Unsworth

SOUTH/NORTH TRANSIT CORRIDOR PROJECT

DRAFT FINDINGS REPORT

WILLAMETTE RIVER CROSSING
MODIFIED CARUTHERS DESIGN OPTION

NOVEMBER 1995

Prepared for:
Tri-Met

Prepared by:
CH2M Hill, Inc.
Parsons Brinckerhoff Quade & Douglas, Inc.
LTK Engineering

100 YEARS

The preparation of this report was financed in part by the U.S. Department of Transportation, Federal Transit Administration and by the Washington State Department of Transportation. The opinions, findings and conclusions expressed in this report are not necessarily those of either the Federal Transit Administration or the Washington State Department of Transportation.

CONTENTS

1.0 OBJECTIVE

The objective of this findings report is to consolidate and summarize the results of the design option for the Willamette River Crossing entitled the Modified Caruthers Design Option. The purpose of this study is to analyze the engineering for this design option for a LRT crossing of the Willamette River south of the existing I-5 Marquam bridge. This study assessed two aspects of the design option: 1) the PP&L Lincoln substation and LRT interface and 2) LRT and West Marquam Interchange clearances.

2.0 SUMMARY OF RESULTS

This river crossing design option study provides results which can be used for relative comparison with the other South Willamette River Crossing Alternatives and Design Options from a conceptual engineering viewpoint. There are other measures, such as environmental impacts, hazardous materials, cost, visual impacts, transit operations and ridership, which are addressed in other findings reports. Furthermore, the river crossings are only one part of a total alignment option. Other factors of the entire alignment option may have more cumulative impact to the attractiveness of an alignment option than just the river crossing element.

The Modified Caruthers Design Option is a viable design option for the Caruthers Alternative River Crossing. A number of specific findings identified in this report are highlighted in this subsection.

- The proximity of this design option to the PP&L Lincoln Substation is not anticipated to have an adverse impact on the LRT or substation operations, with appropriate design mitigation identified in the report.

- Two incoming 115kV transmission lines to the substation would likely need to be raised to provide adequate clearance for this LRT design option; constraints between the conceptual LRT alignment and a buried duct bank to south of the substation would need to be resolved in design refinement.

- A PUC permit would be required if the refinement of this design option identifies the need for property to be transferred from PP&L to Tri-Met.

- Vertical clearance constraints for an LRT overpass at SW Moody Avenue may require a unique structure to clear span the road. If a column could be added at the centerline of SW Moody, a conventional structure type may be an option.

- The alignment of LRT structures under the West Marquam Interchange, as conceptually developed in this design option, can provide clearance for the required structure and LRV operations, including allowances for movements of both structures under future seismic forces.

- It is not recommended to tie the new LRT structure to the existing Marquam Interchange columns because they would move independently of each other during a seismic event.

- It is recommended that the new LRT columns be staggered with the existing Marquam Interchange columns to avoid potential settlement and overload to the existing columns.

- It is recommended that, as a minimum, the three spans of the West Marquam Interchange directly over any portion of the LRT alignments receive phase II seismic retrofit. The goal would be to minimize the chance of the existing columns and footings collapsing under a seismic event.

3.0 BACKGROUND

Previous studies of LRT crossing alternatives and design options for Willamette River f were first summarized in the Draft Findings Report, Willamette River Crossings, July 5, 1994. A supplement to that report was completed in August 1994 for a Mid Ross Island Crossing. In May 1995, a Major River Crossings Report was completed, which summarized work completed prior to this report.

As part of the development of the South/North Transit Corridor Study, conceptual LRT alignments were developed for both the east bank and the west bank of the Willamette River. For the east bank alternatives, a crossing on the existing Hawthorne Bridge was assumed. For the west bank alternative and design options, a new bridge just north of the Sellwood Bridge was the assumed crossing.

During the pre-alternatives and Tier 1 phase of the South/North Corridor project, analysis of alternative alignments in the Portland CBD and continued concern with LRT operation constraints on the existing Hawthorne Bridge led planners and engineers to analyze potential new crossings adjacent to the Hawthorne Bridge as well as farther south near the OMSI site (Caruthers Crossing). Concurrent refinement of east bank and west bank alternative alignments resulted in a request to develop information related to identifying the best place for LRT to cross the Willamette River, rather than simply comparing east bank and west bank alternatives. This information was consolidated and summarized in the Draft Findings Report, Willamette River Crossings, July 5, 1994. This draft findings report supplements that document for the Modified Caruthers Design Option.

