# Cable-stayed Bridge No Ground Improvement Performance Study Memorandum

Multnomah County | Earthquake Ready Burnside Bridge Project

*Portland, OR*

November 10, 2023

## Contents



## Tables



## Figures

## Appendices

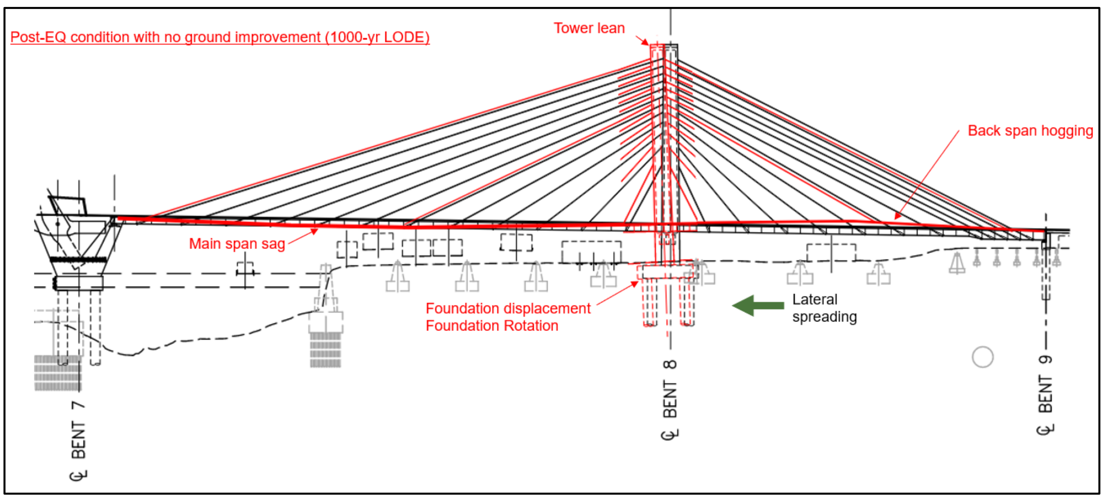
# 1 Memorandum Purpose and Recommendations

The purpose of this study was to gain a better understanding of the effects of lateral spreading on the performance of the cable-stayed approach spans following the Limited Operation Design Earthquake (LODE), and to provide a recommendation if ground improvement should be included in the Earthquake Ready Burnside Bridge (EQRB) Project's Final Design Phase Conceptual Design Data (CDD) submittal.

Additionally, the study was conducted to identify the need for possible structural mitigation measures to reduce residual bridge displacements or improve post-earthquake (EQ) performance and develop updated conceptual quantities and an engineer's estimate.

Lateral spreading without mitigating ground improvement will cause lateral deflection and rotation of the bridge foundation which results in rotation of the bridge tower and deflection in the bridge superstructure as schematically shown in Figure 1. The displacement and rotation shown creates secondary structural effects that can be problematic and must be studied to ensure the bridge can meet project performance requirements to carry emergency vehicles immediately after the LODE and full live load within two weeks.

**Figure 1: Lateral Spreading Effects**




The recommendations from this study are as follows:

1. Elimination of ground improvement for the cable-stayed tower foundation (Bent 8) is recommended. For the CDD submittal, eliminate the cost of ground improvement and include the cost of up-front additional materials to account for slightly higher loads due residual to bridge displacements. This results in an estimated net savings of $28.3 million in programmatic costs and is anticipated to reduce construction risk associated with installation of ground improvement.

2. Post-EQ stay cable adjustments, and their associated costs, are not warranted for structural purposes. Preliminary discussion of results with roadway designers also indicates that cable adjustments are not warranted to re-establish the roadway profile. Findings show that the bridge can carry full HL93 live load without corrective stay cable adjustments (with some up-front strengthening). Additionally, the *EQRB Basis of Design Memorandum: Post-Earthquake Emergency Response and Haul Vehicles Design Assessment* (Multnomah County 2023) states there is an opportunity to define a heavy haul truck-train that is equal to or less than full HL93 live load. Coupling the findings of these two documents then results in a finding that the bridge can carry those heavy haul truck-trains without corrective stay cable adjustments after the LODE.

# 2 Evaluation Approach

## 2.1 Summary of Approach

Based on the behavior shown in Figure 1, the following items were investigated to meet study objectives and ensure the bridge will safely carry live loads in its post-EQ condition:

- Consideration of second order / p-delta effects in the tower legs resulting from permanent displacement and rotation of the shaft cap.
- Evaluation of the cable-stayed structure's ability to immediately carry live loads associated with emergency vehicles (EV2 and EV3) post-EQ without any corrective stay cable adjustments. This includes evaluating the towers, roadway vertical profile, edge girders, stay cables, and drilled shafts.
- Evaluation of the cable-stayed structure's ability to carry full HL93 live loads post-EQ after corrective stay cable adjustments (if necessary). This includes evaluating the towers, roadway vertical profile, edge girders, stay cables, and drilled shafts.

The comparative cost estimate is calculated as the difference between the following items:

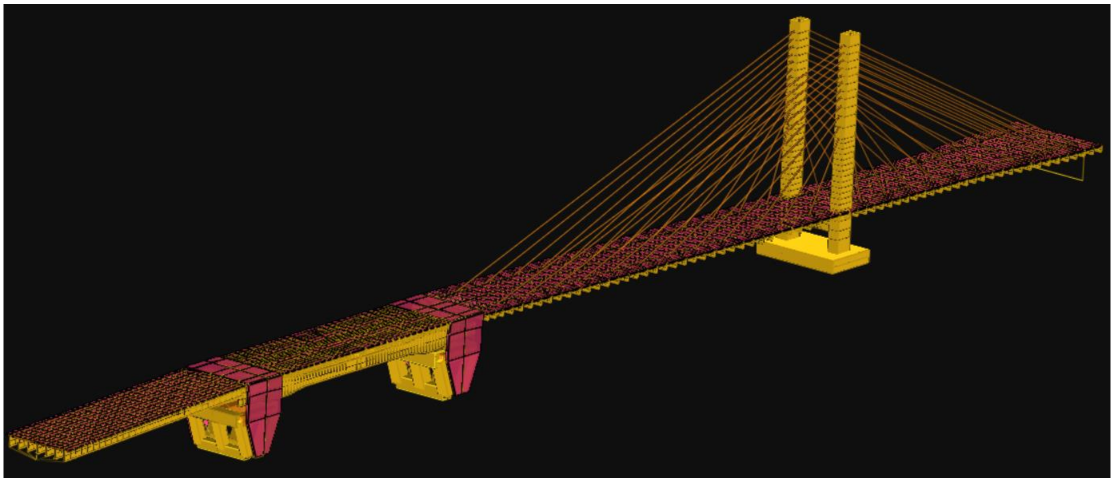
- Cost of structural strengthening without ground improvement.
- Cost of ground improvement.

## 2.2 LARSA Model

A structural analysis model was developed in LARSA 4D to determine load effects on all the structural elements studied, except for the drilled shafts which were determined using a CSiBridge model (discussed in Section 2.3). The LARSA 4D model is shown in Figure 2.

The LARSA model has cable stay member properties consistent with the member geometry shown in the September 2022 conceptual drawings provided as part of the National Environmental Policy Act (NEPA) phase of the project, also provided in Appendix A.

**Figure 2: LARSA 4D Model**



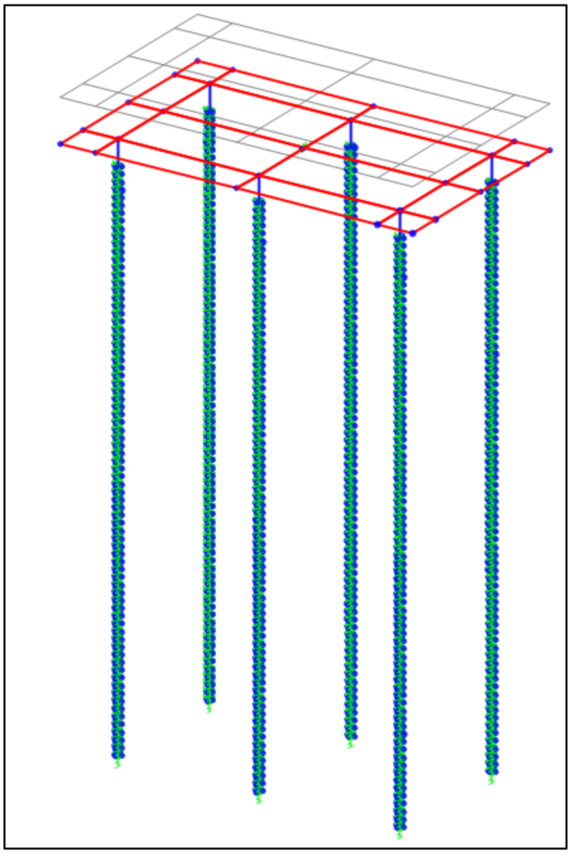
## 2.3 CSiBridge Model

A model was developed in CSiBridge to model the displacement of the foundations due to lateral spreading displacement of the soil. The results of the model were used to determine the displacement and rotation of the cable-stayed tower foundation, and to evaluate the load effects on the drilled shaft foundations.

The CSiBridge model used a bounded approach to account for the stiffness of the cable-stayed bridge that is integral with the shaft cap. Specifically, the CSiBridge model considered two conditions: a rigid cap/shaft connection and free cap condition.

The CSiBridge model is shown in Figure 3.

### Figure 3: CSiBridge Model

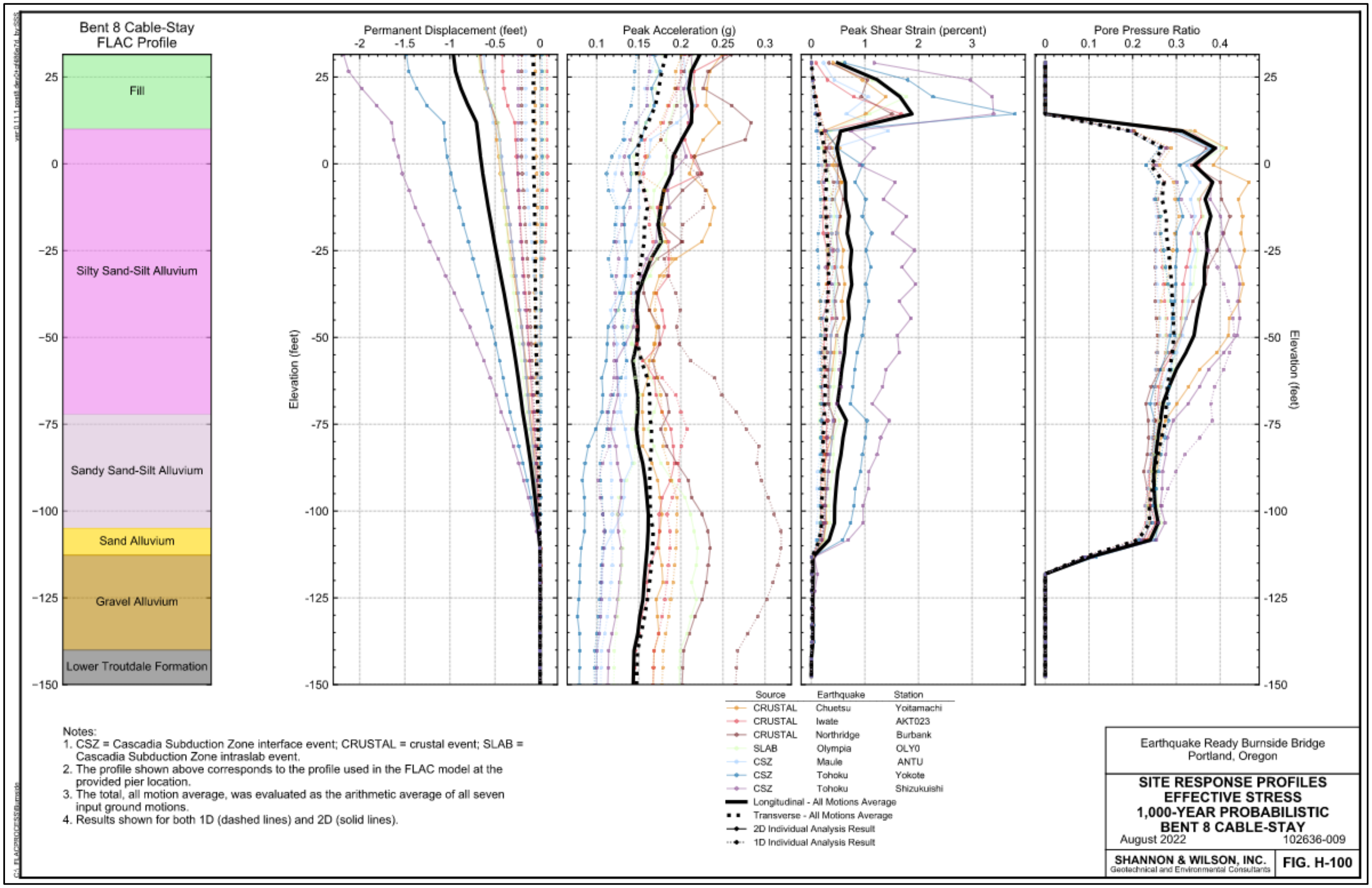


The CSiBridge model includes discrete foundation elements for each drilled shaft and shaft cap. P-y (lateral), t-z (vertical side friction), and q-z (vertical end bearing) soil springs are attached along the height of each drilled shaft. P-y and t-z springs are attached at two-foot intervals, and a single q-z spring is attached at the base of each drilled shaft. A single p-y spring was applied to the buried shaft cap. Soil springs are consistent with the information provided for liquefied soil conditions (effective stress) provided in the *EQRB Final Preliminary NLTH Geotechnical Report* (GER) (Multnomah County 2022a). Group multipliers were also applied to the soil springs, and are consistent with recommendations provided in the GER.

Lateral displacement loading was applied to the drilled shaft and shaft cap by displacing the ground node end of the p-y spring elements a distance equal to the free-field soil displacement for “Longitudinal - All Motions Average” shown in Figure H-100 from the GER and shown in Figure 4. For reference, the All Motions Average free-field displacement shown in Figure H-100 is approximately 11.5 inches at the ground line. Note that free-field soil displacements, which were developed in the finite difference program FLAC, disregard any resistance provided by the foundation elements themselves, providing a conservative upper bound of soil displacements.

As the potential permanent rotation of the tower shaft cap will result in negative structural effects (additional bending in superstructure and tower), the spring values in the CSiBridge model were selectively modified to achieve conservative (upper bound) shaft cap rotations to suit the purposes of this study. Spring modifications included increasing the shaft cap lateral p-y spring by a factor of 10 and decreasing the shaft axial q-z spring by a factor of 10. Both of these modifications result in increased cap rotation, and as a result cap rotations used in this study are approximately double what is anticipated (compared to unmodified p-y and Q-z springs).

## Figure 4: Free Field Ground Displacement




Multnomah County. December 2022. EQRB Final Preliminary NLTH Geotechnical Report (unpublished). Appendix H, Figure H-100.

# 3 Design and Performance Criteria

## 3.1 General

The criteria used to evaluate the performance of the cable-stayed bridge without ground improvement is consistent with the following two documents:

- *EQRB Revised Bridge Design Criteria Report* (BDC) (Multnomah County (2022b).
- *EQRB Revised Seismic Design Criteria Report* (SDC) (Multnomah County 2022c).

Only effects associated with the LODE are evaluated in this study.

Consistent with SDC Section 3.1 and 3.2.2, the following are anticipated for the LODE:

- Damage is repairable but may impact traffic for up to two weeks.
- Limited permanent deformation may occur.

Geotechnical data used for this study is consistent with the following document:

- *EQRB Final Preliminary NLTH Geotechnical Report* (GER) (Multnomah County 2022a).

## 3.2 Load Combinations

The Strength I and Strength II Limit State Load Combinations, as defined in the American Association of State Highway and Transportation Officials (AASHTO) Load and Resistance Factor Design Bridge Design Specifications (adopted by the BDC), are used for evaluation in this study.

The Strength II Limit State Load Combination is applied to the following post-EQ condition:

- Post-EQ structure, prior to corrective stay cable adjustments.

The Strength I Limit State Load Combination is applied to the following post-EQ condition:

- Post-EQ structure, after corrective stay cable adjustments (if adjustments are necessary)

Note that the scope of this study is limited to permanent ground displacement effects. Previous preliminary analysis during the NEPA phase of this project indicates that load combinations of inertial + lateral spreading effects can be accommodated without ground improvement.

## 3.3 Lateral Spread Loading

The effects of the foundation movements on the bridge, due to lateral spreading, are classified as “SE” loads in regard to load factors used in load combinations. The load factor for $\gamma_{SE}$ specified in AASHTO Table 3.4.1-5 shall be taken as 1.00, consistent with load factors for $\gamma_{SE}$ for lateral movement.

## 3.4 Live Loading

The following two live load conditions are assumed in this study:

- Emergency service vehicles in reduced traffic lanes on the post-EQ structure prior to corrective stay cable adjustments, consistent with SDC Section 8.2 and BDC Section 3.4.
- Full HL93 Live Load on the post-EQ structure after corrective stay cable adjustments (if adjustments are necessary), consistent with BDC Section 3.4.

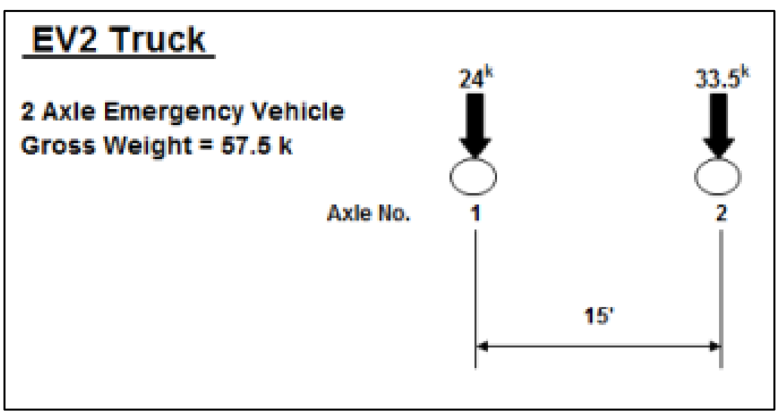
The post-EQ condition is evaluated based on the EV2 and EV3 vehicles, defined in, and consistent with BDC Section 3.4 and shown in Figure 5.

**Figure 5: Post-EQ Live Load (BDC Section 3.4)**

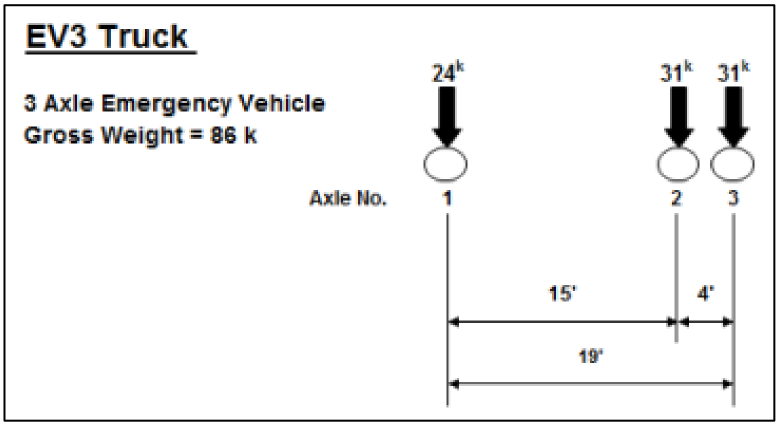
> Following a seismic event, it is expected that the Burnside Bridge will be used by heavy emergency vehicles. Post-seismic operational performance of the bridge would be established using load rating provisions for up to two loaded lanes of EV2 and EV3.

See Figure 6 and Figure 7 for EV2 and EV3 axle loading. Note that lane loads (e.g., HL93 Design Lane Load) are not considered to be present with the EV2 and EV3 loads.

**Figure 6: EV2 Truck Axle Loads**



### Figure 7: EV3 Truck Axle Loads




## 3.5 Limited Permanent Deformation

Limited permanent deformation is acceptable, in accordance with SDC Section 3.1.

The allowable limited permanent deformation is evaluated by comparing the reinforcing steel strain demand in the tower legs and drilled shafts to allowable reinforcing steel strain as defined in the SDC.

The tower legs are limited to strain associated with yield, consistent with other typical Strength Limit State Load Combinations defined in AASHTO.

The drilled shafts are anticipated to undergo larger displacements due to the lateral translation of the foundations associated with lateral spreading of the soil. The drilled shafts, at the Strength Limit State, will be limited to the strains listed in SDC Section 8.2.3 Table 5: repeated in Table 1 below.

### Table 1: LODE Strain Criteria (SDC Section 8.2.3, Table 5)

Table 5. LODE Strain Criteria

| Element | Limited Operation Design Earthquake (LODE) |
|---|---|
| Moderate Inelastic Components (Concrete Columns) | $\varepsilon c = \varepsilon cu$ (confined)<br>$\varepsilon s = 0.80 \times \varepsilon_{bar\ buckling}$ |
| Minimal Inelastic Components (Drilled Shafts, Cable Stay Tower, Moveable Substructure) | $\varepsilon c = \varepsilon cu$ (confined)<br>$\varepsilon s = 0.015$ |

s = steel, c = concrete

$$\varepsilon_{bar\ buckling} = 0.032 + \left[\frac{790 \times \rho_s \times f_{yhe}}{Es}\right] - \left[\frac{0.14 \times P}{Ag \text{ x } f_{ce}}\right]$$

$\varepsilon s = 0.015$ is in accordance with Serviceability Limit Tension Strain discussed by Priestly, Calvi, Kowalsky in "Displacement-Based Seismic Design of Structures"

The reinforcing steel strain comparison is checked for the following two conditions:

- Post-EQ structure, prior to corrective stay cable adjustments, with EV2 and EV3 vehicles in two traffic lanes concurrently.
- Post-EQ structure, after corrective stay cable adjustments (if necessary), with HL93 live load.

## 3.6 Stay Cables

The stay cables are evaluated based on capacity limits defined in *DC45.1-18: Recommendations for Stay Cable Design, Testing, and Installation* (PTI 2018).

The stay cables are checked for the following two conditions:

- Post-EQ structure, prior to corrective stay cable adjustments, with EV2 and EV3 vehicles in two traffic lanes concurrently.
- Post-EQ structure, after corrective stay cable adjustments (if necessary), with HL93 live load.

## 3.7 Steel Edge Girders

The steel edge girders are evaluated in accordance with SDC Section 6.4, which limits the structural steel capacity of the steel edge girders to elastic capacity.

The steel edge girders are checked for the following two conditions:

- Post-EQ structure, prior to corrective stay cable adjustments, with EV2 and EV3 vehicles in two traffic lanes concurrently.
- Post-EQ structure, after corrective stay cable adjustments (if necessary), with HL93 live load.

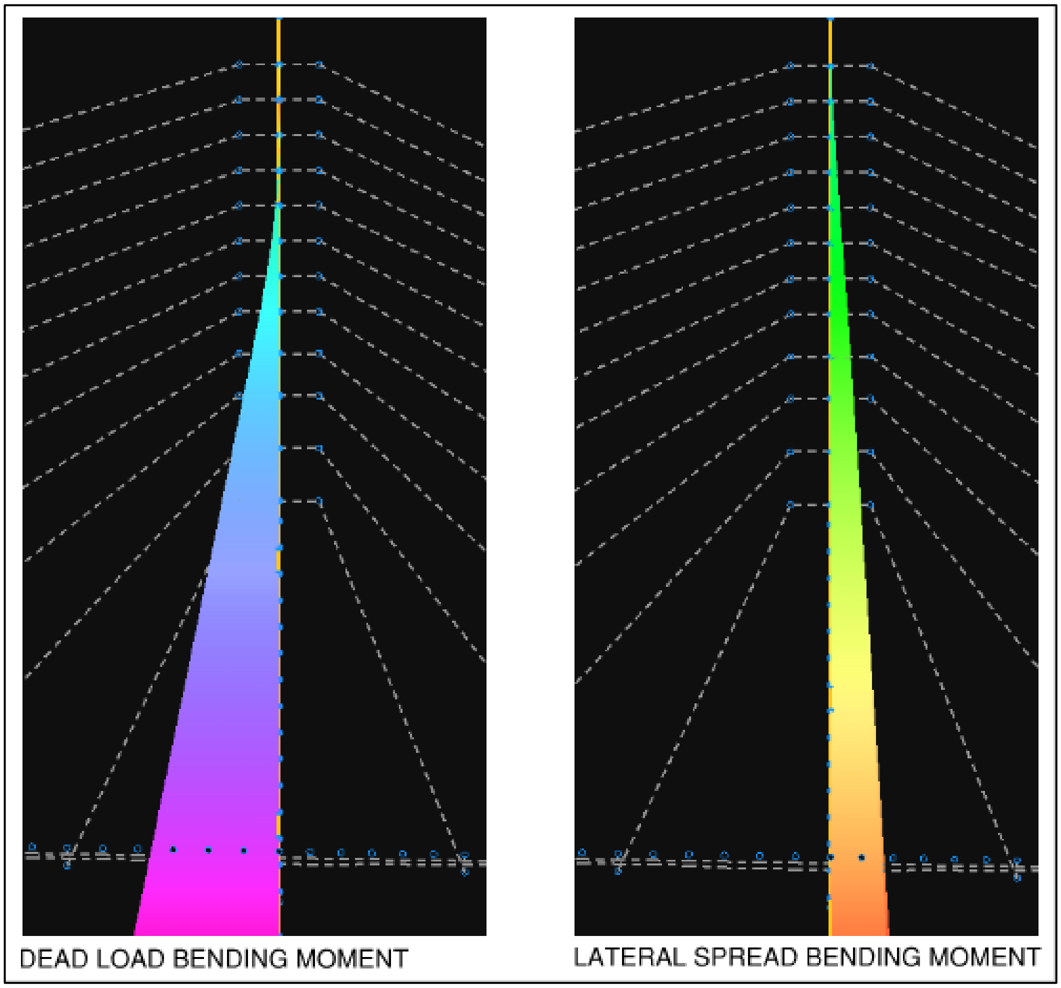
# 4 Study Findings

## 4.1 Tower

This study finds that the towers do not experience problematic permanent displacement and/or rotation. The tower legs translate laterally with the shaft cap approximately ten inches. Base of tower rotations caused by shaft cap rotation are minimal, even with modified soil parameters, and result in additional deflections of approximately one inch at the top of the tower.

