Acknowledgment of Addenda

The undersigned acknowledges receipt of the following addenda to the bidding document:

THE COMPLETED ACKNOWLEDGEMENT OF ADDENDA FORM SHOULD BE RETURNED WITH BID RESPONSE PACKAGE: NOT SENT TO RIPTA SEPARATELY

NOTE: Failure to acknowledge receipt of all addenda may cause the bid to be considered non-responsive to the solicitation. Acknowledged receipt of each addendum must be clearly established and included with the bid.

____
Name of Bidder

____
Street Address

____
City, State, Zip

____
Signature of Authorized Official

____
Date

Request for Proposals Number: 23-34
Addendum 2
Date: July 19, 2023

This addendum serves as notice that Approved Equals/ Questions/ Clarifications due date has been extended until June 28, 2023, by 1PM.

As discussed during the walkdown, the attached Demolition and Lane Closure Investigation was performed in March of 2022 and is provided for background. This information was incorporated into the Design that was provided with RFP.

Attached you will also find an article from 1914 as well as the mandatory prebid sign in sheet.

RHODE ISLAND PUBLIC TRANSIT AUTHORITY

EAST SIDE TUNNEL REHABILITATION

TUNNEL LINING DEMOLITION AND LANE CLOSURE INVESTIGATION

MARCH 7-9, 2022

WSP USA INC.

100 SUMMER STREET, 13TH FLOOR
BOSTON, MA 02110

166 VALLEY STREET, BUILDING 5
PROVIDENCE, RI 02909

WSP.COM

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APPENDICES

1 INTRODUCTION

WSP, with support from a local contractor, conducted an inspection of the original tunnel lining on the nights of March 7th and 8th. On the night of March 9th, the viability of single-lane closures was investigated.

A layer of gunite/shotcrete covers the concrete liner for the full length of the barrel vault section of the tunnel (approx. 1700'). It is believed that the gunite/shotcrete layer was applied as part of a rehabilitation effort undertaken in the early 1990s. To observe the original concrete, the gunite/shotcrete was removed at selected locations along the tunnel.

The locations were chosen by reviewing previous inspection reports and existing conditions during the site visit. Locations with visible defects, such as cracks, dampness and/or active leaks in the walls were investigated. Areas previously sounded and identified as hollow were also explored.

The gunite/shotcrete removal was also intended to provide insight for the design team to observe and evaluate different demolition methods and their labor efforts and durations. Power washing at 1500psi, 2500 psi, an electric chipping gun, and pneumatic hammers at 15# and 30# weights were used.

2 TUNNEL LINING DEMOLITION

2.1 NIGHT ONE – TUNNEL SIDEWALLS

The first night focused on the sidewalls of the tunnel due to malfunctioning of the lift provided by the contractor. A total of 7 locations were investigated, all in the vicinity of STA 14+50 to STA 16+50.

Location 1 (Photos 2 to 4) was on the North Wall, approximately 4 feet above the road surface, within a larger area previously identified as hollow, and confirmed with sounding prior to any removal. Initial blows with a hand hammer removed chips of the gunite/shotcrete, which could also be scraped and/or pried off. Using a power washer was effective at removing an approximately 12”Hx12”W section of the gunite/shotcrete layer, measured to be 2” thick at this location. The gunite/shotcrete was of poor quality, exhibiting a sandy composition easily broken apart by hand. The underlying concrete was sound and strong.

Location 2 (Photos 5 to 10) was on the North Wall, approximately 5 feet above the road surface. Here the gunite/shotcrete exhibited similar behavior and quality as Location 1. After removing the gunite/shotcrete layer with the power washer, the underlying concrete was found to be of extremely poor quality. This pocket of the lining had essentially no cement matrix, only a sandy material amidst an aggregate of smooth rocks and pebbles. The power washer was able to dig out an approximately 16”Hx16”Wx8”D area before abandoning the location to avoid further carving out of the concrete liner.

Locations 3, 4, and 6 (Photos 11, 12 to 16, 20 to 22) were on the North Wall, approximately 5-6 feet above the road surface. These locations proved the power washers ineffective as a removal method as the gunite/shotcrete was of good quality, yet sounded hollow due to a lack of bonding with the concrete liner. The underlying concrete was sound and strong at these locations. The electric chipping gun, and 15-lb and 30-lb pneumatic hammers were used, with increasing effectiveness at removing the gunite/shotcrete (i.e., the 30-lb hammer was most effective however also chipped holes into the sound concrete easily). The gunite/shotcrete removed was approximately 20”Hx8”W at Location 3, 12”Hx12”W at Location 4, and 18”Hx18”W at Location 6, with a thickness of 1-2”.

Location 5 (Photos 17 to 19) was on the South Wall below a weep hole (the down-pipe had been removed previously), approximately 4 feet above the road surface. The 30-lb pneumatic hammer was very effective at removing the gunite/shotcrete layer, which was partially saturated and sandy. The area removed was approximately 12”Hx16”W and 1-½” thick. The underlying concrete was sound and strong.

Location 7 (Photos 23 to 26) was on the South Wall, approximately 5 feet above the road surface. The gunite/shotcrete was visibly damp on the surface, and proved to be of poor quality during removal with the pneumatic hammer. The area removed was approximately 22”Hx16”W and 2” thick. The underlying concrete was sound and strong.

2.2 NIGHT TWO – TUNNEL ARCH

Night two of the investigation focused on the tunnel arch, as the contractor provided a new, working scissor lift. A total of 13 locations were to be investigated, based on observations of visible defects and marked hollow areas made the previous night during a walkthrough of the tunnel.

Location 8 (STA 3+60, Photos 27 to 33) was investigated on both the north and south sides of the tunnel crown. On the southern side, the gunite/shotcrete was glistening with a slow drip falling onto the roadway, and sounded hollow. An approximately 20”Lx8”W area of the gunite/shotcrete layer was removed with the electric chipping gun and 15-lb pneumatic hammer, exposing the concrete liner. A very fine crack with glistening in the concrete liner was observed. On the northern side, a dry, hollow patch on the northern side was also chipped out (8”Lx8”W). The gunite/shotcrete layer was approximately 6” thick or greater in this area. The gunite/shotcrete and underlying concrete were found to be sound and strong at both areas; the hollow sound was attributed to a weak bond between the layers.

Location 9 (STA 4+41, Photos 34 to 36) saw a drip coming through a crack in the gunite/shotcrete layer on both the north and south sides of the tunnel crown. The gunite/shotcrete was only ½” thick, and easily chipped out. The underlying concrete exhibited a <1/2” wide crack, but was otherwise sound at both areas.

Location 10 (STA 5+60, Photos 37 to 39) saw a drip coming through a crack in the gunite/shotcrete layer at the center of the tunnel crown. An approximately 2'Lx2'W area of ½" thick gunite/shotcrete was easily chipped out. The underlying concrete was sound with no visible cracks, but water was seeping through the interface between the gunite/shotcrete and concrete.

Location 11 (STA 5+85, Photos 40 to 42) saw a slow drip coming through a crack with discolored gunite/shotcrete on the south side of the tunnel crown. Initial chipping exposed crack injection ports spaced 2-3" apart on either side of a thin crack in the concrete liner. More detailed observation of the crown revealed crack injection ports covered the entire arch at this location. No further investigation was undertaken to avoid damage to the crack repair.

Location 12 (STA 7+30, Photos 43 and 44) had an existing gunite/shotcrete spall, approximately 1'Lx1'W at the center of the tunnel crown. The ½" thick gunite/shotcrete layer was further chipped to 2'Lx2'W. A ½" dia hole, approximately 4" deep was observed in the concrete liner. Some material (non-structural) fell out of the whole while investigating the location.

Location 13 (STA 7+75) was determined to be another injection crack repair with ports visible throughout the tunnel arch upon close inspection and was therefore not disturbed.

Location 14 (STA 8+93, Photo 45) was an active leak with a brownish mineral material staining the gunite/shotcrete around the crack at the center of the crown. The leaking worsened when scraping and chipping off some of the material with a hand hammer. The location was then abandoned.

Location 15 (STA 11+86, Photos 46 and 47) exhibited a small spall in the gunite/shotcrete amid a dry but hollow area at the center of the crown. After removing the ½" gunite/shotcrete layer, the underlying concrete was revealed to be very damp, soft, and punky. The area exposed was approximately 24"Lx15"W.

Location 16 (STA 13+15, Photos 48 and 49) exhibited a heavy leakage, a similar mineral material as previously seen, and a spall in the gunite/shotcrete at the center of the crown. Close inspection revealed crack injection ports in 2 rows longitudinally, spaced at 2-3" for approximately 7'. No further investigation was undertaken.

Location 17 (STA 14+18, Photos 50 to 52) was a hollow area with leakage at the center of the crown. An area of approximately 30"Lx30"W was chipped and hammered out, going through the thin gunite/shotcrete layer and removing up to 1" of concrete. Water was seeping through the interface between the layers. The concrete in this area was of poor quality, with large aggregate visible within a minimal cement matrix.

Location 18 (STA 14+65, Photo 53) was omitted due to time constraints. The area on the south wall exhibited a large spall in the gunite/shotcrete above a drain pipe, and a smaller spall (approximately 1'Hx1'W) in the underlying concrete. The surrounding concrete was sound and strong.

Location 19 (STA 15+90, Photo 54) was a large spall above and adjacent to a drain pipe on the south wall above the springline. The gunite/shotcrete was thin (< ½"), discolored, and sounded hollow, but dry on the night of the investigation. A smaller area of the concrete, approximately 1'Hx1'W also exhibited a shallow spall.

Location 20 (STA 17+68, Photos 55 to 57) exhibited a heavy leak at the center of the crown. The surrounding gunite/shotcrete was solid. Chipping around the leak led to a hole approximately 1"Lx2- ½"W, with gravel aggregate falling out to a depth of >4". The leak increased from a frequent drip to a small but steady stream, eventually receding to its original drip rate after a few minutes.

3 LANE CLOSURE INVESTIGATION

The 3rd night was used to demonstrate the viability of closing one lane of the tunnel for extended periods in order to benefit the construction schedule. A mock work area was set up in one of the lanes on the west end of the tunnel past the steel supported section and horizontal curve. Barriers with netting were placed on the double-yellow lane divider, measured to provide 128” of clearance from the curb. A bus was driven up and back through the tunnel to gauge the operator’s comfort in passing the barriers. The operator noted they were comfortable passing the barriers but felt uneasy with the drain pipes on the tunnel wall side. Adding 2” to the clearance (130” total) increased the comfort of the operator and left plenty of room for the repair work, per the contractor’s supervisor. Some additional safety measures, both to protect the workers and buses, could be added to improve the repair work. These included full height nets/screens, and traffic control signals.

4 RECOMMENDATIONS

The gunite/shotcrete layer is not well bonded to the underlying concrete and does not contribute to the structural capacity of the tunnel, acting only as a protective coating. As the original concrete is over 100 years old, all identified defects should be repaired to restore the full capacity of the tunnel liner. Previous repairs should also be inspected for potential supplement if they are not fully effective. Given that some defects in the gunite/shotcrete layer did not translate to defects in the concrete liner, and the possibility that the gunite/shotcrete could be covering up defects in the concrete, a large contingency should be allotted for unforeseen defects revealed when the concrete is uncovered. This will be reflected in the estimate in section 5.

After reviewing the inspection reports and observing removal efforts, WSP recommends:

For the sidewalls, removal of the sound, bonded gunite/shotcrete proved difficult and time consuming. Only the heavy 30-lb pneumatic hammer was somewhat effective at demolition of more sound areas, but its use is not recommended due to the ability to produce microcracking in solid concrete surrounding the demolition. The electric chipping gun and lighter 15-lb hammer were more than sufficient at removing cracked, delaminated, and poor-quality gunite/shotcrete areas.

For the tunnel arch, the gunite/shotcrete layer is highly variable in thickness, ranging from ½" to over 6", due to poor quality control when spraying the material. The gunite/shotcrete layer also exhibits longitudinal cracks at apparent overlap areas at the crown and both shoulders. To provide for a uniform thickness, repair defects in the original liner, and improve the appearance of the tunnel arch, the full gunite/shotcrete layer should be removed and replaced above the springline.

SUMMARY OF RECOMMENDATIONS

Option 4

— Walls: On sidewalls, remove all hollow sounding shotcrete areas, and where demolition of the gunite/shotcrete reveals defects in the original concrete liner, those shall be repaired.

— Arch: Removal of the entire gunite/shotcrete layer for the full arch and repair of all leaks.

Option 5

— Walls: On sidewalls, remove all hollow sounding shotcrete areas, and where demolition of the gunite/shotcrete reveals defects in the original concrete liner, those shall be repaired.

— Arch: Removal of the entire gunite/shotcrete layer for the full arch and installation of a waterproofing layer/umbrella system to arch that would allow redeveloping leaks to drain water to sides and into the horizontal longitudinal gutters. This option will require a new layer of shotcrete.

Upon further evaluation of project goals and estimated costs, RIPTA elected to further pursue Option 4, with the addition of replacing the removed gunite/shotcrete layer on the sidewall with new shotcrete to produce a smooth finish.

APPENDIX

A

PHOTOGRAPHS

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 1 **Date:** 3/7/22

Direction Photo Taken:
North

Description:
General view of North Wall prior to gunite/shotcrete demolition.

Photo No. 2 **Date:** 3/7/22

Direction Photo Taken:
Northwest

Description:
General view of Location 1 on North Wall prior to gunite/shotcrete demolition.

PHOTOGRAPH LOG		
Client Name: **RIPTA**	**Site Location:** **East Side Tunnel, Providence, RI**	**Project No.** **XXXXXX**

Photo No. 3	**Date:** 3/7/22
Direction Photo Taken: Northwest	
Description: Location 1 after patch of gunite/shotcrete removed. Note depth (2") and sandy composition of material.	

Photo No. 4	**Date:** 3/7/22
Direction Photo Taken: Northeast	
Description: Location 1 after patch of gunite/shotcrete removed.	

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No.	Date:
5	3/7/22

Direction Photo Taken:
North

Description:
Location 2 removal of gunite/shotcrete and portion of loose aggregate in sidewall. Note lack of cement matrix in the sidewall concrete.

Photo No.	Date:
6	3/7/22

Direction Photo Taken:
North

Description:
Removal of loose aggregate with power washer at Location 2. Note quantity of loose, smooth aggregate on curb.

PHOTOGRAPH LOG		
Client Name: **RIPTA**	**Site Location:** **East Side Tunnel, Providence, RI**	**Project No.** **XXXXXX**

Photo No.	**Date:**	
7	3/7/22	
Direction Photo Taken: North		
Description: Location 2 after removal of loose material.		

Photo No.	**Date:**	
8	3/7/22	
Direction Photo Taken: North		
Description: Location 2 after removal of loose material. Note depth of pocket (approx. 8”)		

PHOTOGRAPH LOG

Client Name:	Site Location:	Project No.
RIPTA	**East Side Tunnel, Providence, RI**	**XXXXXX**

Photo No. 9	**Date:** 3/7/22
Direction Photo Taken: North	
Description: Location 2 after removal of loose material.	

