City of Bellevue

East Link light rail B7/C9T to NE 2nd Portal (B7 – Revised) Alternative

TM06 – Early Concept Alignment

215382/TM06

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1 Executive summary

The B7-Revised alternative extends from the east side of Lake Washington, located in the center of I-90, to NE 3rd place and 110th Avenue NE in Downtown Bellevue. It follows the north side of I-90 and then the west side of I-405 and makes use of the disused BNSF freight corridor. The alternative includes a station and park and ride at the intersection of Bellevue Way and I-90 (A-2 Station/Park and Ride), and a station near Main Street and 114th Avenue SE (East Main Station).

The alignment analysis has optimized the B7-Revised alternative, where possible to reduce adverse impacts to private properties, businesses and sensitive areas and to reduce noise and visual impacts. Alignment drawings are presented in Appendix A. They have been developed to respected specific constraints including the I-405 Master Plan. in the alignment is developed in eight subsections.

Key features of alignment sub-sections:

- I-90 Medians
  - Alignment in I-90 center roadway lane east of Lake Washington Bridge
  - Long span bridge over I-90 west bound with straddle bent over highway
- A2 Station Area
  - Center platform above I-90/Bellevue Way Ramps, approximately 70 feet above ground level
- Mercer Slough
  - Viaduct over wetlands
  - Precast concrete structure
  - Driven steel pipe piles or large diameter drilled shafts
- BNSF Corridor
  - LRT and future freight to share tracks
  - At grade alignment through disused rail corridor with retaining walls where required
  - Turnouts required at each end of corridor for freight connection
- I-405 Viaduct
  - Viaduct adjacent to I-405
  - Impact to STOR-HOUSE public storage. Piers located to avoid impact to building and access
  - Impact to Greenbaum furniture Store. Acquisition of east corner of store to avoid I-405 Master Plan and minimize impact on business. Piers located to minimize impact on access and parking
- Sturtevant Creek
  - Existing Salmon Creek alongside alignment
  - At-grade/retained fill track-way. Requires some relocation of stream bed and environmental mitigation
  - Short bridge required to cross stream
- East Main Station and Portal
  - East Main Station located in trench through Red Lion Hotel site
  - New bridge required under Main Street between I-405 and 112th Avenue SE
  - Trench construction across Sheraton Hotel site to tunnel portal
- Link to Segment C
  - Cut and cover tunnel along north side of NE 2nd Street and along 110th Avenue NE to Bellevue Transit Center Station
  - 6% grade required between portal and station

2 Background

2.1 Project description

The East Link project is an extension to Sound Transit's Link light rail system that will provide light rail service across Lake Washington, linking Seattle, Bellevue, and Redmond (Overlake).

For the segment of East Link between the Lake Washington crossing and downtown Bellevue, Sound Transit has developed the B7 alternative to a conceptual engineering level of design (approximately five percent design) as part of the Draft Environmental Impact Statement (DEIS) for the project which was issued in December 2008.

A Supplemental Draft EIS, which analyzes new alternatives developed since the DEIS, was published in November 2010. That supplemental document includes updated conceptual engineering for the Sound Transit B7 alternative and a C9T alternative that could connect B7 to a station at the Bellevue Transit Center. A Final EIS is expected in the summer of 2011.

At the September 13, 2010, Bellevue City Council Study Session, the council discussed the need for design variations and for additional analysis of revised East Link B7 and C9T alternatives. The objectives of the additional analysis would be to improve performance, to reduce impacts, and to reduce costs, as compared with the Sound Transit B7 and C9T alternatives. As a result of that discussion the council initiated the development of a modified B7 alternative ("B7-Revised"). The council directed City staff to develop an "apples-to-apples" comparison of the Sound Transit B7 and C9T alternatives with a B7-Revised alternative. Arup were commissioned by the City to develop the B7-Revised alternative.

The B7-Revised alternative begins at the transition from East Link Segment A to Segment B at the east shore of Lake Washington and connects with a new elevated station (A-2 Station) over south Bellevue Way/I-90 ramps. The alignment continues east from the station along the north side of I-90 and turns north into the BNSF corridor with an at-grade profile. The alignment transitions to elevated as it leaves the BNSF corridor, crosses over SE 8th Street, and transitions back to at-grade prior to a new station (East Main Station) just south of Main Street on the current Red Lion Hotel site. The alignment crosses under Main Street and turns west on the current Sheraton Hotel site before entering a tunnel portal at NE 2nd Street. The B7-Revised alternative is approximately three miles long with a combination of at-grade, elevated, and open-cut sections.

2.2 Technical memo scope

The conceptual alignment work for the B7-Revised study includes a refinement of the B7-Revised alignment to include: the layout of the transition from Segment A to the A-2 Station; options for the Mercer Slough crossing; placement of the alignment in the BNSF right of Way assuming that the LRT tracks may in the future be shared with freight operations; development of the horizontal and vertical alignment along I-405; layout of the East Main Station; and layout of the transition to the C9T segment. Conceptual pier placements will be identified for the elevated section along I-405.

This Early Concept Alignment technical memo represents an interim report which reports on alignment work completed to date and highlights the key issues along the alignment to allow the City to gain an early understanding of the risks and opportunities associated with the alternative, and is not intended to fully satisfy the scope described above.

This technical memo should be read in conjunction with other technical memos produced for this study, in particular:

- Existing Information (TM01)
- Design Deviations (TM02)
- Station Concept Report (TM03)
- Right of Way (TM08)
- Cost Estimate (TM11)
- Shared Track (TM12)
- B7-Revised Optimization (TM13)

2.3 Technical memo objectives

This technical memo describes the progress of the alignment developed to date and provides an initial assessment of the engineering issues and solutions required. This technical memo discusses:

- The conceptual alignment
- Abutments and Piers at critical locations
- BNSF corridor
- Portal and Red Lion Site

2.4 Key meetings and background documents

Identify relevant meetings to the technical memo

Date	Meeting	Reference (Minutes)
December 16, 2010	City of Bellevue kick-off meeting	Ref: Kick-off Minutes-Issue 2 Issue Date: 1/10/2011
January 6, 2011	Sound Transit kick-off meeting	Ref: ST Meeting 1 Minutes (Issue 2) Issue Date: 1/20/2011
January 13, 2011	B7-Revised optimization workshop	Ref: Optimization Workshop Minutes Issue 2 Issue Date: 2/2/2011
January 13, 2011	WSDOT Meeting (I-90)	Ref: WSDOT Meeting 1 Minutes (Issue 1) Issue Date: 1/26/2011
January 14, 2011	WSDOT Meeting (I-405)	Ref: WSDOT Meeting 2 Minutes (Issue 1) Issue Date: 1/27/2011
January 25, 2011	Open House 1	Ref: OH Notes WB 2011 01 25 Issue Date: 1/31/2011
February 3, 2011	Staff Check-in 3 – Station and Alignment Update	Ref: Staff Check-in3 Minutes (Draft 2) Issue Date: 2/16/2011
February 23, 2011	Staff Check-in 5 – Station, Sturtevant, Public Meeting	Not finalized at time of submittal.

Table 1 - Relevant meetings

Relevant documents and reports used to support the analysis include the following:

- East Link Light Rail Draft Environmental Impact Statement (DEIS)
- East Link Light Rail Supplemental Draft Environmental Impact Statement (SDEIS)
- WSDOT I-405 Corridor Program Master Plan
- Sound Transit Design Criteria (Chapter 4 – Track Alignment and Vehicle Clearances)
- GIS Aerial Mapping and Associated Files (City of Bellevue)

3 Methodology and data

The project team has been directed by Bellevue City Council to prepare an "apples-to-apples" comparison of the B7-Revised alternative with the Sound Transit Draft Environmental Impact Statement (DEIS) and Supplemental Draft Environmental Impact Statement (SDEIS) B7/C9T alternative. Such a comparison requires consistency of three elements – base data and information, key assumptions, and methodology. The following sections and tables outline the key aspects of the alignment, how these aspects were addressed for the Sound Transit B7/C9T alternative and whether this analysis is considered a true "apples-to-apples" comparison. Comment is made particularly for changes in approach.

3.1 Base data and information

B7-Revised	B7/C9T	Apples-to-Apples"	Comment
Sound Transit Design Criteria	Sound Transit Design Criteria	Yes	
I-405 Master Plan	Same	Yes	
Utilities from DEIS/SDEIS	Same	Yes	
Sound Transit C9T CAD Design File	Same	Yes	

Table 2 - Comparison with Sound Transit DEIS and SDEIS base data and information

3.2 Key assumptions

Key operating and design assumptions are as follows:

B7-Revised	B7/C9T	"Apples-to-Apples"	Comment
LRT and Freight can share the same tracks in the BNSF corridor	Additional RoW provided for future freight	No	City of Bellevue requested assessment of shared track. Additional study will also assess impacts of providing additional RoW for freight

Table 3 - Comparison with Sound Transit DEIS and SDEIS key assumptions

3.3 Methodology

B7-Revised	B7/C9T	"Apples-to-Apples"	Comment
Not applicable to this memo.			

Table 4 - Comparison with Sound Transit DEIS and SDEIS methodology

4 Alignment areas

The alignment commences on the east side of the Lake Washington I-90 bridge and follows a corridor on the north side of I-90 across Mercer Slough from where it turns north along the BNSF and I-405 corridors into downtown Bellevue (see Figure 1).

This alignment is split into eight sub-sections for the purpose of this report.

- I-90 Median
- A-2 Station Area
- Mercer Slough
- BNSF Corridor
- I-405 Viaduct
- Sturtevant Creek
- East Main Station and Portal
- Link to Segment C

Each section is described below and highlights any changes from the Sound Transit design, any deviations from established standards or design criteria and any special considerations. An early concept alignment drawing set is included in Appendix A.

Figure 1 - B7-Revised alignment

4.1 I-90 median

This segment of the alignment commences on the east side of Lake Washington at the Segment A/B boundary. The alignment occupies the existing center roadway on the I-90 bridge structure crossing the Lake Washington bridge. It follows these lanes east and is initially at-grade and increases in elevation on retained fill to allow adequate clearance to cross Westbound I-90 on a viaduct. The viaduct that crosses I-90 will have a span of approximately 300 ft. Cast-in-place construction will be difficult over I-90 and therefore a balanced cantilever segmental box girder is proposed at this location. The depth of structure is tapered at the center, while the maximum depth could be as deep as 18ft at the pier.

The design speed for this section ranges from 45 mph around the first curve at Sta. 2001+59 to 30 mph at Sta.2013+29 at the long span across I-90.

4.2 A-2 Station area

The location of the A-2 Station is dictated by the horizontal and vertical rail design requirements in the I-90 median section. The horizontal radius at the span across I-90 westbound has been limited to minimize the span length and locate the station as far north as possible to minimize the pedestrian bridge length. From the I-90 crossing east the two tracks split to allow for a center platform at the station.

The elevations of the I-90 on and off-ramps in the station vicinity are too low to allow the rail to pass under, so the alignment has been designed to span above, approximately 80 feet above original ground. The clearance requirements over these structures and the vertical design criteria govern the height of the A-2 Station. The design criteria require that vertical curves be located 40’ beyond the ends of the station platform which pushes the vertical curve at the station further to the west resulting in a higher aerial section through the I-90 median section.

The A-2 Station tracks are approximately 70 feet above ground level and are set at a 0.5% track slope. The vertical alignment has been designed to provide a minimum clearance of 25 feet above existing highways which allows for 8.5 feet of structure depth. Clearance is above this minimum at all crossing except for the I-90 eastbound on-ramp adjacent to the station where the minimum has been used to set the station height at the lowest possible. The viaduct in this area will be either precast concrete girder bridge or segmental bridge construction type structure type similar to that proposed at the Mercer Slough viaduct.

The planning and design of the station is described in TM03.

4.3 Mercer Slough

4.3.1 Alignment

East of the station the tracks move together and run straight, parallel to I-90. The alignment descends at a 4.85% gradient across the Mercer Slough which is approximately 2100 ft wide at this location.

4.3.2 Mercer Slough viaduct

The Mercer Slough is a wetland area with significant depths of soft peat and clay overlying a bearing strata of Glacial Till. An assessment of the geotechnical conditions of the site is included in Appendix B. It is understood from studies carried out by WSDOT that the peat is moving within the slough as a result of seasonal changes in the water level in Lake Washington, and that this has significantly impacted the performance of the I-90 structures.

The viaduct structure proposed to cross Mercer Slough will be a precast concrete girder bridge or a concrete segmental bridge.

The bridge superstructure will be continuous over column bents supported on deep foundations. In-span expansion joints are used to minimize thermal stress in the rails. The joints will be designed to transfer shear force in the transverse direction, but allow thermal movement in the longitudinal direction of the bridge.

To accommodate long term deflection of the bridge substructure caused by peat flow, the following treatments could be considered in the design:

- Bearing pads installed between the superstructure and the column bents. Extra width will be provided for the pads and the bent caps taking into account the anticipated long term movement caused by peat flow. Adjustable shear brackets could be provided between the superstructure and the bent caps to ensure lateral force transfer during earthquake.
- Monolithic construction between the superstructure and the bents.
- Ballast tracks on the bridge deck. Extra width on the bridge deck will be provided so that the tracks can be adjusted, if excessive movement is experienced on the structure due to peat flow.

Both driven steel pipe piles and drilled shafts are considered feasible for the proposed bridge structure. To resist potential pressure imposed by the peat flow, the deep foundation will penetrate through 60ft of peat and 60ft of soft clay to rest on the glacial till deposit.

4.3.2.1 Bridge types

Two bridge options are considered based on the information available at the current stage of the design.

4.3.2.2 Alternative 1 (Baseline)

A precast concrete segmental bridge is proposed to cross the Mercer Slough with a 240’ typical span. The bridge will be supported on a series of single column bents.

Each column bent will be constructed on a pile cap supported on large diameter drilled shafts. The pile cap will be orientated to provide maximum lateral resistance to the peat flow.

A steel trestle will be installed over the wetland along the proposed alignment to allow a drilling rig to access the site for foundation construction. After the shafts are constructed, the concrete substructure will be constructed with a cast-in-place method. When the substructure concrete reaches sufficient strength, the precast segment will be transported to the site via the trestle or the constructed bridge deck, and erected into position with the gantry.

After the drilled shafts are constructed, sheet piling will be installed, and used as the form for the construction of the pile caps. The pile caps will be cast and used as the base for construction of the concrete columns and the bent cap above.

Figure 2 – Trestle installed to provide access of bridge construction

- Advantages: Proven technology. Sufficient lateral stiffness against peat flow can be easily achieved with large diameter drilled shafts.
- Disadvantages: Significant environmental impact to the wetland as a result of drilled shaft installation, trestle installation and pile cap construction. Trestle piles may need to be extracted from the ground because of environmental considerations.

4.3.2.3 Alternative 2 (Preferred)

A precast concrete girder or segmental bridge is proposed over the Mercer Slough with a 120’ typical span. The bridge will be supported on a series of multi-column bents.

Each bent will be supported on a pile cap founded on a group of driven steel pipe piles. The piles will be arranged in a rectangular pattern and oriented to minimize blockage to the slough/peat flow.

The bridge can be constructed from an erection gantry launched from one side of the slough and proceeds to the other. The gantry will first be cantilevered from the bridge approach. The tip of the gantry will be used as the platform of a pile driving machine. The steel pipe piles will be driven to the ground from the gantry and filled with concrete subsequently for extra strength.

After the piles are constructed, sheet piling will be installed from the gantry for pile cap construction. Formwork will be placed against the sheet piling for the concrete construction. Pile cap will be cast and used as the base for construction of the concrete columns and the bent cap above.

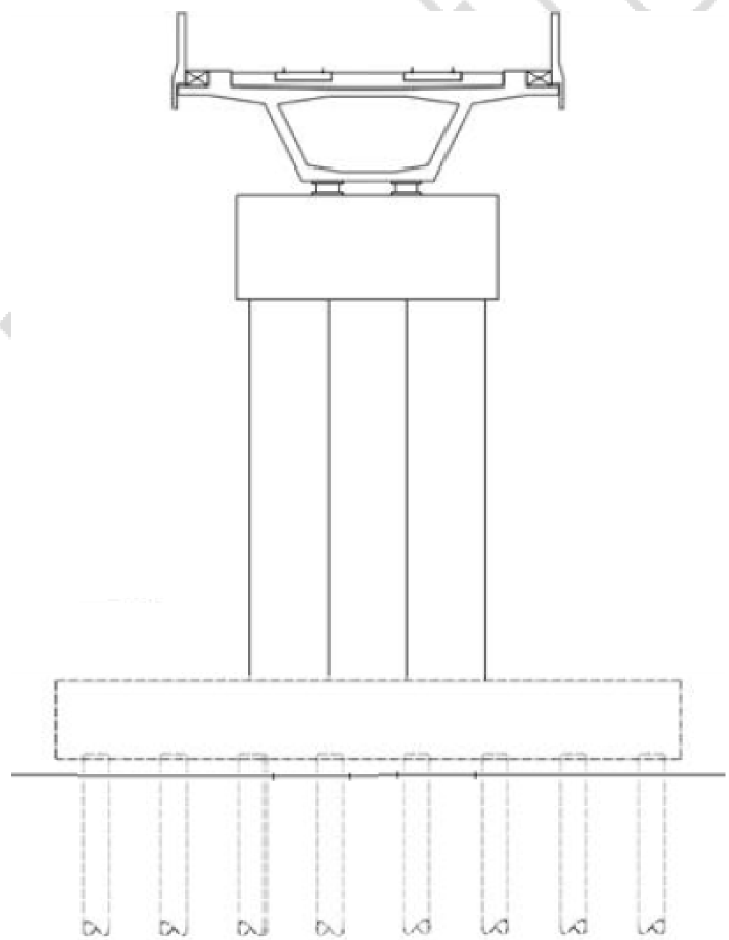


Figure 3 – Typical section of Alternative 2

Precast bent cap and pile cap could be used to minimize environmental impact to the wet land.