4.0 DESIGN OPTION REFINEMENT

The following discusses the issues, characteristics, and constraints for this design option. The new bridge design option considers a structure for LRT only (32-foot-wide double track and two 21-foot-wide single track) and a bridge structure with double track LRT and pedestrian/bicycle traffic (48 feet wide). The crossing structure type presented in this report represents a design option at the conceptual level.

For this bridge design option, a fixed, post-tensioned concrete segmental box girder structure was assumed for the typical bridge type. A typical superstructure cross section is shown in the Appendix (figure 2) of the July 5, 1994 Draft Findings Report, Willamette River Crossings. The new bridge design option has a haunched superstructure profile. The cross section could have a variable structure depth from the shallowest point at mid-span (7 feet) to the deepest point at the piers (20 feet). Portions of the bridge over water could consist of span lengths of 250-500-500-250 feet. This span arrangement would align the piers with the existing Marquam Bridge as much as possible, considering that the two alignments diverge as they cross the river from west to east. The possible pier locations are shown on sheet 1 of 3 at the end of this report. Approach spans over land could consist of span arrangements between 50 and 200 feet long depending on the horizontal alignment and vertical clearance requirements. This crossing design option is only a representative structure type for relative study purposes. Refinement of structure selection will be coordinated with the findings of the Draft Environmental Impact Statement being prepared by Metro.

Navigational clearances for the Willamette River at the location of this design option are summarized in the July 5, 1994 Draft Findings Report, Willamette River Crossings and in the Major River Crossing Report, dated May 1995. The vertical clearance criteria of 75 feet above MHW level (Elevation +27.00 feet), results in a minimum bottom of structure elevation of 102.00 feet (National Geodetic Vertical Datum MSL=0.0 feet). The horizontal navigational channel clearance is assumed to be 240 feet to match that of the Hawthorne Bridge lift span. This channel width for this design option was centered on the deepest part of the river.

4.1 Design Option Description

The Modified Caruthers Design Option is located on the upstream side of the existing I-5 Marquam Bridge. Plan and profile sheets illustrating conceptual horizontal and vertical alignments for this design option are included at the end of this report. As the LRT alignment traverses west to east on the west bank of the Willamette River, it crosses SW Market and SW Clay Streets and parallels SW Harbor Way. It crosses over the southwest corner of the PP&L Lincoln Substation and SW Moody Avenue. The conceptual alignment splits into two single track alignments just east of SW Moody

Avenue and passes beneath the West Marquam Interchange structure. The two single track alignments meet again east of the West Marquam Interchange prior to reaching the west bank of the Willamette River. The conceptual alignment crosses the Willamette River and ends at the elevated Water Avenue Station.

The conceptual alignment is on elevated structure starting just west of SW Moody Avenue until the elevated Water Avenue Station is reached on the east side of the Willamette River. The pedestrian add-on could extend from the elevated Water Avenue Station to an elevated ramp just west of the river, terminating the pedestrian/bicycle traffic at grade. Maximum grades of 5.80% at the west and 5.86% at the east would be required to meet clearance constraints under the West Marquam Interchange and the navigational channel of the river.

The total structure alignment length of this design option is 2,800 feet measured along the northbound alignment. This does not include 220 feet for the elevated Water Avenue Station. The structure length consists of 395 feet of double track and 630 feet of split single track structure at the west approaches. The river span structure consists of 1775 feet of double track with pedestrian/bikeway path and includes the east approach structure.

Vertical clearance constraints over SW Moody Avenue may require a unique structure type to clear span the road. Structure types to achieve the span to depth limits may include a half through steel girder or a concrete fin-back. If a midspan column could be added to a center median on SW Moody Avenue, the span length could be cut in half and a conventional structure type such as a cast-in-place post-tensioned concrete box may be an option.

4.2 Pacific Power & Light Lincoln Substation and LRT Interface

This design option crosses above the Southwest corner of the existing PP&L Lincoln Substation on the west bank of the Willamette River. Meetings with PP&L have indicated that three electrical reactors would be required to be moved to the south to accommodate the design option alignment. PP&L indicated that moving these reactors to the south could be done and is preferable over the construction of an enclosure structure. PP&L requires 10 feet above the reactors for maintenance for a total vertical of 30 feet above finished grade.

