE.
6. SET REINFORCEMENT AND FORMWORK FOR CONCRETE AS SHOWN.
7. PUMP 5,000PSI CONCRETE TO CREATE REPAIR SECTION AS SHOWN.

NOTES

1. **USE THIS REPAIR DETAIL IF IT IS DETERMINED NOT TO RETAIN TUNNEL PUMPED DRAINAGE SYSTEM**

1 0 1/2 1
SCALE IN FEET

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.

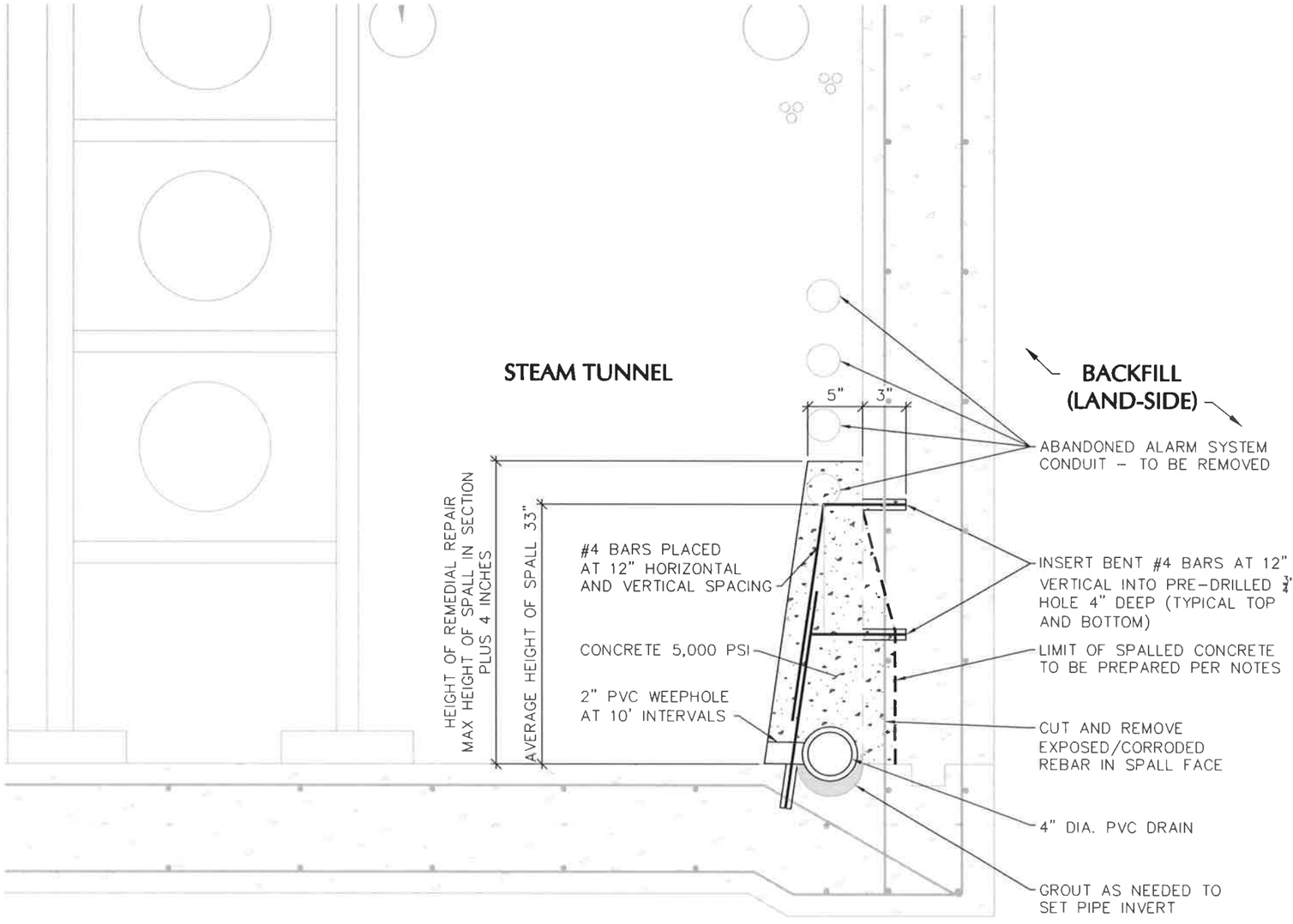
LANGAN
River Drive Center 1, 619 River Drive
Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
Langan Engineering, Environmental, Surveying and Landscape Architecture, D.P.C.
Langan Engineering and Environmental Services, Inc.
Langan CT, Inc
Langan International LLC
Collectively known as Langan
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESSMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
REMEDIAL REPAIR TO TUNNEL INTERIOR (WITHOUT DRAINAGE)

Project No.	Drawing No.
100444601	RR-1
Date: 11/13/2014	
Scale: 1" = 1'	
Drawn By: PP / Checked By: JCO	
Submission Date	

Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- RR 1.dwg Date: 11/10/2014 Time: 18:36 User: vipatel Style Table: Langan.stb Layout: RR-1



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 ¾" DIAMETER HOLES 3" DEEP TO RECEIVE NEW REBAR TOP AND BOTTOM.
4. SET 4" DIAMETER PVC LONGITUDINAL DRAIN IN BOTTOM OF GUTTER TO RECEIVE 2" DIAMETER WEEP-HOLES FOR DRAINAGE.
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. PUMP 5,000PSI CONCRETE TO CREATE REPAIR SECTION AS SHOWN.

NOTES

1. **USE THIS REPAIR DETAIL IF IT IS DETERMINED TO RETAIN TUNNEL PUMPED DRAINAGE SYSTEM**

1 0 1/2 1
SCALE IN FEET

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.

LANGAN
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Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
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Langan Engineering and Environmental Services, Inc.
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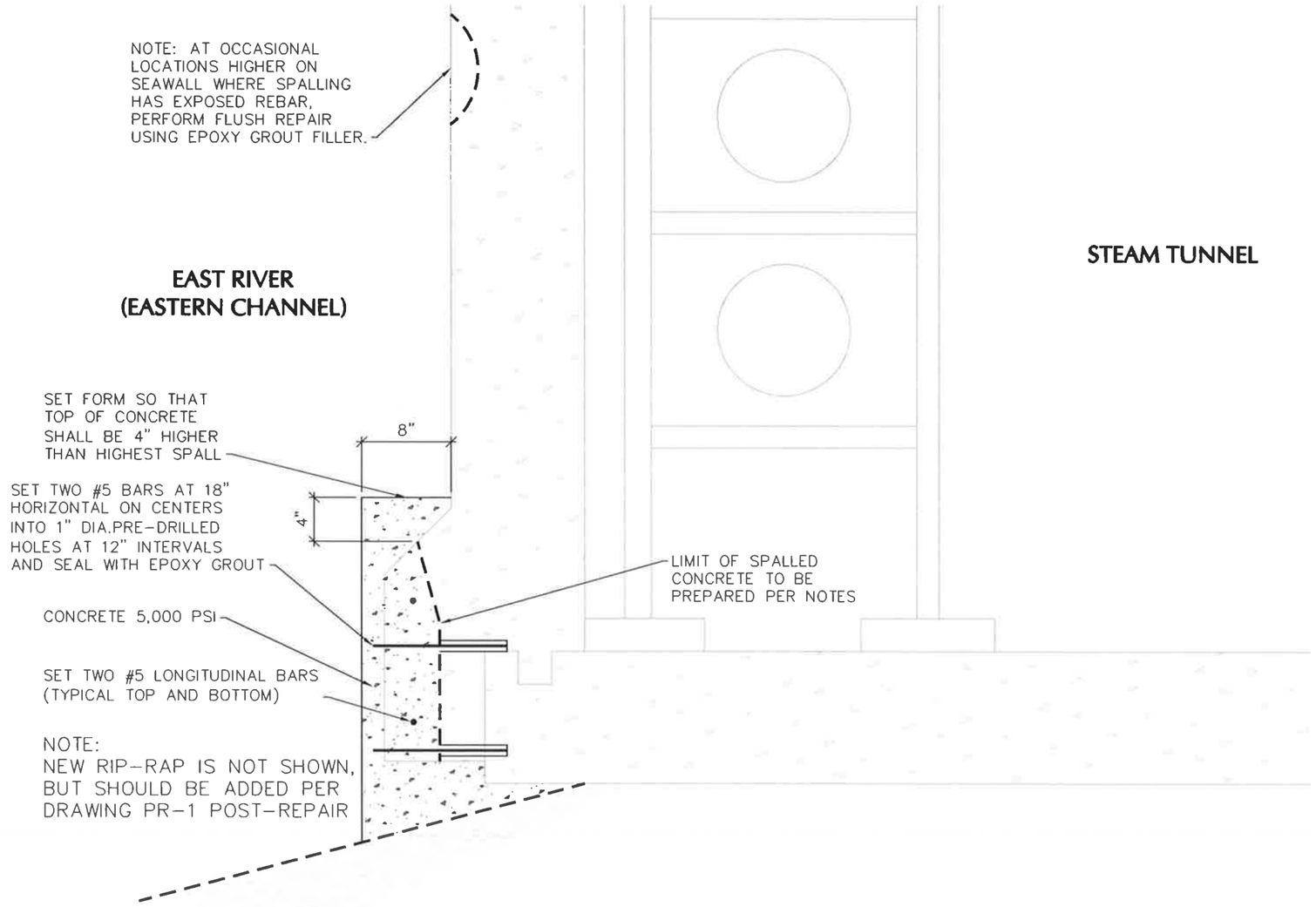
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project
STEAM TUNNEL ASSESSMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
REMEDIAL REPAIR TO TUNNEL INTERIOR
(WITH DRAINAGE)

Project No. 100444601	Drawing No. RR-2
Date 11/13/2014	
Scale 1" = 1'	
Drawn By PP / Checked By JCO	
Submission Date	

Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- RR 2.dwg Date: 11/10/2014 Time: 16:39 User: vpatel Style Table: Langan.stb Layout: RR-2



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.

1 0 1/2 1

SCALE IN FEET

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

LANGAN
River Drive Center 1, 619 River Drive
Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
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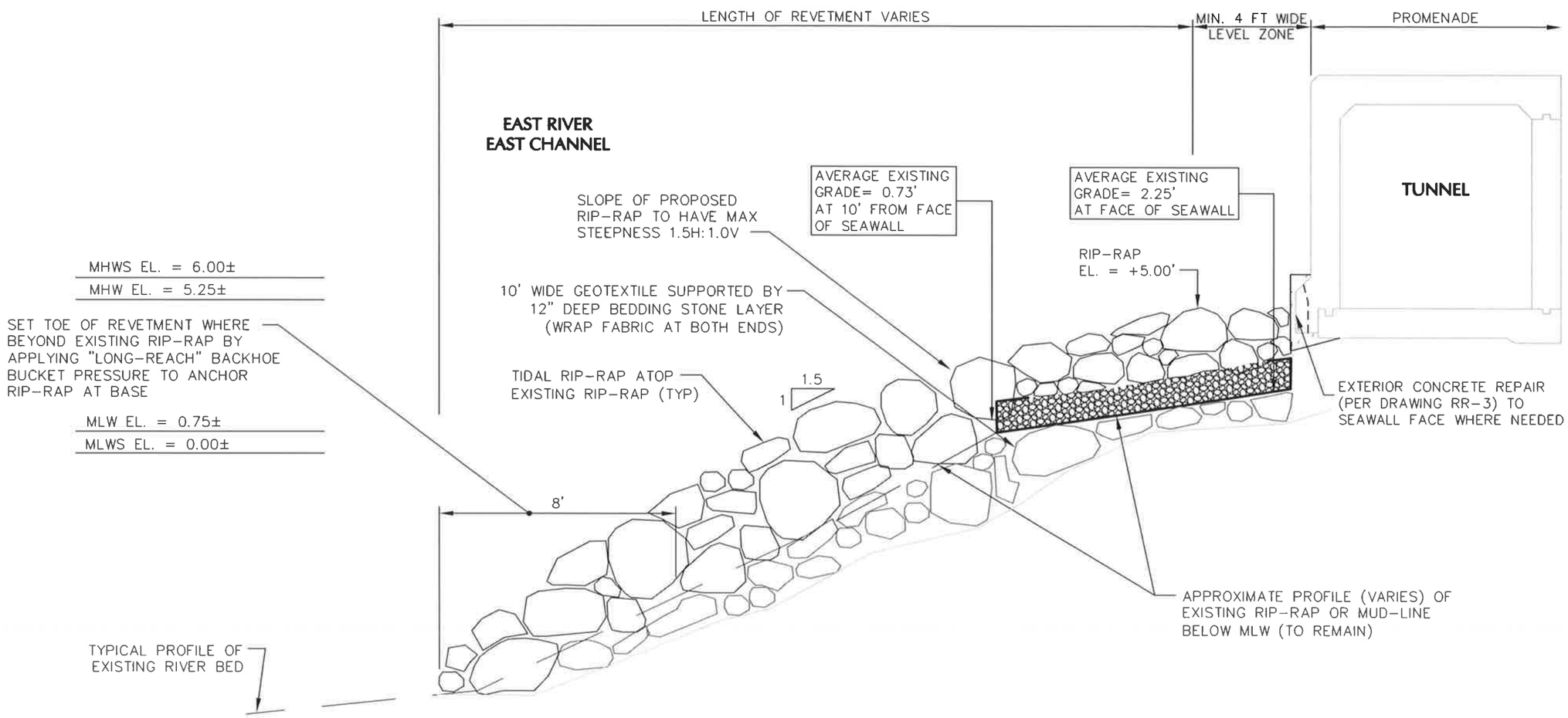
NJ CERTIFICATE OF AUTHORIZATION No. 24GA27996400

Project	STEAM TUNNEL ASSESSMENT ROOSEVELT ISLAND NEW YORK NEW YORK
Drawing Title	REMEDIAL REPAIR TO TUNNEL SEAWALL FACE
Project No.	100444601
Date	11/13/2014
Scale	1" = 1'
Drawn By / Checked By	PP / JCO
Submission Date	
Drawing No.	RR-3

Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- RR 3.dwg Date: 11/14/2014 Time: 14:57 User: vipatel Style Table: Langan.stb Layout: RR-3



NOTE:

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.

0 2' 4' 8' 12'

GRAPHIC SCALE

LANGAN
River Drive Center 1, 619 River Drive
Elmwood Park, NJ 07407
T: 201.794.6900 F: 201.794.0366 www.langan.com
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
STEAM TUNNEL ASSESSMENT
ROOSEVELT ISLAND
NEW YORK NEW YORK

Drawing Title
PLACEMENT OF RIP-RAP WHERE DEFICIENT
STA. 3+00 TO 6+00

Project No.	Drawing No.
100444601	PR-1
Date: 11/03/2014	
Scale: 1/4"= 1'-0"	
Drawn By: PP / Checked By: JCO	
Submission Date	

Filename: \\langan.com\data\EP\data6\100444601\Cadd Data - 100444601\SheetFiles\100444601- PR 1.dwg Date: 11/14/2014 Time: 15:02 User: vipatel Style Table: Langan.stb Layout: PR 1

TABLES

DEFECT OBSERVATIONS

INTERIOR DEFECT OBSERVATIONS
STEAM TUNNEL

Station	Direction	Comments
0+36	Tunnel Floor	Floor Slab Cracking at Joint
1+56	Tunnel Floor	Floor Slab Cracking
3+50	Western Wall (In-Land)	Spalling, Loose Concrete
3+65	Western Wall (In-Land)	Concrete Spalling
4+15 to 4+30	Western Wall (In-Land)	Spalling, Loose Concrete
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
5+08	Western Wall (In-Land)	Concrete Spalling
5+40	Eastern Wall (Seawall)	Leaking Joint
5+45 to 5+55	Tunnel Floor	Floor Slab Cracking
5+90	Tunnel Floor	Raised Joint, Loose Concrete and Leaking at Seawall
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
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+95 to 10+15	Western Wall (In-Land)	Spalling, Re-Bar Exposed and Corroded
11+18	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
11+29	Western Wall (In-Land)	Concrete Spalling
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+90 to 12+96	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
13+31	Western Wall (In-Land)	Spalling, 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
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
15+00	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
15+09 to 15+20	Western Wall (In-Land)	Concrete Spalling
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+70	Tunnel Floor	Concrete Spalling
17+68	Western Wall (In-Land)	Concrete Spalling
17+85 to 18+10	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
18+30 to 18+50	Western Wall (In-Land)	Spalling, Loose Concrete
18+80	Tunnel Floor	Floor Slab Raised at Joint, Cracking, Loose Concrete
19+45	Western Wall (In-Land)	Cracking at Joint, Concrete Missing
19+90 to 19+72	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

INTERIOR DEFECT OBSERVATIONS
STEAM TUNNEL

Station	Direction	Comments
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+68 to 21+75	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed
22+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
26+03 to 26+20	Western Wall (In-Land)	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	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
27+23	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
27+51 to 27+69	Western Wall (In-Land)	Concrete Spalling
27+94	Western Wall (In-Land) - Air Vent 8	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+48	Air Vent 7	Sump Pump in Working Order
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+31	Western Wall (In-Land)	Concrete Spalling
31+51	Tunnel Joint	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 32+80	Western Wall (In-Land)	Concrete Spalling, Re-Bar Exposed and Corroded
32+89 to 33+00	Western Wall (In-Land)	Concrete Spalling
32+84	Tunnel Floor	Floor Slab Cracking
33+02	Western Wall (In-Land)	Concrete Spalling
33+04 to 33+71	Western Wall (In-Land)	Spalling, Loose Concrete
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	Tunnel Floor	Floor Slab Cracked and Displaced
35+52 to 35+63	Western Wall (In-Land)	Concrete Spalling
35+63	Air Vent 5	Flooded
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
36+99 to 36+00	Western Wall (In-Land)	Concrete Spalling up to 5 feet Height
37+35	Tunnel Joint	Joint Separation, Missing Concrete
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+14	Air Vent 4	Flooded
39+23	Tunnel Floor	Floor Slab Cracking
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+40	Western Wall (In-Land)	Concrete Spalling
42+24	Air Vent 3	Sump Pump in Working Order
42+75	Tunnel Floor	Floor Slab Raised at Joint

INTERIOR DEFECT OBSERVATIONS
STEAM TUNNEL

Station	Direction	Comments
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+50	Air Vent 2	Sump Pump in Working Order
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+00		9 Feet Wide
49+09 to 49+23	Western Wall (In-Land)	Concrete Spalling
49+48	Air Vent 1	
49+50 to 51+50	Tunnel Mid-Wall	Cracked, Missing Concrete on its Entirety
49+60 to 49+62	Western Wall (In-Land)	Concrete Spalling
49+17	Tunnel Floor	Joint Filler
50+06	Tunnel Floor	Joint Filler
51+50	Air Vent 00	
55+52	Eastern Wall	1/8" Thick Crack running from the Floor to the roof of the Tunne
55+66	Tunnel Roof	Building Addition, Tunnel Offset
55+84	Eastern Wall	Concrete Cracking
56+52 to 56+55	Tunnel Roof	Concrete Spalling, Exposed rebar
58+00	Eastern Wall	Offset joint
58+54	Eastern Wall	Concrete Spalling around pipe opening
58+96	Western Wall	Concrete Spalling
59+33	Tunnel joint	Failing Joint Sealer
59+53	Eastern Wall	Concrete Spalling around pipe opening
60+10	Eastern Wall	Concrete Cracks
61+50	Southern end of Tunnel	Brick Wall

EXTERIOR DEFECT OBSERVATIONS
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+61	Seawall Joint	Concrete Spalling
5+94	Seawall	Concrete Cracks, Imbedded Wood Missing
6+16	Air Vent 16	Northern Face
6+16	Air Vent 16	Sothern 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+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 Underminec
9+09	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	Sothern Face
9+37 to 10+10	Seawall	Spalling at Haunch, Missing Large Sections of Concrete, Tunnel has been Undermined
9+96	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 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
10+77	Air Vent 14	Northern Face
10+77	Air Vent 14	Sothern Face
11+06	Seawall	Tunnel has been Undermined

