City of Bend: Murphy Road – Segment 3 Preliminary Design Memorandum

PREPARED FOR: City of Bend

PREPARED BY: CH2M HILL

DATE: October 7, 2009

Introduction

This design memorandum documents the preliminary design work performed for Segment 3 of the Murphy Road Corridor. It provides the background information on roadway, drainage and structural design, along with utility information. Cost estimates based on quantities generated from the preliminary design are also included. Technical drawings showing the scope and limits of the project are attached to the report.

Due to significant reductions in transportation capital improvement project (CIP) revenues and the need to re-prioritize CIP expenditures, plans to advance some elements of the Murphy Road corridor to construction have been deferred for several years.

For ease of discussion and to define work efforts, we have divided the Murphy Road project corridor into three segments. CH2M HILL completed the *Murphy Corridor Refinement Plan* in 2008, which included developing alternatives for improvements to Murphy Road from Parrell Road to 15th Street. These limits constitute Segments 2 and 3 of the corridor. Separate design memorandums have been prepared for Segments 1 and 2. Segment 1 describes the new alignment of Murphy Road from Brookswood Boulevard over the Bend Parkway and east to Parrell Road. Segment 2 describes the existing alignment from Parrell Road to Brosterhous Road.

Project Description

Segment 3 of Murphy Road extends from Brosterhous Road to 15th Street. This new extension of Murphy Road to the east will cross the Burlington Northern and Santa Fe Railroad (BNSF) right-of-way.

During the refinement plan phase of the project, a conceptual design alignment extended to 15th Street and terminated as a stop controlled approach. Subsequent to this work, a subdivision was approved for development east of 15th Street, which included a new private street, Golden Gate Place. Golden Gate Place intersects 15th Street several hundred feet north of the alignment developed for Murphy Road that was documented in the Refinement Plan. The City directed CH2M HILL to realign the proposed alignment of Murphy Road to intersect 15th Street directly across from Golden Gate Place and design a roundabout for this intersection. Topographic mapping and boundary resolution suitable for preliminary and final design efforts was collected by CH2M HILL for this segment, but the mapping limits

do not extend north to include the realigned roadway and intersection with Golden Gate Place. Supplemental mapping will be necessary when this design work is resumed.

Existing Conditions

The land use is residential in Segment 3, with existing development located along the north side of the proposed Murphy Road and west of the BNSF tracks. Plans are underway to develop single family homes on the south side of the road and west of the tracks. The land east of the tracks is undeveloped, with an Area of Special Interest (ASI) located along the south side of the propose Murphy Road alignment.

The roadway design standards for Segment 3 are defined in Table 1.

TABLE 1
Design Standards

Design Feature	Design Criteria	Source
Classification	Major Collector	City of Bend
Design Vehicle	WB-50 Accommodate WB-67 (tractor-trailer unit with 53 ft. length)	AASHTO, Chapter 2
Design Speed	40 mph	AASHTO, Chapter 6, p.430
Stopping Sight Distance	305' (grade dependent)	AASHTO, Chapter 3, p.110
Minimum KSAG	64	AASHTO, Chapter 3, p.175
Minimum KCREST	44	AASHTO, Chapter 3, p.271
Minimum L	125' (grade difference <1%, grade breaks are allowed)	City of Bend, Design Stds, Section IIA6, p.9
Maximum K	100' (where drainage is a factor)	City of Bend, Design Stds, Section IIA6, p.9
Minimum Horizontal Curvature	R = 675 ft. (normal crown, low speed urban) or 489 ft. @ 4% Max. Superelevation	City of Bend, Design Stds, Section IIA7, p.10
Maximum Grade	8% (10% for hillsides exceeding 15% slope).	City of Bend, Design Stds, Section IIA1, p.2 and 3
Minimum Grade	0.5%	City of Bend, Design Stds, Section IIA2, p.6
Minimum Cross Slope	2.0%	City of Bend, Design Stds, Section IIA3 and 10, p.6 and 11
Maximum Superelevation	6% (4.0% preferred)	City of Bend, Design Stds, Section IIA3, p.6

TABLE 1
Design Standards

Design Feature	Design Criteria	Source
Lane Widths Travel Lanes Bike Lanes (2) Sidewalk (2)	 12’ 8’ 6’	City of Bend, Design Stds, Section IIA1, p.2 thru 5
Right-of-way Width	80’ Minimum. May increase at intersections as stipulated by City Engineer	Project Specific, City of Bend, Design Stds, Section IIA1, p.2
Bike Lanes	Required on all major collectors	City of Bend, Design Stds, Section IIA1, p.2 thru 4
Side slopes	1:2 Max	City of Bend, Std Dwg 2-1, Typical Cross Section
Curbs	12-inch standard curb with 6” exposure	City of Bend, Std Dwg 2-3, Sidewalk and Conc. Curbs
Clear Zone	Varies	AASHTO Roadside Design Guide, Chapter 3
Access Management	Driveway Spacing: 22’ (Minimum, bottom of curb drop to bottom of curb drop)	City of Bend, Design Stds, Section IIA11, p.11

Note: All references to American Association of State Highway and Transportation Officials (AASHTO) are for *A Policy on Geometric Design of Highways and Streets, 2004,* unless otherwise noted.

The roundabout design standards for Segment 3 are defined in Table 2.

TABLE 2
Roundabout Design Standards

Design Feature	Design Criteria	Source
Classification	Single Lane Urban	FHWA, Exhibit 1-7
Design Year/Traffic	20 year	City of Bend, Design Stds, Section IIA18, p.21
Design Vehicle	WB-50, Emergency Vehicles shall not be required to use truck apron.	City of Bend, Design Stds, Section IIA18, p.21
Circulating Design Speed	20 mph	FHWA, Exhibit 6-4
Inscribed Circle Diameter	120’ minimum	City of Bend, Design Stds, Section IIA18, p.22

TABLE 2
Roundabout Design Standards

Design Feature	Design Criteria	Source
Entry/Exit Width - Striped	15'/18' (Curb to Curb - 20'/20')	City of Bend, Design Stds, Section IIA18, p.22
Circulating Roadway Width	20'-22'	City of Bend, Design Stds, Section IIA18, p.22
Crosswalks	25' minimum from circulating roadway yield line	City of Bend, Design Stds, Section IIA18, p.22
Splitter Island	25' minimum beyond crosswalk	City of Bend, Design Stds, Section IIA18, p.22
Maximum Approach Grade	4.0%	City of Bend, Design Stds, Section IIA18, p.21
Cross Slope	2.0%	FHWA, Section 6.3.11.2, Exhibit 6-37, p.166
Bike Accomodations: Bike Lane Taper Bike Exit Ramp Multi-use Path	15:1 100' upstream of circulating roadway yield line 10'	City of Bend, Design Stds, Section IIA18, p.22 and 23
Illumination	Shall meet minimum AASHTO's Table 3 in "An Informational Guide for Roadway Lighting" requirements	City of Bend, Design Stds, Section IIA18, p.23
Signing	Shall conform to MUTCD and City of Bend Street Signing Specifications	City of Bend, Std Dwg 2-28, Roundabout Signing

Notes:

All references to FWHA are for *ROUNDABOUTS, AN INFORMATIONAL GUIDE,* 2000, unless otherwise noted.

Roadway Typical Sections

The preliminary plans are attached in Appendix A. The typical roadway width for Segment 3 is 40 feet to provide two 12 foot lanes with 8 foot bike lane/shoulders on each side. An 8 foot shoulder, rather than a 6 foot shoulder, was shown in the design based on the location of this segment. In Segment 3, most of the roadway is on an elevated embankment or bridge, with no sidestreets or left-turn lane. The shoulder of the road must also serve as a breakdown lane or refuge to clear the travel lane for emergency vehicles.

Intersection Design

A roundabout has been selected as the intersection form for the Murphy Road intersection with 15th Street and Golden Gate Place, and has been designed according to the criteria provided in Table 2. The inscribed circle diameter used for the roundabout design shown is 120 feet.