PP&L uses microwave radio communications to Mt. Scott. This equipment is located underneath the West Marquam Interchange. The LRT alignment and operation may interfere with this communication and may require the relocation of the microwave equipment. PP&L desires to perform any work associated with this substation themselves.

There are two incoming 115kV transmission lines to the PP&L Lincoln Substation. These lines would cross over the design option's alignment and may need to be raised to meet clearance requirements over the LRT overhead wires. One of these incoming lines is from the Urban Substation while the other line is from the Harrison Substation.

There may be a buried duct bank to the south of the PP&L Lincoln Substation. Locations of possible LRT foundations and approach fills may need to be adjusted, or the duct bank relocated as appropriate based on further study.

The PP&L 115kV transmission lines would likely need to be raised to provide adequate clearance for the design option alignment. A minimum clearance of six feet between the LRT catenary wires and the 115kV transmission lines is needed for safe electrical operations. However, a clearance of 20 feet is advisable to allow for safe maintenance access by vehicles and maintenance personnel.

The proximity of the design option's alignment and the substation is not anticipated to have an adverse impact on the LRT or substation operations. A PUC permit would be required if the refinement of this design option identifies the need for property to be transferred from PP&L to Tri-Met.

4.3 LRT and West Marquam Interchange Clearance

The design option's conceptual alignment passes underneath the West approach ramps to the I-5 Marquam bridge. Possible clearance constraints are existing column and foundation locations, future seismic retrofit of existing columns and foundations, horizontal seismic movements of existing columns and future LRT columns. The seismic integrity of the existing West Marquam Interchange structure could also be a significant issue with this design option.

4.3.1 Clearance with Existing West Marquam Columns

The design option's conceptual alignment weaves through the existing West Marquam Interchange 8-foot-diameter columns. The conceptual alignment splits into two single track structures each 21 feet wide at this area.

The Oregon Department of Transportation (ODOT) performed a field survey on June 9, 1995 to locate the West Marquam Interchange approach columns and the bottom elevation of the cross beams. The design option's conceptual alignment is established to meet horizontal and vertical clearance constraints with the existing columns and crossbeams as surveyed. The column clearance constraints have been estimated to take into consideration a future phase II seismic retrofit of the existing columns, and the horizontal movements of the existing West Marquam Interchange columns and future

LRT structure under seismic forces. Location constraints of LRT foundations include existing foundations and their future phase II seismic retrofit.

Horizontal movements of the existing columns under seismic forces were estimated using a horizontal acceleration of .75g (75% of the structure's weight applied horizontally as a force to simulate seismic forces). Inelastic influence on the horizontal movement was approximated and taken into consideration in the analysis. Footing displacements, both horizontal and rotational, were also approximated. Horizontal seismic movements of the existing columns were determined on an individual basis and varied from 1.25 feet to 2.25 feet. Seismic forces using .75g were also used to estimate the horizontal deflections of the future LRT structure. The horizontal deflection of the new LRT structure 35 feet above grade was estimated to be 1 foot for all locations. The deflections for the existing columns were added to the future LRT structure and increased by a safety factor of 1.5.

An increase in existing column diameter of 1 foot was assumed for a future phase II retrofit of the existing Marquam structure. The desired minimum horizontal clearances include the horizontal seismic displacements of both existing and proposed structures (times the safety factor) plus the effects of increasing the diameter of the existing columns. This leaves ample space so that the structures would not collide in the assumed seismic event. Horizontal clearances were determined for each existing column in terms of edge of LRT structure to the face of existing column and are summarized below:

Bent	Desired Minimum Clearance (feet)	Estimated Proposed Clearance (feet)
C6	4	3.85
C5-D5	5	4.99
C4-D4	5.5	20.18
A11-B11	4.5	6.95
A12-B12	5	4.1
A13-B13	5.5	5.15

The design option conceptual alignment shown on the plan and profile sheets meets these minimum clearances with the following exceptions. Column C6 does not fall within the desired clearance criteria by 0.15 feet, B12 by 0.9 feet, and B13 by 0.35 feet. Column C5 does not fall within the desired clearance criteria by 0.01 feet and is considered negligible. The safety factor of 1.5 used in developing the seismic deflections may allow for these exceptions. Also, increasing the existing column diameter by 1 foot should lower the horizontal seismic deflections thereby reducing the desired minimum clearance.