Photo No. 10	**Date:** 3/7/22
Direction Photo Taken: North	
Description: Location 2 after removal of loose material.	

PHOTOGRAPH LOG

Client Name:	Site Location:	Project No.
RIPTA	**East Side Tunnel, Providence, RI**	**XXXXXX**

Photo No.	Date:
11	3/7/22

Direction Photo Taken:
North

Description:
Location 3 after removal of hollow gunite/shotcrete patch.

Photo No.	Date:
12	3/7/22

Direction Photo Taken:
Northeast

Description:
Location 4 after removal of hollow gunite/shotcrete patch.

Client Name:	Site Location:	Project No.
RIPTA	East Side Tunnel, Providence, RI	XXXXXX

Photo No. 13 **Date:** 3/7/22

Direction Photo Taken:
Northeast

Description:
Location 4 after removal of hollow gunite/shotcrete patch.

Photo No. 14 **Date:** 3/7/22

Direction Photo Taken:
South

Description:
Location 4 after removal of hollow gunite/shotcrete patch.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 15	Date: 3/7/22

Direction Photo Taken:
South

Description:
Location 4 after removal of hollow gunite/shotcrete patch.

Photo No. 16	Date: 3/7/22

Direction Photo Taken:
Southeast

Description:
Location 4 after removal of hollow gunite/shotcrete patch.

wsp	**PHOTOGRAPH LOG**

Client Name:	**Site Location:**	**Project No.**
RIPTA	**East Side Tunnel, Providence, RI**	**XXXXXX**

Photo No. 17

Date: 3/7/22

Direction Photo Taken:
South

Description:
Location 5 prior to removal of gunite/ shotcrete patch. Note extensive staining from leakage at broken drainpipe.

Photo No. 18

Date: 3/7/22

Direction Photo Taken:
Southwest

Description:
Location 5 after removal of gunite/shotcrete patch.

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 19 | **Date:** 3/7/22

Direction Photo Taken:
South

Description:
Location 5 after removal of gunite/shotcrete patch.

Photo No. 20 | **Date:** 3/7/22

Direction Photo Taken:
North

Description:
Location 6 after removal of hollow gunite/shotcrete patch.

PHOTOGRAPH LOG

Client Name:	Site Location:	Project No.
RIPTA	**East Side Tunnel, Providence, RI**	**XXXXXX**

Photo No.	Date:
21	3/7/22

Direction Photo Taken:
North

Description:
Location 6 after removal of hollow gunite/shotcrete patch.

Photo No.	Date:
22	3/7/22

Direction Photo Taken:
North

Description:
Location 6 after removal of hollow gunite/shotcrete patch.

PHOTOGRAPH LOG

Client Name:	Site Location:	Project No.
RIPTA	East Side Tunnel, Providence, RI	XXXXXX

Photo No. 23 **Date:** 3/7/22

Direction Photo Taken:
South

Description:
Location 7 after removal of gunite/shotcrete patch.

Photo No. 24 **Date:** 3/7/22

Direction Photo Taken:
Southeast

Description:
Location 7 after removal of gunite/shotcrete patch.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 25 | **Date:** 3/7/22

Direction Photo Taken:
South

Description:
Location 7 after removal of gunite/shotcrete patch.

Photo No. 26 | **Date:** 3/7/22

Direction Photo Taken:
South

Description:
Location 7 after removal of gunite/shotcrete patch.

	PHOTOGRAPH LOG

Client Name: **RIPTA**	**Site Location:** **East Side Tunnel, Providence, RI**	**Project No.** **XXXXXX**

Photo No. 27	**Date:** 3/8/22
Direction Photo Taken: South	
Description: Location 8 prior to removal of gunite/ shotcrete patches.	

Photo No. 28	**Date:** 3/8/22
Direction Photo Taken: East	
Description: South side of crown at Location 8 during removal of gunite/shotcrete patch.	

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 29	Date: 3/8/22

Direction Photo Taken:
South

Description:
South side of crown at Location 8 during removal of gunite/shotcrete patch.

Photo No. 30	Date: 3/8/22

Direction Photo Taken:
North

Description:
North side of crown at Location 8 after removal of gunite/shotcrete patch.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 31 | **Date:** 3/8/22

Direction Photo Taken:
South

Description:
South side of crown at Location 8 after removal of gunite/shotcrete patch.

Photo No. 32 | **Date:** 3/8/22

Direction Photo Taken:
South

Description:
South side of crown at Location 8 after removal of gunite/shotcrete patch.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 33	Date: 3/8/22

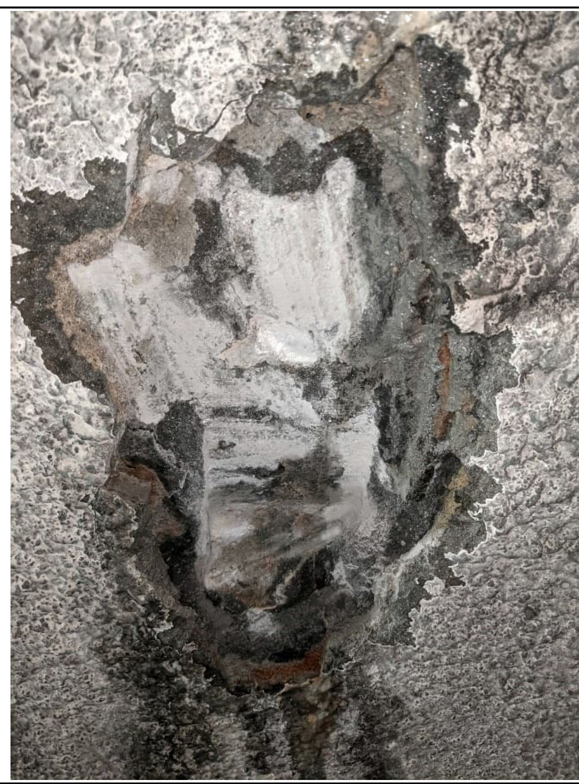
Direction Photo Taken:
South

Description:
South side of crown at Location 8 after removal of gunite/shotcrete patch.

Photo No. 34	Date: 3/8/22

Direction Photo Taken:
South

Description:
South side of crown at Location 9 after removal of gunite/shotcrete patch.



		PHOTOGRAPH LOG
Client Name: **RIPTA**	**Site Location:** **East Side Tunnel, Providence, RI**	**Project No.** **XXXXXX**

Photo No.	**Date:**
35	3/8/22

Direction Photo Taken:
North

Description:
North side of crown at Location 9 during removal of gunite/shotcrete patch. Note fine crack in structural liner.

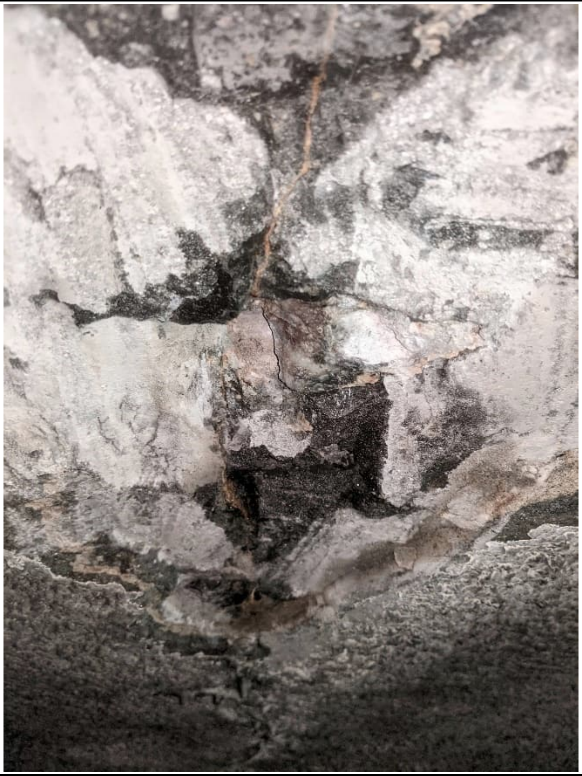


Photo No.	**Date:**
36	3/8/22

Direction Photo Taken:
North

Description:
North side of crown at Location 9 after removal of gunite/shotcrete patch. Note fine crack in structural liner.

PHOTOGRAPH LOG

Client Name: **RIPTA**	**Site Location:** **East Side Tunnel, Providence, RI**	**Project No.** **XXXXXX**

Photo No. 37	**Date:** 3/8/22

Direction Photo Taken:
West

Description:
Center of crown at Location 10 during removal of gunite/ shotcrete later.

Photo No. 38	**Date:** 3/8/22

Direction Photo Taken:
East

Description:
Location 10 after removal of gunite/shotcrete later. Note glistening at edge from water seepage between layers.

	PHOTOGRAPH LOG

Client Name: RIPTA	**Site Location:** East Side Tunnel, Providence, RI	**Project No.** XXXXXX

Photo No. 39	**Date:** 3/8/22
Direction Photo Taken: Northeast	
Description: Location 10 after removal of gunite/shotcrete later.	

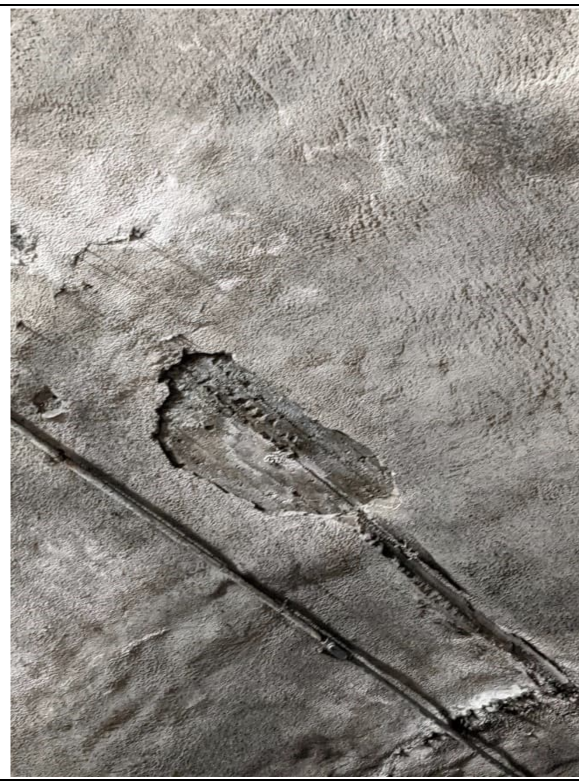


Photo No. 40	**Date:** 3/8/22
Direction Photo Taken: South	
Description: Location 11 after removal of gunite/concrete patch. Note plastic injection port casings from previous joint repair..	

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 41	Date: 3/8/22
Direction Photo Taken: South	
Description: Location 11 after removal of gunite/concrete patch.	

Photo No. 42	Date: 3/8/22
Direction Photo Taken: South	
Description: View of joint repair along crown at Location 11.	

	PHOTOGRAPH LOG

Client Name:	Site Location:	Project No.
RIPTA	**East Side Tunnel, Providence, RI**	**XXXXXX**

Photo No.	**Date:**
43	3/8/22

Direction Photo Taken:
North

Description:
Location 12 prior to gunite/shotcrete removal.

Photo No.	**Date:**
44	3/8/22

Direction Photo Taken:
West

Description:
Location 12 following gunite/shotcrete removal.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 45 **Date:** 3/8/22	
Direction Photo Taken: N/A	
Description: Staining and mineral material at Location 14.	

Photo No. 46 **Date:** 3/8/22	
Direction Photo Taken: Southwest	
Description: Location 15 prior to removal of hollow gunite/ shotcrete patch.	

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 47	Date: 3/8/22

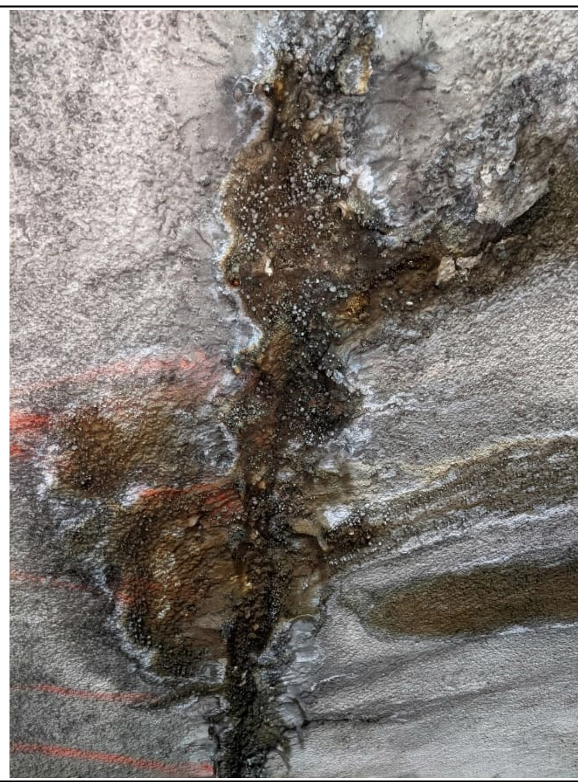
Direction Photo Taken:
South

Description:
Location 15 after removal of hollow gunite/ shotcrete patch. Note discolored punky concrete.

Photo No. 48	Date: 3/8/22

Direction Photo Taken:
West

Description:
Previous crack repair in crown at Location 16.



PHOTOGRAPH LOG

Client Name:	Site Location:	Project No.
RIPTA	**East Side Tunnel, Providence, RI**	**XXXXXX**

Photo No.	Date:
49	3/8/22

Direction Photo Taken:
South

Description:
Previous crack repair in crown at Location 16. Note heavy leakage and brown mineral materal.