Traffic Analysis

Traffic analysis for Segment 3 was performed and summarized in the Murphy Corridor Refinement Plan. Detailed analysis is included in Appendix C (Traffic Methodology), Appendix D (Existing Conditions) and Appendix E (Future Conditions and Deficiencies). The Murphy Road/15th Street intersection was analyzed as stop controlled Tee intersection, with a left turn lane provided on Murphy Road. This intersection should be re-evaluated using a roundabout when design resumes to evaluate this intersection with the new alignment to Golden Gate Place.

Horizontal Alignment

The proposed horizontal alignment for Murphy Road in Segment 3 is constrained by the existing development and right-of-way dedication along the north side of the alignment and west of the tracks and the ASI on the east side of the tracks. The design is also driven by the City's desire to connect with Golden Gate Place, in order to avoid offset intersections with 15th Street.

Vertical Alignment

The vertical alignment for Segment 3 is governed by the clearance requirements over the BNSF tracks. The west approach utilizes retaining walls for both excavation and embankment slopes to minimize the impact to adjacent land, while the east approach is designed with unretained embankments. For the roadway profile, see Appendix A.

Bridge and Wall Design

The crossing of the BNSF railroad right-of-way is in a location where their right-of-way expands from 100 feet wide to 200 feet wide for a small rail yard. Coordination with BNSF yielded approval to place bridge piers within the BNSF right-of-way. Documentation of this approval is contained in Appendix B. An evaluation of bridge span layouts and bridge type was conducted for this overcrossing. The evaluation resulted in a recommended two span 60" deep bulb tee beam with a cast-in-place concrete deck. A MSE retaining wall is provided at the west end of the proposed bridge in order to contain the roadway embankment within roadway right of way limits and outside the BNSF west right-of-way limit at the west end of the bridge. A separate design memorandum with additional detail on the bridge and wall options evaluated is attached in Appendix B.

Right-of-Way

No right-of-way has been acquired or dedicated on the east side of the tracks. On the west side of the tracks, the existing development north of the Murphy Road alignment dedicated 40 feet of right-of-way, which constitutes a half street width. Existing right-of-way is shown on the preliminary plans. The design assumptions for the roadway assume an

additional 40 feet of right-of-way will be dedicated on the south side of the alignment. On the east side of the tracks, signficiant additional right-of-way will be required due to the unretained embankment proposed. New or proposed right-of-way and easements are not shown on the preliminary plans and will need to be established once the design is refined and the roadway footprint finalized.

Drainage

A new stormwater conveyance system is proposed for Segment 3. The bridge is the high point in the roadway profile, defining the sub basin boundary. West of the bridge, stormwater flows west into Segment 2 to a treatment and discharge location. East of the bridge, stormwater flows east to a treatment and discharge location currently shown along the north side of Murphy next to 15th Street. The Segment 3 water quality facility is preliminarily sized to treat and dispose of runoff from 1.4-acres of roadway from the project. The system utilizes an infiltration swale and then discharges flows exceeding the water quality flow into drywells for disposal. The vegetative WQF allows for a reduction of the required volume to be disposed of through the use of drywells. The drywell disposal calculation assuming a 20-foot depth identifies the requirement of 3 new drywells for disposal of all flows above the water quality flow.

More details on the storm drainage design are contained in Appendix C.

Utilities

Table 3 shows the utilities, contacts and action needed for future phases of design development for Segment 3:

TABLE 3
Murphy Road Utilities

Utility	Owner	Contact	Action Needed
Water	City of Bend		No current facilities. Plans to extend service along the Murphy Road alignment to 15th Street.
Sewer	City of Bend		No current facilities. Plans to extend large interceptor line along the Murphy Road alignment.
Electric	Pacific Power	Mike Bower 328 NE Webster Ave Bend, OR 97701 541-388-7167	Facilities along Murphy Road and 15th Street. Define and coordinate facility relocations along Murphy Road.
Natural Gas	Cascade Natural Gas	Donna Dunlap 3334 NE Hawthorne Ave. Bend, OR 97701 541-382-6465	Facilities along 15th Street. Define and coordinate conflict resolution.
Communications	Qwest	Bob Kitchen 100 NW Kearney St. Bend, OR 97701 541-385-0224	Qwest has underground facilities in Segment 3, but has not provided information. Obtain facility locations, define and resolve conflicts.

TABLE 3
Murphy Road Utilities

Utility	Owner	Contact	Action Needed
Communications	Bend Broadband	Jeff James 63090 Sherman Road Bend, OR 97701 541-388-5820-3-1 jkjames@bendbroadband.net	Majority of facilities on Pacific Power poles, with some underground. Define and resolve conflicts.

Cost

A preliminary cost estimate was developed for Segment 3, including construction, engineering, administrative and right-of-way costs. A construction contingency of 30 percent is included and the costs are based on 2009 unit cost empirical data with no escalation. Actual project cost will vary depending on year of construction, actual labor and material costs, competitive market conditions, final project scope, and other variable factors.

The estimated construction costs are summarized in the Table below. A detail cost breakdown is included in Appendix D.

TABLE 4
Estimated Construction Costs – Segment 3

Task	Cost
Construction (with contingency)	$7,390,000
Engineering, Administration, Other	$1,478,000
Right of Way	$2,507,000
Total	**$11,375,000**

APPENDIX A

Preliminary Drawings

MURPHY ROAD - SEGMENT 3

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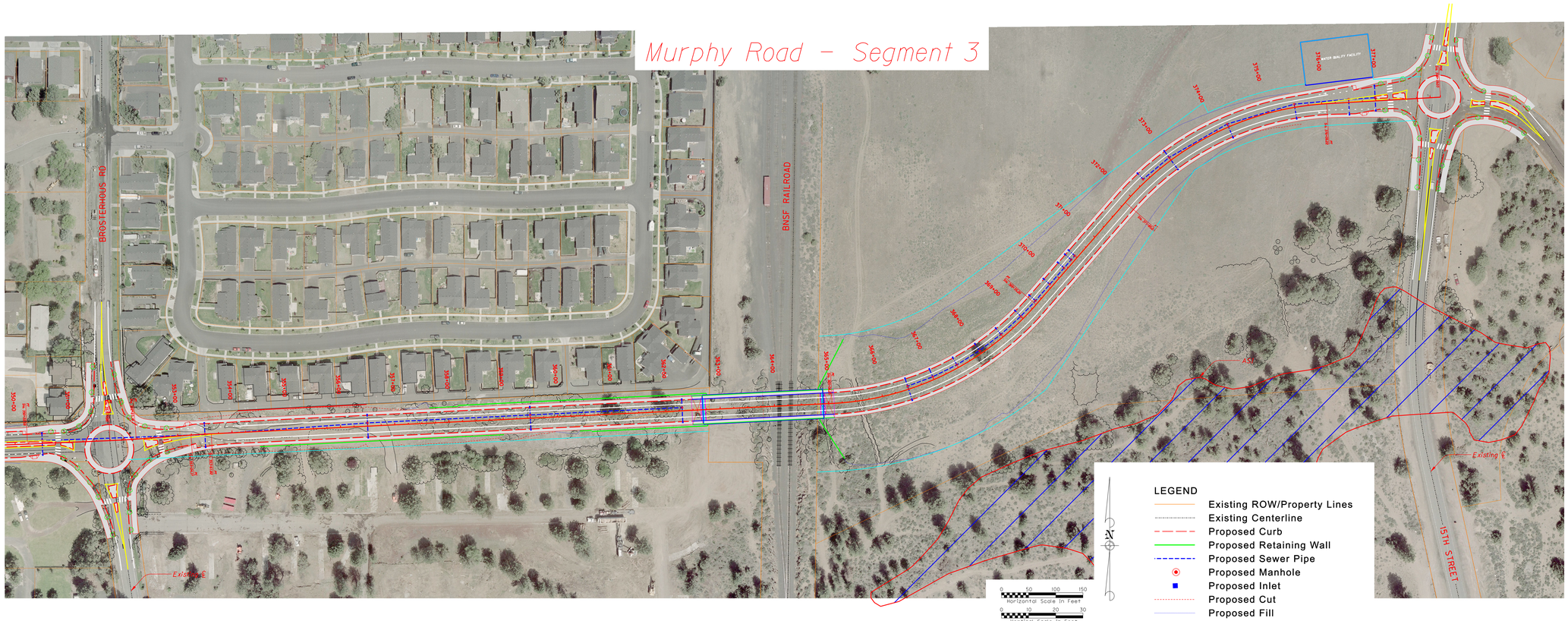
1" = 10' V

