Appendix 5

Bridge Type Selection Study

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Henderson Interchange Feasibility Study
Bridge Type Selection Study

1. Introduction

This report summarizes findings of the bridge type selection study for the Henderson Interchange (I-515/I-215/I-11) Feasibility Study project in Henderson, Nevada. Two interchange layout alternatives were considered as part of this project with each alternative consisting of approximately ten bridges each. In order to provide a cost-effective type selection study, only five bridges are included in this report. Two representative bridges were evaluated for Option 1- Expanded Existing Configuration including the "NW" Ramp and the "NBCD" Ramp. Three representative bridges were evaluated for the Option 2- Diverging Diamond Interchange consisting of the "WN" Bridge over UPRR, the "SW" Bridge over UPRR, and the I-515 South Crossover Bridge.

A design criteria summary and cost estimate are also provided as part of this report. The design criteria summary will document applicable loads to the bridge. The cost estimate provided only includes construction costs of the bridges and are based on a unit cost per square foot of deck area.

2. Project Purpose and Need

Due to the extraordinary growth in the Las Vegas area, the existing Henderson interchange has exceeded its design capacity in only the 15 plus years it has been in service. There are issues with traffic congestion, weaving, delays, and traffic accidents in the interchange. To relieve these issues and meet additional projected traffic demands, improvements to the interchange, including the new bridges and widenings, are needed. The bridge configurations and superstructure types presented herein provide a reasonable basis for developing preliminary interchange geometry and planning level cost estimates. Table 1 is a summary of the 5 bridges investigated for the two alternatives.

Table 1

Summary of Recommended Configurations and Types

Bridge Description	Proposed Improvement	Bridge Configuration and Type
"NW" Ramp Flyover Bridge	New	9-Span CIP PT Box Girder *
"NBCD" Ramp Flyover Bridge	New	8-Span CIP PT Box Girder *
"WN" Bridge over UPRR	New	Single Span CIP PT Box Girder *
"SW" Bridge over UPRR	New	3-Span Steel Plate I-Girder
I-515 South Crossover Bridge	New	Single Span PC/PS Bulb Tee Girder **

* CIP PT = Cast-in-place concrete, post-tensioned
** PC/PS = Precast-prestressed

3. Type, Selection and Layout Discussion and Recommendations

3.1 Option 1- Expanding Existing Configuration

"NW" Ramp Flyover Bridge

A new flyover structure is proposed to replace the existing ramp bridge (I-2110). The existing bridge is comprised of composite steel I-girders and was built in 2003. It consists of 12 spans with a total length of approximately 1673'. It is a single 12' lane bridge with 12' and 8' shoulders. Since the existing bridge is a flyover structure with single column piers it is not feasible to widen. The only practical way to add capacity to the north to west movement is to replace the existing ramp bridge.

The proposed replacement bridge is a 9 span structure with a total length of 1525'. The longest span is 205'. The proposed structure type is cast-in-place post-tensioned concrete box girders with a structure depth of 8'-6" and a depth to span ratio of 0.0415. The overall width varies from 39' to 45'-2 3/8" and accommodates two 12' lanes, 8' outside shoulder, a varying inside shoulder with a minimum width of 4' and two 1'-6" barrier rails. This new proposed bridge width will increase capacity and meet future traffic projections.

An alternative to the post-tensioned concrete box girder would be composite steel I-girders. The biggest advantage to using the steel girders would be a faster construction time and less impact to maintenance of traffic (MOT). However, the steel girder alternative would result in a significantly higher cost.

A significant amount of falsework and shoring will be required to construct the post-tensioned concrete box girders. The roadway profile will need to be set to maintain the required 16' temporary clearance for traffic below the falsework and shoring. Although more falsework and shoring make the MOT and construction of the post-tensioned concrete box girders a little more complicated, it is the most common structure type and has the lowest cost for construction and maintenance of all the bridge types in Nevada making it the preferred alternative.

The Nevada Department of Transportation selected Post-tensioned concrete box girders for similar flyover bridges on both the US-95/CC-215 and I-15/US-95 Interchange projects currently underway.

The proposed abutments are seat type and founded on spread footings. The interior supports are integral pier caps at the fixed piers and drop cap at the expansion piers. They are supported on 8' diameter single columns founded on 10' diameter over-sized drilled shafts. During final design, spread footings may be considered for the piers but limited space will most likely preclude the use of spread footings regardless of soil conditions at the site.

"NBCD" Ramp Flyover Bridge

A new flyover structure is proposed to replace the existing "EN" ramp bridge (I-2109). The existing bridge is comprised of composite steel I-girders and was built in 2003. It consists of 15 spans for a total length of approximately 2501.5'. It is a single 12' lane bridge with 12' and 8' shoulders that was recently restriped to carry two travel lanes to provide additional capacity. Since the existing bridge is a flyover structure with single column piers it is not feasible to widen. The only practical way to add capacity to the east to north movement is to replace the existing ramp bridge.

The proposed replacement bridge for this portion of the ramp is an 8-span structure with a total length of 1460'. The longest span is 232'. The proposed structure type is cast-in-place post-tensioned concrete box girders with a structure depth of 9'-5" and a depth to span ratio of 0.0406. The overall width of 63' accommodates three 12' lanes, 12' shoulders and two 1'-6" barrier rails. This new proposed width will increase capacity considerably and meet future traffic projections.

An alternative to the post-tensioned concrete box girder would be composite steel I-girders resulting in faster construction time and less impact to MOT. However, the steel girder alternative would result in a significantly higher cost.

Although construction of the post-tensioned concrete box girders is more complicated as previously mentioned, it is the most common structure type and has the lowest cost for construction and maintenance making it the preferred alternative.

The proposed abutments are seat type and founded on spread footings. The interior supports are integral pier caps at the fixed piers and drop cap at the expansion piers. Since this is a third level structure, column heights will get very tall resulting in a larger column diameter. The 10' diameter single columns are founded on 12' diameter over-sized drilled shafts. During final design, spread footings may be considered for the piers but limited space will most likely preclude the use of spread footings regardless of soil conditions at the site.

3.2 Option 2- Diverging Diamond Interchange

"WN" Bridge over UPRR

A new structure is proposed to accommodate the "WN" ramp over UPRR. Since the "EN" ramp will be relocated for this interchange configuration, the "WN" bridge will be able to replace the existing "EN" Ramp bridge in its current location. Refer to the previous section 3.1 for a description of the existing "EN" Ramp bridge (I-2109).

The proposed "WN" bridge over UPRR is a single span structure, 99'-1 ½" long. The proposed structure type is cast-in-place post-tensioned concrete box girders with a structure depth of 4'-6" and a depth to span ratio of 0.0454. The overall width is 27', which accommodates one 12' lane, an 8' outside shoulder, a 4' inside shoulder, and two 1'-6" barrier rails. This proposed bridge will be located to allow for the widening of the I-515 NB Bridge over UPRR. The ramp profile will be set to provide more than the 23'-4" minimum required UPRR clearance to accommodate falsework to construct the girders.

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The 38’ widening of the I-515 NB Bridge over UPRR will be a continuation of the existing bridge type, a cast-in-place post-tensioned box girder superstructure. It will maintain the 2% cross slope and profile of the existing bridge, there-by reducing the existing 23’ minimum clearance. Coordination with UPRR will be needed as the design progresses for this bridge to verify that the sub-standard minimum vertical clearance is acceptable. If not, it may require the removal and replacement of the existing I-515 bridge to the median to meet the required minimum vertical clearance requirements.