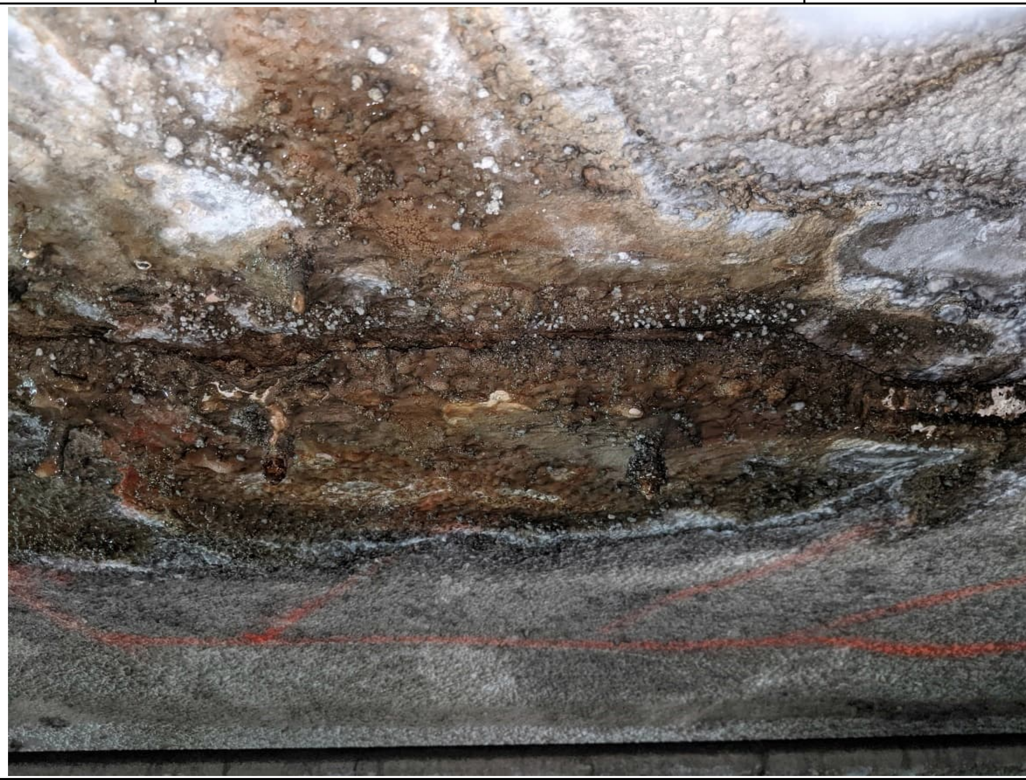


Photo No.	Date:
50	3/8/22

Direction Photo Taken:
North

Description:
Location 17 after removal of gunite/shotcrete layer.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No.	Date:
51	3/8/22

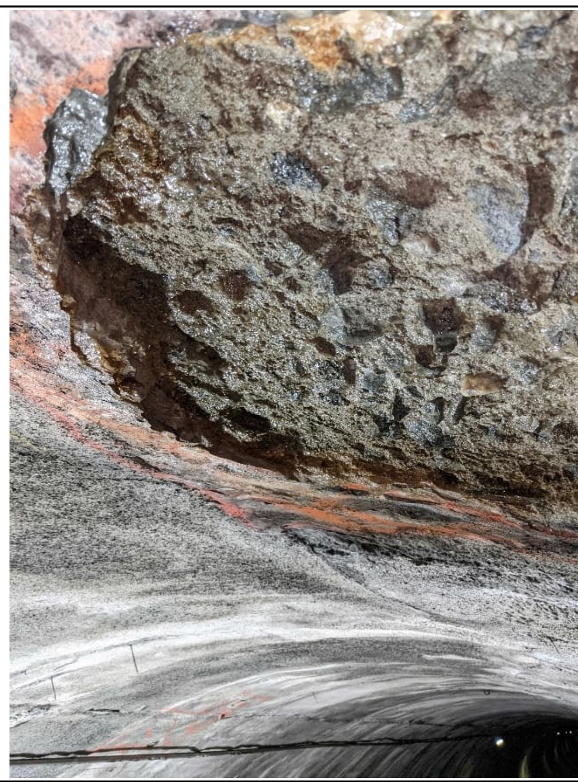
Direction Photo Taken:
North

Description:
Location 17 after removal of gunite/shotcrete layer.

Photo No.	Date:
52	3/8/22

Direction Photo Taken:
East

Description:



PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No.	Date:
53	3/8/22

Direction Photo Taken:
South

Description:
Spall in gunite/shotcrete layer and smaller spall within in concrete at Location 18.

Photo No.	Date:
54	3/8/22

Direction Photo Taken:
South

Description:
Location 19 after removal of gunite/shotcrete patch. Note heavy staining.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

Photo No. 55	Date: 3/8/22

Direction Photo Taken:
South

Description:
Hole in crown at Location 20.

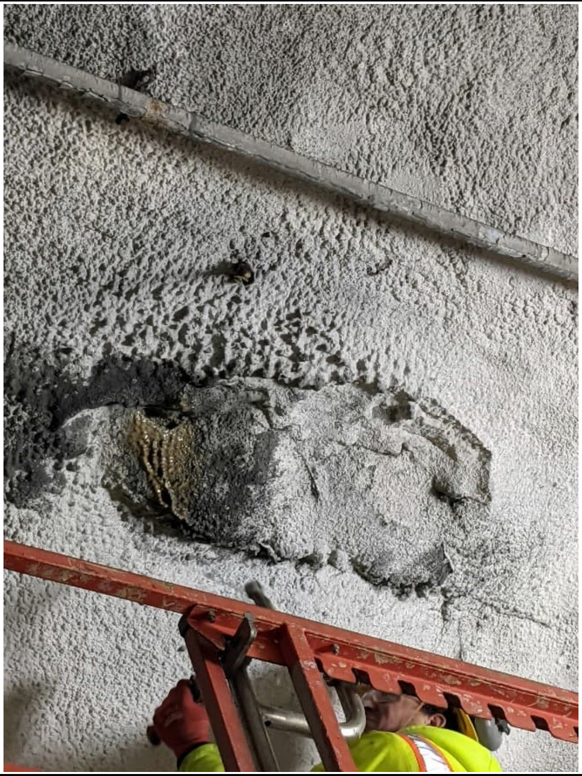


Photo No. 56	Date: 3/8/22

Direction Photo Taken:
West

Description:
Hole in crown at Location 20. Note heavy dripping coming down through hole.

PHOTOGRAPH LOG

Client Name: RIPTA	Site Location: East Side Tunnel, Providence, RI	Project No. XXXXXX

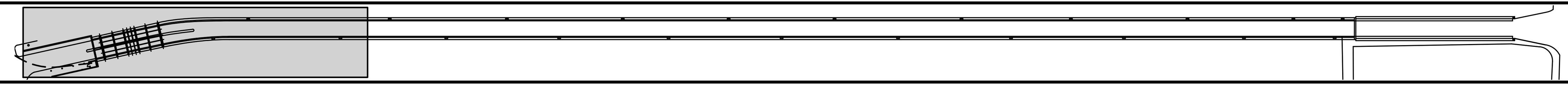
Photo No. 57	**Date:** 3/8/22
Direction Photo Taken: N/A	
Description: Inside of hole (over 4" deep after removal of loose material) at Location 20.	

APPENDIX

B

DEMOLITION LOCATION PLANS

KEY PLAN
N.T.S.



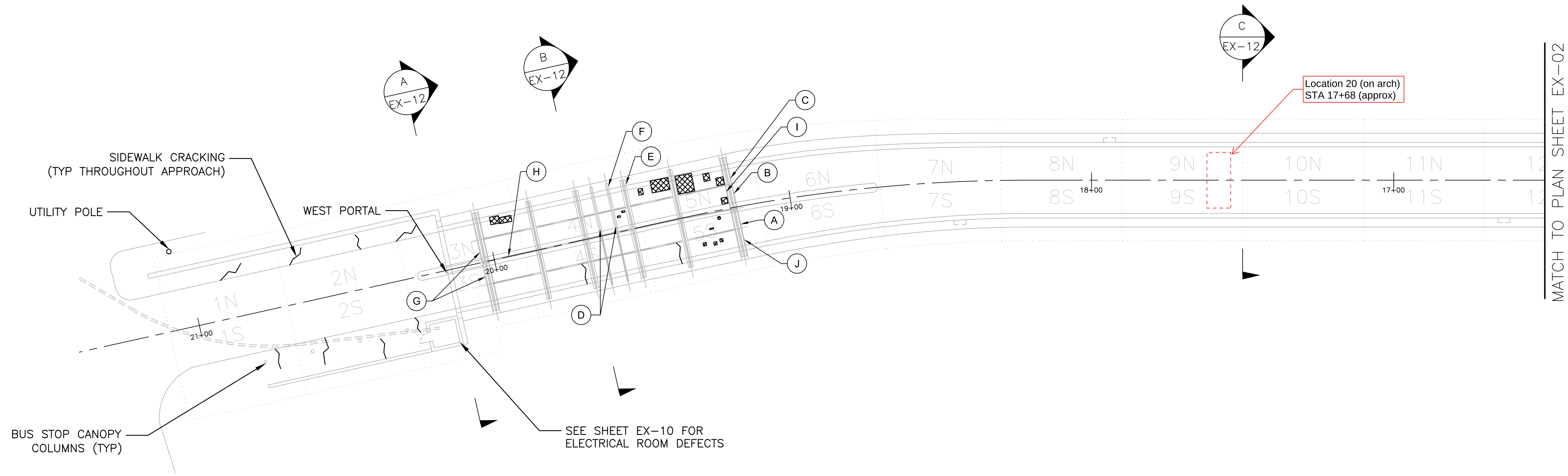
DEFECT LEGEND
CRACKS:
DRY
WET*

SPALLING

SPALL w/
EXPOSED REBAR

DELAMINATION

*WET CRACKS ARE DEFINED AS CRACKS OBSERVED TO HAVE ACTIVE LEAKAGE, EFFLORESCENCE, AND/OR A GLISTENING SURFACE



DETERIORATION NOTES:

(A) EAST GIRDER F @ E. ELEV OF WEB w/ 7' L x FH SECTION LOSS (SL) WITH PITS UP TO $\frac{1}{4}$" $\frac{3}{16}$" D

(B) EAST GIRDER F @ E. ELEV. OF WEB w/ 8' L x UP TO $\frac{1}{4}$" D ($\frac{1}{8}$" AVG) SL @ TOP AND BOTTOM
EF N OF STR B BF SL, 20"L x DOWN TO $\frac{1}{8}$" REM

(C) EAST GIRDER F @ E. ELEV OF BF w/ 2' L SL – TAPERS FROM $\frac{5}{8}$" REMAINING @ WEB TO $\frac{5}{16}$" REMAINING AT TOE

(D) GIRDER CA & CB TWO OPEN DRILL HOLES FOR THROUGH ROD

(E) GIRDER 2" L x FH x $\frac{3}{4}$" D WF OVER

(F) EF CB WEB HOLE FH x 2" L W ADT SL LINE WEB 5"Lx2"Hx$\frac{1}{4}$"D WEB BOWED $\frac{1}{4}$" TO EAST

(G) WEST GIRDER 8F w/ FL x FW x UP TO $\frac{1}{16}$" DP SL w/ HEAVY LAMINATE RUST

(H) STRINGERS @ 8 ELEV CONNECTION TO 4"D UNDER w/ FH x $\frac{1}{4}$" WIDE GAP

(I) ACTIVE LEAKAGE PENETRATING BETWEEN GIRDER AND DECK WITH STALACTITES

(J) E. GIRDER F @ E ELEV 01 w/ FL x FW x $\frac{1}{8}$" REM

SHEET NOTES:

1. SEE SHEET G-03 FOR STRUCTURAL NOTES.
2. SEE SHEETS EX-05 TO EX-08 FOR DEFECTS IN TUNNEL ARCH AND SIDEWALLS.

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SCALE: 1"=20'
GRAPHIC SCALE

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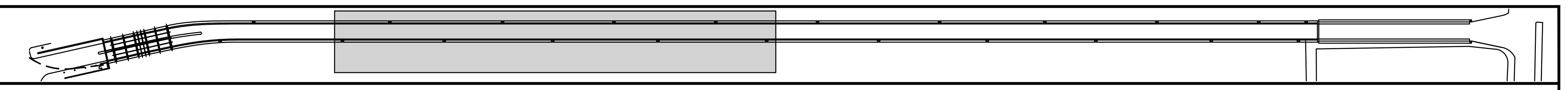
EAST SIDE TUNNEL REHABILITATION
PROVIDENCE RHODE ISLAND

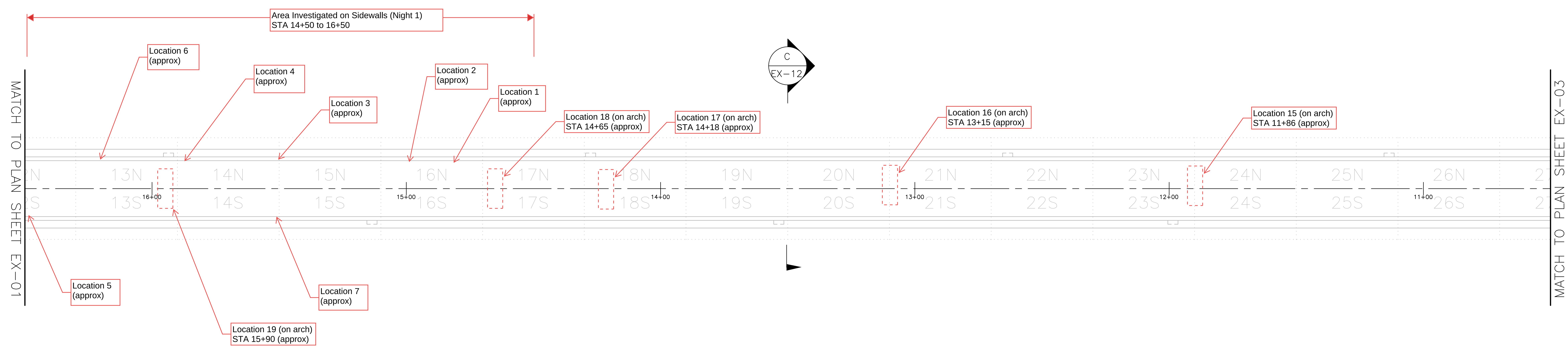
EXISTING TUNNEL PLAN 1

DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX-01
SHEET: 4 OF: 84

TGENERAL001.dwg

KEY PLAN
N.T.S.





SHEET NOTES:

1. SEE SHEETS EX–05 TO EX–08 FOR DEFECTS IN TUNNEL ARCH AND SIDEWALLS.

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EAST SIDE TUNNEL REHABILITATION

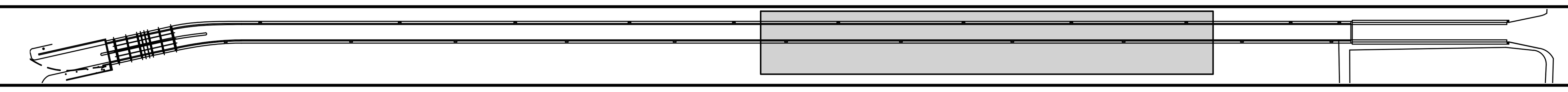
PROVIDENCE RHODE ISLAND

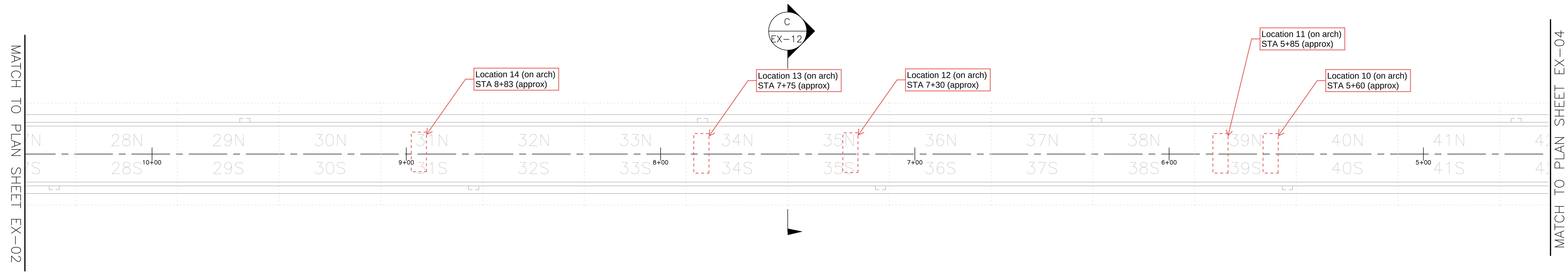
EXISTING TUNNEL PLAN 2

DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX–02
SHEET: 5 OF: 84

TGENERAL002.dwg

KEY PLAN
N.T.S.