The precast concrete girders or segments will be transported to the site by girder transporter via the previously constructed bridge deck, and erected into position by winches from the gantry.

After one span is constructed, the gantry will be advanced for the construction of the next span. A similar procedure will be repeated span by span until the gantry reaches the other side of the slough.

- Advantages: Accelerated construction. Reduced environmental impact to the wetland when compared to other options. Fluctuation of groundwater table will have little impact on construction activity on the gantry. Using pile driving gantry crane is more cost effective than using temporary work platform.
- Disadvantages: Significant initial investment in the gantry is required for the contractor.

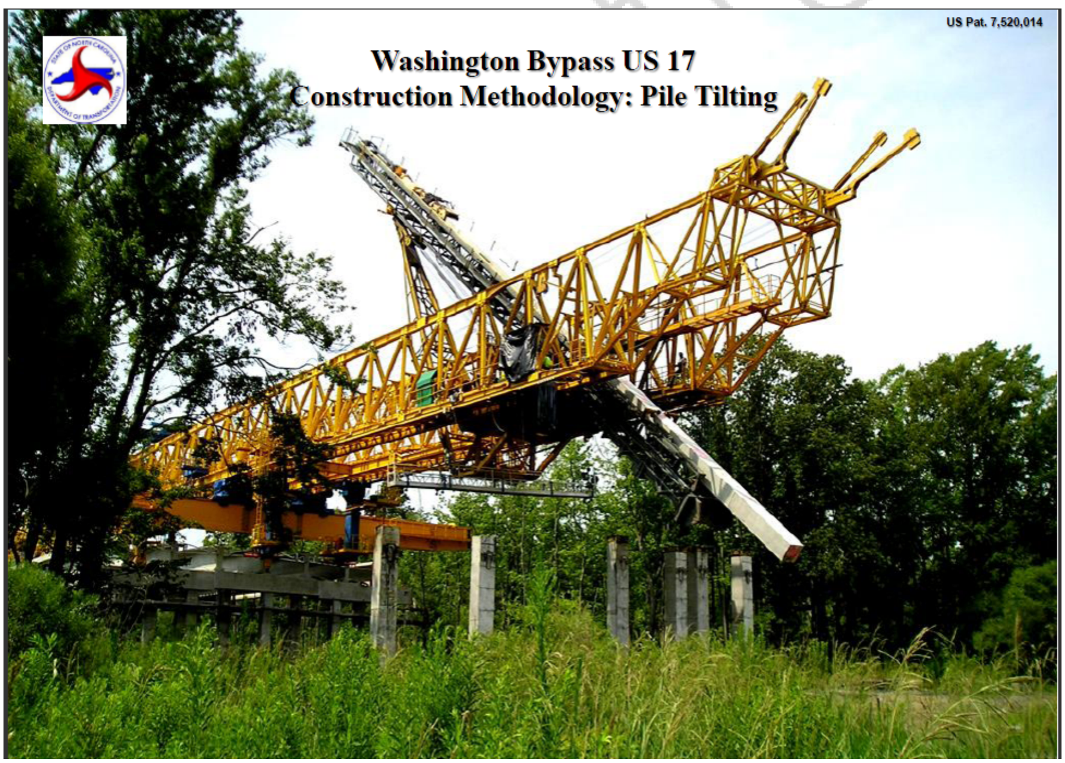


Figure 4 – Example of gantry being used for driving piles

4.3.2.4 Recommendation

Alternative 1 and Alternative 2 are considered feasible for the proposed site according to the preliminary engineering investigation. The environmental footprint of Alternative 2 is smaller than that of Alternative 1; however, the construction cost of Alternative 2 is also significantly lower than that of Alternative 1. It is our recommendation that Alternative 2 is considered as the preferred alternative during the next stage of the design.

4.3.3 Impact to WSDOT facilities

WSDOT have expressed significant concern regarding the construction and operation of new facilities adjacent to their I-90 structures. These concerns are a result of the damage experienced by those structures from the movement of the peat, described above, and the studies that have been carried out to investigate this phenomenon. These issues were the subject of a presentation to the City by WSDOT.

Construction of the proposed viaduct may cause concerns including:

- Construction vibration impacts, particularly related to driven piles
- Lateral displacement of soil related to driving piles
- Surface loading of the peat imposing lateral pressures on the highway foundations
- Transfer of load from LRT or trestle foundations into the highway foundations
- Impact of new foundations on the flow patterns of the peat and the potential for increased impact on the highway structures

The foundations provide under the schemes described above, based on the conceptual design work completed to date, will provide sufficiently robust structures to accommodate the movement of the peat and the anticipated soil loads.

While the foundations are located at a distance from the I-90 structures which are expected to minimize the impacts of the new foundation on the I-90 structures, more detailed analysis will be required to further understand the extent of potential interactions, to define construction mitigations to minimize them, and to satisfy WSDOT that the selected approach is appropriate.

4.4 BNSF corridor

The abandoned BNSF freight rail corridor runs from SE 32nd Street in the south to the site of the now removed Wilburton Tunnel in the north. This section is approximately 4750 ft long and the Right of Way of the corridor is typically approximately 100’ wide, with a narrow section approximately 50’ wide to the south end immediately north of SE 32nd Street. Generally, the eastern edge of the corridor is higher than the western edge, with the existing single track section slightly raised above the existing ground.

On closure of the line this corridor became subject to a rail banking agreement which is intended to provide the opportunity to re-establish freight service in the future if required. The City of Bellevue has requested that this be addressed in two ways. Firstly to provide two tracks on the assumption that a future freight operator will run on the shared LRT tracks (operating at different times of the day), and secondly that an alternative be developed which provides space for an additional freight track alongside LRT in the future. The former is the basis of this technical memo. A second technical memo will consider the second option.

Technical Memo TM12- Shared Running with Freight Rail, should be considered in conjunction with this section as it discusses in more detail the issues of LRT and freight sharing the same tracks.

The alignment is at-grade through this section and broadly follows the alignment of the existing track bed, and has been optimized to reduce retaining wall requirements. Retaining walls are required at some locations to accommodate the varying existing elevations on either side of the corridor. Where space is available, a cross section has been adopted which allows for open drainage ditches alongside the track and is typically 75 feet wide (Figure 5). Where retaining walls are required the section has been narrowed to reduce the extent of the retaining walls. Where walls are required on both sides the section is approximately 43 ft wide to the outside of the walls (Figure 3). This cross section could be further reduced by providing piped drainage, to reduce retaining wall length; however, this would increase drainage costs and is expected to have little impact on overall cost.

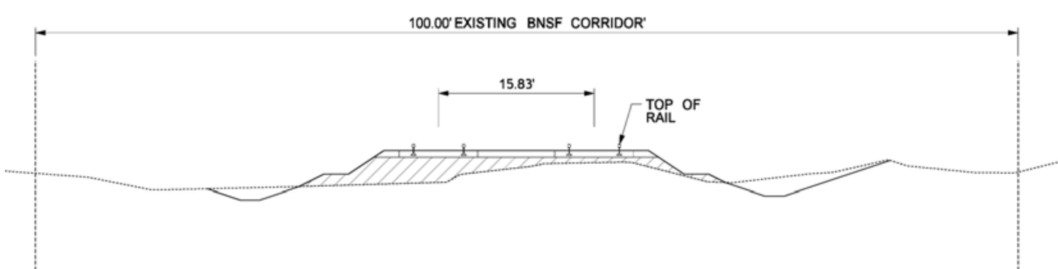


Figure 5 - Shared Track typical section with drainage ditches

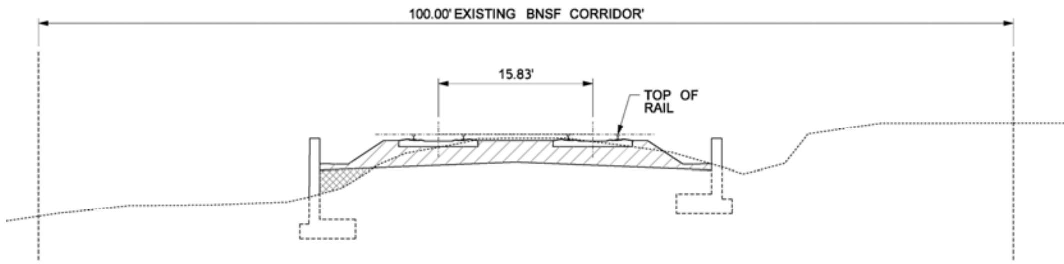


Figure 6 - Shared Track typical section dual retaining walls

The typical shared track section maintains nine feet of horizontal clearance, Sound Transit prefers eight foot minimum, from the centerline of track to allow for emergency walkway. Drainage channels have been assumed for both cut and fill slopes with dimensions of 1.5 feet deep with 1V:3H side slopes, and a 2 foot bottom width. Maximum cut and fill slopes of 1V:2H have been utilized to suit the geotechnical conditions in the corridor and top be consistent with Sound Transit criteria. A more detailed discussion of the geotechnical conditions along this corridor is provided in Appendix B.

Retaining walls are used when the cut or fill slopes with drainage channels do not fall within the existing BNSF property. They are located at nine feet from the track centerline to allow emergency walkway on the outside of the tracks. All walls are assumed to be cantilever retaining walls for estimating purposes. The use of alternate wall types, such as structural earth walls or gabion walls will be explored in the next phase. The following table indicates the location, length and height of retaining walls required for this option. A retained section is provided for the southern 280 feet where the right-of-way is only 50 feet to eliminate the need for additional property acquisition.

Start STA	End STA	Length (ft)	Avg. Height (ft)
WB Side			
2053+99	2059+20	521	12
2063+15	2065+15	200	13
2066+40	2067+05	65	12
2067+45	2070+76	331	14
2072+51	2077+75	524	14
2078+50	2081+70	320	12
2083+45	2085+30	185	10
2090+60	2090+80	20	11
2092+45	2095+15	270	13
2210+00	2212+00	200	10
EB Side			
2053+99	2056+83	284	10
2067+70	2071+00	330	11.5
2097+66	2099+07	141	10
	Total	3391	

Table 5 - BNSF corridor shared track retaining walls (for Shared Track option)

The alignment has been developed to allow for the future connection to freight tracks that would follow the freight corridor to the north and south of this section of the light rail alignment. On establishment of the freight corridor a turnout would be placed at approximately STA 2099+00 to allow freight trains to connect between the light rail tracks and the freight corridor as it crosses I-405 at the site of the old Wilburton tunnel. At the south end of this section two alternatives are feasible:

- Continue the straight track to the north of STA 2054+00 southwards for freight and install a turnout for LRT trains. As a result of the superelevation required for the curve to the south of STA 2054+00 the running speed across the turnout would be reduced from 30mph to 20mph (deviation from the DCM standards would be required for 20mph running speed) or 15mph (no deviation required).

- Install a turnout for freight rail on the straight track at approximately STA 2056+00. This will allow 30mph running speed but would require a future property taking on the east side of the alignment when freight rail is established.

Upon establishment of the freight rail, the OCS pole configuration, which supports the traction power guide wire, would need to be reconfigured to two posts, one on either side of the tracks, and elevated to reach freight running clearances. The pantograph for Sound Transits rolling stock would also need replacement to accommodate the increased catenary clearance that would be required by running freight on the tracks.

The existing disused rail bridge at the south end of this corridor would be replaced to accommodate the new freight line when the freight line was implemented.

An overhead electrical transmission line that crosses the corridor near the SE 23rd Street crossing will need to be raised or relocated.

The design speed of the curve at the south of the corridor is 30 mph and the design speed through the corridor is 55 mph. At the north end the design speed is 45 mph.

4.5 I-405 viaduct

North of the BNSF corridor, the alignment transitions on to a viaduct running parallel to I-405 for approximately 4000 feet. The viaduct is required to accommodate a steep grade change and to pass over several roadways, including 118th Avenue SE, SE 8th Street, and the intersection of SE 6th Street and 114th Avenue, SE. In addition, there are two significant businesses along this alignment and the alignment has been set to minimize the impacts to these parcels. The STOR-HOUSE Self Storage is at STA 2108+00 and the Greenbaum Furniture Store is at STA 2123+00.

Typically, the viaduct will be of concrete box girder construction with piers at approximately 120-140 feet centers and a structural depth of up to 8.5 feet. At its highest point, the viaduct is sixty feet above the existing grade, but it is generally between 40 and 50 feet above the ground.

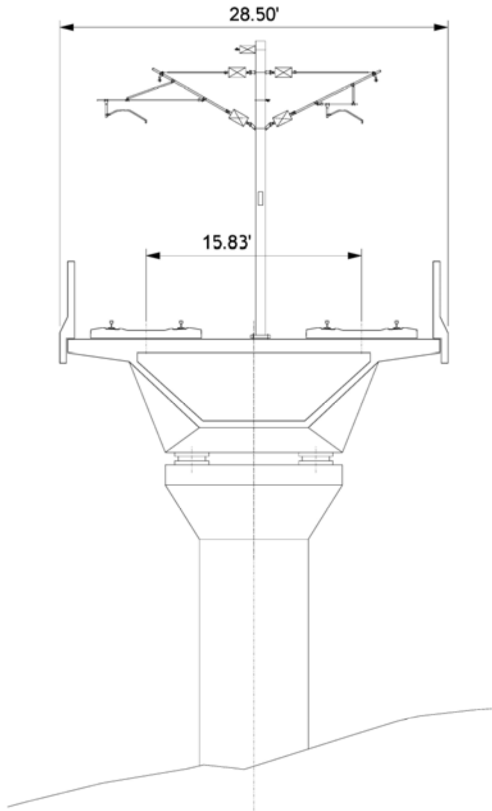


Figure 7 - Viaduct typical section

4.5.1 STOR-HOUSE self storage facility

The STOR-HOUSE Self Storage facility is a recently constructed self storage facility immediately north of where the alignment diverges from the BNSF corridor. The B7-Revised alignment passes approximately 10 feet to the east of the building on a viaduct approximately 40-50 feet above grade.

Figure 8 shows the alignment relative to the building and property line. Provisional pier locations are indicated which avoid impact to the building and access on the east side of the building. The pier locations may impact the retaining walls recently constructed for the I-405 widening and within the storage unit. Grading and reconstruction of the wall will be required at these locations to allow the construction of the piers and maintain the stability of the walls.

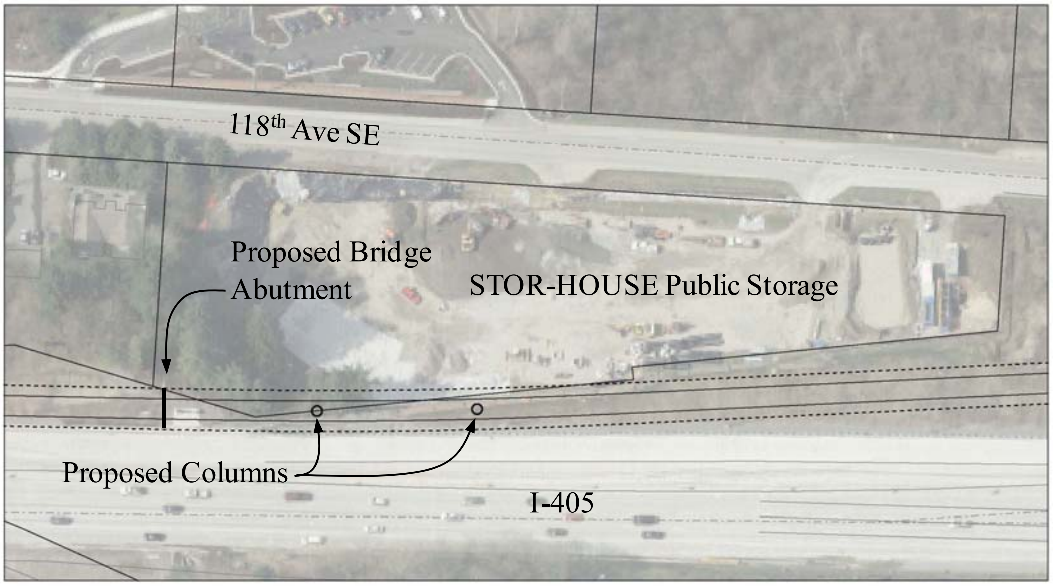


Figure 8 - STOR-HOUSE self storage site

4.5.2 Greenbaum Furniture Store

The alignment has been developed to accommodate the future I-405 Master Plan. In the section adjacent to the Greenbaum furniture the Master Plan comprises widening of I-405 and the relocation of 118th Avenue SE to the west, partly within the Greenbaum parking lot, providing insufficient space for the light rail alignment to pass between the relocated road and the store.

