Washington State Department of Transportation

Memorandum

July 12, 2017

TO: H. Huynh
Northwest Region, NB82-117

FROM: T. M. Allen/C.J. Heathman
WSDOT Geotechnical Office, 47365

SUBJECT: I-5, MP 141.4 to 142.8, XL-4359
I-5/SR 161/SR 18 Interchange Improvements Stage 2
Conceptual Geotechnical Recommendations

Based on your request, this memorandum presents our conceptual geotechnical recommendations for the proposed retaining structures, bridge structure, embankment fills, and permanent cut slopes to be included in this project. A vicinity map illustrating the project location is presented in Figure 1.

The analyses, conclusions, and recommendations in this report are based upon borings conducted within the project corridor for this and earlier projects, published geologic information for the site and vicinity and our experience with similar geologic materials. The existing borings are assumed to be representative of the subsurface conditions throughout the project area. The current subsurface explorations may not be sufficient for final design. Additional subsurface explorations may need to be planned and conducted by the Design Builder to provide all of the subsurface data necessary for final design.

PROJECT DESCRIPTION

This project will add a new collector distributer (CD) line to southbound I-5 at the I-5/SR-161/SR-18 interchange. Major project elements include:

- New embankment fills and retaining walls along various portions of the roadway widening and new CD roadway alignment.
- A new bridge crossing SR-18 and associated on and off ramps adjacent to the existing southbound I-5 alignment.
- A new exit ramp off the CD line at S 356th in order to provide another access to SR-161 south of the SR-18 interchange. This exit ramp contains the only significant area of permanent slope cuts that will be constructed as part of the project.
- A new roundabout at the terminus of the new exit ramp, at the intersection of SR-161, S 356th St and 16th Ave. Retaining walls will be necessary at several of the approaches to the new roundabout.

SUBSURFACE EXPLORATION

A total of 28 drilled borings were performed specifically for the design of this project. The samples from those drilled borings were transported to the WSDOT HQ Materials Laboratory, where the material descriptions were revised based on further observation and laboratory testing on selected samples. Final logs and the detailed descriptions of the field exploration program and laboratory testing procedures are included in the Geotechnical Data Report for the project. Existing historical borings completed for other projects between 2008 and 2010 were also used to interpret the subsurface conditions. Final logs and a detailed description of the field exploration program and laboratory testing procedures for the existing historical borings are included in the geotechnical Reference Documents for the project. The approximate locations of the newer borings and historical borings are shown on Figure 2A through 2B.

GEOTECHNICAL RECOMMENDATIONS

Embankments

Embankment fills on the project with slope angles flatter than 1.8H:1V should be feasible without the use of geosynthetic reinforcement. Common Borrow can likely be used to construct embankments with slopes of 2H:1V or less. Embankments steeper than 2H:1V but less than or equal to 1.8H:1V will need to be constructed of quality material, such as Gravel Borrow, in order to reduce the potential for surface slope instability and erosion issues. Embankments steeper than 1.8H:1V may need to be constructed as reinforced slopes. For planning purposes, we anticipate that reinforcement lengths equal to approximately 70 percent of the overall slope height will be necessary.

Permanent Cut Slopes

The primary area where significant cuts are expected to occur is the new NS01 ramp exit alignment, which will provide the new access to S 356th Street. The subsurface conditions in this area were interpreted from borings H-87-08 and NW03-01-14. The locations of these borings are shown on Figure 2A. Based on the conditions observed in the borings, the subsurface conditions consist of dense to very dense sand and gravel. Groundwater is anticipated to be below the bottom of the proposed cuts. However, it is possible that pockets of perched groundwater may be present.

We performed a preliminary slope stability analysis to estimate the feasibility of cut slopes steeper than 2H:1V. Based on the results of that analysis, slopes up to 1.75H:1V are considered feasible and should not result in any long term maintenance issues. From a geotechnical standpoint, slopes steeper than 1.75H:1V may be feasible. However, careful consideration will need to be made during design regarding the proper surface erosion protection for the slopes, and whether or not a small amount of cohesion in the soil can be counted on long term. The evaluation of slopes steeper than 1.75H:1V will require additional subsurface exploration and laboratory testing to be performed by the design-builder.

Retaining Walls

Retaining walls are generally characterized in two categories: fill walls and cut walls. Fill walls will primarily be the type used on this project. The conceptual design for the project includes a total of 10 standalone retaining walls. The locations of the walls are shown on the Wall Vicinity Map, included as Figures 2A and 2B. We performed an assessment of the likely fill wall types that would be feasible for each wall based on the wall site data provided by the Project Office

and the subsurface conditions that were observed within the borings that were performed at or near the wall alignments.

Retaining Walls NS-04_W1, NS-04_W2, NS-04_E1, and NS-04_E2

Plan and profile views of walls NS-04_W1, NS-04_W2, NS-04_E1, and NS-04_E2 are presented on Figures 3A and 3B in Appendix A. The wall geometry is summarized in Table 1.

Table 1: Summary of Wall Geometry for NS-04_W1, NS-04_W2, NS-04_E1, and NS-04_E2

Wall Name	Maximum Exposed Height (ft)	Approximate Length (ft)
NS-04_W1	30	815
NS-04_W2	16	45
NS-04_E1	28	279
NS-04_E2	13	45

The subsurface conditions at these walls were explored with borings NS04-01-14, NS04-02-14, NS-04-04-14, NS04-05-14, NS04-07-14, NS04-08-14, and NS04-10-14. Based on the conditions observed in the borings, the subsurface conditions near the walls consist of 6 to 30 feet of loose to medium dense silty sand underlain by very dense silty sand and silty gravel. Based on measurements taken at the time of drilling, the groundwater is more than 40 feet below the current ground surface. The groundwater should not have an impact on the wall construction or the consideration of feasible wall types.

Due to the potential presence of loose near surface soils, we consider preapproved proprietary structural earth walls and Standard Plan geosynthetic walls to be the most likely wall types to be used. These wall types should be able to accommodate the amount of settlement that may occur, and should not require any overexcavation and replacement of the subgrade soils to meet the requirements for bearing capacity, sliding, and overturning.

However, the current locations of walls NS-04_W1 and NS-04_E1 do not meet the requirement in the WSDOT Geotechnical Design Manual for back-to-back MSE walls to have a minimum face-to-face dimension of 1.1 times the average wall height. The retaining walls are located where they are because there are constraints on both sides. It is our understanding that the location of wall NS-04_W1 cannot be moved any further outward. Wall NS-04_E1 is constrained on the east side by the existing bridge alignment. One alternative to meet the back-to-back requirement could be to use a tiered wall system for retaining wall NS-04_E1, shifting the lower portion of the wall outward and located under the existing bridge between the bridge piers. This would only need to be done for a portion of wall NS-04E1 alignment where the back-to-back walls are near their tallest height. The lower wall will need to be designed to have enough clearance below the existing bridge to be able to construct and compact the wall backfill.

Retaining Walls LW_W and NS01_W

Plan and profile views of walls LW_W and NS01_W are presented on Figures 3C and 3D in Appendix A. The wall geometry is summarized in Table 2.

Table 2: Summary of Wall Geometry for LW_W and NS01_W

Wall Name	Maximum Exposed Height (ft)	Approximate Length (ft)
LW_W	5	1,935
NS-01_W	2	110

The subsurface conditions at wall LW_W were explored with borings RS-1p-14, RS-2p-14, RS-3p-14, RS-4p-14, RS-5p-14, RS-6p-14, and RS-7-14, and RS-8-14. The borings indicate that the subsurface conditions along the wall profile consist of approximately 15 to 20 feet of mostly medium dense to very dense sand and gravel underlain by very dense sand and gravel. Occasional layers of loose sand approximately 5 feet in thickness are present within the upper 20 feet. Measurements of the groundwater level indicate that that any water that might be present is far enough below the bottom of the wall that it should not affect the wall design or construction.

Wall LW_W crosses over existing drainage pipes at various locations. Based on conversations with the Project Office, we understand that the drainage pipes may need to be replaced as part of the project to accommodate higher flows, and it is anticipated that the profile of the new pipes will be able to be adjusted to accommodate most wall types. There is an adjacent creek near the base of the existing embankment slope. We understand that the creek has a low flow rate and has maintained its current channel for a very long time without migrating and scouring away the adjacent embankment. Therefore, it should be feasible to locate the bottom of the wall for only 2 feet of embedment, consistent with the geometry shown on the current set of conceptual plans. However, a more thorough scour analysis will be necessary during the final design to determine the impact, if any, on the location and depth of embedment for the wall.

Due to the potential presence of occasional loose layers of sand in the upper 15 feet below the ground surface, we consider preapproved proprietary welded wire structural earth walls and Standard Plan geosynthetic walls to be the most likely wall types to be used for wall LW_W. These wall types should be able to accommodate the amount of settlement that may occur, and should not require any overexcavation and replacement of the subgrade soils to meet the requirements for bearing capacity, sliding, and overturning. Standard Plan reinforced concrete walls are also considered feasible, provided that a minimum of 2 feet of overexcavation and replacement can be performed.

The subsurface conditions at wall NS01_W were interpreted from existing boring H-109-09, which was completed as part of the design of a previous project. Boring H-109-09 indicates that the subsurface conditions along the wall profile consist of very dense sand and gravel starting from the current ground surface. Measurements of the groundwater level taken at the time of drilling indicate that the groundwater is greater than 20 feet below the current ground surface and should not affect the wall design or construction.

Based on the conditions observed in boring H-109-09, we consider preapproved proprietary structural earth walls, Standard Plan geosynthetic walls, and Standard Plan reinforced concrete

walls to be the most likely wall types to be used for wall NS-01_W. Gravity block walls are also considered feasible as long as they meet the aesthetic requirements of the Project. These wall types should be able to accommodate the amount of settlement that may occur, and should not have any issues to meet the requirements for bearing capacity, sliding, and overturning.

Retaining Walls R-SW_W1, R-SW_W2, R-SW_E1, and R-SW_E2

Plan and profile views of walls R-SW_W1, R-SW_W2, R-SW_E1, and R-SW_E2 are presented on Figures 3E and 3F. The wall geometry is summarized in Table 3.