SHEET NOTES:

1. SEE SHEET G-03 FOR STRUCTURAL NOTES.
2. SEE SHEETS EX-05 TO EX-08 FOR DEFECTS IN TUNNEL ARCH AND SIDEWALLS.

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EAST SIDE TUNNEL REHABILITATION

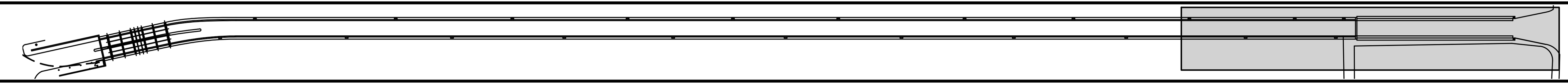
PROVIDENCE RHODE ISLAND

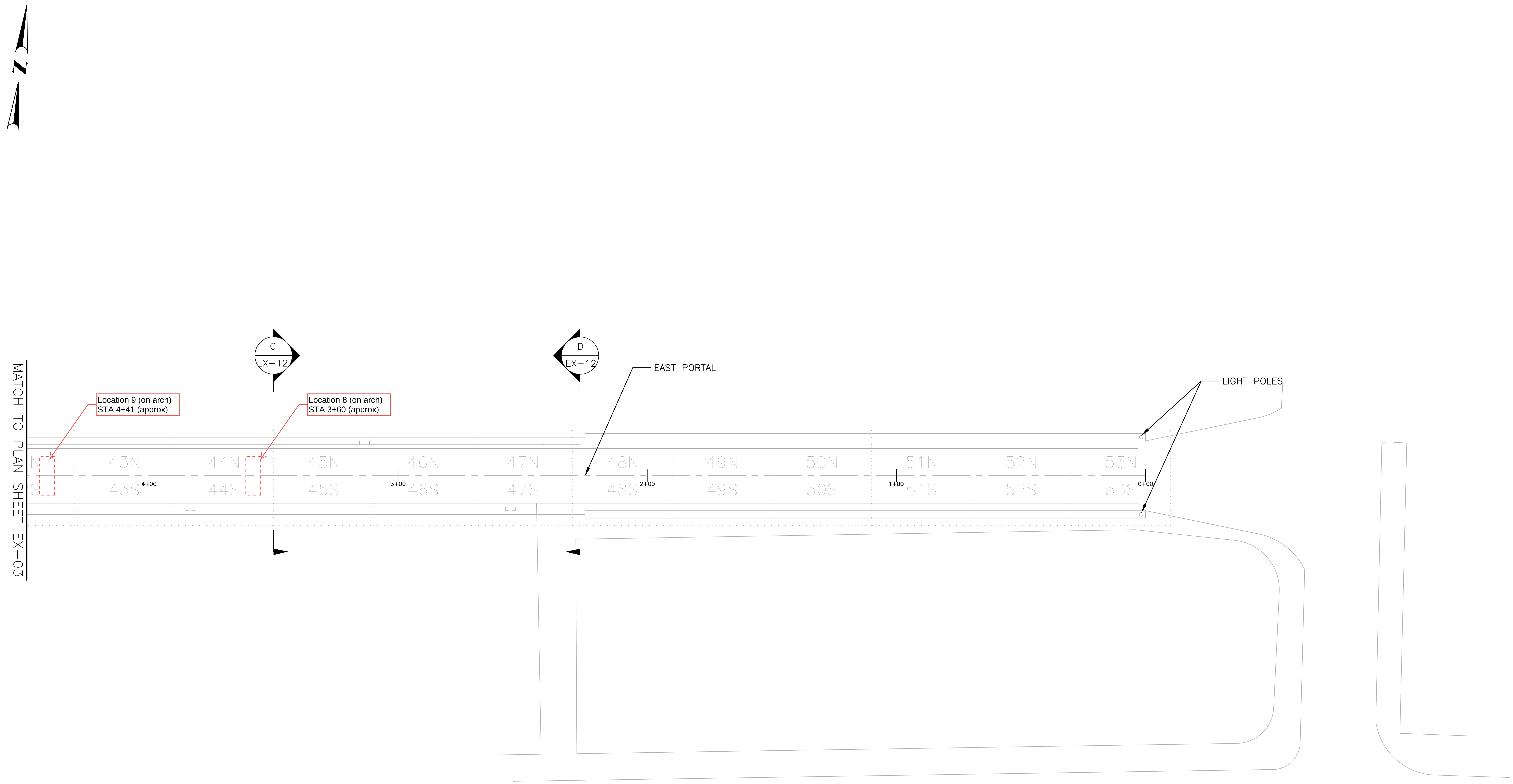
EXISTING TUNNEL PLAN 3

DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX-03
SHEET: 6 OF: 84

TGENERAL003.dwg

KEY PLAN
N.T.S.





SHEET NOTES:

1. SEE SHEET G-03 FOR STRUCTURAL NOTES.
2. SEE SHEETS EX-05 TO EX-08 FOR DEFECTS IN APPROACH WINGWALLS AND TUNNEL ARCH AND SIDEWALLS.

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EAST SIDE TUNNEL REHABILITATION

PROVIDENCE RHODE ISLAND

EXISTING TUNNEL PLAN 4

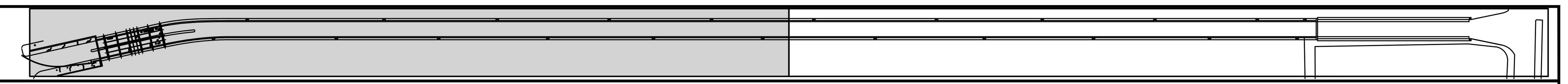
DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX-04
SHEET: 7 OF: 84

TGENERAL004.dwg

SHEET NOTES:

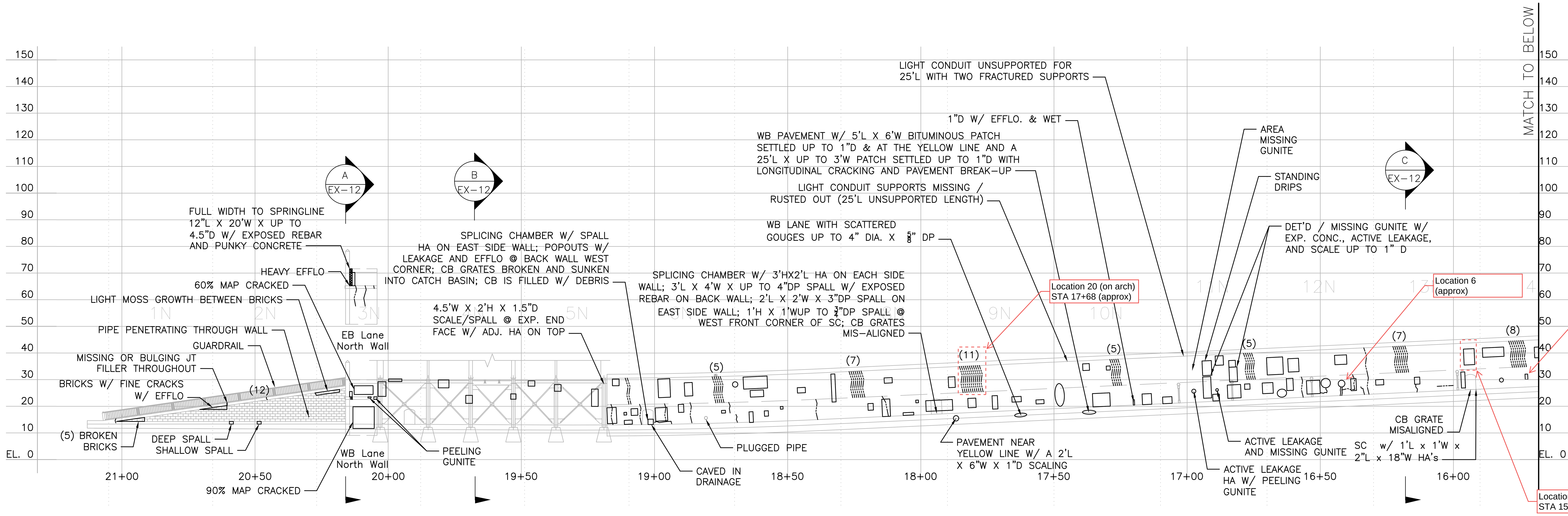
1. SEE SHEET G-03 FOR STRUCTURAL NOTES.

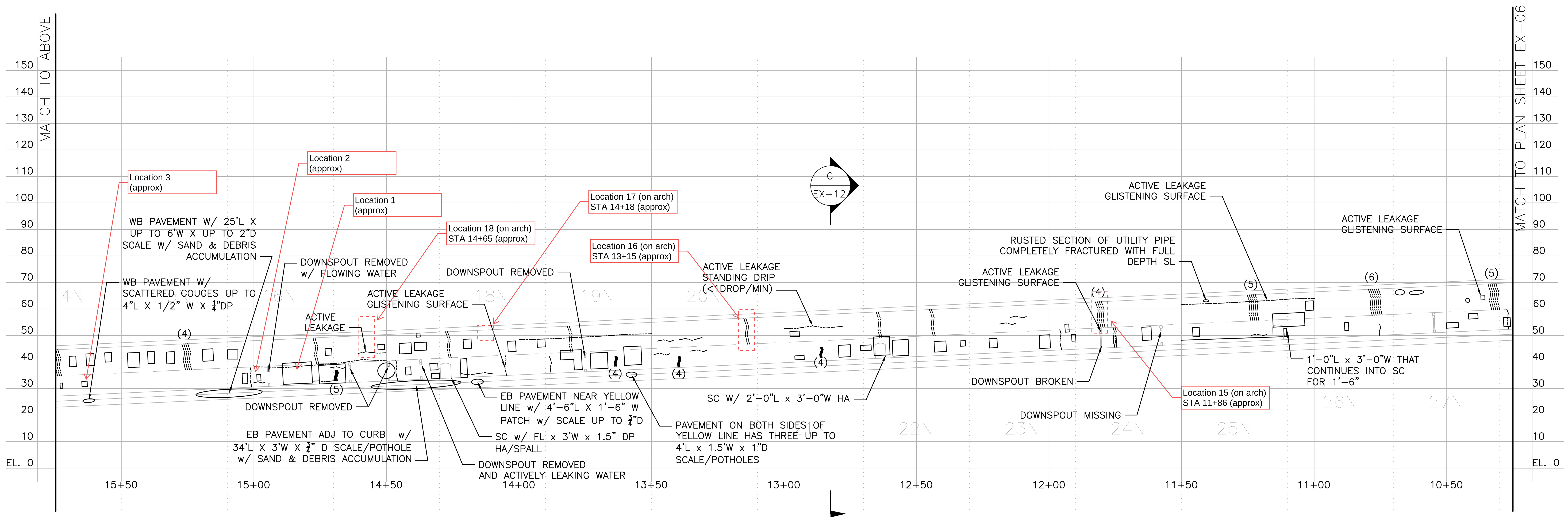
KEY PLAN
N.T.S.



DEFECT LEGEND
CRACKS:
DRY
WET*
SPALLING
SPALL W/ EXPOSED REBAR
DELAMINATION

*WET CRACKS ARE DEFINED AS CRACKS OBSERVED TO HAVE ACTIVE LEAKAGE, EFFLORESCENCE, AND/OR A GLISTENING SURFACE





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EAST SIDE TUNNEL REHABILITATION

PROVIDENCE RHODE ISLAND

EXISTING ELEVATION 1 - LOOKING NORTH

DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX-05
SHEET: 8 OF: 84

TPROFILE001.dwg

SHEET NOTES:

1. SEE SHEET G-03 FOR STRUCTURAL NOTES.

KEY PLAN
N.T.S.

DEFECT LEGEND
CRACKS:
DRY
WET*
SPALLING
SPALL W/ EXPOSED REBAR
DELAMINATION

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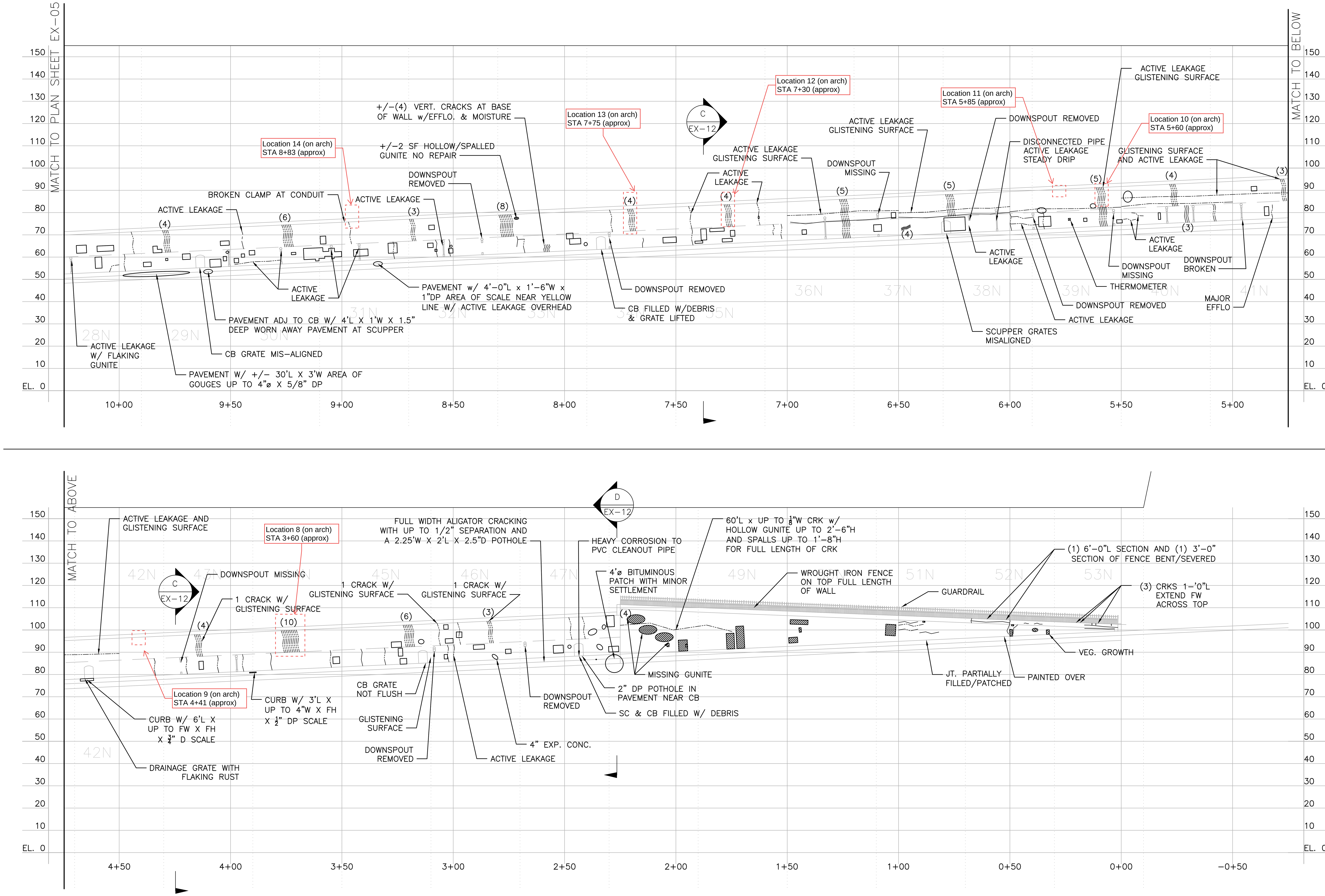