EXTERIOR DEFECT OBSERVATIONS
STEAM TUNNEL

Station	Direction	Comments
11+19	Seawall Joint	Remnant of Timber Formwork
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+51	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 Door Unlocked, Broken Lock
12+84	Air Vent 13	Northern Face
12+84	Air Vent 13	Sothern Face
13+10	Seawall Joint	Spalling at Haunch, Missing Large Sections of Concrete
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+37	Seawall Joint	Concrete Spalling, Loose Sections of Concrete
15+06	Seawall Joint	Concrete Spalling, Loose Sections of Concrete
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	Sothern Face
15+63	Seawall Joint	Concrete Spalling, Exposed Re-bar
16+23	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
16+63	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
16+88	Seawall Joint	Joint Repair
17+55	Seawall	Spalling & Cracking of Concrete Haunch
17+76	Air Vent 11	Northern Face
17+76	Air Vent 11	Sothern Face
17+85	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
18+19	Seawall	Spalling & Cracking of Concrete Haunch
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	Sothern Face
20+73	Seawall Joint	Concrete Spalling and repair
21+33	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
22+64	Seawall Joint	Concrete Spalling
22+84	Air Vent 9	Northern Face
22+84	Air Vent 9	Sothern Face
23+88	Seawall Joint	Concrete Spalling
24+53	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
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	Sothern Face
25+82	Seawall Joint	Concrete Spalling
26+48	Seawall	Undermined Seawall
26+95	Seawall	Undermined Seawall
27+07	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
27+07	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
27+92	Air Vent 7	Northern Face
27+92	Air Vent 7	Sothern Face
28+02	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
28+24	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
28+34	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec

EXTERIOR DEFECT OBSERVATIONS
STEAM TUNNEL

Station	Direction	Comments
28+34	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
28+96	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
28+96	Seawall Joint	Concrete Spalling, Loose Concrete
29+62	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
29+62	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
29+62	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
30+24	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
30+24	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
30+46	Air Vent 6	Northern Face
30+46	Air Vent 6	Sothern Face
30+88	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
31+52	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
31+52	Seawall Joint	Concrete Spalling, Loose Section of Concrete, Re-Bar Exposec
32+16	Seawall Joint	Concrete Spalling, Loose Section of Concrete, Re-Bar Exposec
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 Exposec
32+79	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
32+79	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
33+00	Air Vent 5	Northern Face
33+00	Air Vent 5	Sothern Face
33+84	Seawall	Concrete Spalling
34+06	Seawall Joint	Concrete Repair Spalling
34+06	Seawall Joint	Concrete Repair Spalling
34+70	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
34+70	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
34+70	Seawall Joint	Concrete Spalling, Loose Concrete
35+38	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
35+54	Air Vent 4	Northern Face
35+54	Air Vent 4	Sothern Face
35+93	Seawall	Exposed Re-Bar, Concrete Spalling
37+22	Seawall Joint	Concrete Spalling
37+22	Seawall Joint	Concrete Spalling
37+55	Seawall	Cut in wall (Inch Deep)
38+82	Seawall Joint	Concrete Spalling
38+82	Seawall Joint	Concrete Spalling
39+03	Air Vent 3	Northern Face
39+03	Air Vent 3	Sothern Face
39+22	Seawall	Exposed Re-Bar
40+39	Seawall Joint	Concrete Spalling
40+39	Seawall Joint	Concrete Spalling
41+31	Seawall Joint	Concrete Repair
41+31	Seawall Joint	Concrete Cracks and Repairs
41+97	Seawall	Concrete Repair
42+18	Air Vent 2	Northern Face
42+18	Air Vent 2	Sothern Face
42+39	Seawall Joint	Concrete Repair Over Metal Plate, Cracks
43+04	Seawall	Spalling at Haunch
43+04	Seawall	Spalling at Haunch
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

EXTERIOR DEFECT OBSERVATIONS
STEAM TUNNEL

Station	Direction	Comments
45+34	Air Vent 1	Northern Face
45+34	Air Vent 1	Sothern Face
45+77	Seawall Joint	Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposec
45+97	Southern Seawall Terminus	Spalling at Haunch
45+97	Southern Seawall Terminus	Start of Seawall
46+39	Tunnel Surface Joint	Raised Join, Visible Cracks and Concrete Repairs

APPENDIX A

PHOTOGRAPHIC OBSERVATIONS

INTERIOR CONDITIONS

LANGAN

Station 0+36

Direction: Tunnel Floor

Comments: Floor Slab Cracking at Joint

Station 1+56

Direction: Tunnel Floor

Comments: Floor Slab Cracking

Station 3+50

Direction: Western Wall (In-Land)

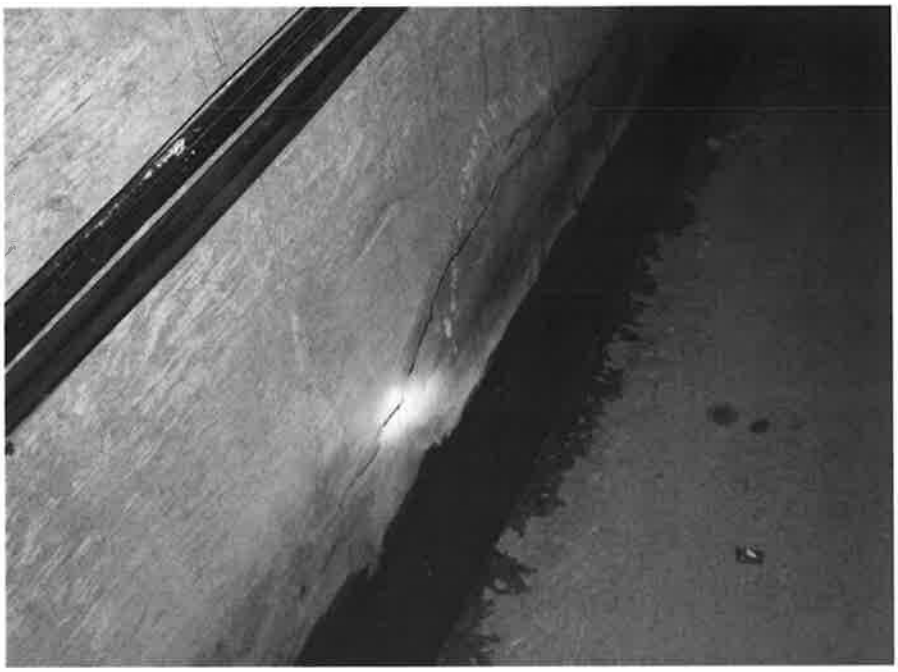
Comments: Spalling, Loose Concrete

Station 3+65

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 4+15 to 4+30



Direction: Western Wall (In-Land)

Comments: Spalling, Loose Concrete

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

Station 5+08

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 5+40

Direction: Eastern Wall (Seawall)

Comments: Leaking Joint

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+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 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+95 to 10+15

Direction: Western Wall (In-Land)

Comments: Spalling, Re-Bar Exposed and Corroded

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+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+90 to 12+96

Direction: Western Wall (In-Land)

Comments: Concrete Spalling, Re-Bar Exposed and Corroded

Station 13+31

Direction: Western Wall (In-Land)

Comments: Spalling, 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 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+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+70

Direction: Tunnel Floor

Comments: Concrete Spalling

Station 17+68

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 17+85 to 18+10

Direction: Western Wall (In-Land)

Comments: Concrete Spalling, Re-Bar Exposed and Corroded

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 19+45

Direction: Western Wall (In-Land)

Comments: Cracking at Joint, Concrete Missing

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+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+68 to 21+75

Direction: Western Wall (In-Land)

Comments: Concrete Spalling, Re-Bar Exposed

Station 22+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 26+03 to 26+20

Direction: Western Wall (In-Land)

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

Direction: Western Wall (In-Land)

Comments: Concrete Spalling, Re-Bar Exposed and Corroded

Station 27+23

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+94

Direction: Western Wall (In-Land) - Air Vent 8

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+48

Direction: Air Vent 7

Comments: Sump Pump in Working Order

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+31

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 31+51

Direction: Tunnel Joint

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 32+80

Direction: Western Wall (In-Land)

Comments: Concrete Spalling, Re-Bar Exposed and Corroded

Station 32+89 to 33+00

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 32+84

Direction: Tunnel Floor

Comments: Floor Slab Cracking

Station 33+02

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 33+04 to 33+71

Direction: Western Wall (In-Land)

Comments: Spalling, Loose Concrete

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: Tunnel Floor

Comments: Floor Slab Cracked and Displaced

Station 35+52 to 35+63

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

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 36+99 to 36+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 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+23

Direction: Tunnel Floor

Comments: Floor Slab Cracking

Station 39+58 to 39+74

Direction: Western Wall (In-Land)

Comments: Concrete Spalling, Re-Bar Exposed and Corroded

Station 40+02 to 40+03

Direction: Western Wall (In-Land)

Comments: Concrete Spalling, Re-Bar Exposed and Corroded

Station 40+50 to 40+90

Direction: Western Wall (In-Land)

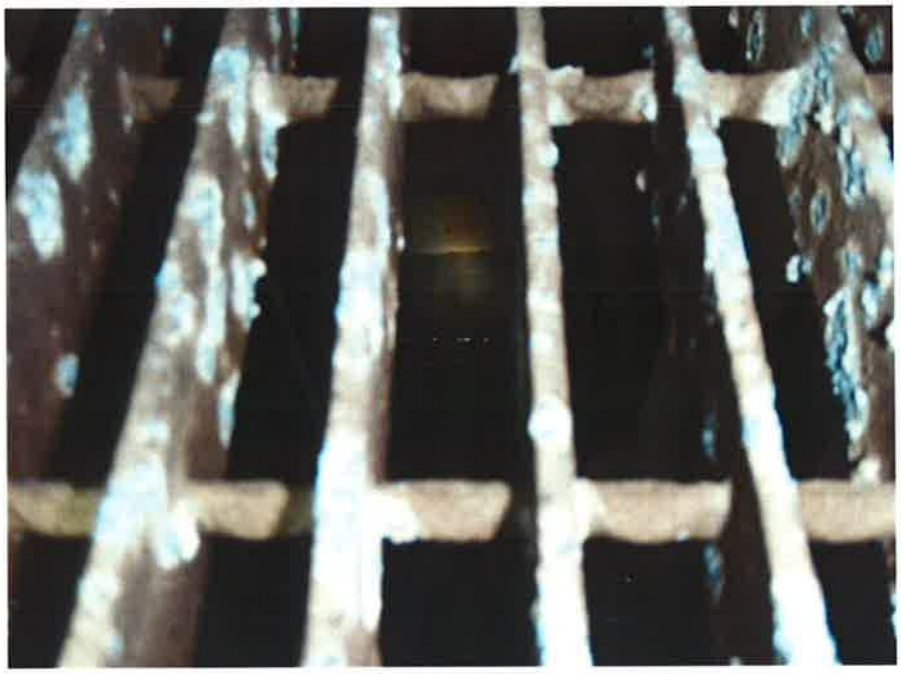
Comments: Concrete Spalling

Station 40+98 to 41+40

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 42+24



Direction: Air Vent 3

Comments: Sump Pump in Working Order

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+50

Direction: Air Vent 2

Comments: Sump Pump in Working Order

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+50 to 51+50

Direction: Tunnel Mid-Wall

Comments: Cracked, Missing Concrete on its Entirety

Station 49+60 to 49+62

Direction: Western Wall (In-Land)

Comments: Concrete Spalling

Station 49+17

Direction: Tunnel Floor

Comments: Joint Filler

Station 50+06

Direction: Tunnel Floor

Comments: Joint Filler

Station 55+52

Direction: Eastern Wall

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

Station 55+66

Direction: Tunnel Roof

Comments: Building Addition, Tunnel Offset

Station 55+84

Direction: Eastern Wall

Comments: Concrete Cracking

Station 56+52 to 56+55

Direction: Tunnel Roof

Comments: Concrete Spalling, Exposed rebar

Station 58+00

Direction: Eastern Wall

Comments: Offset joint

Station 58+54

Direction: Eastern Wall

Comments: Concrete Spalling around pipe opening

Station 58+96

Direction: Western Wall

Comments: Concrete Spalling

Station 59+33

Direction: Tunnel joint

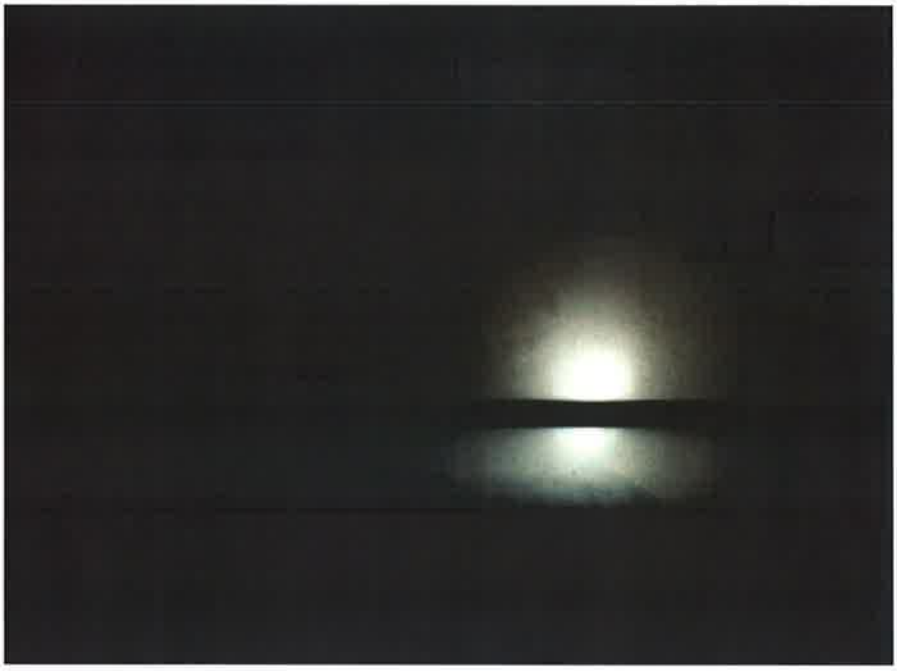
Comments: Failing Joint Sealer

Station 59+53

Direction: Eastern Wall

Comments: Concrete Spalling around pipe opening

Station 60+10



Direction: Eastern Wall

Comments: Concrete Cracks

Station 61+50

Direction: Southern end of Tunnel

Comments: Brick Wall

EXTERIOR CONDITIONS

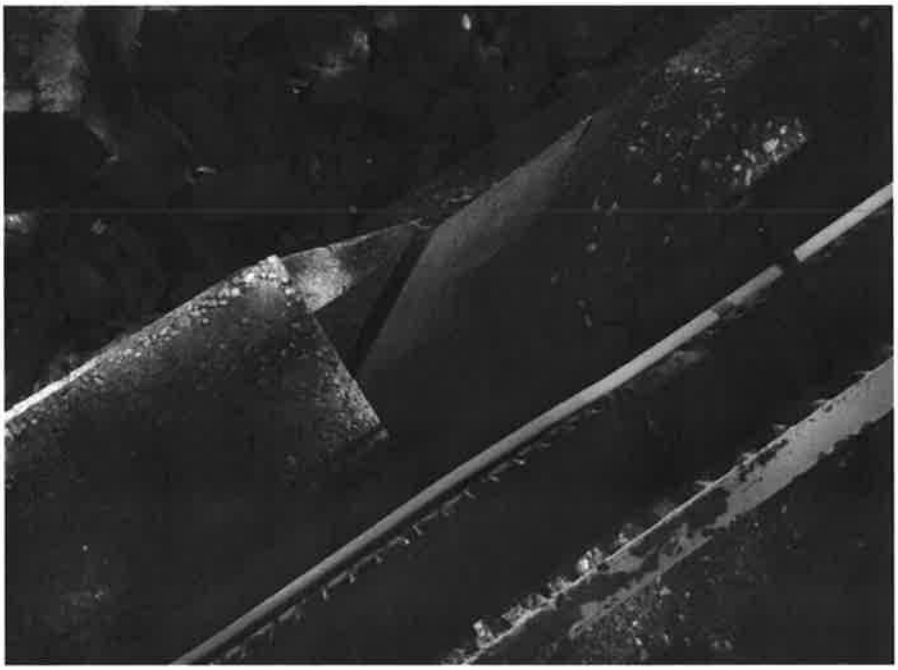
LANGAN

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+61

Direction: Seawall Joint

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

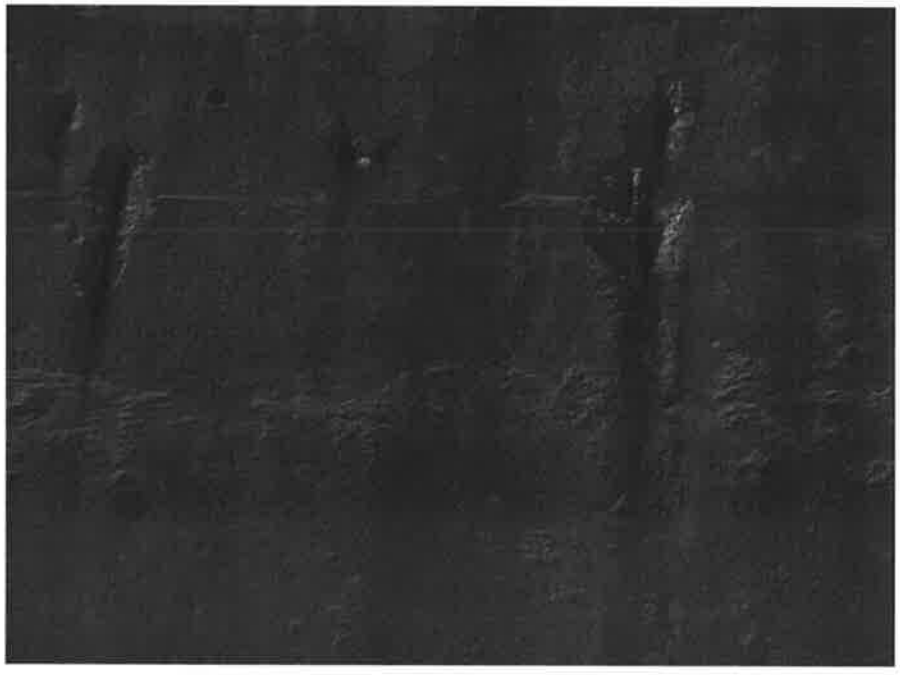
Comments: Missing Rip-Rap, Tunnel Undermined

Station 7+26

Direction: Seawall Joint

Comments: Spalling at Haunch, Missing Large Sections of Concrete

Station 7+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+09

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: Sothern Face

Station 9+37 to 10+10

Direction: Seawall

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

Station 9+96

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 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: Sothern Face

Station 11+06

Direction: Seawall

Comments: Tunnel has been Undermined

Station 11+19

Direction: Seawall Joint

Comments: Remnant of Timber Formwork

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+51

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 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 13+10