Table 3: Summary of Wall Geometry for NS-04_W1, NS-04_W2, NS-04_E1, and NS-04_E2

Wall Name	Maximum Exposed Height (ft)	Approximate Length (ft)
R-SW_W1	5	94
R-SW_W2	13	435
R-SW-E1	10	289
R-SW_E2	14	403

The subsurface conditions at these walls were explored with borings RSW-1-16, RSW-2-16, RSW-3-16, and RSW-4-16. The borings indicate that the subsurface conditions near the walls consist of up to 10 feet of loose to medium dense sand underlain by very dense sand and gravel. Measurements of the groundwater level taken at the time of drilling indicate that the groundwater is greater than 20 feet below the current ground surface. The groundwater should not have an impact on the wall construction or the consideration of feasible wall types.

Due to the potential presence of loose to medium dense near surface soils, we consider preapproved proprietary structural earth walls, Standard Plan geosynthetic walls, and cantilever soldier pile walls to be the most likely wall types to be used. These wall types should be able to accommodate the amount of settlement that may occur, and should not require any overexcavation and replacement of the subgrade soils to meet the requirements for bearing capacity, sliding, and overturning.

Standard plan Geosynthetic walls are considered feasible for Wall R-SW_E2. From approximately station 11+50 to 12+75 the curvature of the wall may require that additional geosynthetic material be used to maintain 100% reinforcing coverage. Due to the presence of an existing wall along SR-161 which the new wall will need to tie into, shoring perpendicular to the wall face may be necessary where the two walls meet so that the new Geosynthetic wall can be constructed without disturbing the existing wall and its backfill. Alternatively, a short section of cantilever soldier pile wall could be incorporated into Wall R-SW_E2 so that the excavation for the geosynthetic reinforcement occurs far enough away from the existing wall so that it does not conflict with the existing wall.

NS-04 Bridge

The subsurface conditions at the NS-04 bridge were interpreted from borings H-58p-08, H-59-08, NS04-03-14, NS04-04-14, NS04-05-14, NS04-08-14, NS04-09-14. A plan view showing the boring locations is included as Figures 4A through 4C. A bridge profile view with the boring logs is included as Figures 5A through 5C. The borings indicate that the subsurface conditions

consist of mostly loose to medium dense silty sand to a depth of 14 to 30 feet underlain by very dense silty sand and silty gravel. Groundwater measurements taken in several of the borings indicate that the groundwater is in the range of 35 to 70 feet below the current ground surface.

Due to the potential presence of up to 30 feet of loose to medium dense soils, we consider drilled shafts to be a feasible bridge foundation alternative. The bridge abutments will likely consist of multiple drilled shafts with a diameter of 6 to 7 feet connected together by a shaft cap. The interior piers will likely consist of a single shaft with a diameter of 8 to 10 feet integrally connected to the bridge pier columns. The shafts will likely be in the range of 60 to 80 feet in length. Depending on structure width, multiple columns may be necessary.

INTENDED USE AND LIMITATIONS

This report has been prepared to assist the I-5/SR 161/SR 18 Interchange Improvements Stage 2 project team in preparing the RFP documentation for this project. It should not be used,in part or in whole for other purposes without contacting the WSDOT Geotechnical Office for a review of the applicability of such reuse.

Additional subsurface explorations will need to be performed by the Design-Builder to obtain sufficient subsurface information for the final design. Some of the existing borings used to develop our recommendations were drilled prior to construction of the existing roadway, embankments and bridges. The process of roadway, embankment and bridge construction can significantly change the nature of subsurface materials. Furthermore, in some instances for this conceptual design report, assumptions regarding subsurface conditions were based on borings which were drilled some distance away from the proposed roadway, embankment and bridge construction.

If you have questions or require further information, please contact Tony Allen at (360) 709-5450 or Chris Heathman at (360) 709-5592.

TMA/cjh

CJH

cc: T. La Bolle, NW Region, NB82-117
B. Khaleghi, HQ Bridge and Structures, MS 47340