To allow the opportunity to retain the store, avoid impact on the Master Plan and to minimize the skew of the 118th Avenue SE crossings, the alignment runs above the east corner of the existing building. The eastern portion if the building will need to be acquired as Sound Transit guidelines do not permit the placement of tracks over structures. Provisional pier spacing within the lot and the extent of the building acquisition are shown in Figure 9 and have been set at 140 feet spacing where possible to minimize impact on the Greenbaum parking lot and access. The parking and access to the store will require reconfiguration.

Overhead electricity cables will require relocation in this area.

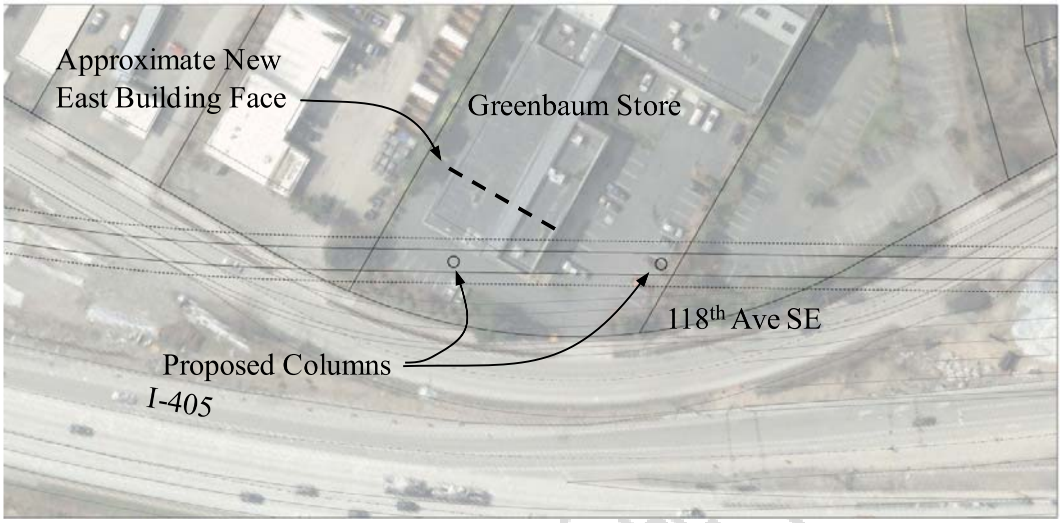


Figure 9 - Greenbaum furniture store

4.6 Sturtevant Creek/Hilton Site

North of SE 6th Street the alignment follows 114th Avenue SE, the frontage road in this area, and descends from viaduct to at-grade near the Hilton Hotel.

The I-405 Master Plan in this area removes the existing 114th Avenue SE and replaces it with a collector-distributor road to the west of its current location, closer to the Hilton Hotel site. Sturtevant Creek, an existing salmon bearing creek, flows between the hotel and 114th Avenue SE.

Both an elevated viaduct and an at-grade option were considered in this area. It was concluded that while the impacts to the stream would be greater with the at-grade alignment than the elevated alignment and that permitting would be more complex that the impacts could be reasonably mitigated. Further details of the environmental impacts and mitigations in this area are provided in TM 10.

The at-grade alignment runs between the creek and the realigned frontage road and is approximately 21 feet from the hotel building at the northern end. A retaining wall approximately 775 feet long will be required on the west side. This wall will be up to 16ft high at its south end, but will be typically 6ft where it adjacent to the stream. A smaller wall will be required on the east side along the edge of I-405. The wall will be located near the bottom of the creek which in some areas will require the channel to be relocated to the west to maintain the channel capacity. On-site mitigation will be provided to provide planting and enhancement of the creek bed. A 25 ft low profile bridge will be provided over the stream where it crosses to I-405 to avoid extension of the existing I-405 culvert.

Overhead electricity cables will be relocated from the intersection of 114th Avenue SE and 6th Avenue SE to East Main Station.

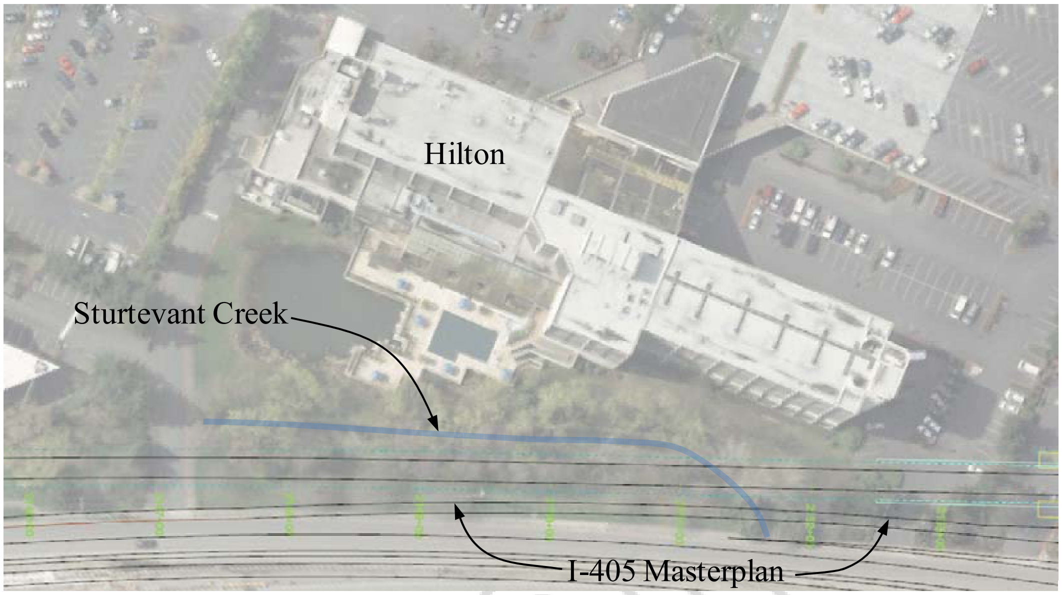


Figure 10 - Hilton site and Sturtevant Creek

The northern end of the creek is fed by a series of culverts, two 48 inch concrete pipes and a 42 inch corrugated metal pipe from under I-405, and a 36 inch corrugated metal pipe from the Red Lion site. This segment accepts minor flows from the existing frontage road and the pond serving the Hilton site, prior to discharging downstream through a 108 inch corrugated metal pipe.

An initial review of the hydraulic performance of the revised stream cross section indicates sufficient capacity; however this will need to be reviewed in later phases of the design.

4.7 Red Lion and Sheraton sites

The revised East Main Station will be located on the existing Red Lion Hotel Site. The platforms will be located on a 0.3% grade with the tracks located 5 feet below existing ground at the south, and 15 feet below grade at the north end. From this point to Main Street, the LRT will be retained by walls on both sides approximately 20 feet high. This is a deviation from the original C9T alignment, which was an elevated station, with different environmental impacts which are discussed in TM10.

The alignment passes under the western approach to the existing Main Street / I-405 over crossing, through a simple span bridge over the tracks that is assumed to be part of the B7 project works as WSDOT does not have funds allocated to reconstruct Main Street. This bridge would require close cooperation with WSDOT and the City of Bellevue as construction of this bridge will require lane closures and relocation of traffic to allow the bridge to be built in sections. This bridge will be required regardless if the I-405 Master Plan realignment of Main Street is advanced or if the existing crossing remains.

If the phasing between the East link construction and the construction of the I-405 Master Plan is concurrent it may be possible to build the Main Street crossing as part of the Master Plan potentially reducing overall cost, and traffic disruption. This would require detailed coordination between Sound Transit, The City of Bellevue and WSDoT.

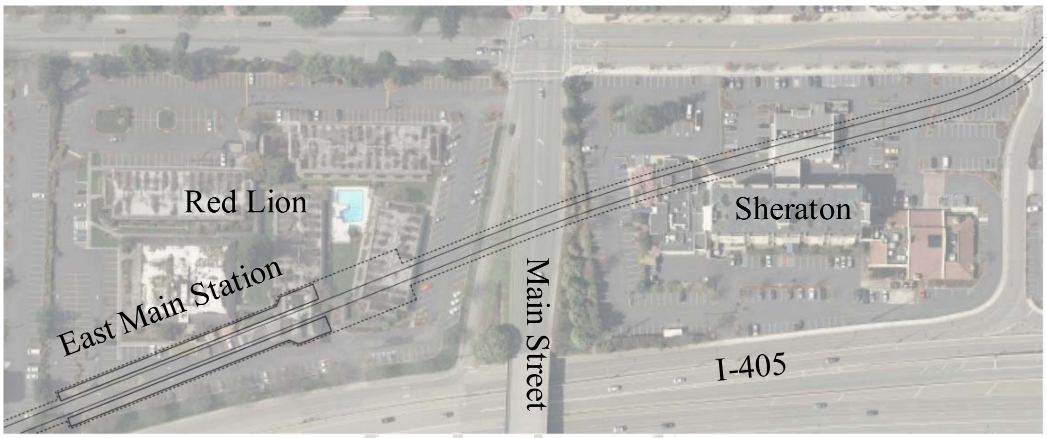


Figure 11 - Red Lion and Sheraton sites

Several options were explored to retain the Sheraton Hotel. They are governed by the alignment criteria associated with the East Main Station, and all options would have significant impact on the hotel during construction and operations. A direct alignment which allows a more efficient portal location was selected and would require the acquisition of the Sheraton site. The proposed design places the LRT in a trench with retaining walls on the east and west side at a height of approximately 40 feet.

The alignment splits the site. To enhance opportunities for future development it would be possible to cap the trench to form a cut and cover tunnel. This would require an assessment of tunnel ventilation and fire-life-safety issues. The current scheme does not account for this.

4.8 Link to Segment C

The horizontal alignment follows the northern side of NE 2nd Street and 110th Avenue NE, tying into the previous C9T at the south end of the Bellevue Transit Center Station.

The vertical alignment of this section is restricted by overhead clearance at the intersection of NE 2nd Street and 112th Avenue NE near the tunnel portal entrance. A 25 foot clearance from the top of rail to finished ground level has been assumed. This allows 10 feet for the cut and cover structure and utilities, and achieves the desired minimum clearance criteria. A maximum mainline track grade of 6% has been used to match the Bellevue Transit Center Station levels and grade from the previous C9T design. To achieve the tie-in, the length of the vertical curve at Sta. 2175+00 has been set between the absolute minimum and desired minimum.

Utility relocations will be required within the section from the Red Lion site through to the Bellevue Transit center and include gas, oil, electric and sewer.

The design speed for this corridor is 15 mph due to the horizontal radius of 250 feet at the NE 2nd Street/110th Avenue SE interchange.

5 Summary

The alignment has been developed using Sound Transit Design Criteria with derogations noted above. The alignment analysis has further detailed the B7-Revised alternative, where possible to minimize adverse impacts to private properties, businesses, sensitive areas and noise and visual impacts. It has been developed and has respected specific constraints including the I-405 Master Plan.

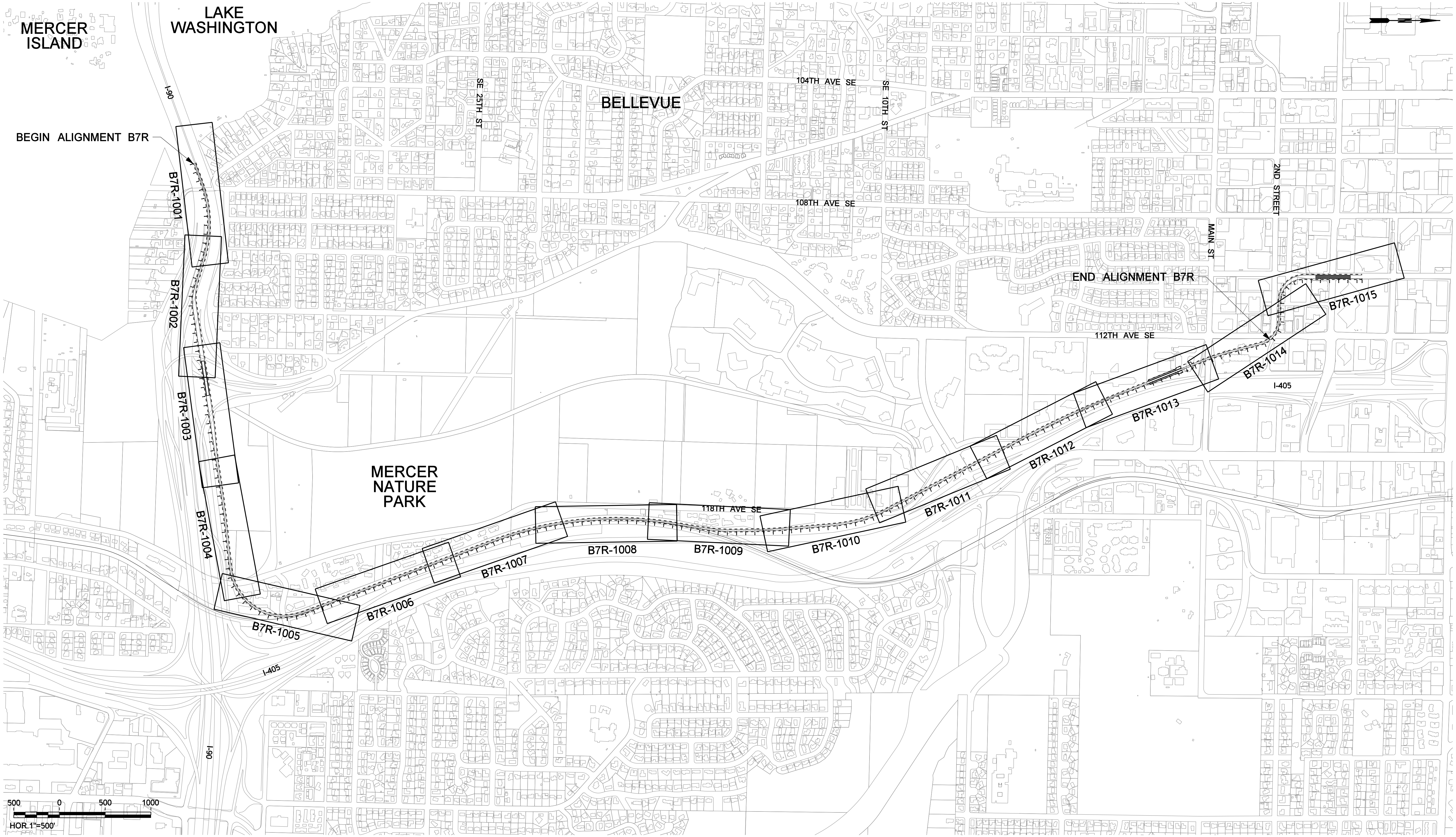
6 Next steps

The following next steps will be to further develop the preferred alternative to concept level. Several items will be looked at in further detail:

- Mercer Slough foundation and pile cap constructability
- Retaining wall material types along the BNSF shared track segment
- Refined viaduct columns spacing along I-405 viaduct

Appendix A

Early Concept Alignment Drawings



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CHECKED BY D. HUNT
IN CHARGE R. PRUST
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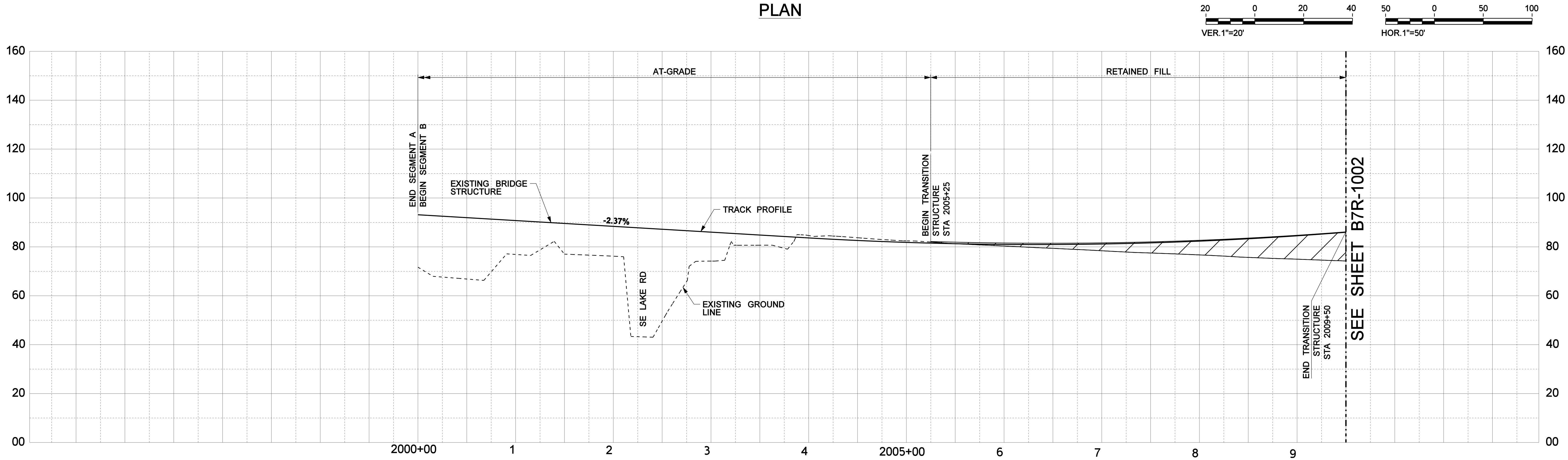