The proposed abutments for both the new “WN” bridge and the widening will be in line with the existing abutments and MSE walls. They will be relatively short integral abutments founded on drilled shafts through the mechanically stabilized earth (MSE) fill. The existing abutment configuration of shallow spread footings founded on top of the MSE fill is no longer allowed.

“SW” Bridge over UPRR

A new structure is proposed for the “SW” ramp and to replace the north section of the I-215 Bridge over UPRR (G-1958). The existing bridge is comprised of composite steel I-girders and was built in 2003. It consists of 3 spans for a total length of approximately 328’-1”. It is a multi-lane bridge that carries the “SW” ramp, “NW” ramp and I-215 mainline over UPRR. In this alternative, this bridge will be entirely removed and replaced.

The new proposed “SW” bridge over the UPRR is a 3-span structure with a bridge length of 329’-6¾”. The span lengths are 82’-1 ¾”, 142’-6”, and 104’-11”. The proposed structure type is composite steel I-girders with a structure depth of 5’ and a depth to span ratio of 0.0351. The overall width is 43’, which accommodates two 12’ lanes, a 12’ outside shoulder, a 4’ inside shoulder, and two 1’-6” barrier rails. The bridge is skewed at an angle of approximately 60 degrees to the UPRR tracks. Due to the severe skew of the structure, a steel I-girder superstructure is proposed. The ramp profile for this bridge will be set to provide the required minimum vertical clearance over UPRR.

The proposed abutments are seat type abutments on spread footings. The abutments are approximately 8’tall. The interior supports are 4’-6” diameter multi-column hammerhead piers founded on spread footings.

I-515 South Crossover Bridge

The proposed I-515 South Crossover Bridge is needed to take the “NW” and I-515 NB roadways over I-515 SB, “ES”, and “WS” roadways. Due to the extreme skew of the structure, it is proposed to orient the girders normal to the roadway below instead of parallel with the roadway above as is common. The proposed bridge is a single span structure with the span length varying from 68’ to 137’-9”. The length of the bridge measured along the “N” line is 379’-7 ¾”. The proposed bridge will accommodate a minimum of four 12’ lanes, two 12’ shoulders, and two 2’ barrier rails.

The proposed structure type is precast/prestressed bulb tee girders with a 7'-3" structure depth and a minimum depth to span ratio of 0.0526. To save cost and to allow for better lighting and ventilation underneath the bridge, approximately half of the girders will remain uncovered (no deck). Girders will only be topped with a cast-in-place deck where needed to accommodate the roadways above. To provide better long-term maintenance and structural stability for the uncovered girders, bulb tee girders will be utilized. Bulb tee girders have a wider top flange and offer more stability than AASHTO type girders. Concrete girders are also less maintenance than steel girders.

The abutments have to step out to span the roadways below as they diverge underneath the structure. There are 2" deck joints at the step out locations to accommodate differential deflections in the girders and to break up the bridge transversely to reduce the amount of transverse thermal movement.

The proposed abutments are seat type abutments on spread footings. The abutments are approximately 25' tall. The majority of the abutments will be retaining embankment, but there are portions that will not be retaining. At these locations one option to consider as the design progresses is to leave the abutment open and use columns and a pier cap instead of a full abutment wall. Opening up the abutment would allow better lighting and ventilation and also reduce the construction cost.

4. Preliminary Plans

See attached plan sheets for the layout of the recommended alternatives.

5. Cost Estimate

See Table 2 for the construction cost estimate of each of the five bridges included in this report.

Table 2

Construction Cost Estimate

Bridge Description	Deck Area	Unit Cost	Total Bridge Cost
"NW" Ramp Flyover Bridge	61830 SF	$170/SF	$10.5M
"NBCD" Ramp Flyover Bridge	94400 SF	$170/SF	$16.0M
"WN" Bridge over UPRR	2740 SF	$150/SF	$0.4M
"SW" Bridge over UPRR	14500 SF	$240/SF	$3.5M
I-515 South Crossover Bridge	69200 SF *	$125/SF	$8.7M

* Deck is based on total bridge area regardless if there is a deck on top of the girders

6. Design Criteria Summary

Specifications

1. NDOT Structures Manual with 2011-1 and 2014-01 Revisions
2. AASHTO LRFD Bridge Design Specifications, 8th Edition, 2017
3. AASTHO Guide Specification for LRFD Seismic Bridge Design, 2nd Edition, 2012 with current interims

Loads

1. Load Modifier (AASHTO 1.3.2)
   a. AASHTO specifies an increase or reduction of strength loads via a load modification factor based on the ductility, redundancy and importance of the structure.
   b. A load modification factor of 1.0 is used.
2. Load Factors and Load Combinations (AASHTO 3.4)
   a. Load combinations and load factors are in accordance with AASHTO Tables 3.4.1-1 and 3.4.1-2.
3. Permanent Loads (AASHTO 3.5)
   a. Components and Attached Dead Loads (DC)
      1. Normal Weight (NW) Concrete = 0.150 kcf
      2. Barrier Rail: Single sloped rail = 0.57 klf
   b. Wearing Surface and Utilities (DW)
      1. Wearing surface allowance = ½" sacrificial wearing surface
      2. Future wearing surface = 0.038 ksf
   c. Permanent loads applied to the composite structure are distributed evenly to all girders for bridges with 6 girders or less per NDOT Structures Manual Section 12.2.3
4. Live Load and Impact (AASHTO 3.6.1 & 3.6.2)
   a. The design live load consists of the following:
      1. HL-93, consisting of a combination of:
         i. Design truck or design tandem, and
         ii. Design lane load.
      2. NDOT P13 Permit Vehicle (Strength II)
   b. Pairs of design tandems and design trucks, as described in AASHTO C3.6.1.3.1, are considered for multi-span bridges.

   c. Deflection due to live load is investigated per AASHTO 3.6.1.3.2 with the live load deflection limit of 1/800 of the span for bridges with vehicular traffic. The live load will be combined for deflection evaluation per AASHTO 3.6.1.3.2. Live load distribution factor for deflection per AASHTO 2.5.2.6.2.

   d. The dynamic load allowance (impact) is applied in accordance with AASHTO 3.6.2 to superstructure and substructure elements that are above ground level. Impact is not applied to foundation elements that are completely below ground level or to elastomeric bearings.

5. Braking Forces (AASHTO 3.6.4)

6. Vehicular Collision Forces (AASHTO 3.6.5)

   a. Vehicle collision with parapets is designed in accordance with AASHTO 3.6.5.2 and Section 13.

   b. Use TL-4 impact loads.

   c. Protection of structures (AASHTO 3.6.5.1)

7. Wind Loads (AASHTO 3.8)

   a. Wind loads are computed for base design wind velocities shown in AASHTO Table 3.8.1.1.2-1.

   b. The site locations for wind design is "Open Terrain".

8. Earth Forces (AASHTO 3.11)

   a. Due to the approach slabs, no live load surcharge (LS) is applied to the abutments or wingwalls.

   b. 0.001H wall translation required for active pressure per AASHTO C.3.11.1.

9. Force Effects due to Superimposed Deformations (AASHTO 3.12)

   a. Procedure A is used in determining the design thermal movement associated with uniform temperature obtained from Figure 19.1-A of the NDOT Structures Manual.

   b. Forces and moments due to temperature rise and fall are calculated for the following temperature ranges:

      1. Coefficient of thermal expansion = 6.0 x 10^-6 / °F for concrete and 6.5 x 10^-6 / °F for steel girder superstructures.