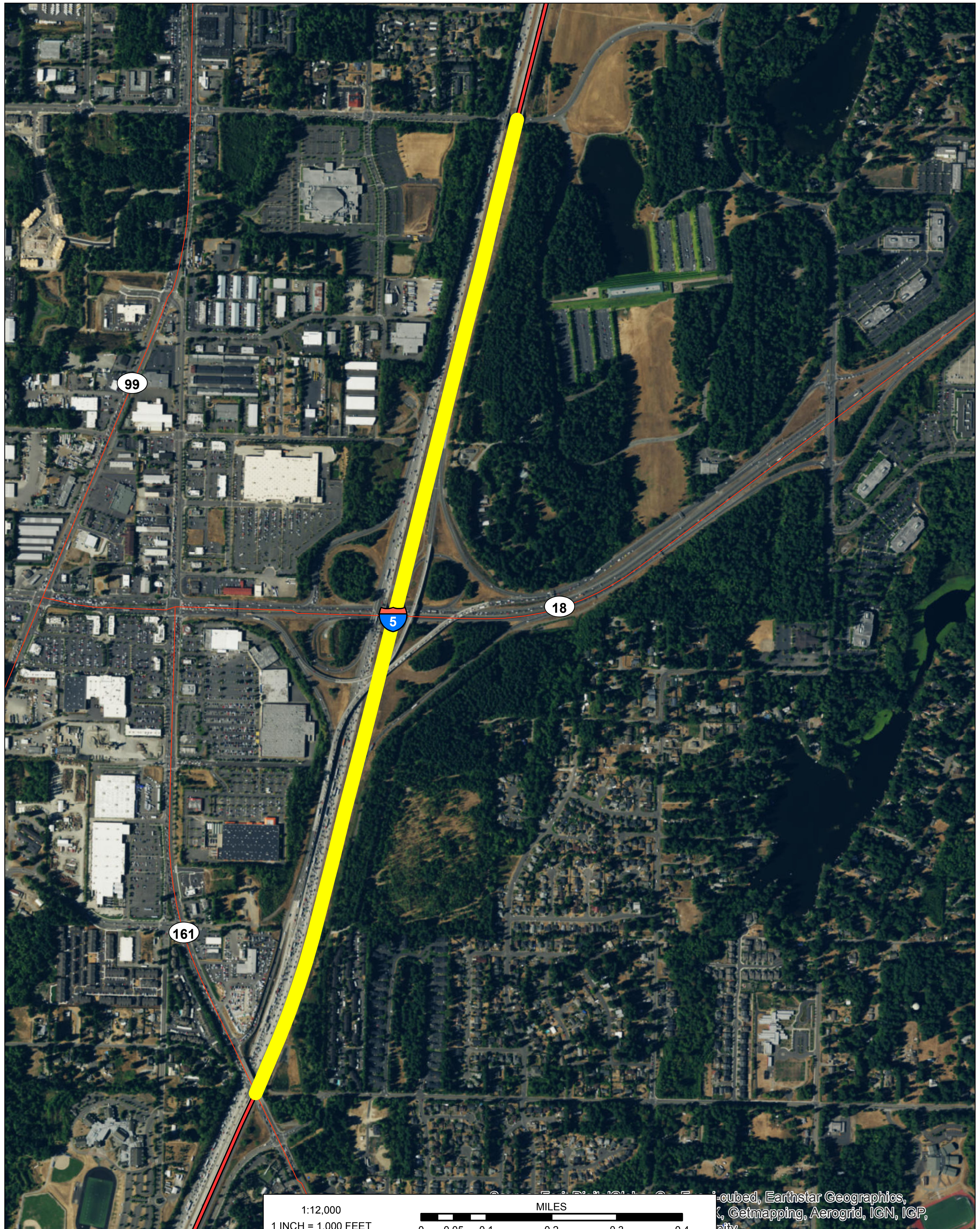
Attachments

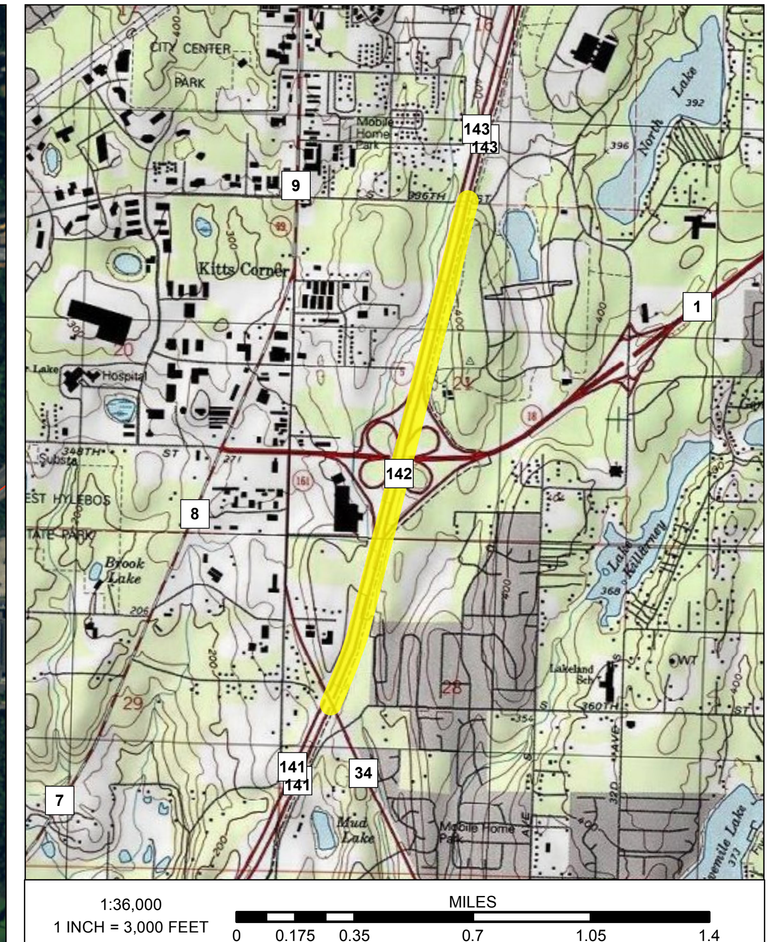
7/12/2017

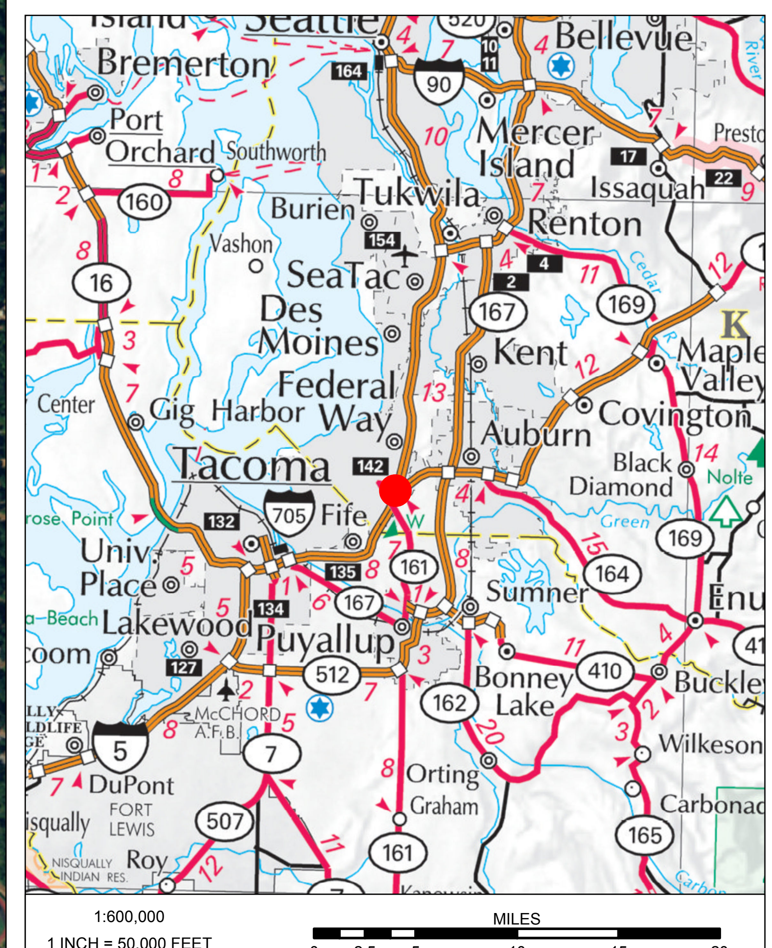
Prepared By: Christopher J. Heathman P.E.
Senior Foundation Engineer

Reviewed By: James G. Cuthbertson P.E.
Chief Foundation Engineer

Agency Approval: Tony M. Allen, P.E.
State Geotechnical Engineer



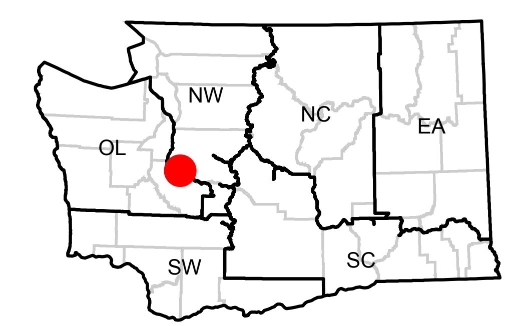




LEGEND

- Site
- Site Location
- U.S. Interstate
- State Route
- WSDOT Regions
- County Boundaries (1:500K)

N



JOB # XL-4359 **STATE ROUTE** 5 **MILEPOST** 141.40 to 142.80

FIGURE 1: SITE VICINITY

I-5/SR 161/SR 18
Interchange Improvements
Stage2

Washington State Department of Transportation
GEOTECHNICAL OFFICE

PREPARED BY Tracy Trople **DATE** June 24, 2016

File Location: M:\GEOGIS\Projects\SR-005\SR5-XL4359-IntersectionImprovement\Projects

H-1-16 WSDOT TEST BORING LOCATION

RS-1p-14 WSDOT PIEZOMETER LOCATION

0 100 200

SCALE IN FEET

JOB# XL-4359 **STATE ROUTE** 5/18/161 **MILEPOST(S)** 141.4-142.8

FIGURE 2A: WALL VICINITY MAP

I-5/SR161/SR18 INTERCHARGE IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

File Location: I:\XL-4359 I-5 Triangle Stage 2\New 6-21-16\XL4359 WSD Plan1.dgn

H-1-16 WSDOT TEST BORING LOCATION

RS-1p-14 WSDOT PIEZOMETER LOCATION

0 100 200
SCALE IN FEET

JOB# XL-4359	STATE ROUTE 5/18/161	MILEPOST(S) 141.4-142.8

FIGURE 2B:
WALL VICINITY MAP

I-5/SR161/SR18 INTERCHARGE IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery DATE June, 2017

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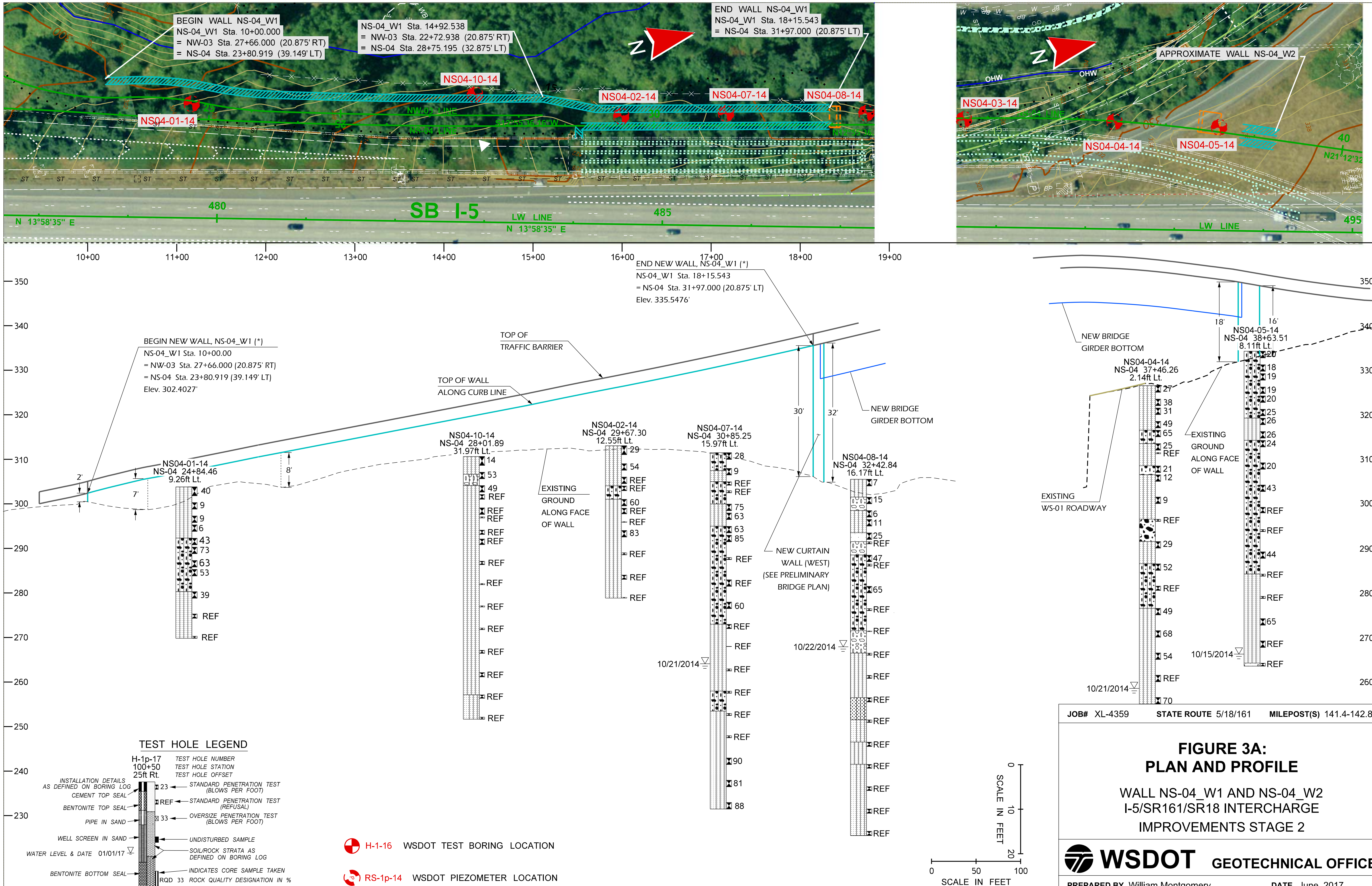

JOB# XL-4359 **STATE ROUTE** 5/18/161 **MILEPOST(S)** 141.4-142.8

FIGURE 3A:
PLAN AND PROFILE

WALL NS-04_W1 AND NS-04_W2
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

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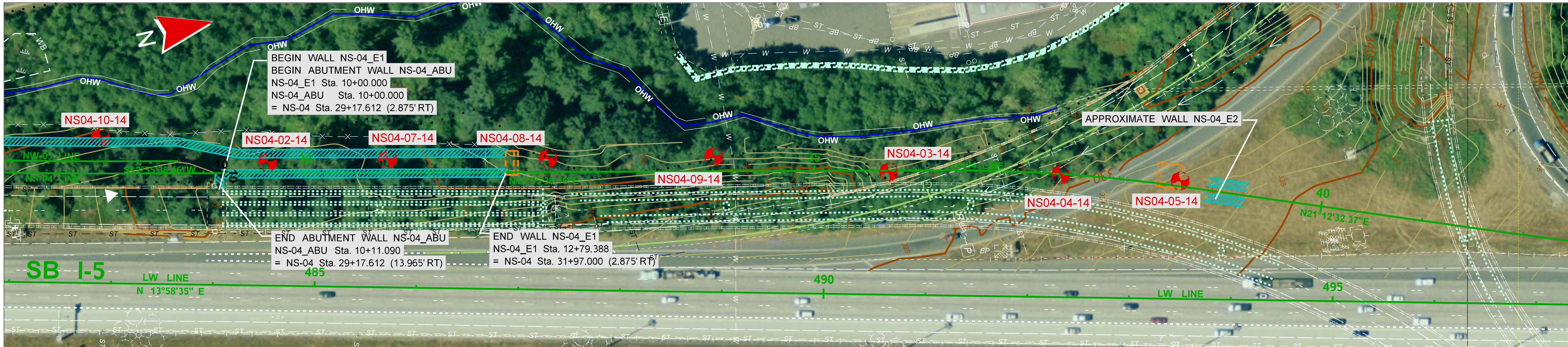