The foundation rotation created by lateral spreading causes bending moments opposing those of permanent loads (e.g., dead load), as illustrated in Figure 8. A similar response is found for the shear demands. Increases in tower reinforcement or changes to the cross-sectional dimensions of the tower are not required as a result.

**Figure 8: Tower Bending Moment**




Targeted demand/capacity ratios are 0.85 for the towers. As described in the previous paragraph, the bending/shear demands in the tower are actually reduced with lateral spreading, and the tower demand/capacity ratios improve as a result.

These findings are applicable to the tower geometry studied (see Appendix A). Other tower geometry may not result in the same findings. For example, canted tower legs (e.g., V-shaped tower) are more susceptible to second-order effects, and these findings may not be applicable.

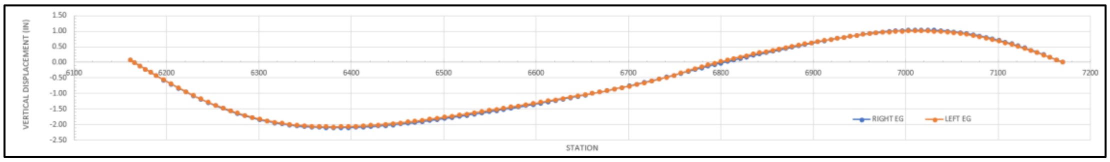
## 4.2 Roadway Vertical Profile

Superstructure vertical displacements resulting from lateral spread loading were also investigated. These displacements are shown in Figure 9 which shows a maximum sag displacement of approximately two inches in the main span and a maximum hogging displacement of approximately one inch in the back span, based on the conservative foundation rotation considered.

These displacements are not detrimental structurally and are not anticipated to be problematic with respect to roadway profile or drainage, but this needs to be verified. It is possible that additional drainage inlets may be necessary to adequately drain the structure when considering the permanent displacements; this will be further studied in Final Design.

In addition, sag in the main span will cause rotation and possibly an associated grade break at the bascule pier joint equal to approximately 0.08%. This grade break is minimal and can be addressed quickly following the LODE, if required, before fully opening to all traffic.

**Figure 9: Superstructure Vertical Displacement**

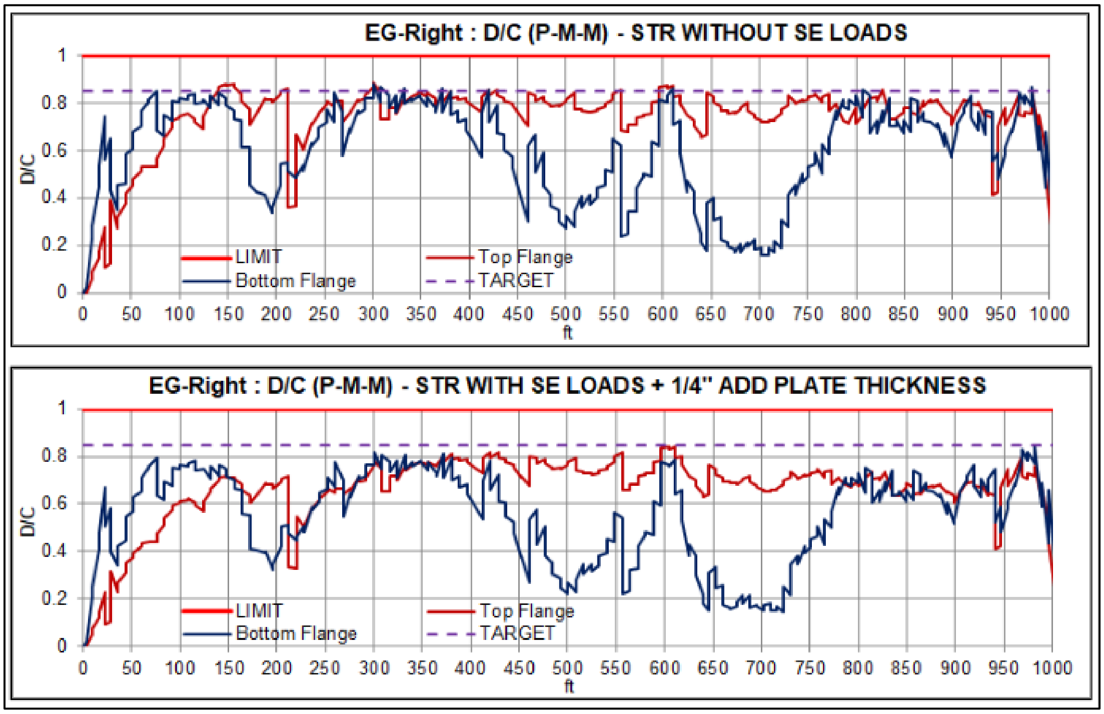



## 4.3 Edge Girders

The steel edge girders were found to adequately carry the specified emergency vehicles in the Strength II Limit State without need for modification and need only minor increases in material quantity to carry full HL93 live load in the Strength I Limit State without cable adjustments.

Targeted demand/capacity ratios are 0.85 for the edge girders, with SE loading (without ground improvement) and without SE loading (with ground improvement). This study finds that increasing the thickness of the edge girder top and bottom flanges by one quarter inch is sufficient to carry full HL93 live load in the Strength I Limit State without cable adjustments. Note that one quarter inch was assumed as a conservative and practical minimum for this study. The calculated increase in thickness was found to be less than this amount. Figure 10 shows demand/capacity ratios with and without SE loading.

**Figure 10: Edge Girder Demand / Capacity Ratios**




The change in material quantity is provided in Section 5.

## 4.4 Stay Cables

The Stay Cables were found to adequately carry the specified emergency vehicles in the Strength II Limit State without need for modification and need only minor increases in material quantity to carry full HL93 live load in the Strength I Limit State.

Targeted demand/capacity ratios are 0.85 for the stay cables, with SE loading (without ground improvement) and without SE loading (with ground improvement). This study finds that 28 of the 48 cables on the bridge would need additional strands to accommodate SE loading without ground improvement. Of the 28 cables needing additional strands, only 4 of them need 2 strands. The remaining cables need one additional strand.

The change in material quantity is provided in Section 5.

## 4.5 Drilled Shafts

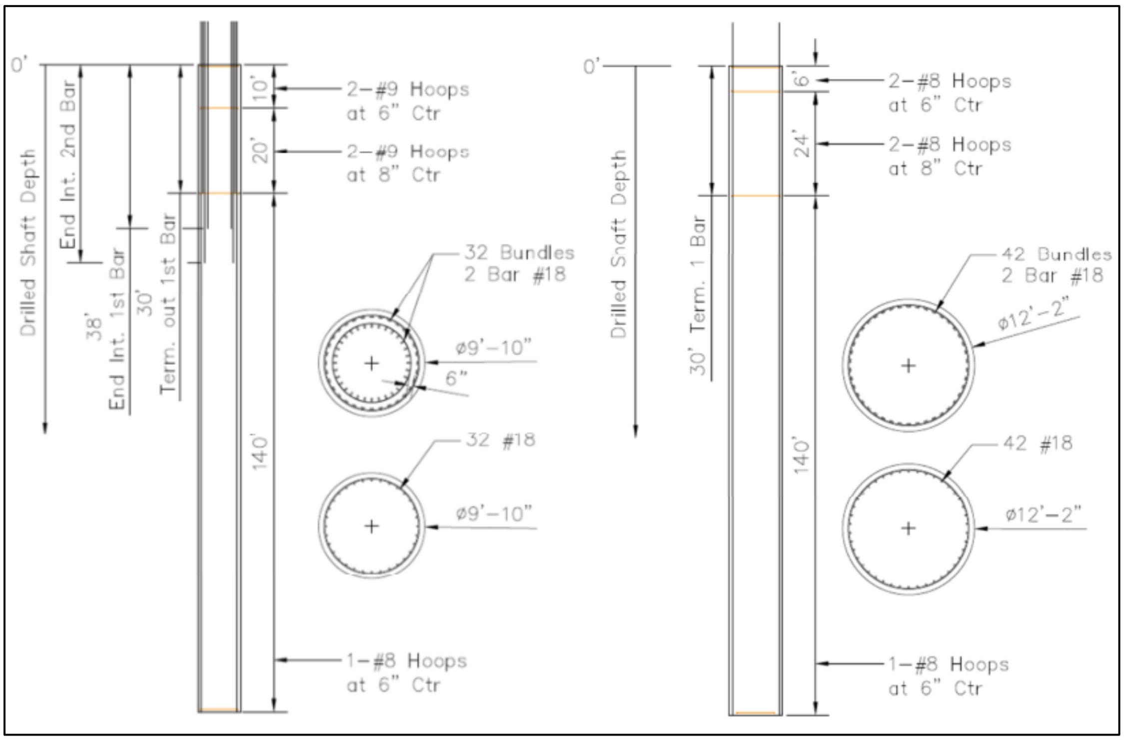
Without ground improvement, the 10-foot diameter drilled shafts were found to need increases in material quantity associated with adding additional reinforcement. Changes in shaft diameter, spacing, and number were not found to be required. However, the post-EQ demand/capacity ratios are relatively high, approximately 0.90. This demand/capacity ratio is higher than desirable at this level of design. In addition, the required reinforcement density is high, approximately five percent near the top of the drilled shafts. Both items represent an increased risk of requiring changes to shaft diameter as design progresses.

Design for 12-foot diameter drilled shafts was developed for comparison. A maximum demand/capacity ratio equal to 0.85 was targeted and the design resulted in reinforcement densities of approximately 2% near the top of the drilled shafts and 1% (held as a minimum) for the remainder of the drilled shafts. Note that this design was developed using existing loads from the analysis for 10-foot diameter drilled shafts. New analysis was not performed to account for difference in shaft stiffness and soil group effects.

Solutions for the 10-foot diameter drilled shaft and 12-foot diameter drilled shaft are shown in Figure 11. Note that 10-foot and 12-foot diameter are nominal sizes. Actual sizes used for this study are consistent with metric oscillator sizing, as this is the anticipated method of construction.

The change in material quantity (including an allowance for changes to the shaft cap) is provided in Section 5.

**Figure 11: Bent 8 Drilled Shaft Comparison**




## 4.6 Miscellaneous Items

Expansion joints, bearings, and tie-down elements at the ends of the cable-stayed bridge will all need to accommodate ten inches of increased movement associated with lateral spreading. This additional movement can be accommodated in the modular joints and bearings at the ends of the cable-stayed bridge with readily available larger movement joints and bearings. The tie-down elements will need a minor increase in material quantity to carry full HL93 live load in the Strength I Limit State. The change in quantity is associated with adding a few strands to some of the tie-down elements. The estimated additional cost of these items is provided in Section 5.

## 4.7 Summary of Findings

The results of this study show that, if ground improvement is not utilized, the effects of lateral spreading on the performance of the cable-stayed approach spans following the LODE are not significantly detrimental to the structure.

Relatively minor increases in material quantity are required in the edge girders, stay cables, tie-down elements, and drilled shafts to carry full HL93 live load without post-EQ corrective cable adjustments.

Expansion joints, bearings, and tie-down elements will all need to accommodate ten inches of increased movement associated with lateral spreading.

Vertical deflections of the superstructure and the resulting change in the roadway vertical profile are minor. This magnitude of displacement does not present structural problems, is not anticipated to result in unacceptable profile or drainage issues and does not warrant post-EQ cable adjustments. While not a direct focus of this study, it is also worth noting that the time required to adjust cables in a post-EQ scenario is anticipated to be longer than the two-week allowance for repairs prior to opening the bridge to all traffic, as described in the performance requirements for the LODE in Section 3.2.2 of the SDC, further supporting the elimination of post-EQ cable adjustments.

# 5 Quantity / Cost Impacts

Based on the previously presented findings, elimination of ground improvement will require some increases in material quantities and cost to the structure to achieve acceptable performance criteria. Those quantities and cost impacts are presented in Figure 12 and Figure 13.

The costs presented in Figure 12 and Figure 13 are based on unit costs and cost factors established for the EQRB project during the NEPA phase, except for Bent 8 drilled shaft and Bent 8 ground improvement costs. Those costs were updated for this study and provided by independent estimators, as directed by the County.

Figure 12 shows the total programmatic costs with ground improvement:

- Project cost with ground improvement = $905.6 million

Figure 13 shows the total programmatic costs without ground improvement:

- Project cost without ground improvement = $877.3 million

The difference between Figure 12 and Figure 13 shows a project cost savings by eliminating ground improvement = $28.3 million.

## Figure 12: Quantities and Estimate with Ground Improvement

**EARTHQUAKE READY BURNSIDE BRIDGE COST ESTIMATE WORKSHEET**

**Alt1: Girder - Bascule - Cable Stayed Bridge Type Configuration**

| | | | |
|---|---|---|---|
| BRIDGE NUMBER(S): 00511, 00511A, 00511B | | COUNTY Multnomah | |
| BRIDGE NAME Burnside Bridge and Approaches | STATE HIGHWAY NUMBER N/A | ROUTE NUMBER N/A | |
| Mile Post / SCOPE: Alt1: Girder - Bascule - Cable Stayed Bridge Type Configuration | REFERENCE NAME/PHONE Steve Drahota / (503) 423-3712 | Date Entered: 8/3/2021 | SMD Date Checked: 10/2/2022 |

| No. | ITEM | | UNIT | QUANTITY | UNIT COST | SUB TOTAL | | Section Totals | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | **Preparation** | | | | | Contingency = | 15% | $ 53,546,000 | |
| | Mobilization | 8.0% | LS | 1 | $ 19,207,000 | $ 19,207,000 | | | |
| | Temp Erosion & Sediment Control | 1.0% | LS | 1 | $ 2,401,000 | $ 2,401,000 | | | |
| | Temp. Protection and Direction of Traffic | 2.0% | LS | 1 | $ 4,802,000 | $ 4,802,000 | | | |
| | Removal of Existing Structure and Obstruction | | LS | 1 | $ 16,500,000 | $ 16,500,000 | | | |
| | Removal of Existing Buildings | | LS | 1 | $ 1,250,000 | $ 1,250,000 | | | |
| | Site Preparation | 1.0% | LS | 1 | $ 2,401,000 | $ 2,401,000 | | | |
| | **Civil/Roadwork** | | | | | Contingency = | 20% | $ 16,233,000 | |
| | Roadway Surface | | LS | 1 | $ 1,154,000 | $ 1,154,000 | | | |
| | Traffic Signals | | LS | 1 | $ 1,200,000 | $ 1,200,000 | | | |
| | Illumination | | LS | 1 | $ 926,000 | $ 926,000 | | | |
| | Earthwork | | LS | 1 | $ 1,195,000 | $ 1,195,000 | | | |
| | Storm Water & Drainage | | LS | 1 | $ 2,572,000 | $ 2,572,000 | | | |
| | Erosion Control & Planting | 1.00% | LS | 1 | $ 2,580,000 | $ 2,580,000 | | | |
| | ~~Pedestrian Connections (East-West Elev Basis)~~ | | LS | 0 | $ - | $ - | | | |
| | LRT Impacts | | LS | 1 | $ 2,320,000 | $ 2,320,000 | | | |
| | Utilities | | LS | 1 | $ 1,580,000 | $ 1,580,000 | | | |
| | **Bridge Structure** | | | | | Contingency = | 25% | $ 248,596,000 | |
| | West Approach Conventional | | LS | 1 | $ 13,933,163 | $ 13,933,163 | | | |
| | West Approach Long | | LS | 1 | $ 7,831,088 | $ 7,831,088 | | | |
| | Main River Movable Span | | LS | 1 | $ 117,459,658 | $ 117,459,658 | | | |
| | East Approach Long | | LS | 1 | $ 52,271,629 | $ 52,271,629 | | | |
| | East Approach Conventional | | LS | 1 | $ 3,198,774 | $ 3,198,774 | | | |
| | Pier Protection | | LS | 1 | $ 2,000,000 | $ 2,000,000 | | | |
| | Harbor Wall Reconstruction | | LS | 0 | $ 1,500,000 | $ - | | | |
| | Existing Pier Rip-Rap Removal | | LS | 1 | $ 2,182,000 | $ 2,182,000 | | | |
| | **Temporary Construction** | | | | | Contingency = | 15% | $ 31,830,000 | |
| | ~~Temporary Diversion Bridge~~ | | LS | 0 | $ - | $ - | | | |
| | ~~Staged Construction Premium~~ | | LS | 0 | $ - | $ - | | | |
| | Temporary Marine Works (work bridges, cofferdams, etc.) | | LS | 1 | $ 27,678,000 | $ 27,678,000 | | | |
| | **Geotechnical Hazard Mitigation** | | | | | Contingency = | 15% | $ 27,458,000 | |
| | East Approach Ground Improvement | | LS | 1 | $ 23,875,704 | $ 23,875,704 | | | |
| | West Approach Ground Improvement | | LS | 0 | $ - | $ - | | | |
| | **Other Related Items** | | | | | Contingency = | 30% | $ 153,508,000 | |
| | Aesthetics Premium | 2% | LS | 1 | $ 5,000,000 | $ 5,000,000 | | | |
| | Willamette River Mitigation (floodway, habitat) | | LS | 1 | $ 412,500 | $ 412,500 | | | |
| | Contractor Access Premium (barges, RR, parks, off-site staging) | | LS | 1 | $ 15,000,000 | $ 15,000,000 | | | |
| | Facility Impacts (classroom, Esplanade, Sat. Mkt, skatepark) | | LS | 1 | $ 1,500,000 | $ 1,500,000 | | | |
| | Sewer pipe relocation (west bank) | | LS | 0 | $ 10,000,000 | $ - | | | |
| | TriMet (temporary catenary, bus bridge) | | LS | 0 | $ 800,000 | $ - | | | |
| | UPRR Protection and Flagging | | LS | 1 | $ 3,000,000 | $ 3,000,000 | | | |
| | Gross Receipts Tax (3%) | | LS | 1 | $ 11,329,890 | $ 11,329,890 | | | |
| | Contractor Work Zone Security | | LS | 1 | $ 3,000,000 | $ 3,000,000 | | | |
| | Tug Assists | | LS | 1 | $ 800,000 | $ 800,000 | | | |
| | River Patrol | | LS | 1 | $ 600,000 | $ 600,000 | | | |
| | General Conditions (from Owner's Rep Ind Cost Estimate) | | LS | 1 | $ 77,440,000 | $ 77,440,000 | | | (1) |
| | | | | | | Weighted Direct Contingency = | 23.9% | | |
| | **Construction Total with Contingency** | | | | | | | $ 531,171,000 | |
| | Subtotal (wo Other Related Items) | | | | | $ 310,518,016 | $ 377,663,000 | | |
| | Other Related Items | | | | | $ 118,082,390 | $ 153,508,000 | | |
| | **Cost Risk Analysis - Additional Contingency** | | | | | | | $ 22,400,000 | |
| | Market Conditions, Material Fluctuations, Risks, and Uncertainties | | | | | $ 22,400,000 | | | |
| | | | | | | Weighted Total Project Contingency = | 29.2% | | |
| | **Right of Way** | | | | | | | $ 27,781,000 | |
| | **Engineering & Project Delivery** | | | | | | | $ 171,748,393 | |
| | NEPA Phase | | | | | $ - | | | |
| | PE (Incl. Design, PI, ROW Acquisition, OR, CMGC) + | (PE) | | | | $ 90,000,000 | | | |
| | County Admin. (Oversight, Permits, etc) | | | | | $ - | | | |
| | Construction Engineering | (CEI) | 15% | | | $ 81,748,393 | | | |
| | **Total Project Cost before Inflation (2022 $)** | | | | | | | $ 753,100,393 | (2) |
| | **Const Cumulative Inflation (annual rate)** | 3.5% | years | 6.2 | 23.8% | $ 145,717,000 | | | (3) |
| | **ROW Cumulative Inflation (annual rate)** | 5.0% | years | 4.5 | 24.6% | $ 6,821,000 | | | (4) |
| | **Total Project Programmatic Cost (2028 $)** | | | | | | | $ 905,638,393 | |

Notes:

(1) General Conditions is estimated separately from the Direct Costs and Contingencies included within each item

(2) Cost Risk Analysis was performed by an Independent CRA Specialist consistent with FHWA Procedures cited here: https://www.fhwa.dot.gov/majorprojects/cost_estimating/

(3) This is the non-escalated subtotal of all Program costs (in 2022 dollars)

(4) Equivalent time to mid-point of construction for various work packages (weighted)

(5) Assumes ROW is acquired before construction phase of Main Construction Package

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### Figure 13: Quantities and Estimate Without Ground Improvement

**EARTHQUAKE READY BURNSIDE BRIDGE COST ESTIMATE WORKSHEET**
**Alt1: Girder - Bascule - Cable Stayed Bridge Type Configuration**

| | | | |
|---|---|---|---|
| BRIDGE NUMBER(S): 00511, 00511A, 00511B | | COUNTY: Multnomah | |
| BRIDGE NAME: Burnside Bridge and Approaches | STATE HIGHWAY NUMBER: N/A | ROUTE NUMBER: N/A | |
| Mile Post / SCOPE: Alt1: Girder - Bascule - Cable Stayed Bridge Type Configuration | REFERENCE NAME/PHONE: Steve Drahota / (503) 423-3712 | Date Entered: 8/3/2021 | SMD / Date Checked: 10/2/2022 |

| No. | ITEM | | UNIT | QUANTITY | UNIT COST | SUB TOTAL | | Section Totals | Notes |
|---|---|---|---|---|---|---|---|---|---|
| | **Preparation** | | | | | Contingency = | 15% | $ 54,083,000 | |
| | Mobilization | 8.0% | LS | 1 | $ 19,518,000 | $ 19,518,000 | | | |
| | Temp Erosion & Sediment Control | 1.0% | LS | 1 | $ 2,440,000 | $ 2,440,000 | | | |
| | Temp. Protection and Direction of Traffic | 2.0% | LS | 1 | $ 4,880,000 | $ 4,880,000 | | | |
| | Removal of Existing Structure and Obstruction | | LS | 1 | $ 16,500,000 | $ 16,500,000 | | | |
| | Removal of Existing Buildings | | LS | 1 | $ 1,250,000 | $ 1,250,000 | | | |
| | Site Preparation | 1.0% | LS | 1 | $ 2,440,000 | $ 2,440,000 | | | |
| | **Civil/Roadwork** | | | | | Contingency = | 20% | $ 16,290,000 | |
| | Roadway Surface | | LS | 1 | $ 1,154,000 | $ 1,154,000 | | | |
| | Traffic Signals | | LS | 1 | $ 1,200,000 | $ 1,200,000 | | | |
| | Illumination | | LS | 1 | $ 926,000 | $ 926,000 | | | |
| | Earthwork | | LS | 1 | $ 1,195,000 | $ 1,195,000 | | | |
| | Storm Water & Drainage | | LS | 1 | $ 2,572,000 | $ 2,572,000 | | | |
| | Erosion Control & Planting | 1.00% | LS | 1 | $ 2,628,000 | $ 2,628,000 | | | |
| | ~~Pedestrian Connections (East-West Elev Basis)~~ | | LS | 0 | $ - | $ - | | | |
| | LRT Impacts | | LS | 1 | $ 2,320,000 | $ 2,320,000 | | | |
| | Utilities | | LS | 1 | $ 1,580,000 | $ 1,580,000 | | | |
| | **Bridge Structure** | | | | | Contingency = | 25% | $ 253,396,000 | |
| | West Approach Conventional | | LS | 1 | $ 13,933,163 | $ 13,933,163 | | | |
| | West Approach Long | | LS | 1 | $ 7,831,088 | $ 7,831,088 | | | |
| | Main River Movable Span | | LS | 1 | $ 117,459,658 | $ 117,459,658 | | | |
| | East Approach Long | | LS | 1 | $ 56,111,477 | $ 56,111,477 | | | |
| | East Approach Conventional | | LS | 1 | $ 3,198,774 | $ 3,198,774 | | | |
| | Pier Protection | | LS | 1 | $ 2,000,000 | $ 2,000,000 | | | |
| | Harbor Wall Reconstruction | | LS | 0 | $ 1,500,000 | $ - | | | |
| | Existing Pier Rip-Rap Removal | | LS | 1 | $ 2,182,000 | $ 2,182,000 | | | |
| | **Temporary Construction** | | | | | Contingency = | 15% | $ 31,830,000 | |
| | ~~Temporary Diversion Bridge~~ | | LS | 0 | $ - | $ - | | | |
| | ~~Staged Construction Premium~~ | | LS | 0 | $ - | $ - | | | |
| | Temporary Marine Works (work bridges, cofferdams, etc.) | | LS | 1 | $ 27,678,000 | $ 27,678,000 | | | |
| | **Geotechnical Hazard Mitigation** | | | | | Contingency = | 15% | $ - | |
| | East Approach Ground Improvement | | LS | 0 | $ - | $ - | | | |
| | West Approach Ground Improvement | | LS | 0 | $ - | $ - | | | |
| | **Other Related Items** | | | | | Contingency = | 30% | $ 152,647,000 | |
| | Aesthetics Premium | 2% | LS | 1 | $ 5,000,000 | $ 5,000,000 | | | |
| | Willamette River Mitigation (floodway, habitat) | | LS | 1 | $ 412,500 | $ 412,500 | | | |
| | Contractor Access Premium (barges, RR, parks, off-site staging) | | LS | 1 | $ 15,000,000 | $ 15,000,000 | | | |
| | Facility Impacts (classroom, Esplanade, Sat. Mkt, skatepark) | | LS | 1 | $ 1,500,000 | $ 1,500,000 | | | |
| | Sewer pipe relocation (west bank) | | LS | 0 | $ 10,000,000 | $ - | | | |
| | TriMet (temporary catenary, bus bridge) | | LS | 0 | $ 800,000 | $ - | | | |
| | UPRR Protection and Flagging | | LS | 1 | $ 3,000,000 | $ 3,000,000 | | | |
| | Gross Receipts Tax (3%) | | LS | 1 | $ 10,667,970 | $ 10,667,970 | | | |
| | Contractor Work Zone Security | | LS | 1 | $ 3,000,000 | $ 3,000,000 | | | |
| | Tug Assists | | LS | 1 | $ 800,000 | $ 800,000 | | | |
| | River Patrol | | LS | 1 | $ 600,000 | $ 600,000 | | | |
| | General Conditions (from Owner's Rep Ind Cost Estimate) | | LS | 1 | $ 77,440,000 | $ 77,440,000 | | | (1) |
| | | | | | | Weighted Direct Contingency = | 24.4% | | |
| | **Construction Total with Contingency** | | | | | | | $ 508,246,000 | |
| | Subtotal (wo Other Related Items) | | | | | $ 290,997,161 | $ 355,599,000 | | |
| | Other Related Items | | | | | $ 117,420,470 | $ 152,647,000 | | |
| | **Cost Risk Analysis - Additional Contingency** | | | | | | | $ 22,400,000 | |
| | Market Conditions, Material Fluctuations, Risks, and Uncertainties | | | | | $ 22,400,000 | | | |
| | | | | | | Weighted Total Project Contingency = | 29.9% | | |
| | **Right of Way** | | | | | | | $ 27,781,000 | |
| | **Engineering & Project Delivery** | | | | | | | $ 171,748,393 | |
| | NEPA Phase | | | | | $ - | | | |
| | PE (Incl. Design, PI, ROW Acquisition, OR, CMGC) + | (PE) | | | | $ 90,000,000 | | | |
| | County Admin. (Oversight, Permits, etc) | | | | | $ - | | | |
| | Construction Engineering | (CEI) | 15% | | | $ 81,748,393 | | | |
| | **Total Project Cost before Inflation (2022 $)** | | | | | | | $ 730,175,393 | (2) |
| | **Const Cumulative Inflation (annual rate)** | 3.5% | years | 6.2 | 23.8% | $ 140,267,000 | | | (3) |
| | **ROW Cumulative Inflation (annual rate)** | 5.0% | years | 4.5 | 24.6% | $ 6,821,000 | | | (4) |
| | **Total Project Programmatic Cost (2028 $)** | | | | | | | $ 877,263,393 | |

Notes:

(1) General Conditions is estimated separately from the Direct Costs and Contingencies included within each item
(2) Cost Risk Analysis was performed by an Independent CRA Specialist consistent with FHWA Procedures cited here: https://www.fhwa.dot.gov/majorprojects/cost_estimating/
(3) This is the non-escalated subtotal of all Program costs (in 2022 dollars)
(4) Equivalent time to mid-point of construction for various work packages (weighted)
(5) Assumes ROW is acquired before construction phase of Main Construction Package

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# 6 Conclusion

This study's findings indicate the following:

- Material increases are necessary in the edge girders, stay cables, tie-down elements, and drilled shaft foundation to achieve project performance requirements after the LODE.
- Expansion joints, bearings, and tie-down elements will all need to be up-sized to accommodate ten inches of increased movement associated with lateral spreading.
- Vertical deflections of the superstructure, due to lateral spreading, and the resulting change in the roadway vertical profile are minor. This magnitude of displacement likely does not result in an unacceptable roadway profile and drainage and does not warrant post-EQ cable adjustments.
- The permanent deformation in the towers (approximately one inch at the top of the tower) resulting from lateral spreading is not structurally problematic and is aesthetically acceptable.
- The cost of the estimated material increases required if ground improvement is not utilized are less than the estimated cost of ground improvement.