      2. Assumed design installation temperature of 60° F

10. Centrifugal Forces (AASHTO 3.6.3)

11. Seismic Effects (AASHTO 3.10)

Materials

1. Concrete

Type	Class	f'c (ksi)	n	Unit Weight (kcf)	Design Unit Weight (kcf)
Cast-in-place Substructure Concrete	A Modified	4.5	8	0.145	0.150
Cast-in-place Superstructur e Concrete	E Modified	5.0	8	0.145	0.150
Precast/ Prestressed Girders	PAA	6.5 (release) 8.0 (final)	5	0.150	0.155

2. Reinforcing Steel
   a. Use Grade 60 reinforcing steel conforming to ASTM A615 unless noted otherwise.
   b. All reinforcing steel bends conform to CRSI Standards or as noted otherwise.
   c. Minimum concrete cover is 2 inches unless otherwise noted.
   d. The maximum length for reinforcing bars is 60’-0”. Cut reinforcing bars to CRSI tolerances.
   e. No allowance is made in bar length except for corrections associated with standard hooks and special bends.
   f. All bent bar dimensions are taken as out-to-out.
   g. Reinforcing splice lengths shall be determined according to AASHTO 5.11.5.
   h. Minimum splice lengths are shown in the plans and/or bar lists.
3. Prestressing Steel (Girders)
   a. Prestressing steel is 0.6 inch nominal diameter (area = 0.217 in^2) Grade 270 "Uncoated Seven-Wire Low Relaxation Strands for Prestressed Concrete", AASHTO M203. Minimum ultimate strength per strand is 58.1 kips.
   b. Limit initial stress to 70 percent of the specified minimum ultimate tensile strength (NDOT Standard Specification 503.03.06)
   c. Limit temporary tensile stress, jacking stress, to 80 percent of the specified minimum ultimate tensile strength (NDOT Standard Specification 503.03.06)
   d. Modulus of elasticity, E = 28,500 ksi is assumed (AASHTO 5.4.4.2).

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4. Structural Steel
    a. Welded plate steel I-girders will be AASHTO M 270 grade 50.
5. Miscellaneous Structural Steel
    a. Angles, plates, stiffeners, gusset plates will be grade 36.

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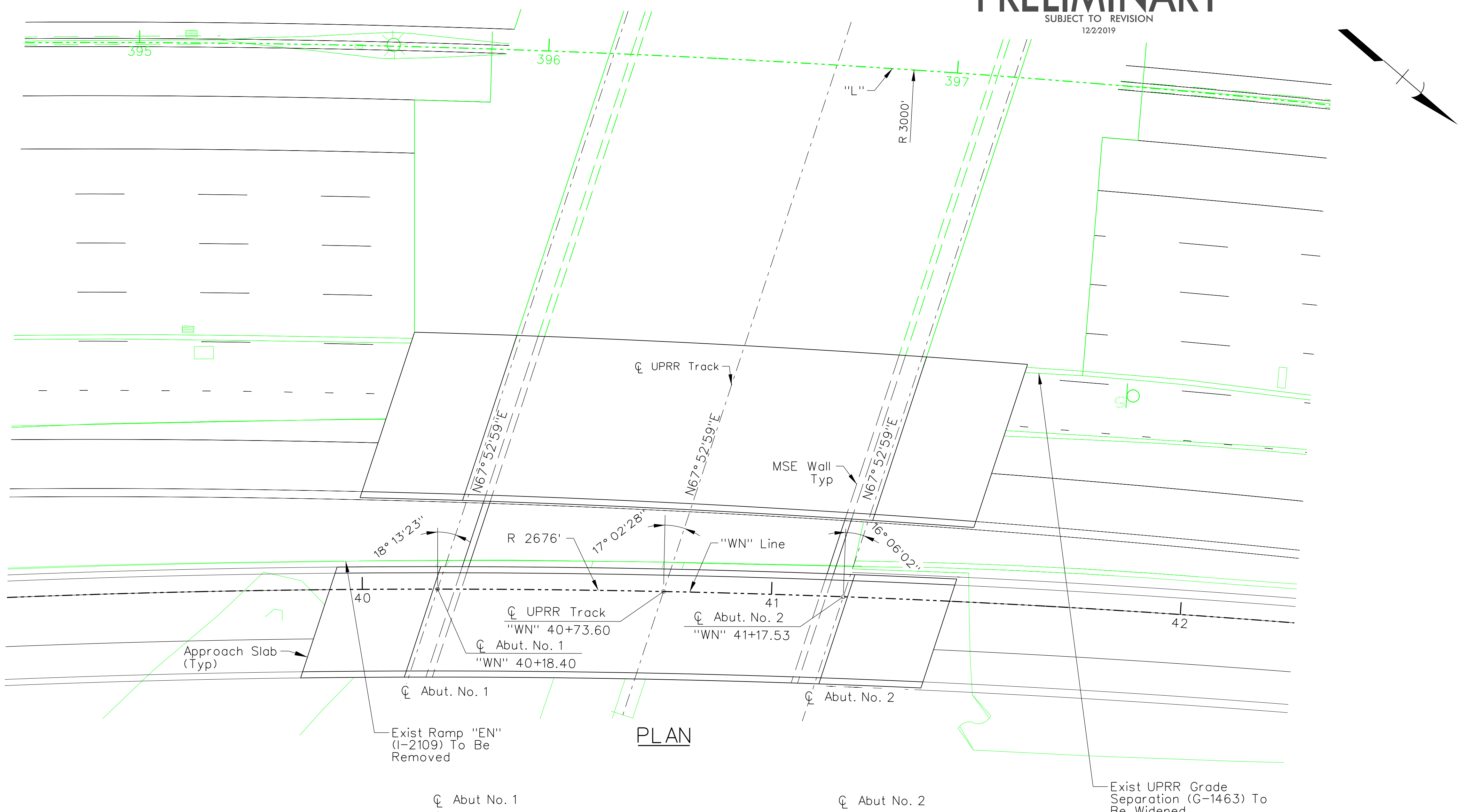
12/2/2019



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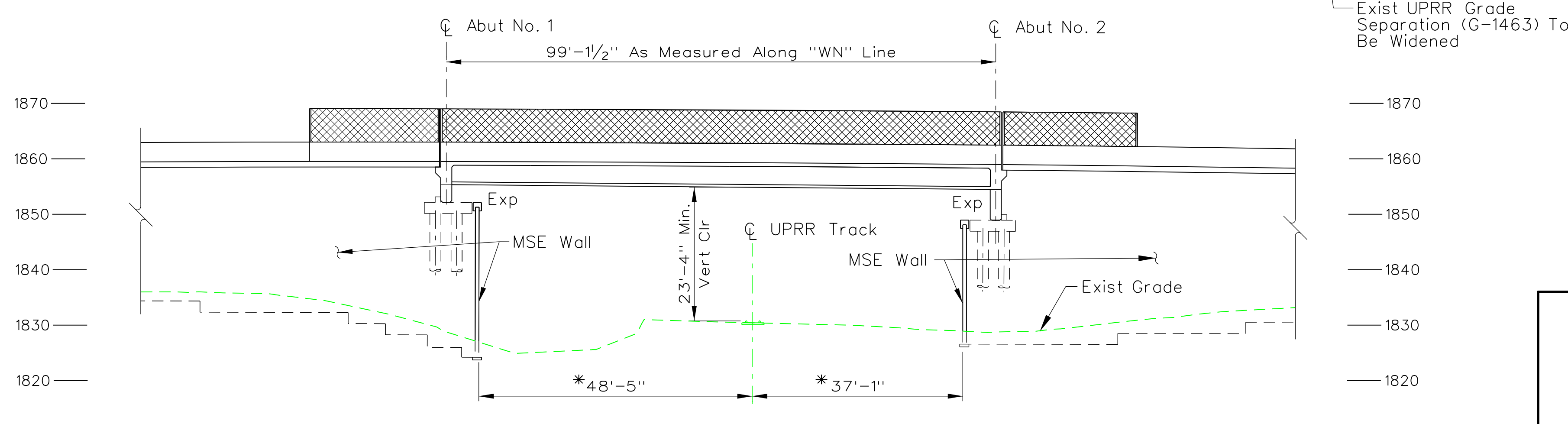