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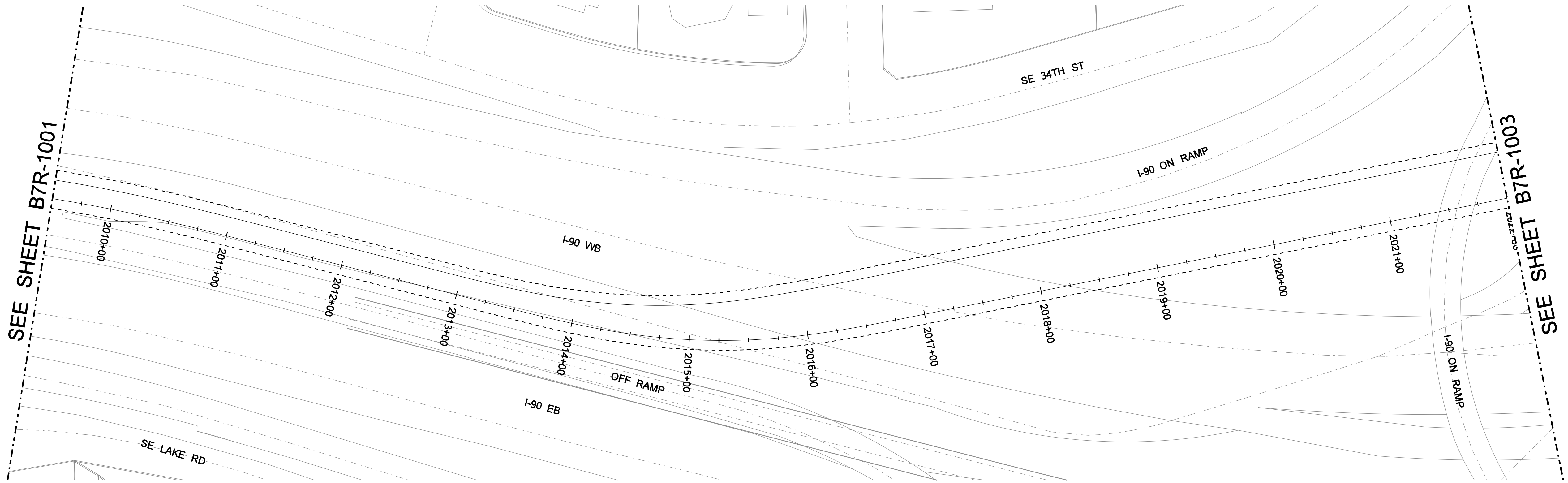

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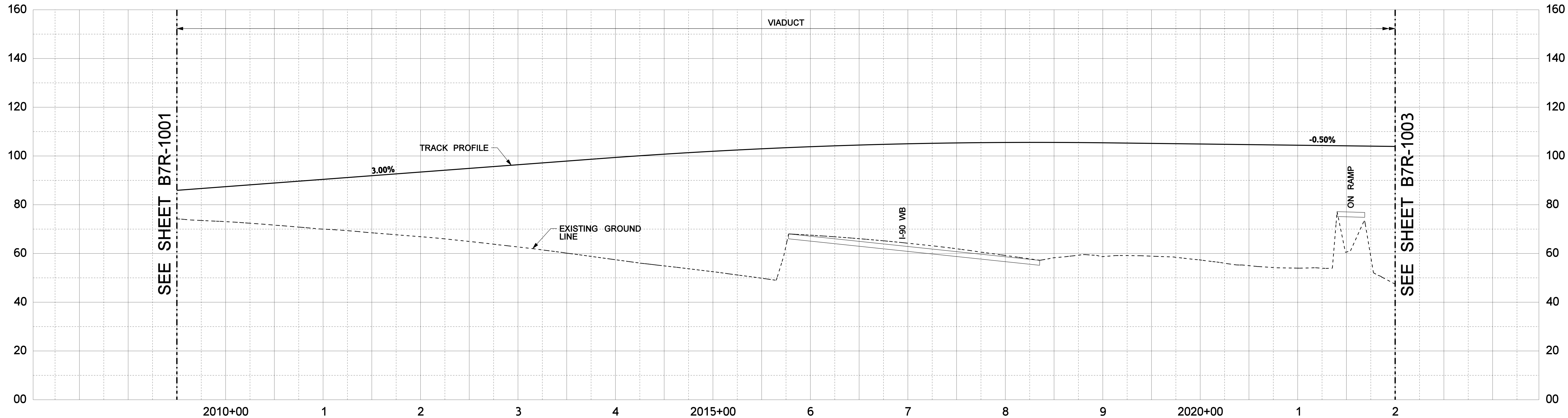

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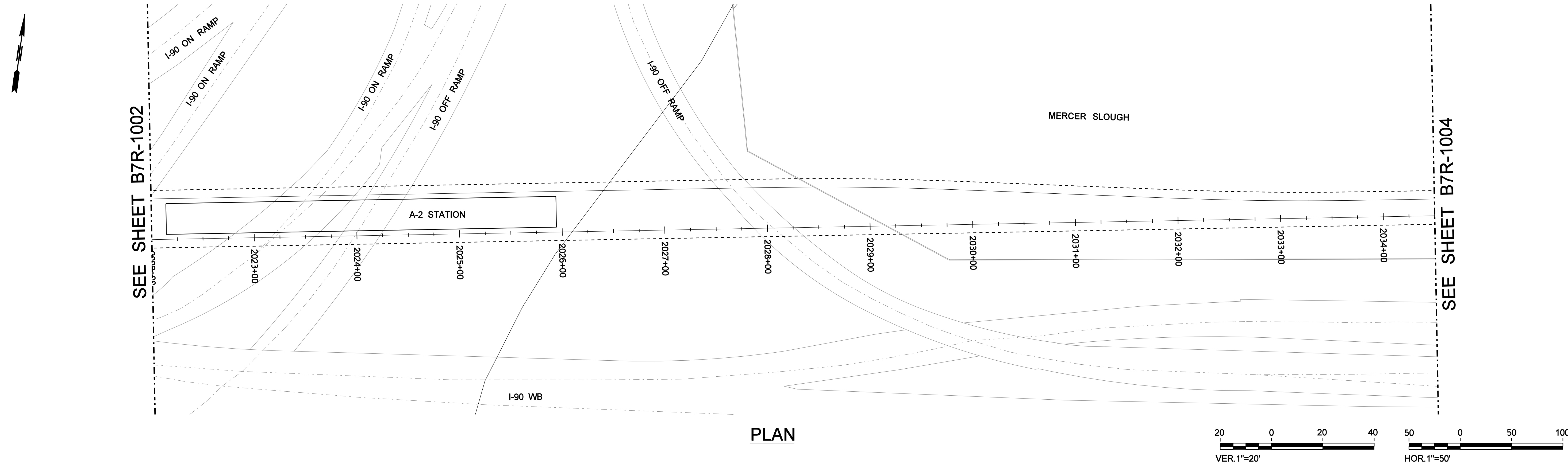

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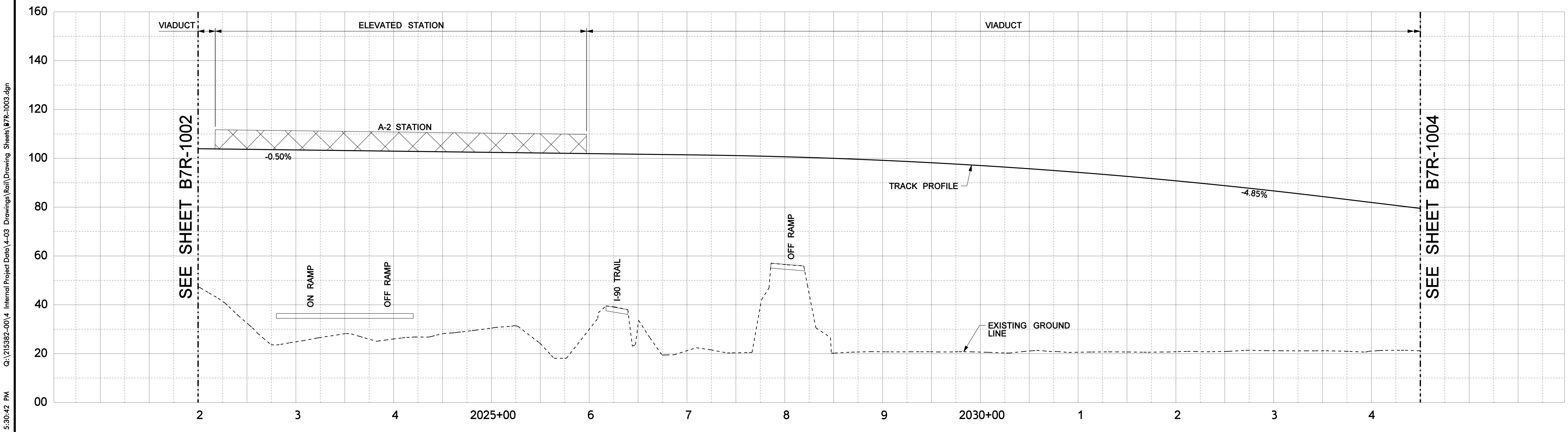

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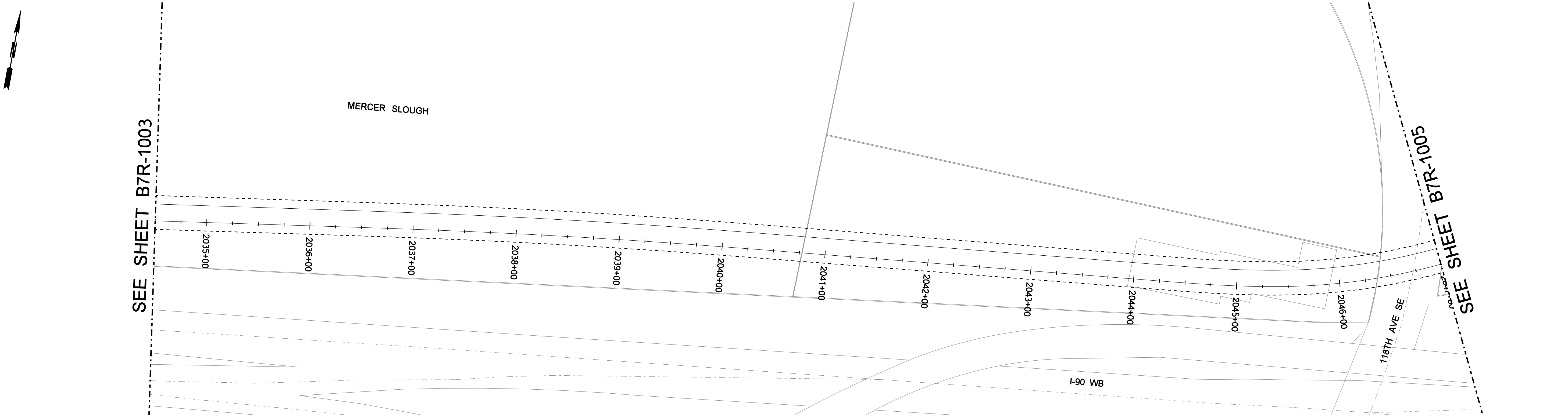

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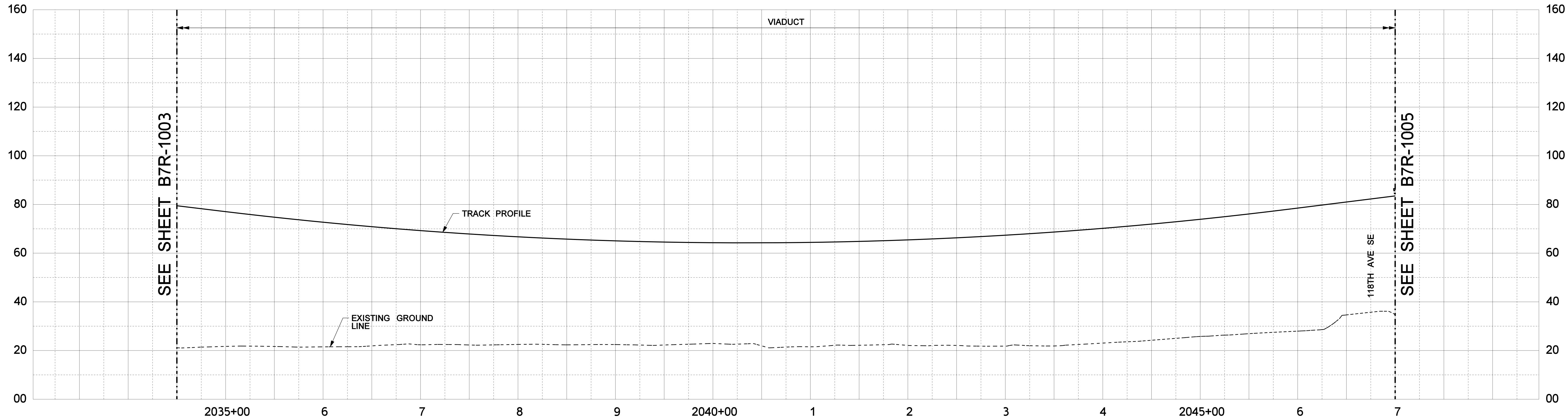

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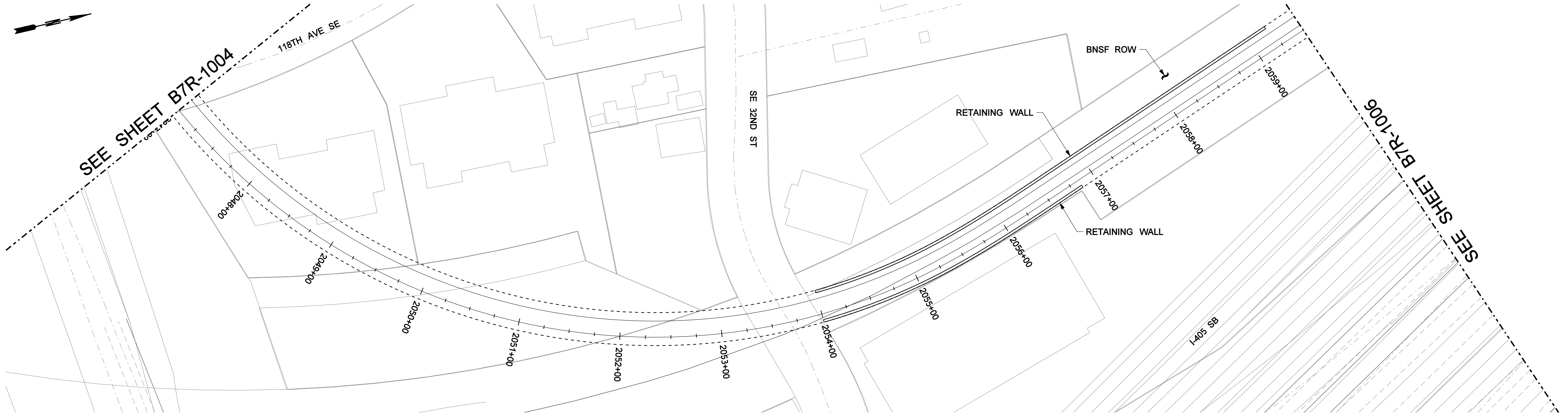