Direction: Seawall Joint

Comments: Spalling at Haunch, Missing Large Sections of Concrete

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+37

Direction: Seawall Joint

Comments: Concrete Spalling, Loose Sections of Concrete

Station 15+06

Direction: Seawall Joint

Comments: Concrete Spalling, Loose Sections of Concrete

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: Sothern Face

Station 15+63

Direction: Seawall Joint

Comments: Concrete Spalling, Exposed Re-bar

Station 16+23

Direction: Seawall Joint

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

Station 16+63

Direction: Seawall Joint

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

Station 16+88

Direction: Seawall Joint

Comments: Joint Repair

Station 17+55

Direction: Seawall

Comments: Spalling & Cracking of Concrete Haunch

Station 17+76

Direction: Air Vent 11

Comments: Northern Face

Station 17+76

Direction: Air Vent 11

Comments: Sothern Face

Station 17+85

Direction: Seawall Joint

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

Station 18+19

Direction: Seawall

Comments: Spalling & Cracking of Concrete Haunch

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: Sothern Face

Station 20+73

Direction: Seawall Joint

Comments: Concrete Spalling and repair

Station 21+33

Direction: Seawall Joint

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

Station 22+64

Direction: Seawall Joint

Comments: Concrete Spalling

Station 22+84

Direction: Air Vent 9

Comments: Northern Face

Station 22+84

Direction: Air Vent 9

Comments: Sothern Face

Station 23+88

Direction: Seawall Joint

Comments: Concrete Spalling

Station 24+53

Direction: Seawall Joint

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

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: Sothern Face

Station 25+82

Direction: Seawall Joint

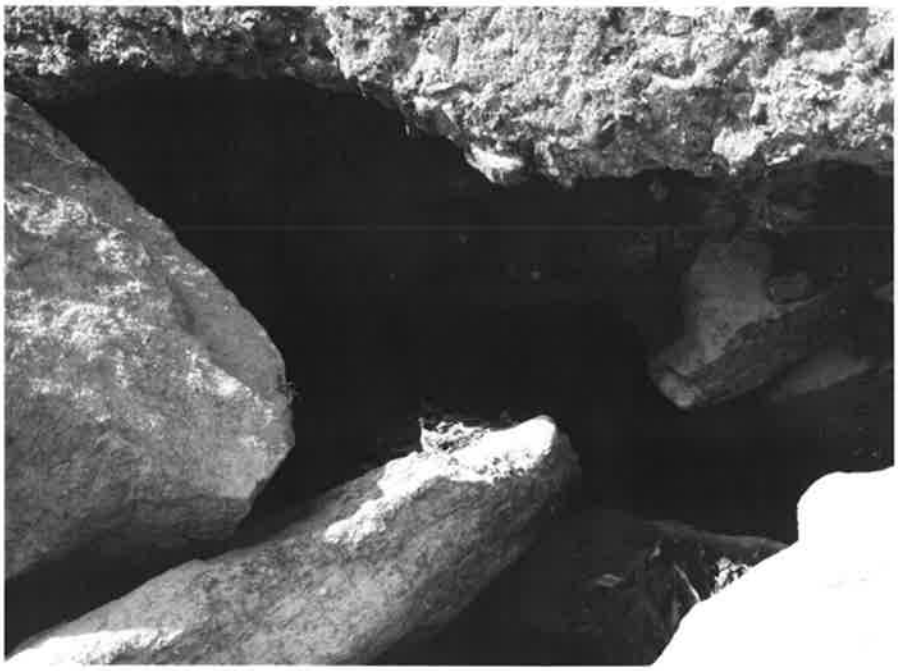
Comments: Concrete Spalling

Station 26+48

Direction: Seawall

Comments: Undermined Seawall

Station 26+95



Direction: Seawall

Comments: Undermined Seawall

Station 27+07

Direction: Seawall Joint

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

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: Sothern Face

Station 28+02

Direction: Seawall Joint

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

Station 28+24

Direction: Seawall Joint

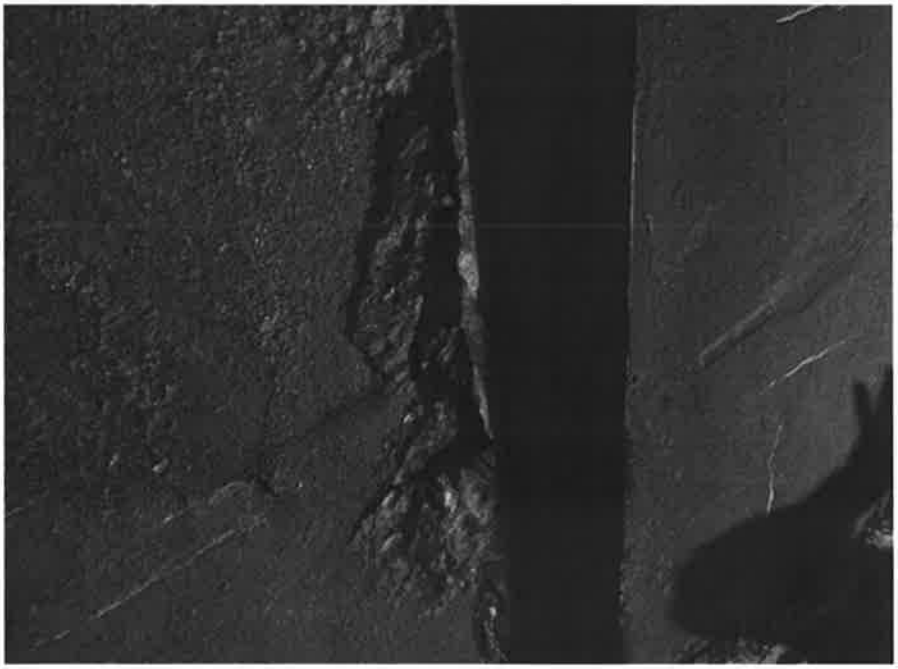
Comments: Concrete Spalling, Missing Large Section of Concrete, Re-Bar Exposed

Station 28+34

Direction: Seawall Joint

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

Station 28+34



Direction: Seawall Joint

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

Station 28+96

Direction: Seawall Joint

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

Station 28+96

Direction: Seawall Joint

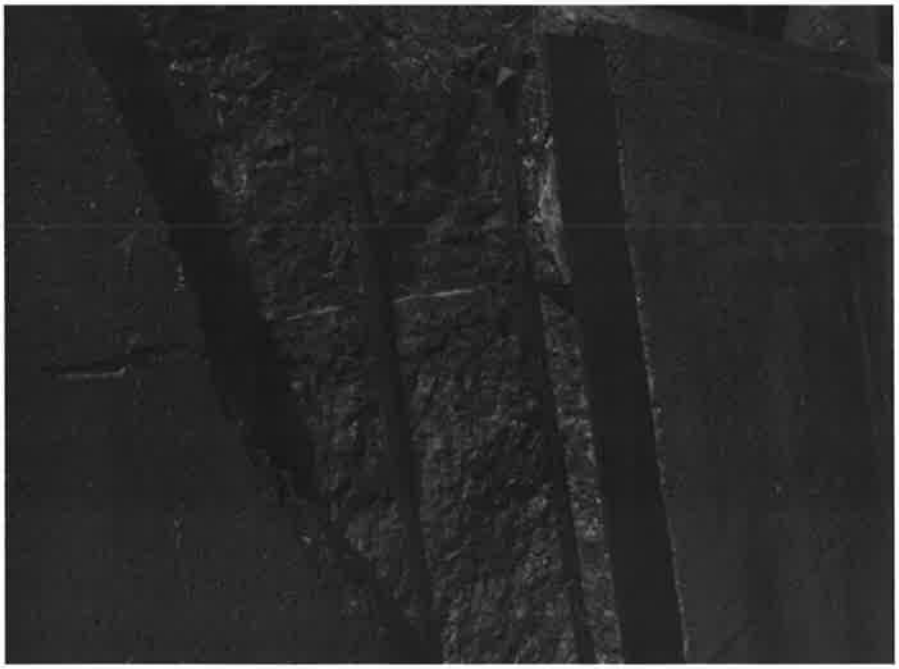
Comments: Concrete Spalling, Loose Concrete

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+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: Sothern Face

Station 30+88

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 31+52

Direction: Seawall Joint

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

Station 32+16

Direction: Seawall Joint

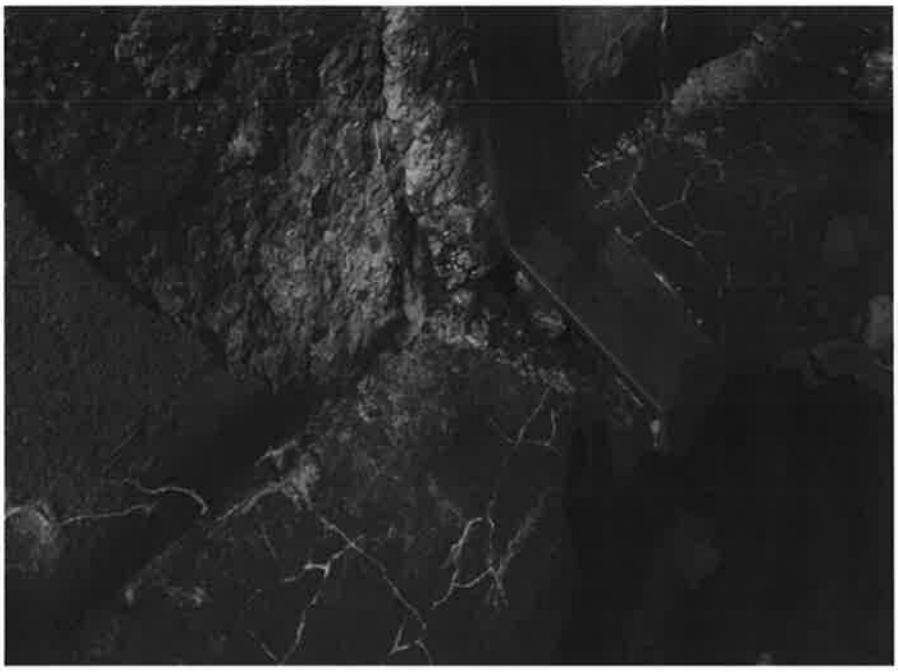
Comments: Concrete Spalling, Loose Section of Concrete, Re-Bar Exposed

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 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: Sothern Face

Station 33+84

Direction: Seawall

Comments: Concrete Spalling

Station 34+06

Direction: Seawall Joint

Comments: Concrete Repair Spalling

Station 34+06

Direction: Seawall Joint

Comments: Concrete Repair Spalling

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, 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: Sothern Face

Station 35+93

Direction: Seawall

Comments: Exposed Re-Bar, Concrete Spalling

Station 37+22

Direction: Seawall Joint

Comments: Concrete Spalling

Station 37+22

Direction: Seawall Joint

Comments: Concrete Spalling

Station 37+55

Direction: Seawall

Comments: Cut in wall (Inch Deep)

Station 38+82

Direction: Seawall Joint

Comments: Concrete Spalling

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: Sothern Face

Station 39+22

Direction: Seawall

Comments: Exposed Re-Bar

Station 40+39

Direction: Seawall Joint

Comments: Concrete Spalling

Station 40+39

Direction: Seawall Joint

Comments: Concrete Spalling

Station 41+31

Direction: Seawall Joint

Comments: Concrete Repair

Station 41+31

Direction: Seawall Joint

Comments: Concrete Cracks and Repairs

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

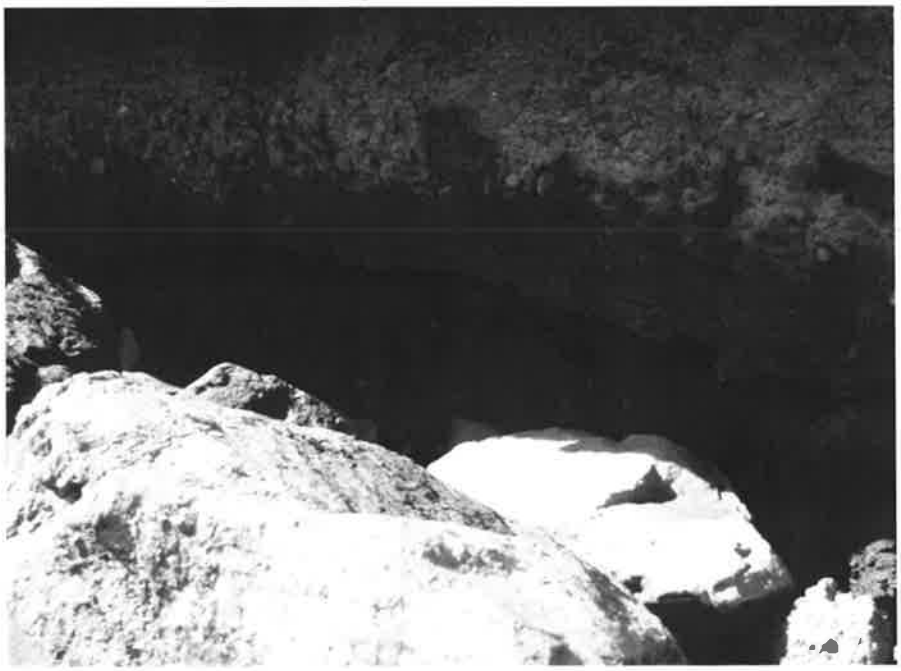
Comments: Sothern Face

Station 42+39

Direction: Seawall Joint

Comments: Concrete Repair Over Metal Plate, Cracks

Station 43+04



Direction: Seawall

Comments: Spalling at Haunch

Station 43+04

Direction: Seawall

Comments: Spalling at Haunch

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: Sothern Face

Station 45+77

Direction: Seawall Joint

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

Station 45+97

Direction: Southern Seawall Terminus

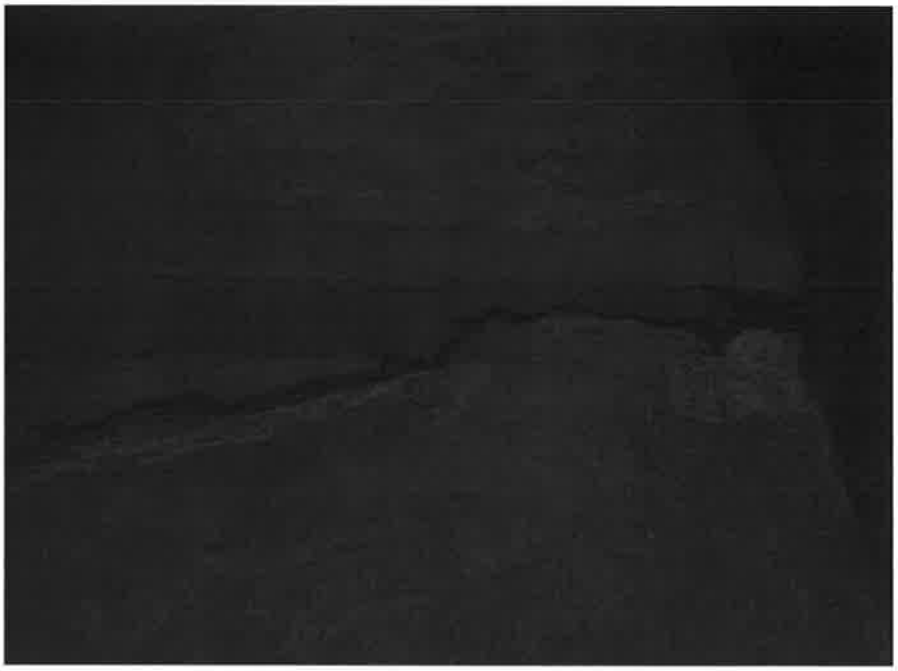
Comments: Spalling at Haunch

Station 45+97

Direction: Southern Seawall Terminus

Comments: Start of Seawall

Station 46+39



Direction: Tunnel Surface Joint

Comments: Raised Join, Visible Cracks and Concrete Repairs

APPENDIX B

SECURITY SURVEY

Station 6+16

Direction: Air Vent 16

Comments: Northern Face

Station 6+16

Direction: Air Vent 16

Comments: Sothern Face

Station 9+21

Direction: Air Vent 15

Comments: Northern Face

Station 9+21

Direction: Air Vent 15

Comments: Sothern Face

Station 10+77

Direction: Air Vent 14

Comments: Northern Face

Station 10+77

Direction: Air Vent 14

Comments: Sothern 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

LANGAN

Langan Project No.: 100444601

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 ar eas 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 sytem. See detail for 1949 waterproofiing 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 stancion 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 occuring. 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.

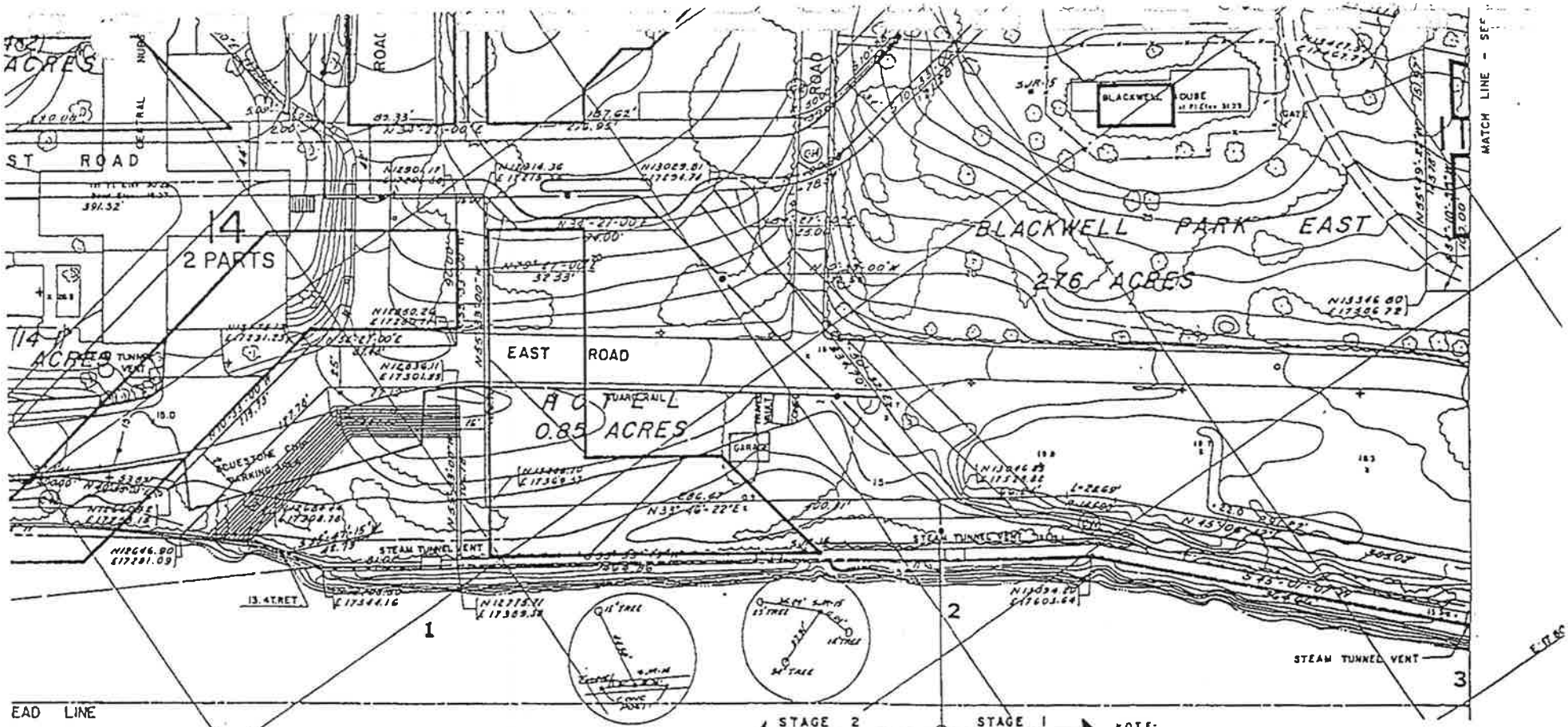
RECOMMENDATION
Replace rip rap as required. Repair expansion joints. Check tunnel piers, piles & caps for deterioration. Repair as required.

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.