CH2MHILL

Murphy Road – Segment 3



Segment 3 Vertical Alignment

PROJECT
MURPHY ROAD
SEGMENT 3 - PLAN AND PROFILE

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APPENDIX B

Bridge Design Technical Memorandum

Murphy Road: Segment 3
Bridge Over BNSF Railroad

PREPARED FOR: City of Bend

PREPARED BY: CH2M HILL

DATE: April 20, 2009

INTRODUCTION

Murphy Road is an east-west collector between Highway 97 and Brosterhous Road. The proposed extension of Murphy Road from Brosterhous Road to the east to 15th Street will require the crossing of BNSF right of way and railroad tracks. The BNSF right of way is 200 feet wide at the crossing and includes a siding track with turnout and a mainline track located within the eastern portion of the right of way. In addition, a future track located 25 feet to the east of the existing mainline track and 25 feet from the eastern right of way limit is planned by BNSF. Previous documented discussions with BNSF Railroad gained approval to place one bridge bent within the railroad right-of-way.

GEOMETRICS

The proposed Murphy Road extension horizontal alignment beginning at the Brosterhous Road intersection is tangent for the western portion and extends across the BNSF right of way at an approximate skew angle of 3.7 degrees. A short distance to the east of the BNSF right of way the horizontal alignment curves to the north and to the east to the desired location of the intersection with 15th Street.

The proposed Murphy Road extension vertical alignment includes reverse vertical curves at each end for the connections to the intersections at Brosterhous Road and 15th Street with a 1.00% up grade from west to east on the bridge over the BNSF railroad tracks. The proposed vertical alignment provides a minimum vertical clearance of 23.5' over the existing and future railroad tracks.

The proposed Murphy Road extension roadway will have a 2 percent normal crown section beginning at Brosterhous Road which extends onto the western portion of the proposed bridge over the BNSF right of way. The normal crown section transitions on the eastern portion of the proposed bridge to a 2 percent shed cross slope down to the north for the horizontal curve to the north adjacent to the east end of the bridge, transitions to a 2 percent cross slope down to the south for the reverse curve to the east, and then transitions to a 2 percent normal crown section for the connection to 15th Street.

Right of Way

The Murphy Road extension between Brosterhous Road and the BNSF right of way has a right of way width of 40 foot wide each side of the roadway centerline due to existing development. East of the BNSF right of way, the Murphy Road right of way extends

through undeveloped land such that the proposed right of way width is available to accommodate the maximum roadway embankment width of approximately 240 feet.

BRIDGE DESIGN STANDARDS

Design of the proposed bridge shall be in accordance with the AASHTO LRFD Bridge Design Specifications Fourth Edition – 2007 with 2008 Interims and ODOT Bridge Design and Drafting Manual (BDDM) updated April, 2009. Design live load shall be HL-93. Seismic design site bedrock acceleration shall be 0.11g for 1000 year return period seismic event.

TYPICAL BRIDGE SECTION

The proposed bridge width is 54 feet which provides two 12 foot lanes, two 8 foot shoulders, two 6 foot sidewalks, and two bridge rails. The bridge rails will include concrete parapets with steel pedestrian railings full length of the bridge. Chain link protective fencing 8 feet high above the parapets will be provided at the BNSF tracks.

ALTERNATIVE SPAN ARRANGEMENTS

Two alternative span arrangements were investigated for the proposed bridge. One span arrangement included two spans and the other included three spans.

The two span alternative is 220′ long which includes two 110′ long spans. End bents are located adjacent to the BNSF right of way limits and the interior bent is located horizontally 25′ minimum clear from the existing BNSF siding track and turnout per BNSF requirements. A MSE retaining wall is provided at west end of the proposed bridge in order to contain the roadway embankment within roadway right of way limits and outside the BNSF west right of way limit at the west end of the bridge and a MSE retaining wall is provided at the east end of the bridge to contain the roadway embankment outside the BNSF east right of way limit.

The three span alternative is 280′ long which includes 110′, 110′, and 60′ long spans. The west end bent is located adjacent to the BNSF west right of way limit, the west interior bent is located horizontally 25′ minimum clear from the existing BNSF siding track and turnout, the east interior bent is located adjacent to the BNSF east right of way limit, and the east end bent is located sufficiently from the BNSF east right of way limit for the roadway embankment toe of slope to be located outside of the BSNF right of way eliminating the need for a retaining wall. A MSE retaining wall is provided at the west end of the proposed bridge in order to contain the roadway embankment within roadway right of way limits and outside the BNSF west right of way limit at the west end of the bridge.

ALTERNATIVE STRUCTURE TYPES

Two alternative structure types were investigated for the proposed bridge: 48″ deep precast prestressed concrete box beams with asphalt wearing surface and waterproof membrane and 60″ deep bulb tee precast prestressed concrete beams with cast in place concrete deck.

Each alternative is supported by cast in place reinforced concrete bents normal to the centerline of the roadway. Spread footings founded in the roadway embankments are provided for end bents and spread footings founded on rock are provided for the

intermediate bents. The front edges of end bent spread footings are located 2.5' minimum from the front face of MSE retaining walls.

The 48" deep precast prestressed concrete box beams utilize a variable thickness asphalt concrete wearing surface for the span over the BNSF railroad tracks and adjacent span to the east to accommodate the variable roadway cross slope. The 60" deep bulb tee precast prestressed beams utilize a variable thickness concrete haunch above the top flanges of the beams to accommodate the variable cross slope.

Preliminary plan, elevation and typical section drawings for the two span and three span bridge alternatives and retaining wall plan and elevation drawings are attached.

PRELIMINARY CONSTRUCTION COST ESTIMATES

Preliminary construction cost estimates were developed for the alternative span arrangements and structure types including bridge and MSE retaining wall elements, mobilization and contingencies of 25 percent. For the comparison of the two span and three span alternatives, the estimated costs for additional embankment, aggregate base, and asphalt concrete pavement for the two span alternative were determined based upon conceptual quantities.

Detailed breakdowns of the bridge cost estimates for the 60" deep bulb tee beams with CIP concrete deck and 48" deep box beams with asphalt concrete wearing surface and including estimated quantities and unit costs are attached. Unit costs were based upon ODOT average unit bid prices in 2008. Actual project construction cost for the bridge and MSE retaining walls will vary depending actual labor and material costs, competitive market conditions, and final project scope.