ELEVATION

* Measured Perpendicular To UPRR Track

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

HENDERSON INTERCHANGE OPTION 2

RAMP "WN" OVER UPRR
PLAN AND ELEVATION

12/2/2019

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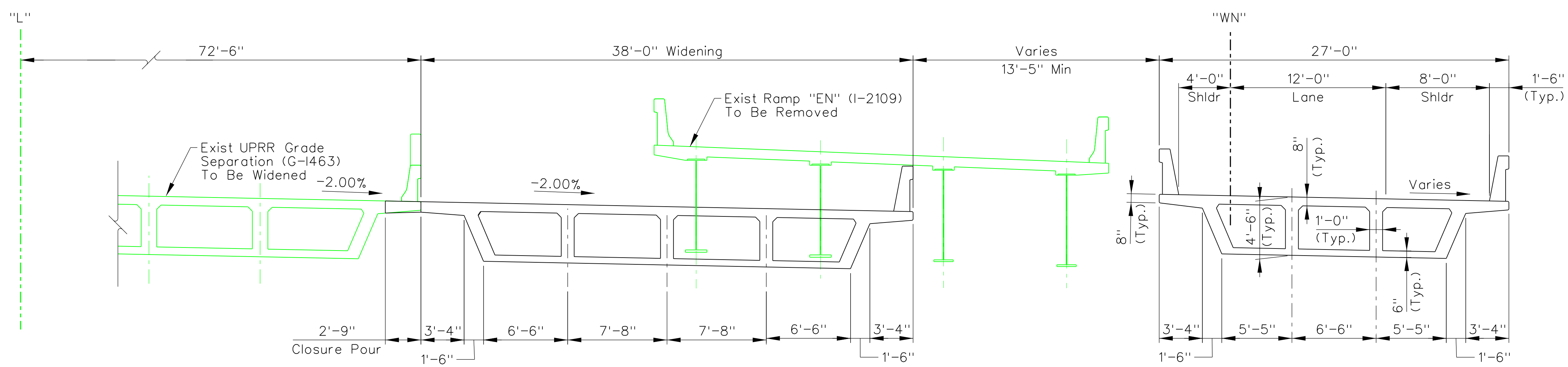

TYPICAL SECTION

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

HENDERSON INTERCHANGE OPTION 2

RAMP "WN" OVER UPRR
TYPICAL SECTION

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NEVADA		CLARK	BB-1

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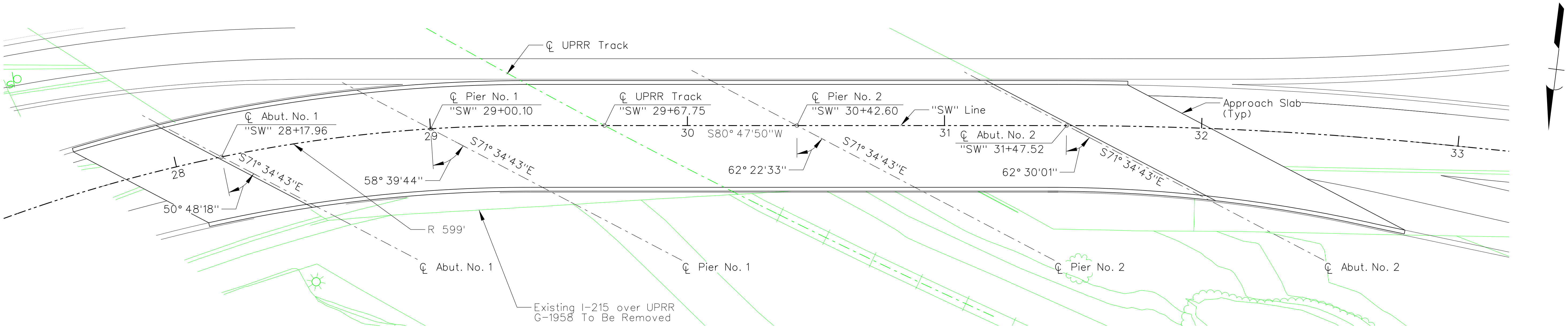

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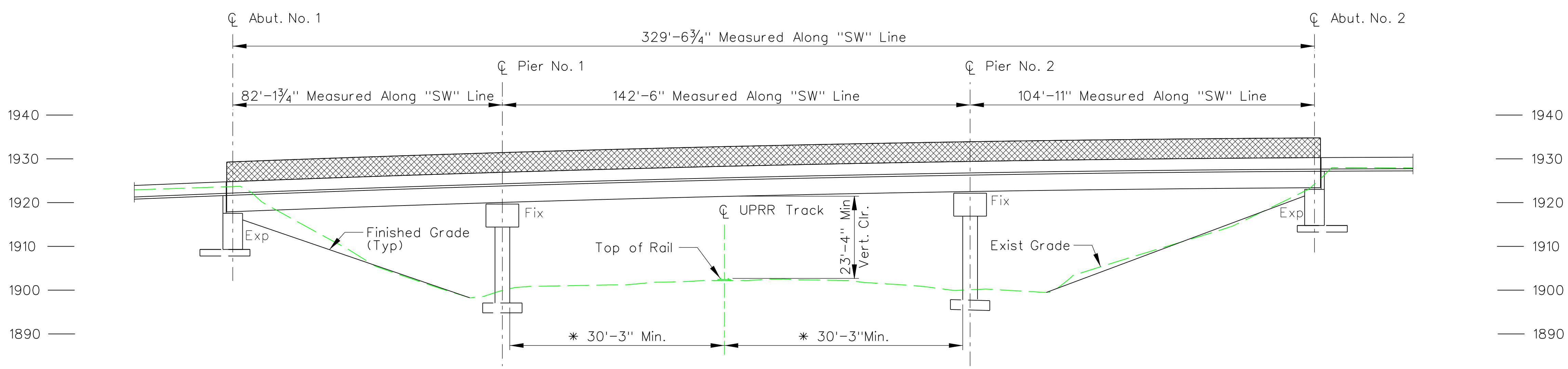