Based on this study's findings, elimination of ground improvement for the cable-stayed tower foundation (Bent 8) is recommended. For the CDD submittal, the recommendation is to eliminate the cost of ground improvement and include the cost of up-front additional materials to account for slightly higher loads due to residual bridge displacements. This results in an estimated net savings of $28.3 million in programmatic costs.

Note that these findings are applicable to tower style/bridge configuration modeled. Other tower styles may not result in similar findings.

# 7 References

Multnomah County

2023 EQRB Basic of Design Memorandum: Post-Earthquake Emergency Response and Haul Vehicles Design Assessment (Available Upon Request).

2022a EQRB Final Preliminary NLTH Geotechnical Report (Unpublished).

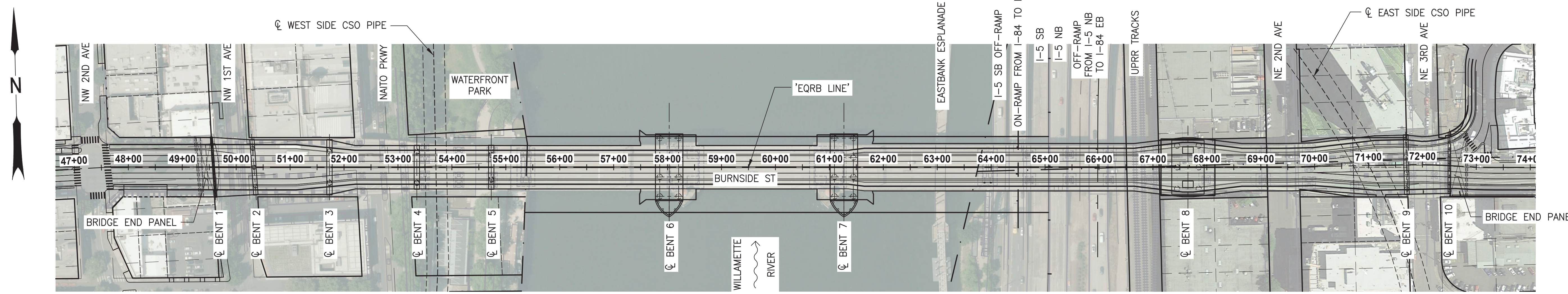
2022b Revised Bridge Design Criteria Report. https://www.multco.us/file/121738/download.

2022c Revised Seismic Design Criteria Report. https://www.multco.us/file/121739/download.

PTI (Post-Tensioning Institute)

2018 DC45.1-18: Recommendations for Stay Cable Design, Testing, and Installation. https://www.post-tensioning.org/publications/store/productdetail.aspx?ItemID=DC451&Language=English&Units=Metric

# Appendix A. Cable-Stayed Bridge Plans




PLAN

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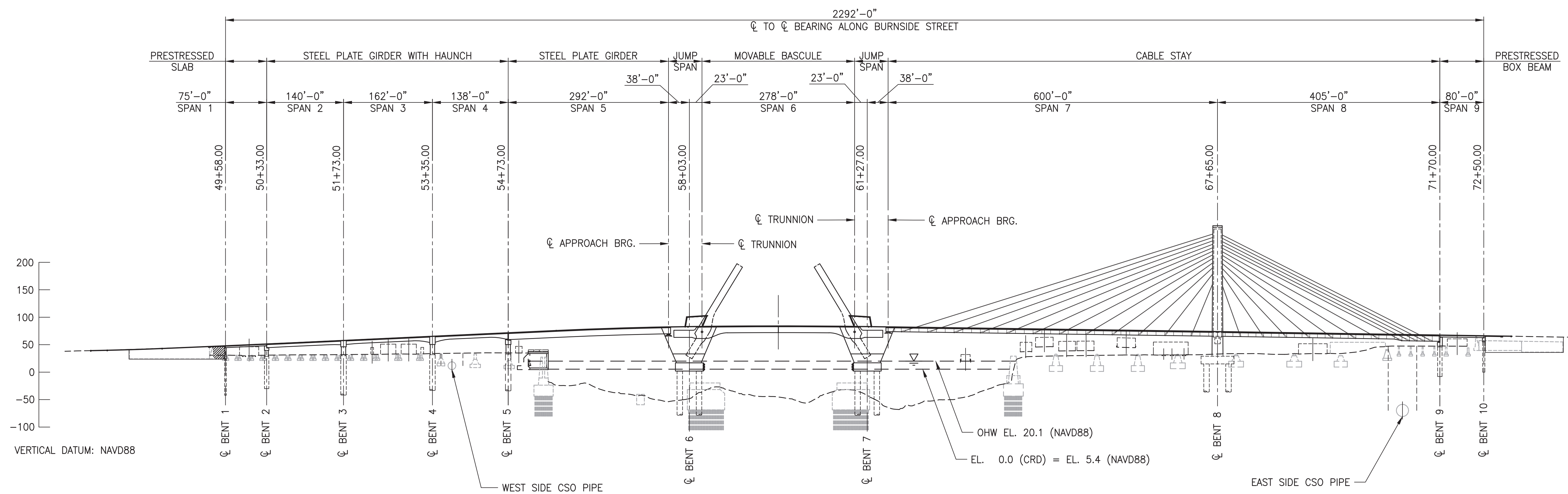


ELEVATION

SCALE: 1"=100'

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*General Layout*

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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CHECKED BY: HDR

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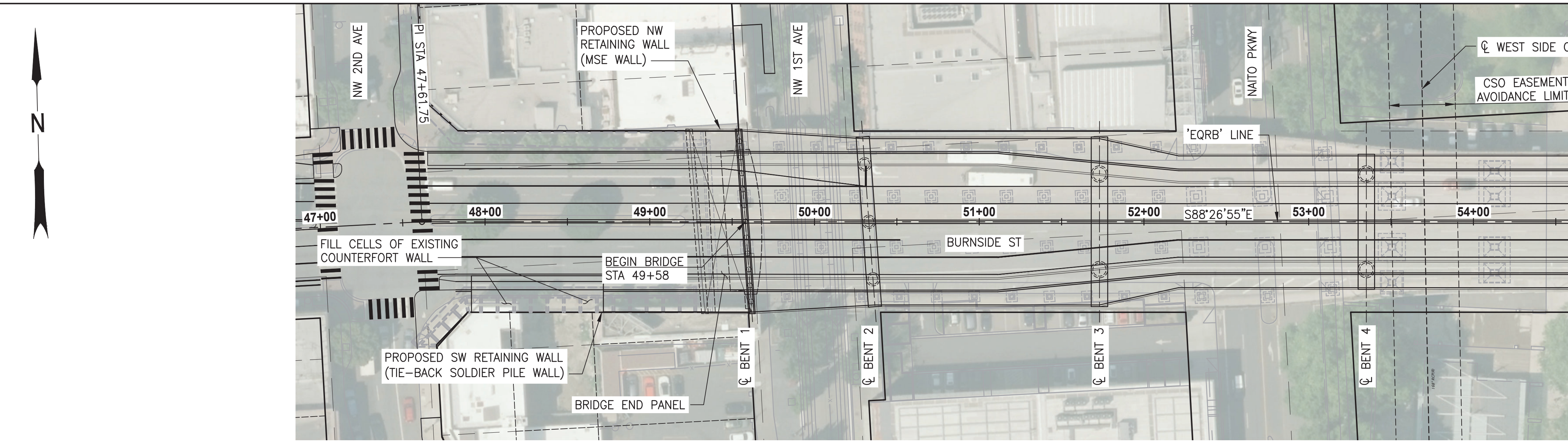


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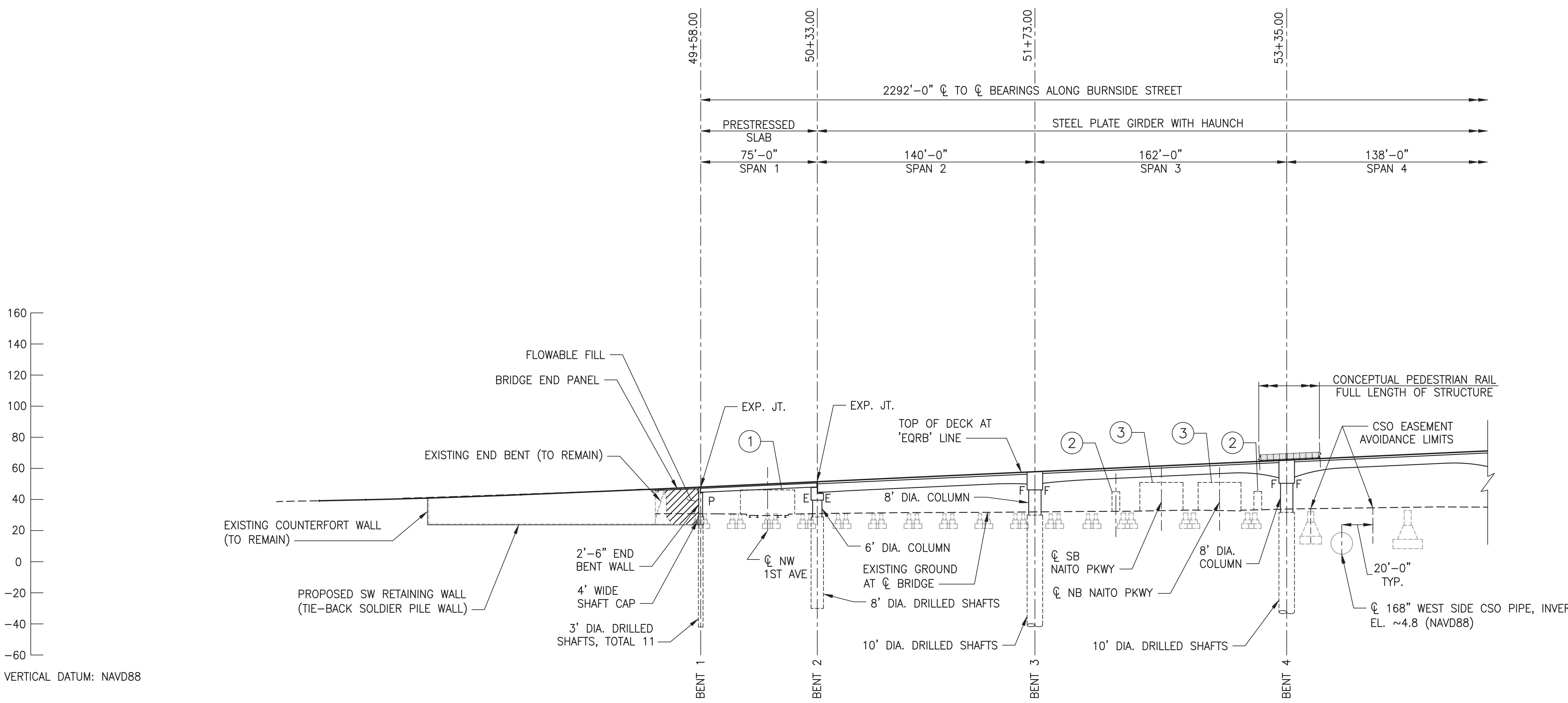


ELEVATION

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

| | | |
|---|---|---|
| 1 | TRIMET LRT | 15'-6" |
| 2 | PEDESTRIAN | 12'-0" |
| 3 | CITY STREET | 18'-0" |

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Plan and Elevation - 1*

DATE: 9/2022 | PROJECT NO.:

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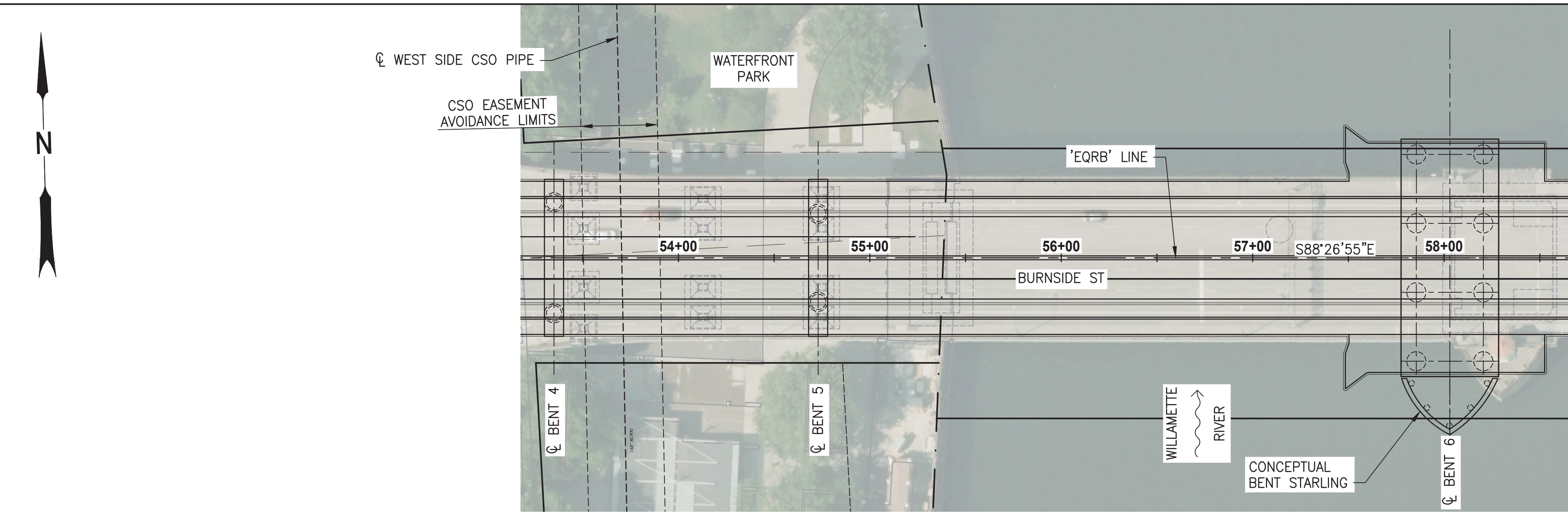


PLAN
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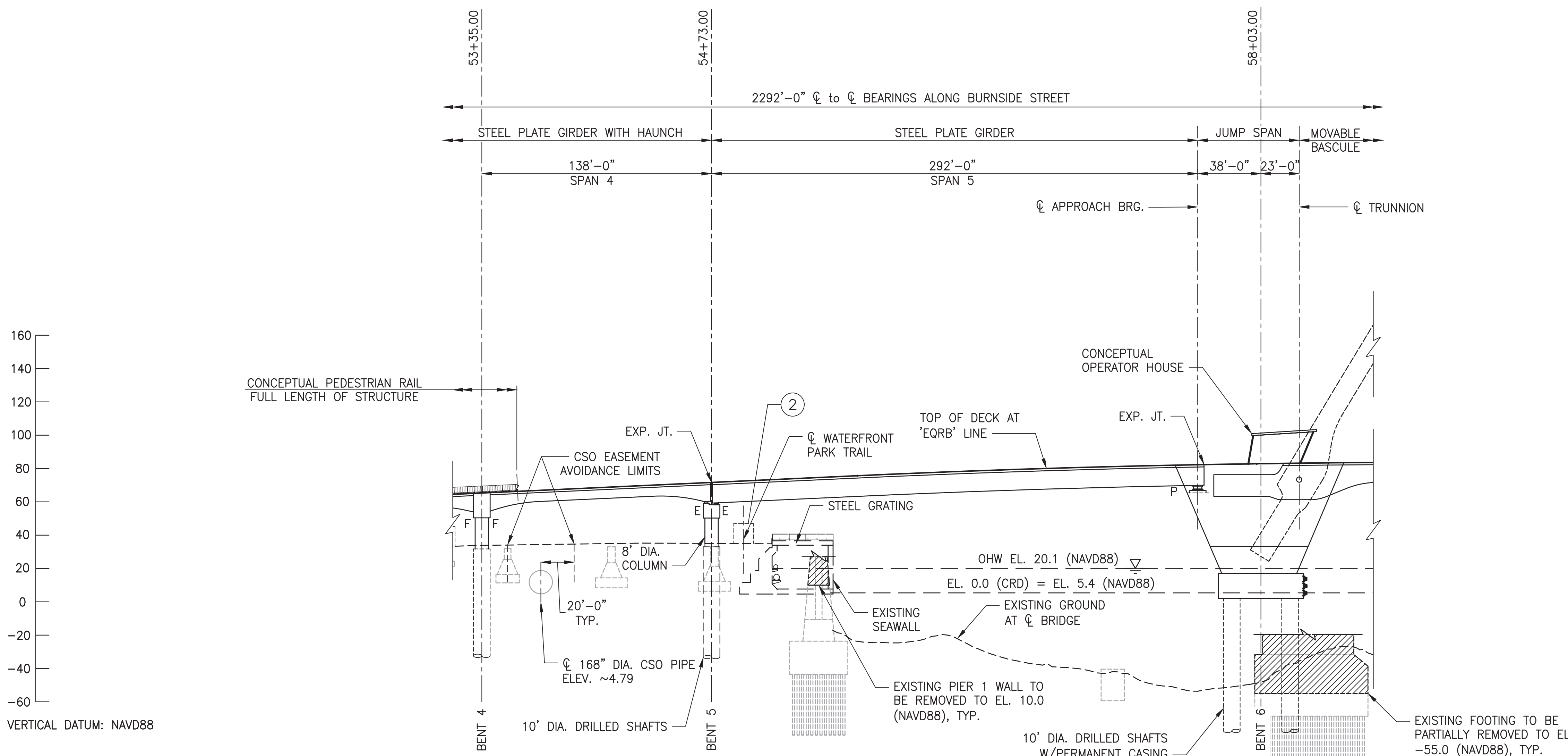


ELEVATION
SCALE: 1"=40'

LEGEND

BRIDGE REMOVAL

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

(2) PEDESTRIAN 12'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Plan and Elevation -2*

DATE: *9/2022* PROJECT NO.:

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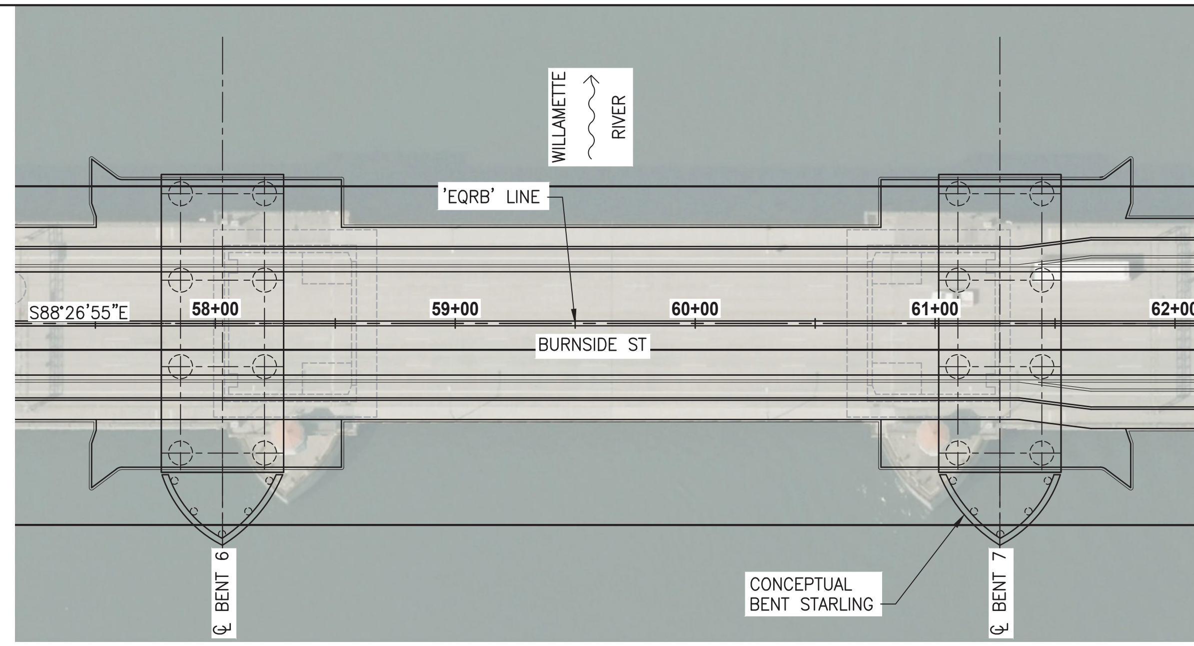


## PLAN

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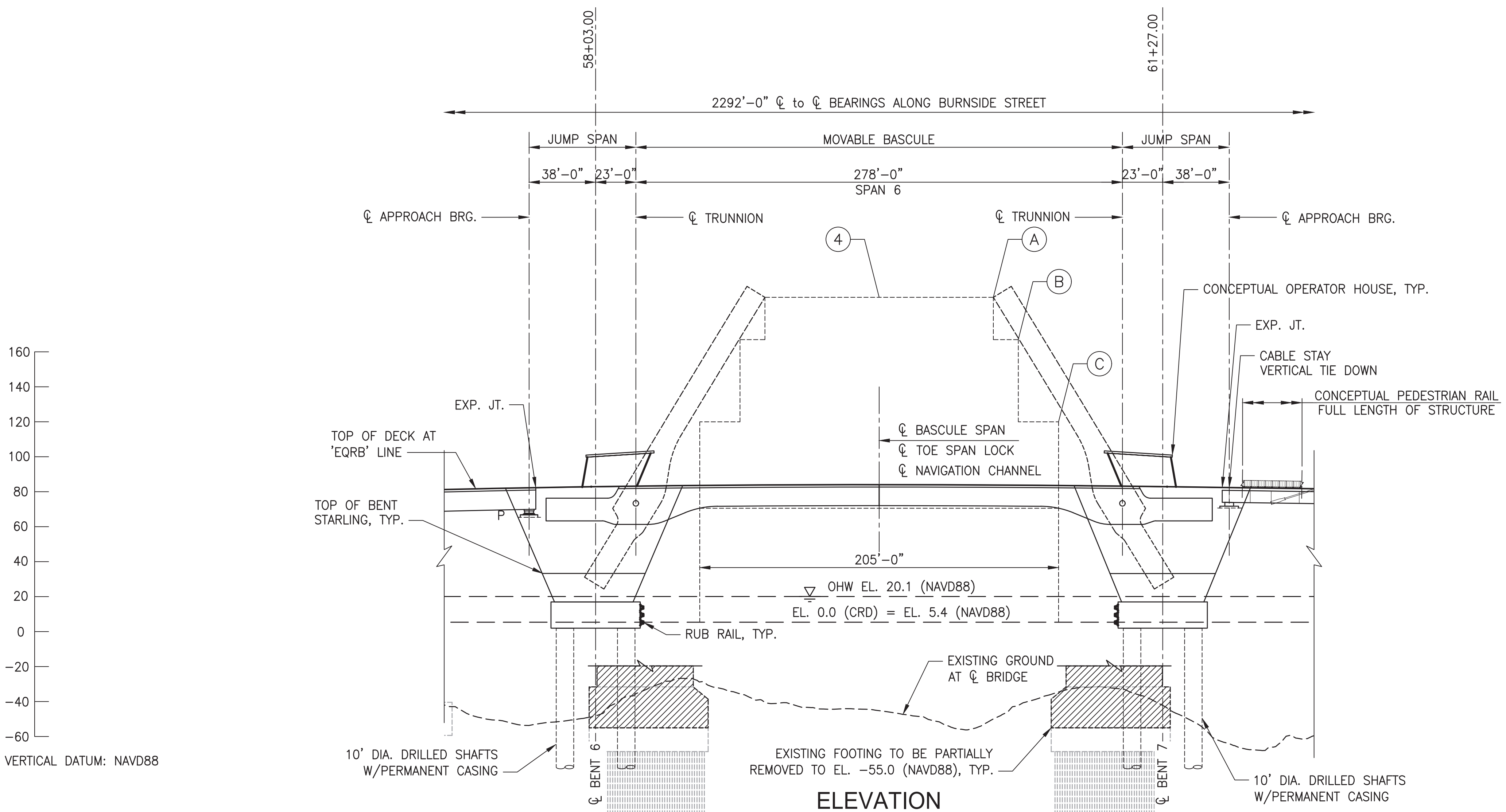