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EAST SIDE TUNNEL REHABILITATION
PROVIDENCE RHODE ISLAND

EXISTING ELEVATION 2 - LOOKING NORTH

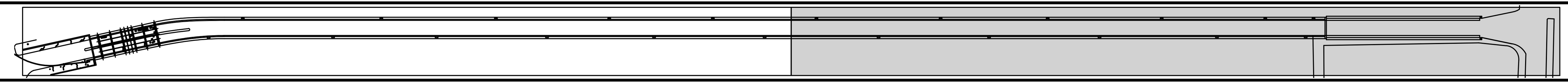
DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX-06
SHEET: 9 OF: 84

TPROFILE002.dwg

SHEET NOTES:

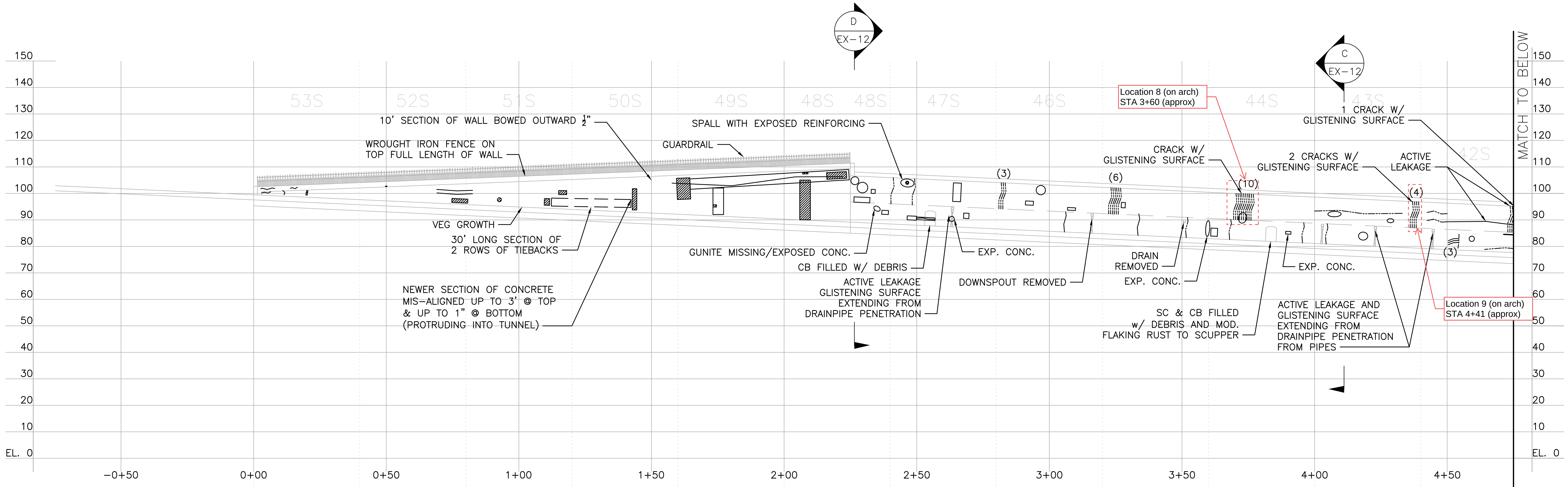
1. SEE SHEET G-03 FOR STRUCTURAL NOTES.

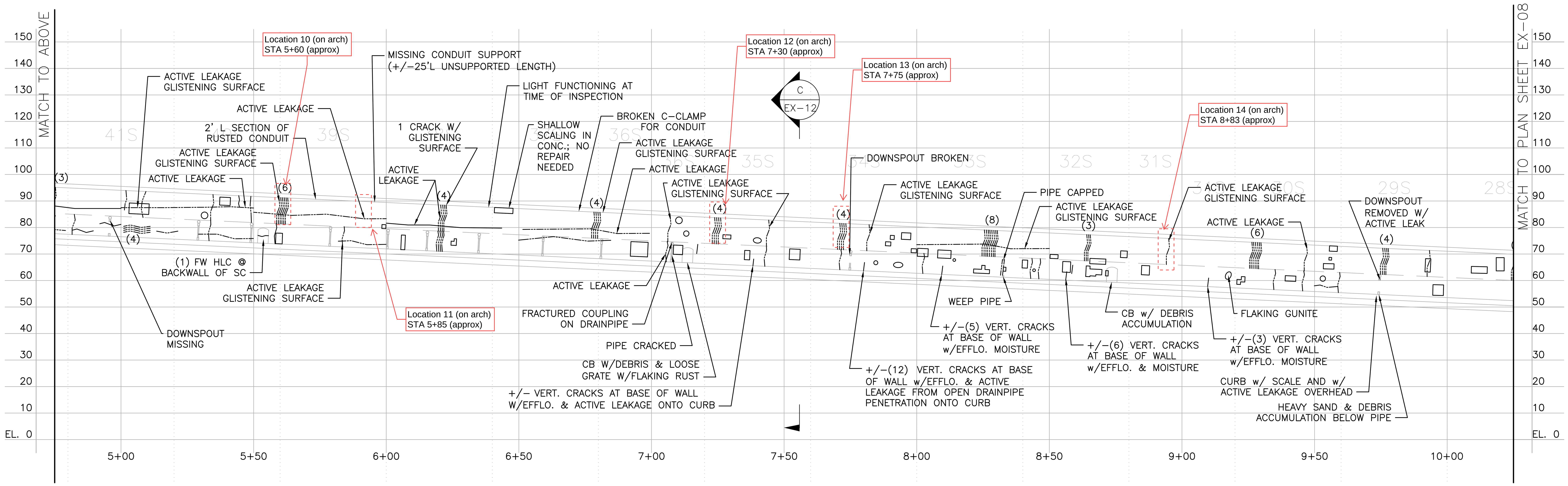
KEY PLAN
N.T.S.



DEFECT LEGEND
CRACKS:
DRY
WET*
SPALLING
SPALL W/ EXPOSED REBAR
DELAMINATION

*WET CRACKS ARE DEFINED AS CRACKS OBSERVED TO HAVE ACTIVE LEAKAGE, EFFLORESCENCE, AND/OR A GLISTENING SURFACE





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EAST SIDE TUNNEL REHABILITATION
PROVIDENCE RHODE ISLAND
EXISTING ELEVATION 3 - LOOKING SOUTH

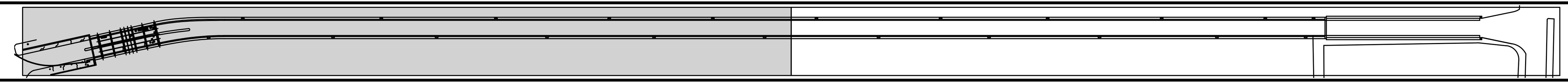
DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX-07
SHEET: 10 OF: 84

TPROFILE003.dwg

SHEET NOTES:

1. SEE SHEET G-03 FOR STRUCTURAL NOTES.

KEY PLAN
N.T.S.



DEFECT LEGEND

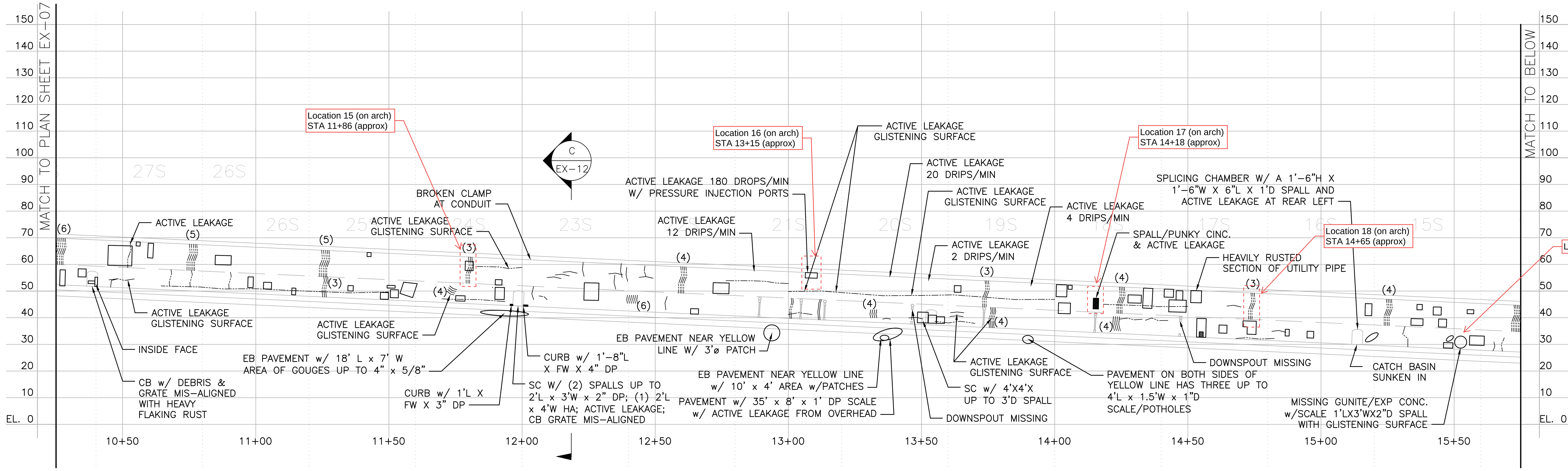
CRACKS:
- DRY
- WET*

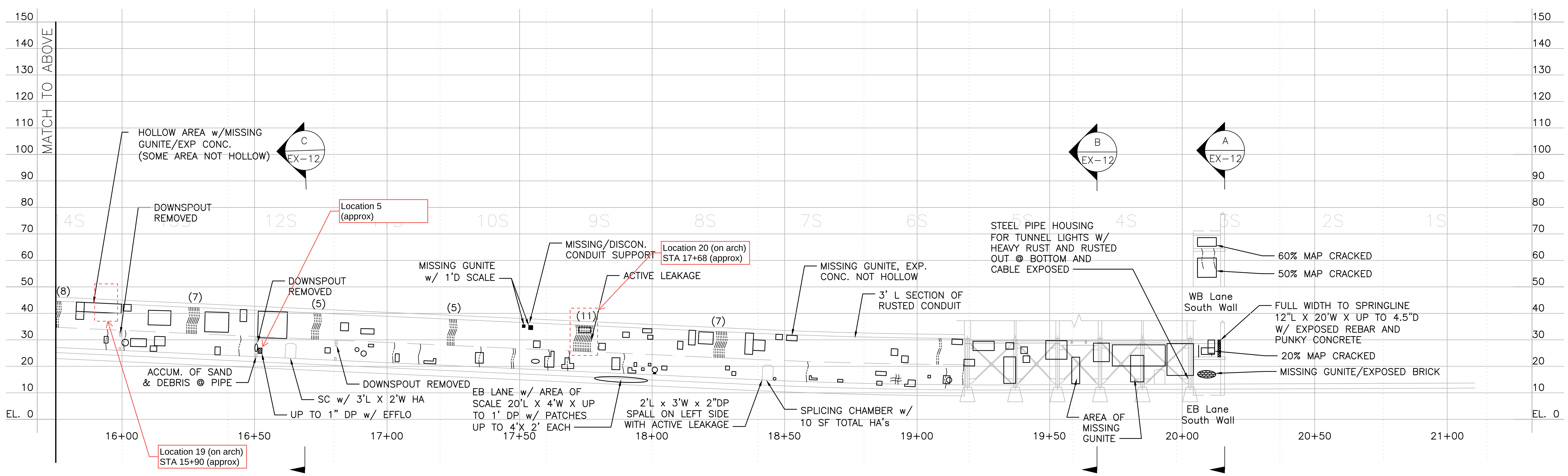
SPALLING

SPALL w/ EXPOSED REBAR

DELAMINATION

*WET CRACKS ARE DEFINED AS CRACKS OBSERVED TO HAVE ACTIVE LEAKAGE, EFFLORESCENCE, AND/OR A GLISTENING SURFACE





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EAST SIDE TUNNEL REHABILITATION

PROVIDENCE RHODE ISLAND

EXISTING ELEVATION 4 - LOOKING SOUTH

DESIGNED BY: HPM
CHECKED BY: SCQ
DATE: 04/14/2023
PLAN NO.: EX-08
SHEET: 11 OF: 84

TPROFILE004.dwg

East Side Tunnel of the Rhode Island Co., Providence

By Heaton R. Robertson*

SYNOPSIS—The engineer in charge of design and construction here gives an interesting report on construction of a tunnel which will improve the transportation facilities in Providence. Some difficult work is described in working under a large brick structure and in soft ground under heavy residences. The methods of timbering, concreting and bench excavation as carried on in the long rock section, make a notable addition to American practice.

⌘

Various schemes have been proposed to improve the transportation facilities in Providence, where troubles arise from having the chief residential section on a hill about 125 ft. in elevation above narrow and congested business streets. The two most popular schemes have been a graded highway on a viaduct and a tunnel for street cars only. Finally, in 1912, the General Assembly in a franchise, empowered the Rhode Island Co., which operates the street-railway system, to build the tunnel in the location shown by the accompanying plan. The city secured the right to purchase the tunnel at cost on completion. In June, 1912, the writer was placed in charge and preliminary work was begun.