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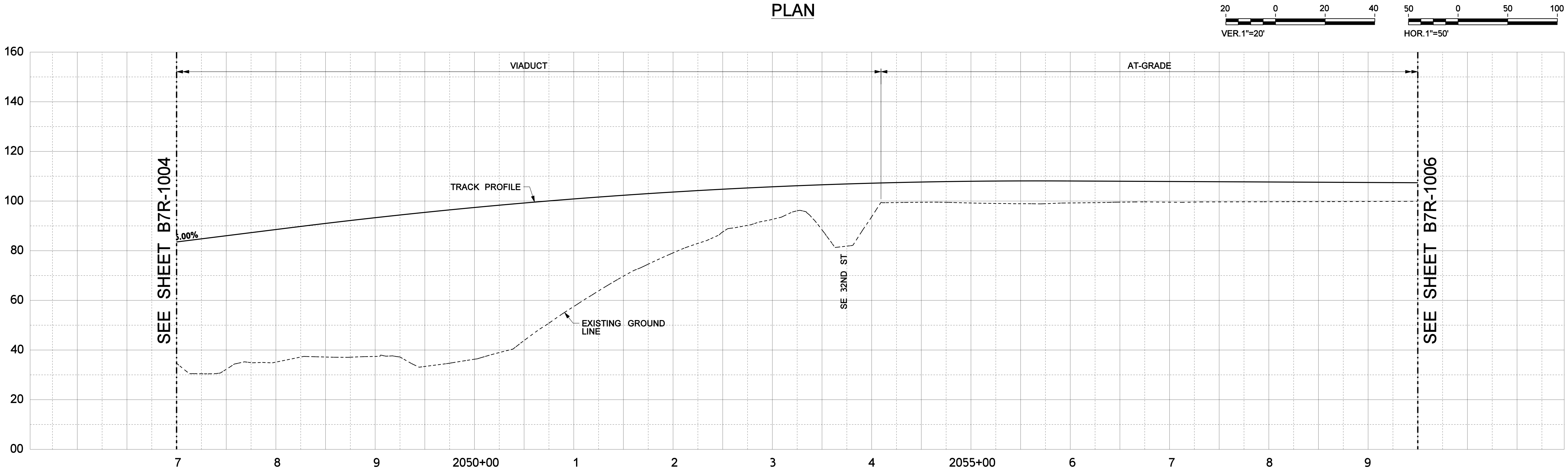

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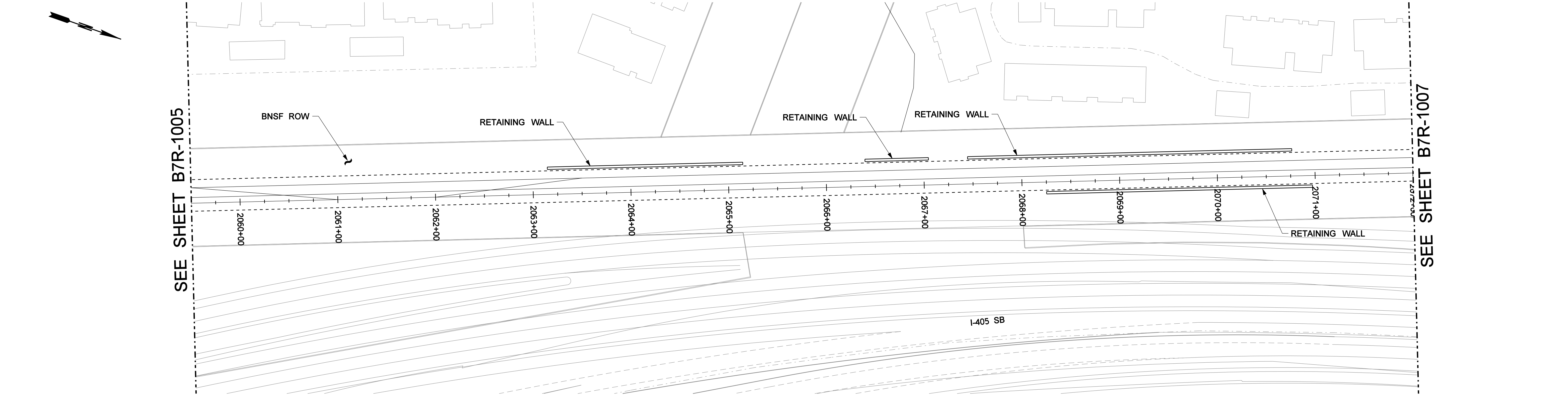

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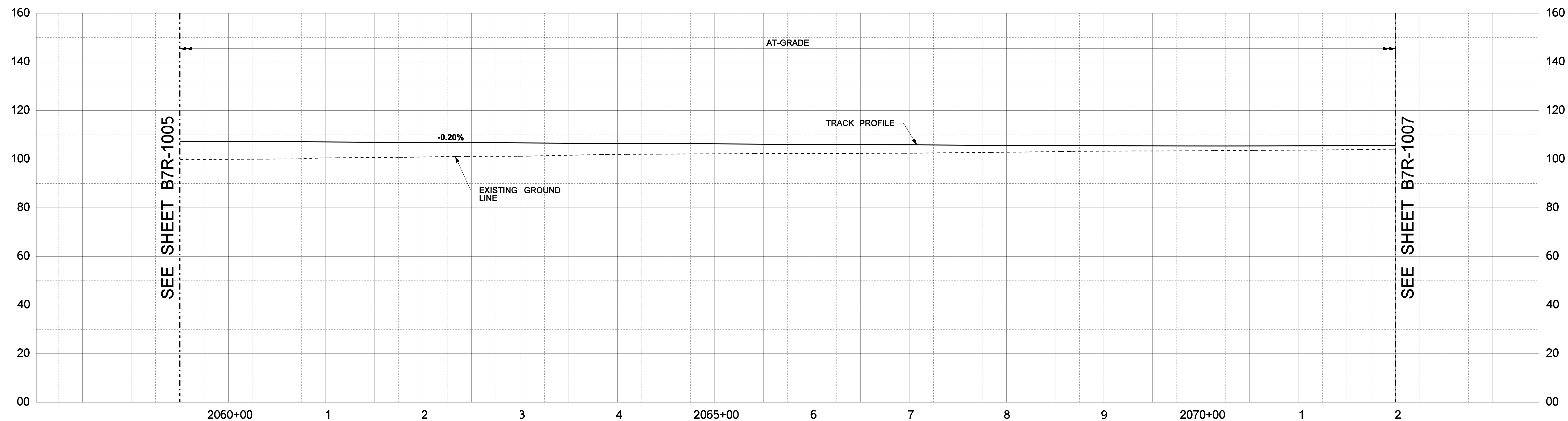

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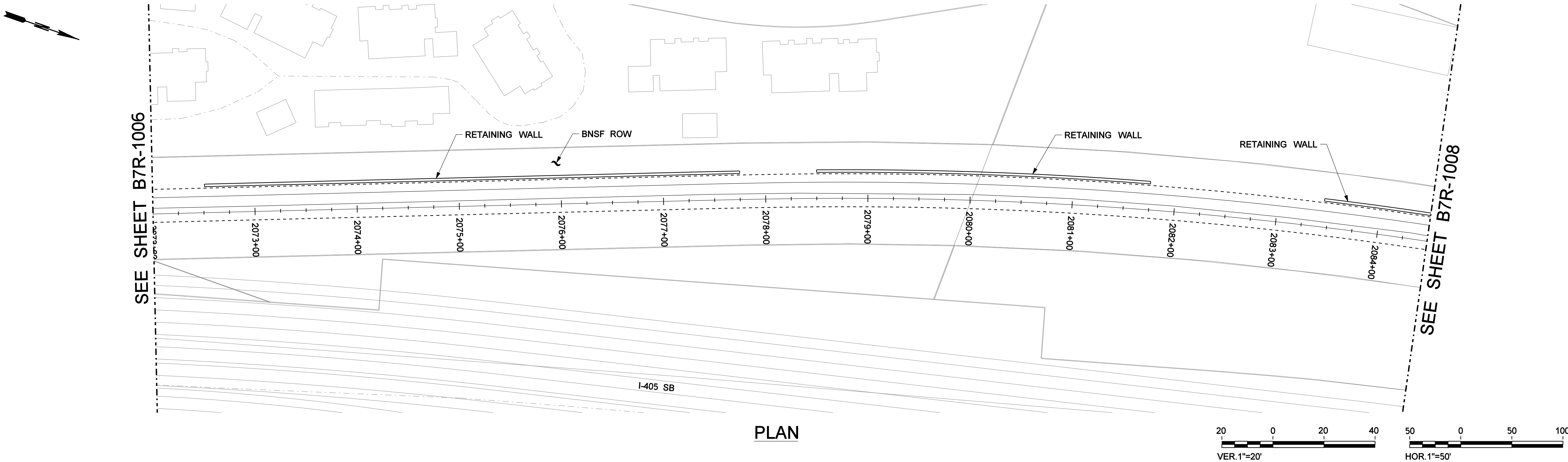

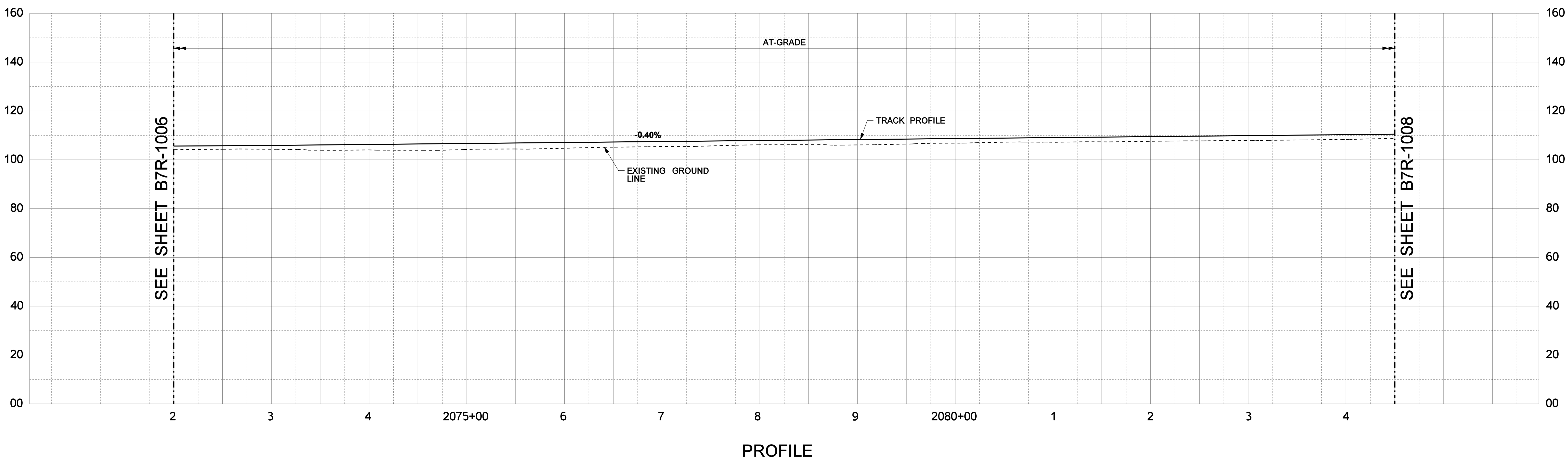

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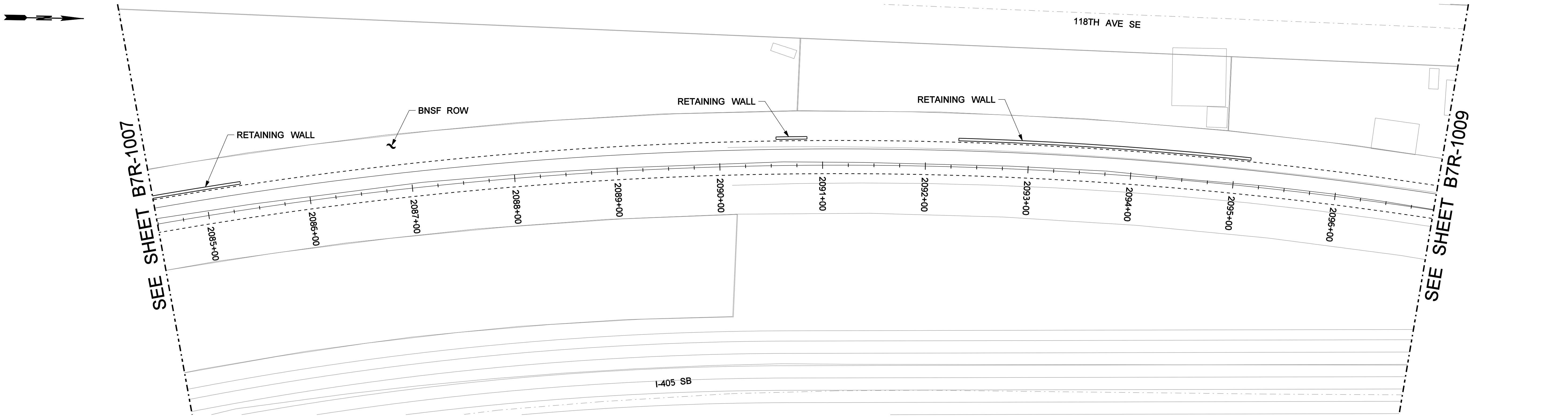

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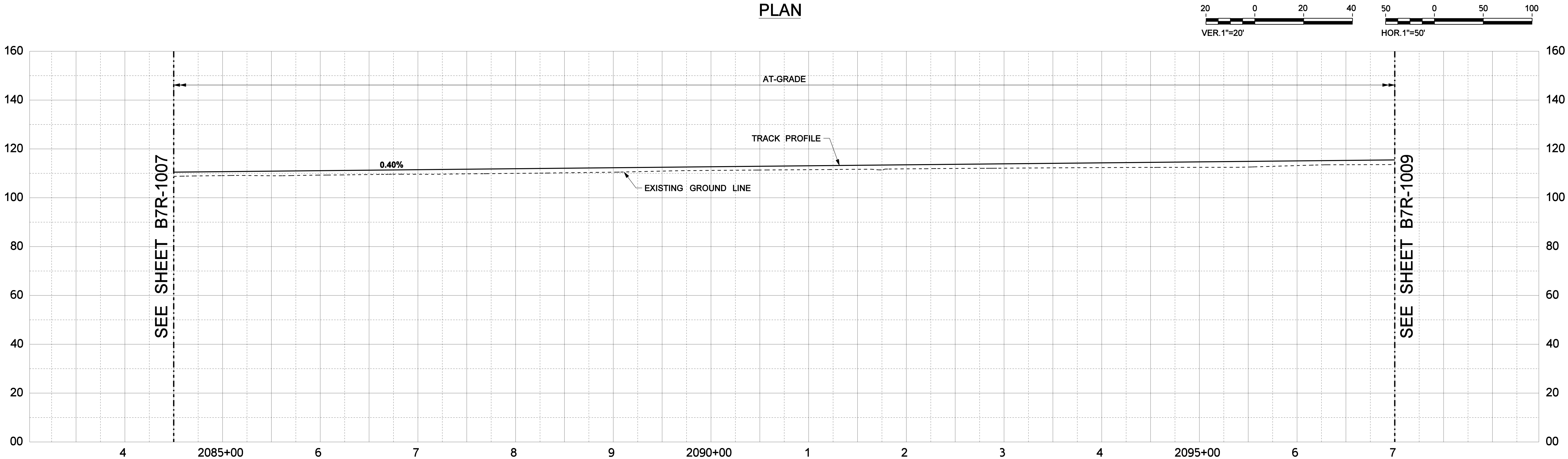

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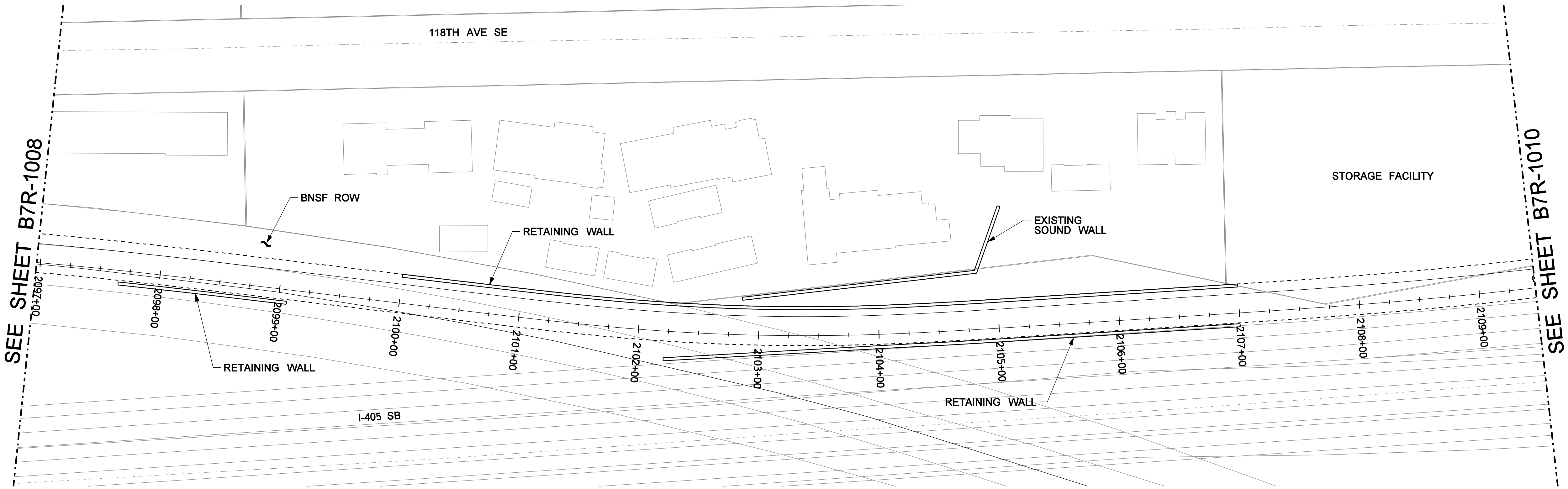