## ELEVATION

SCALE: 1"=40'

LEGEND

BRIDGE REMOVAL

NAVIGATION CLEARANCE ENVELOPE LEGEND

(4) NAVIGATION ENVELOPES

| ENVELOPE | VERTICAL CLEARANCE TO CRD | HORIZONTAL CLEARANCE |
|---|---|---|
| OPEN A | INFINITE | 130'-6" |
| OPEN B | 161'-7" | 159'-0" |
| OPEN C | 114'-7" | 205'-0" |
| CLOSED | 65'-2" | 205'-0" |

CRD: COLUMBIA RIVER DATUM

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Plan and Elevation - 3*

DATE: 9/2022 PROJECT NO.:

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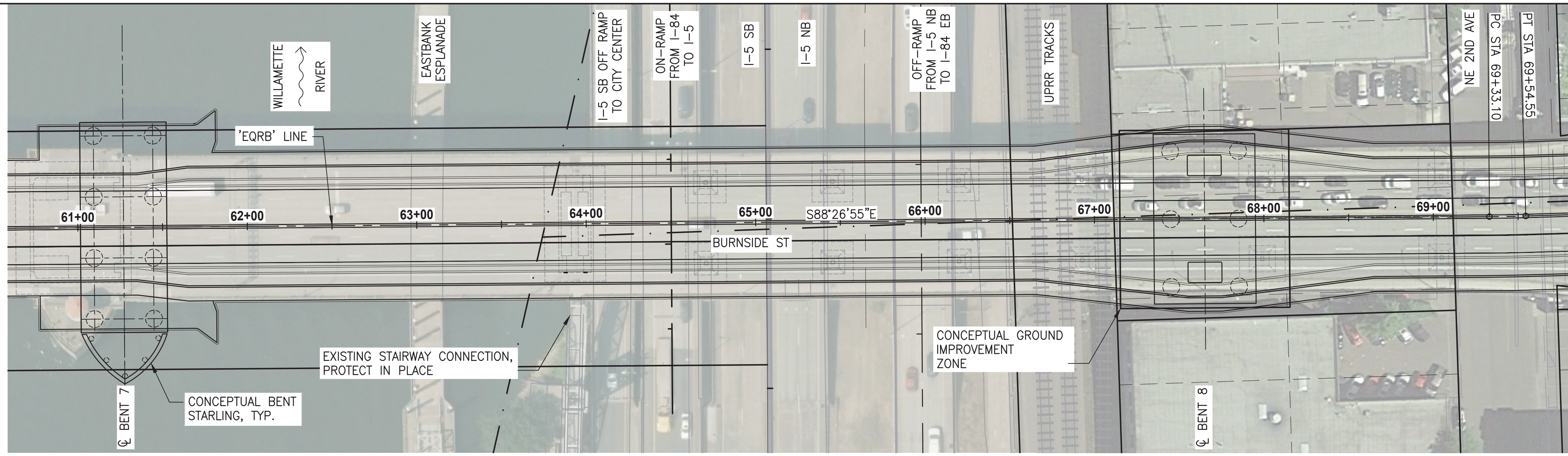


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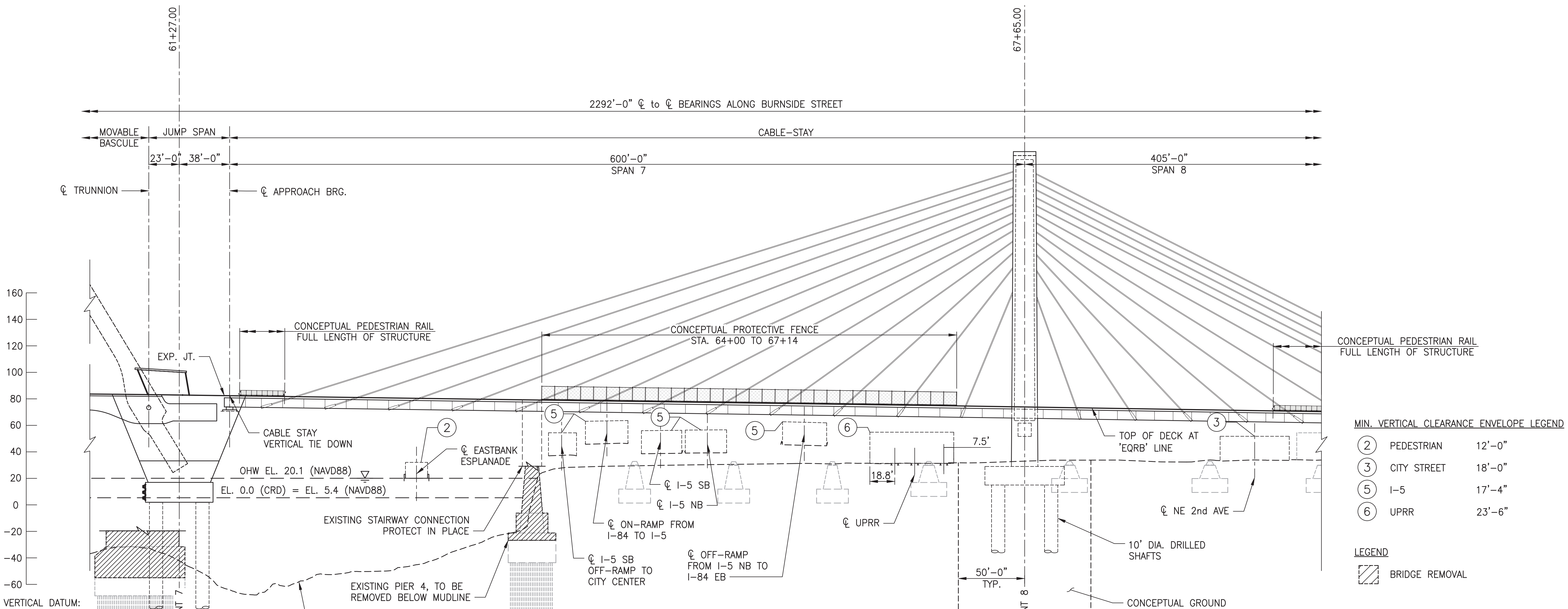


## ELEVATION

SCALE: 1"=40'

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Plan and Elevation -4*

DATE: 9/2022 PROJECT NO.:

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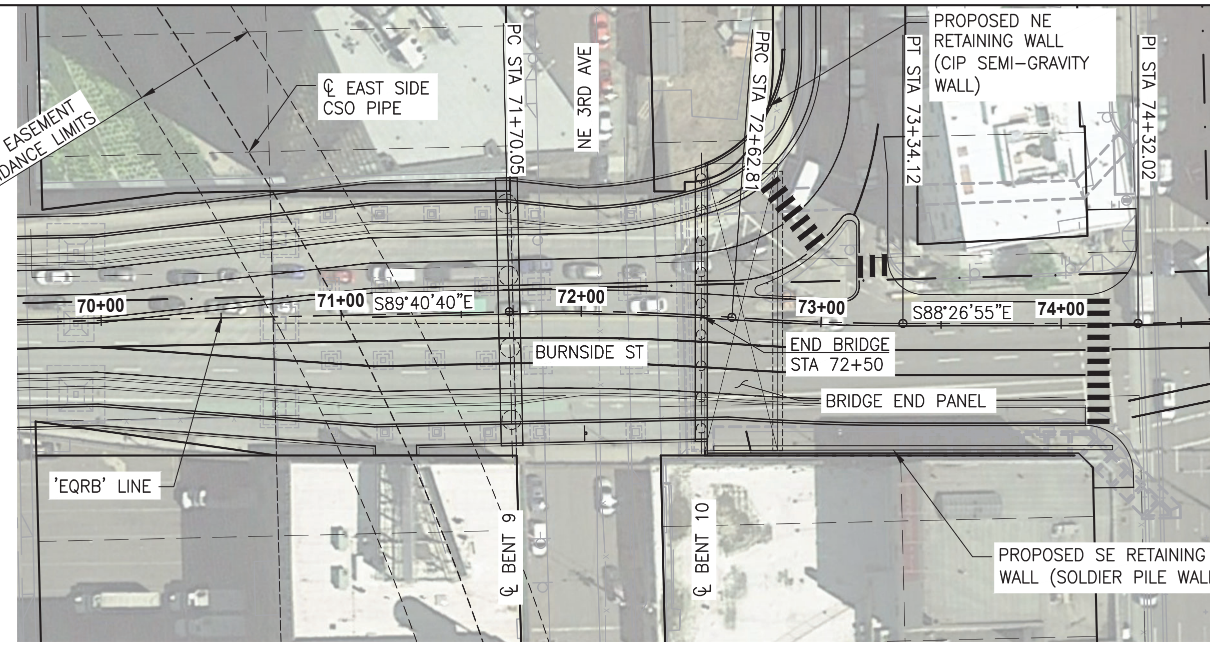


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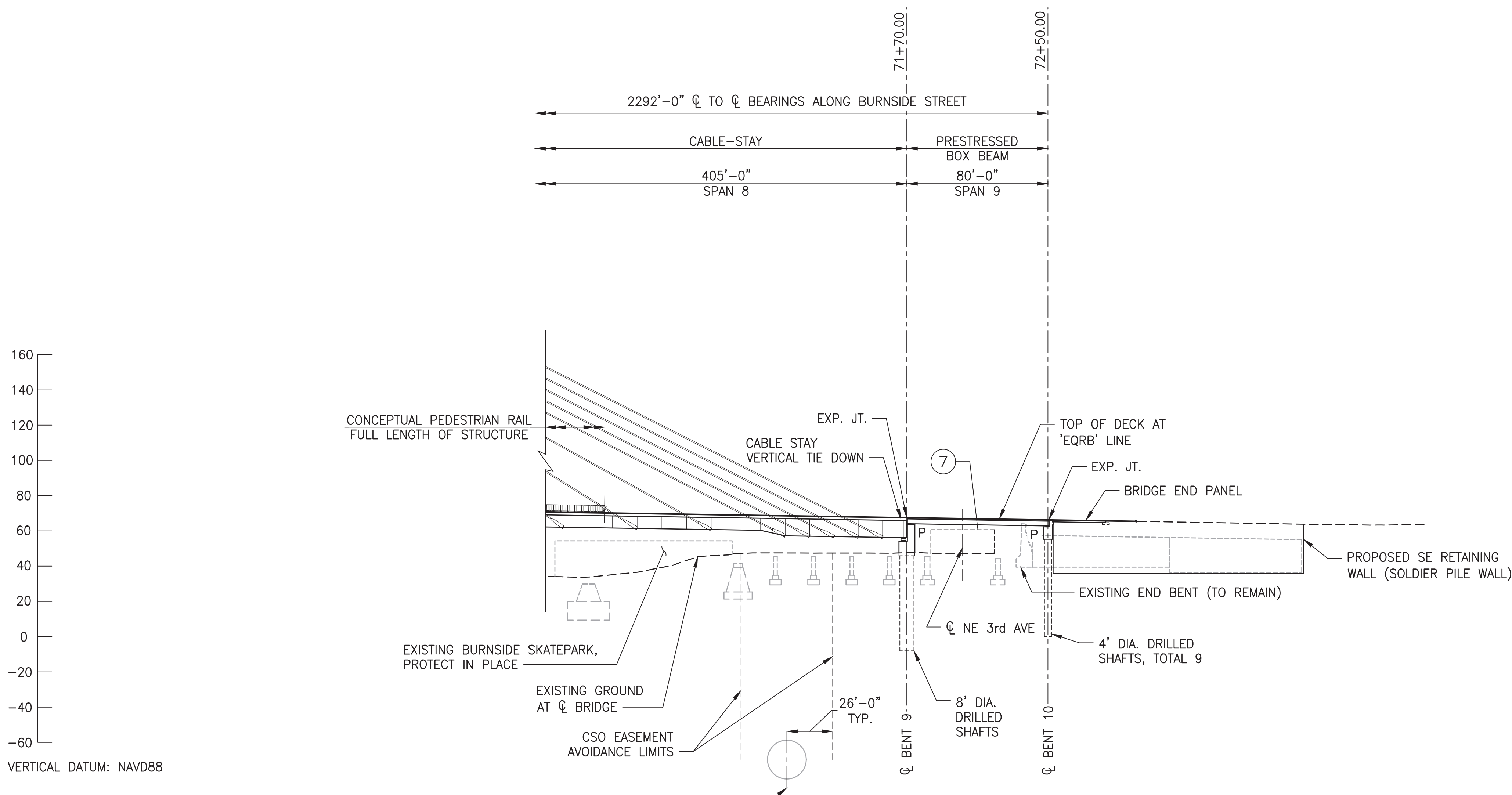


## ELEVATION
SCALE: 1"=40'

MIN. VERTICAL CLEARANCE ENVELOPE LEGEND

| | | |
|---|---|---|
| 7 | CITY STREET @ NE 3rd AVE | 13'-8" |

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Plan and Elevation - 5

DATE: 9/2022 | PROJECT NO.:

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CONCEPTUAL PLANS
SEPTEMBER 2022

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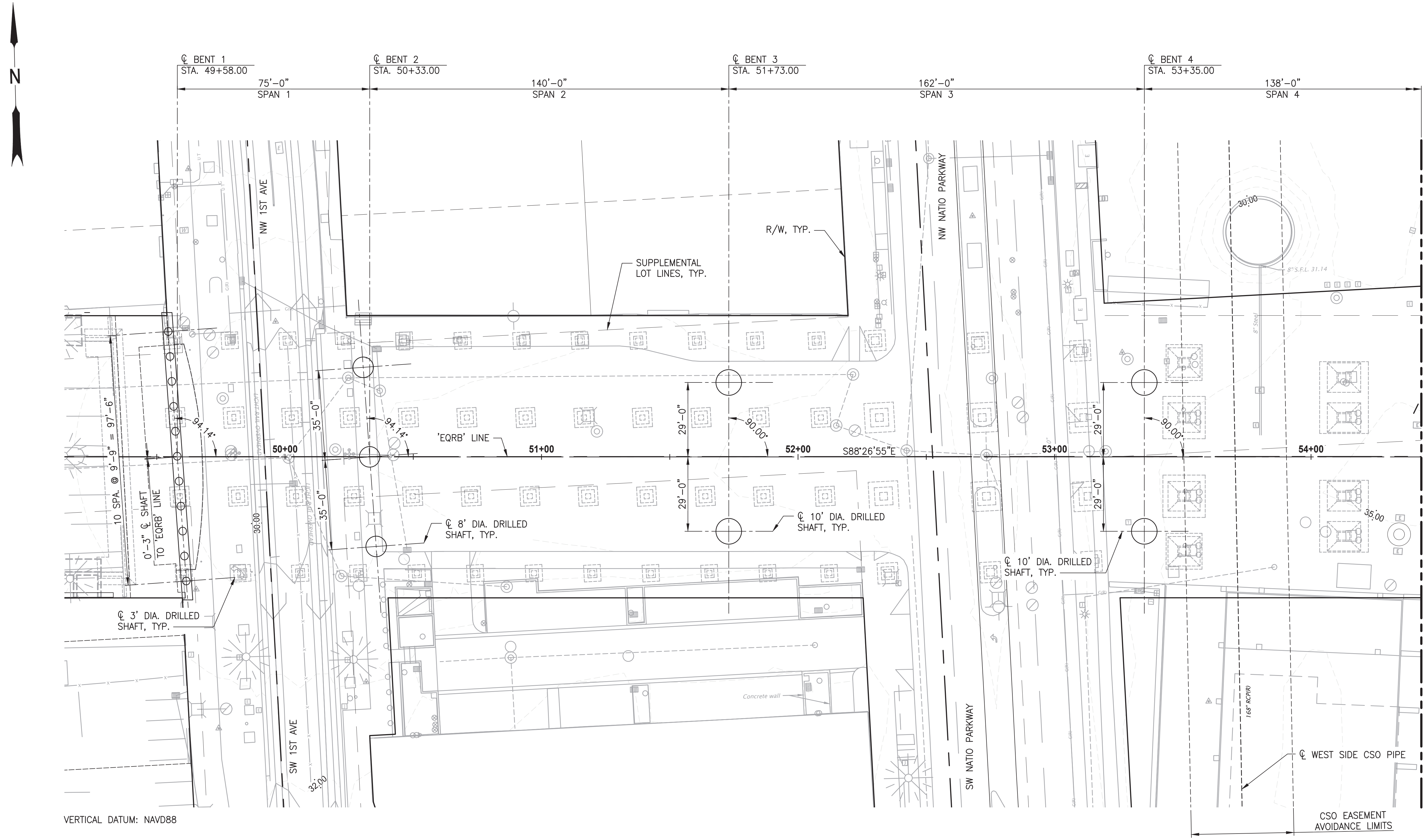


VERTICAL DATUM: NAVD88

## FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Foundation Plan - 1*

DATE: *9/2022* PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
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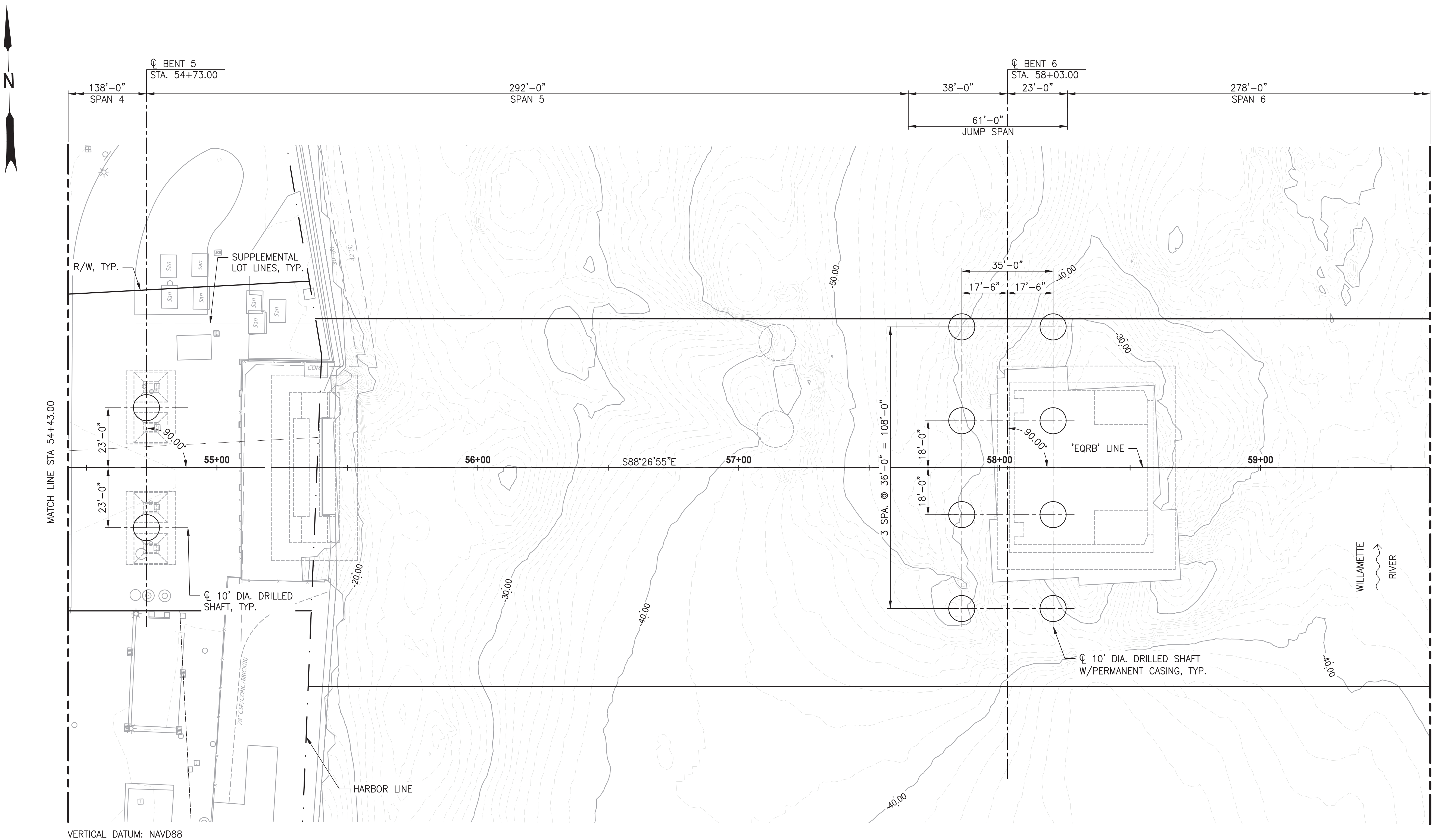


## FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25
2. CONCEPTUAL BENT STARLING FOUNDATION NOT SHOWN

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan -2

DATE: 9/2022

PROJECT NO.:

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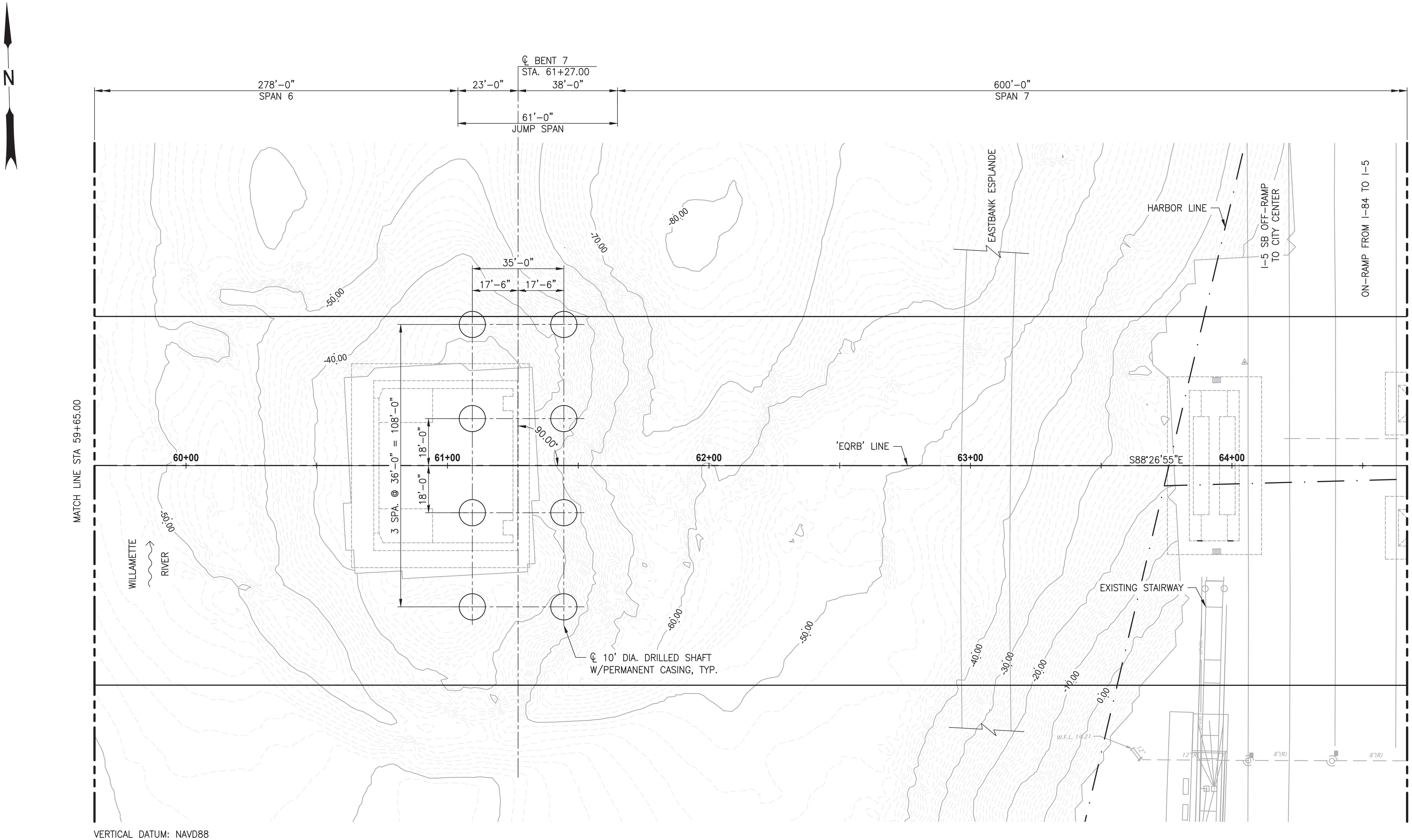


## FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25
2. CONCEPTUAL BENT STARLING FOUNDATION NOT SHOWN

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Foundation Plan – 3*

DATE: *9/2022*

PROJECT NO.:

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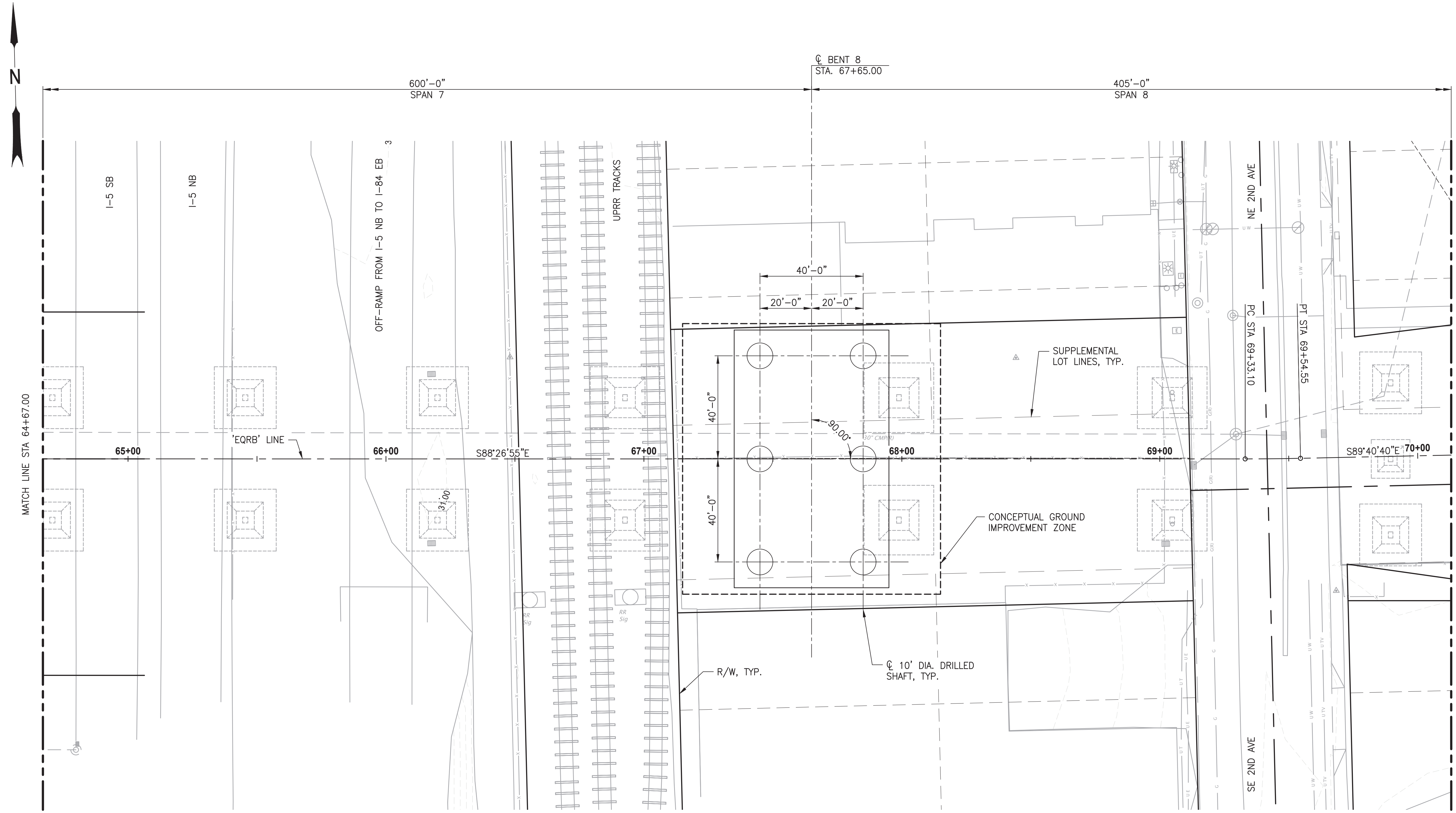


VERTICAL DATUM: NAVD88

## FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan -4

DATE: 9/2022 | PROJECT NO.:

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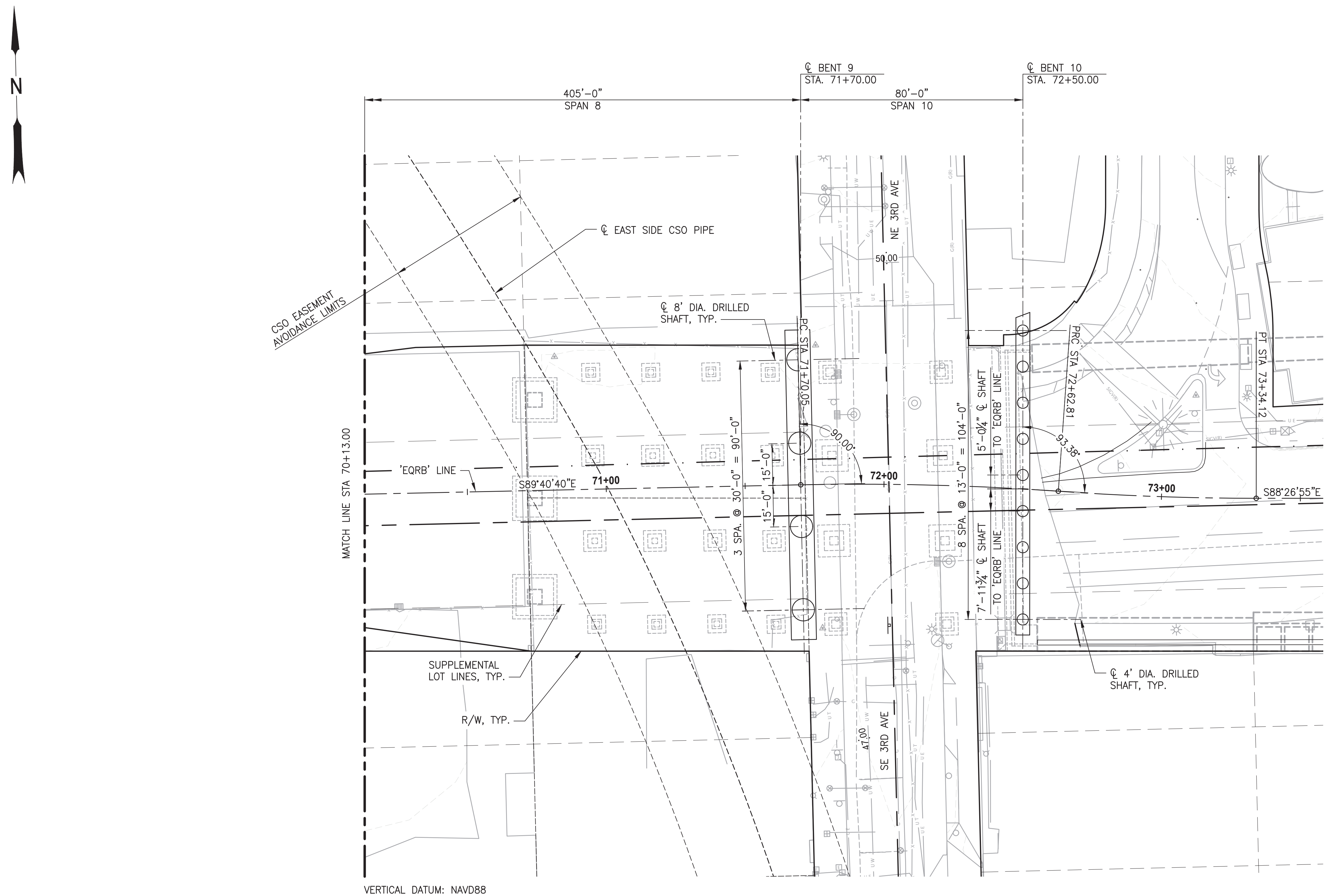


## FOUNDATION PLAN

SCALE: 1"=20'

NOTES:

1. FOR SUBSTRUCTURE INFORMATION NOT SHOWN, SEE SHEETS BR16–BR25

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Foundation Plan – 5

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

JON HENRICHSEN, COUNTY ENGINEER

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|---|---|---|
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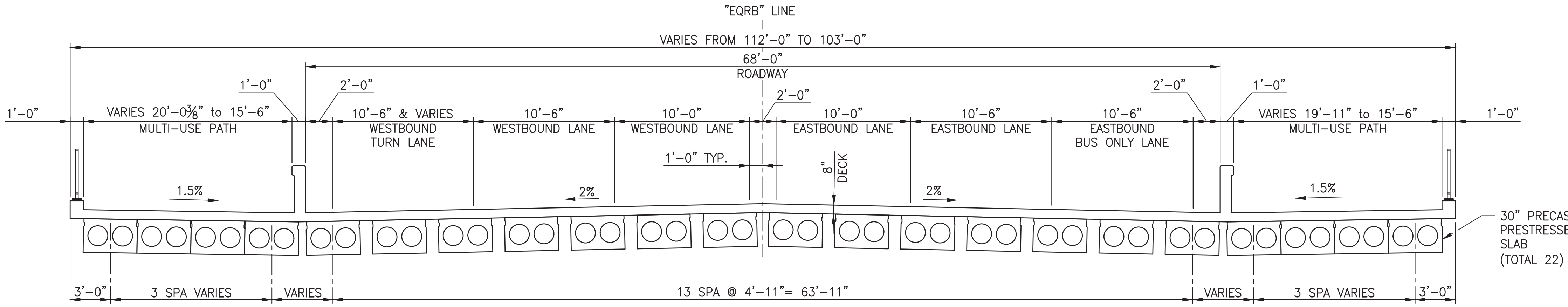
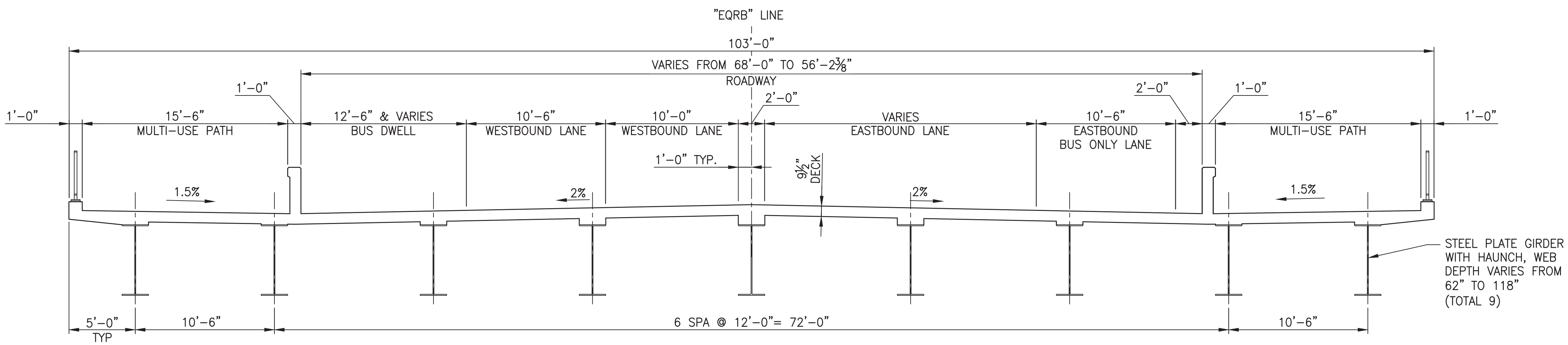


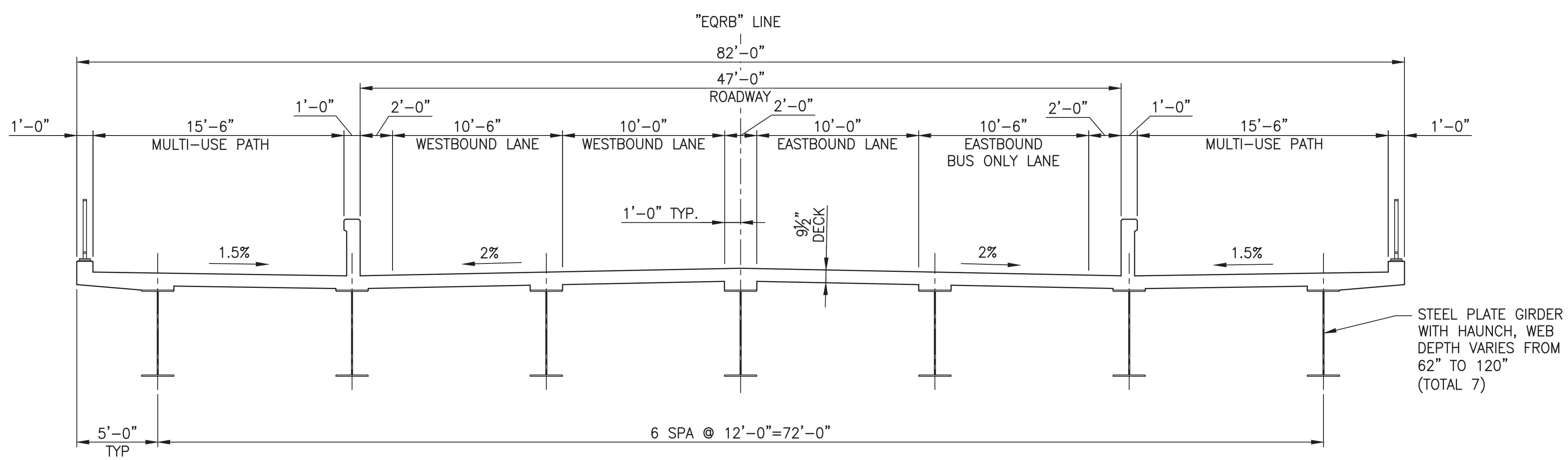

**TYPICAL SECTION - SPAN 1**

SCALE: 1" = 5'-0"
(AT BENT 2)




**TYPICAL SECTION - SPAN 2**

SCALE: 1" = 5'-0"
(AT BENT 3)




**TYPICAL SECTION - SPAN 3 THRU 4**

SCALE: 1" = 5'-0"
(MIDSPAN)

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Typical Sections -1*

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

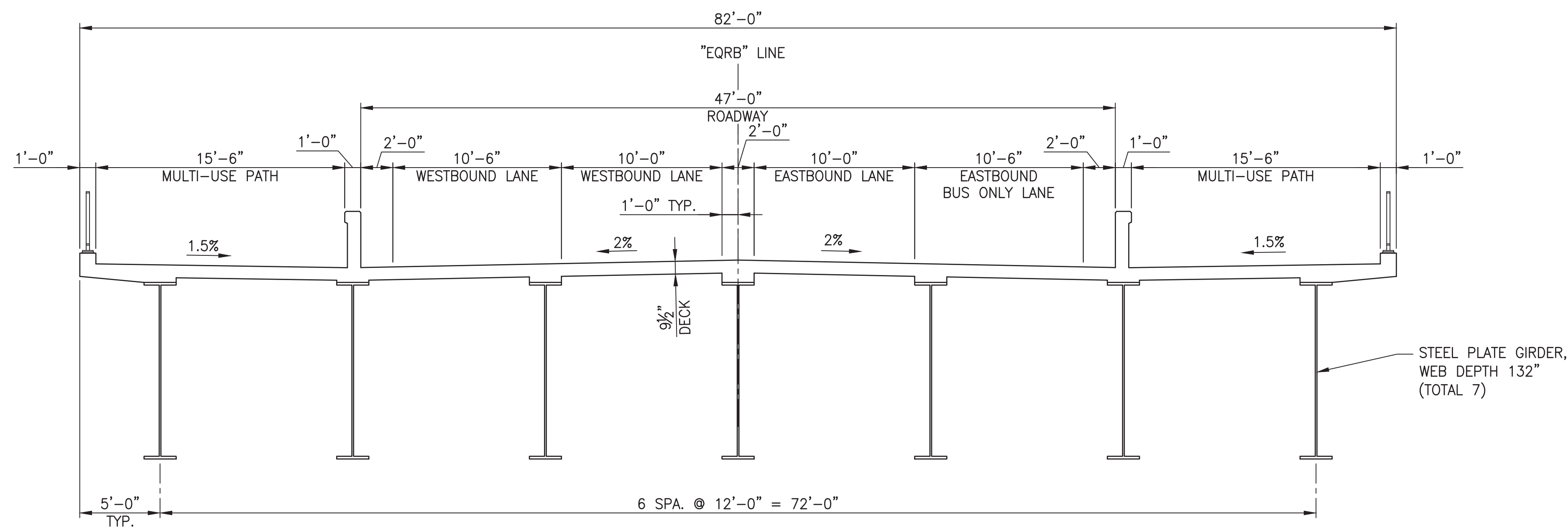
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

REVISIONS

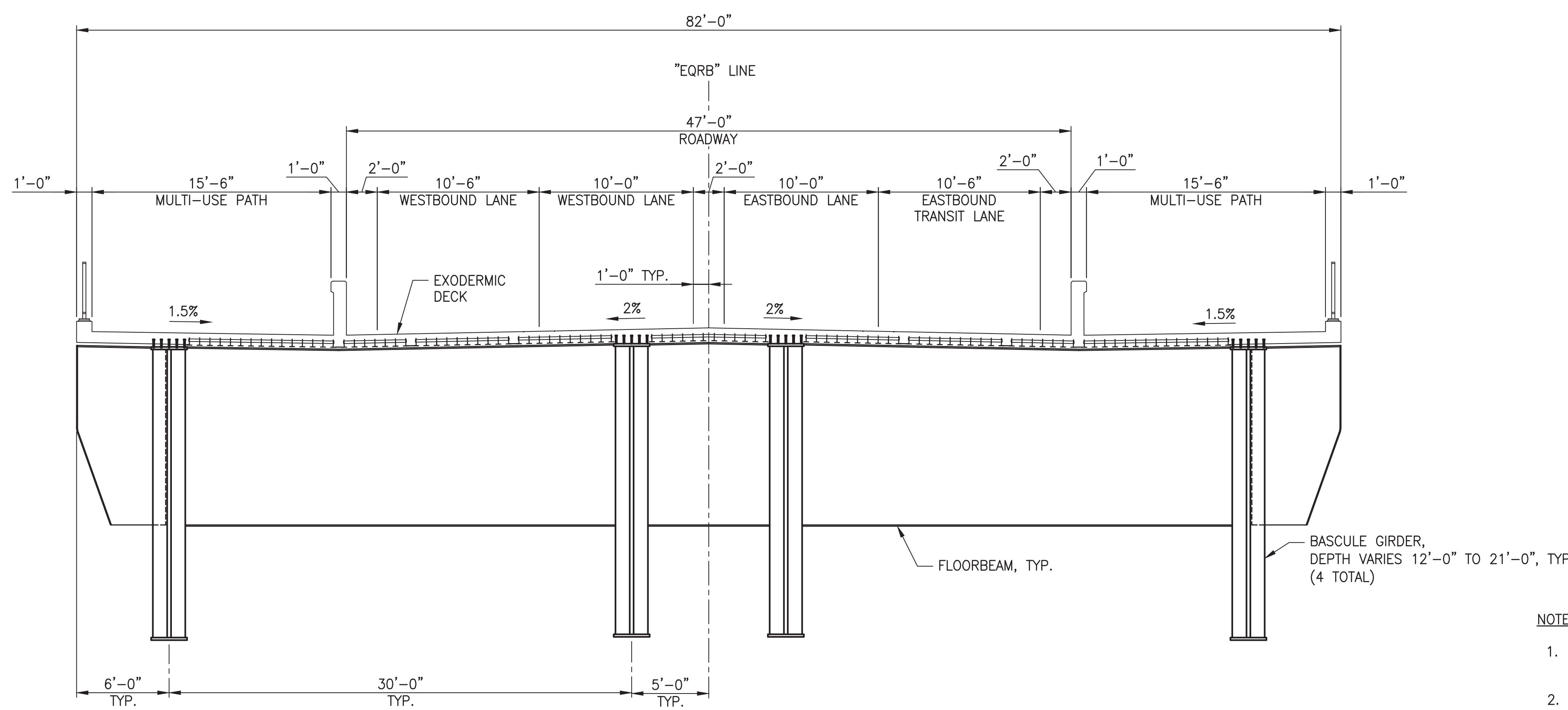
| NO | DATE: | | | |
|---|---|---|---|---|

Sheet No.
*BR12*




**TYPICAL SECTION - SPAN 5**

SCALE: 1" = 5'-0"




**TYPICAL SECTION - BASCULE SPAN**

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.
3. ADDITIONAL BRIDGE WIDTH WITHIN EXTENTS OF PIER 6&7 NOT SHOWN.

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Typical Sections -2*

DATE: *9/2022*

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

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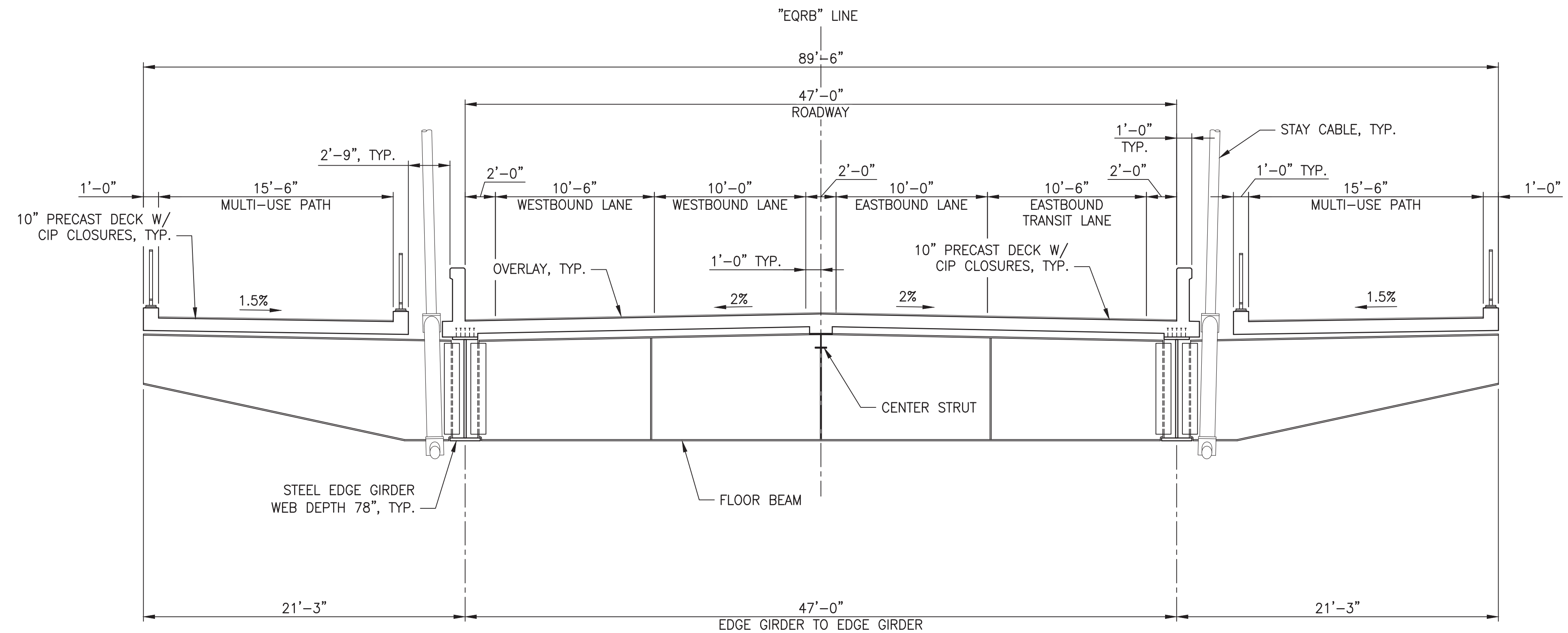
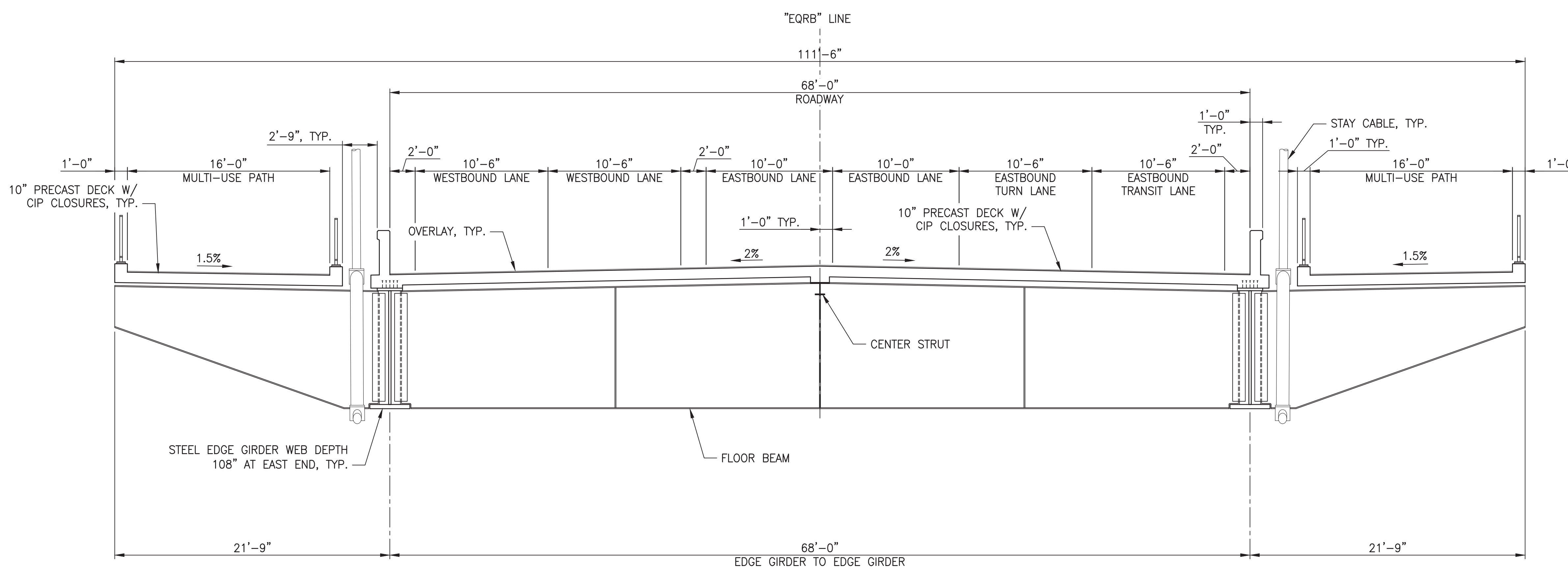
|---|---|---|---|---|---|

Sheet No. *BR13*




**4-LANE TYPICAL SECTION - CABLE-STAY SPAN (MINIMUM WIDTH)**

SCALE: 1" = 5'-0"




**6-LANE TYPICAL SECTION - CABLE-STAY SPAN (MAXIMUM WIDTH)**

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.
3. BRIDGE WIDTH VARIES THROUGHOUT SPANS 7&8 DUE TO ADDITION OF TOWERS, TURN LANES, AND BICYCLE LANE TRANSITIONS.
4. ADDITIONAL MULTI-USE PATH WIDTH FOR BELVEDERES NOT SHOWN.