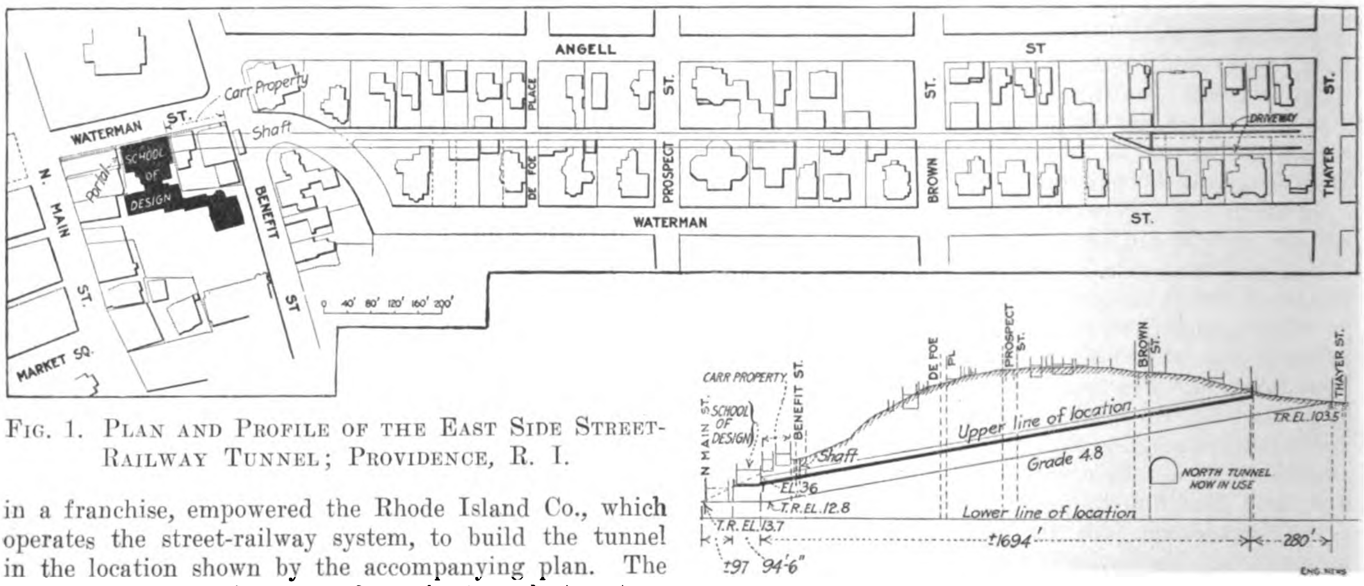

Fig. 1. Plan and Profile of the East Side Street-Railway Tunnel; Providence, R. I.

As there are now at least 4000 railway tunnels, built in many countries and under widely varying conditions, many different methods of tunnel construction have been used. Each given problem of design and construction is dependent on surrounding conditions, and given these as a basis the solution logically develops. The construction methods employed in this case proved similar to those most commonly employed in Europe but comparatively little followed in this country.

Three main feaures of the undertaking presented themselves at first—the condemnation of property, the plans and specifications for awarding of contract, and the methods of construction. All were closely related.

Condemnation—The first step was a determination of tunnel size and approximate alignment referred to city street lines. The width of the tunnel was made 25 ft., which with tracks on 11-ft. centers gave a clearance of 2 ft. between the outside of a 10-ft. car and the sidewall. This is sufficient for any future needs, as large cars with a wide spacing of tracks cannot be used on account of the narrow streets of Providence. The height of the tunnel was made 17½ ft. above top of rail at the center with a view to giving about 16 ft. 5 in. over the center of each track as determined by a preliminary sketch. This gives a clearance of at least 3 ft. 6 in. over the largest street car now operated in either Rhode Island or Connecticut. More clearance is required by cars with a trolley pole than by those operated from third rail, for in the latter case a total height of only 14 ft. 9 in. over track centers has given satisfactory results.

For condemnation purposes, 7½ ft. was allowed on each side for the walls, overbreak, or possible change of alignment, thus making the entire width to be taken 40 ft. Inasmuch as no appreciable change of alignment was made, an allowance of 5 ft. on each side would have sufficed. An allowance of about 5 ft. in addition to the extreme height above top of rail was made for crown bars and lagging overhead. The lower limit of easement was taken at sea level, it being expected that damage claims would be based upon the distance of the upper line of easement from the surface of the ground.

The northerly line of condemnation followed the northerly line of Fones Alley and the southerly line was taken 20 ft. southerly of the proposed center line of tunnel. and so described. Had this southerly line of location been described as passing from point to point on each cross street it would have been easy to determine the points where it crossed each property without running out the whole line. No difficulty arose in this connection but had the location of the line been questioned, such a scheme would have prevented much trouble.

As soon as the papers and plans were filed and a bond furnished, the company had the right to enter the ground in order to begin construction.

Plans and Specifications—An accurate closed sur-

*Division Engineer, The Rhode Island Co., Providence, R. I.

vey was run from a point on the line of Waterman St. (which is parallel with the west approach) over the surface of the tunnel to a point in the line of the proposed east portal, thence around the block and back on another street to the point of beginning. The accurate distance

FIG. 2. WEST PORTAL AND RHODE ISLAND SCHOOL OF DESIGN

and direction of the center of the east portal from the west approach could thus be located by the method of latitudes and departures. The long tangent of the tunnel was then run over the hill on a 7-ft. offset in Fones Alley and marked permanently by copper nails in three 12x12-in. blocks, 3 ft. long, set in concrete.

The arched section of the tunnel was studied with care, and a standard section (Fig. 4) determined which it was thought would contain a minimum thickness of arch and walls in the ground that it was expected to encounter. This proposed standard section was intended to be a basis for bids but was subject to change at any time upon payment of unit prices for extra concrete or extra excavation involved. The shape of the intrados as already outlined was dependent chiefly upon the clearance re-

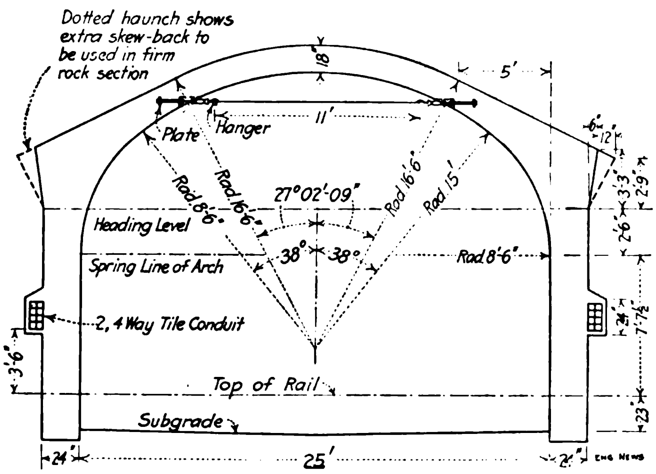

FIG. 4. TYPICAL SECTION OF MAIN TUNNEL

quired; however, a flatter arch might be used to advantage in a very deep tunnel, where pressures might come more from the sides than would be probable in a tunnel near the surface. The extrados was designed with a view to giving the arch a uniform strength according to the elastic theory when the loads were assumed to be vertical. The skewback was for the purpose of giving support to the arch until the sidewalls were in place, as by the adopted method of construction the arch was to be built first.

Two lines of four-way conduit were placed behind each sidewall, waterproofed, and covered with concrete. Conduits are often placed in the bottom of a tunnel near the

FIG. 3. EAST PORTAL AND APPROACH

walls and thus form a convenient walk, but probably cost more, as when they are placed behind the walls less extra concrete is required, and the overbreak will take care of most of the excavation. The possible rental value of such conduit in a large city is obvious. Splicing chambers were designed 6 ft. high and 4 ft. wide to be placed alternately and 160 ft. apart in each wall.

Eye-bolts (¾-in.) were placed on each side of the arch for the support of cross spans to carry the trolley wires and were set back beyond neat lines in order to give a longer span at the proper elevation. There are several methods of supporting trolley wires in a tunnel and the question was given careful consideration. The less clearance required for supports the less is the height of the tunnel, with a presumable decrease in cost. Some of the methods requiring least clearance, however, are open to certain objections. The more expensive trolley rod, rigidly fastened to the roof of the tunnel, is apt to be noisy and to cause annoyance to residents overhead, while the ordinary trolley wire attached to fixed hangers over the tracks will wear unduly at the points of suspension. By sinking the eye-bolts into the concrete a satisfactory cross-span can be used with but little loss in clearance. The trolley wire could be offset from the track toward the center of tunnel if necessary.

The plans of construction under the School of Design were worked out in detail before bids were asked, as it was then thought the work would be begun at this point. The front wall of the building (Fig. 6) and a parallel brick partition wall to the south could rest upon the tunnel sidewalls, and the cross walls and partitions of the building be carried on girders. In order to reduce the depth of these girders and to give more clearance underneath, they were designed to rest upon center columns. In order to avoid settlement, the tunnel walls for the support of the school were designed heavier than would have been the case had they been intended for the original foundation of the building. The use of the center columns necessitated a wider tunnel at this point, and as the tunnel curved toward the east it gradually narrowed to the standard section, which gave each arch ring for the next 112 ft. different span and radii. Heavier side walls were required as shown in Fig. 6. This curved and narrowing section was to be another special piece of work on account of its position in soft ground only 6 to 8 ft. under the two heavy residences of the Carr property (Fig. 1).

Retaining-walls for the east and west approaches were designed approximately, for the purpose of estimating unit bids.

It is often a considerable problem to find the best means for the economical disposal of a large quantity of material to be taken from the center of a large city. Perhaps the cheapest plan considered would have been to load into trolley cars at the west approach or in the tunnel and haul through the city streets to a dumping ground three miles distant. It happened, however, that the material could be used to advantage in filling a trestle of the New York, New Haven & Hartford R.R. over the Seekonk River; and although a shaft and temporary trolley line in Benefit St. was required to load the standard-gage cars for the purpose, this was offset by other considerations and became the adopted method. By means of the shaft the longer portion of the tunnel to the east could be begun at once, without waiting to finish the shorter but slow and more difficult portion under the School of Design and the Carr property. With the installation of the line along Benefit St., a vacant lot, at the point where the steam cars beneath were loaded, could be utilized for mixing concrete and storing materials. In this way, while the disposal itself, measured in terms of actual hauling and dumping, was not cheap, the whole system became economical and efficient.

In preliminary work of this kind it should be borne in mind that general plans may be considerably altered in detail as construction progresses. But the experience here shows that this should occasion no difficulty where unit prices are bid. Great care was given to the specifications, however. It was essential that they should be an accurate and final explanation of the intentions of the company in regard to the work of construction. No amount of thought in such cases is wasted in making specifications detailed and comprehensive. For instance, they should describe the work in general and explain fully what is required for the payment of each unit price; to avoid frequent causes of misunderstanding, the definition of rock excavation should be precise, and it is well to define common excavation as excavation of all other material; there should be a description of the quality of concrete required, and a synopsis of material to be furnished by the contractor and by the company; provision should also be made for extra work, or work done at the request of the Engineer which cannot be included in the bids.

PRELIMINARY WORK—When the contract was awarded, the plan of construction was resolved into several parts: The 95 ft. of special construction under the Rhode Island School of Design; the 112 ft. of soft ground tunnel under the two heavy residences of the Carr property adjoining; the 1585 ft. of long tunnel tangent; and the grading and concrete at the approaches. The easterly 75 ft. of the long tangent was to be excavated by the cut-and-cover method.

Preliminary work consisted in sinking the shaft in Benefit St. at a point which divided the long straight portion of the tunnel from the short sections of special work to the west. An extra siding was installed near the portal of the steam-road tunnel which passes under Benefit St. two blocks to the north, and above this siding the contractor built a timber trestle to support storage bins beneath a narrow-gage track which runs thence along Benefit St. to the shaft. By means of this track, excavated material which is hoisted from the shaft is hauled by a trolley locomotive to the bins where it is emptied into standard-gage cars beneath, these being hauled at night to the Seekonk River and dumped. The greater part of the material from that portion of the tunnel below Benefit St. to the west was hauled up the hill by team and then to the bins.

The shaft was commenced Nov. 12, 1912, and was sunk a short distance below tunnel subgrade, a slab of concrete

FIG. 5. BENEFIT ST. SHAFT AND PART OF CARR PROPERTY

12 in. thick being placed in the bottom. The entire shaft was in soft ground and the depth from the street to the top of the tunnel about 15 ft. Spoil was lifted by a 75-hp. electric hoist installed in the street. When the upper portion of the tunnel was being excavated, the 3-yd. narrow-gage cars which operated in Benefit St. were lowered below heading level to receive the material from the small steel cars used in the tunnel. When the lower portion of the tunnel was being excavated, 3- and 4-yd. cars were lowered to the bottom of the shaft and hauled by a locomotive to the shovel used.

The concrete mixer, the cement shed, and the various concrete materials were located in the vacant lot near the bins, and concrete from the mixer was hauled through Benefit St. by the electric locomotive (Fig. 5) to the shaft. The compressor plant and blacksmith shop were installed in the basement of a building purchased in connection with the acquisition of property for the west approach of the tunnel (seen at the right in Fig. 2). One-half of the building originally stood on the ground required for the west approach and the remaining half, besides affording space for compressor and blacksmith shop, gives room above for construction offices of the company and the contractor. A vacant lot near the east portal served as space for the concrete plant and storage of material to be used in the construction of the east approach and the cut-and-cover portion of the tunnel.

As soon as the shaft was finished, the top heading of the long tangent of the tunnel was begun. When this work had progressed some distance, a drift was run from the shaft westerly to the location of the west portal and a pipe from the end of this drift connected with the city sewer in North Main St., to provide drainage and guard against the danger of filling the shaft and workings with water in case any considerable amount of ground or spring water was encountered. Water in abundance, by filling the workings, would have washed the earth from behind the timbers and thereby endangered the work. This drift was in firm glacial till for the entire distance and no rock was located under the Carr property or the School of Design. The portion of the tunnel to the east was in this same material for about 200 ft. before rock of any stability was found. The greater part of the tunnel was in graphitic carboniferous schists considerably fractured by compression. In driving the drainage drift a location was chosen along the southerly tunnel wall composing the portal of the tunnel. It was found when driving the drainage drift that the west wall of the building extended to within a few feet of the level of the west approach below, and was doubtless so constructed to prevent sliding of the structure.