Tying the new LRT structure to the existing West Marquam Interchange columns is not recommended. This is due to the different dynamic response characteristics of a new LRT structure and the existing West Marquam structure. This dynamic response is influenced by the period of the structures. The period is a relationship between the structure's mass, and stiffness. The stiffness is driven by the structure's height, column size, footing type and size, soil type, structure material, and mass. Two structures with different dynamic responses tied together will have the desire to move independently of each other. This places large forces on the area tying the two structures together. In other words, the two structures will attempt to tear themselves apart from each other. The preferred structural approach may be to allow the two structures to move the way they naturally want to, independent of each other. In addition, tying a new LRT structure to the existing columns would induce concentrated lateral loads at an intermediate point of the column, which could seriously impact the column's ability to carry vertical and lateral loads.

4.3.2 Clearance with Existing West Marquam Interchange Footings

It may be desirable to place new LRT foundations far enough away from existing foundations to minimize the load influence to the existing foundations. This is desirable due to the fact that the existing foundations have had time to settle under the loads they have experienced. In the case of the West Marquam Interchange, there has been over 35 years of load support. When a new foundation is placed within close proximity of an existing foundation the new structure may place additional loads on the existing foundation. This sudden increase in loads on the existing foundations may cause renewed settlement and possible overload of the soil or piles of the existing foundation.

Additional settlement of an existing structure or an overload of the soil or piles may cause problems for the existing structure. There are varying issues that could influence this situation. In general, an existing spread footing will be more susceptible than a pile foundation. However, pile driving operations themselves can induce significant forces on existing foundations. Type of pile foundations also have impact on this load influence. Friction piles will tend to have more influence on and be influenced by, than point bearing piles.

Approximate foundation spacing guidelines for piles are 8 pile diameters for friction piles and 5 pile diameters for bearing piles. These spacing guidelines would be to the existing piles and not future phase II seismic retrofit piles. Future phase II seismic retrofit piles would carry live and seismic loads. The existing structure dead loads would continue to be carried by the existing piles.

Placing new LRT structure foundations on common footings with existing footings during retrofit construction may not be desirable because of the settlement and overload concerns discussed above. A phase II seismic retrofit of the existing footings could add

8 feet to each side of the footing, 16 feet total in each direction. The new LRT structure footing could be 12 feet square.

It is recommended that the new LRT columns be staggered with the existing West Marquam Interchange columns to avoid the possible adverse influence discussed above. This would also leave adequate construction access for a possible future phase II seismic retrofit of the existing West Marquam Interchange.