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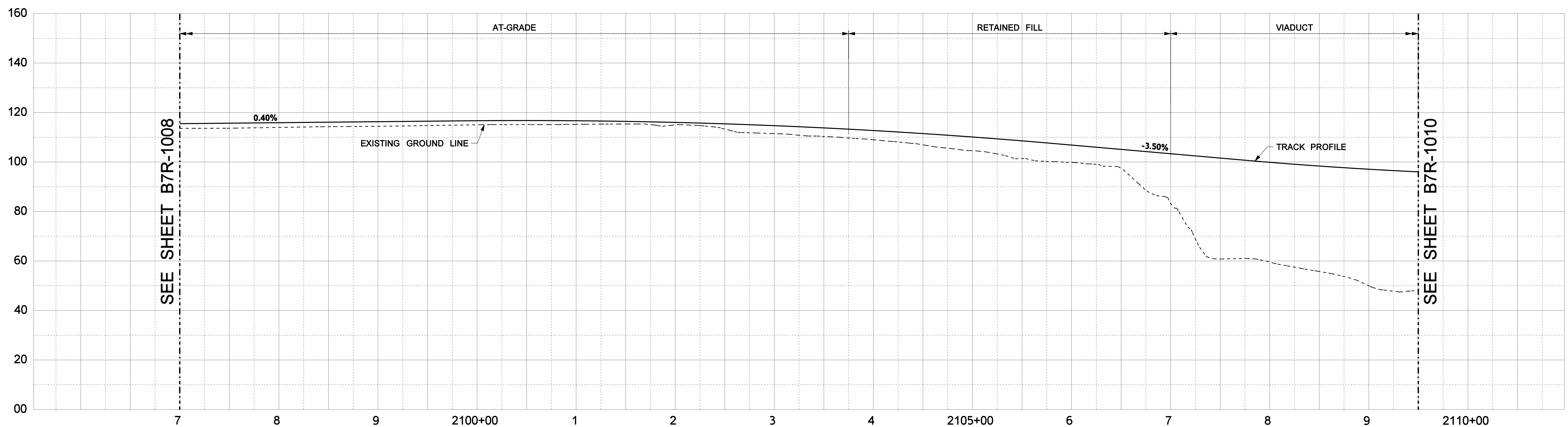

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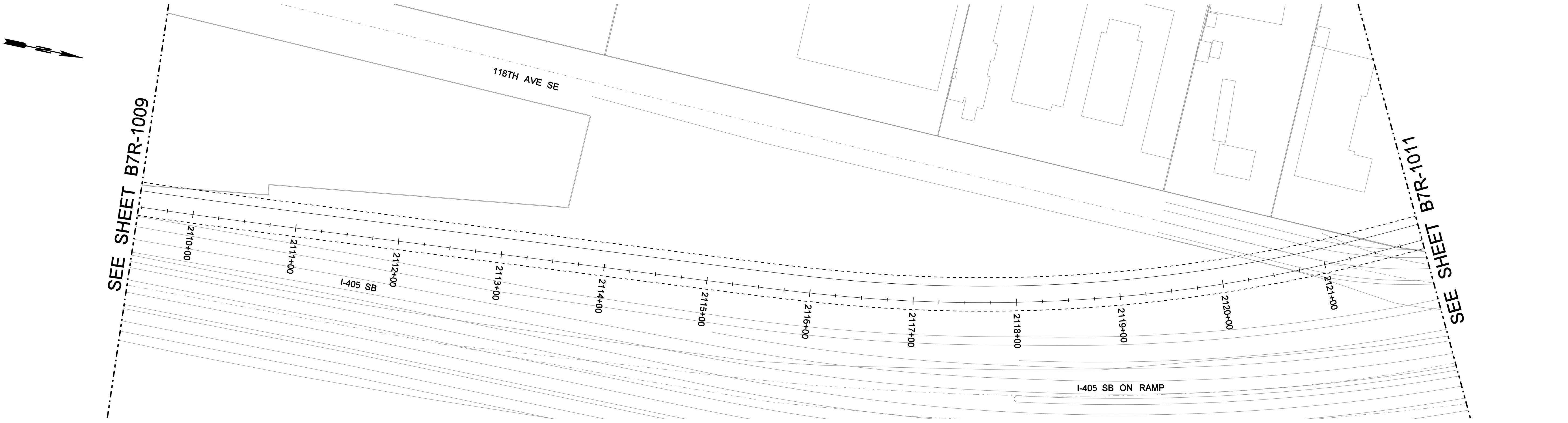

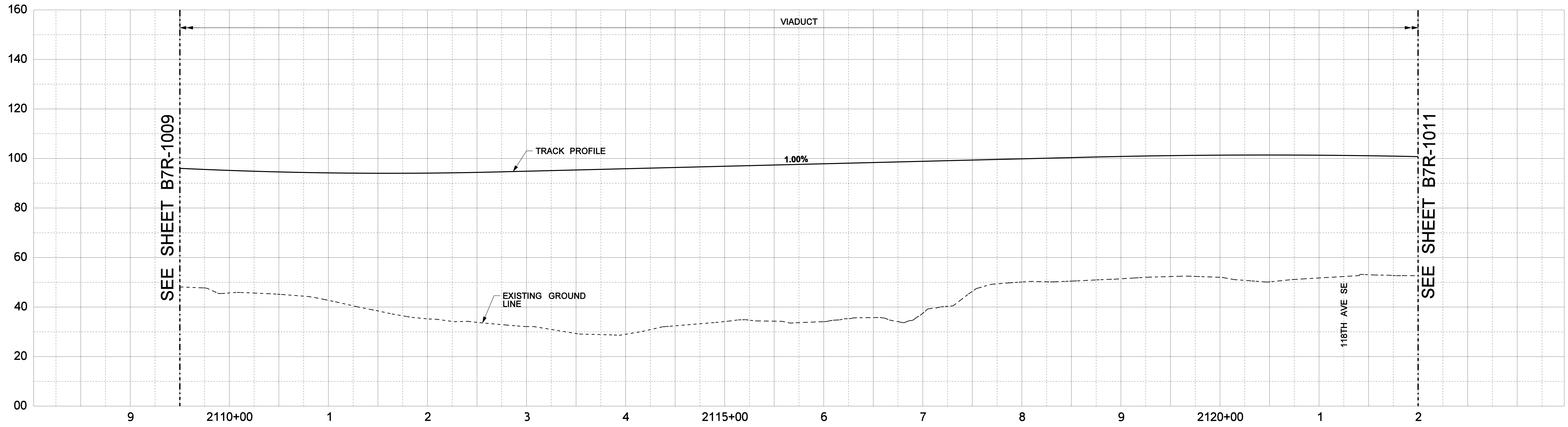

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CITY OF BELLEVUE WASHINGTON

SUBMITTED	DATE	APPROVED	DATE

EAST LINK LIGHT RAIL

B7/C9T TO NE 2nd PORTAL
(B7 REVISED) ALTERNATIVE
TRACK PLAN & PROFILE
STA. 2109+50 TO 2122+00

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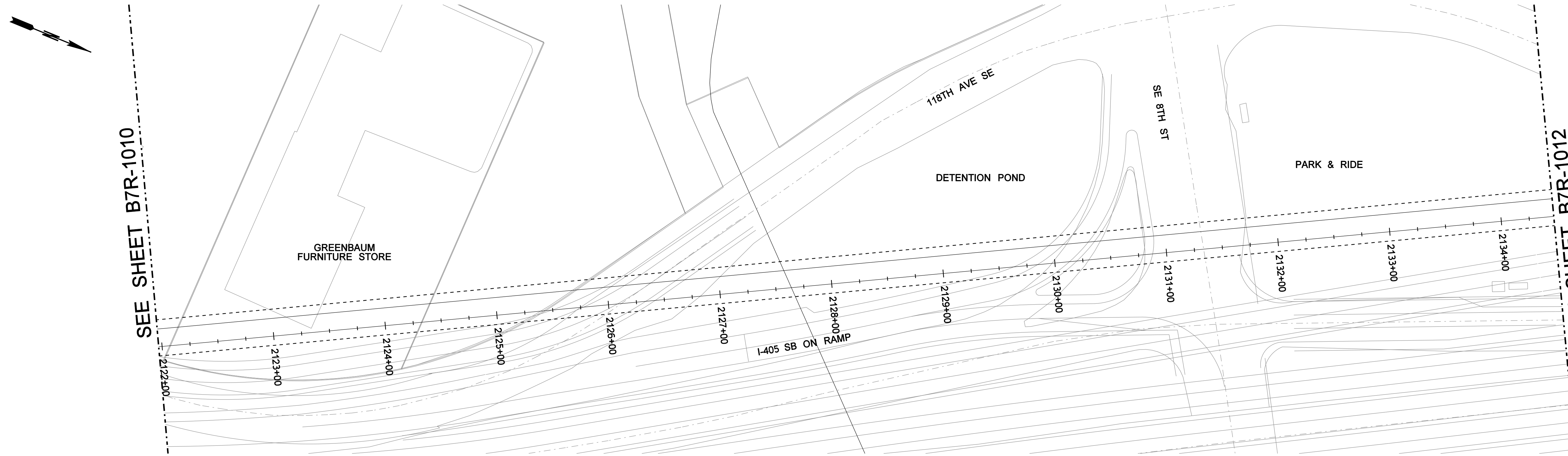
SHEET NO. SHEET 11



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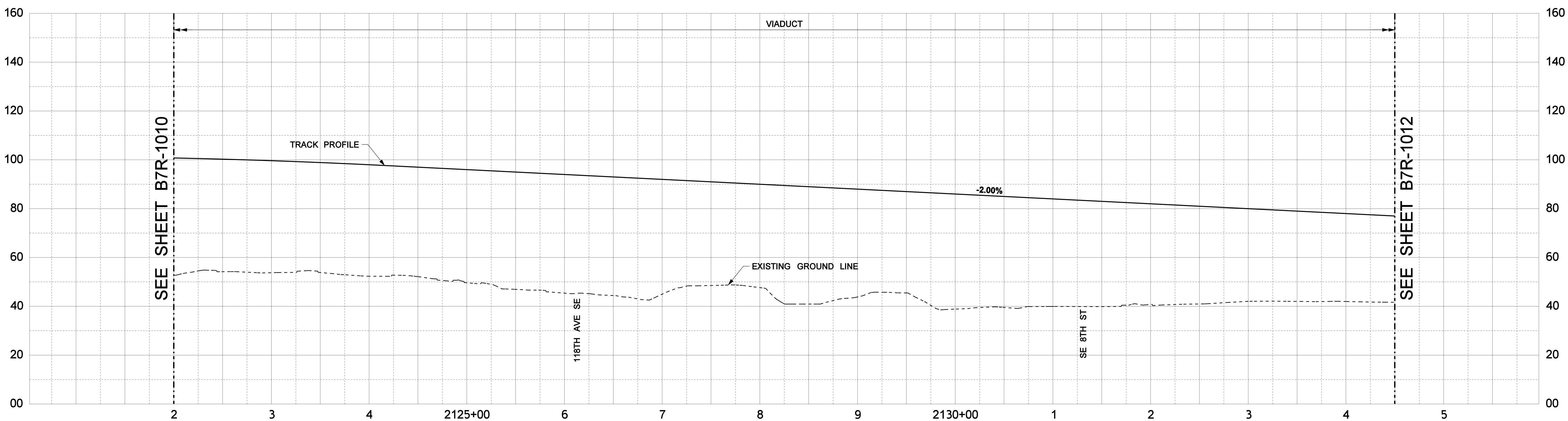

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thomas.natwick

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C	03/15/11	PT	NW	RP	EARLY CONCEPT ALIGNMENT SUBMITTAL
B	03/07/11	PT	NW	RP	REVISED 1% SUBMITTAL
A	02/16/11	PT	DH	RP	1% SUBMITTAL

DESIGNED BY T. NATWICK
DRAWN BY P. TONKIN
CHECKED BY D. HUNT
IN CHARGE R. PRUST
DATE 04/29/11

REVISED 1% SUBMITTAL

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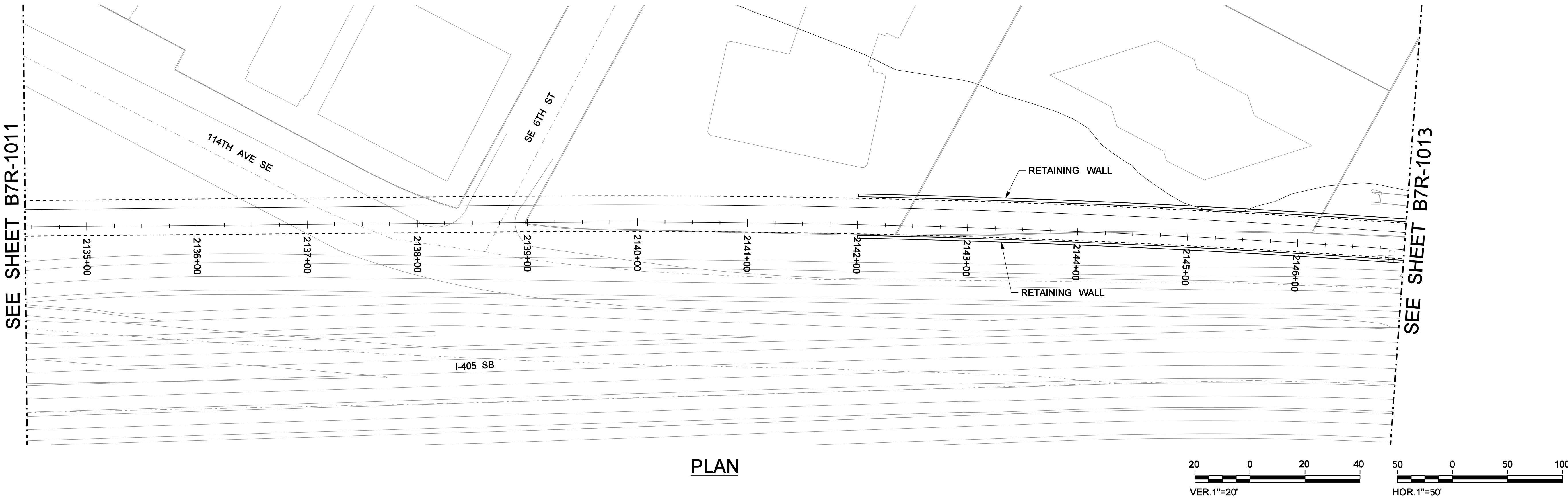

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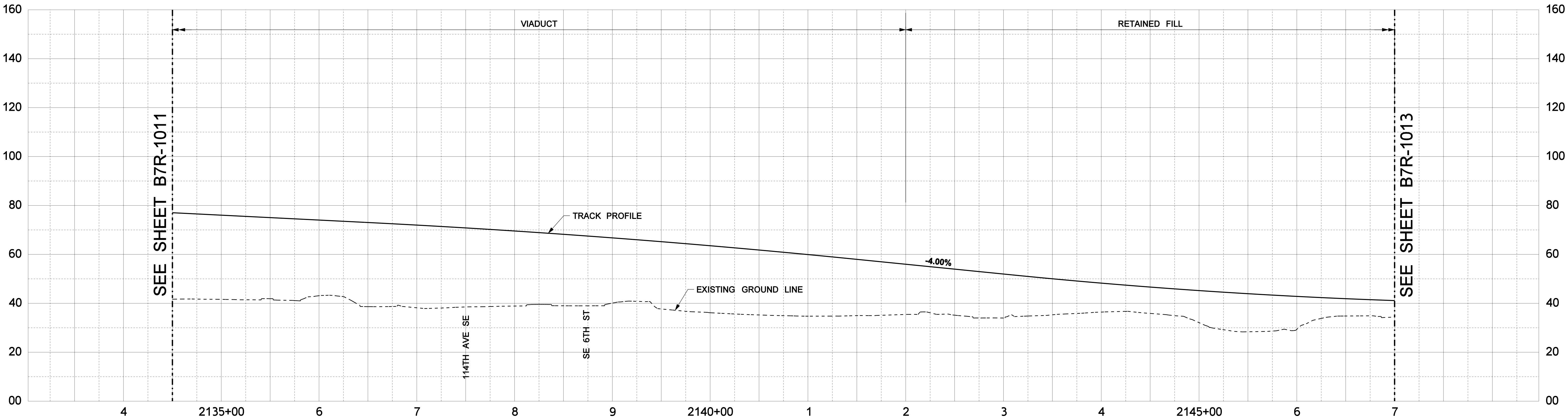

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A	02/16/11	PT	DH	RP	1% SUBMITTAL