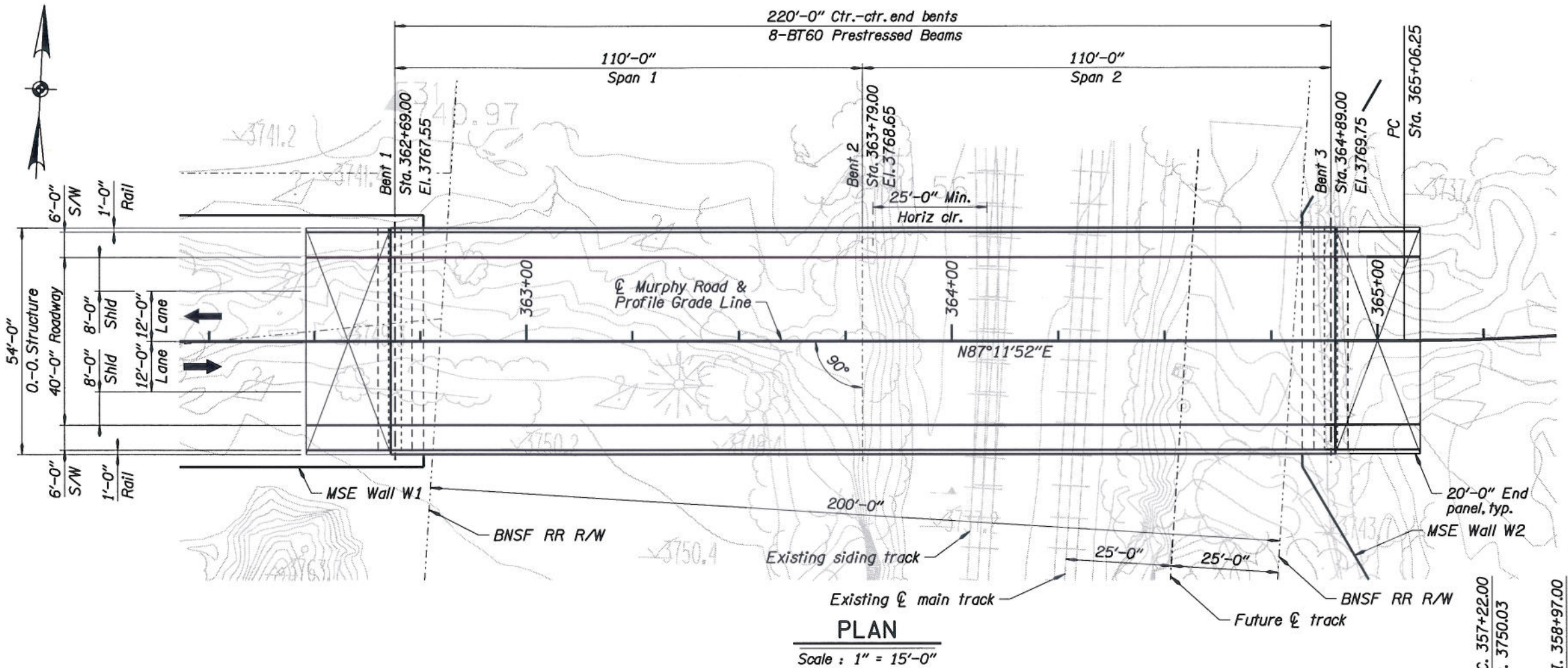
A summary of these preliminary construction cost estimates is as follows:

	Two Span Bridge		Three Span Bridge	
	60" bulb tee beams with CIP conc deck	48" box beams with ACWS	60" bulb tee beams with CIP conc deck	48" box beams with ACWS
Bridge	$2,177,000	$2,237,000	$2,841,000	$2,987,000
MSE Ret. Walls	$1,259,000	$1,259,000	$908,000	$908,000
Add'l Emb.	$175,000	$175,000	$0	$0
Add'l Aggr Base	$8,000	$8,000	$0	$0
Add'l Asph Conc	$17,000	$17,000	$0	$0
Total	$3,636,000	$3,696,000	$3,749,000	$3,895,000

RECOMMENDATIONS

The two span 60" deep bulb tee beam with CIP concrete deck alternative has the least estimated construction cost and will also have lower maintenance costs over the life cycle of the facility compared to the other alternatives. Lower maintenance costs are the result of having the least length of the structure to maintain and the likely need in the future to replace or overlay the asphalt concrete wearing surfaces and replace expansion joints at each bent for the 48" deep box beam alternatives. If the bridge is to be constructed in the near

future, then the two span 60" deep bulb tee beam with CIP concrete deck is the recommended alternative for the structure. If the bridge will not be constructed until sometime later in the future, then the estimated construction costs should be reviewed in the future to verify that the two span 60" deep bulb tee beam with CIP concrete deck is the most cost effective structure to construct and maintain at that time, since all of the alternatives have estimated construction costs that are within approximately 5 percent of each other.



PLAN

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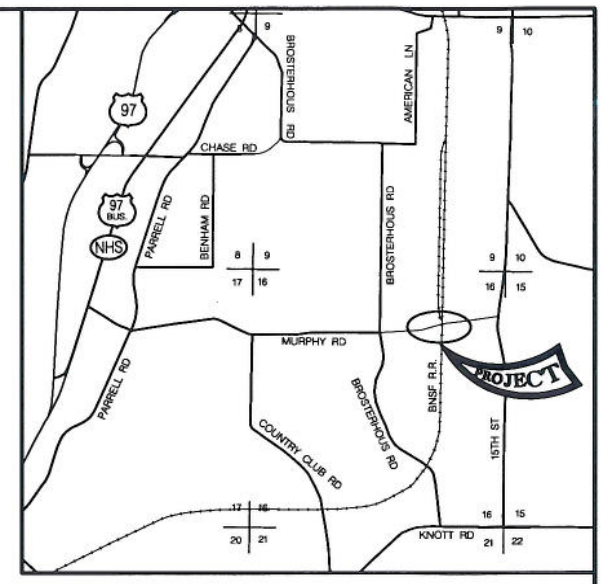

LOCATION MAP

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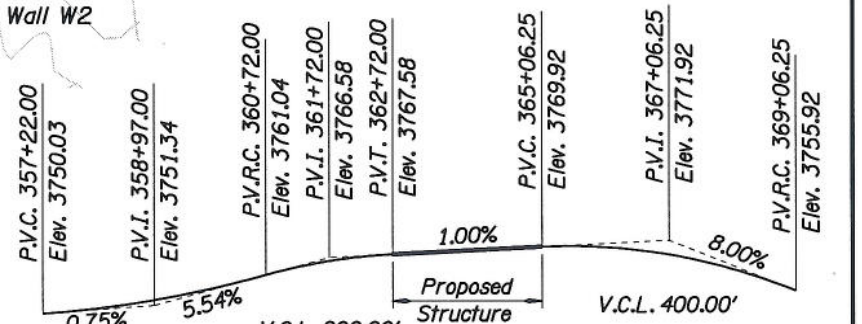

MURPHY ROAD GRADELINE

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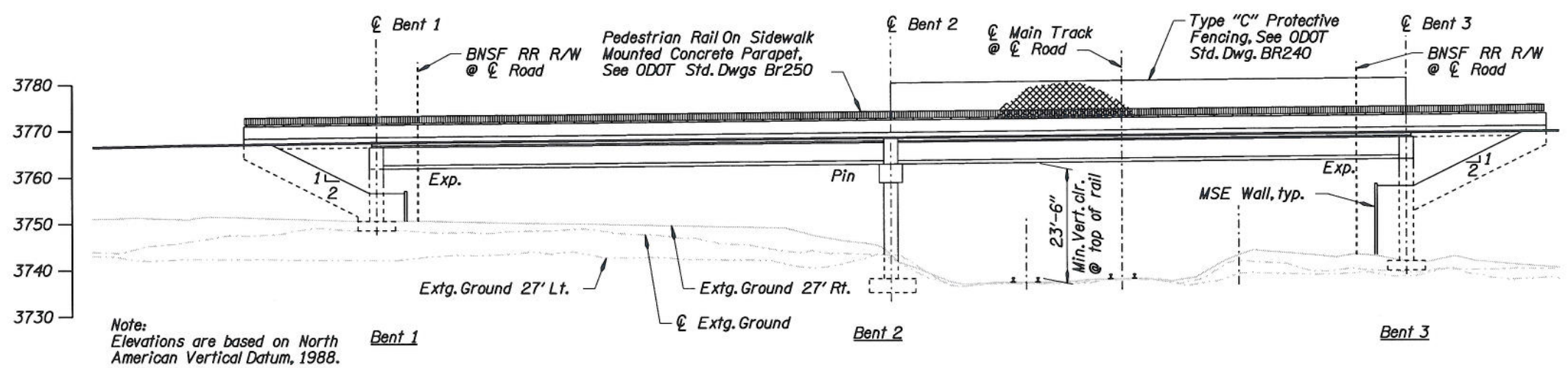

Note:
Elevations are based on North American Vertical Datum, 1988.

Note:
All dimensions shown are in English units unless otherwise noted.