NOTE:

1. 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.
2. BENCHMARK ON N.W. CORNER OF QUEENSBORO BRIDGE PIER ON EASTERLY BANK OF WELFARE ISLAND EL. 17.458.
3. THE COORDINATE SYSTEM IS BASED UPON THE ONE ESTABLISHED BY THE U.S. ARMY ENGINEERS (DRAWING NO. S.D.975) AND THE FOLLOWING TRANSLATION WAS MADE:

	U.S. COORDINATES		E&S COORDINATES
U.S. ARM. IN	S 11,393.254	N	A 10,000.000
	W 842.168	E	E 15,000.000

Remarks

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0' 20' 60' 100' 200'

GRAPHIC SCALE

EAST	TYPE	ELEVATION
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353.95	MON. & B.M.	EL. 17.777
502.19	MONUMENT	—
151.10	MONUMENT	—
795.96	MON. & B.M.	EL. 15.666

NEW YORK STATE URBAN DEVELOPMENT CORPORATION
WELFARE ISLAND DEVELOPMENT COR

MASTER ENGINEERING PLAN
PARCELIZATION, HORIZONTAL CONTROLS & BENCH MA
SOUTH TOWN & TOWN CENTER

Gibbs & Hill, Inc.	SCALE	DATE	DWG. No.	SHEET
ENGINEERS, DESIGNERS, CONSTRUCTORS New York	AS SHOWN	MAY 1971	2133B M-ST3	3 OF SHEET
JOB NO. 2133				

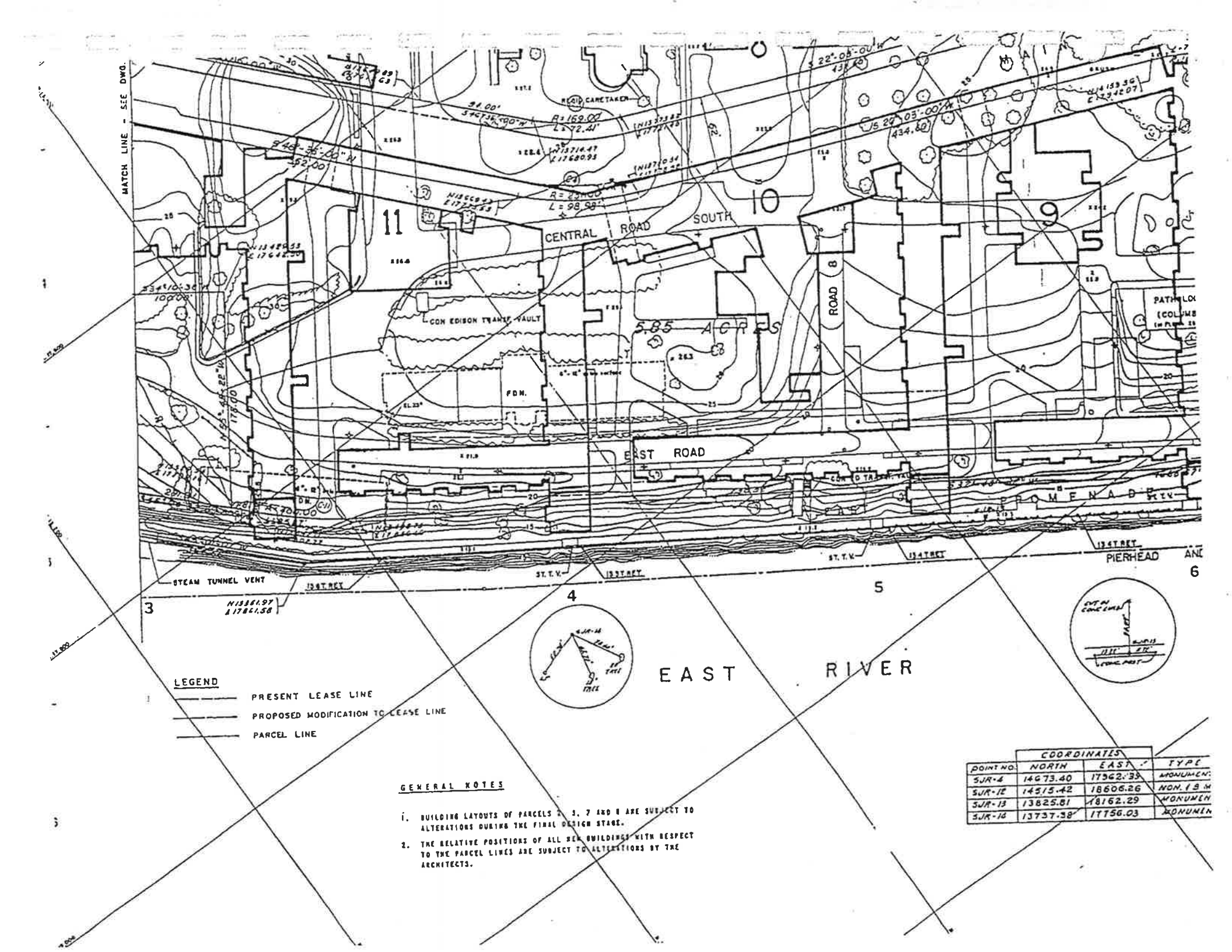
ISSUE NO.	DATE	DRWN	CHKD							
1	6-15-71	L.C.	HG							

MASTER ENGINEERING PLAN

ISSUED FOR

APPROVALS

APPENDIX A



GENERAL NOTES

1. BUILDING LAYOUTS OF PARCELS 2, 3, 7 AND 8 ARE SUBJECT TO ALTERATIONS DURING THE FINAL DESIGN STAGE.
2. THE RELATIVE POSITIONS OF ALL SEA BUILDINGS WITH RESPECT TO THE PARCEL LINES ARE SUBJECT TO ALTERATIONS BY THE ARCHITECTS.

POINT NO.	COORDINATES NORTH	EAST	TYPE
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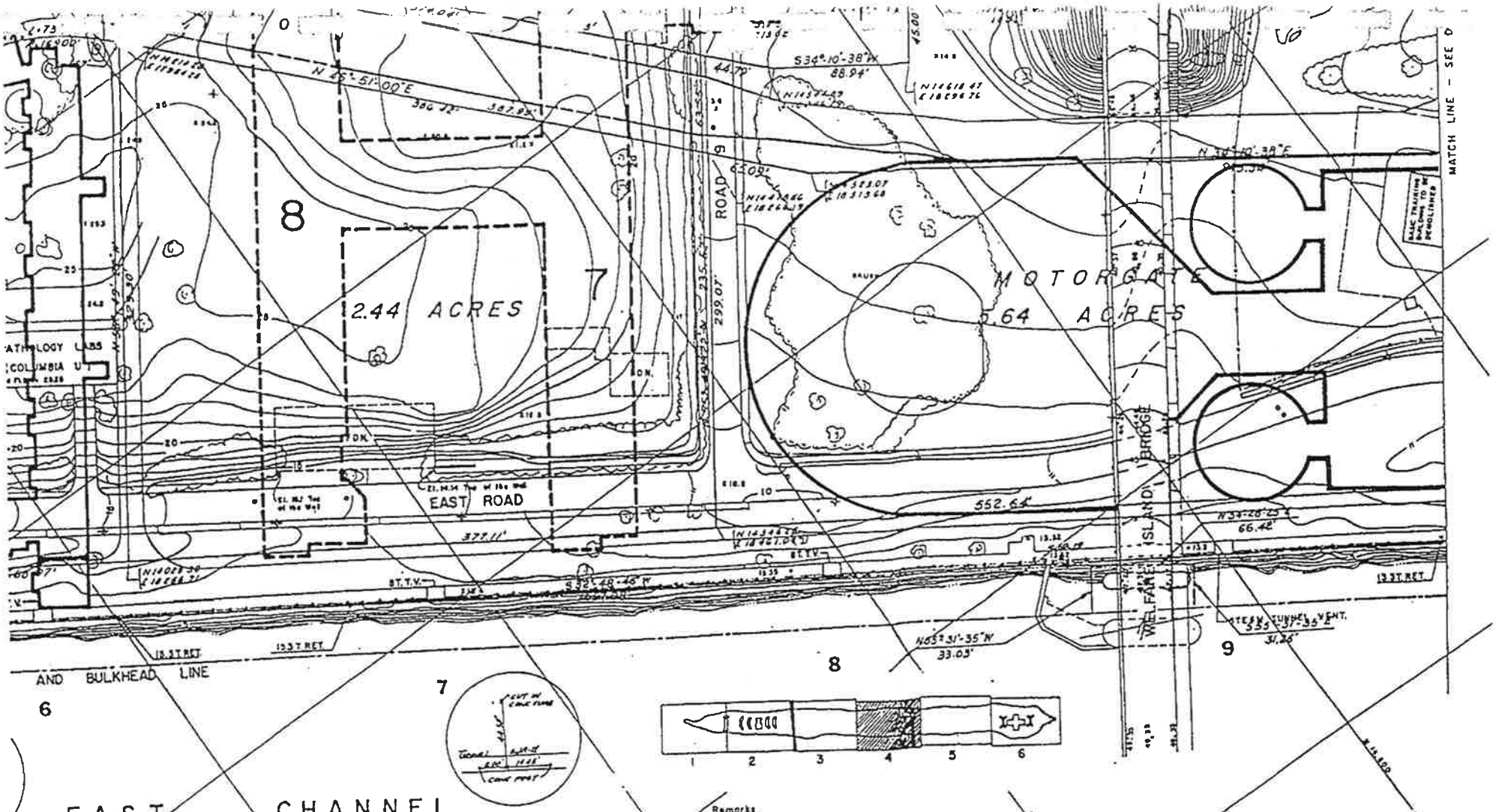
SJR-12	14515.42	18606.26	MON. IN W
SJR-13	13825.81	18162.29	MONUMEN
SJR-14	13737.38	17756.03	MONUMEN



TYPE	ELEVATION
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ON. I.B.M.	EL. 13.364
ONUMENT	——
ONUMENT	——

NOTES:

1. 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.
2. BENCHMARK ON N.W. CORNER OF QUEENSBORO BRIDGE PIER . OR EASTERLY BANK OF WELFARE ISLAND EL. 17.958.
3. THE COORDINATE SYSTEM IS BASED UPON THE ONE ESTABLISHED BY THE U.S. ARMY ENGINEERS (DRAWING NO. S.D.278) AND THE FOLLOWING TRANSLATION WAS MADE:

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	W 642.168	=	E 15,000.000

Remarks

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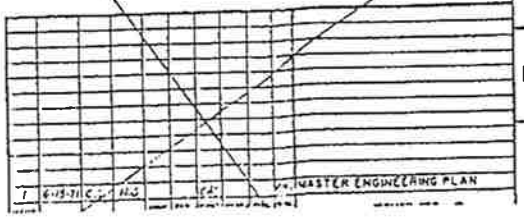
GRAPHIC SCALE

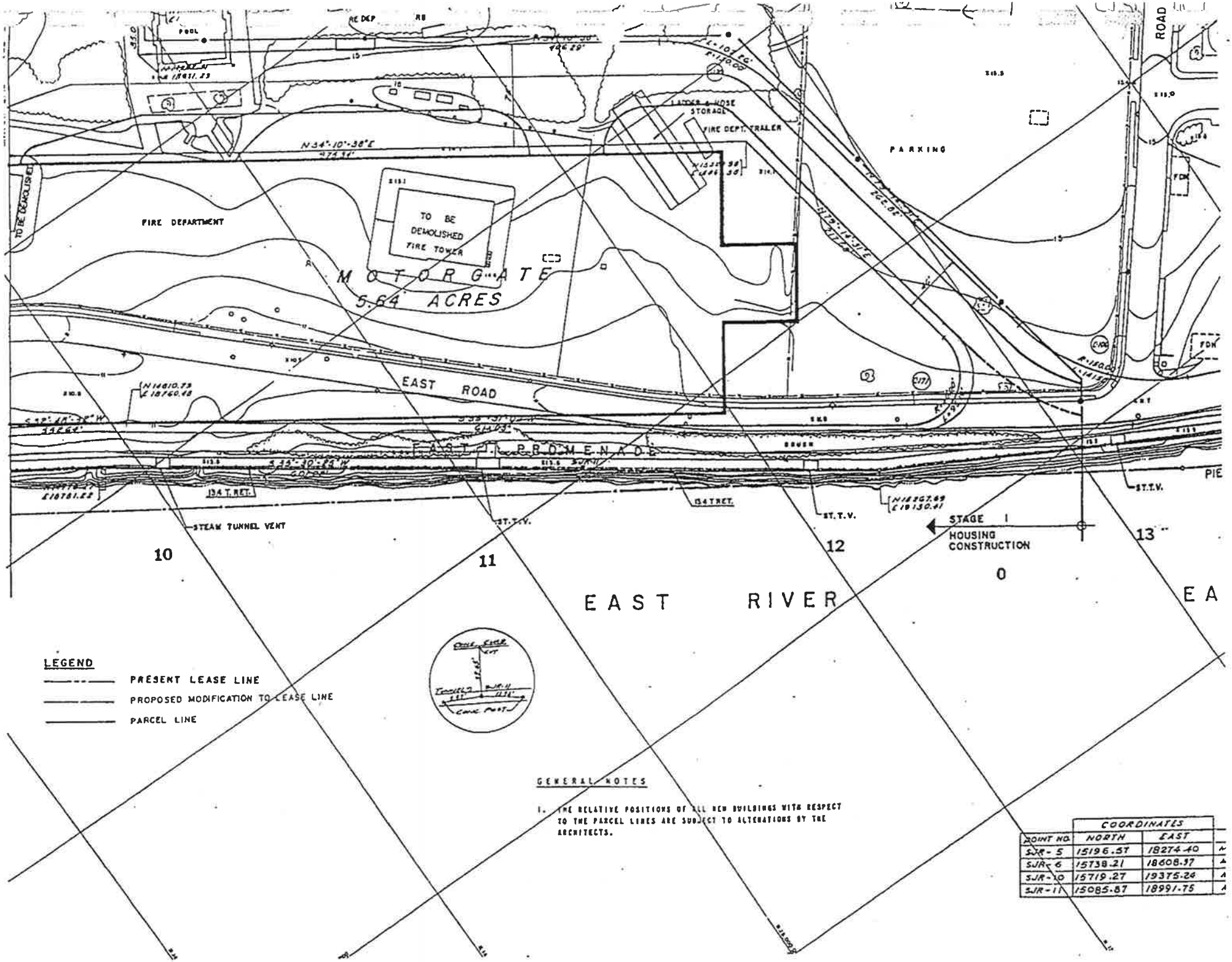


NEW YORK STATE URBAN DEVELOPMENT CORPORA

WELFARE ISLAND DEVELOPMENT

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

Gibbs & Hill, Inc.	SCALE	DATE	DWG. No.
JOB NO. 2133	AS SHOWN	MAY 1971	21338 M-ST4



GENERAL NOTES

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

POINT NO.	COORDINATES NORTH	EAST
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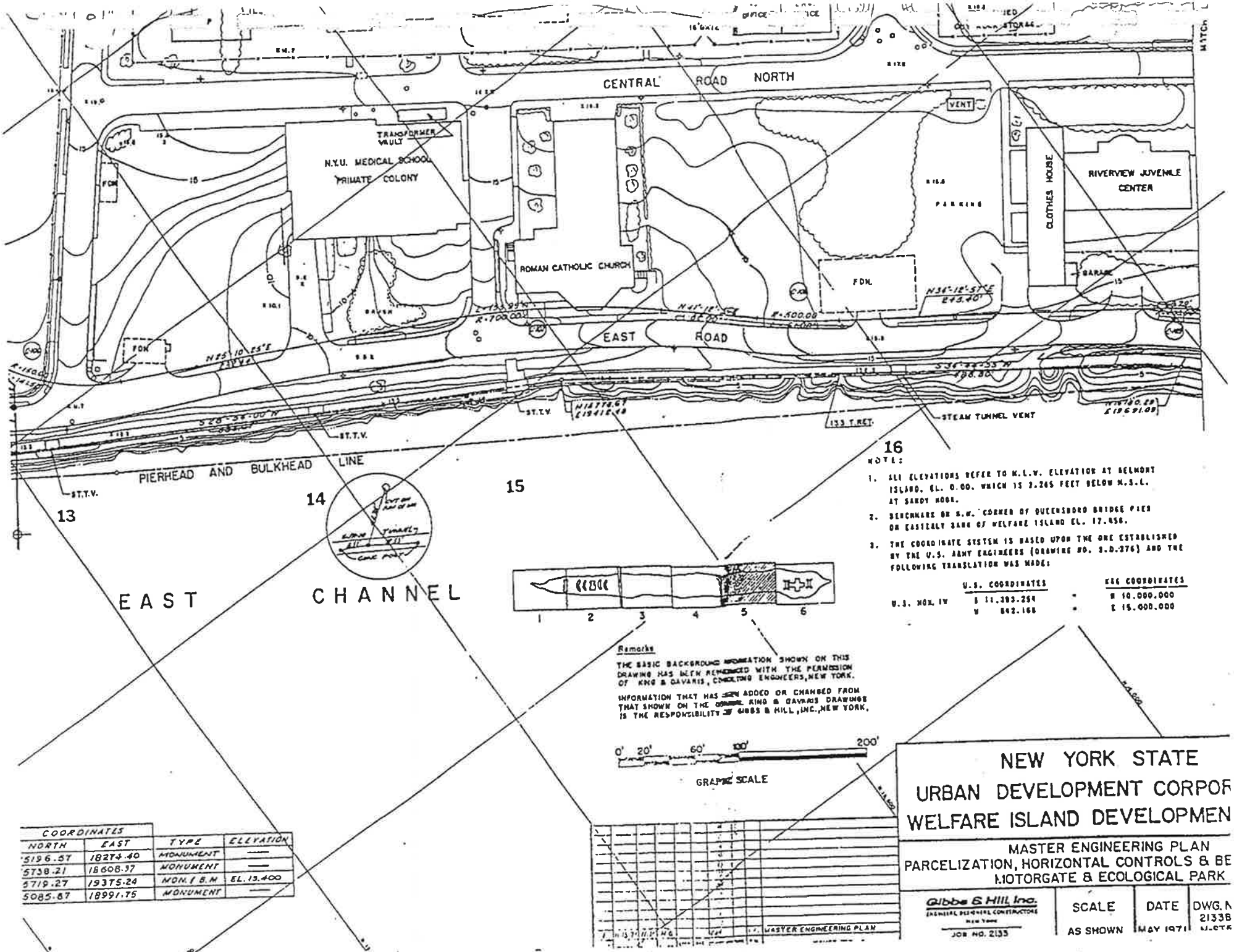

NOTE:

1. 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.
2. BENCHMARK ON S.W. CORNER OF QUEENSBORO BRIDGE PIER ON EASTERLY SIDE OF WELFARE ISLAND EL. 17.656.
3. THE COORDINATE SYSTEM IS BASED UPON THE ONE ESTABLISHED BY THE U.S. ARMY ENGINEERS (DRAWING NO. S.D.376) AND THE FOLLOWING TRANSLATION WAS MADE:

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	W 842.168	=	E 15,000.000

Remarks

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0' 20' 60' 100' 200'

GRAPHIC SCALE

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5738.21	18608.37	MONUMENT	—
5719.27	19375.24	MON. & B.M.	EL. 13.400
5085.67	18991.75	MONUMENT	—

NEW YORK STATE URBAN DEVELOPMENT CORPOR
WELFARE ISLAND DEVELOPMEN

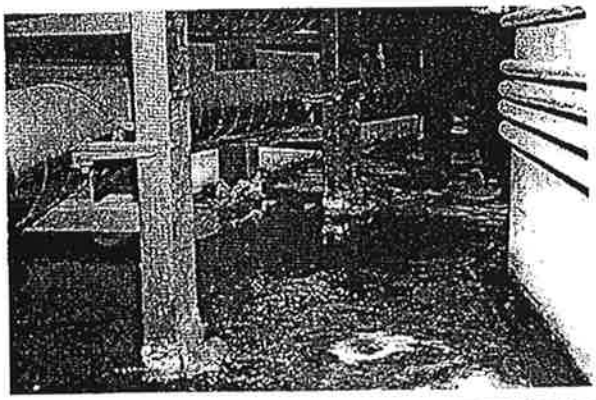
MASTER ENGINEERING PLAN
PARCELIZATION, HORIZONTAL CONTROLS & BE
MOTORGATE & ECOLOGICAL PARK

Gibbs & Hill, Inc.
ENGINEERS, DESIGNERS, CONSTRUCTORS
NEW YORK

JOB NO. 2133

SCALE	DATE	DWG. N
AS SHOWN	MAY 1971	21338

VENT 1 - VENT 2



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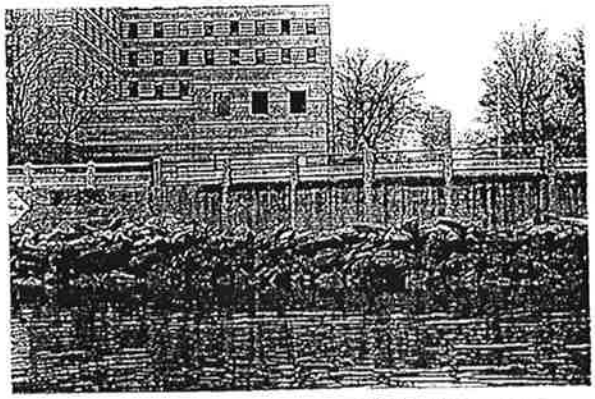

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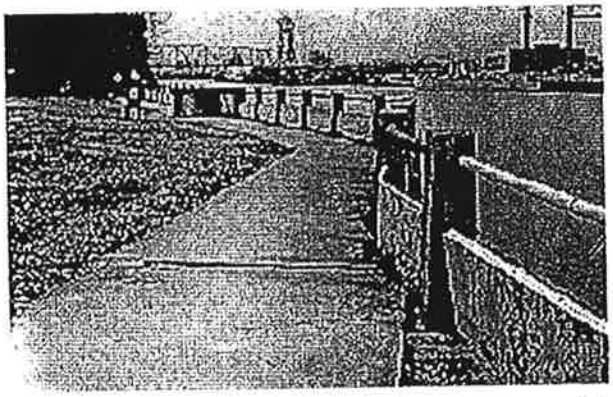

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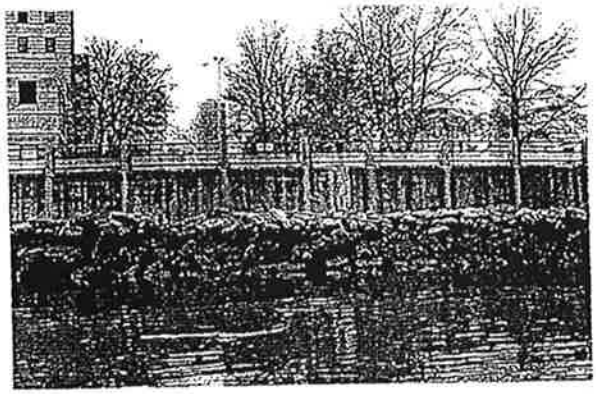