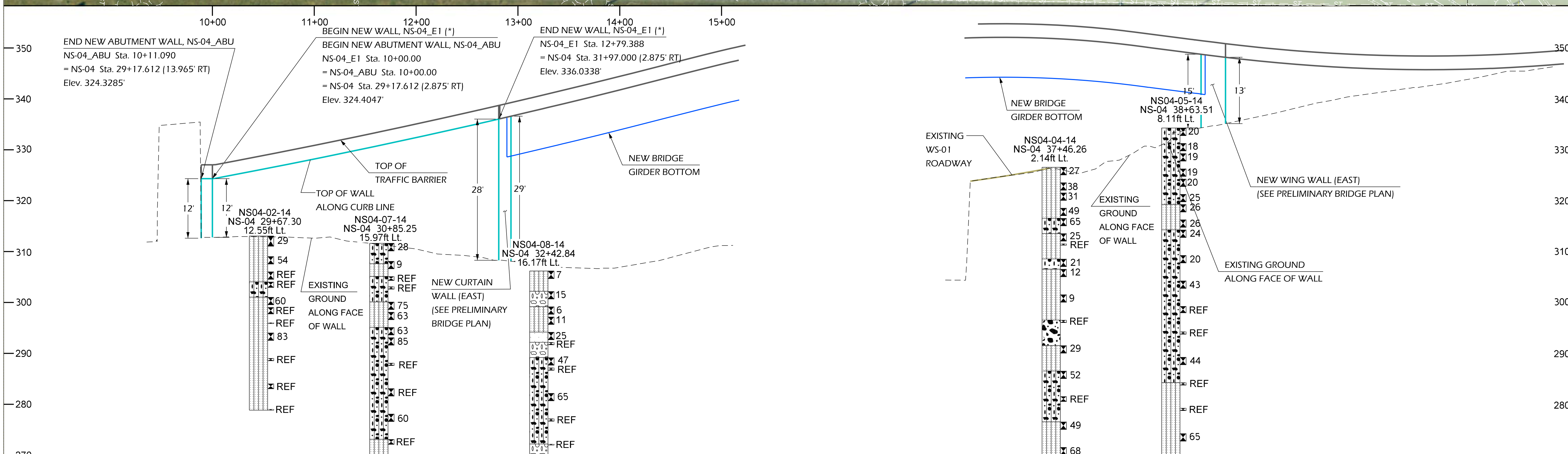

JOB# XL-4359	STATE ROUTE 5/18/161	MILEPOST(S) 141.4-142.8

FIGURE 3B:
PLAN AND PROFILE

WALL NS-04_E1 AND NS-04_E2
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery DATE June, 2017

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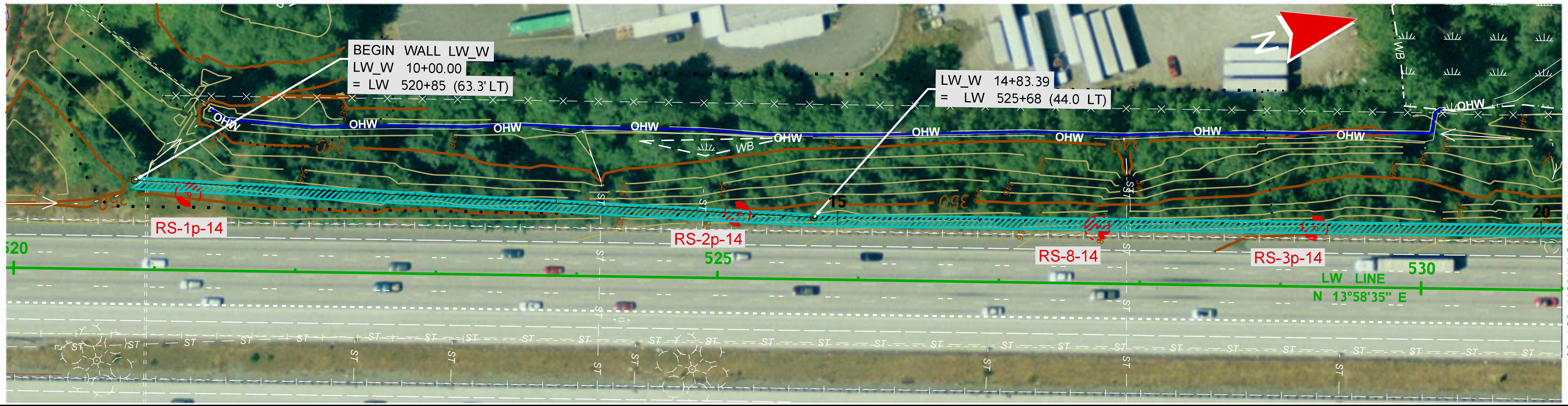