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DATE 04/29/11

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STA. 2134+50 TO 2147+00

CONTRACT NO. 215382
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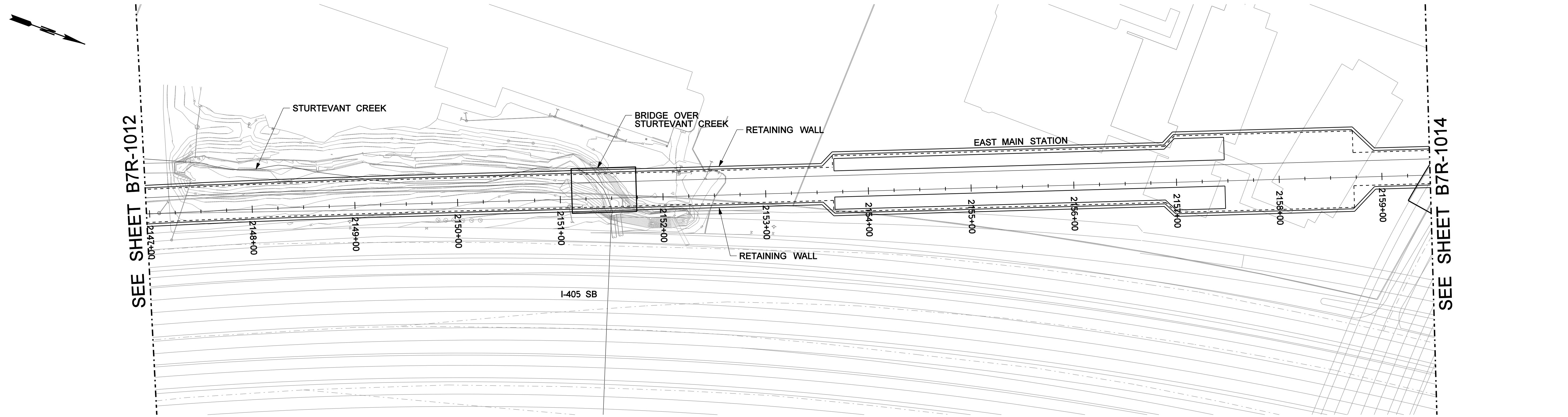

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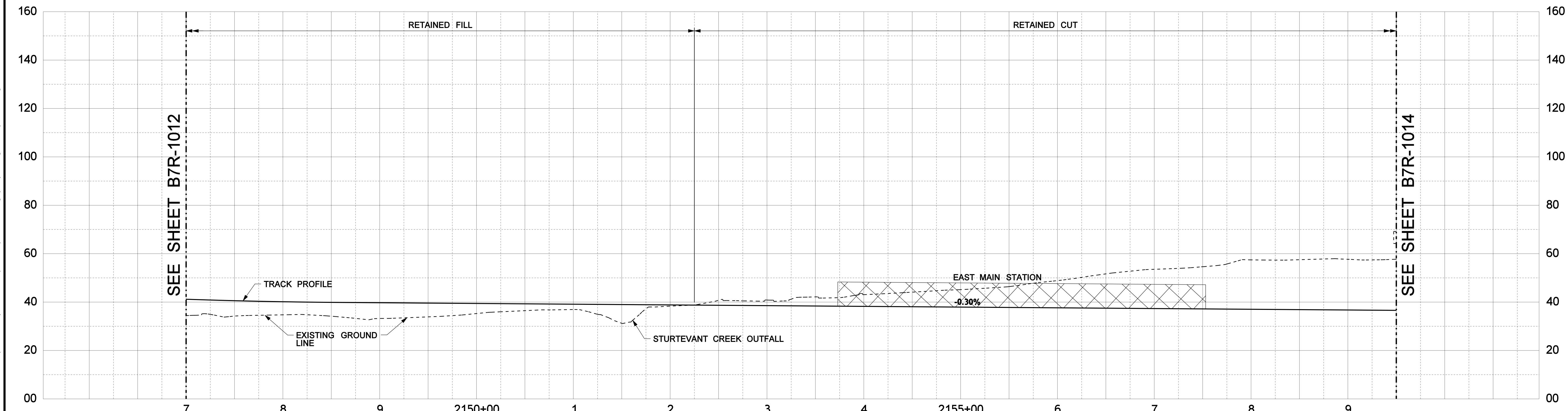

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A	02/16/11	PT	DH	RP	1% SUBMITTAL

DESIGNED BY T. NATWICK
DRAWN BY P. TONKIN
CHECKED BY D. HUNT
IN CHARGE R. PRUST
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TRACK PLAN & PROFILE
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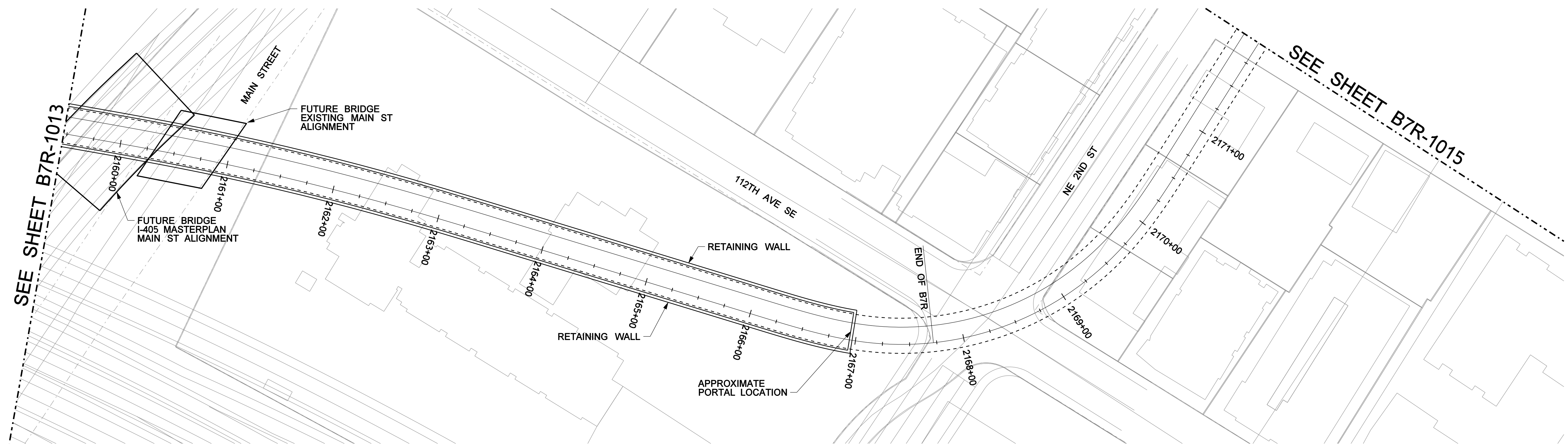

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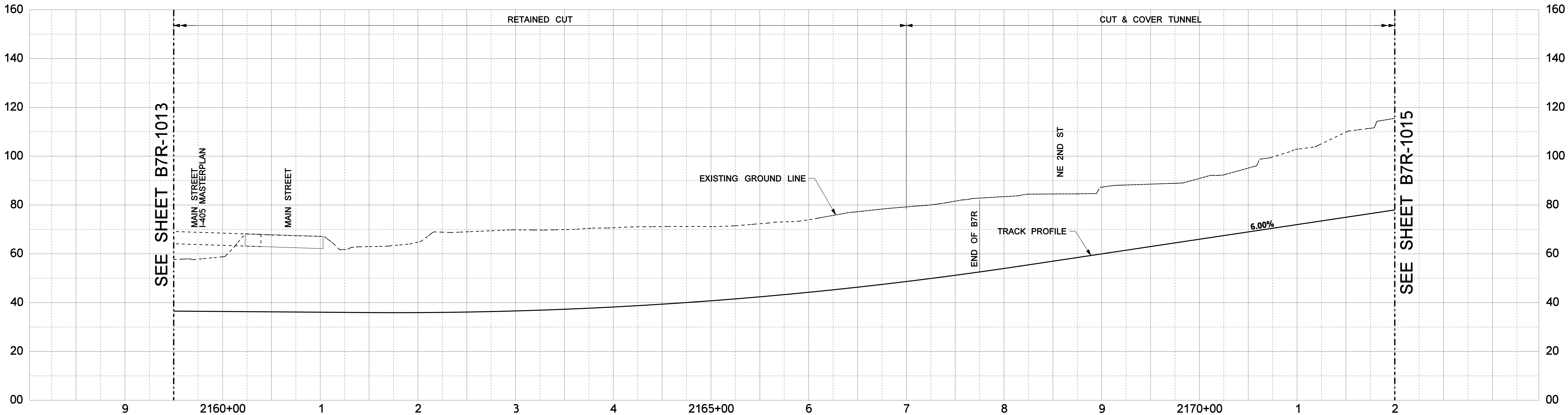

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A	02/16/11	PT	DH	RP	1% SUBMITTAL

DESIGNED BY T. NATWICK
DRAWN BY P. TONKIN
CHECKED BY D. HUNT
IN CHARGE R. PRUST
DATE 04/29/11

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STA. 2159+50 TO 2172+00

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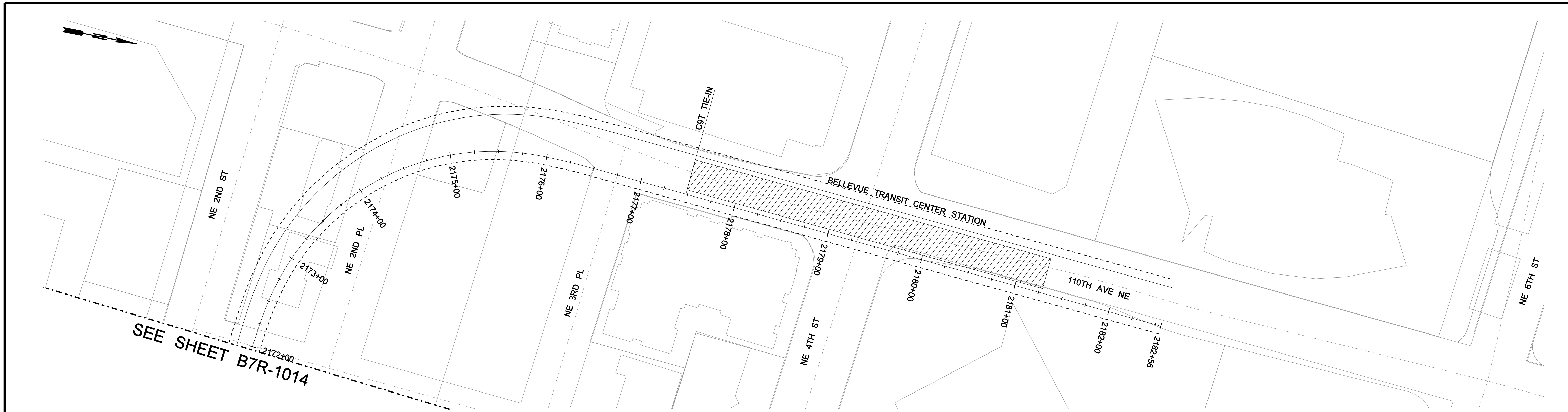

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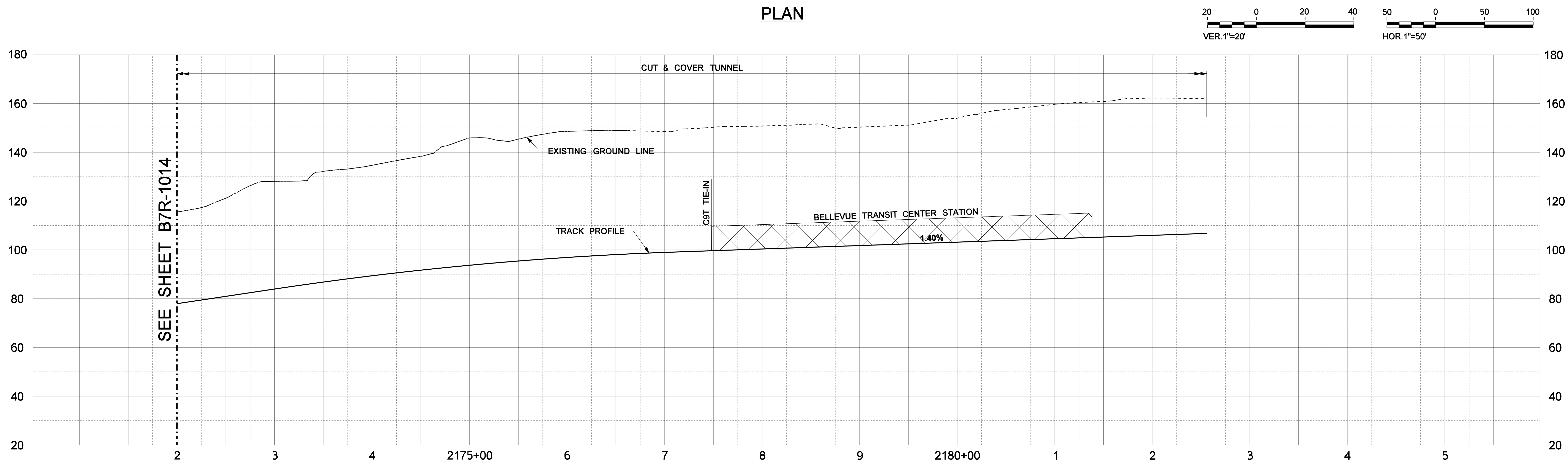

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B	03/07/11	PT	NW	RP	REVISED 1% SUBMITTAL
A	02/16/11	PT	DH	RP	1% SUBMITTAL

DESIGNED BY T. NATWICK
DRAWN BY P. TONKIN
CHECKED BY D. HUNT
IN CHARGE R. PRUST
DATE 04/29/11

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thomas.natwick

Appendix B

Conceptual Engineering Geotechnical Memorandum

KLEINFELDER
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KLEINFELDER MEMORANDUM

TO: David Hunt-ARUP
Richard Prust-ARUP

FROM: David Cotton-Kleinfelder

DATE: March 7, 2011

SUBJECT: Task 3 Conceptual Engineering Portal and Red Lion Site, Bellevue B7 Alternative, City of Bellevue, Washington

---

The purpose of this memorandum is to summarize the geotechnical information collected in Task 1, and provide conceptual geotechnical advice based on experience and engineering judgment for the tunnel portal and Red Lion Site for the B7 alignment through Bellevue, Washington.

SITE CONDITION AND STATION PLAN

As currently planned the East Main Station and tunnel portal have been combined into one structure. The new plan begins in the southeast corner of the existing Red Lion Motor Inn Property located on the southeast corner of 112th Avenue NE and Main Street in downtown Bellevue. The station is approximately 375 feet long and will be fully exposed at the south end and about 18 feet below ground surface on the north end of the station.

SOIL AND GROUNDWATER CONDITIONS

Native materials at the portal and station site include glacial deposits of dense to very dense glacial till grading at depth to advance outwash deposits. The glacial till is made up of a nonsorted mixture of clay, silt, sand, gravel, cobbles, and boulders. The upper 2 to 5 feet is often weathered and typically medium dense to dense, then grading to very dense. The advance outwash deposits, include stratified sand with gravel and some cobbles and boulders. Perched groundwater occurs in lenses of sand in the glacial till unit. However, the quantity of flow is usually limited and manageable by sumping and pumping in localized areas where groundwater is encountered. In general, the areal groundwater table occurs in the very dense outwash deposits below the glacial till.

Artesian conditions also exist in parts of the downtown area of Bellevue, with the most significant flows occurring around the Bellevue convention center and the Bravern Office and Apartment Complex. A deep well system was installed for both projects, and the artesian pressure lowered prior to major excavations by extensive dewatering. Based on the most recent borings in the area and the geologic profile provided in the preliminary route selection study the glacial till overlying the advance outwash could be less than 30 feet. This would mean that a deep well system would be required to relieve the artesian groundwater conditions below the planned excavation. There were no settlement issues surrounding the previous dewatering operation, due to the dense nature of native soil deposits supporting structures in the immediate area. We would anticipate a similar approach at this site, however, based on the limited depth of the excavation, 18 to 20 feet below existing ground surface, dewatering will likely not be a significant issue. Adequate test borings specifically located on the station site are anticipated in the future to verify the actual groundwater conditions. The proximity of Sturtevant Creek, and the natural drainage course across SR 405 that drains Lake Bellevue would increase the likelihood of active perched groundwater in the till and or an artesian groundwater condition in the advance outwash deposits. However, it is assumed that future borings will be completed to verify this interpretation made from the current limited data.

SITE SEISMICITY

This project site is in a region of high historical seismicity in terms of earthquake magnitude and the frequency of earthquake occurrence. Four earthquake hazards were previously considered and three were determined to not impact the site. These included surficial ground rupture from the Seattle Fault, seismically induced landslides, and soil liquefaction. However, seismically induced ground motion must be considered in the design and the Sound Transit Link Light Rail Design Criteria Manual provides design earthquake parameters.