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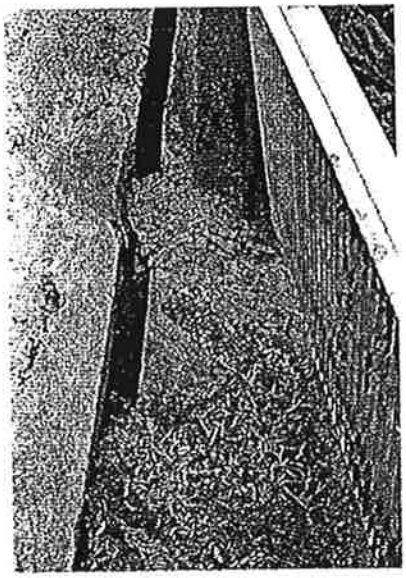

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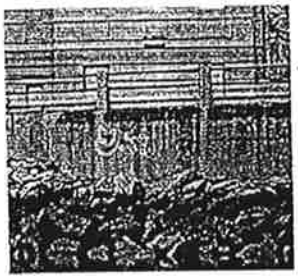
4



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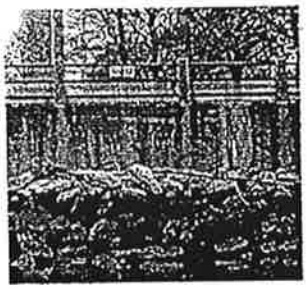

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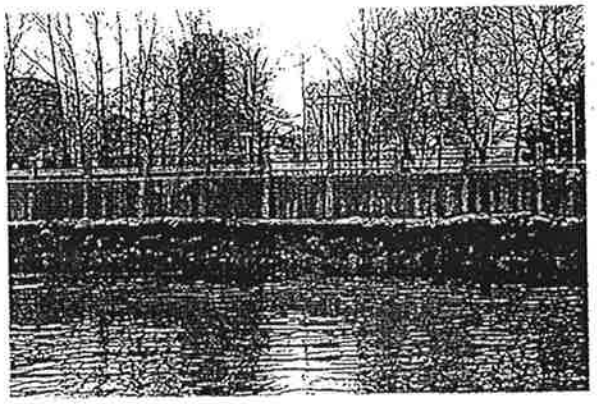

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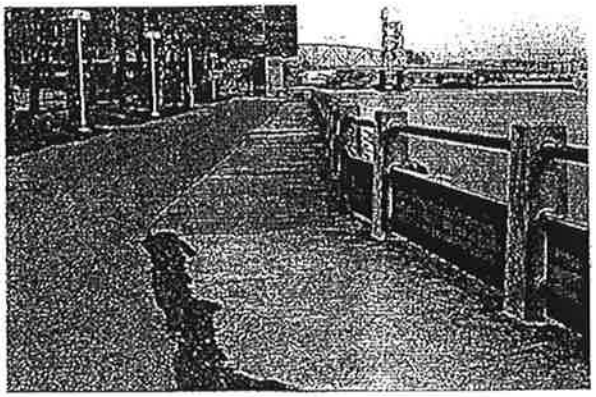

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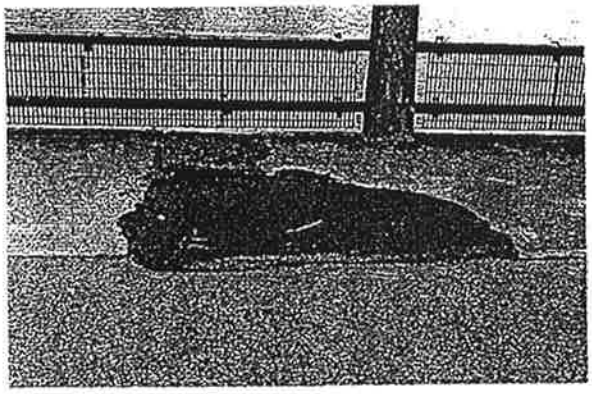

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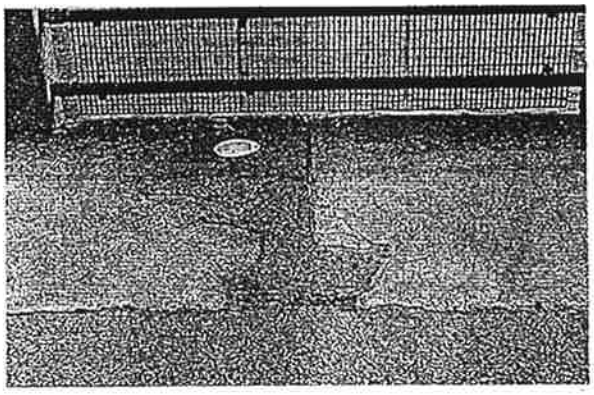

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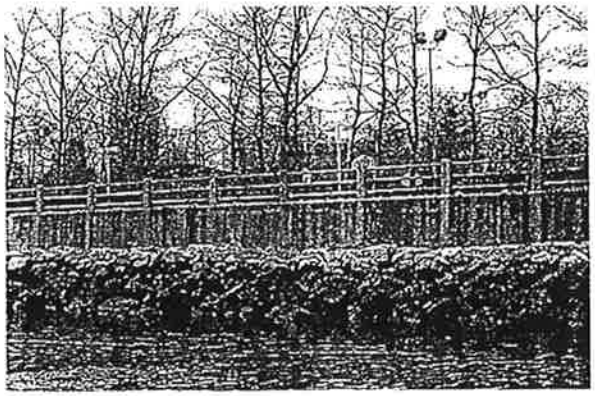

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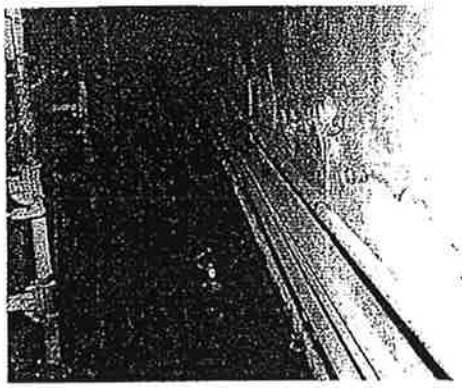

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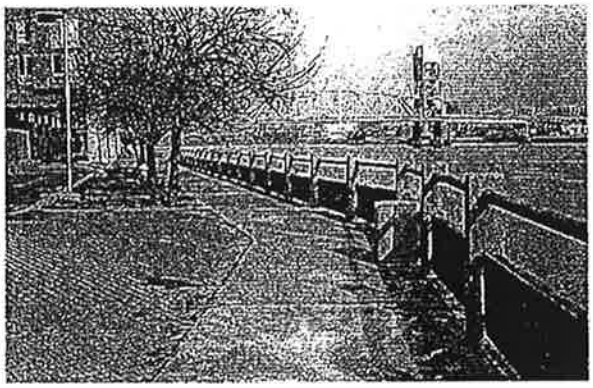

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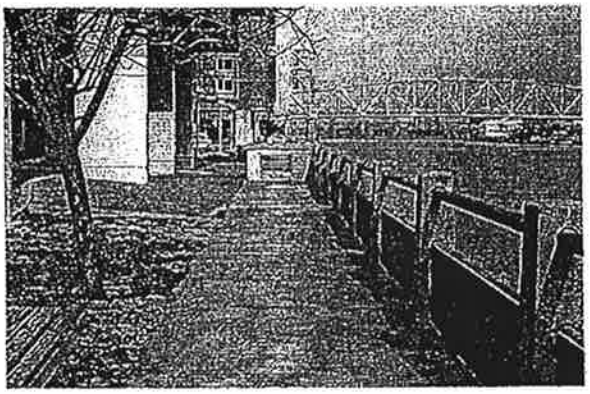

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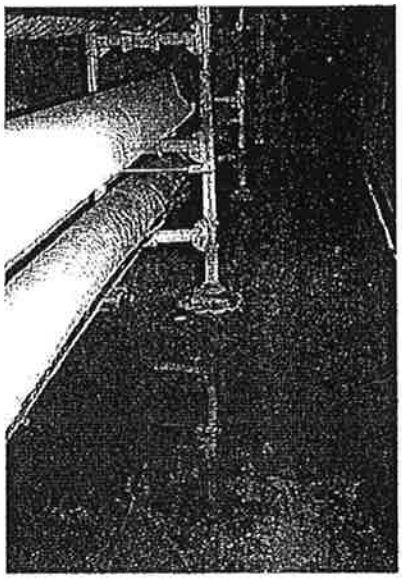

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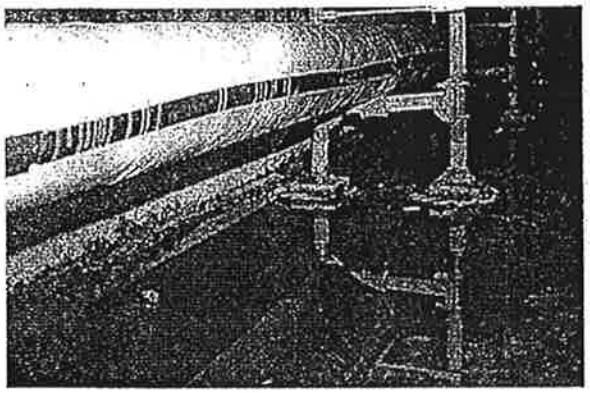

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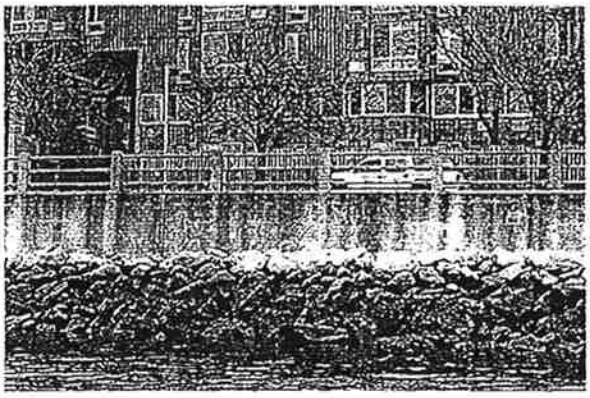

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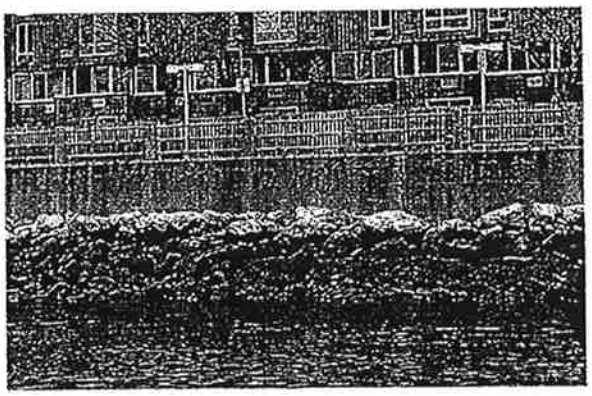

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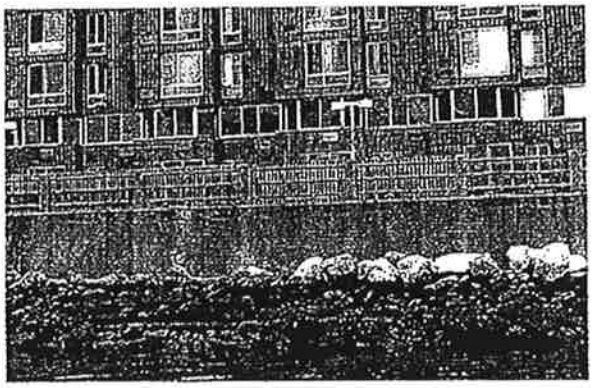

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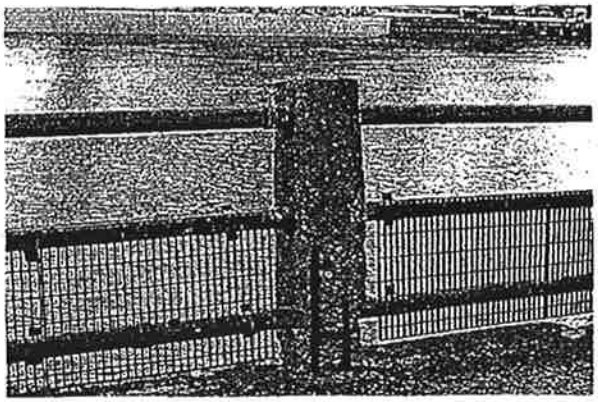

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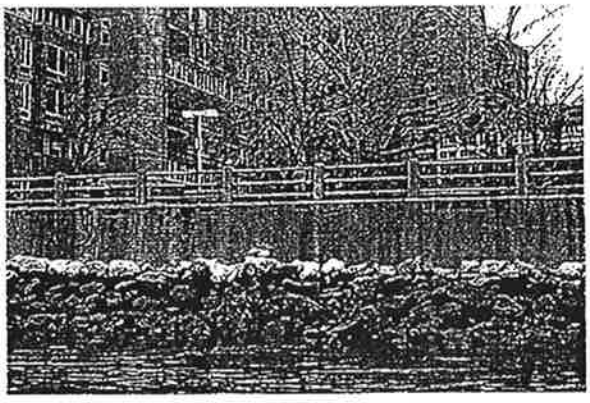

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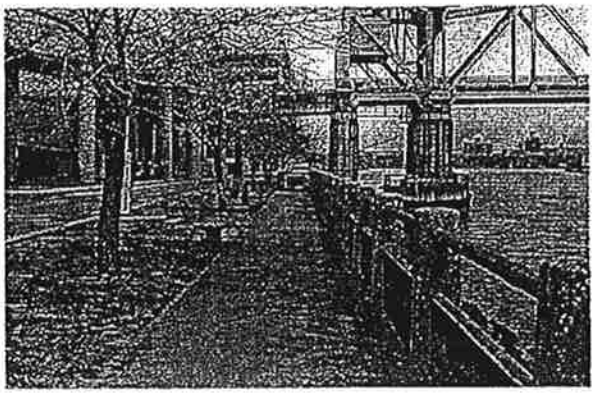

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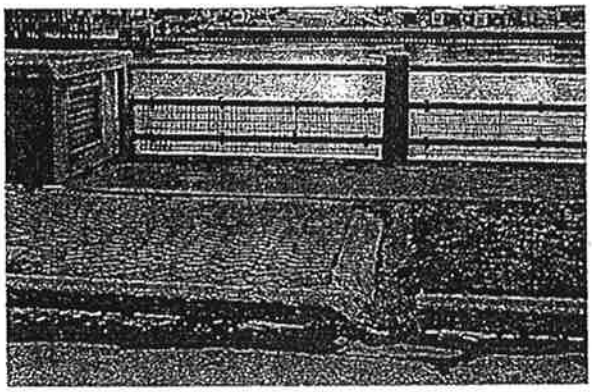

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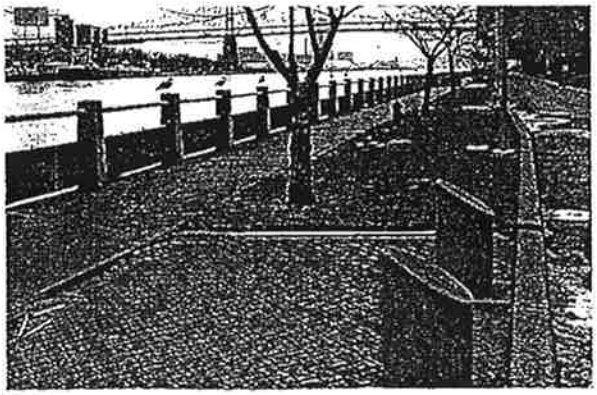

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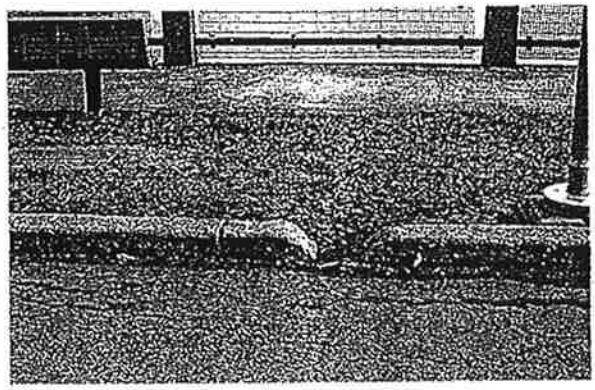

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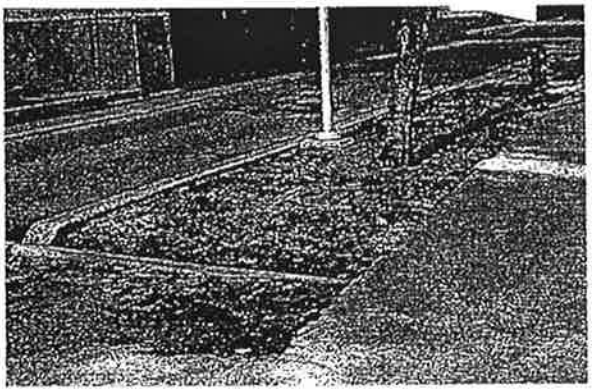

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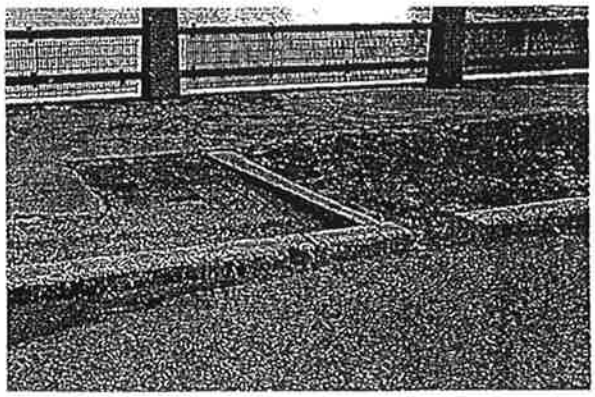

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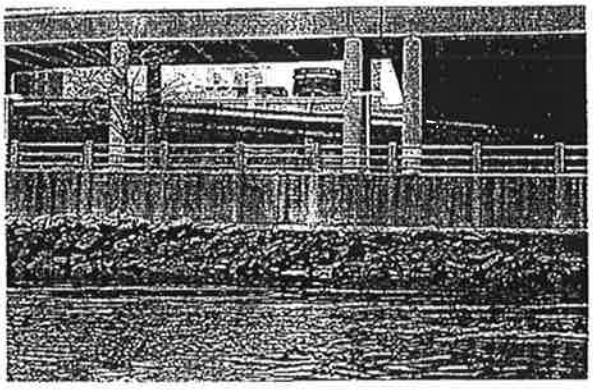

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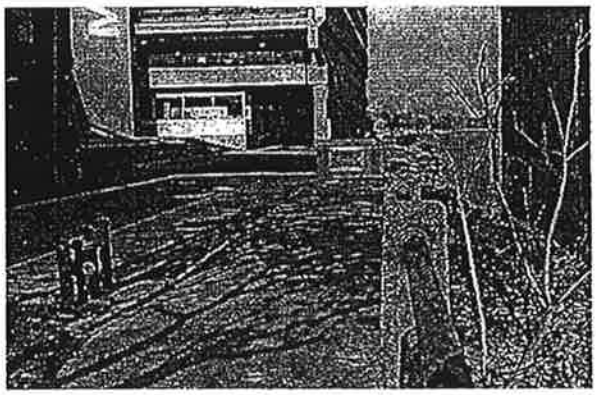

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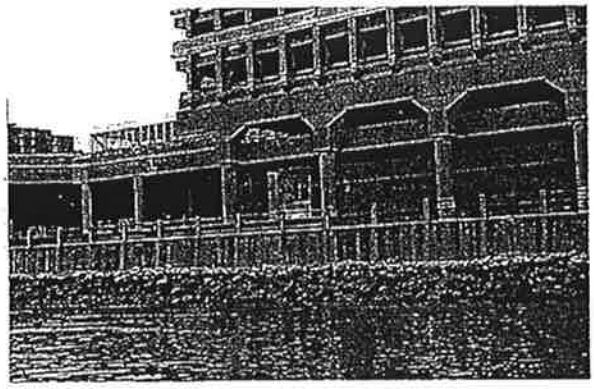