ELEVATION

* Measured Perpendicular to UPRR Track

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

HENDERSON INTERCHANGE OPTION 2

RAMP "SW" OVER UPRR
PLAN AND ELEVATION

12/2/2019

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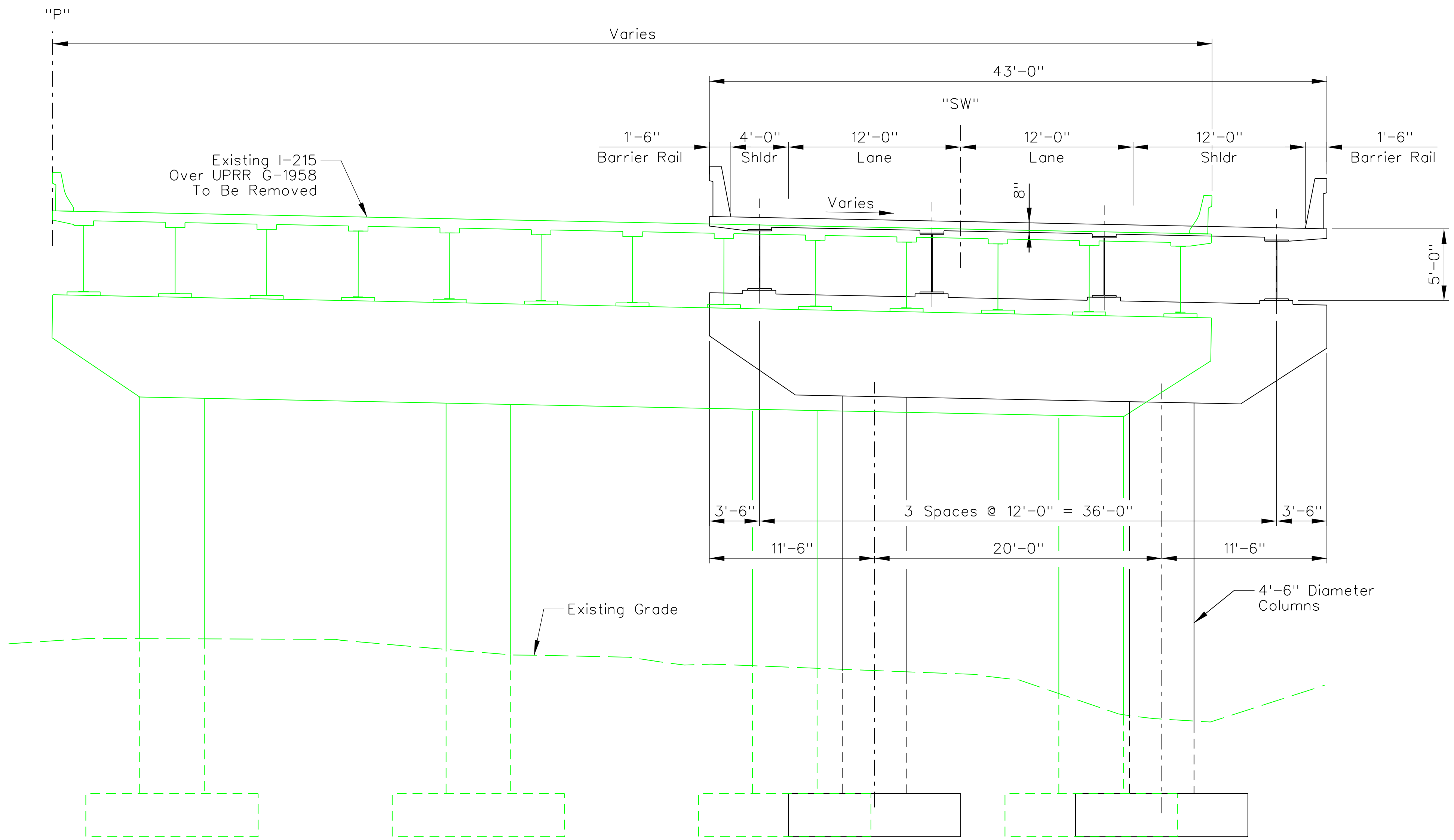

TYPICAL SECTION

STATE OF NEVADA
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HENDERSON INTERCHANGE OPTION 2

RAMP "SW" OVER UPRR
TYPICAL SECTION

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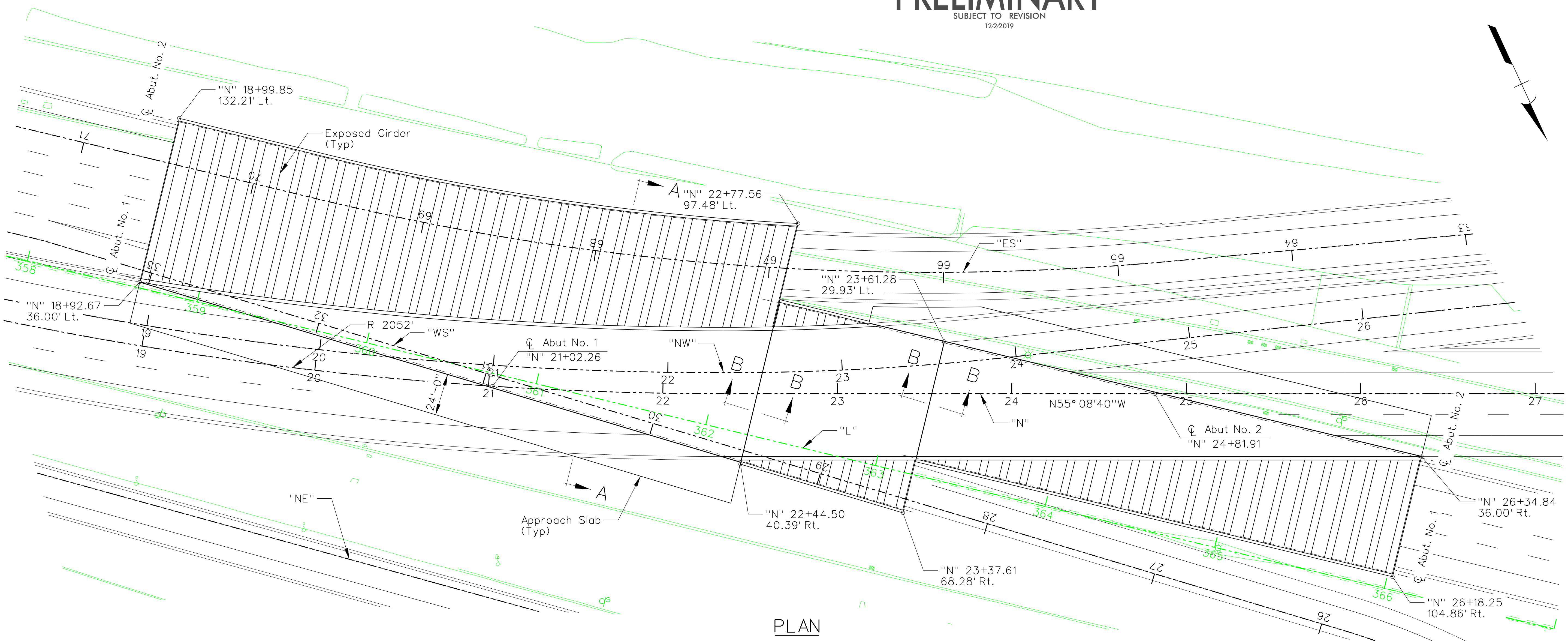

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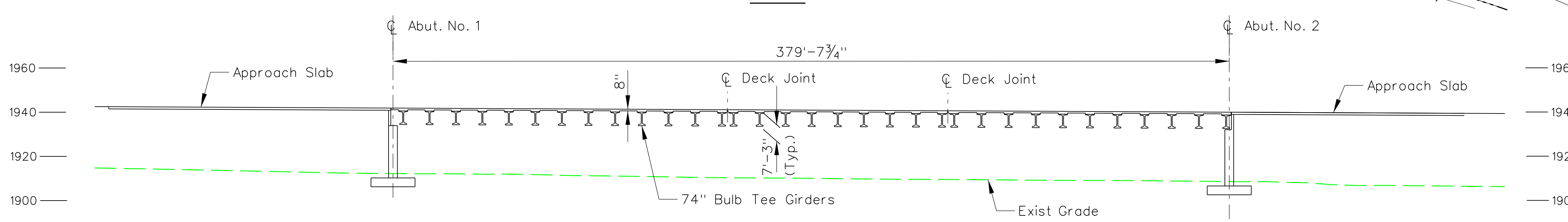

NOTES:
1. See Sheet BC-2 For Sections A-A and B-B.