ELEVATION

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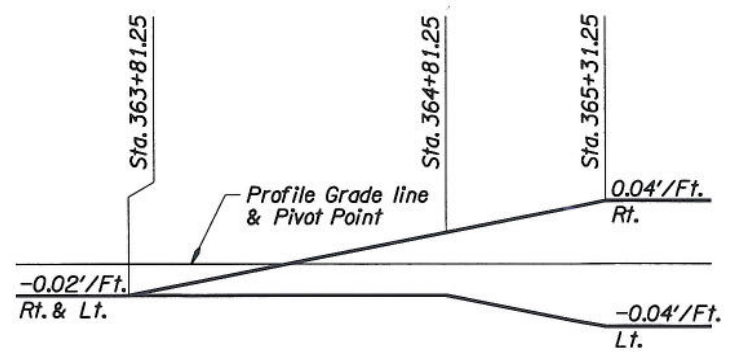

MURPHY ROAD SUPERELEVATION DIAGRAM

No Scale

△	DATE	REVISION	BY

DRAFTED: T. Chancellor
DESIGNED: D. Wagner
CHECKED: G. Conner
REVIEWED:

CH2MHILL

OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE ENGINEERING SECTION

BRIDGE NO.
DATE Apr. 2009
CALC. BOOK

MURPHY ROAD - SEGMENT 3
BRIDGE OVER BNSF RAILROAD
BEND, OREGON

PLAN & ELEVATION - 2 SPAN ALT.

SHEET 1 OF 5
DRAWING NO. S-1

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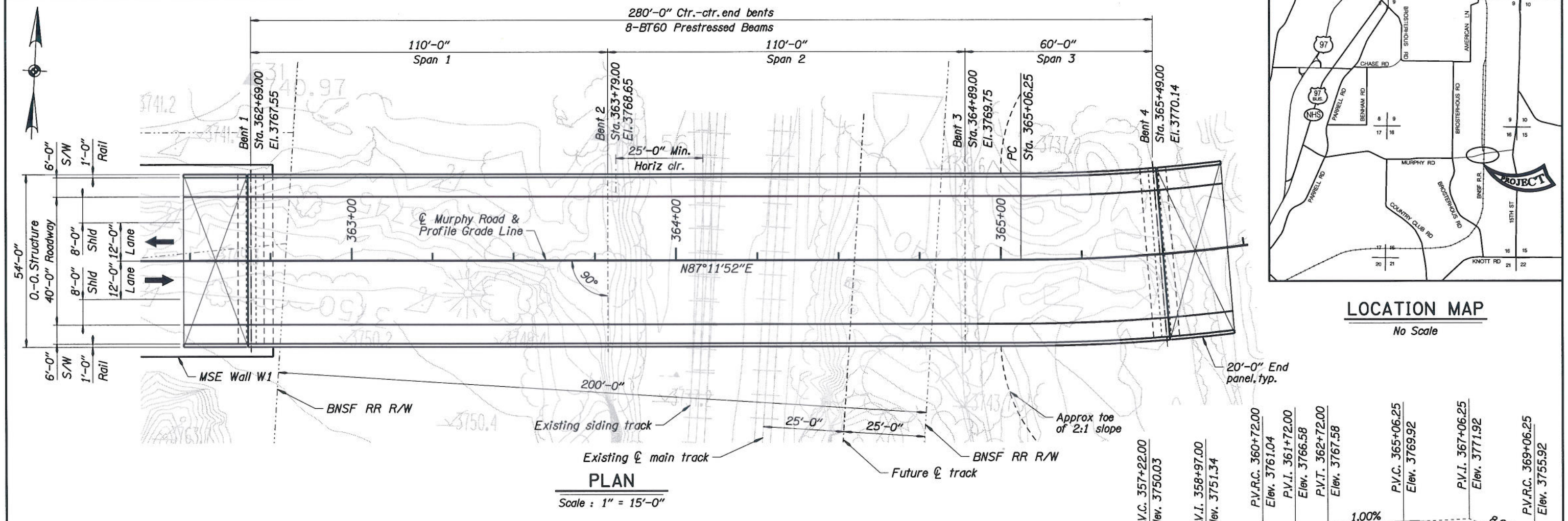

PLAN

Scale : 1" = 15'-0"

LOCATION MAP

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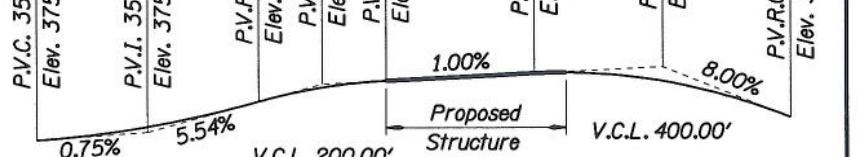

MURPHY ROAD GRADELINE

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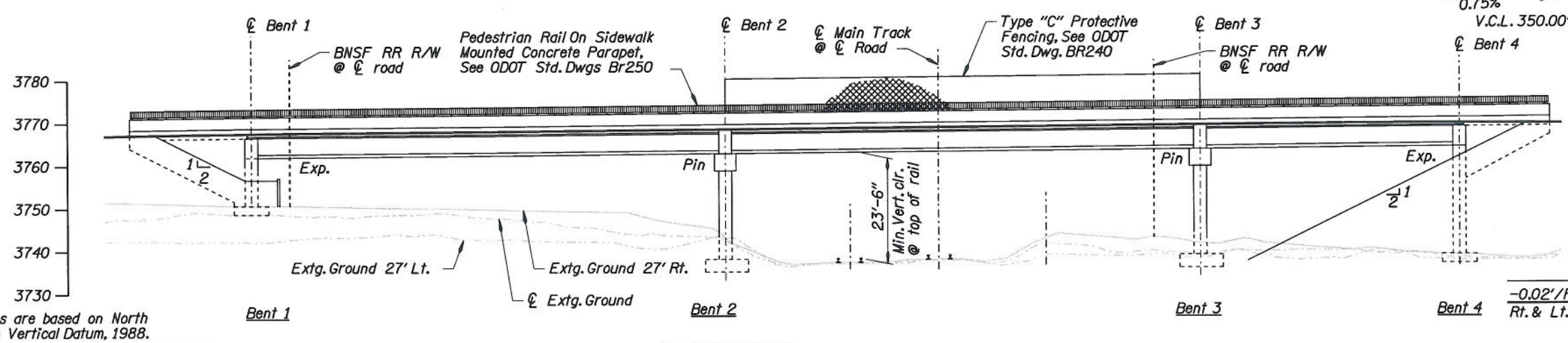

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ELEVATION

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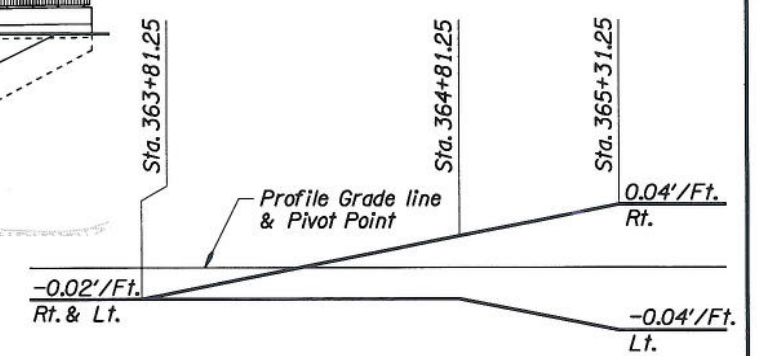

MURPHY ROAD SUPERELEVATION DIAGRAM

No Scale

Note:
All dimensions shown are in English units unless otherwise noted.

△	DATE	REVISION	BY

DRAFTED: T. Chancellor
DESIGNED: D. Wagner
CHECKED: G. Conner
REVIEWED:

CH2MHILL

OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE ENGINEERING SECTION

BRIDGE NO.
DATE: Apr. 2009
CALC. BOOK

MURPHY ROAD - SEGMENT 3
BRIDGE OVER BNSF RAILROAD
BEND, OREGON

PLAN & ELEVATION - 3 SPAN ALT.