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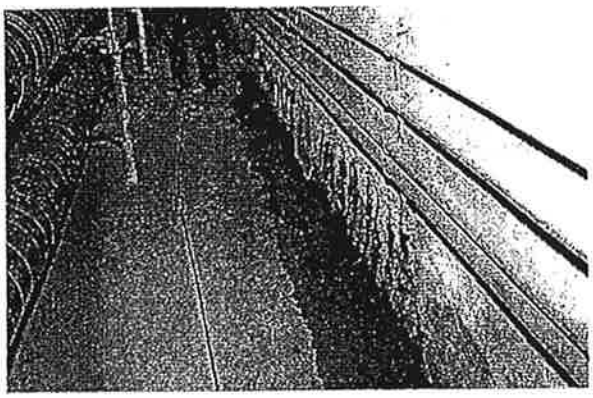

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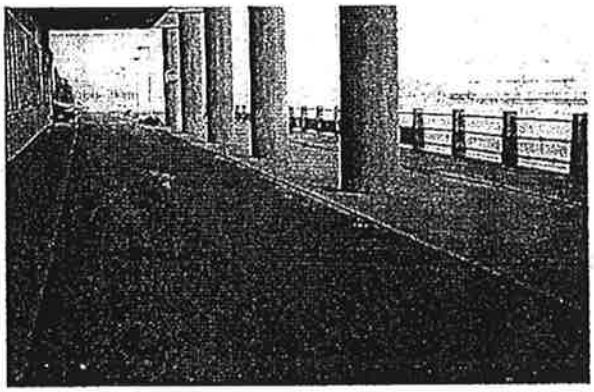

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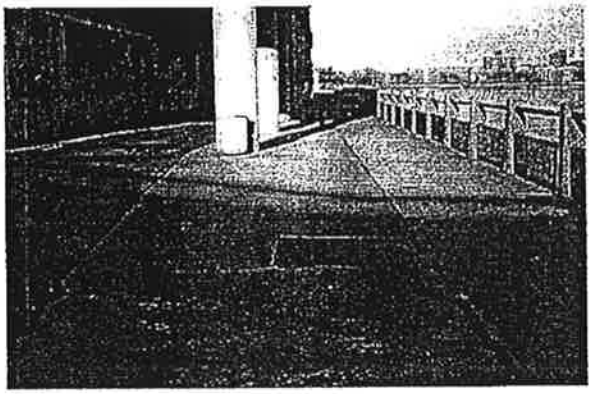

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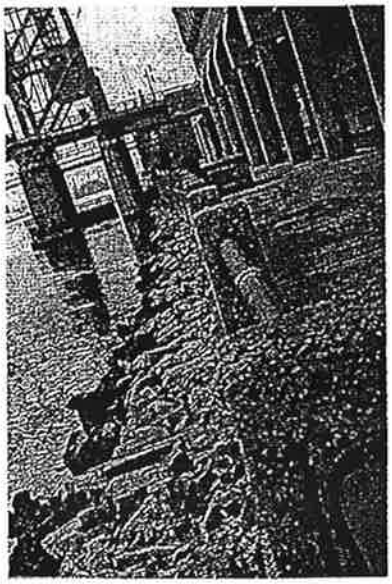

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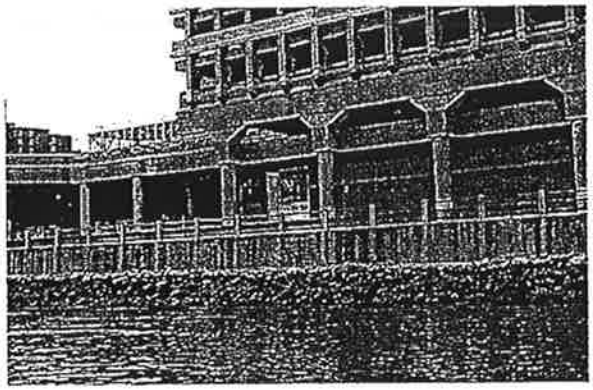

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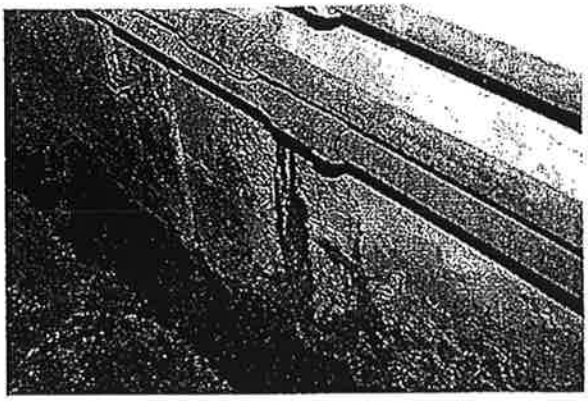

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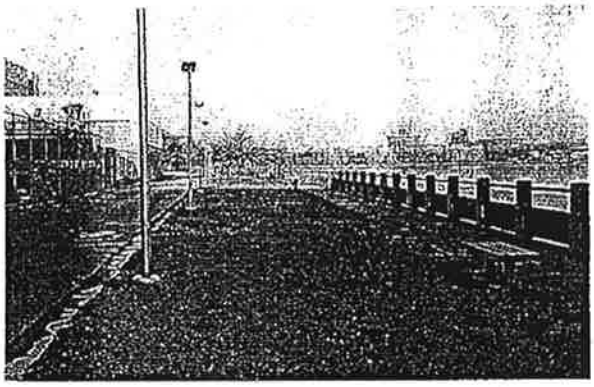

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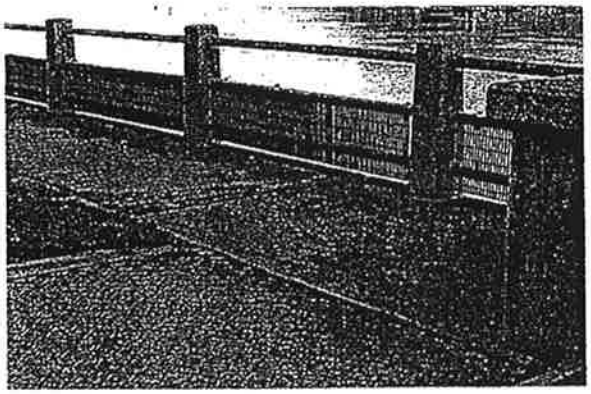

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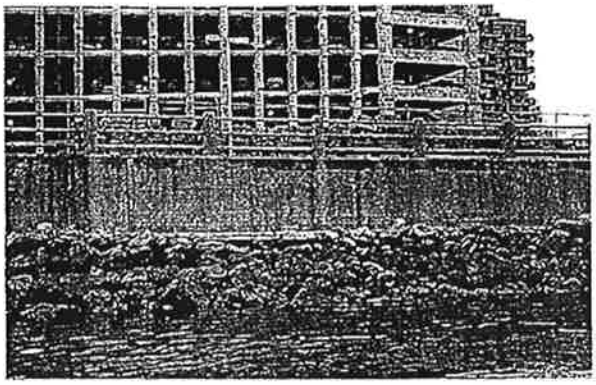

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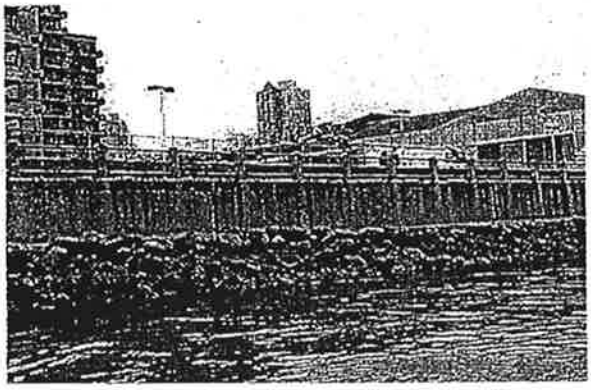

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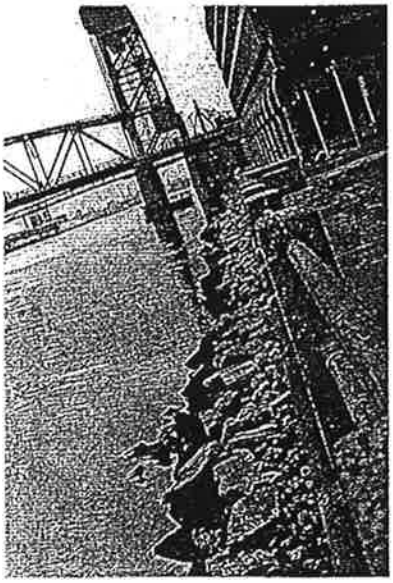

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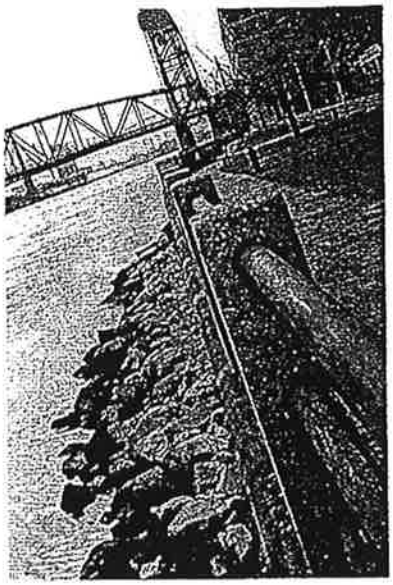
VENT 12 - VENT 13



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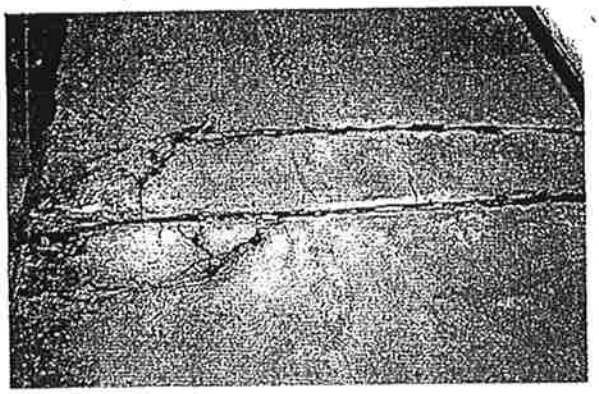

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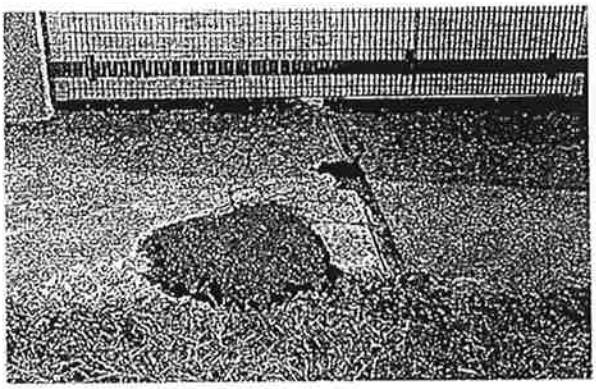

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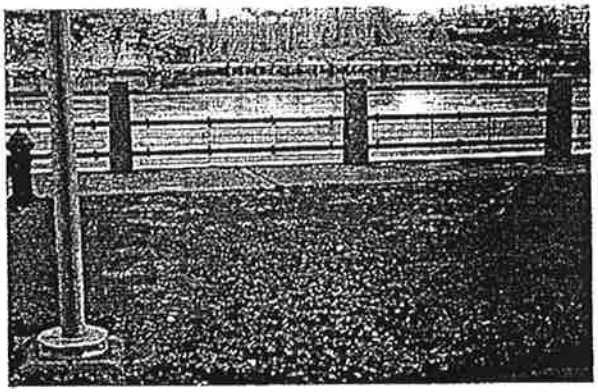

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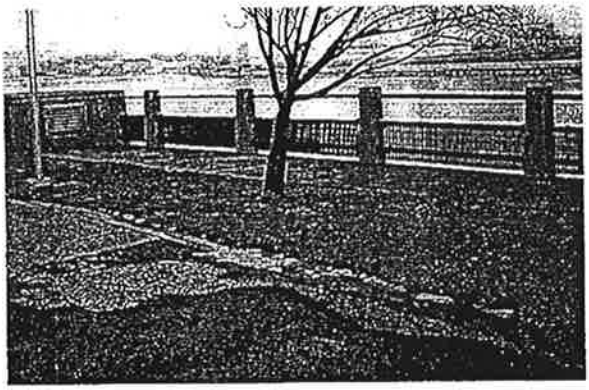

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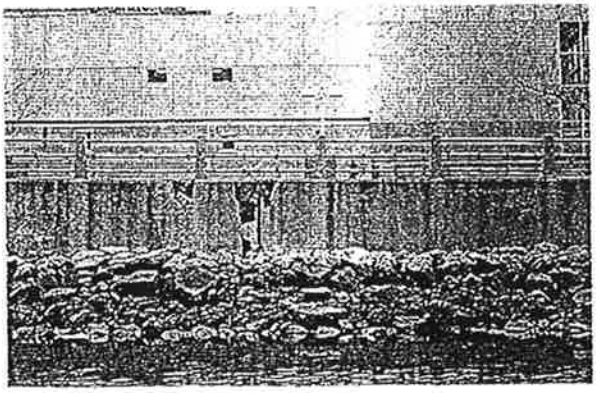

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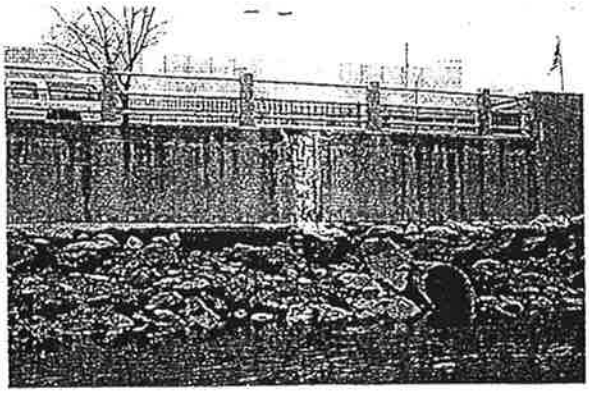

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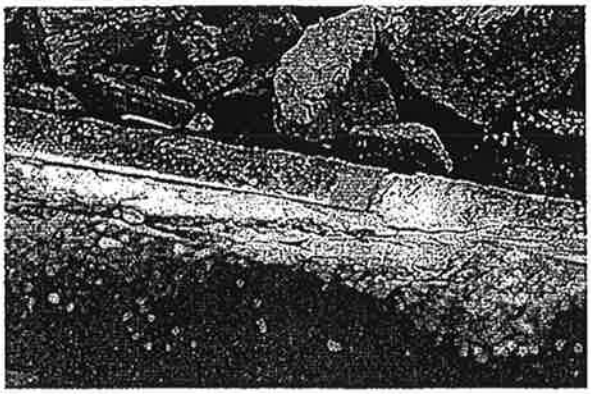
VENT 13 - VENT 14



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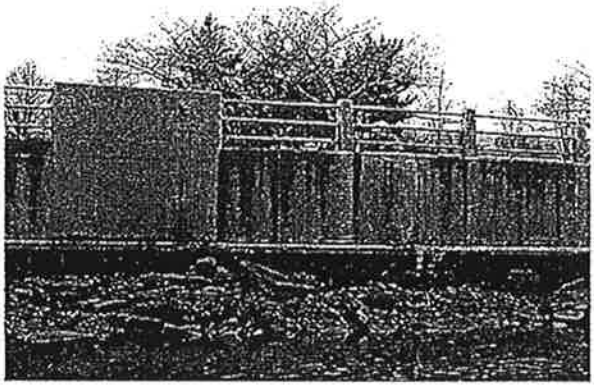

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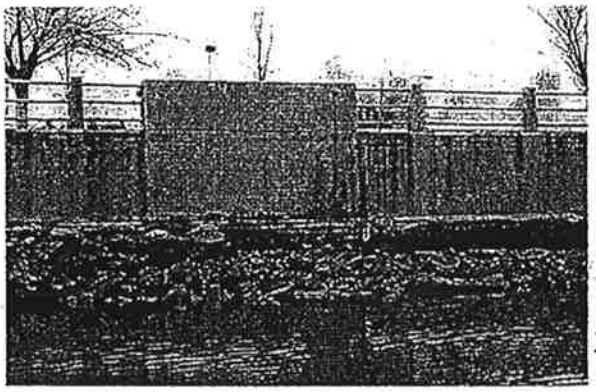

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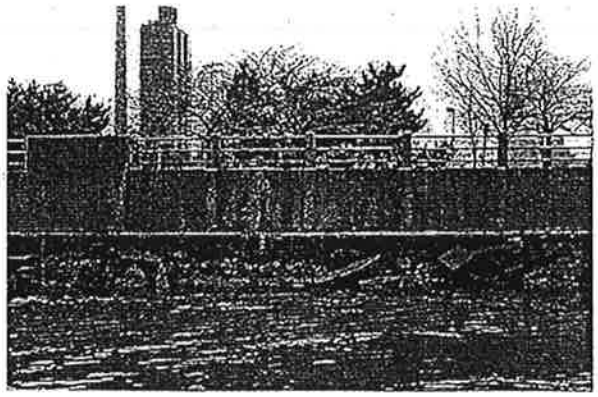

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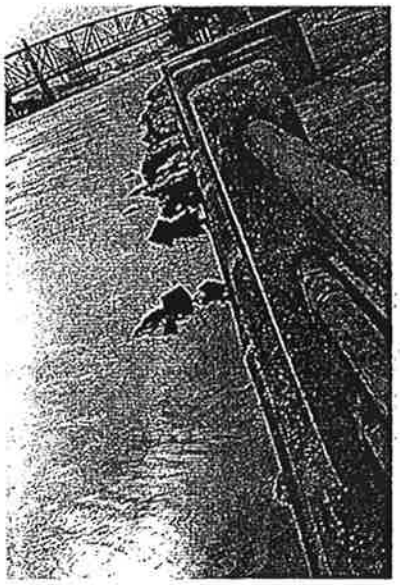

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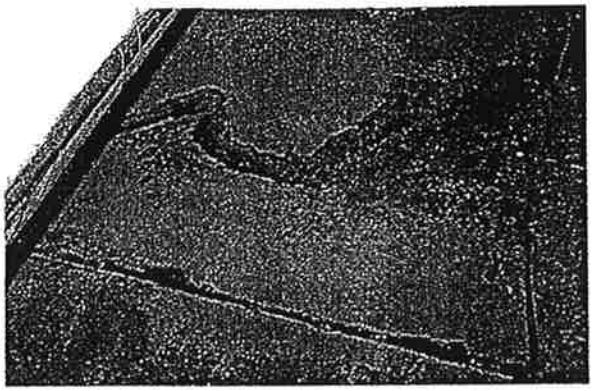
VENT 15 - VENT 16



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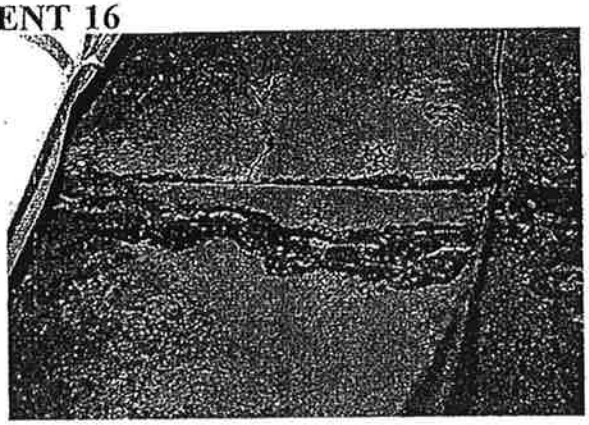

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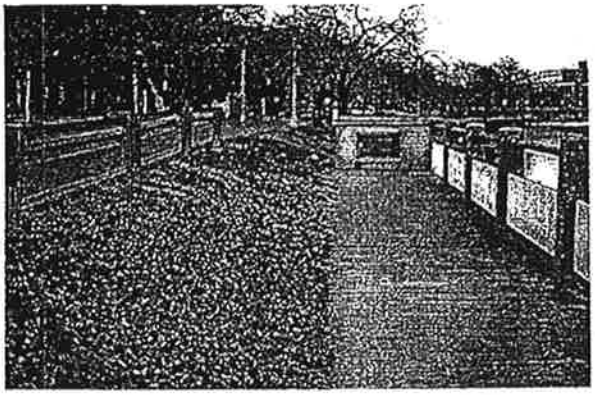