LONGITUDINAL SECTION
(SHOWN ALONG "N" LINE)

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

HENDERSON INTERCHANGE OPTION 2

I-515 SOUTH CROSSOVER
PLAN AND ELEVATION

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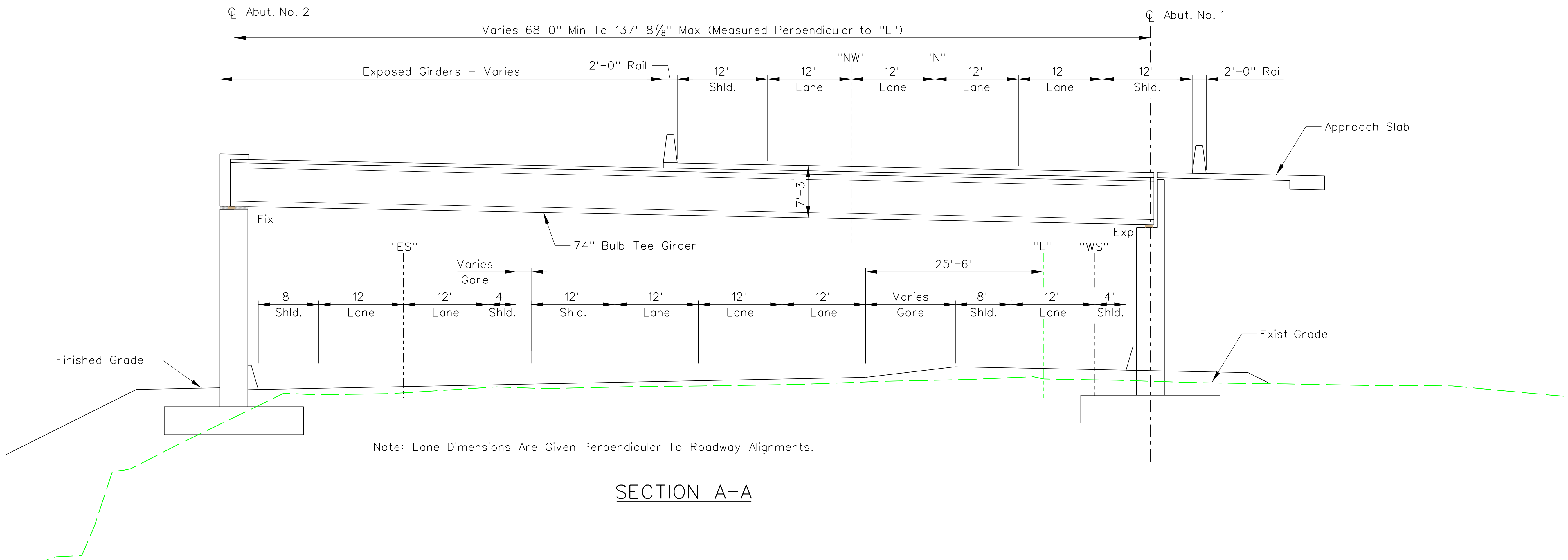
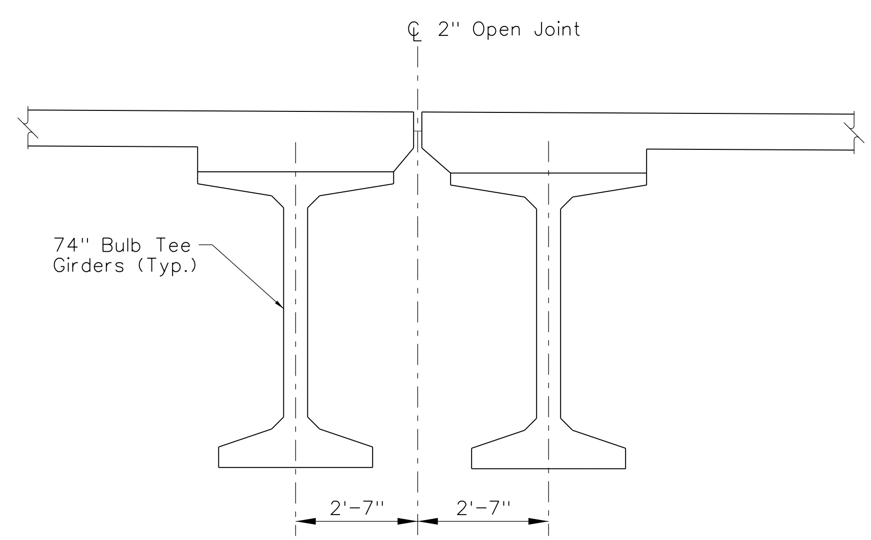


SECTION A-A



SECTION B-B

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

HENDERSON INTERCHANGE OPTION 2

I-515 SOUTH CROSSOVER
SECTIONS

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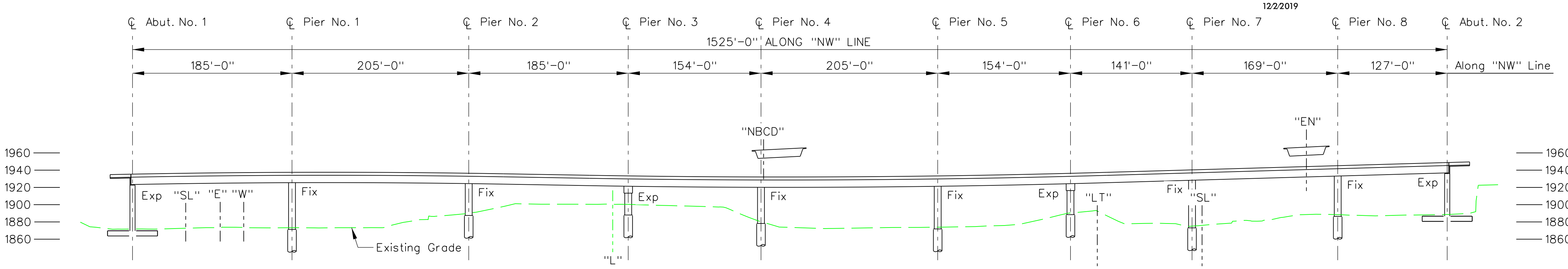