The general plan of procedure was to underpin the front wall of the building with the north wall of the tunnel and the longitudinal partition wall 29 ft. distant with the south wall of the tunnel and to connect this south wall with the wall already placed in the drainage drift under the Carr property. It was proposed, as soon as sufficient portions of the tunnel walls were completed, to excavate shafts in which to place the steel-center supporting columns; then to set in place one at a time the steel girders which were to carry the transverse lines of cast-iron columns, brick partitions and outer walls. The work was accomplished as follows:

Needle beams spanning the location of the north tun-

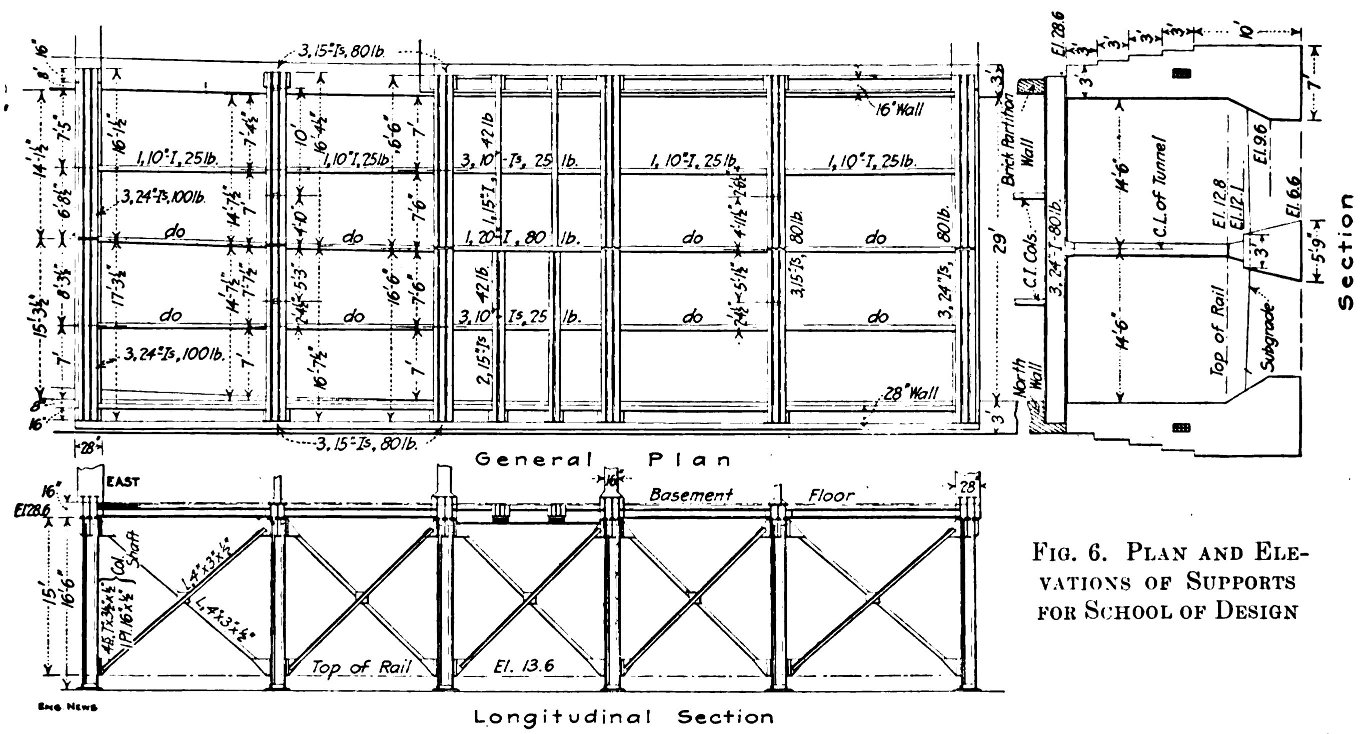

Fig. 6. Plan and Elevations of Supports for School of Design

as far as the face of the School of Design and thence to the portal under the portion of that building carrying the least load. One tunnel sidewall from subgrade to spring line was then concreted in the drift under the Carr property.

Supports for the School of Design—After the construction of the main tunnel was well under way, in the beginning of February, 1913, the underpinning of the school was begun. This building is a three-story brick structure (Fig. 2), the foundation walls of which support a load of about 16,000 lb. per running foot. The north and west walls are pierced by large arched windows which concentrate the building loads on six piers along Waterman St. and three piers across the entrance of the tunnel. Two lines of iron building columns and two brick partition walls cross the tunnel opening. A longitudinal partition wall runs two-thirds the distance through the building directly over the south wall of the tunnel. The easterly outer cross-wall has no openings. The building rests on a sidehill, and a 10-ft. drive west of the building was supported by a masonry wall which has now been replaced by a reinforced arch and parapet

nel sidewall and resting on blocking were placed to carry the first two piers of the front building wall. A trench about 15 ft. in length under the corner of the building was then excavated and braced with 3-in. sheathing, after which the concrete wall was brought up by degrees and the crossbraces removed as concrete was placed. This wall was brought to within 6 to 12 in. of the bottom of the building wall and when the concrete had set, brick piers were built to within one course of the foundation. The next day the final course was put in and pinned with iron wedges driven into the mortar. Plates with parallel wedges are sometimes used for underpinning but the method employed was satisfactory and no settlement was recorded in connection with it. Each 15-ft. section of wall was underpinned before the adjoining section was excavated and, by working on alternate sides, the length of building wall needled at one time was minimized. As soon as the two piers on opposite sides of the tunnel at the west wall of the building were underpinned the needle beams were removed and used to support the central building pier. A pit was then excavated to a depth of 22 ft. and concrete for a center column base placed. After a set of about six days, the steel column was erected. Up to this point the portions of this west wall between the needle beams at the center and the ends supported by the tunnel walls, rested on their original foundations. The whole north half was then needled, from column to tunnel wall, with small beams and the original foundations were cut away to allow placing the triple girder (Fig. 6). This girder and all the similar ones shown consisted of three 24-in. I-beams bolted together and riveted to a common plate at the wall end. The north half of the wall length was then pinned off by bricking up on top of this girder. The south half was needled and a girder put in similarly; then the heavy needles were removed from the central pier. The brick partition walls, the lines of cast-iron columns, and the easterly outer wall of the building crossing the tunnel were supported in a similar manner. The basement floor was replaced by a reinforced-concrete slab.

half of Fig. 9, the width along the tunnel being about 6 ft. In connection with this work, Drift 4 was driven a distance of 8 ft. or 2 ft. beyond the enlargement to enable continuation after the concrete arch was in place. Drift 4 was not a drift in the ordinary sense as it was only for setting up the segment posts and facilitating enlargement.

The enlargement was carried from the center toward the haunches by laying steel lagging piece by piece, supporting these at one end by the segment in place and at the other end by temporary 3-in. planks. The center of each piece of lagging was also supported by 3-in. planks where the ground appeared heavy. The steel lagging was $\frac{3}{8}$x6 in.x6 ft., weighing about 600 lb. per ft. of tunnel length.

As soon as the enlargement was completed, 8x12-in. segmental timbers were put in 3 ft. apart and the ground excavated to within a couple feet of the spring line; then the steel centers were set up, covered with beveled strips and a 5-ft. section of arch concreted. When this ring had set sufficiently the next 6-ft. section was enlarged and the arch ring placed similarly. This method of operation was carried on simultaneously from each end of the portion of the tunnel under the residences in question, and by having open only a small amount of ground at one time the dangers from settlement were reduced to a minimum. As soon as the arch was completed the rest of the core was removed between the west portal and the shaft and the excavation carried to subgrade. Only a few segmental timbers were removed. No difficulty was experienced in packing concrete around the segments. There was some settlement of the residences overhead as for a part of the distance nothing but sand was encountered overhead.

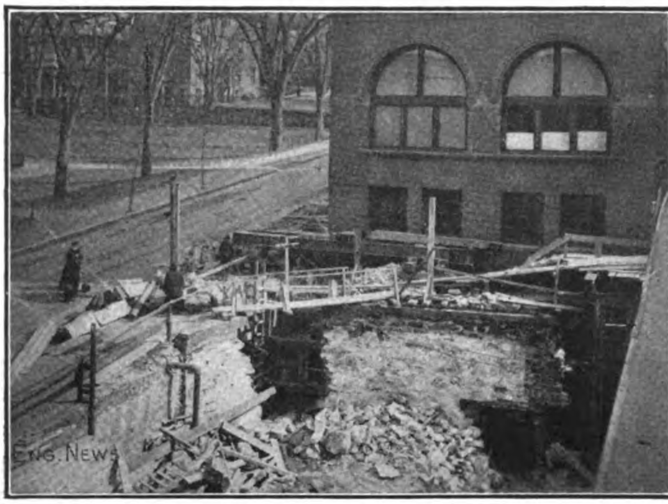

Fig. 7. Beginning New Foundations, Drainage Drift at the Right

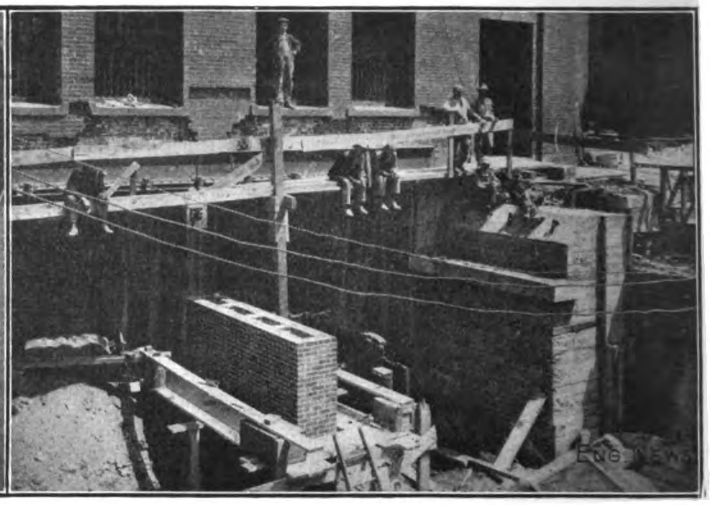

Fig. 8. Steelwork under West Wall and Foundations of Driveway Arch

Figs. 7 and 8. Tunnel Work under School of Design

After the foundations and steelwork under the school were completed, a double reinforced arch, carried on the two sidewalls, and a central pier of brick was built to carry the 10-ft. driveway of the school; a brick parapet wall, built at the edge of the driveway, served as a railing to the drive as well as for the architectural features of the portal.

Work under the Carr Property—As soon as that portion of the north wall of the tunnel which supports the School of Design was in place, a drift (No. 2, Fig. 9) was run westerly from the shaft along the location of the north tunnel side wall to connect therewith. The side wall was concreted in this drift from subgrade to spring line similarly to that previously placed in the drainage drift on the opposite side of the tunnel. The space behind these walls was filled with boulder concrete.

The remaining core under the greater portion of the School of Design being removed by teams, a top center heading drift (No. 3, Fig. 9) was excavated from the School under the residences of the Carr property to the shaft. Steel lagging was used in the roof of this drift and was set at the grade of the proposed extrados of the arch. Wood lagging was used at the sides where necessary. When the center drift had progressed sufficiently, enlargement was begun, as shown in the right

The lowest point in the tunnel is under these buildings, about 120 ft. from the west portal, where a brick catch basin $4\frac{1}{2}$ ft. in diameter and 7 ft. deep was constructed and connected by an 8-in. pipe to the North Main St. sewer. Small pipes running to this basin drain the ground under the School while a 6-in. pipe brings the drainage from the main tunnel.

Main Tunnel—The method of driving the long tangent of the tunnel was somewhat unusual in certain fea-

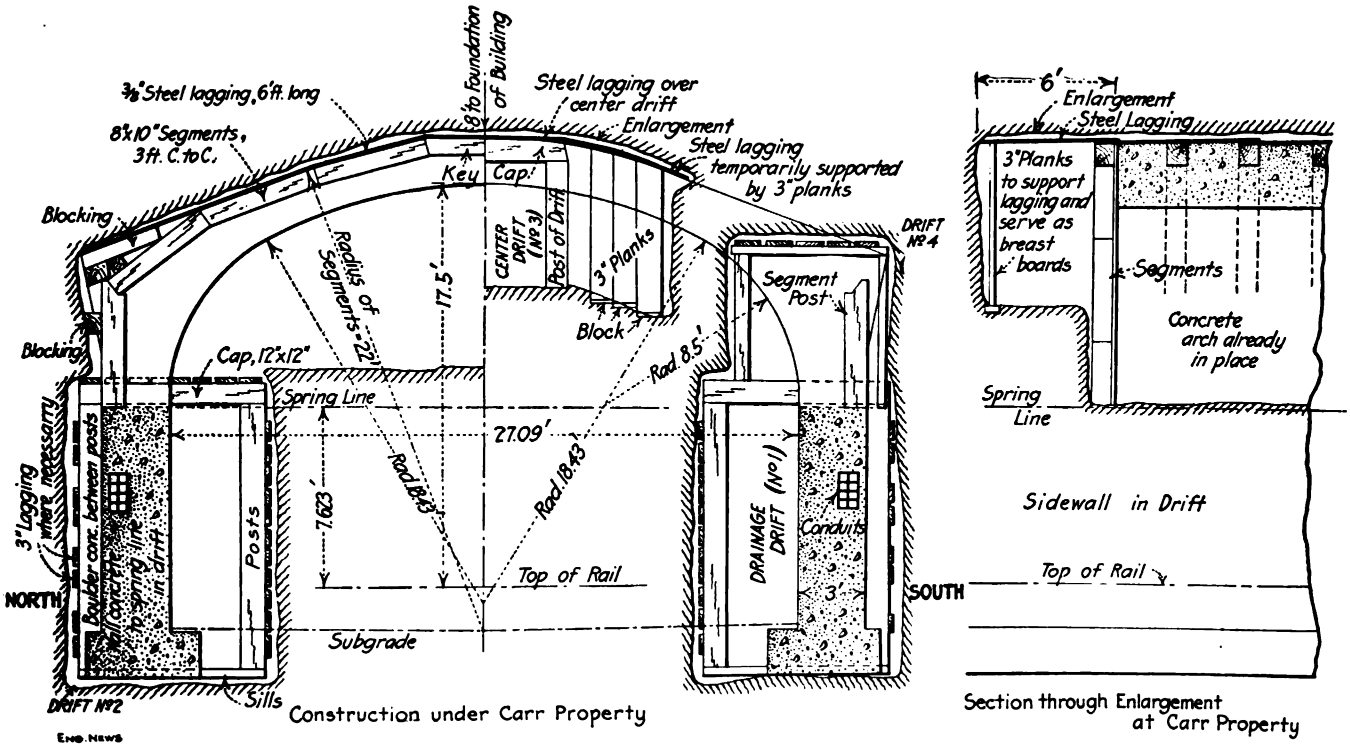

FIG. 9. TUNNEL TIMBERING UNDER CARR PROPERTY

tures. First, a center drift was driven below the crown, as shown in Fig. 10; this was next enlarged to the full width of the tunnel, the ground overhead being supported by lagging, crown bars and posts. Next, centers were set up and the arch rings concreted, the haunches resting upon the ground. After this portion of the tunnel above heading level was concreted its entire length, the lower part, or bench, was excavated to subgrade between the neat lines by steamshovel, and as this work progressed it was followed by excavation and concreting of sidewalls.