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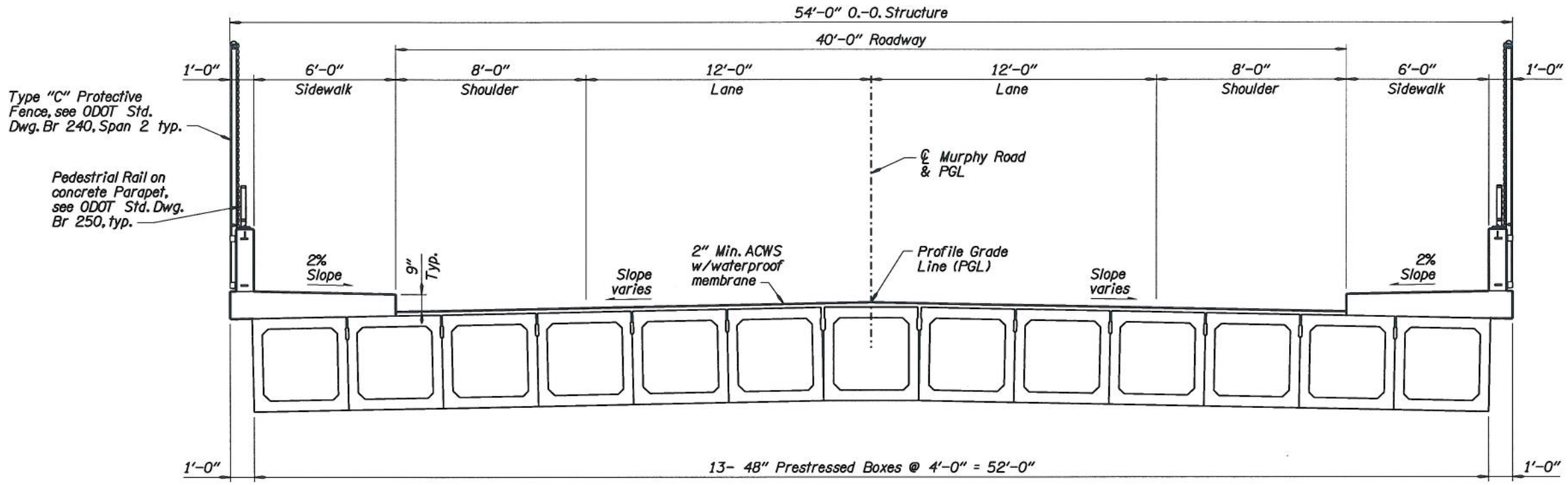

TYPICAL SECTION - 48" PRESTRESSED BOX BEAMS

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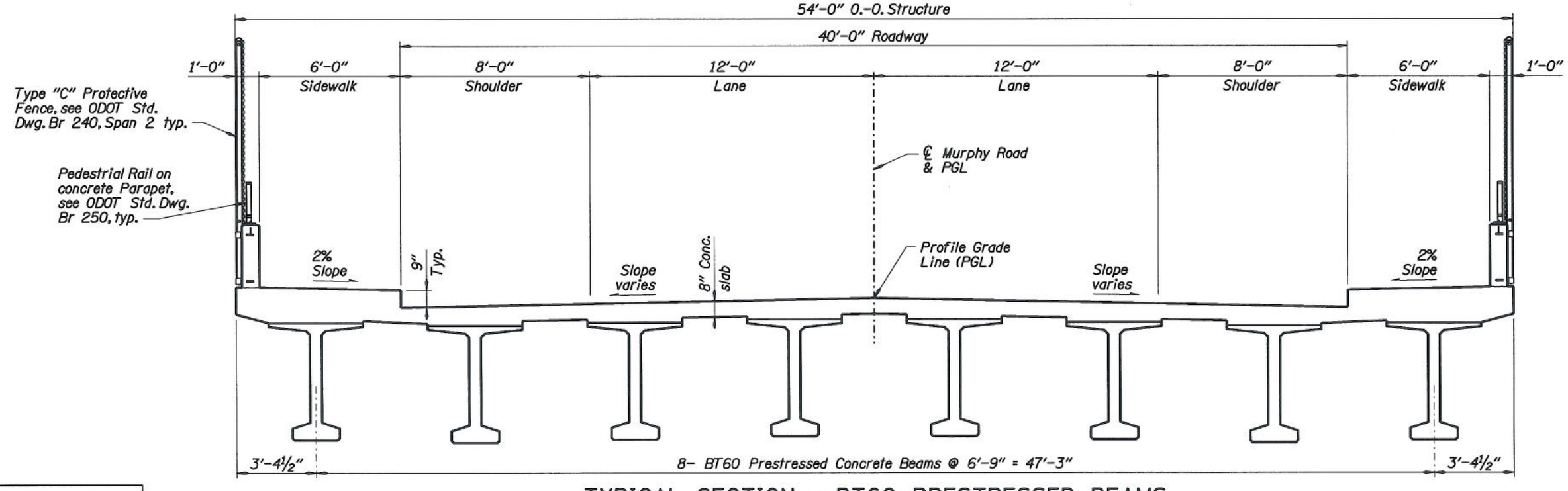

TYPICAL SECTION - BT60 PRESTRESSED BEAMS

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

Note:
All dimensions shown are in English units unless otherwise noted.

△	DATE	REVISION	BY

DRAFTED: T. Chancellor
DESIGNED: D. Wagner
CHECKED: G. Conner
REVIEWED:

CH2MHILL

OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE ENGINEERING SECTION

BRIDGE NO.
DATE: Apr. 2009
CALC. BOOK

MURPHY ROAD - SEGMENT 3
BRIDGE OVER BNSF RAILROAD
BEND, OREGON

TYPICAL SECTION

SHEET 3 OF 5

DRAWING NO. S-3

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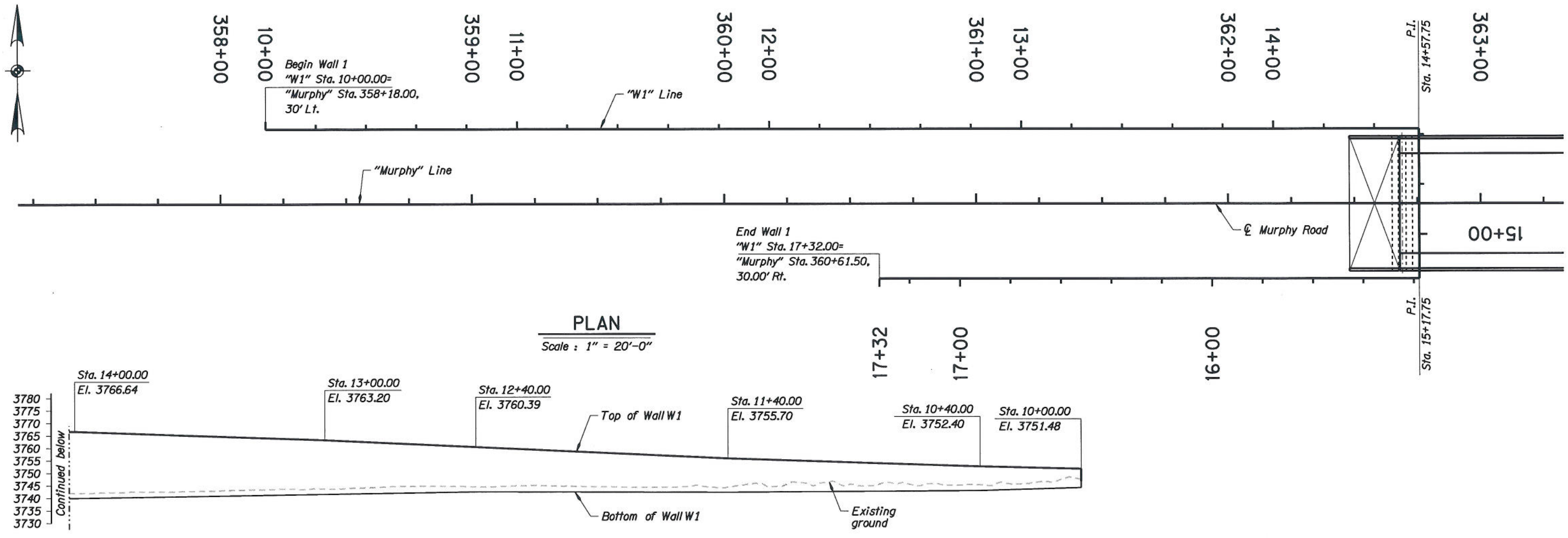
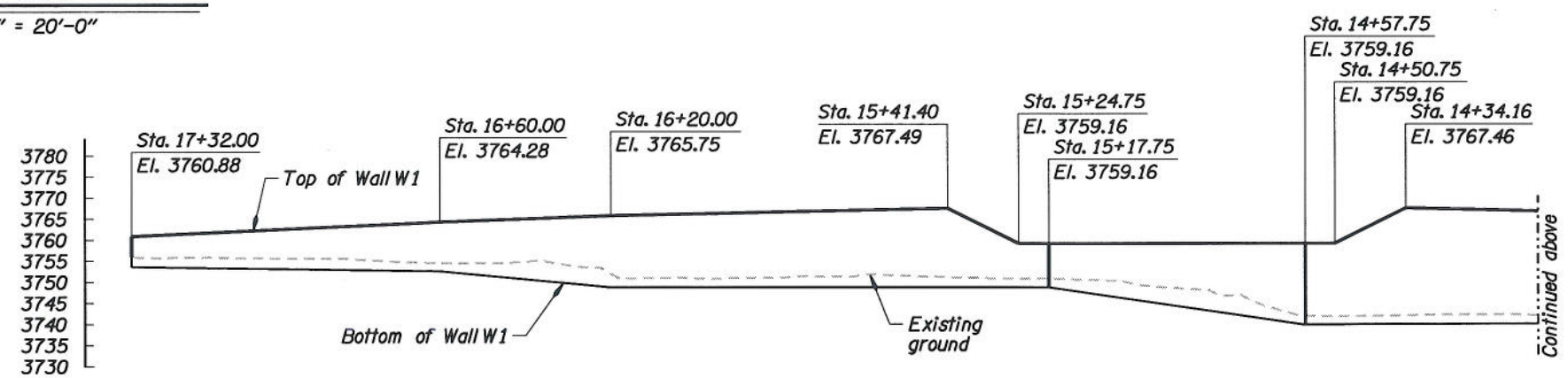