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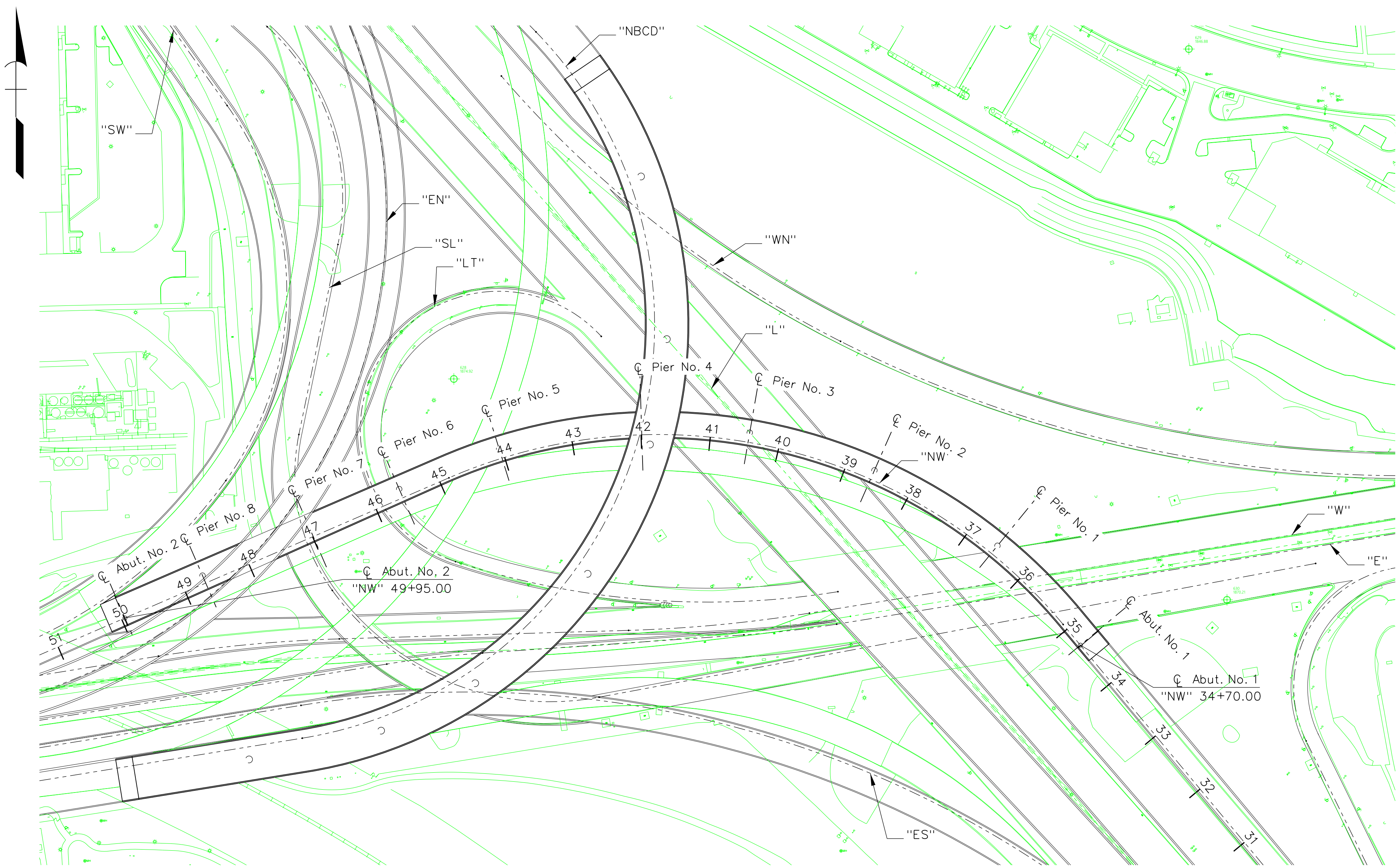

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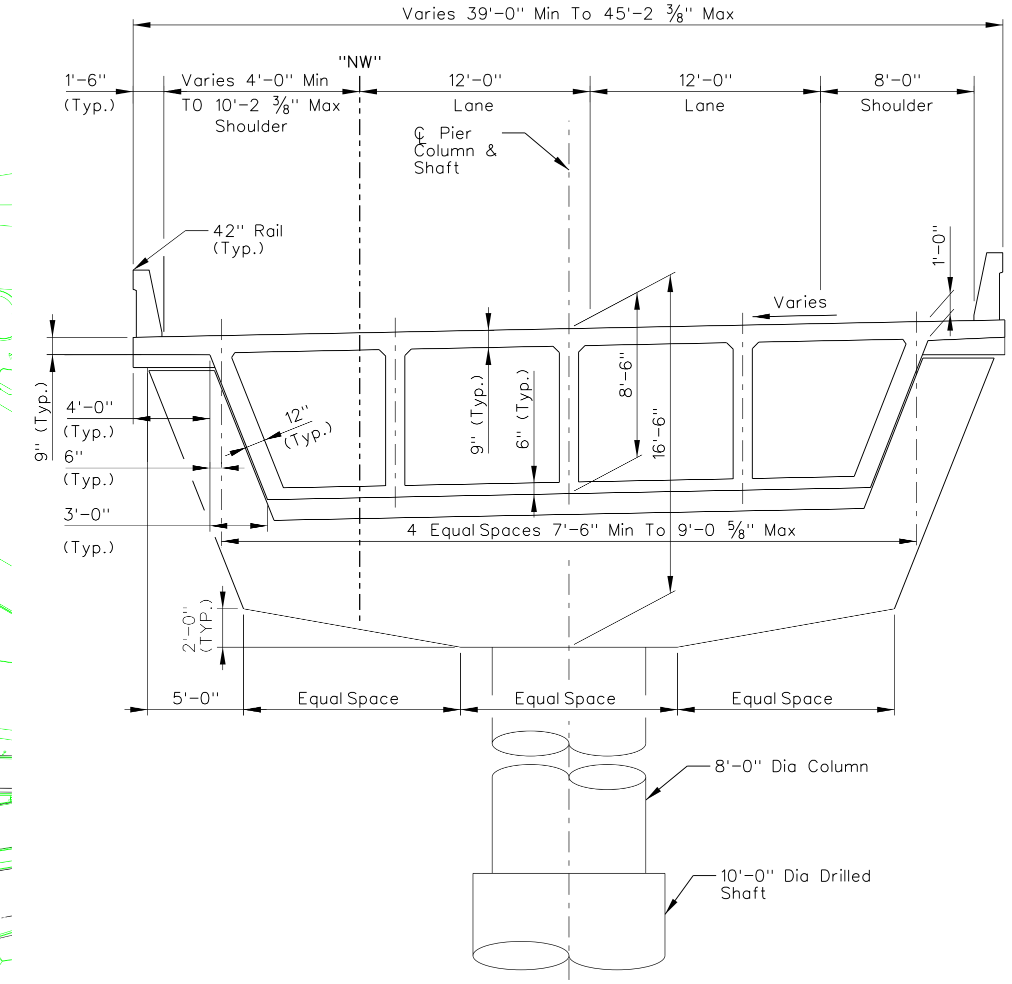

TYPICAL SECTION AT DROP CAP

STATE OF NEVADA
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HENDERSON INTERCHANGE OPTION 1

RAMP "NW"
PLAN, ELEVATION AND
TYPICAL SECTION

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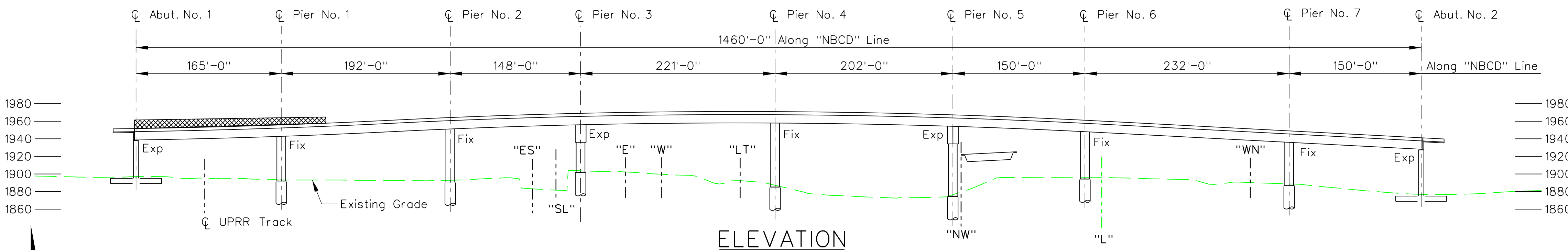