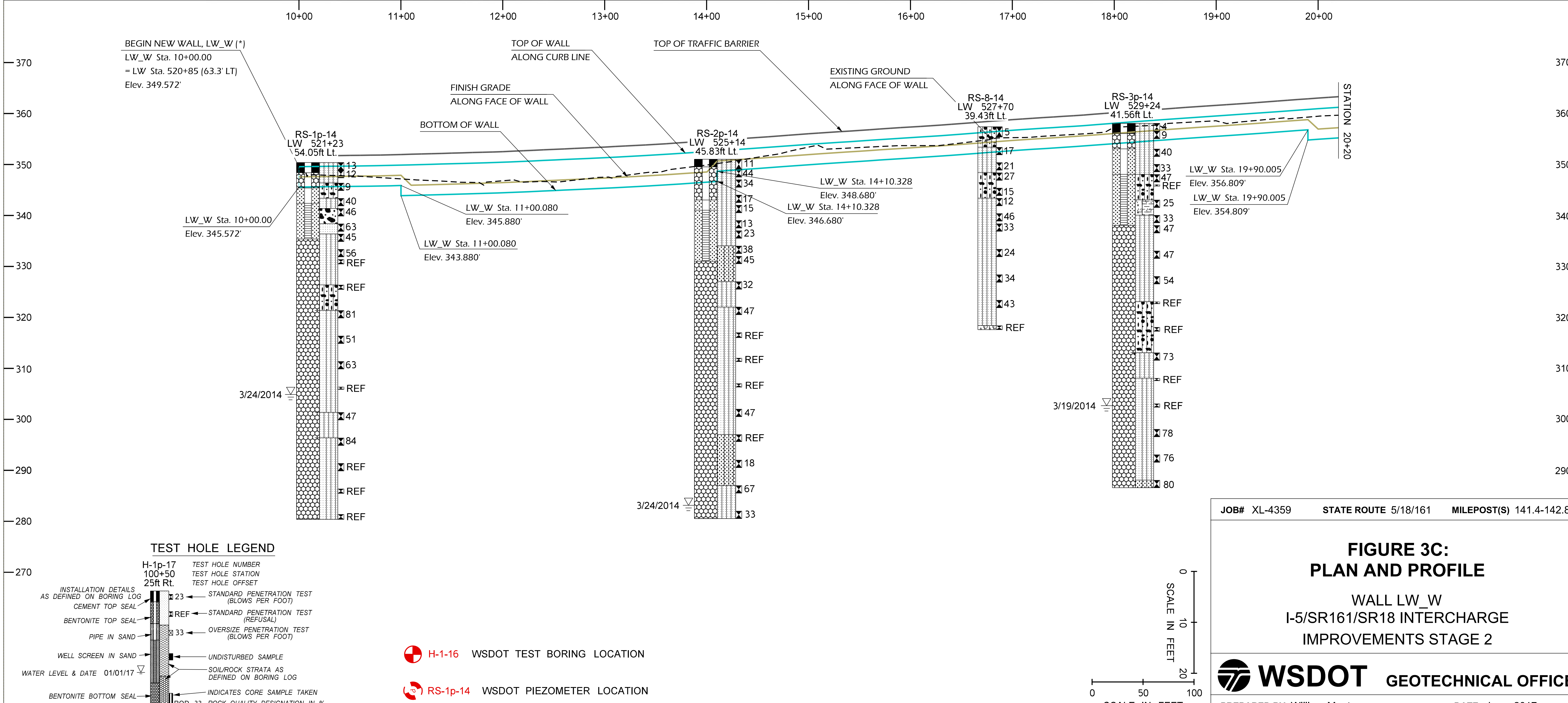

JOB# XL-4359 **STATE ROUTE** 5/18/161 **MILEPOST(S)** 141.4-142.8

FIGURE 3C: PLAN AND PROFILE

WALL LW_W
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

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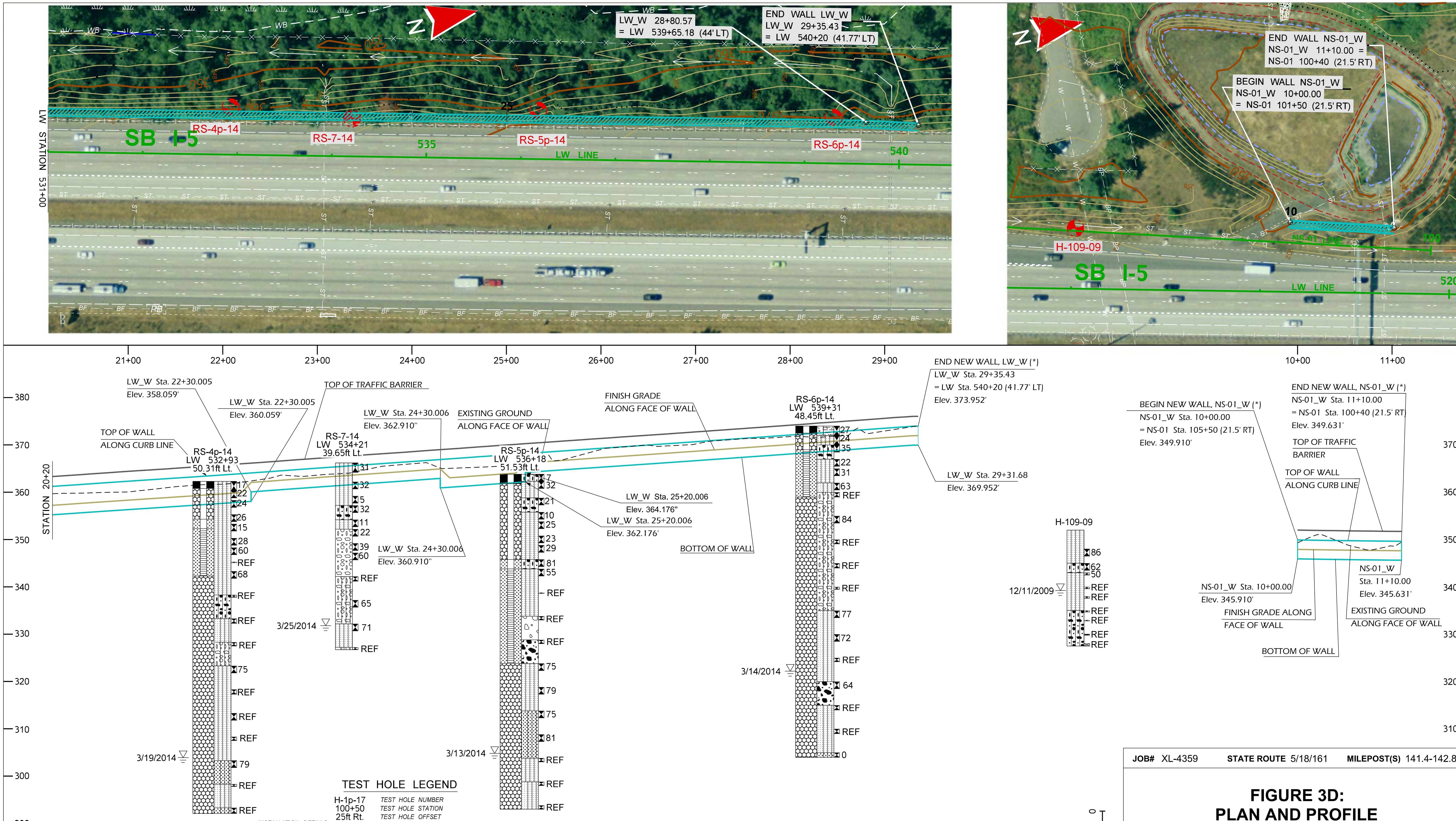

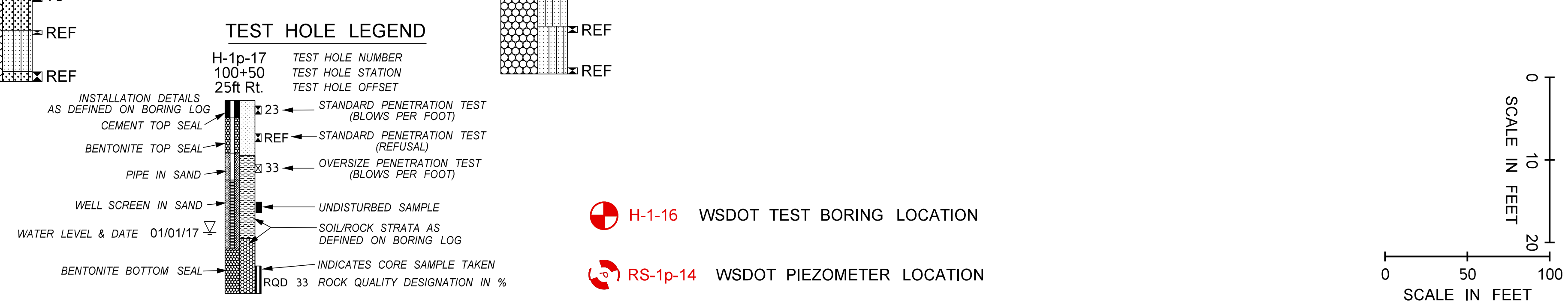

JOB# XL-4359	**STATE ROUTE** 5/18/161	**MILEPOST(S)** 141.4-142.8

FIGURE 3D: PLAN AND PROFILE

WALL LW_W AND NS-01_W
I-5/SR161/SR18 INTERCHANGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

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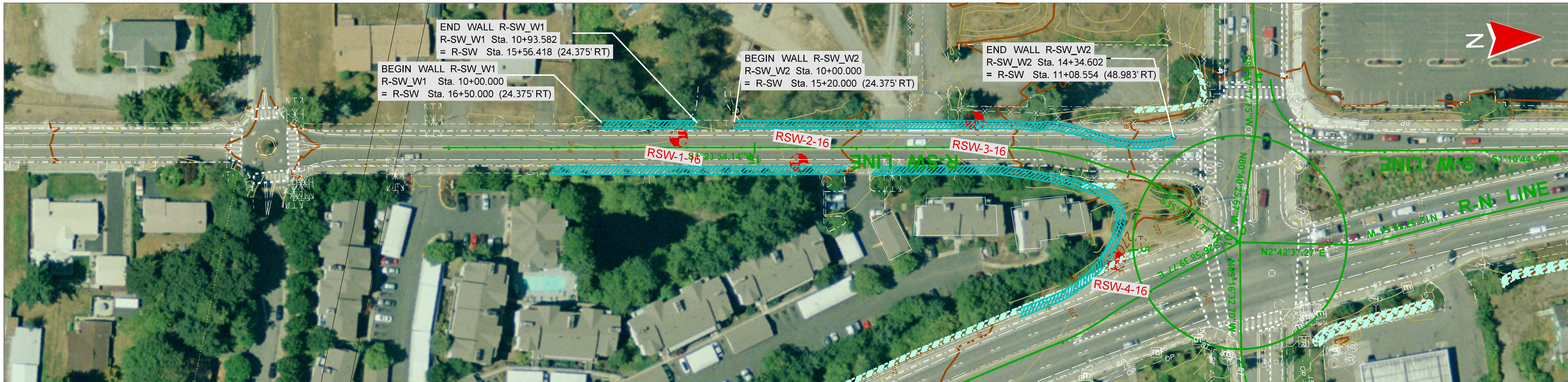