PLAN

Scale : 1" = 20'-0"

DEVELOPED ELEVATION

Scale : 1" = 20'-0"



DEVELOPED ELEVATION

Scale : 1" = 20'-0"

Note:
All dimensions shown are in English units unless otherwise noted.

△	DATE	REVISION	BY

DRAFTED: D. Monk
DESIGNED: D. Wagner
CHECKED: G. Conner
REVIEWED:

CH2MHILL

OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE ENGINEERING SECTION

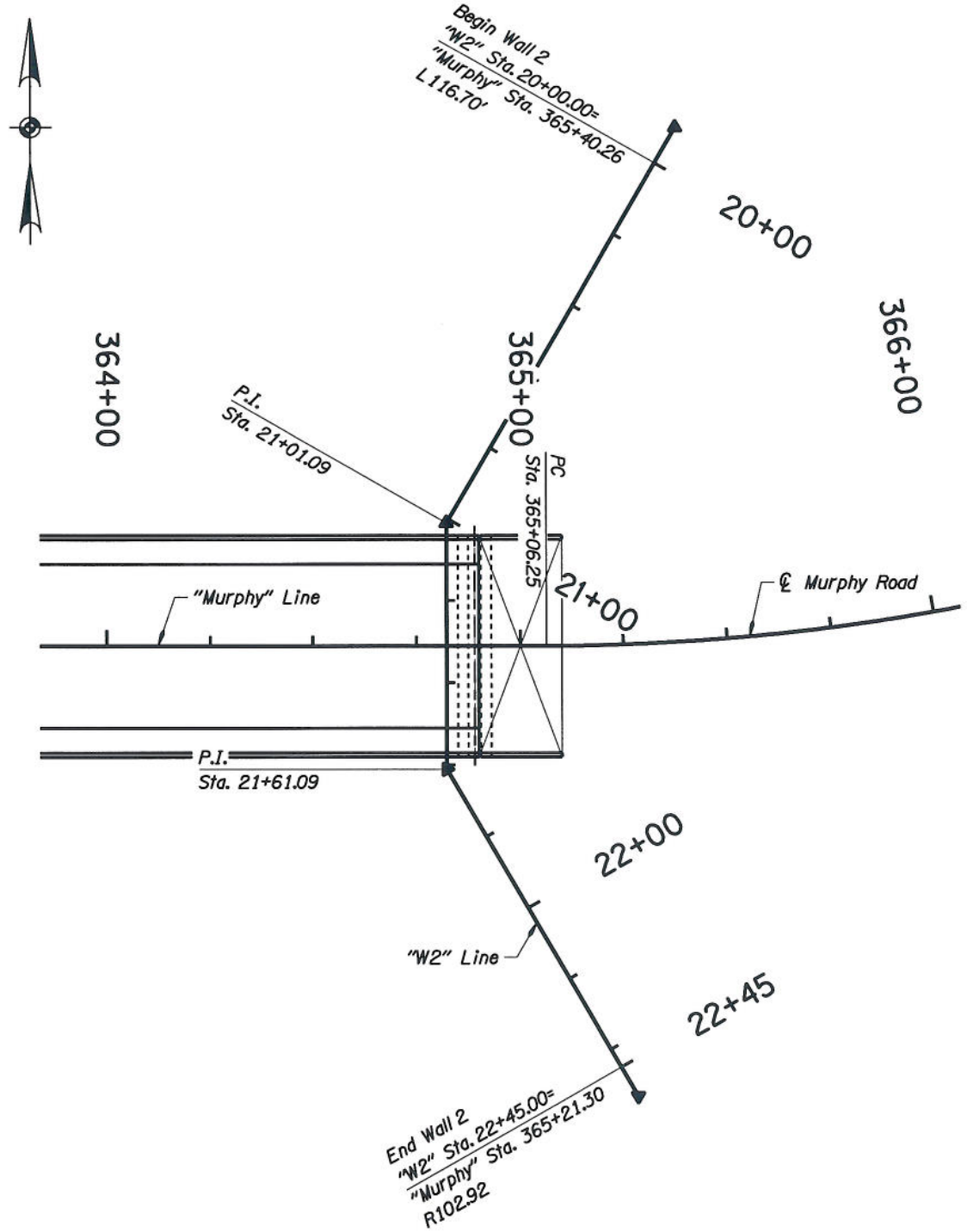
BRIDGE NO.
DATE Apr. 2009
CALC. BOOK

MURPHY ROAD - SEGMENT 3
BRIDGE OVER BNSF RAILROAD
BEND, OREGON

WALL W1 PLAN & ELEVATION

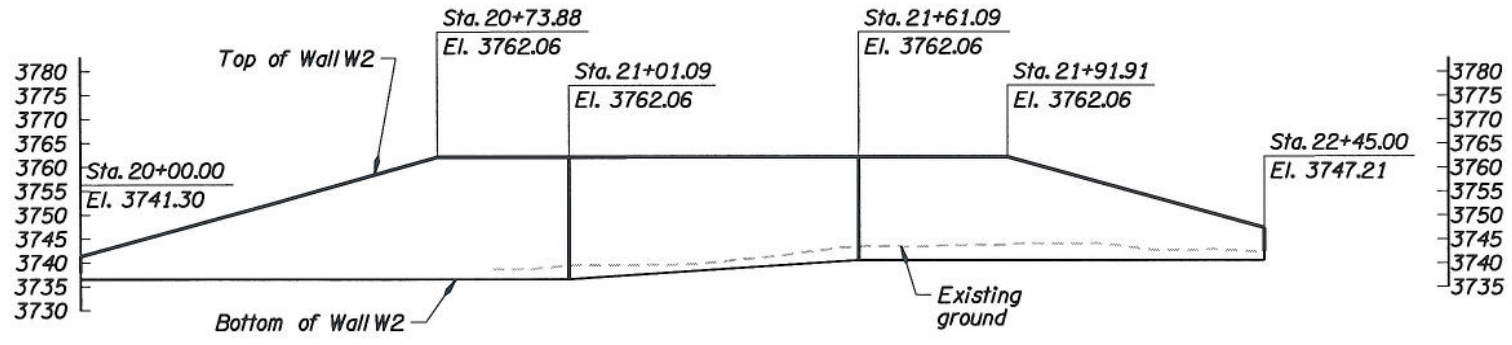
SHEET 4 OF 5
DRAWING NO. S-4

FILENAME: 348153_rw1pe.dgn PLOT DATE: 4/20/2009 PLOT TIME: 12:24:54 PM



PLAN

Scale : 1" = 20'-0"



DEVELOPED ELEVATION

Scale : 1" = 20'-0"

Note:
All dimensions shown are in English units unless otherwise noted.