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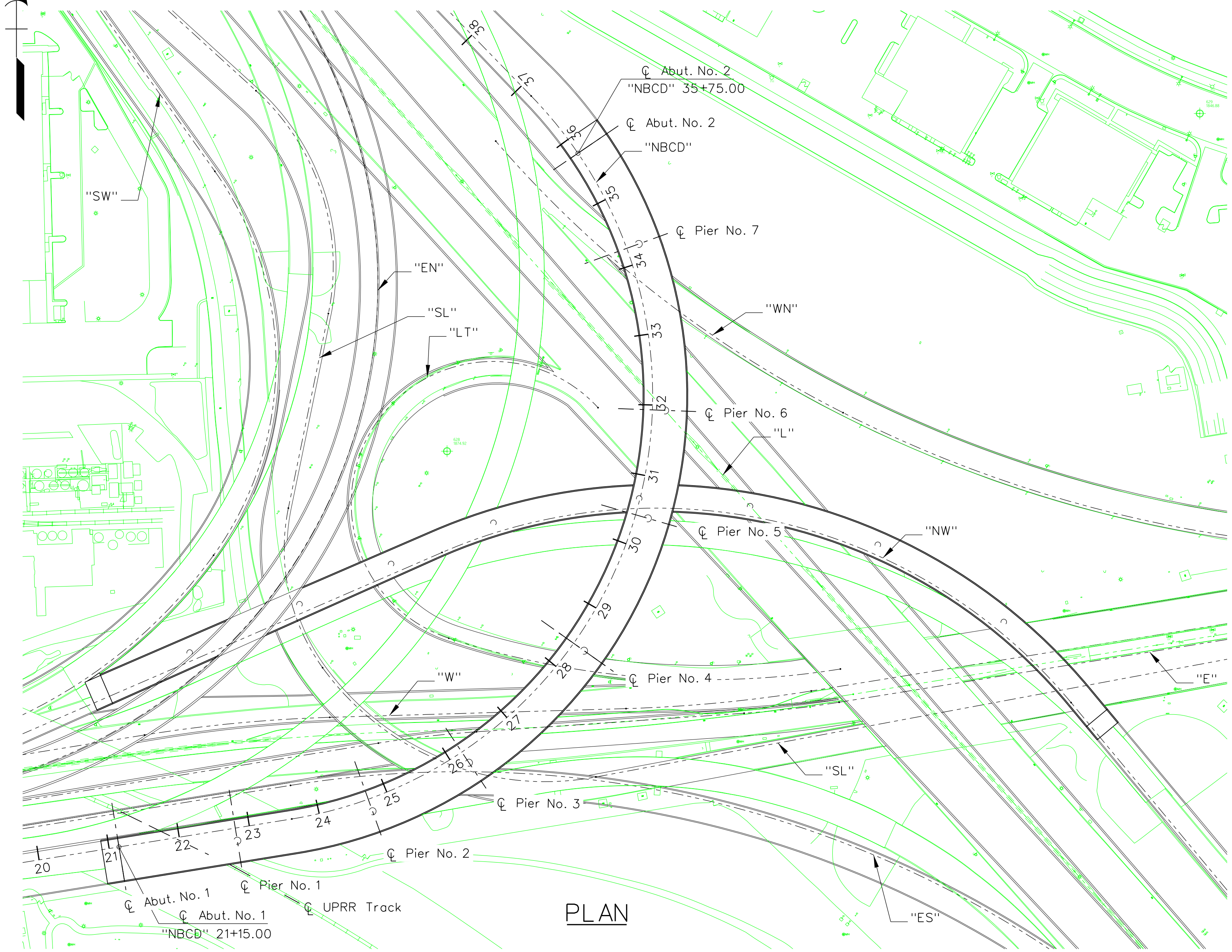

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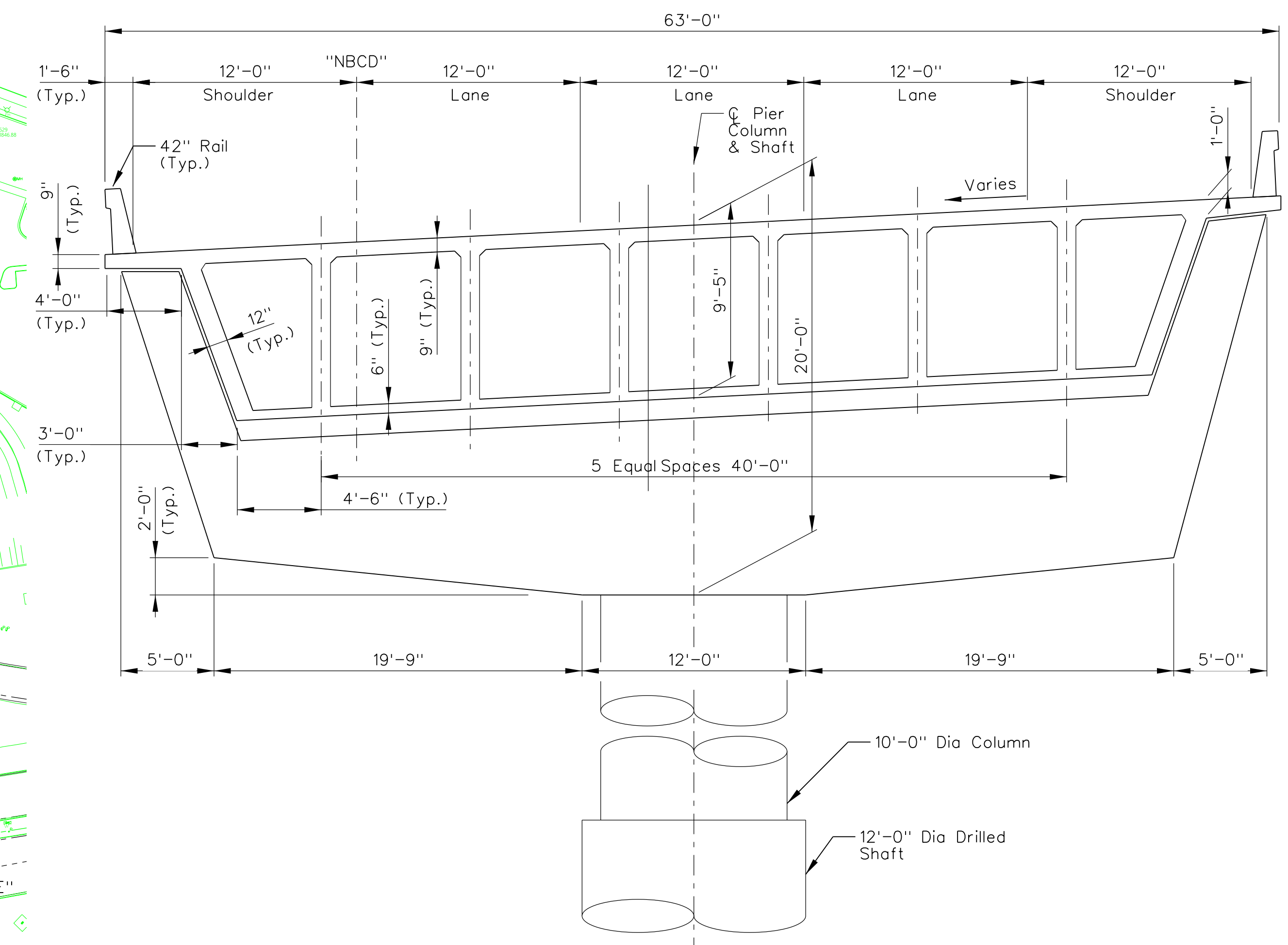

TYPICAL SECTION AT DROP CAP

STATE OF NEVADA
DEPARTMENT OF TRANSPORTATION

HENDERSON INTERCHANGE OPTION 1

RAMP "NBCD"
PLAN, ELEVATION AND TYPICAL SECTION

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