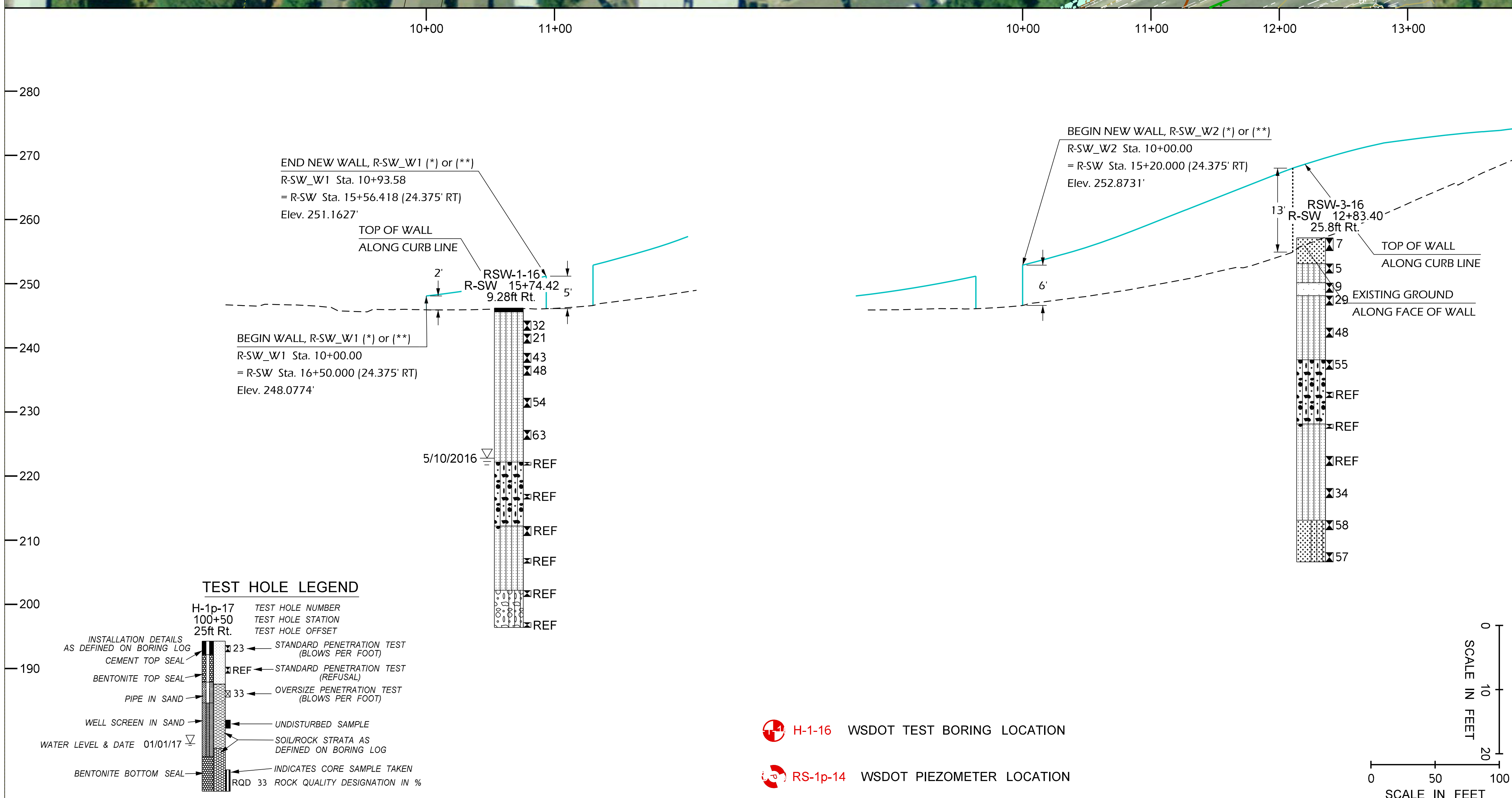

JOB# XL-4359 **STATE ROUTE** 5/18/161 **MILEPOST(S)** 141.4-142.8

FIGURE 3E: PLAN AND PROFILE

WALL R-SW_W1 AND R-SW_W2
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

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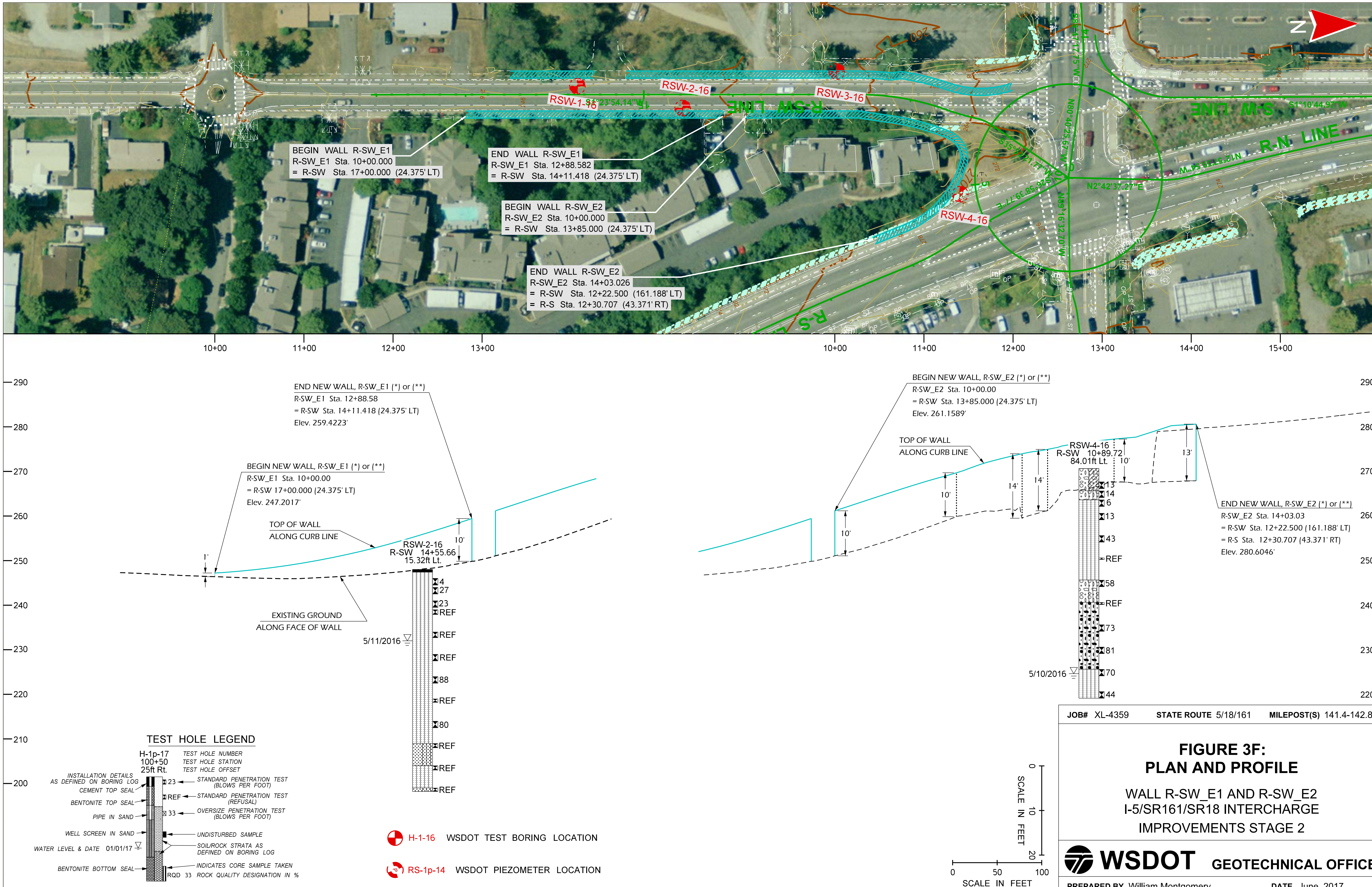

JOB# XL-4359 **STATE ROUTE** 5/18/161 **MILEPOST(S)** 141.4-142.8

FIGURE 3F: PLAN AND PROFILE

WALL R-SW_E1 AND R-SW_E2
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

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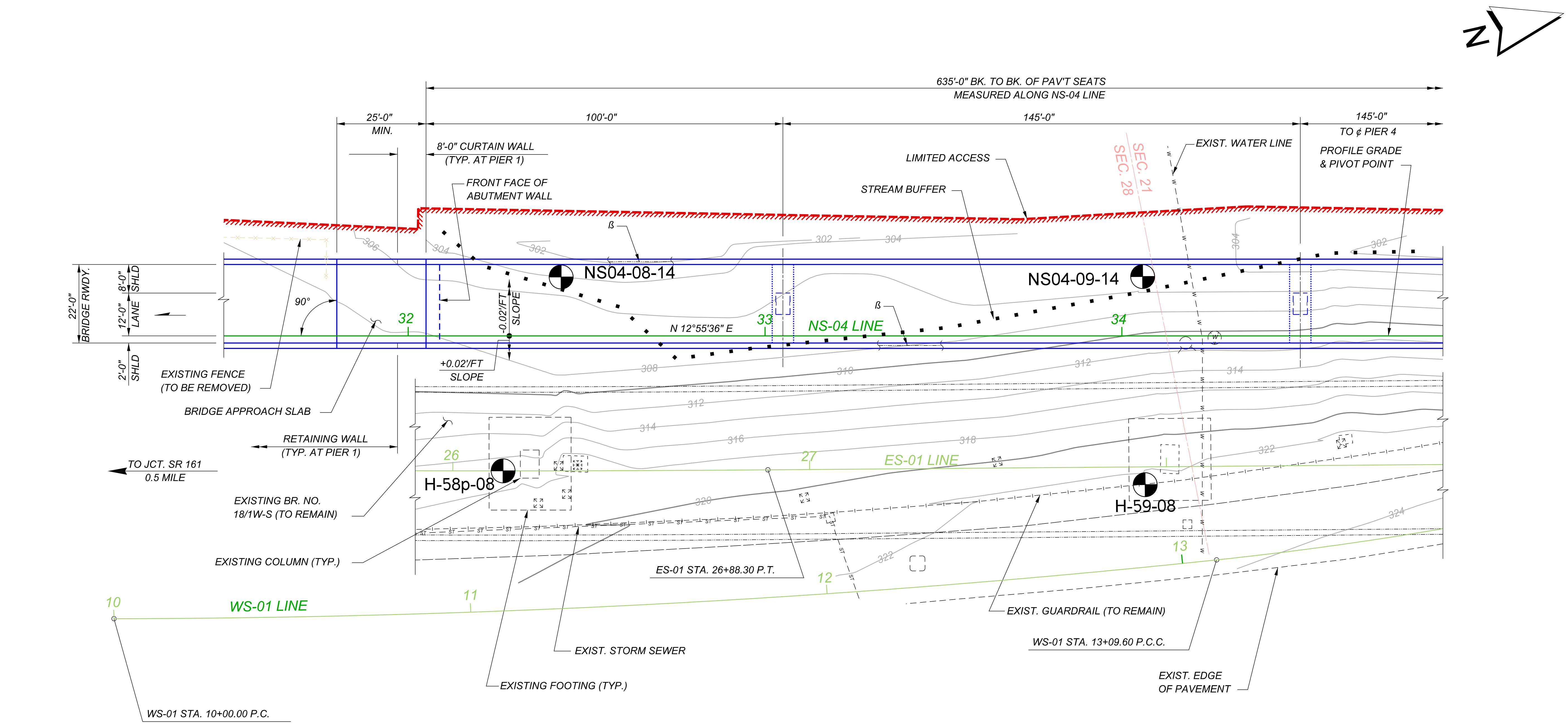

NOTE:
ALL EXISTING UTILITY LINES SHALL REMAIN UNLESS OTHERWISE NOTED.

H-1-14 TEST BORING LOCATION

JOB# XL-4359 **STATE ROUTE** 5/161/18 **MILEPOST(S)** 141.4-142.8

FIGURE 4A: BRIDGE PLAN VIEW

NS-04 BRIDGE
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

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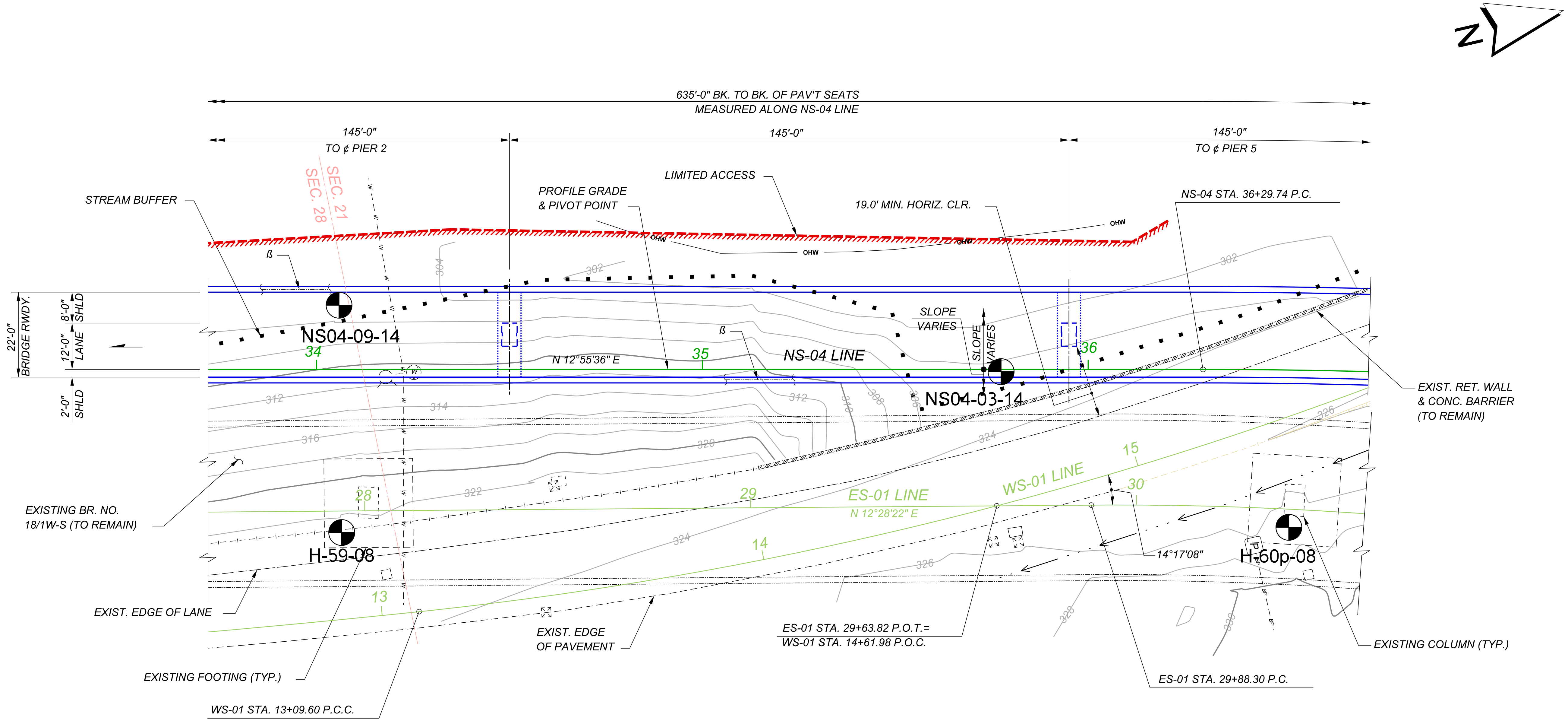

0 15 30
SCALE IN FEET

JOB# XL-4359 **STATE ROUTE** 5/161/18 **MILEPOST(S)** 141.4-142.8

FIGURE 4B: BRIDGE PLAN VIEW

NS-04 BRIDGE
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT **GEOTECHNICAL OFFICE**

PREPARED BY William Montgomery **DATE** June, 2017

NOTE:
ALL EXISTING UTILITY
LINES SHALL REMAIN
UNLESS OTHERWISE NOTED.