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Typical Sections -3*

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
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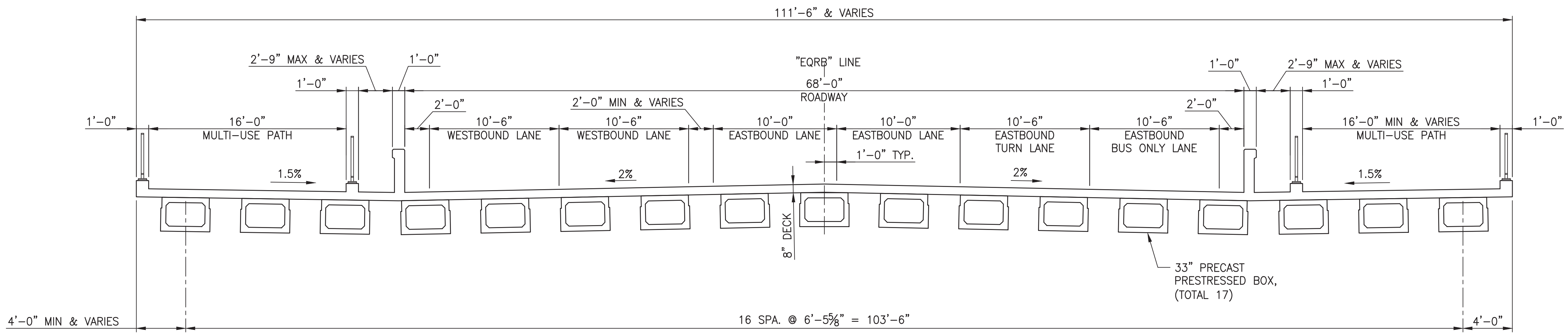
Sheet No. BR14




**TYPICAL SECTION - SPAN 9**

SCALE: 1" = 5'-0"

NOTES:

1. FOR BRIDGE PROFILE, SEE ROADWAY SHEETS.
2. CROSS SECTION DIMENSIONS SHOWN FOR PLANNING PURPOSES ONLY. FINAL DIMENSIONS TO BE DETERMINED DURING THE FINAL DESIGN PHASE.

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Typical Sections -4

DATE: 9/2022 | PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

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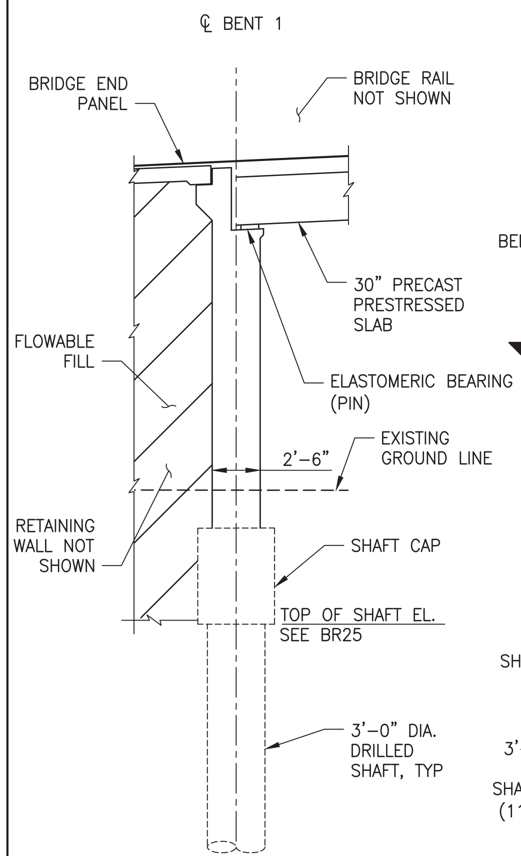
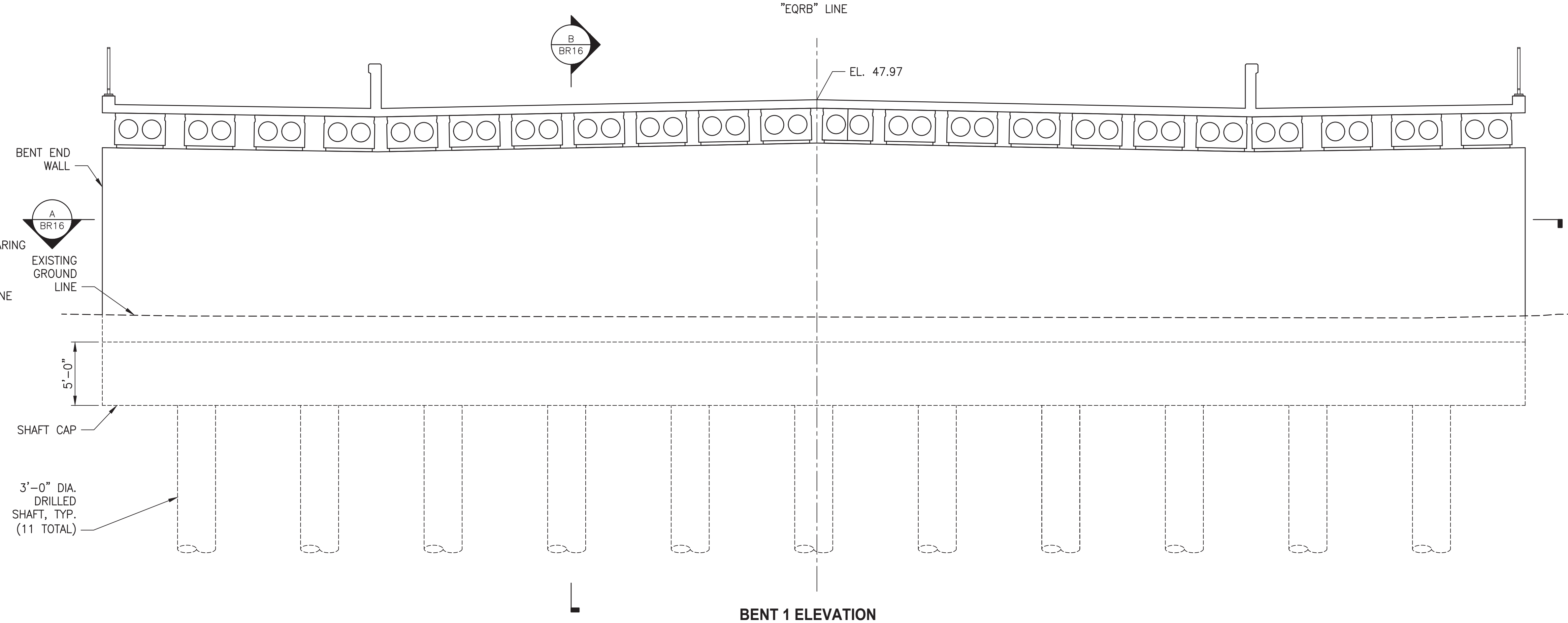
NO | DATE:

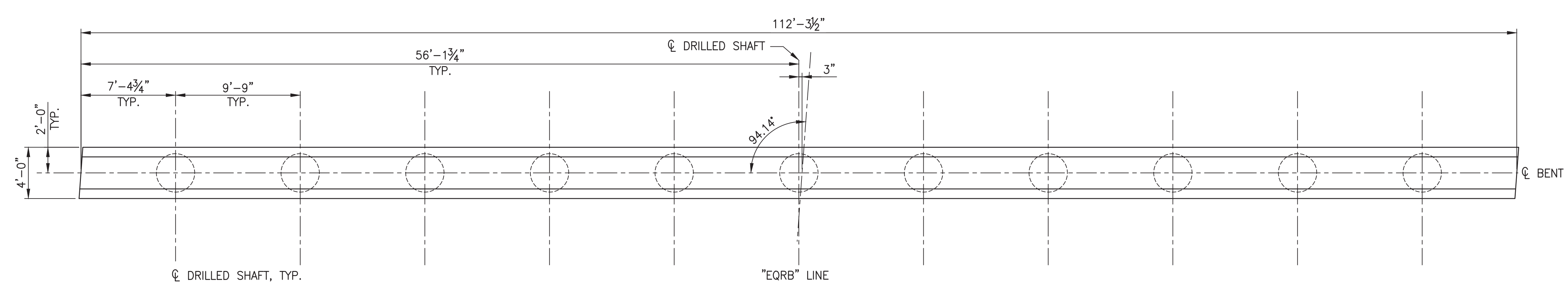
Sheet No. BR15




**SECTION B**
SCALE: 1" = 5'-0"




**BENT 1 ELEVATION**
SCALE: 1" = 5'-0"
(LOOKING BACK ON STATION)




**SECTION A**
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Bent 1 Details*

DATE: 9/2022 PROJECT NO.:


MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999
JON HENRICHSEN, COUNTY ENGINEER


DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

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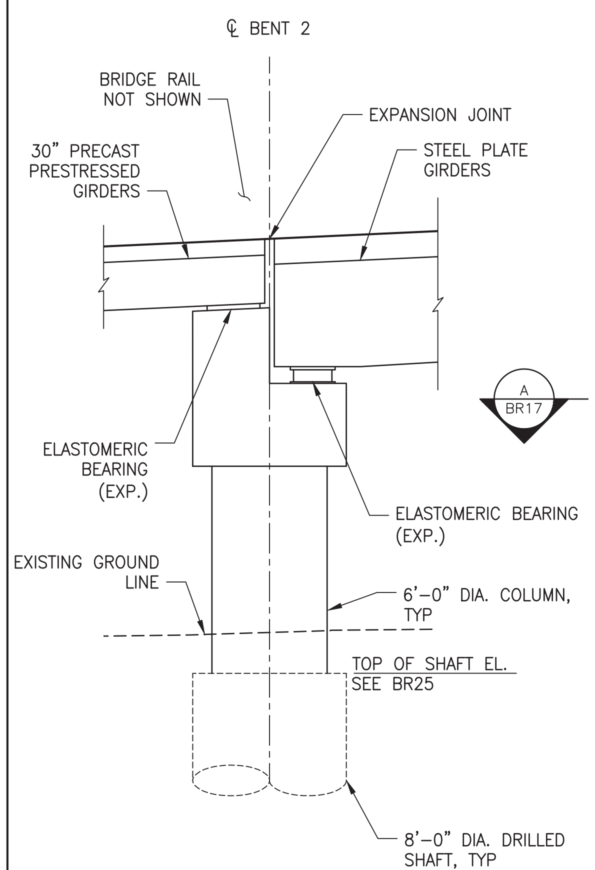
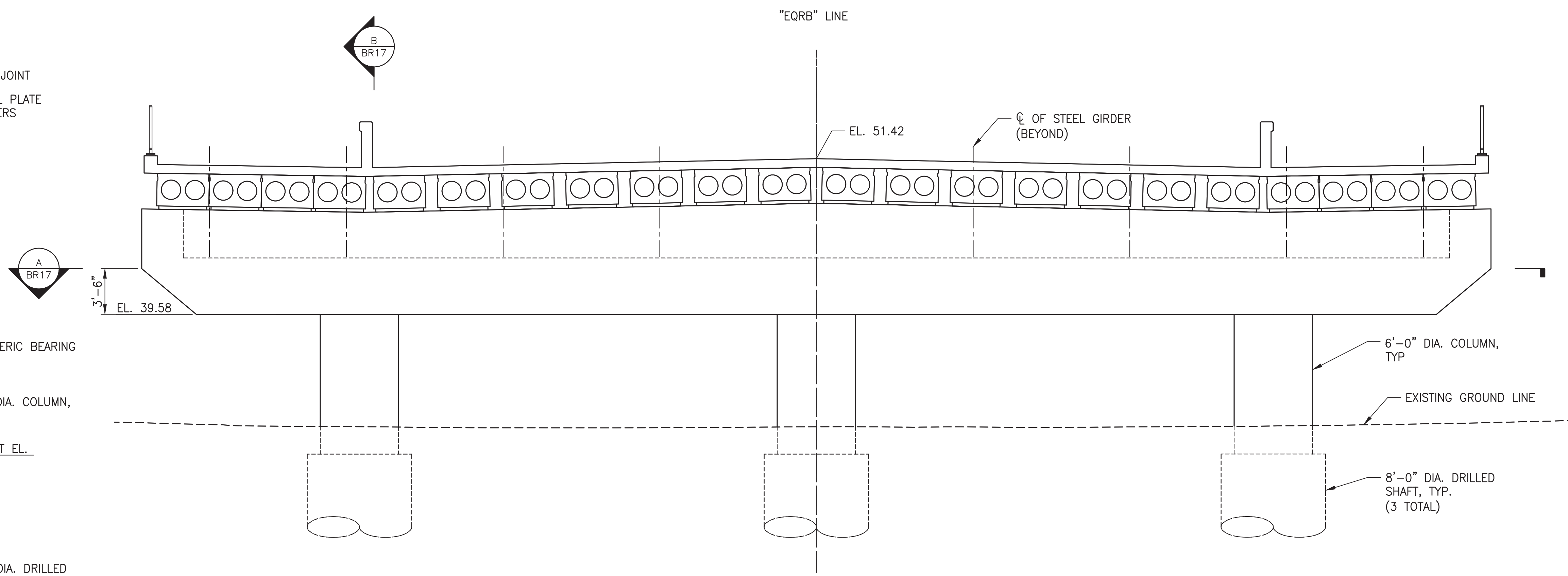
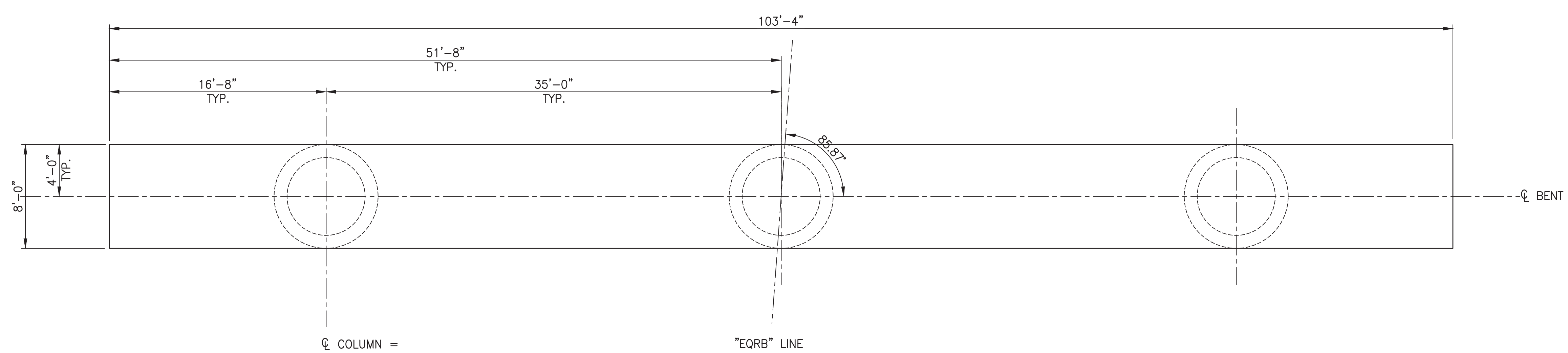
Sheet No. BR16




**SECTION B**
SCALE: 1" = 5'–0"




**BENT 2 ELEVATION**
SCALE: 1" = 5'–0"
STEEL PLATE GIRDERS OMITTED FOR CLARITY




**SECTION A**
SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 2 Details

PROJECT NO.:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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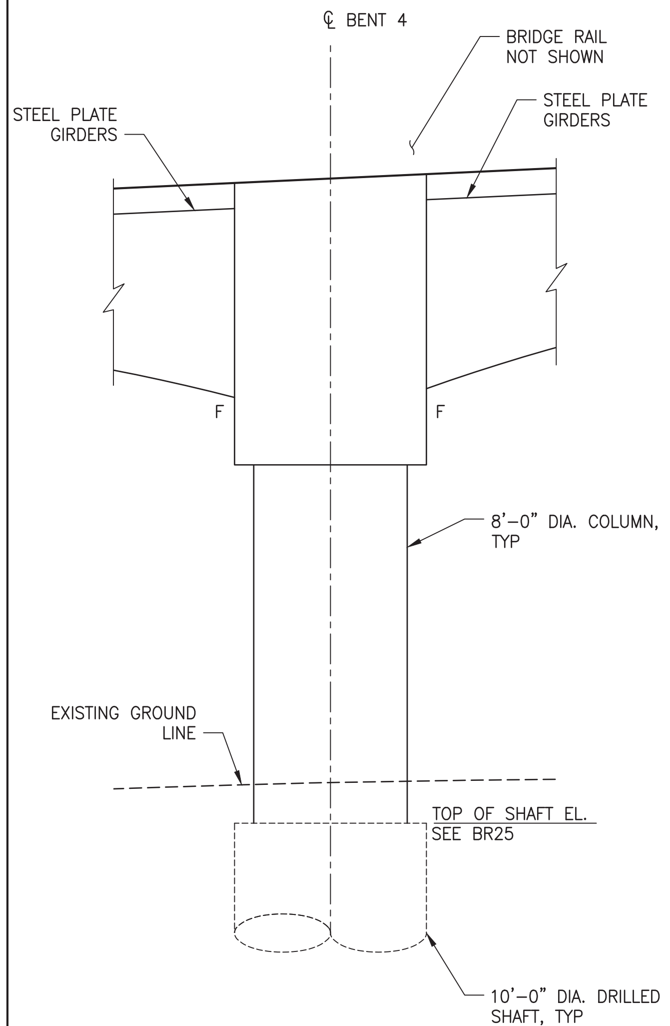
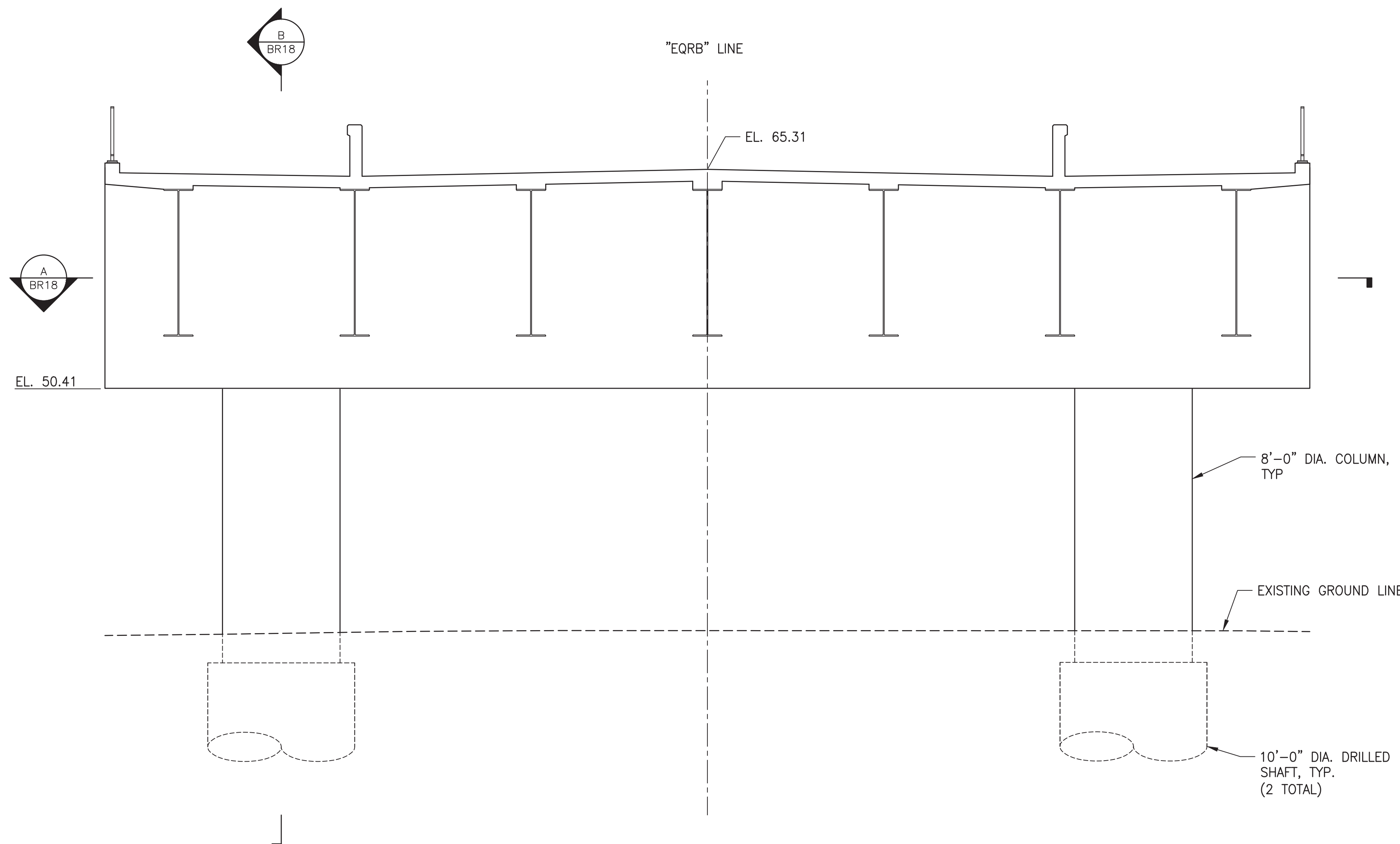
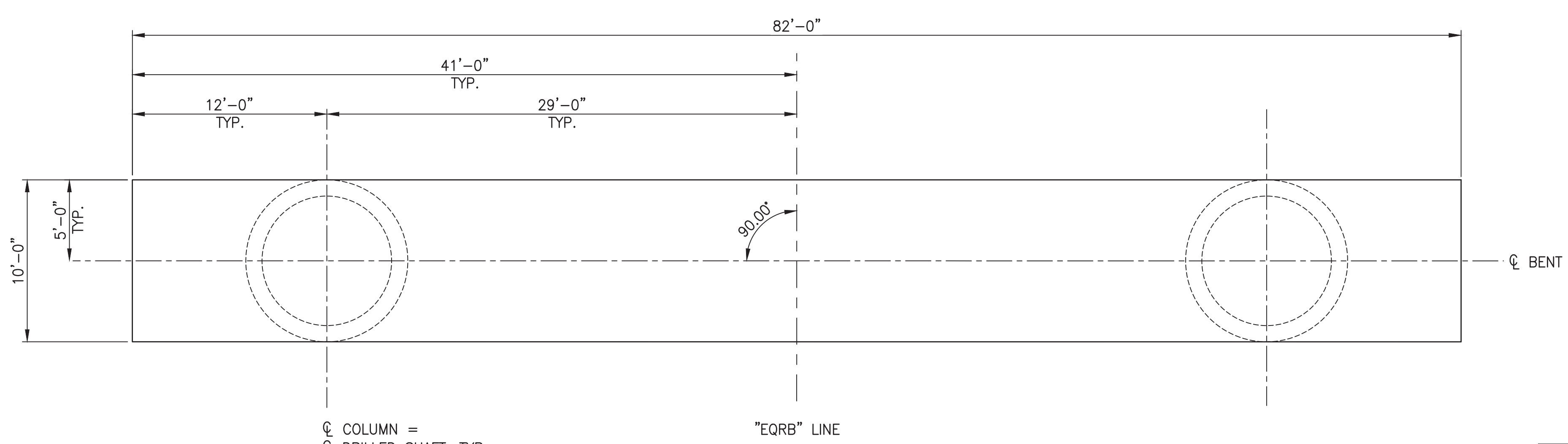
Sheet No.
BR17




**SECTION B**
SCALE: 1" = 5'-0"
(BENT 3 SIMILAR)




**BENT 4 ELEVATION**
SCALE: 1" = 5'-0"
(BENT 3 SIMILAR)




**SECTION A**
SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Bent 3 and 4 Details*

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
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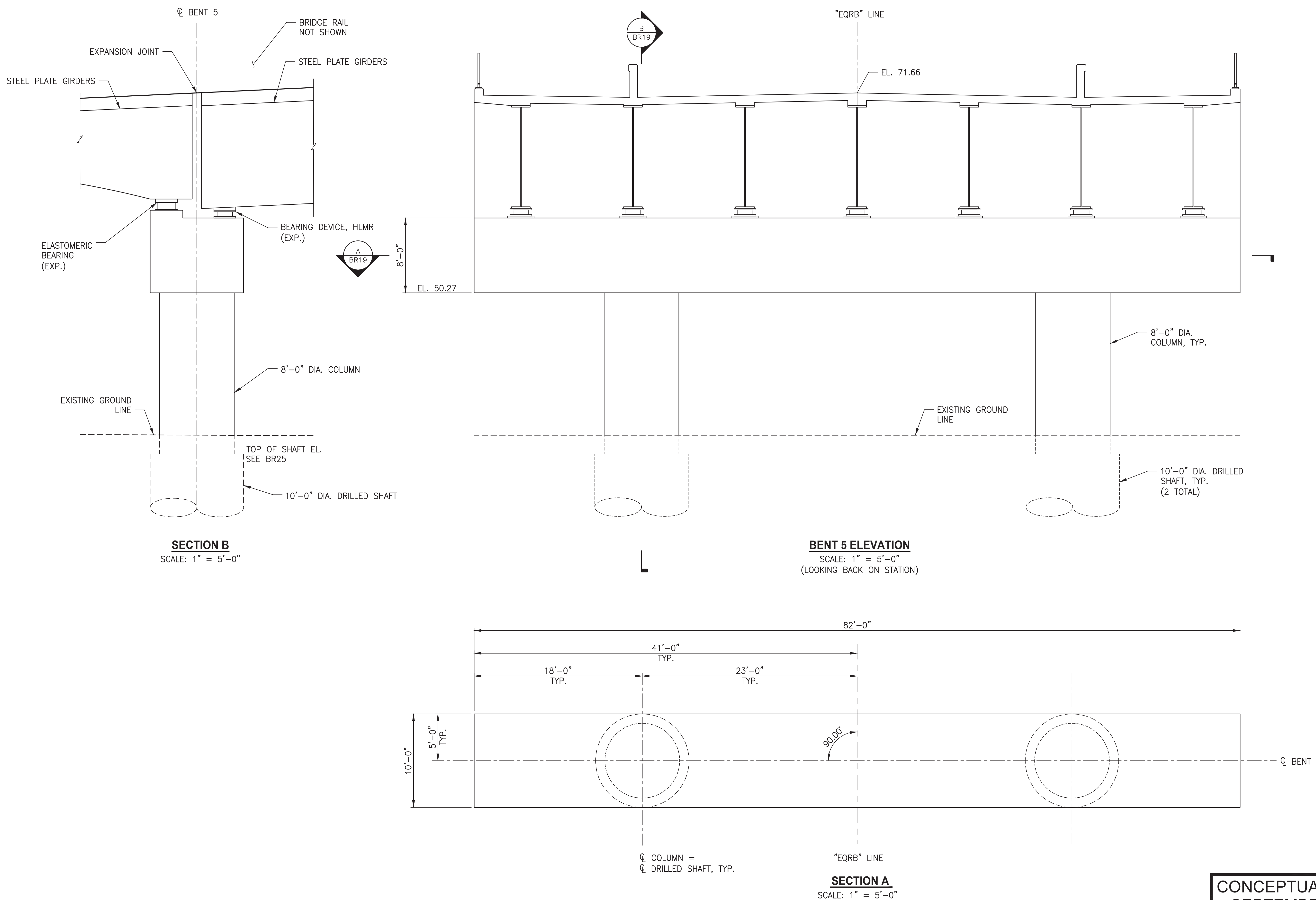
Sheet No. *BR18*




CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 5 Details

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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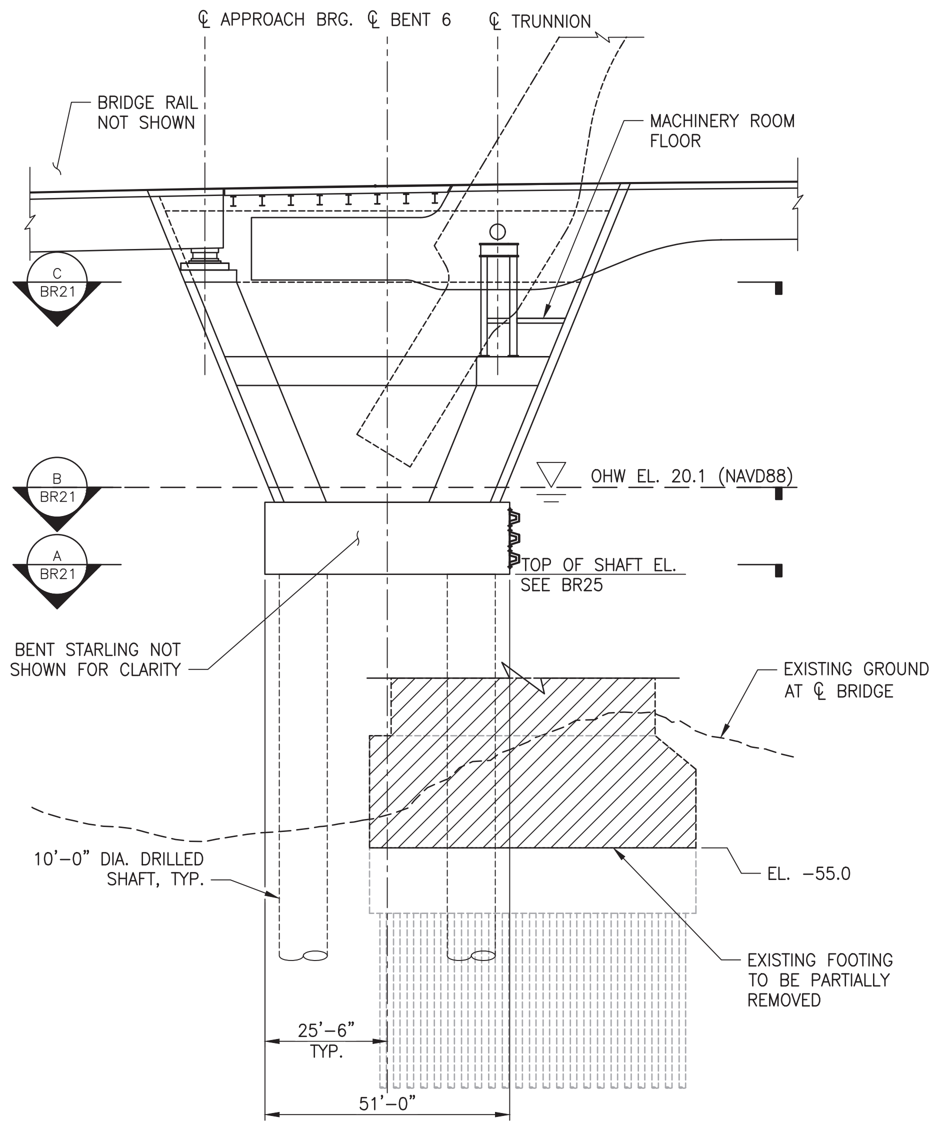
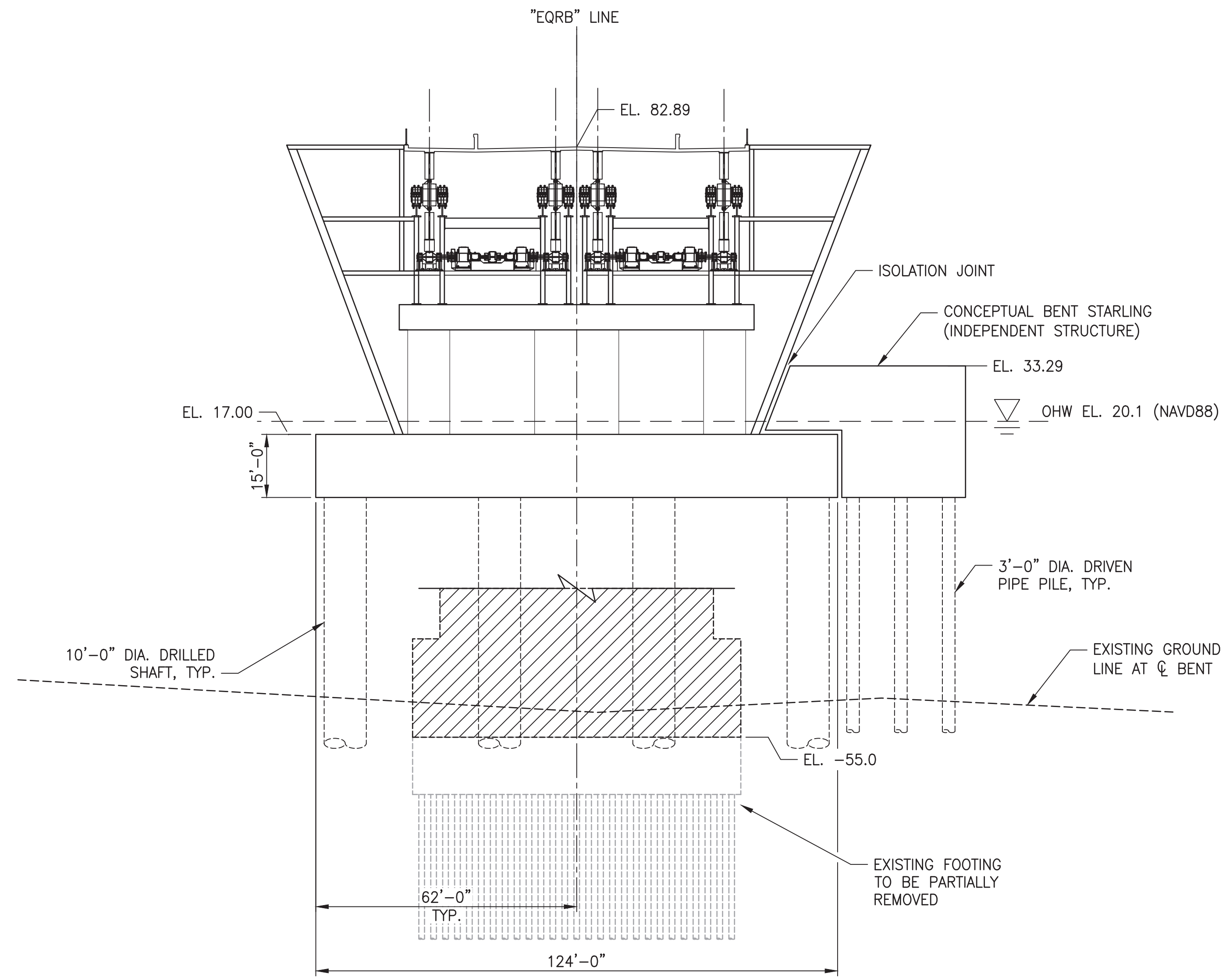
Sheet No. BR19




**BENT 6 ELEVATION**

SCALE: 1" = 20'–0"
(LOOKING NORTH, BENT 7 SIMILAR BUT MIRRORED)




**BENT 6 SIDE ELEVATION**

SCALE: 1" = 20'–0"
(BENT 7 SIMILAR BUT MIRRORED)

NOTES:

1. CONCEPTUAL OPERATOR HOUSE NOT SHOWN.
2. FOR ADDITIONAL DETAIL SEE ARCHITECTURAL DRAWINGS.

LEGEND

BRIDGE REMOVAL

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Bent 6 and 7 Elevations*

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

JON HENRICHSEN, COUNTY ENGINEER

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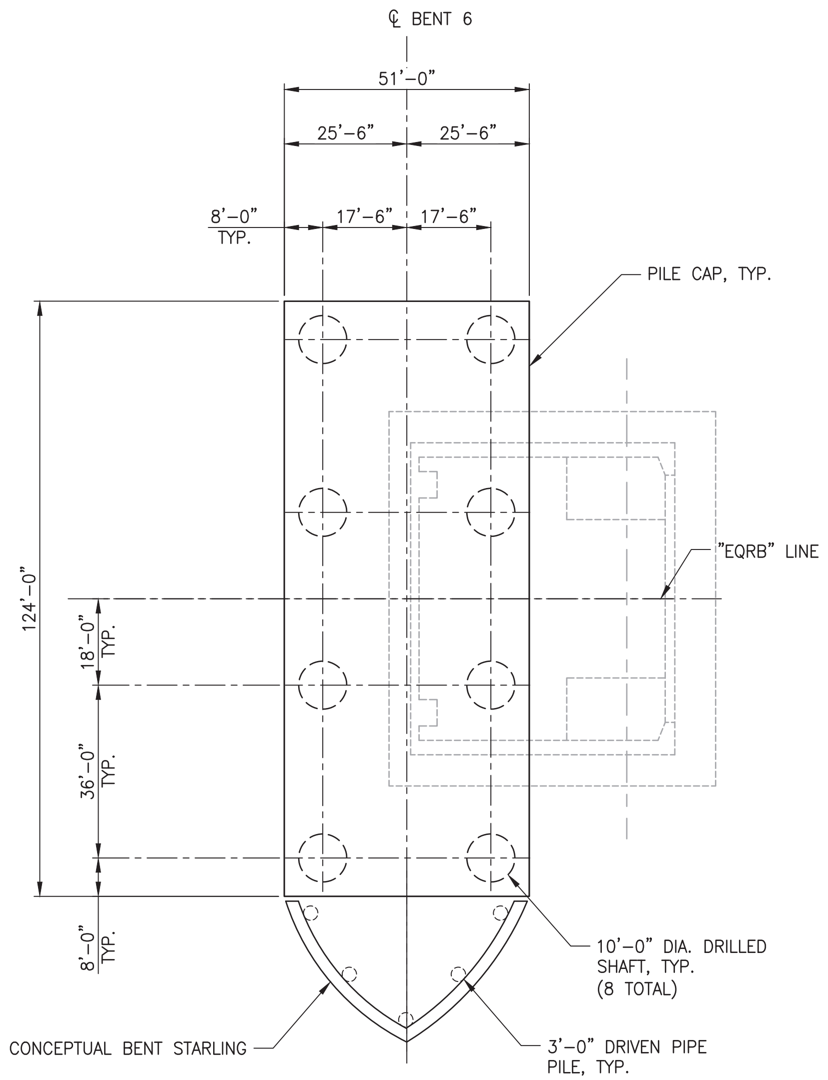
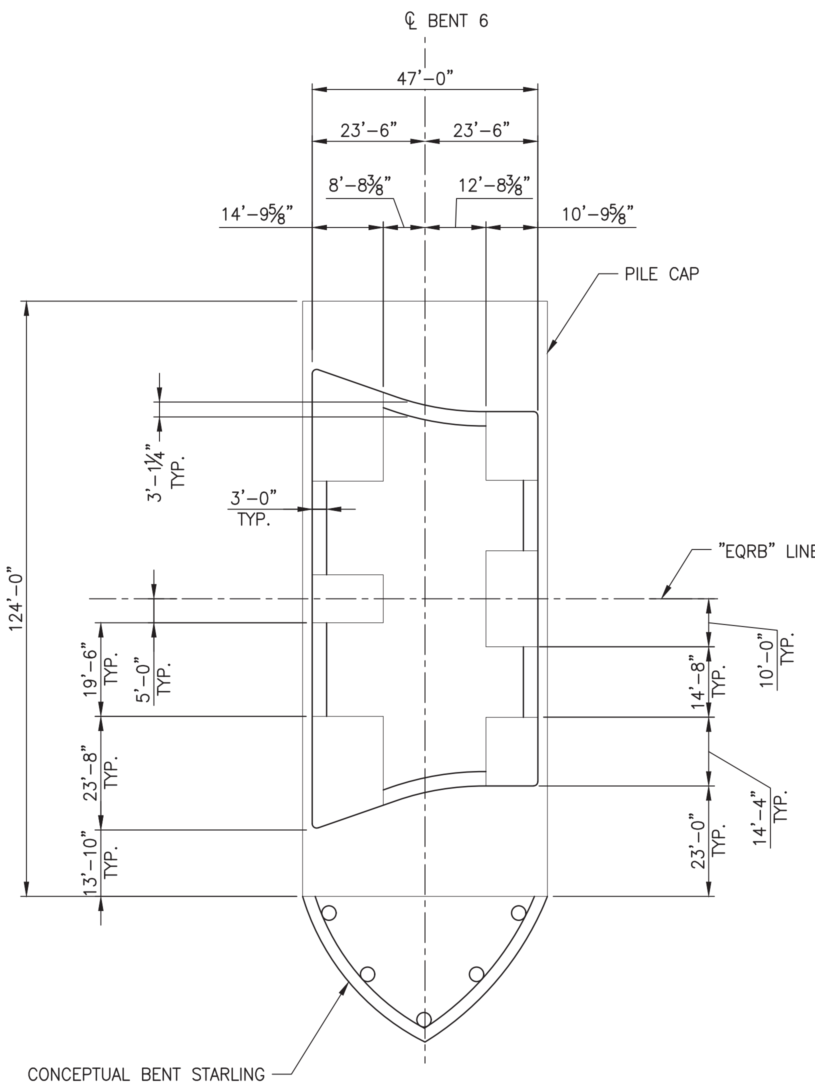
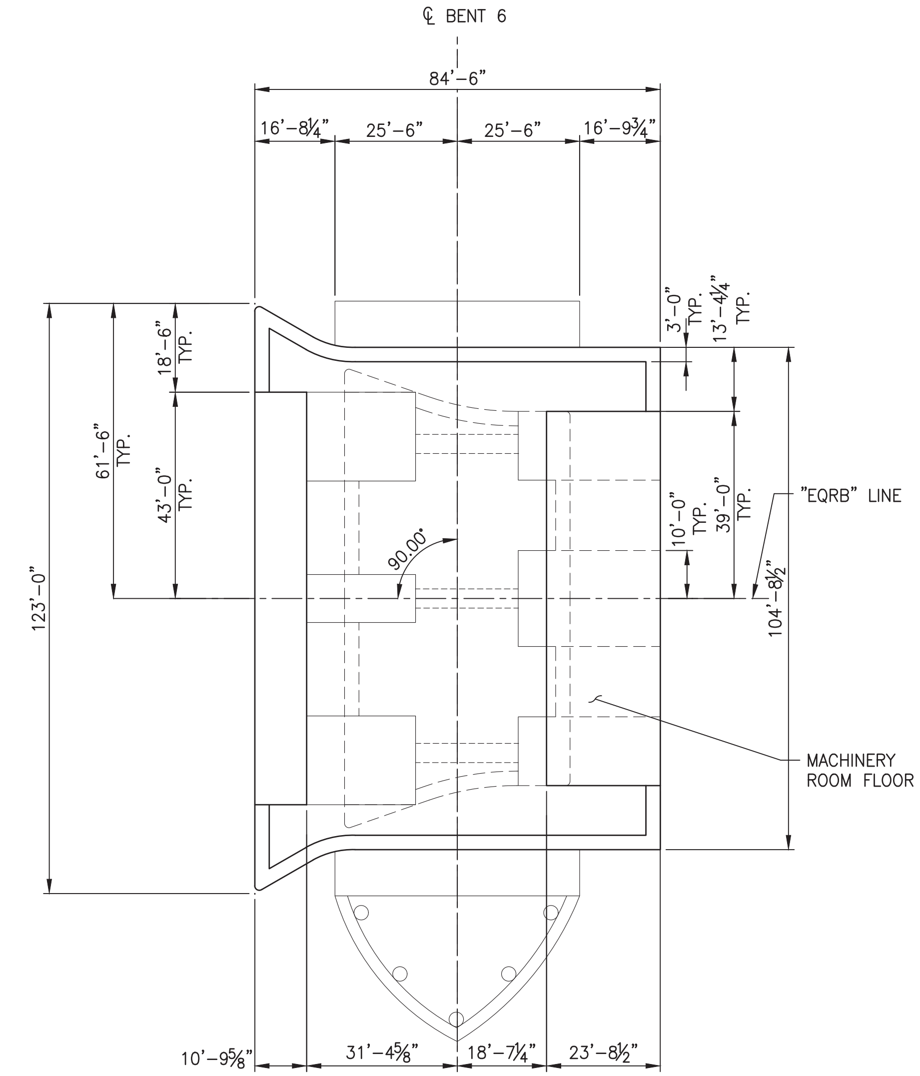
Sheet No. BR20




**SECTION A**
SCALE: 1" = 10'–0"




**SECTION B**
SCALE: 1" = 10'–0"




**SECTION C**
SCALE: 1" = 10'–0"
(AT MACHINERY ROOM FLOOR)

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Bent 6 and 7 Sections*

DATE: 9/2022 PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
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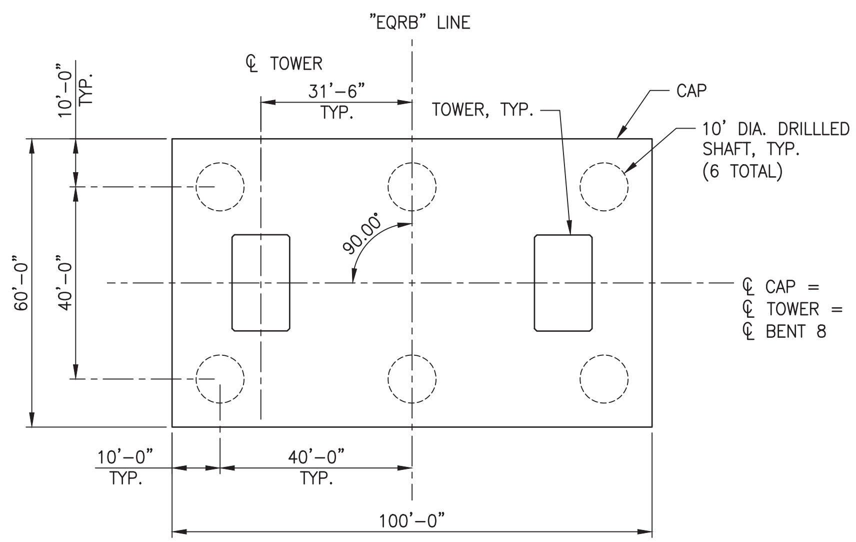
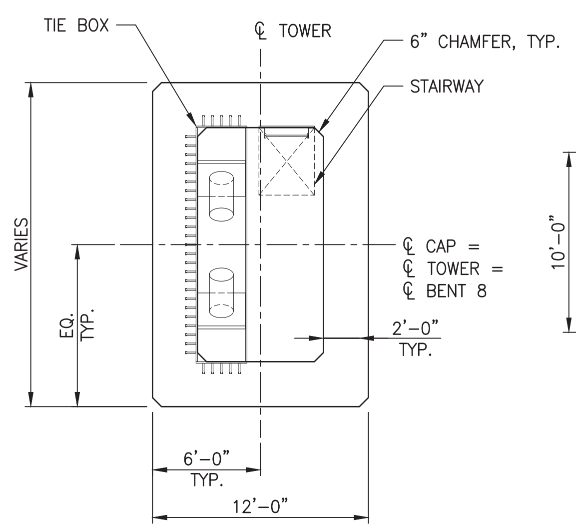
| | | | | |

Sheet No. *BR21*



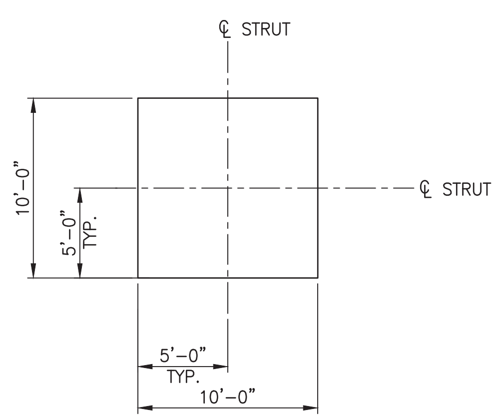

**BENT 8 PLAN**

SCALE: 1" = 20'-0"



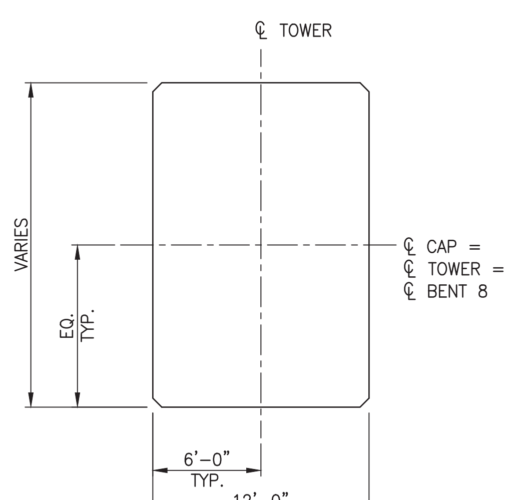

**SECTION A**

SCALE: 3/16" = 1'-0"



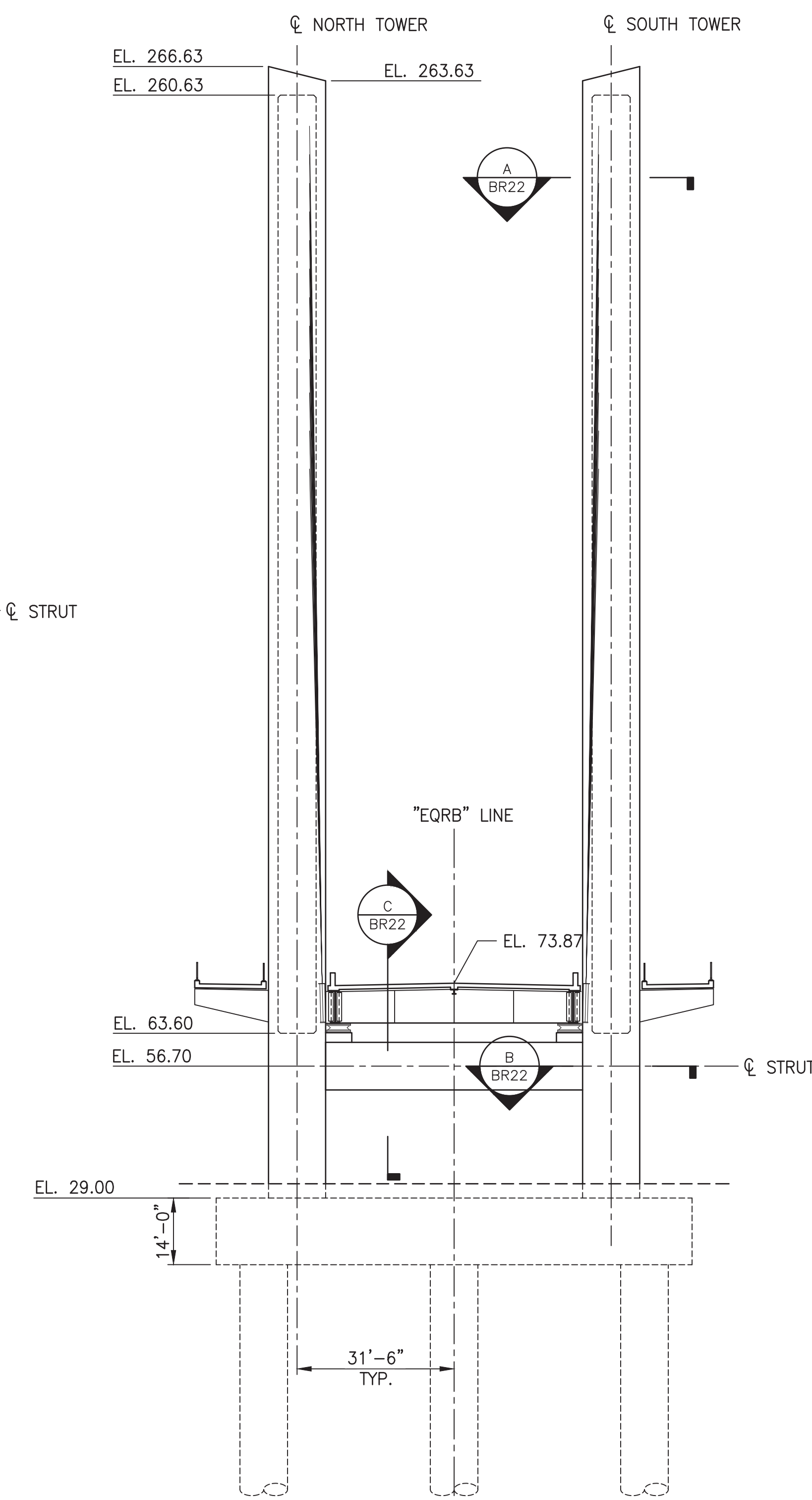

**SECTION C**

SCALE: 3/16" = 1'-0"