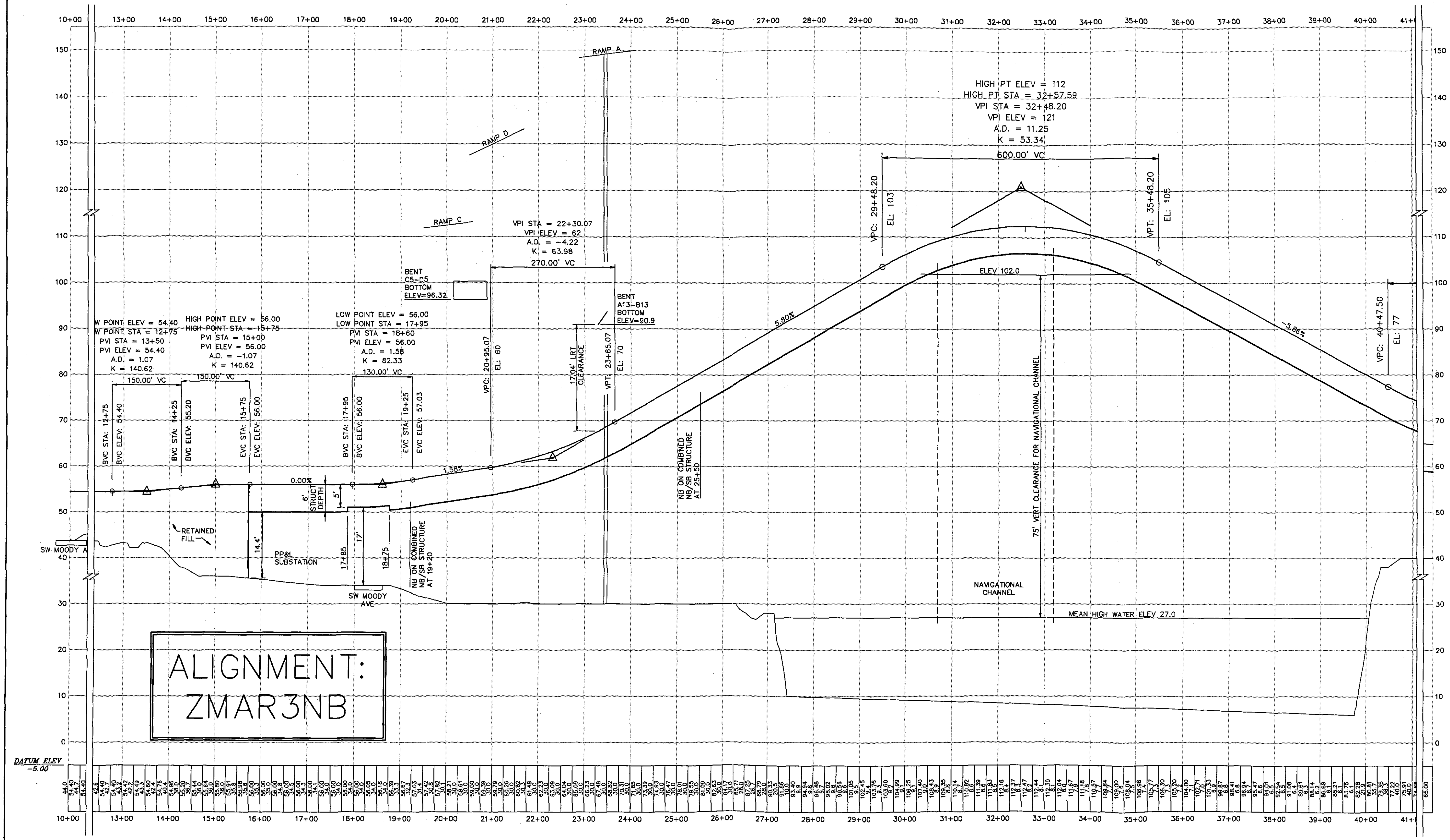
4.3.3 Seismic Integrity of Existing West Marquam Interchange

The West Marquam Interchange is currently undergoing a phase I seismic retrofit. The goal of this retrofit is to minimize the chances of the superstructure (deck and girders) from falling off their supports during a seismic event. The goal of a phase II seismic retrofit is to minimize the chances of the substructure (columns and footings) collapsing. It is important to understand that a seismic retrofit does not eliminate the risk of damage or collapse but decreases the chances that it will occur.

It is recommended that, as a minimum, the three spans of the West Marquam Interchange directly over any portion of the LRT alignment receive a phase II seismic retrofit. This would include the span directly over the alignment and the adjacent spans on each side.

The cost in 1995 dollars for a phase II seismic retrofit could be $60/SF. Historical data for phase II seismic retrofits is not available in Oregon. California and Washington have done some phase II seismic retrofit, and those costs have been utilized in two final reports, Prioritization of State Bridges for Seismic Retrofit for the Oregon Department of Transportation, and Bridge Seismic Retrofit Prioritization for the City of Portland. Both of these reports consider an average cost of $30/SF for typical structure types. Considering the complexity and extra height of the Marquam ramp structures, the cost was doubled for this study.