H-1-14 TEST BORING LOCATION

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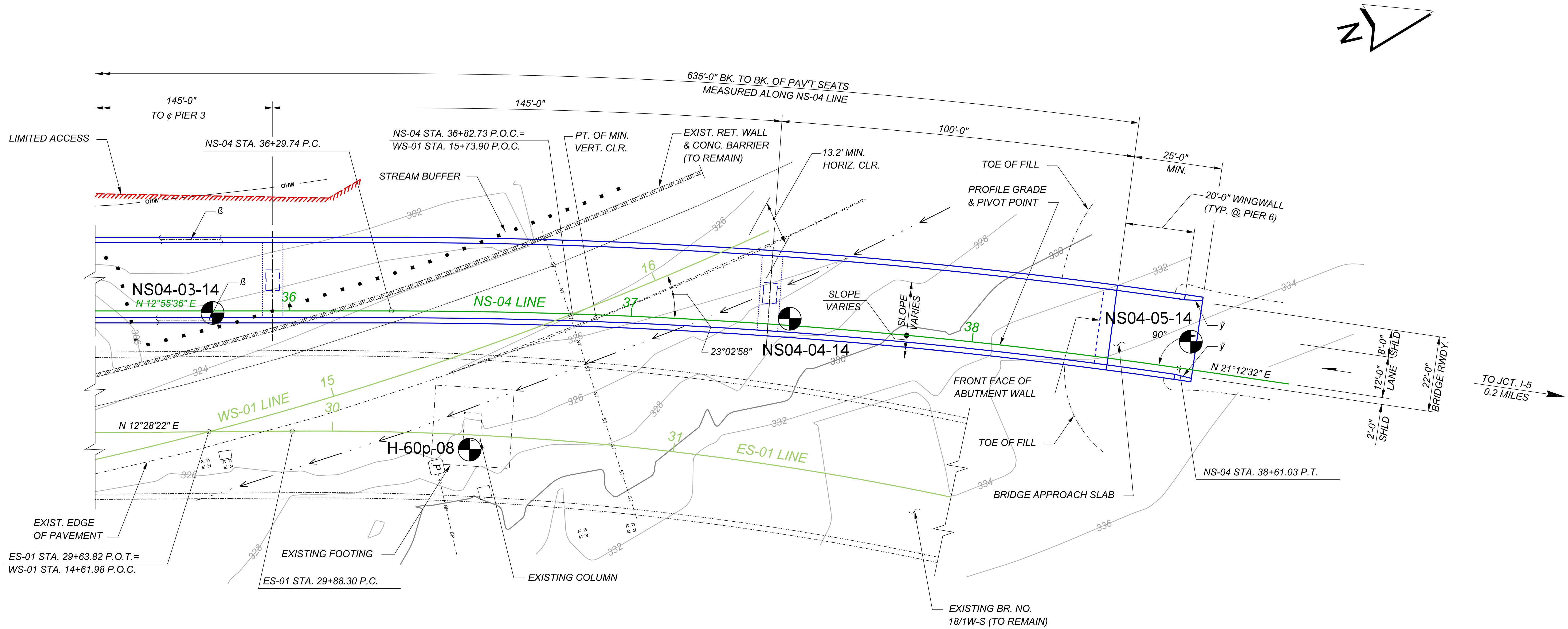

H-1-14 TEST BORING LOCATION

0 15 30
SCALE IN FEET

JOB# XL-4359	**STATE ROUTE** 5/161/18	**MILEPOST(S)** 141.4-142.8

FIGURE 4C:
BRIDGE PLAN VIEW

NS-04 BRIDGE
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

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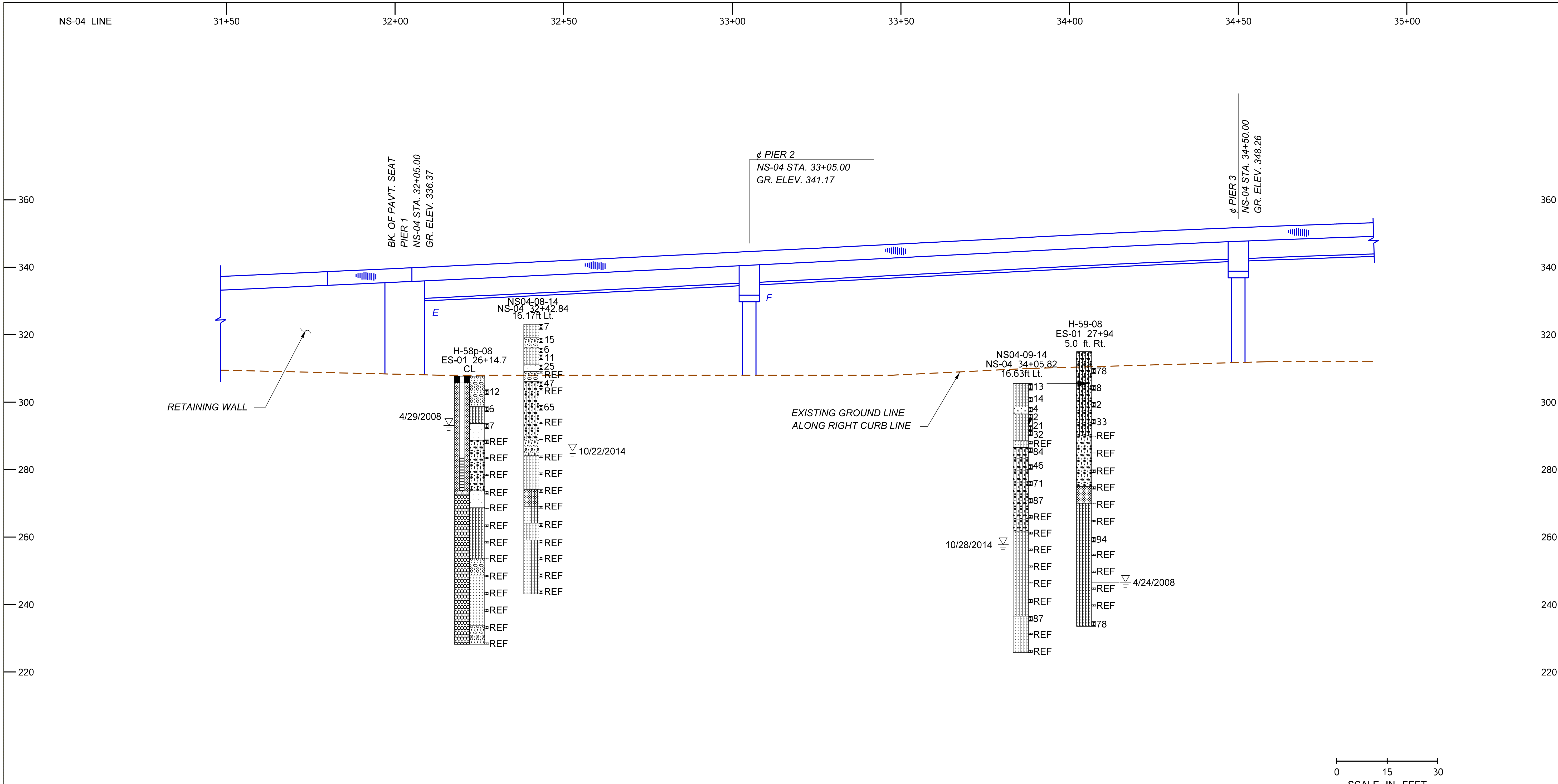
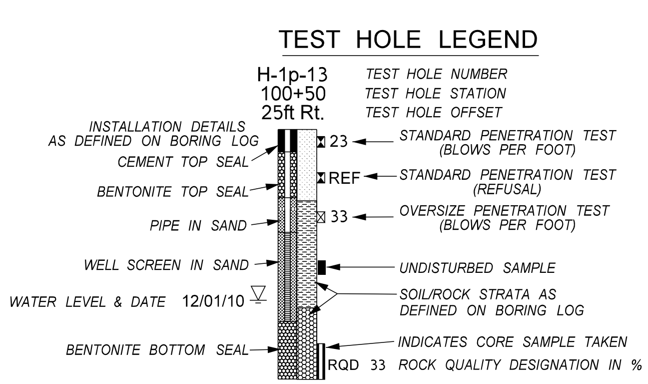