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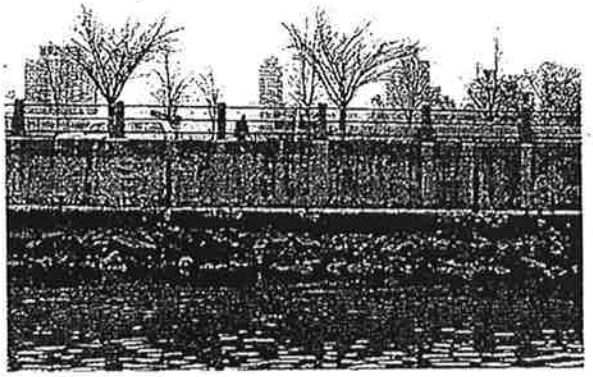

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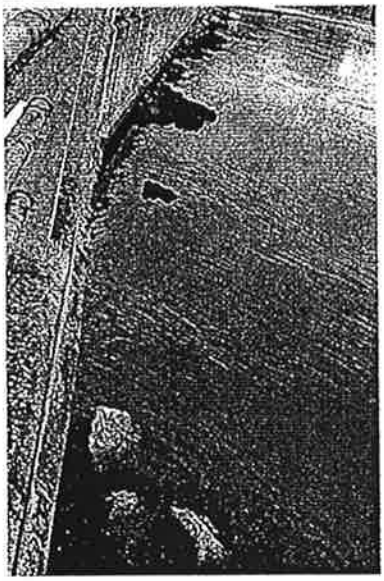

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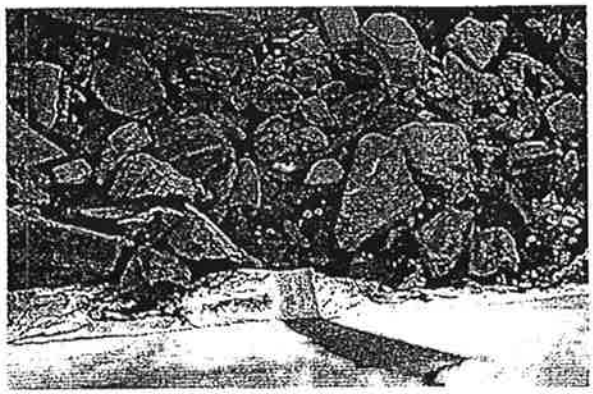

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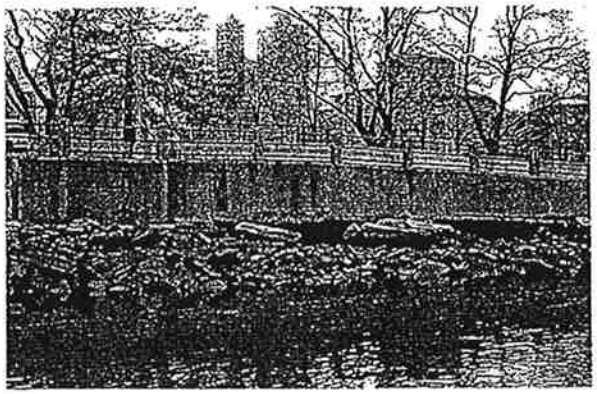
VENT 16 - TO LAND VENT



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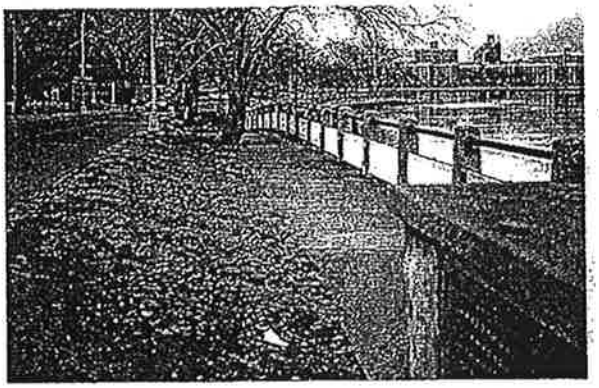

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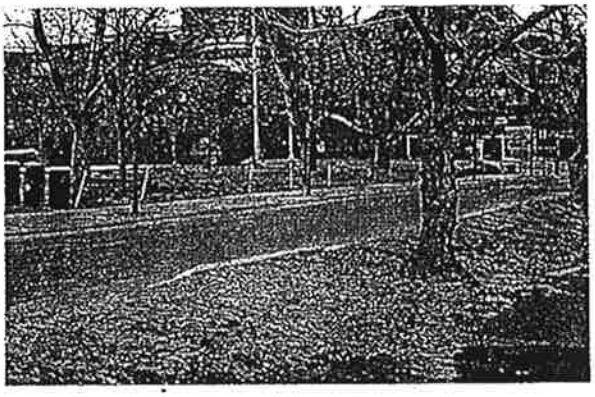

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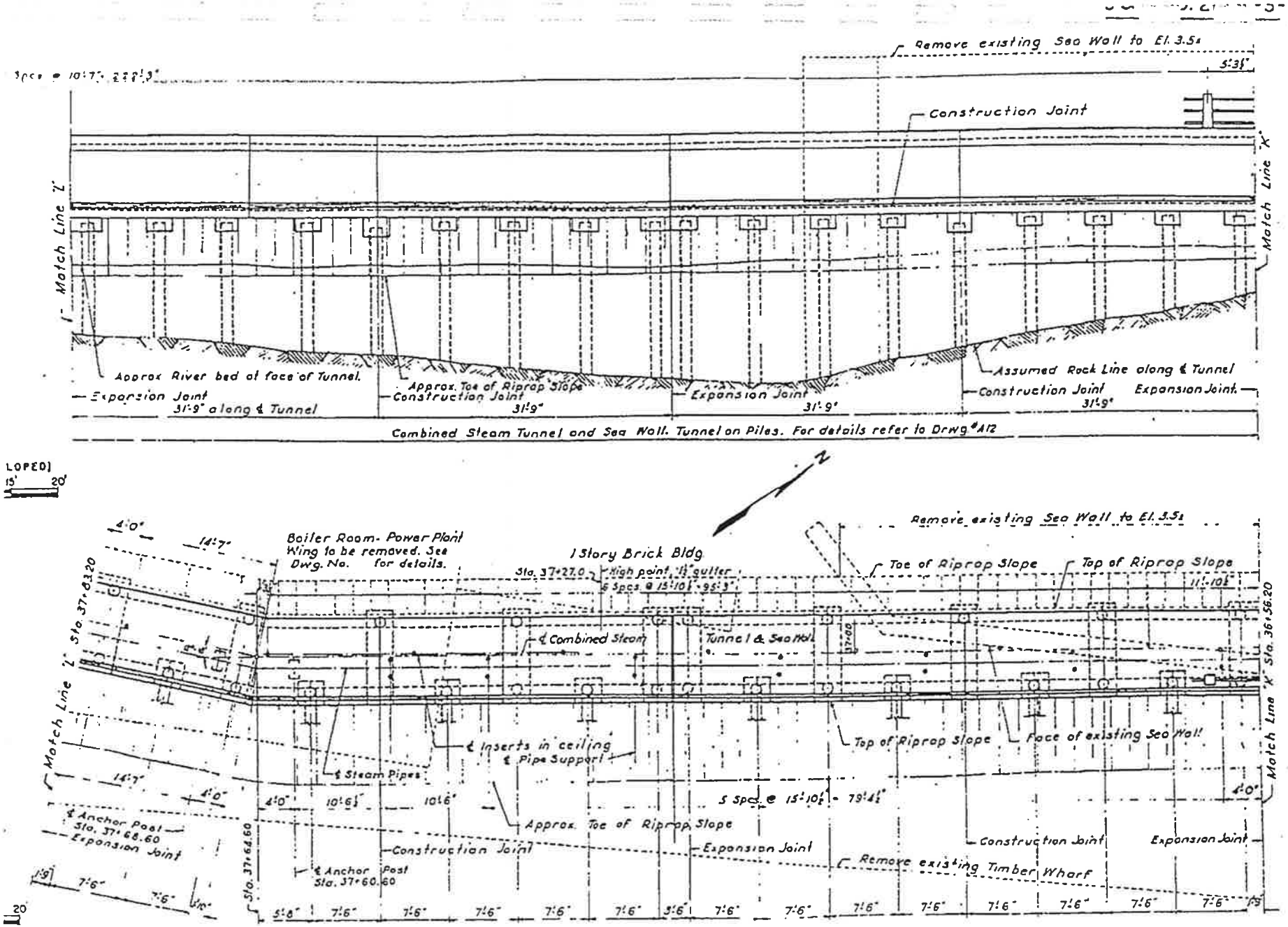
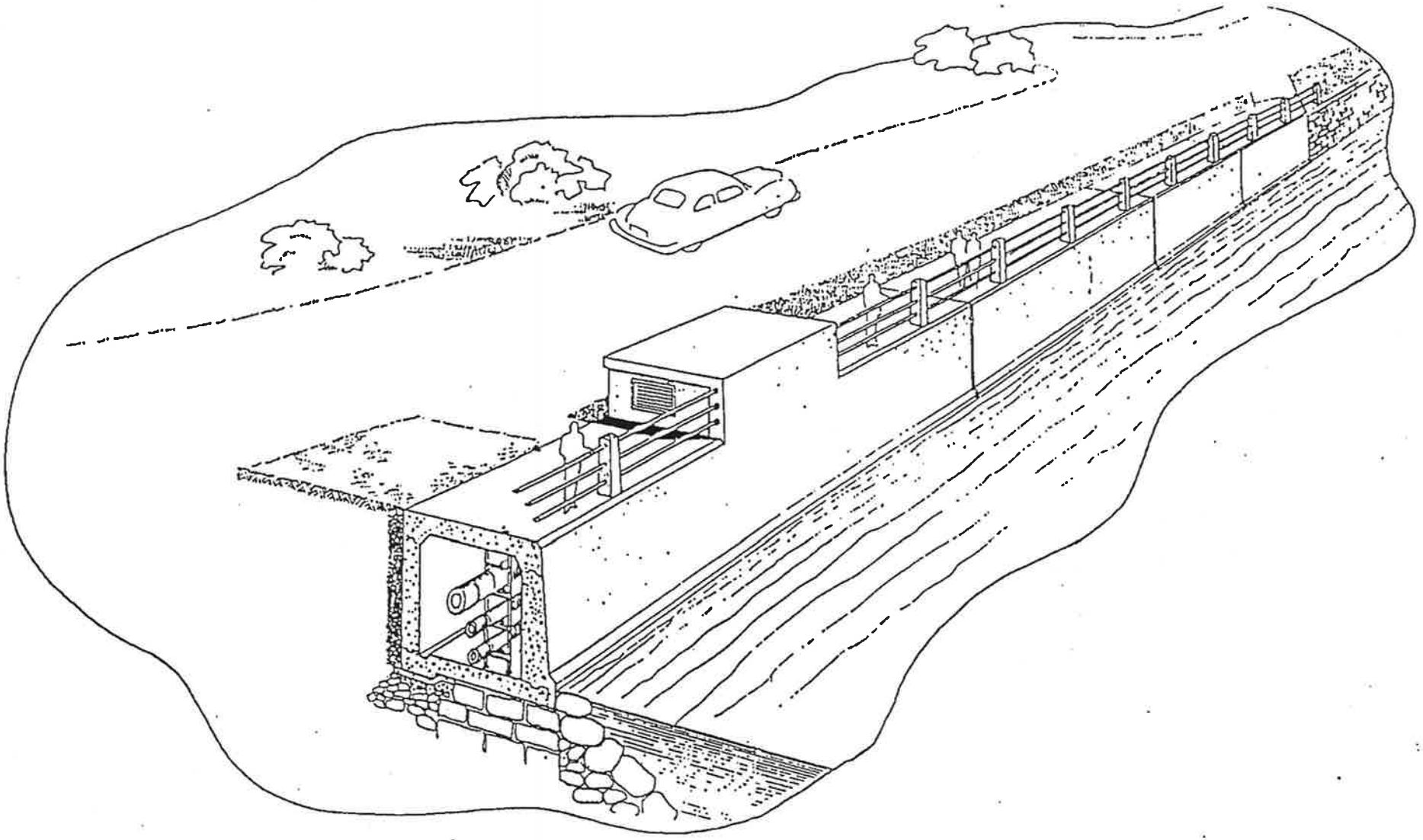
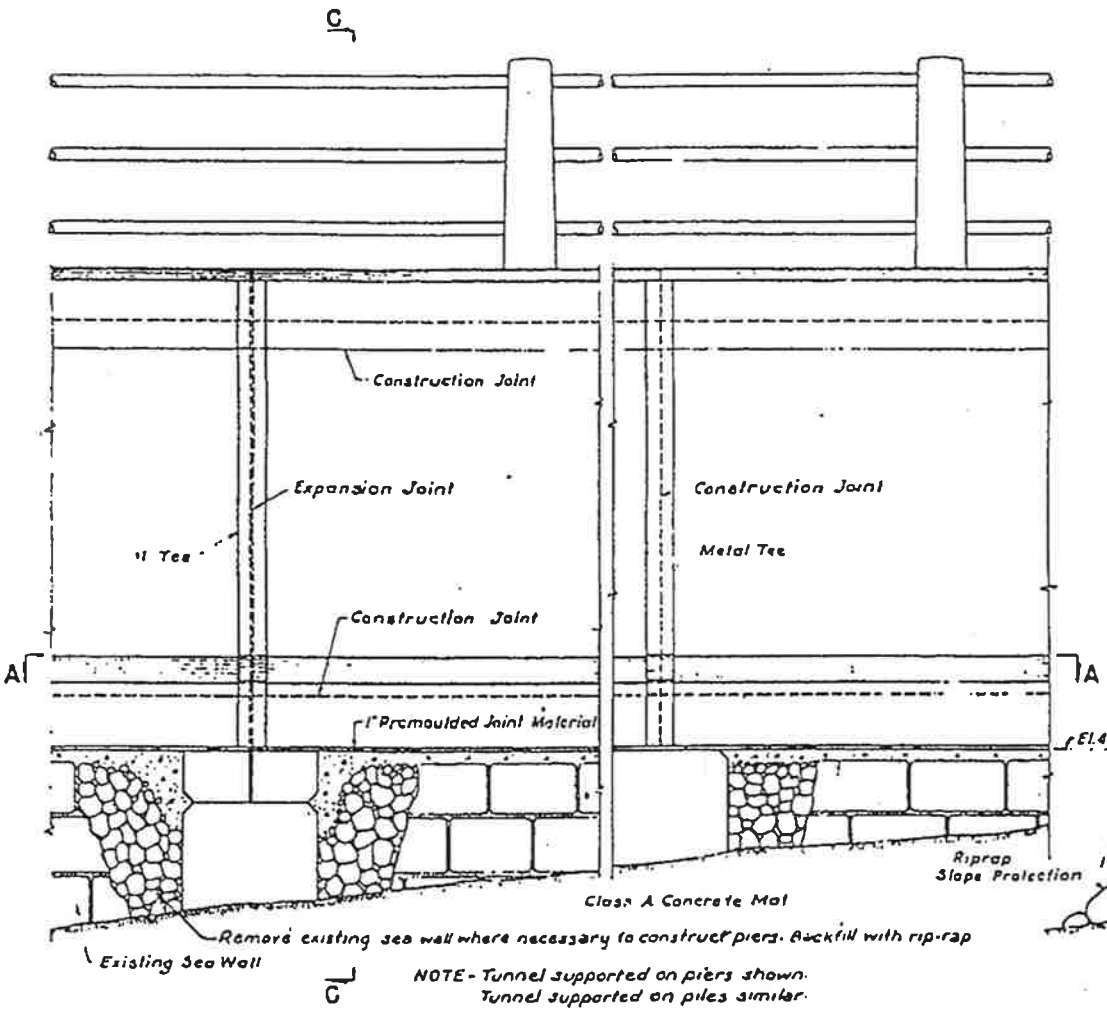
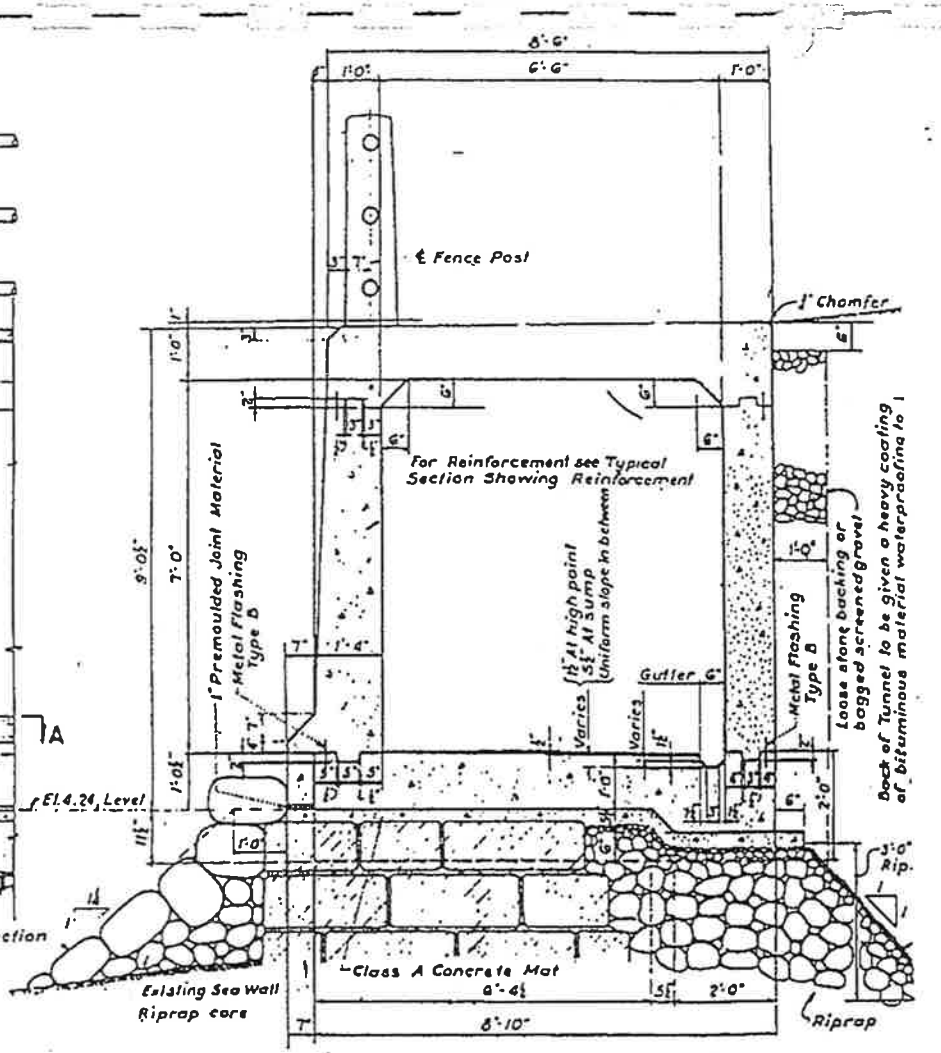

Remove existing Sea Wall to El. 3.5±
Construction Joint
Match Line 'Y'
Match Line 'X'
Approx River bed at face of Tunnel.
Expansion Joint
31'-9" along ℄ Tunnel
Approx. Toe of Riprap Slope
Construction Joint
31'-9"
Expansion Joint
31'-9"
Assumed Rock Line along ℄ Tunnel
Construction Joint
31'-9"
Expansion Joint.
Combined Steam Tunnel and Sea Wall. Tunnel on Piles. For details refer to Drwg #A12
Boiler Room- Power Plant Wing to be removed. See Dwg. No. for details.
1 Story Brick Bldg
Sta. 37+27.0
High point in gutter
℄ Combined Steam
Tunnel & Sea Wall
Toe of Riprap Slope
Top of Riprap Slope
Sta. 37+63.20
Sta. 36+56.20
℄ Inserts in ceiling
℄ Pipe Support
℄ Steam Pipes
Top of Riprap Slope
Face of existing Sea Wall
℄ Anchor Post Sta. 37+68.60
Expansion Joint
Approx. Toe of Riprap Slope
Construction Joint
Expansion Joint
Remove existing Timber Wharf
℄ Anchor Post Sta. 37+60.60
Sta. 37+64.60
Remove existing Sea Wall to El. 3.5±
9 Spcs. @ 10'-7" = 95'-3"