GEOTECHNICAL RECOMMENDATIONS

In this area of Bellevue, the dense glacial till is usually at or near the ground surface, with the exception being localized layers of compacted fill materials in the upper 10 feet of the ground surface. The bearing capacity of these dense soils is often in excess of 6,000 psf. Therefore the station can be supported on shallow foundations. The station walls will most likely be single sided cast in place steel reinforced concrete walls, with a shoring system as the back side of the wall. If the station can be excavated with open cuts, the walls will likely be double sided cast in place concrete, and then backfilled with structural fill, compacted in place. Buried station walls should have permanent drain systems in the backfill material or geodrain systems placed on the shoring wall so that groundwater does not build up on the station walls. In addition, drains should be provided beneath the planned floor slab system at the base of the station. Any waterproofing consideration would only be for aesthetic reasons. If localized discoloring from minor water/moisture seepage is not desirable then waterproofing should be planned for the walls. In general, at rest versus active earth pressures are recommended for these type wall systems since little to no movement is expected during or after construction. Since the at rest earth pressures are higher it would lead to a thicker wall than a standard basement or basement parking garage wall in an office building or apartment building.

CONSTRUCTION CONSIDERATIONS

Excavations required for the portal and station can be completed with open cuts and shoring systems. For planning purposes temporary cut slopes in the glacial till typically remain stable for construction projects at 1H:1V. Actual safe construction cut slopes are the responsibility of the contractor and depend on site specific conditions at the time of excavation. We have seen temporary cut slopes in this area of Bellevue in the glacial till as steep as 3/4-1/2H:1V. Temporary cut slopes are normally covered with plastic during the rainy system to limit surface water sediments and erosion damage to the slopes. Standard shoring systems that have been successful in Bellevue have included soldier pile and tiebacks and soil nail systems.

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KLEINFELDER MEMORANDUM

TO: David Hunt-Arup
Richard Prust-Arup

FROM: David Cotton-Kleinfelder
Bob Plum-Kleinfelder

DATE: February 22, 2011

SUBJECT: Task 3 Conceptual Engineering Mercer Slough, Bellevue B7 Alternative, City of Bellevue, Washington

---

The purpose of this memorandum is to summarize the geotechnical information collected under Task 1 and provide conceptual geotechnical advice based on experience and engineering judgment for the Mercer Slough portion of the elevated rail on the B7 alignment.

SITE CONDITIONS AND ALIGNMENT PLAN

The portion of the proposed B7 light rail alignment, that extends from Bellevue Way SE on the west to the interchange of I-90 and I-405 on the east crosses the Mercer Slough and has an approximate length of 2,250 feet and will be constructed parallel to and immediately north of the existing I-90 roadway. As currently planned, vertical columns will support the rail on approximately 240 feet center to center spacing. Each column will be supported by a deep foundation system. The columns are currently sized at approximately 7 feet in diameter. The Mercer Slough is an environmentally sensitive area and requires special considerations when building structures over and through the area.

The columns supporting the bridge decks for the I-90 roadway crossing the Mercer Slough were constructed in the 1960's and 1980's. Each column is supported on a pile cap at the mudline, which includes four 12-inch diameter driven steel piles. All four piles extend to a depth of over 100 feet and are founded on a dense glacial bearing layer. We have also learned that the pile caps for the columns supporting the I-90 bridge decks have been moving laterally and causing the columns to move off of the bearing pads on the bottom of the decks. A study completed by WSDOT has concluded that the movements are the result of the native peat deposits in the upper 50 to 60 feet moving laterally with fluctuations in the groundwater level. Fluctuations in the groundwater level in the peat has been attributed to changes in the level of Lake

Washington which cycle 2 feet per year from the control of the locks located to the west near Puget Sound.

SOIL AND GROUNDWATER CONDITIONS

The Mercer Slough is located in a north-trending trough about 2 miles long and one-half-mile wide that opens on the south into Lake Washington. A narrow, dredged channel drains the slough on the south. North trending ridges rise steeply more than 150 feet bound the slough to the east and west. The topography within the slough ranges from approximately 10 to 13 feet. The marshy wet lands that make up the slough are dominated by grasses/sedges, cattails, and willow.

Based on information provided by WSDOT, thick peat deposits in excess of 60 feet underlie the site. Locally there are also thick deposits of soft clay. The peat has been characterized as fibrous near the surface and grading increasingly with depth to a decomposed and amorphous material. Moisture contents range from 500 to 1200 percent with no trends at depth. The Standard Penetration N-Values are typically zero. However, vane shear tests have indicated peak undrained strengths of 10 to 160 psf and remolded strengths of 8 to 35 psf. Piezocone penetration tests indicated a uniform tip resistance of about 350 psf and a friction ratio of 1.5 to 6.0 percent. Pore pressures during penetration were nearly hydrostatic in the soft soils. Unconsolidated-undrained triaxial tests yielded undrained strengths ranging from 50 to 180 psf. Consolidated-drained triaxial and direct shear tests resulted in friction angles ranging between 9 and 13 degrees. Dynamic response of the peat was evaluated using resonant column tests. These tests indicated increasing stiffness with confining stress with a highly nonlinear stress-strain behavior, characteristics very similar to cohesionless soil. The low strength and stiffness of the peat deposit is expected to amplify long-period ground motions and to develop large strains in response.

Underlying the peat deposits in the central portion of the slough is a very soft, low to high plasticity silty clay with scattered organics and shell fragments. This deposit also includes minor interbeds of silt and fine sand. This deposit has a maximum thickness of about 50 feet.

Beneath the soft clay and peat is a medium dense to very dense, clean to silty sand with minor gravels, cobbles, and boulders. This silty sand deposit has thin beds of hard sandy silt and silt. The average depth of this deposit varies from 100 to 125 feet below ground surface. This glacially over-consolidated soil deposit has been interpreted to be an advance outwash deposit of Vashon age or older.

Artesian groundwater levels were measured in advance outwash deposit underlying the site. Some springs have also been encountered in isolated areas within the peat deposits. Where measured, the artesian flow had a level about 2 to 8 feet above the ground elevation.

SITE SEISMICITY

This project site is in a region of high historical seismicity in terms of earthquake magnitude and the frequency of earthquake occurrence. Four earthquake hazards were previously considered and three were determined to not impact the site. These included surficial ground rupture from the Seattle Fault, seismically induced landslides, and soil liquefaction. However, seismically induced ground motion must be considered in the design and the Sound Transit Link Light Rail Design Criteria Manual provides design earthquake parameters.

Due to the significant depth of soft soils, ground amplification may occur with associated large deformations. The seismic response of the Light Rail structure will be a major engineering consideration.

GEOTECHNICAL RECOMMENDATIONS

The conceptual foundation recommendations presented below are based on local experience in areas of deep soft soils. The geotechnical conditions presented by the deep, very soft soils will be a challenge to resolve and warrant assessment of several potential options possibly including creative solutions. The primary geotechnical foundation issues and likely resolution include:

- PROVIDING ADEQUATE VERTICAL SUPPORT FOR THE GUIDEWAY: The axial loads of the guideway will have to be supported on a deep foundation that is founded in the glacial soils at depths of 100 to 125 feet below the ground surface. Typical deep foundation types used in the area include driven pipe piles and drilled piers.
- CONTROLLING HORIZONTAL FORCES AND MOVEMENTS DURING SEISMIC EVENTS: It may be difficult to design a vertical pile or pier that can adequately support and protect the guideway during the design seismic event. With over 100 feet of very soft soils, the pile or pier would tend to move laterally with the ground motion during an earthquake. One option would be to use drilled piers with diameters large enough to develop the required lateral stiffness. Another option would be to improve the soil around the foundation to create an "island" of more stable ground.

* RESOLVING THE ANTICIPATED LONG TERM LATERAL CREEP OF THE DEEP SOFT SOILS AS OBSERVED IN THE CURRENT I-90 STRUCTURES: This is a similar problem to the seismic problem discussed above but the loads would develop on the foundations in a long term, static creep manner. A suitable foundation design to accommodate these static creep loads may be resolved by the requirements for the design seismic loads and deformations. Another option might be to design for future movements with the ability to monitor and adjust for movements.

At this time, the foundation options considered suitable for support of the guideway include:

* VERTICAL DRILLED PIERS: Large diameter driller piers could be installed. Drilled shafts up to 12 feet in diameter are commonly used, in the area however, at diameters greater than 12 feet, more costly methods of construction are required. Beyond some diameter, the costs and construction risks associated with very large drilled piers may make ground improvement cost effective. This option is discussed below.

* VERTICAL DRIVEN PILES: Driven pipe piles supporting a large pile cap could be used. If adequate lateral stiffness and strength could be developed. It may be necessary to use ground improvement to make this option feasible.

* BATTER PILES: Normally batter piles are not used in high seismic zones due to the level of seismic forces that can develop on the relatively rigid batter pile system. However, batter piles may be a cost effective option compared with the need for extensive ground improvement.

* GROUND IMPROVEMENT: There are a variety of ground improvement methods available to create an "island" of stable ground around the foundation elements. This approach was used to support the guideway for the current Light Rail System crossing the Duwamish River Valley in Seattle, Washington near the Maintenance Facility. Construction consisted of installing a 10 foot diameter drilled pier and then installing stone columns and/or compaction grouting elements to form a 50 foot "donut" around the drilled shaft. The main purpose of the ground improvement was to stiffen the soil and reduce liquefaction risks. Since the problem soils underlying the slough area are primarily peats and soft clay, ground improvement methods such as stone columns or compaction grouting would not strengthen the native soils but would provide stiffener elements within the softer native soils. More appropriate methods might include deep soil mixing, lime cement columns or other methods that install strong

vertical elements into the ground. Due to the majority of the soils being peat, methods that rely on mixing of native soils with cement or lime may not result in a suitable soilcrete mixture. In this case, the methods would require that virtually all of the materials within the holes are replaced with soilcrete which would increase the costs. It might also be difficult to implement these methods and meet any environmental criteria in the slough. WSDOT is currently using a Cutter Soil Mix technology with a cement replacement slurry wall configuration around drilled shafts on the King Street to Holgate Street elevated Alaska Way Viaduct highway project. The slurry wall encasement of the 10 foot diameter drilled shafts is constructed to a depth of 50 feet and is considered a stress shield, limiting or eliminating liquefaction and reducing the lateral movements expected during an earthquake. Rectangular shaped encasements have inside dimensions of 30 by 24 feet in some cases, for a 10 diameter drilled shaft.

CONSTRUCTION CONSIDERATIONS

Due to the soft nature of the surficial material covering the slough, a temporary pile supported trestle will need to be built to support the construction equipment required to install the drilled shafts and build the columns over the shafts. The low strength and high compressibility of the peat deposits precludes the use of a temporary embankment fill roadway across the slough. In addition, the cost of collecting, treating and recirculating the drilling muds during drilled shaft installation or ground modification methods, will also be required to avoid environmental damage to the slough vegetation. Casing will be required, and based on the artesian groundwater conditions, special methods to control and manage groundwater flows from the open shaft will be required.

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KLEINFELDER MEMORANDUM

TO: David Hunt-ARUP
Richard Prust-ARUP

FROM: David Cotton-Kleinfelder

DATE: March 1, 2011

SUBJECT: Task 3 Conceptual Engineering BNSF alignment, Bellevue B7 Alternative, City of Bellevue, Washington

---

The purpose of this memorandum is to summarize the geotechnical information collected in Task 1 and provide conceptual geotechnical advice based on experience and engineering judgment for the BNSF portion of the B7 alignment through Bellevue, Washington. In general the BNSF alignment is underlain by dense native soils with minimal geotechnical constraints.

SITE CONDITIONS AND ALIGNMENT PLAN

The portion of the B7 alignment that will follow the existing BNSF corridor adjacent to the existing SR 405 alignment is approximately 5000 feet long. The proposed alignment begins just north of the intersection of SR 90 and SR 405, approximately where the BNSF crosses 32nd Street, in the northwest corner of the intersection. The proposed light rail alignment follows the BNSF corridor north between the SR 405 and 118th Avenue SE to the point where the BNSF corridor previously crossed the SR 405 in the previously existing Wilburton Lid/Tunnel. This is the end point of the BNSF corridor and is located roughly at a place where 16th Street on the east side of SR 405 would cross the alignment if it was projected across SR 405. The existing corridor is located on a cut bench on the side of a west facing slope that is part of a north-south trending ridge through Bellevue. Since the double track guideway and trail system design section will be wider than the existing developed BNSF corridor, cuts on the uphill side and fills on the downslope side will be required. The current design concept only involves fill walls in areas on the downslope side with simple unsupported cuts and fills elsewhere.

SOIL AND GROUNDWATER CONDITIONS

Surficial material along the current corridor consists of railroad ballast placed over native soils in a cut section. Native materials along the alignment include glacial deposits of dense to very dense glacial till, advance outwash deposits, and transitional beds. Approximately the southern one third section of this portion of the alignment includes transitional beds grading into glacial till. The transitional beds are glacial deposits which consist mostly of thick sections of hard clay and silt and dense to very dense fine sand. The glacial till is made up of a nonsorted mixture of clay, silt, sand, gravel, cobbles, and boulders, and is typically dense to very dense. The native soil conditions in the northern two thirds section of this portion of the alignment consist of advance outwash deposits, which include stratified sand with gravel and some cobbles and boulders.

Variable groundwater conditions have been historically observed along the SR 405 roadway immediately up slope of the railroad grade. The depth of groundwater in a recent report on the HOV expansion of the roadway indicated a range of 11 feet to 58 feet below the roadway surface. Most of this groundwater has been interpreted by others to be perched groundwater on top of the glacial till or on top of the silty layers within the outwash and transitional beds. Perched groundwater develops where a relatively impermeable soil horizon impedes the vertical infiltration of surface water. Multiple perched water levels can form within stratified and interlayered soil deposits. Since the railroad grade is at or below the SR 405 roadway elevation, seepage areas may occur on the slopes above or below the railroad grade at anytime of the year.

SITE SEISMICITY

This project site is in a region of high historical seismicity in terms of earthquake magnitude and the frequency of earthquake occurrence. Four earthquake hazards were previously considered and three were determined to not impact the site. The non-impact hazards included surficial ground rupture from the Seattle Fault, seismically induced landslides, and soil liquefaction. However, seismically induced ground motion must be considered in the design and the Sound Transit Link Light Rail Design Criteria Manual provides design earthquake parameters.

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GEOTECHNICAL RECOMMENDATIONS

The primary engineering issues on this section of the alignment are ground support for the rail guideway and retaining walls. Feasible wall types for supporting fills on the west side of the section include WSDOT type standard plan walls (concrete cantilever retaining walls) or flexible wall systems such as structural earth walls (SEW), gabion walls, and gravity block walls. The primary issues with regard to wall selection are settlement and bearing capacity. Allowable bearing capacities for spread footing foundations in undisturbed, dense to very dense glacial till typically range from 6 ksf to 16 ksf. Based on a WSDOT report for the SR 405 the majority of the existing bridge foundations in this area of the corridor were designed for allowable bearing capacities of 4 ksf to 12 ksf. For the advanced outwash deposits bearing capacities of 4 ksf to 10 ksf have been successfully used on bridge and retaining wall foundations on undisturbed native outwash. A similar range of bearing capacities has also been used on the transitional beds. In general, therefore, if the native materials are not disturbed during construction all three native soil conditions will provide good subgrade support for the railroad ballast that will be placed to establish the light rail guideway and any selected retaining wall system.

Adequate drainage should be provided behind retaining walls to prevent a build-up of hydrostatic pressures. Permanent toe drains may be required in cut areas

Permanent cut slopes above the guideway section on the east should not exceed 2H:1V. In addition, fill wall designs on the west side of the guideway should include appropriate surcharge loads from the light rail guideway. If fill slopes are required we would recommend that slope angles not be steeper than 2H:1V. In general, cut and fill slope designs are likely to be controlled by aesthetics, vegetation, and erosion control.

CONSTRUCTION CONSIDERATION

The glacial till and transitional beds typically contain a significant percentage of fines (silts and clays) and are moisture sensitive. When the moisture content is more than a few percent above the optimum moisture content, these glacial deposits become muddy and unstable under construction traffic. Wet weather construction is generally not recommended for glacial tills and transitional deposits without the use of admixtures to control moisture content. Negligible infiltration rates are typically encountered in these soils due to the high fines content. In general these soils are not good for reuse as embankment fill for walls or fill slopes due to the fine content and moisture sensitivity.

The advances outwash deposits often contain relatively low fines content. Locally, these deposits can be silty and contain layers of fine-grained sands and silts. They are in general less moisture sensitive than the glacial till and transitional beds. Moderate to high infiltration rates are often encountered in the advance outwash soils. The infiltration rate is dependent on the silt content of the soil and the presence of interbedded layers with higher silt contents. The sandy portions of the advance outwash can be used as backfill for walls or embankment fills for slopes. However, it is often difficult for contractors to separate the silty portions of the advance outwash from the sandy portions. Therefore, we would suggest not considering these materials for reuse on site.

There are no historic landslide hazards designated or experienced previously along this portion of the corridor.