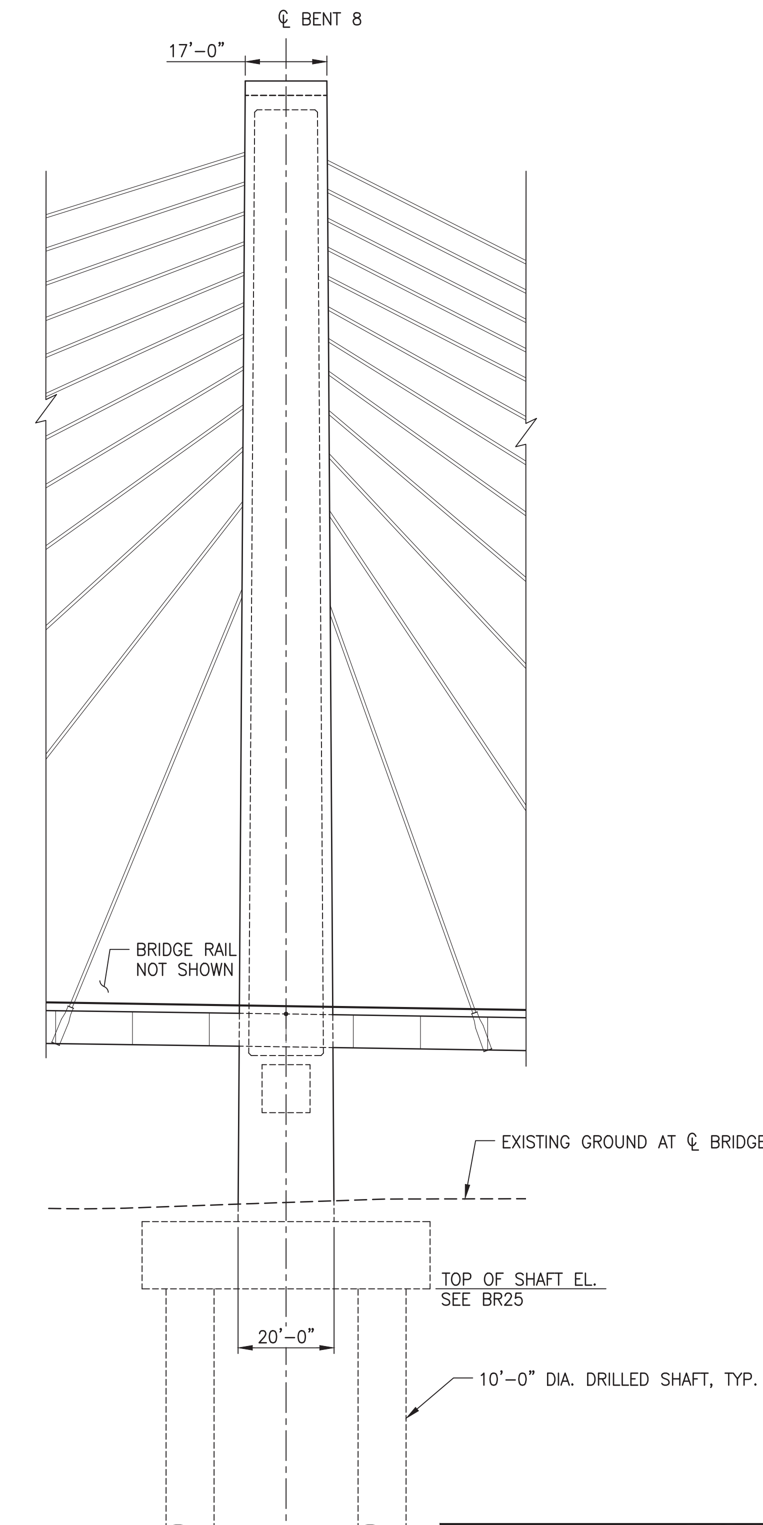

**SECTION B**

SCALE: 3/16" = 1'-0"




**BENT 8 ELEVATION**

SCALE: 1" = 20'-0"




**BENT 8 SECTION**

SCALE: 1" = 20'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*

*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Bent 8 Details*

PROJECT NO:

DATE: 9/2022

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

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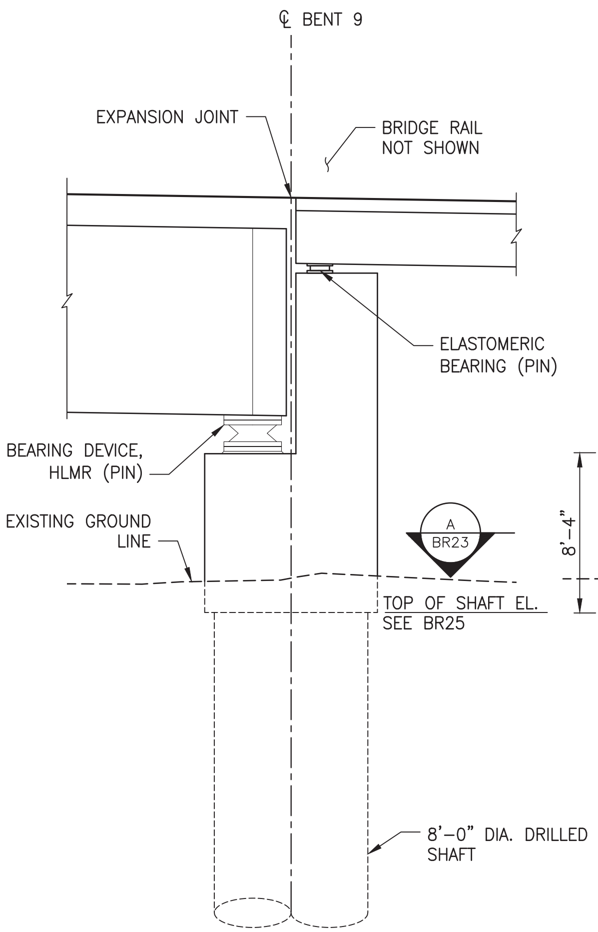
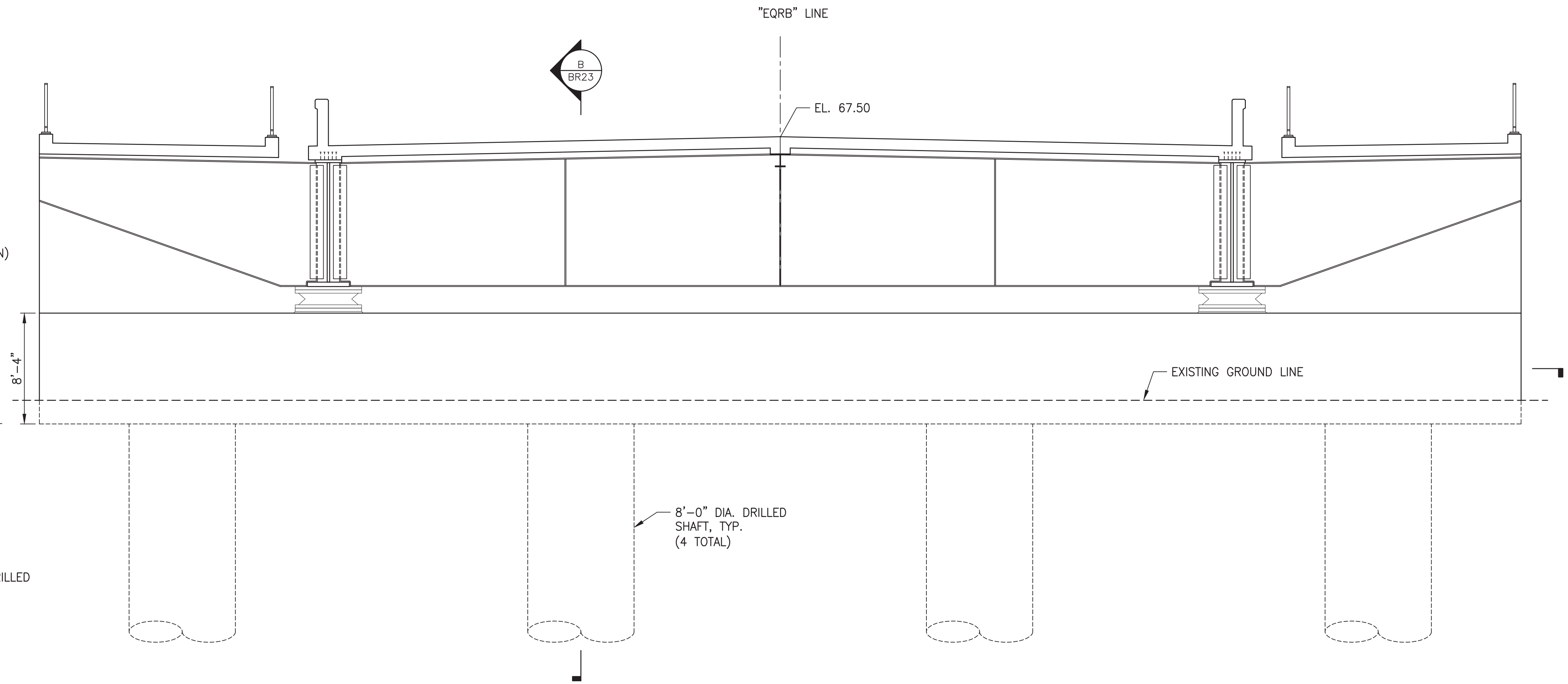


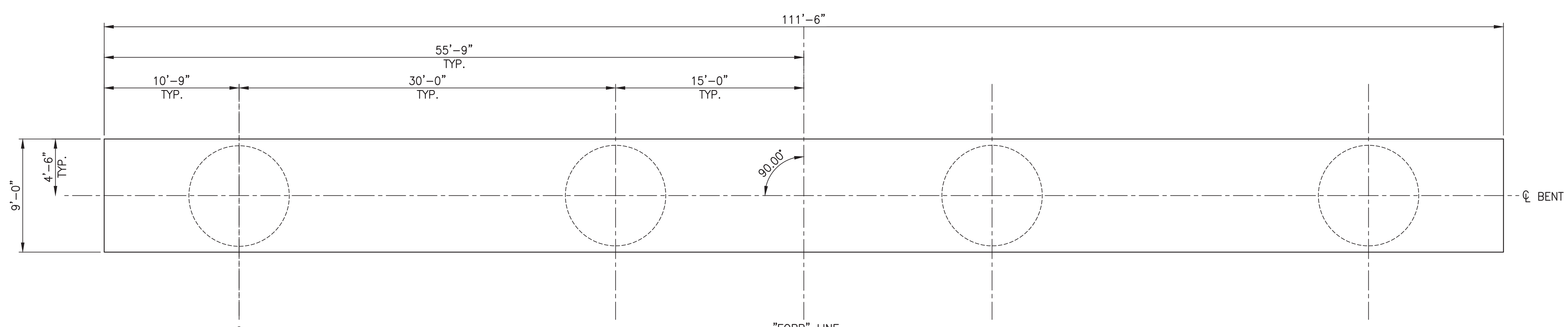

**SECTION B**

SCALE: 1" = 5'–0"




**BENT 9 ELEVATION**

SCALE: 1" = 5'–0"




**SECTION A**

SCALE: 1" = 5'–0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 9 Details

DATE: 9/2022
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233–5999

JON HENRICHSEN, COUNTY ENGINEER

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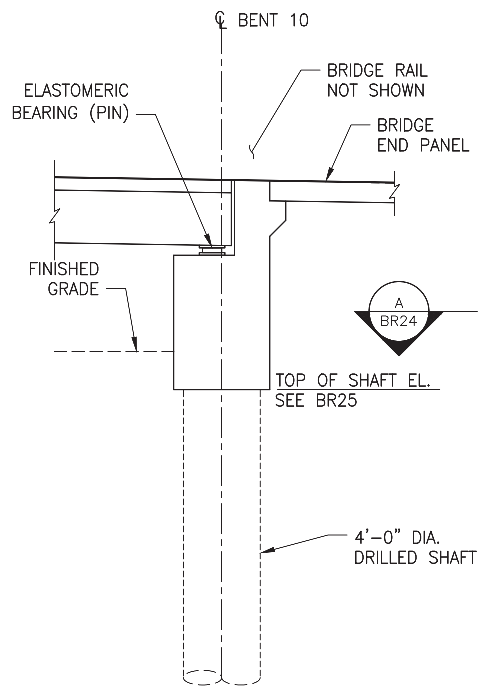
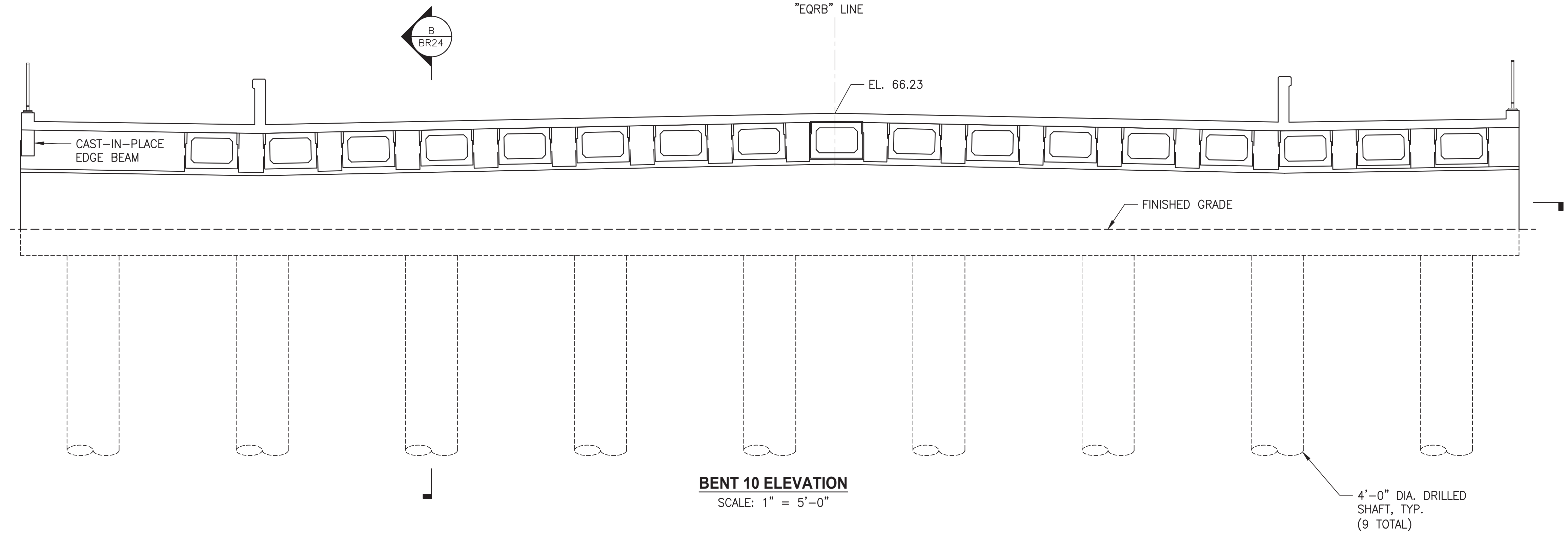
Sheet No. BR23



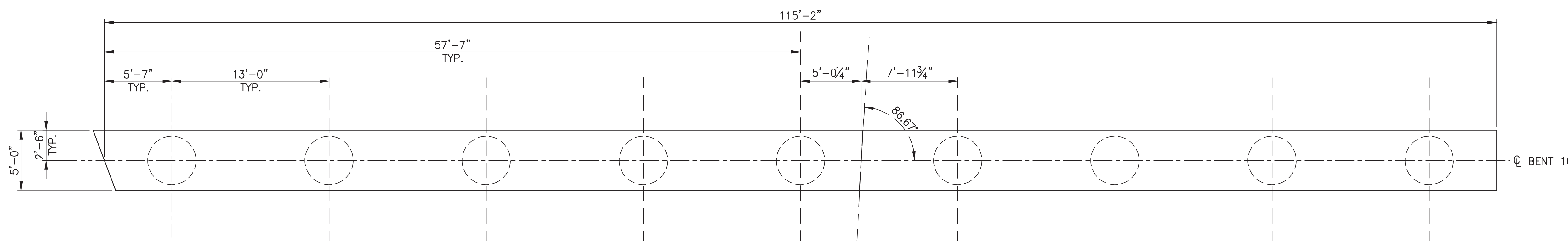

**SECTION B**

SCALE: 1" = 5'-0"




**BENT 10 ELEVATION**

SCALE: 1" = 5'-0"




**SECTION A**

SCALE: 1" = 5'-0"

CONCEPTUAL PLANS
SEPTEMBER 2022

Earthquake Ready Burnside Bridge

Replacement Movable Bridge
Bascule with Cable Stay Approach
Bent 10 Details

DATE: 9/2022

PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: HDR
DRAFTED BY: HDR
CHECKED BY: HDR

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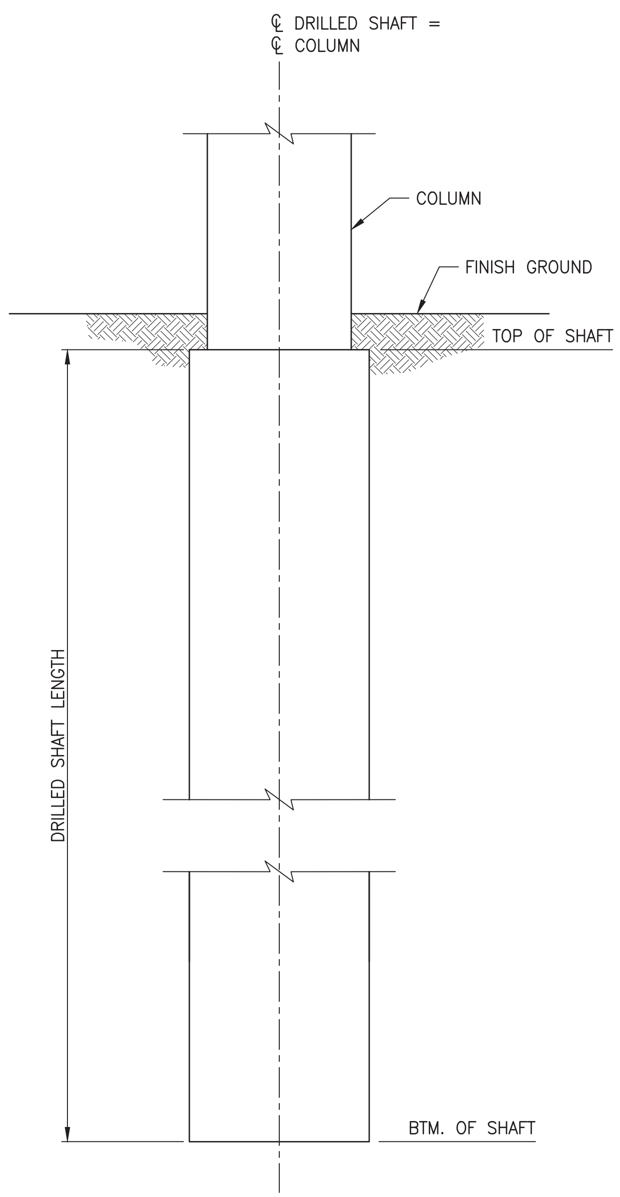
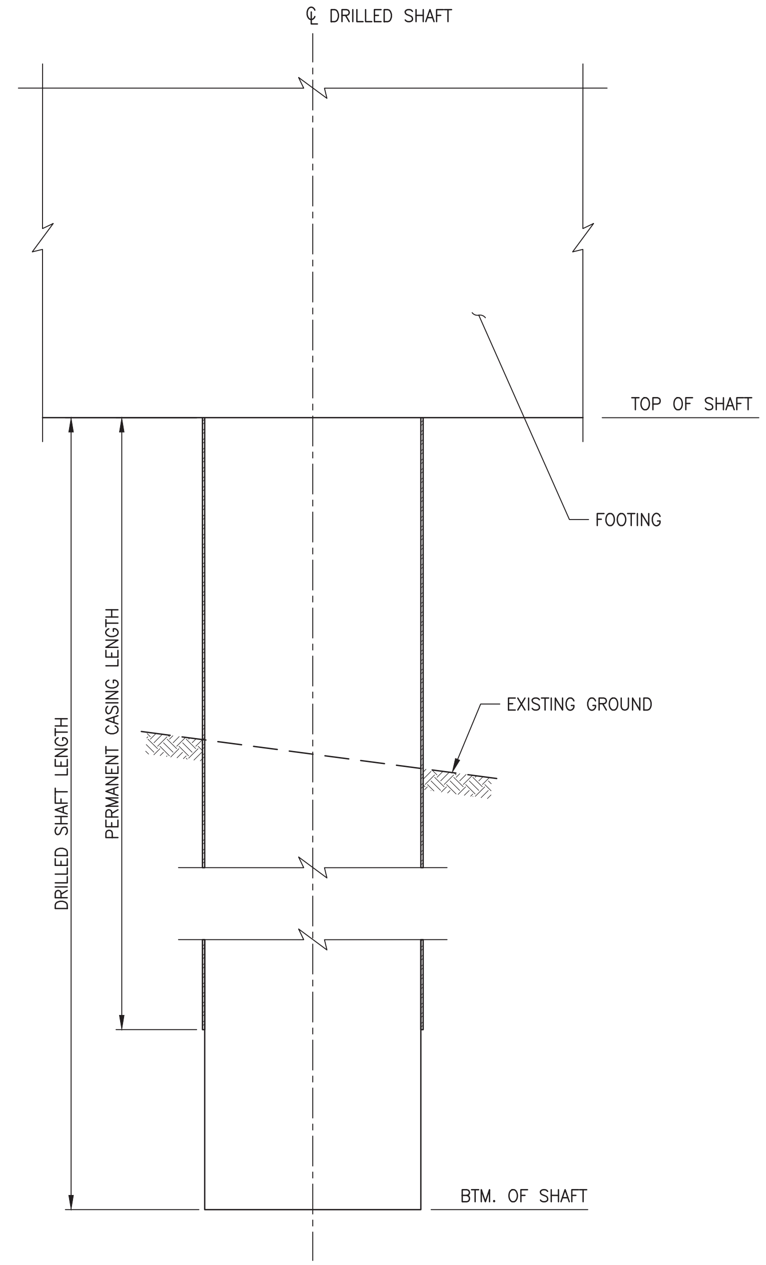
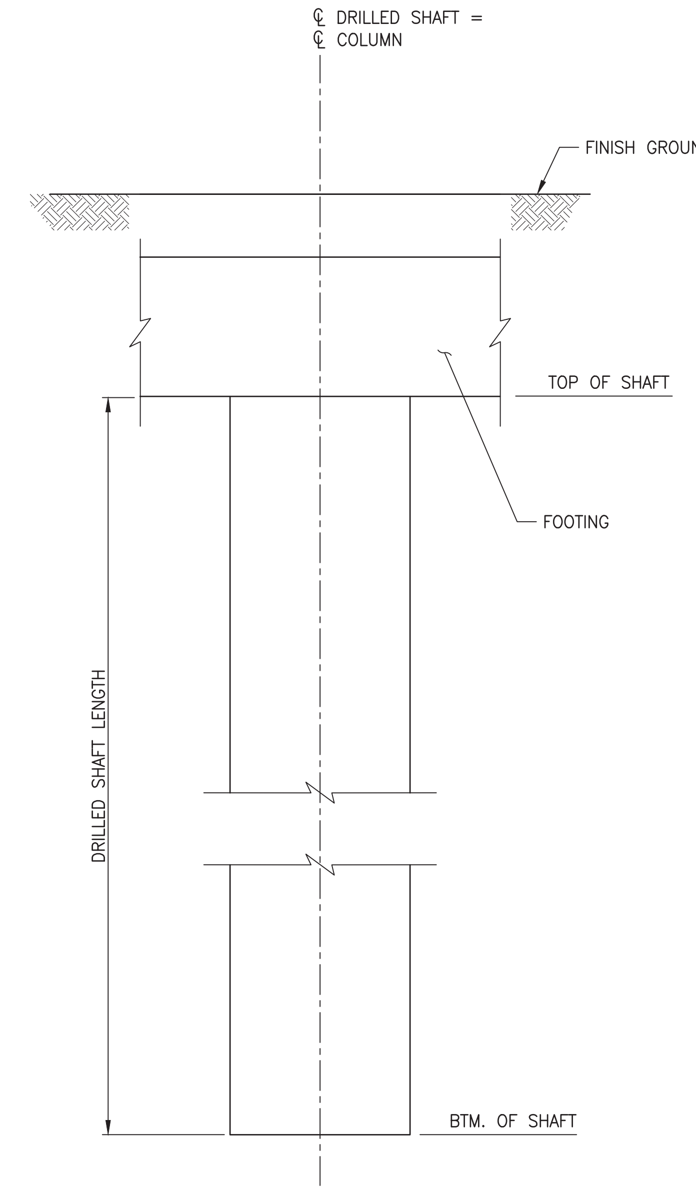
Sheet No. BR24




**DRILLED SHAFT DETAIL - BENTS 1 - 5, 9 & 10**
NOT TO SCALE




**DRILLED SHAFT DETAIL - BENTS 6 & 7**
NOT TO SCALE




**DRILLED SHAFT DETAIL - BENT 8**
NOT TO SCALE

| BENT | SHAFT DIAMETER (FT) | NUMBER OF SHAFTS | ELEVATIONS (NAVD88) | | | | | SHAFT LENGTH (FT) | CASING LENGTH (FT) |
|---|---|---|---|---|---|---|---|---|---|
| | | | FINISH GROUND | ESTIMATED ROCK* | TOP OF SHAFT | BOTTOM OF CASING | BOTTOM OF SHAFT | | |
| 1 | 3.00 | 11 | 31.52 | −26.47 | 24.52 | NA | −42.00 | 66.52 | NA |
| 2 | 8.00 | 3 | 31.50 | −33.85 | 29.50 | NA | −65.00 | 94.50 | NA |
| 3 | 10.00 | 2 | 32.02 | −41.63 | 30.02 | NA | −65.50 | 95.52 | NA |
| 4 | 10.00 | 2 | 33.67 | −43.01 | 31.67 | NA | −62.50 | 94.17 | NA |
| 5 | 10.00 | 2 | 34.97 | −57.43 | 32.97 | NA | −74.00 | 106.97 | NA |
| 6 | 10.00 | 8 | −55.00 | −105.00 | 2.00 | −77.50 | −126.00 | 128.00 | 79.50 |
| 7 | 10.00 | 8 | −55.00 | −130.00 | 2.00 | −77.50 | −153.00 | 155.00 | 79.50 |
| 8 | 10.00 | 6 | 32.65 | −148.80 | 15.00 | NA | −155.00 | 170.00 | NA |
| 9 | 8.00 | 4 | 48.00 | 2.79 | 46.00 | NA | −8.00 | 54.00 | NA |
| 10 | 4.00 | 9 | 57.00 | 14.06 | 55.00 | NA | 0.00 | 55.00 | NA |

* ESTIMATED ROCK ASSUMED AS TOP OF LOWER TROUTDALE SUBSURFACE LAYER

CONCEPTUAL PLANS
SEPTEMBER 2022

*Earthquake Ready Burnside Bridge*
*Replacement Movable Bridge*
*Bascule with Cable Stay Approach*
*Drilled Shaft Details*

DATE: *9/2022*
PROJECT NO.:

MULTNOMAH COUNTY
DEPARTMENT OF COMMUNITY SERVICES
TRANSPORTATION DIVISION
1620 S.E. 190th AVE. PORTLAND, ORE. 97233-5999

JON HENRICHSEN, COUNTY ENGINEER

DESIGNED BY: *HDR*
DRAFTED BY: *HDR*
CHECKED BY: *HDR*

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Sheet No. *BR25*