This method has proved successful in a number of instances. In soft ground, however, it is not suitable as settlement of the arch would undoubtedly occur between the time of excavating the bench and placing of sidewalls. In this case, for the short distance east of the shaft in which soft ground was encountered, the sidewalls were put in trenches excavated in short sections before the core

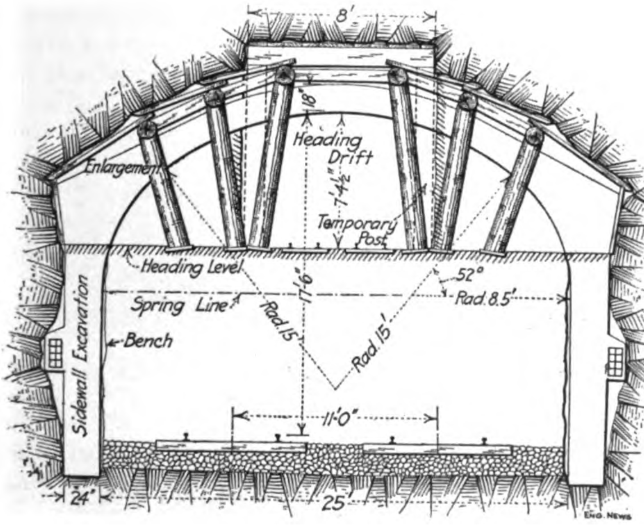

FIG. 10. TIMBERING IN MAIN TUNNEL

was removed. In the hardest kind of rock, blasting of the bench is likely to crack and disfigure the arch, the method being most advantageous in ground which, like the case in hand, consists of a rock soft enough to be easily broken and at the same time of sufficient strength and firmness to stand without danger on the vertical plane of the neat lines. The purpose of the skewback is for support of the arch while the bench and sidewalls are being removed and the wall concrete placed.

HEADING AND ENLARGEMENT—The upper drift was started Nov. 26, 1912, work being pushed day and night. It was 10 to 11 ft. high and of a width requiring 8- to 10-ft. caps. With the exception of 75 ft. it was driven from one end only and was holed July 16, 1913; the length being 1495 ft., an average rate of progress of 6½ ft. per day was made. This figure is not a fair idea of progress, however, as work on the heading was stopped while the drainage drift was being driven, and, moreover, as it was a short tunnel, the usual delays in the first few weeks count heavily against the average. During the last four months an average progress of 235 ft. per month was made.

The method of timbering the heading drift (Fig. 10) consisted in placing sets of caps and posts about 5 ft. apart, the ground being supported overhead with 2-in. lagging. As soon as sufficient space was made the caps were supported by oak crown bars 20 to 25 ft. long, resting on batter posts 5 or 6 ft. apart; the original temporary posts being removed and used again for posting caps. The crown bars were kept in position by stretchers. In ground where 20 ft. could be tunneled without timbering, the crown bars were put in directly.

Excavated material was trammed to the shaft in one-ton steel cars which ran down the 4.8% grade on a narrow-gage track, the empty cars being pulled back to the heading by mules. Stalls for the latter were erected under the portion of the arch already concreted.

The alignment of the first 300 ft. of heading was found by dropping two plumb bobs down the shaft on the center line. When the heading had progressed 300 ft., a 6-in. well hole was sunk from the surface on the 7-ft. offset line established over the hill and the line of the rest of the tunnel was found by plumbing down this hole and down the shaft. The final error at the other end was negligible.

vated per day. Although a low-grade explosive will usually break soft or fractured rock to better advantage, 60% dynamite was used here in order to reduce the volume of smoke. No means of ventilation was employed other than that afforded by the use of compressed air, and the atmosphere became decidedly close during the last month before the heading was holed.

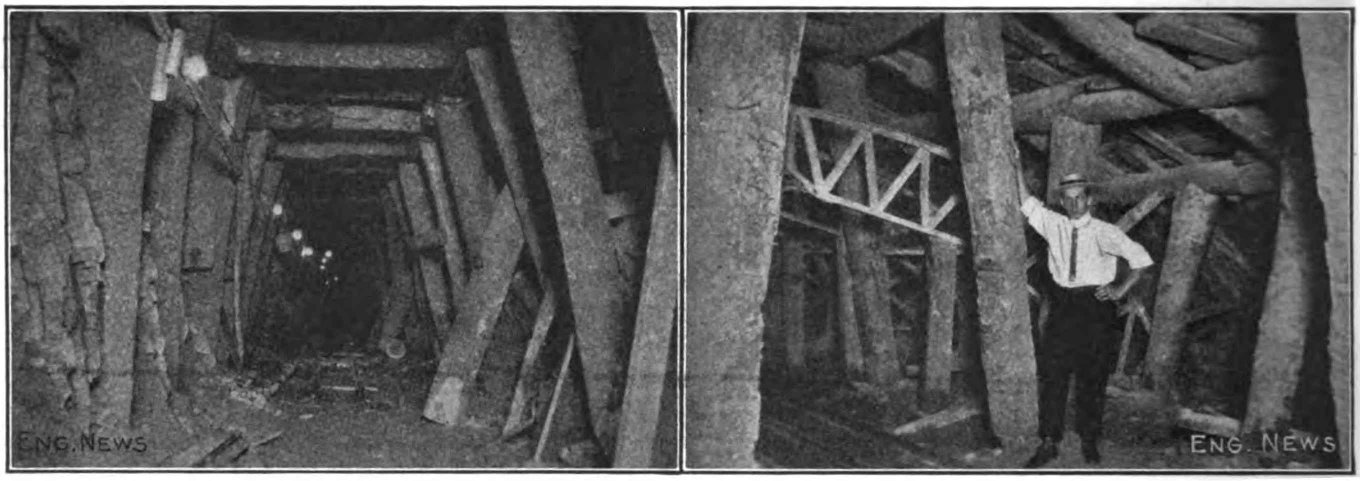

FIG. 11. UPPER HEADING AND ENLARGEMENT; MAIN TUNNEL

As soon as the heading had been driven about 150 ft., the enlargement was started and an effort made to keep it a uniform distance from the heading. Taking a section equal in length to the crown bars, the ground was excavated toward each haunch from the center drift, lagging being driven over the bars and pointing across the tunnel. As soon as sufficient space was made the No. 2 bars were placed and posted, the process being continued until the enlargement of the entire section was complete. The skewback was often not cut, however, until just before the forms were set up. The operation was essentially the same as though a drift 20 or 25 ft. wide was being driven across the tunnel to each side from the center.

As the bars were set above the required extrados, a space was left under the lagging between them which had to be filled either with concrete or dry packing; this space also represents overbreak. Yet if the bars were set lower it would be necessary to chop them out in short lengths as each ring was being concreted, a process which seriously interferes with the operations of the concrete crew. In any case it would be advisable to make an allowance to provide for bars not placed at precisely the correct elevation and to allow for possible settlement. To insure an adequate height of lagging at all times this allowance should be equal to at least one-half the diameter of the bars. It was thought best, therefore, to set them clear of the required extrados in the first place in order to diminish the amount of necessary cutting and to facilitate the concrete work.

The drilling of the heading was done by an average crew of one foreman, four drill runners and four drill helpers on each shift. The drilling and timbering of the enlargement and the placing of the crown bars was done by an average crew of one foreman, six drill runners and timbermen, and three or four helpers on each shift. The mucking crew for the heading and enlargement consisted of a foreman and 25 or 30 laborers on each shift with a tramming equipment of three mules and 10 to 12 one-ton cars. About 100 yd. of rock in place was exca-

The tunnel arch above heading level was concreted in 5- and 10-ft. rings, depending on the nature of the ground. In heavy ground the posts supporting the crown bars cannot be removed with safety to leave a 10-ft. span and in such cases only 5-ft. rings were put in. Steel centers in two sections bolted together in the center, resting on blocks at the haunches and supported by posts, were used. Form lagging consisting of beveled strips 3x4 in. and 5 ft. long, dressed on three sides, was laid on the centers as the concrete progressed toward the center of the arch. Forms were left in place until the concrete had set 6 days. The space between the required extrados and the roof lagging was filled with concrete

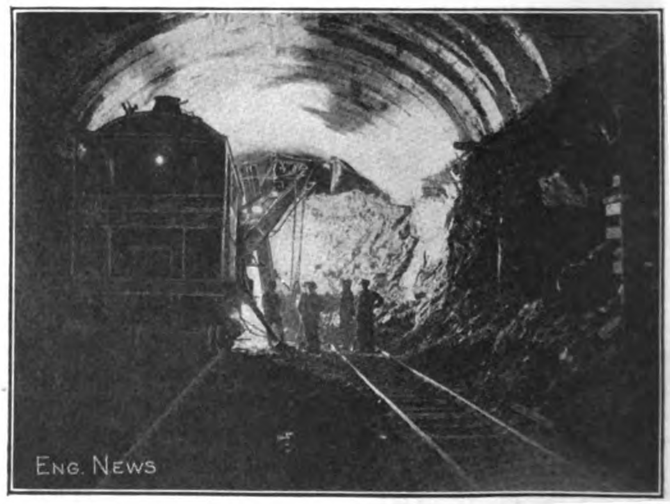

FIG. 12. REMOVING BENCH WITH SHOVEL; EAST SIDE TUNNEL, PROVIDENCE

from the haunches to the No. 2 bars, then as specified the space over the center of the arch was packed with rock. Concreting was done by the day shift and the packing at night.

Concrete was mixed on the surface, poured into a chute at the shaft, and hauled up the tunnel grade by mules. It was then dumped on sheet-steel plates and shoveled into the arch, care being taken to equalize the load on each side. The concrete was kept about 150 ft. behind the enlargement excavation. Blocks were set in the ends of each ring and under the haunches to form a key. The average concrete force consisted of a foreman and seven men mixing on the surface, a mule boy, and a foreman with eight men and a spader to shovel into the forms. Four men set the ribs and built the housing.

BENCH AND SIDEWALL—The work underneath the Carr property was finished, so that the core could be removed, at about the same time the main tunnel arch was completed. This enabled a No. 20 Marion steamshovel to be brought in through the west portal and set up without delay east of the shaft. This was done early in September, 1913. It was operated by compressed air from the west-portal plant. No reheater was used.

The 3-yd. cars operated on Benefit St. were lowered down the shaft to subgrade, and thence hauled by electric locomotive to the bench.

The bench stood a trifle more than 12 ft. in height and was broken by a line of four holes extending across the tunnel and fired simultaneously. The holes were drilled to a depth of 2 ft. below subgrade, and chambered at the bottom before the final charge was inserted. In order that the long drills might be used, it was necessary to obtain clearance for them under the arch by excavating a trench 4 to 5 ft. deep along the line of holes. About 10 ft. of bench was removed at a blast, requiring 50 to 70 lb. of 40% dynamite. The lower grade of explosive could be used then when there was plenty of ventilation through the tunnel.

It was important that the least necessary amount of powder be used, in order to minimize damages to property on the surface from concussion; it was also essential that the rock be broken to the neat lines of the tunnel only to prevent undue shattering of rock underlying the haunches and skewback. Where the ground was broken out under the haunches the arch was posted until the concrete sidewall reached that point. Drilling was done by a crew of ten men including four drill runners and four drill helpers. In addition to the shovel engineer and cranesman, a force of six men took care of the pit and track and did what mucking was necessary. Work was being done in the day shift only.

As soon as the shovel advanced a sufficient distance to give it a reasonable amount of space in which to back away from the blasts, the excavation and concreting of the sidewalls was commenced. This work was kept at a distance of about 150 ft. behind the shovel. The sidewall forms were held in place by a series of steel uprights on each side, which rolled along a rail laid close to the wall. These uprights were held firmly at the bottom by bracing the rail and their tops by steel struts extending across the tunnel between them. The whole framework thus formed could be moved along the tunnel at will. The struts across the tunnel served also as supports for the trolley wire required for the operation of the locomotive to and from the shovel.

Sidewall sections were excavated in 16-ft. lengths, care being taken not to have sections adjoining or sections opposite open at the same time. The concrete was mixed on the surface, hauled up the tunnel by the empty muck trains and dumped on a sheet-steel plate, from which it was shoveled into the wall. The wall was brought up to the duct line and after a set of 12 hr. the conduits were waterproofed and laid in place, whereupon the concrete was finished to within 6 in. of the bottom of the arch. After 24 hours the last 6 in. of concrete was rammed in place and wedged to form a tight key. The sidewall excavation crew consisted of a foreman, four drill runners and ten men; the concrete crew underground consisted of a foreman, two carpenters and 12 men. The total excavation of bench and sidewall was about 140 yd. in place per day, the average progress being between 60 and 70 ft. per week.

APPROACHES—Work on the approaches and the 75 ft. of cut-and-cover tunnel at the east approach was commenced early in the spring of 1913. The work on the approaches consisted in the construction of the usual concrete retaining-walls, excavation for which was made in trenches on account of buildings and other property adjoining. The retaining wall at the west approach was faced with brick to match the portal. The east portal is a simple parapet and coping with panels over the arch, and a steel fence running across the top and down along the retaining-walls terminating at the ends of the approach in a combination lamp and trolley pole on either side. In event of continuing the tunnel to the Seekonk River (City subway plan), the retaining walls at the east portal must be rebuilt.

The 75-ft. of tunnel arch adjoining the east portal which was excavated by the cut-and-cover method underlies Fones Alley, and therefore being subject to live-loads, was reinforced. There is no particular difficulty connected with reinforcing the arch of a subway or tunnel constructed by the cut-and-cover method, but where this is attempted underground the cost is considerably increased on account of the difficulty of shoveling concrete between the rods in more or less cramped quarters. The greater part of the excavation from the east approach and cut-and-cover portion of the tunnel was trammed down through the tunnel to the shaft. Until the heading was holed through, this material was teamed away for land filling a mile away near the Seekonk.

The last bench shot was fired on Feb. 27, and at that time, there still remained 300 ft. of sidewall to be excavated and concreted. The contract work, which included the construction of the tunnel complete to subgrade, ready for ties, rails and ballast, was practically finished April 1. Placing of ballast, track and overhead construction was begun by the Rhode Island Co., April 6. The rock ballast will have to be teamed from freight cars to a temporary wooden platform at the west approach from which it will be dumped into narrow-gage cars and hauled into the tunnel by a small electric locomotive. It is expected that about two months will be required for all this work and for connections to outside tracks, paving in city streets and in the approaches. Cars should run through by the first of June.

The contractor was Joseph McCabe, who was experienced in railway and tunnel construction in both East and West. A. D. McDonald was the Contractor's Superintendent on this work. The maximum engineering force, in addition to the Division Engineer, consisted of the Resident Engineer, W. H. Mulgrew, an instrument man, a rodman, a chainman and three inspectors. The estimated total cost, including property, will be about $700,000.

Rhode Island Public Transit Authority

265 Melrose Street
Providence, Rhode Island 02907

Pre Bid (Proposal) Meeting Sign-In Sheet

Date: **JULY 13. 2023**

BID # & PROPOSAL TITLE **RFP 23-34 Providence Bus Tunnel Drainage and Interior Rehabilitation**

Name of Representative	Company	Disadvantage Bus. Enterprise	Telephone Number
Alex Levey	R. Zoppo Corp.	N/A	[redacted]
FRED SARMENTO	D'AMBRA	N/A	[redacted]
BROOKE MICHALSKI	AETNA	N/A	[redacted]
ERIC OFFENBERG	WSP		[redacted]
Carl Nordstrom	Tower Construction		[redacted]
Ben Hyman	Bentley Builders		[redacted]
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