TRIMET3.DWG 28-Nov-1995 08:55:48 SCALE: 1=

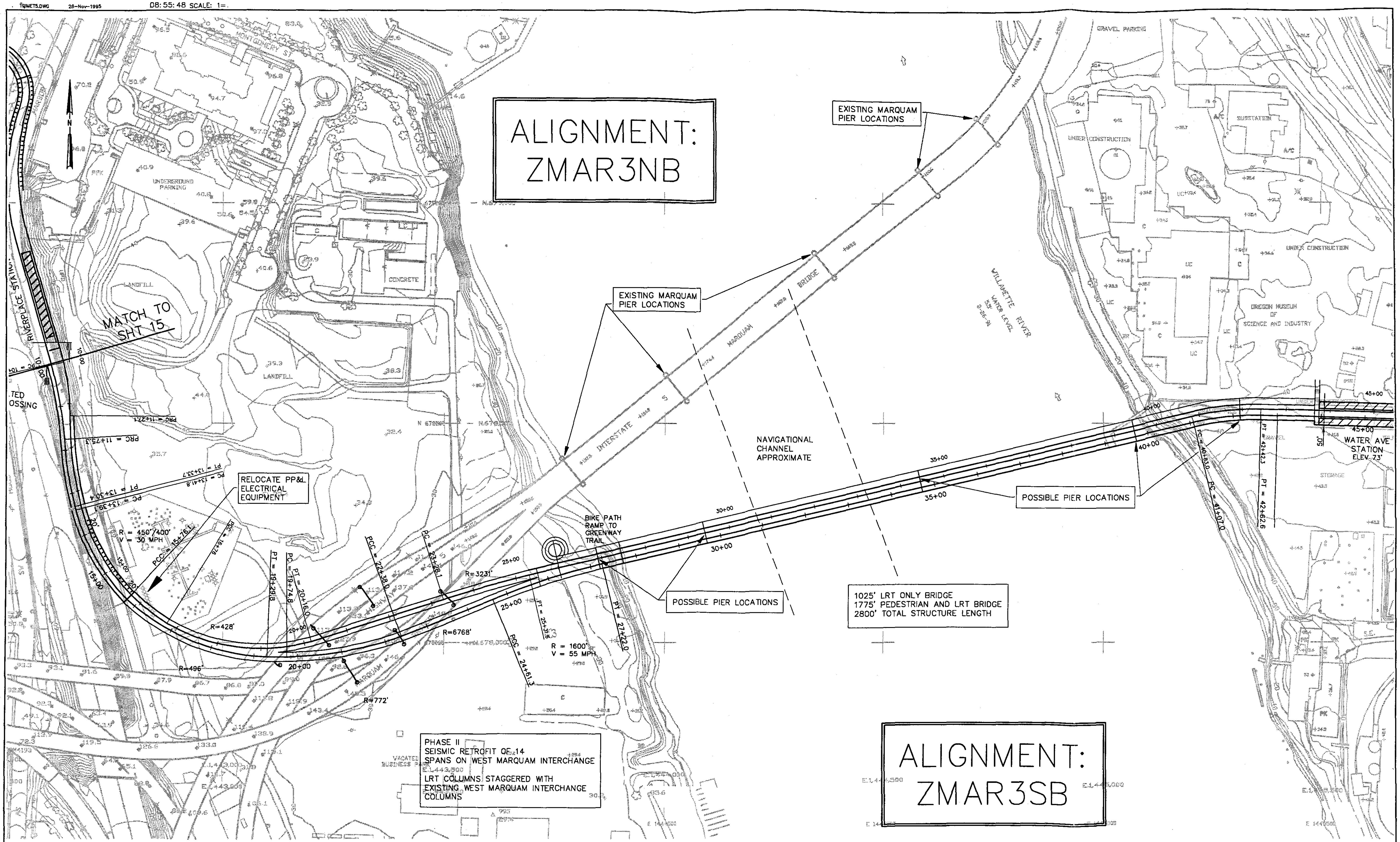


CH2M HILL	DSGN D MOYANO DR TRIMET3.DWG DL MONK CHK APVD	NO. DATE REVISION BY APVD	VERIFY SCALES BAR IS ONE INCH ON ORIGINAL DRAWING 0 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	TRI-COUNTY METROPOLITAN DISTRICT OF OREGON S/N LRT EAD	MODIFIED CARUTHERS DESIGN OPTION NORTH PROFILE

SHEET 2 of 3
DATE NOV 1995
PROJ NO. OPT37830.B0

DRAFT

TRIMET5.DWG 28-Nov-1995 08:55:48 SCALE: 1=.



CH2M HILL	DSGN D. MOYANO DR TRIMET5.DWG DL MONK CHK APVD	NO.	DATE	REVISION	BY	APVD	

VERIFY SCALES
BAR IS ONE INCH ON ORIGINAL DRAWING
0 1"
IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.