JOB# XL-4359	**STATE ROUTE** 5/161/18	**MILEPOST(S)** 141.4-142.8

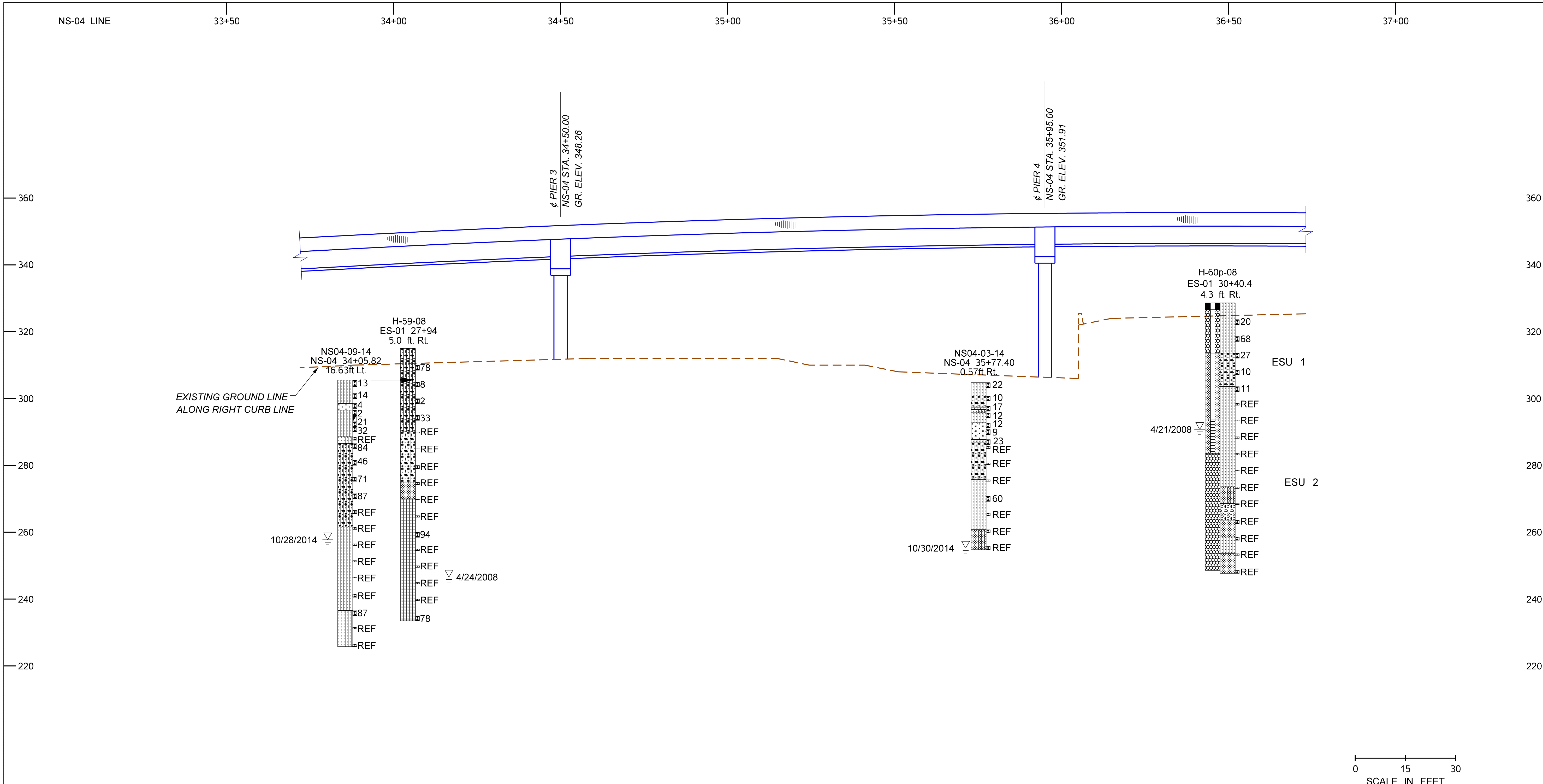
FIGURE 5A: BRIDGE PROFILE VIEW

NS-04 BRIDGE
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

File Location: I:\XL-4359 I-5 Triangle Stage 2\New Bridge 6-21-16\NS-04 LAYOUT 1.dgn



TEST HOLE LEGEND

H-1p-13	TEST HOLE NUMBER
100+50	TEST HOLE STATION
25ft Rt.	TEST HOLE OFFSET

- INSTALLATION DETAILS AS DEFINED ON BORING LOG
- CEMENT TOP SEAL
- BENTONITE TOP SEAL
- PIPE IN SAND
- WELL SCREEN IN SAND
- WATER LEVEL & DATE 12/01/10
- BENTONITE BOTTOM SEAL
- 23 — STANDARD PENETRATION TEST (BLOWS PER FOOT)
- REF — STANDARD PENETRATION TEST (REFUSAL)
- 33 — OVERSIZE PENETRATION TEST (BLOWS PER FOOT)
- UNDISTURBED SAMPLE
- SOIL/ROCK STRATA AS DEFINED ON BORING LOG
- INDICATES CORE SAMPLE TAKEN
- RQD 33 — ROCK QUALITY DESIGNATION IN %

JOB# XL-4359 **STATE ROUTE** 5/161/18 **MILEPOST(S)** 141.4-142.8

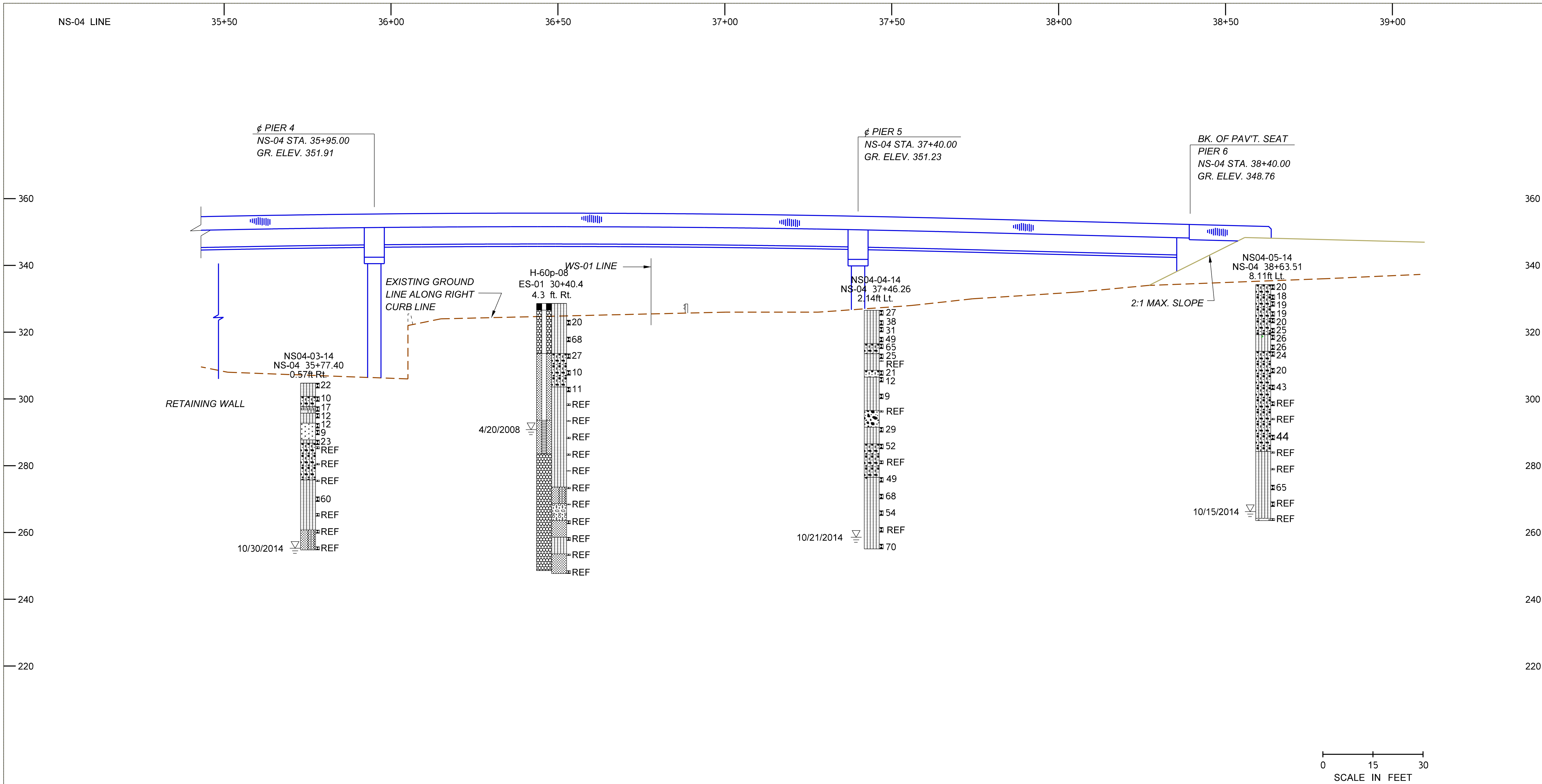
FIGURE 5B: BRIDGE PROFILE VIEW

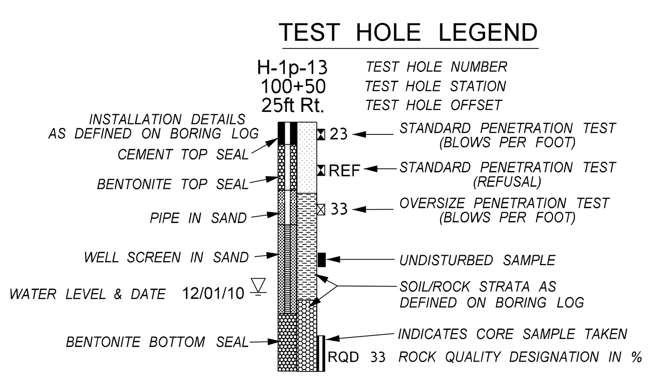
NS-04 BRIDGE
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

File Location: I:\XL-4359 I-5 Triangle Stage 2\New Bridge 6-21-16\NS-04 LAYOUT 2.dgn





JOB# XL-4359 **STATE ROUTE** 5/161/18 **MILEPOST(S)** 141.4-142.8

FIGURE 5C: BRIDGE PROFILE VIEW

NS-04 BRIDGE
I-5/SR161/SR18 INTERCHARGE
IMPROVEMENTS STAGE 2

WSDOT GEOTECHNICAL OFFICE

PREPARED BY William Montgomery **DATE** June, 2017

File Location: I:\XL-4359 I-5 Triangle Stage 2\New Bridge 6-21-16\NS-04 LAYOUT 3.dgn