APPENDIX C





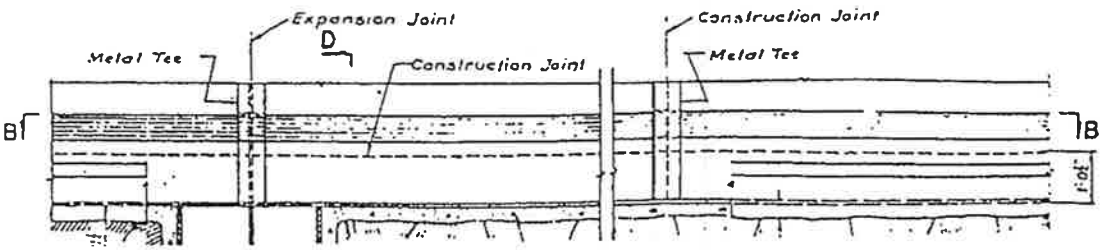
ELEVATION

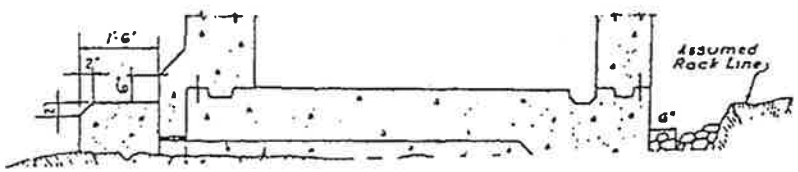


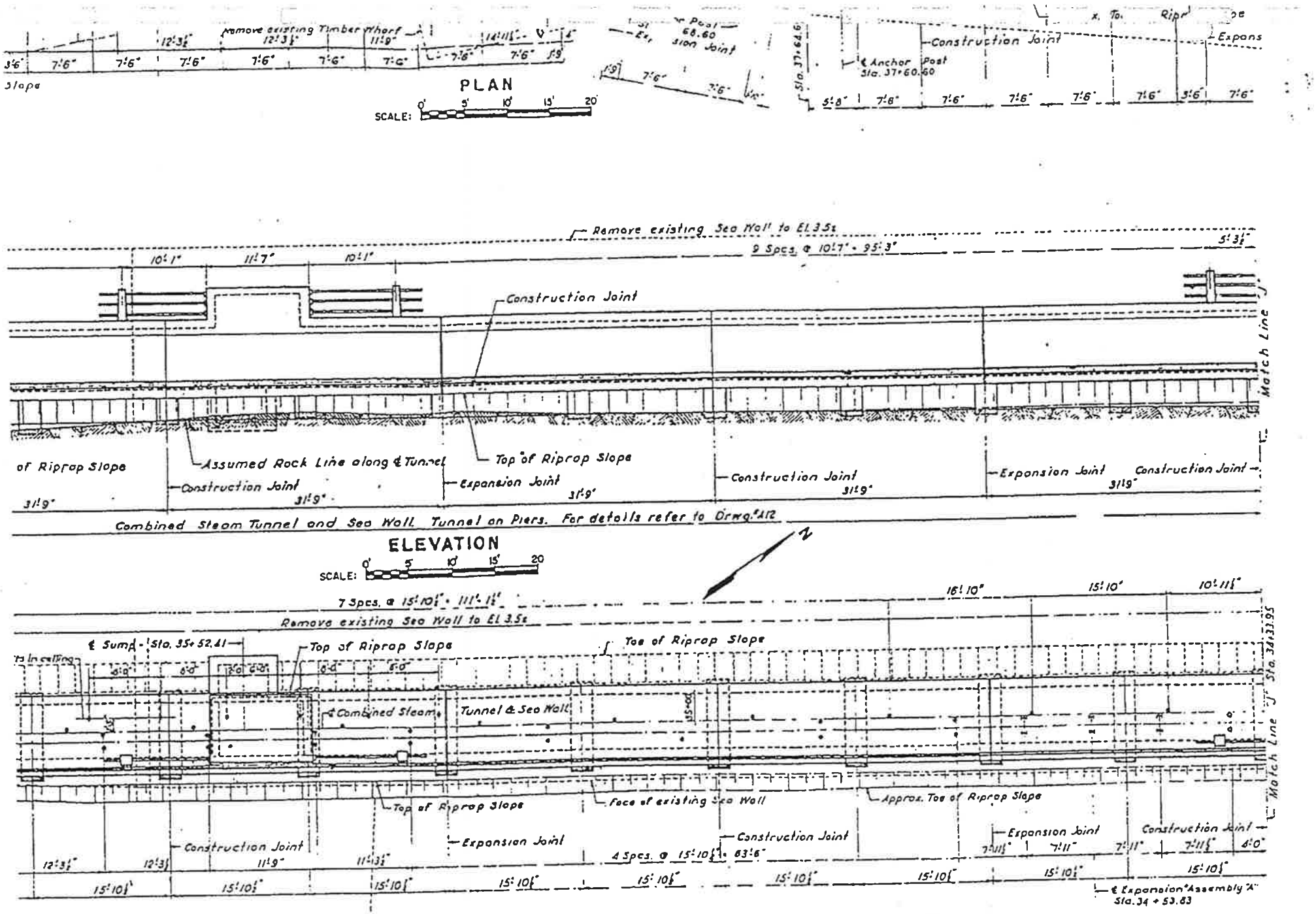
SECTION C - C

COMBINED STEAM TUNNEL AND SEA WALL
TUNNEL ON EXISTING SEA WALL

SCALE:

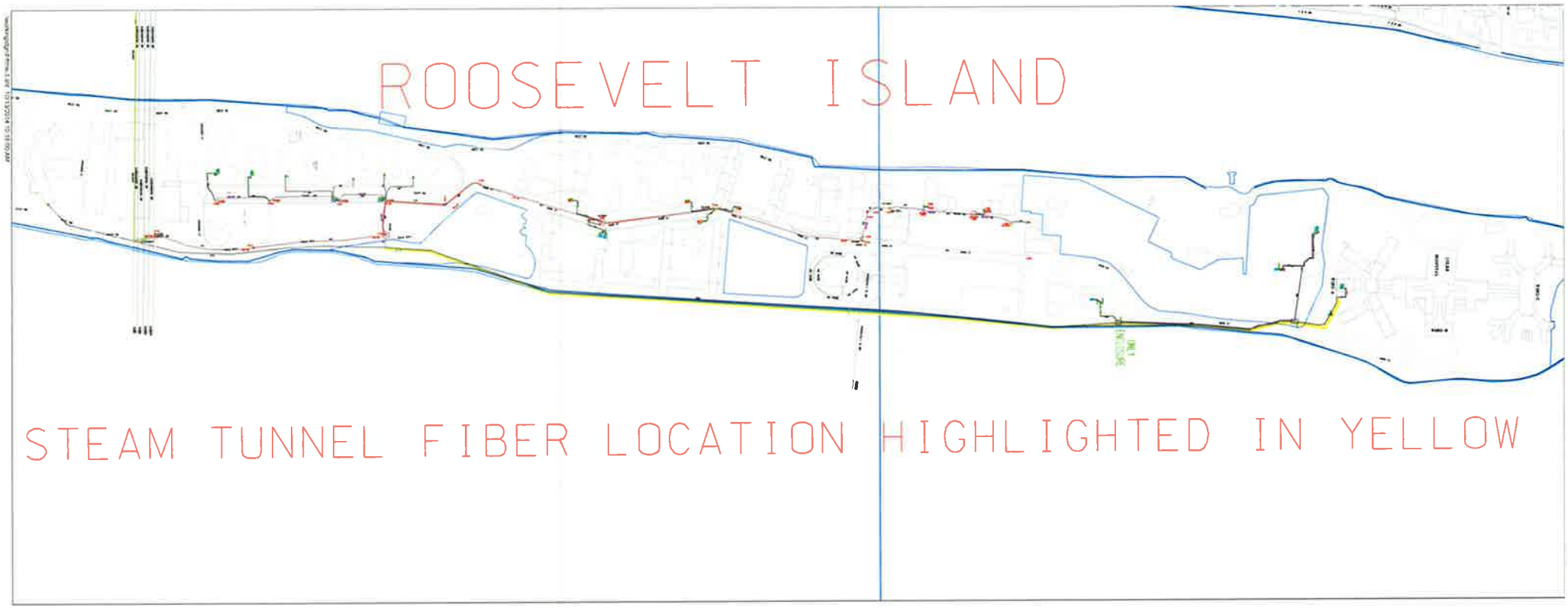





Remove existing Timber Wharf
Construction Joint
Expans
Anchor Post
Sta. 37+60.60
PLAN
SCALE: 0' 5' 10' 15' 20'
Remove existing Sea Wall to El 3.5±
9 Spcs. @ 10'-7" = 95'-3"
Construction Joint
Match Line
Assumed Rock Line along ℄ Tunnel
Top of Riprap Slope
Expansion Joint
Construction Joint
Combined Steam Tunnel and Sea Wall Tunnel on Piers. For details refer to Drwg. #12
ELEVATION
SCALE: 0' 5' 10' 15' 20'
7 Spcs. @ 15'-10½" = 111'-1½"
Remove existing Sea Wall to El 3.5±
℄ Sump - Sta. 35+52.41
Top of Riprap Slope
Toe of Riprap Slope
℄ Combined Steam Tunnel & Sea Wall
Face of existing Sea Wall
Approx. Toe of Riprap Slope
Expansion Joint
Construction Joint
4 Spcs. @ 15'-10½" = 63'-6"
℄ Expansion Assembly "A"
Sta. 34 + 53.83
PLAN
SCALE: 0' 5' 10' 15' 20'

APPENDIX D

AVAILABLE UTILITY MAPS



STEAM TUNNEL FIBER LOCATION HIGHLIGHTED IN YELLOW


FRANKLIN D. ROOSEVELT ISLAND
C3C-48F

APPENDIX E

THERMAL MODELING AND CALCULATIONS FOR FREEZE AND ICE-EXPANSION

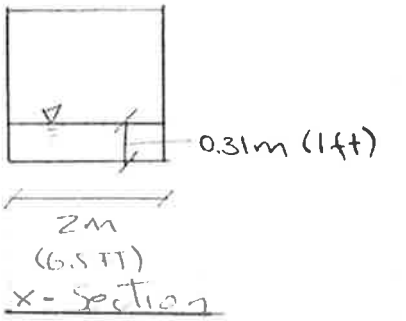
Time to Freeze & Time to Expand

Assumptions:

1. Starting conditions for weather is 32°F (0°C) and for water is 32°F (0°C).
2. Rapid temperature drop to 10°F (-12°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 1ft (0.31m) of standing water, infinate lenght, un-drained through joints.

Time to Freeze

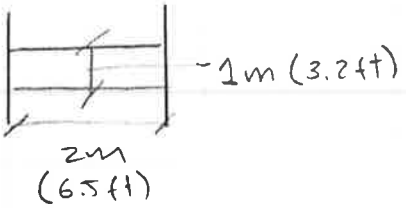
- Surface Area = $2m \times 1m = 2m^2$
- Volume = $2m \times 1m \times 0.31m = 0.62m^3$
- Weight = $0.62m^3 \times 1000 \frac{Kg}{m^3} = 620Kg$
- Heat of Fusion (Water) = $3.3 \times 10^3 J/Kg$



x-Section

$\Delta Q = 620 Kg \times 3.3 \times 10^3 J/Kg$

$\Delta Q = 2.05 \times 10^8 J$



Plan View

Heat Flow $\Rightarrow$ $q = \frac{K A \Delta T}{L}$

$K_{air} = 0.024 \ W/mC^\circ$

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

$L = 0.001m$

Steam Tunnel Time to Freeze & Time to Expand.	BY _____ DATE _____ CKD. _____ DATE _____	PROJ NO 1004446 01 SHEET 1 OF 2

LANGAN

Time to Freeze Continuation

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

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

Time to Expand (0° to -6°)

- Specific Heat of Ice = $2.1 \times 10^3 \frac{J}{Kg°C}$

$$\Delta Q = 670 Kg \times 2.1 \times 10^3 J/Kg°C \times 6°C = 7.8 \times 10^6 J$$

$K_{ice} = 1.6 W/m°C$

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

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

Total time to Freeze and Expand

99 hrs + 35 hrs = 134 hrs

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

Steam Tunnel Time to Freeze & Time to Expand	BY _____ DATE _____ CKD. _____ DATE _____	PROJ NO. 100444601 SHEET 2 OF 2

LANGAN

APPENDIX F

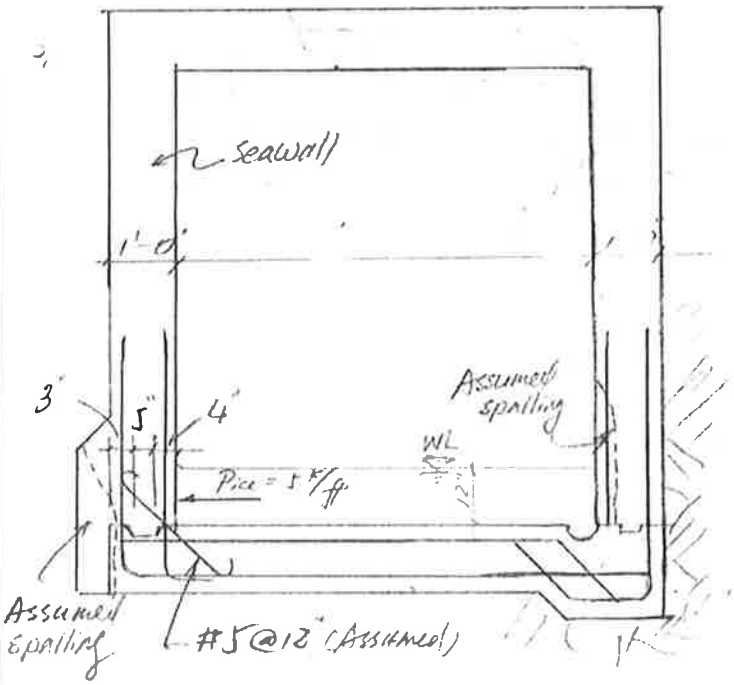
CALCULATIONS FOR ICE-EXPANSION FORCES AND STRUCTURAL CAPACITY

1. Check Seawall

(1) Shear taken by Keyway

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

$P_s = 5^K/ft.$ $P_u = 5 \times 1.6 = 8.0^K/ft$



Assume the keyway as shown the outer width $b = 2"$, $f_c' = 2000psi$, shear resistance = 70% of regular shear key due to the trapigoi shape

$\therefore \phi V_c = 0.75 \times 2\sqrt{2000} \times 2 \times 12 \times .70$

$= 1.127^K/ft$

(2) Shear taken by Dowels

$\phi V_{vf} = \phi A_{vf} \cdot f_y \cdot \mu$

where, $A_{vf} = 0.31^{in^2}/ft.$

$f_y = 40.0\ ksi$

$\mu = 0.80$ due to low strength of Conc.

$\phi V_{vf} = 0.75 \times 0.31 \times 40 \times 0.80$

$= 7.44^K/ft.$

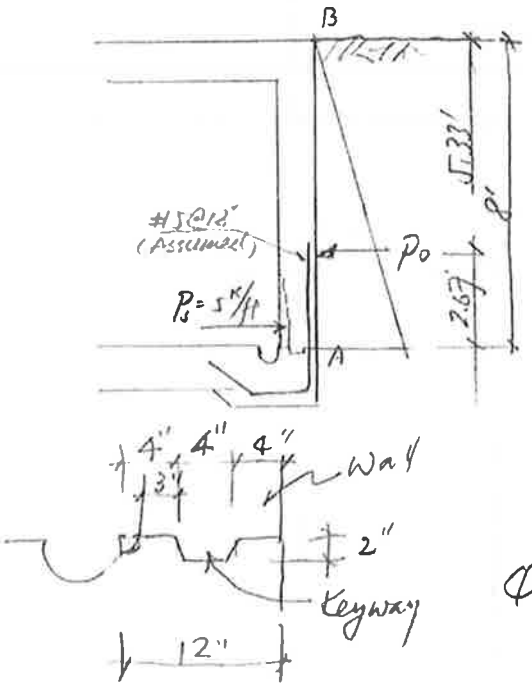
$\phi V_{vf} + \phi V_c = 7.44 + 1.127 = 8.567^K/ft > P_u = 8.0^K$.

$\therefore$ OK!

	BY AJS DATE 11/4/14	PROJ. NO
	CKD. DATE	SHEET OF

LANGAN

2. Check Landside Wall



Use $K_o = 1 - \sin 33° = 0.45$, $\gamma = 120 pcf$

$\therefore P_o = \frac{8^2}{2} \times 0.12 \times 0.45$

$= 1.747^K/ft$

$V_{A_o} \times 7.5 = P_o \times (5.33 - 0.5)$

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

$= 1.126^K/ft$ ← Shear Resist. by Soil Pressure

Assume the shear key as shown

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

$= 1.69^K/ft$ ← Shear Resist. by Keyway

$\Phi V_{vf} = \Phi A_{vf} \cdot f_y \cdot \mu$

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

$= 7.44^K/ft$

$\Sigma \Phi V = 7.44 + 1.69 + 1.276 = 10.41^K/ft > P_u = 8.0^K/ft$ ∴ OK!

	BY ____ DATE ____	PROJ. NO ____
	CKD ____ DATE ____	SHEET ____ OF ____

LANGAN

APPENDIX G

TEST-PIT LOGS

LANGAN

DAILY FIELD REPORT

Project No.	10044601	Client: RIOC	Date:	October 23, 2014
Project	Steam Tunnel		Weather:	Rain – 55 Degrees
Location	Roosevelt Island, NY		Time:	7:30 am – 1:30 pm

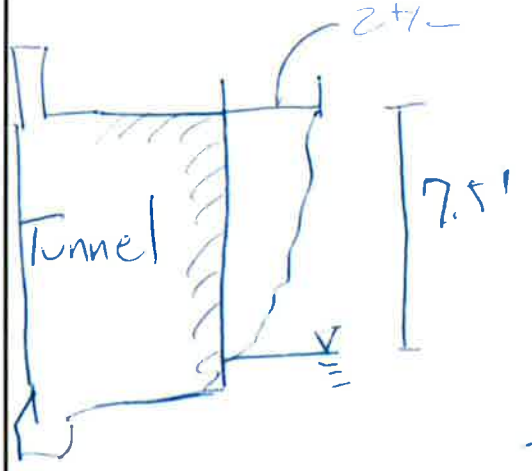
Contractor & Equipment:

Fleming & Sons, Backhoe

Present At Site:
Martin Fleming, 3 Laborers, Juan C. Osorio (Langan)

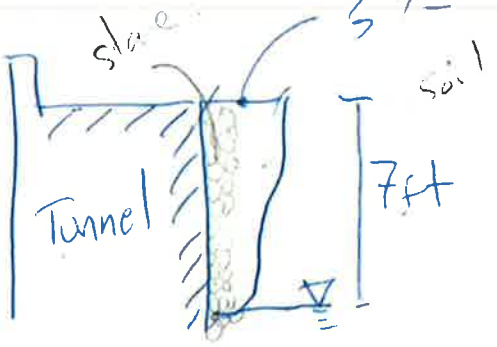
Observations, Discussions, Test Results, Etc.

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 RIOC.



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

Test Pit 6 - STA: [redacted] 8+92



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

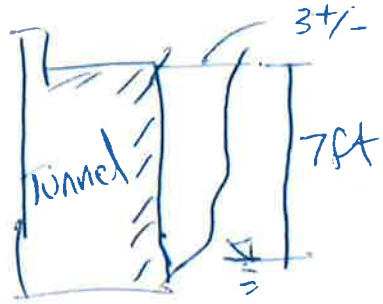
Test Pit 5 - STA: 11+99

cc:

By: Langan Engineering and Environmental Services

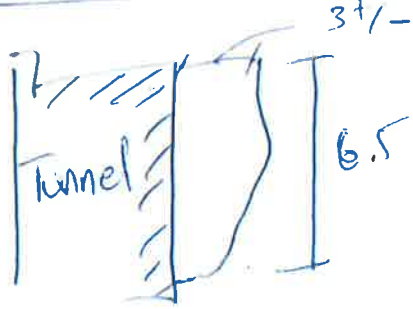
Juan C. osorio

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



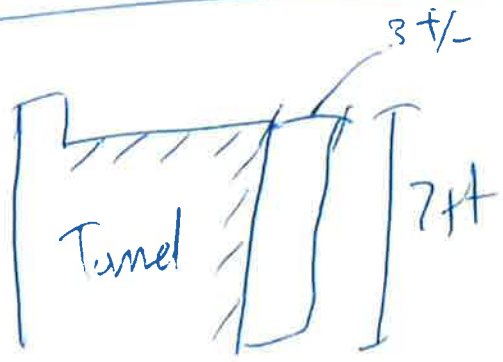
- wall in good condition, no cracks visible
- No water proofing
- Crushed stone.

Test Pit 4 STA: 171+13



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

Test Pit 3 STA: 75+90



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

Test Pit 1 STA: 45+60

Steam Tunnel Roosevelt Island, NY Project No.: 10044601	**DAILY REPORT**	SHEET 3 of 4 October 23, 2014

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