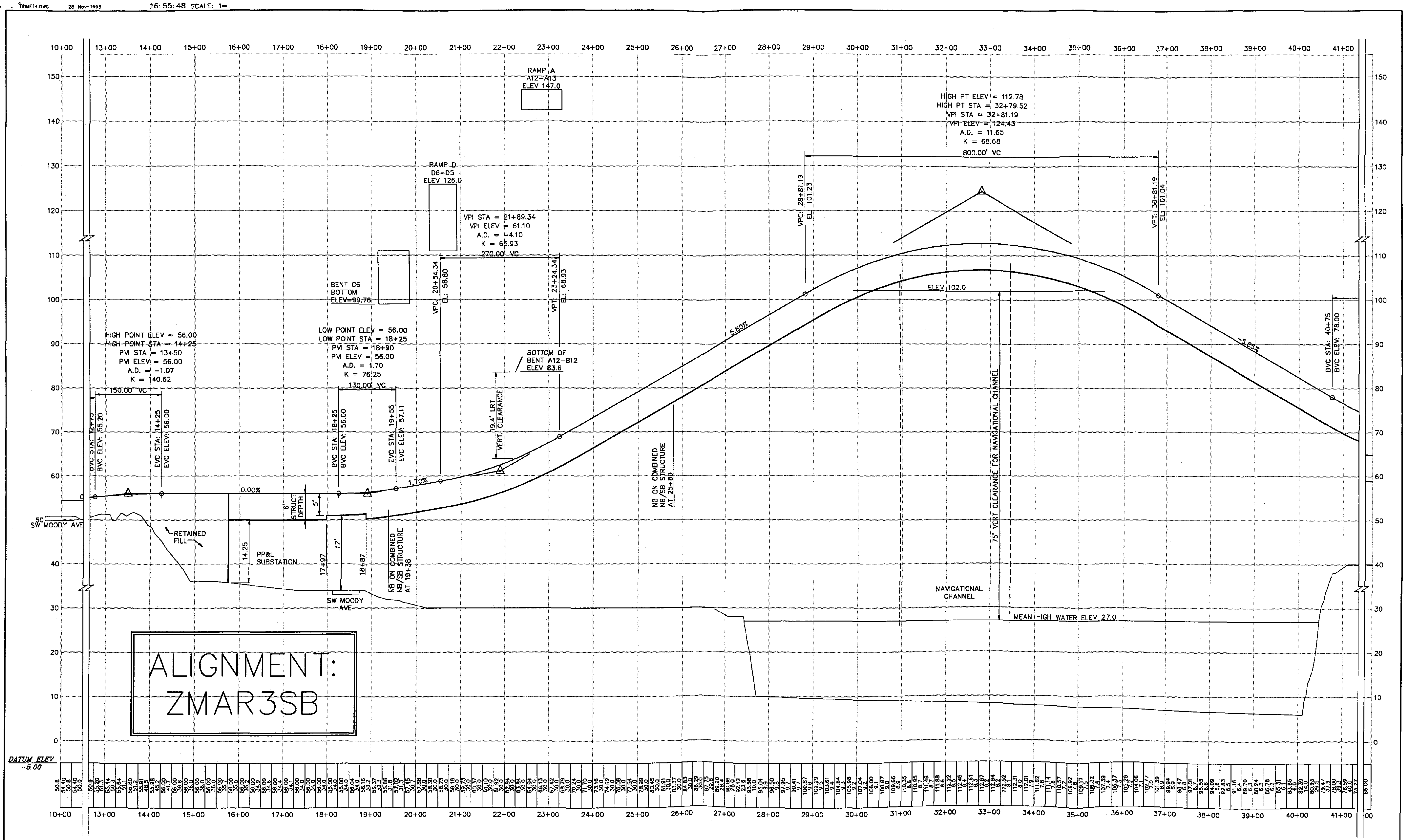
TRI-COUNTY METROPOLITAN DISTRICT OF OREGON
S/N LRT EAD

MODIFIED CARUTHERS
DESIGN OPTION
PLAN

SHEET 1 of 3
DATE NOV 1995
PROJ NO. OPT37830.B0

DRAFT

TRIMET4.DWG 28-Nov-1995 16:55:48 SCALE: 1=.



CH2M HILL	DSGN D. MOYANO					VERIFY SCALES BAR IS ONE INCH ON ORIGINAL DRAWING 0 — 1" IF NOT ONE INCH ON THIS SHEET, ADJUST SCALES ACCORDINGLY.	TRI-COUNTY METROPOLITAN DISTRICT OF OREGON S/N LRT EAD	MODIFIED CARUTHERS DESIGN OPTION SOUTH PROFILE	SHEET 3 of 3
	DR TRIMET4.DWG DL MONK								DATE NOV 1995
	CHK								PROJ NO. OPT37830.B0
	APVD	NO.	DATE	REVISION	BY APVD				

DRAFT