△	DATE	REVISION	BY

DRAFTED: D. Monk
DESIGNED: D. Wagner
CHECKED: G. Conner
REVIEWED:

CH2MHILL

OREGON DEPARTMENT OF TRANSPORTATION
BRIDGE ENGINEERING SECTION

BRIDGE NO.
DATE: Apr. 2009
CALC. BOOK

MURPHY ROAD - SEGMENT 3
BRIDGE OVER BNSF RAILROAD
BEND, OREGON

WALL W2 PLAN & ELEVATION

SHEET 5 OF 5
DRAWING NO. S-5

377691 FILENAME: 348153_rw2pe.dgn PLOT DATE: 4/20/2009 PLOT TIME: 12:31:30 PM

Preliminary Estimate Sheet

Bridge Name: BNSF Railroad Undercrossing Bridge — Br. No.:
Section: — Co.Br.No.: — Station:
Highway: Murphy Road - Segment 3 — M.P.: — City: Bend — Loading: HL-93
Description: Precast Prestressed Concrete BT60 Beams
Two span (110', 110'), 40 foot roadway, 2 - 6 foot sidewalks, 54 foot o-o
Estimate Made By: D. Wagner — Date: 4/20/2009 — Calc.Book No.:
Checker: G. Conner — Date: 4/20/2009 — Calc.Book No.:
Estimate From: ☑ No Plans ☐ Sketch ☐ Plans, Dwgs. Nos.:

ITEMS	UNIT	QUANTITIES			COST	
		Substr.	Superstr.	Total	Rate	Amount
Structure Excavation	cy	250		250	$ 40	$ 10,000
Granular Structure Backfill	cy	140		140	$ 50	$ 7,000
Reinforcement	lbs	55000	105000	160000	$ 1.25	$ 200,000
Structural Concrete, Class 3600	cy	200		200	$ 500	$ 100,000
Structural Concrete, Class 4350	cy	100	560	660	$ 800	$ 528,000
Reinforced Concrete Bridge End Panels	SY		240	240	$ 250	$ 60,000
BT60 Precast Prestressed Beams	ft		1760	1760	$ 300	$ 528,000
Concrete Parapet with Pedestrian Railing	ft		524	524	$ 245	$ 128,380
Type C Protective Fencing	ft		220	220	$ 50	$ 11,000
Asphaltic Plug Joint Seal	ft		108	108	$ 100	$ 10,800
MSE Retaining Wall	ft^2	16650		16650	$ 55	$ 915,750

	Rounded Subtotal	$2,499,000
Plus 10 %	Mobilization	$ 249,900
	Subtotal	$2,748,900
Plus 25 %	for Contingencies	$ 687,000
	TOTAL COST	$3,435,900
	ROUNDED TOTAL COST:	$3,436,000

Width (ft)	Length (ft)
54	220

	Superstr	Cost/ft^2	$	111
Includes MSE walls ===>	Substr	Cost/ft^2	$	99
	MSE walls and coping	Cost/ft^2	$	77

Does not include Mobilization or Contingency (includes retaining walls) :	Total	Cost/ft^2	$	210
Does not include Mobilization or Contingency (Does not include retaining walls) :	Total	Cost/ft^2	$	133
Includes Mobilization and Contingency (includes retaining walls) :	**Total**	**Cost/ft^2**	**$**	**289**

Preliminary Estimate Sheet

Bridge Name: BNSF Railroad Undercrossing Bridge — Br. No.:
Section — Co.Br.No. — Station:
Highway: Murphy Road - Segment 3 — M.P. — City: Bend — Loading: HL-93
Description: Precast Prestressed Concrete BT60 Beams
Three span (110', 110', 60'), 40 foot roadway, 2 - 6 foot sidewalks, 54 foot o-o

Estimate Made By: D. Wagner — Date: 4/20/2009 — Calc.Book No.:
Checker: G. Conner — Date: 4/20/2009 — Calc.Book No.:
Estimate From: ☐ No Plans ☐ Sketch ☐ Plans, Dwgs. Nos.:

ITEMS	UNIT	QUANTITIES			COST	
		Substr.	Superstr.	Total	Rate	Amount
Structure Excavation	cy	280		280	$ 40	$ 11,200
Granular Structure Backfill	cy	200		200	$ 50	$ 10,000
Reinforcement	lbs	90000	130000	220000	$ 1.25	$ 275,000
Structural Concrete, Class 3600	cy	340		340	$ 500	$ 170,000
Structural Concrete, Class 4350	cy	160	700	860	$ 800	$ 688,000
Reinforced Concrete Bridge End Panels	SY		240	240	$ 250	$ 60,000
BT60 Precast Prestressed Beams	ft		2240	2240	$ 300	$ 672,000
Concrete Parapet with Pedestrian Railing	ft		644	644	$ 245	$ 157,780
Type C Protective Fencing	ft		220	220	$ 50	$ 11,000
Asphaltic Plug Joint Seal	ft		108	108	$ 100	$ 10,800
MSE Retaining Wall	ft^2	12000		12000	$ 55	$ 660,000

	Rounded Subtotal	$2,726,000
Plus 10 %	Mobilization	$ 272,600
	Subtotal	$2,998,600
Plus 25 %	for Contingencies	$ 750,000
	TOTAL COST	$3,748,600
	ROUNDED TOTAL COST:	$3,749,000

Width (ft)	Length (ft)
54	280

	Superstr	Cost/ft^2	$	108
Includes MSE walls ===>	Substr	Cost/ft^2	$	72
	MSE walls and coping	Cost/ft^2	$	44

Does not include Mobilization or Contingency (includes retaining walls) :	Total	Cost/ft^2	$	180
Does not include Mobilization or Contingency (Does not include retaining walls) :	Total	Cost/ft^2	$	137
Includes Mobilization and Contingency (includes retaining walls) :	**Total**	**Cost/ft^2**	**$**	**248**

Preliminary Estimate Sheet

Bridge Name: BNSF Railroad Undercrossing Bridge — Br. No.:
Section: — Co.Br.No.: — Station:
Highway: Murphy Road - Segment 3 — M.P.: — City: Bend — Loading: HL-93
Description: Precast Prestressed Concrete 48" Deep Box Beams
Two span (110', 110'), 40 foot roadway, 2 - 6 foot sidewalks, 54 foot o-o

Estimate Made By: D. Wagner — Date: 4/20/2009 — Calc.Book No.:
Checker: G. Conner — Date: 4/20/2009 — Calc.Book No.:
Estimate From: ☐ No Plans ☐ Sketch ☐ Plans, Dwgs. Nos.:

ITEMS	UNIT	QUANTITIES			COST	
		Substr.	Superstr.	Total	Rate	Amount
Structure Excavation	cy	270		270	$ 40	$ 10,800
Granular Structure Backfill	cy	160		160	$ 50	$ 8,000
Reinforcement	lbs	60000	25000	85000	$ 1.25	$ 106,250
Structural Concrete, Class 3600	cy	200		200	$ 500	$ 100,000
Structural Concrete, Class 4350	cy	110	220	330	$ 800	$ 264,000
Reinforced Concrete Bridge End Panels	SY		240	240	$ 250	$ 60,000
48" Deep Precast Prestressed Box Beams	ft		2860	2860	$ 300	$ 858,000
Concrete Parapet with Pedestrian Railing	ft		524	524	$ 245	$ 128,380
Type C Protective Fencing	ft		220	220	$ 50	$ 11,000
HMAC	ton		350	350	$ 80	$ 28,000
Waterproof Membrane	ft^2		8880	8880	$ 4.00	$ 35,520
Asphaltic Plug Joint Seal	ft		162	162	$ 100	$ 16,200
MSE Retaining Wall	ft^2	16650		16650	$ 55	$ 915,750

	Rounded Subtotal	$2,542,000
Plus 10 %	Mobilization	$ 254,200
	Subtotal	$2,796,200
Plus 25 %	for Contingencies	$ 699,000
	TOTAL COST	$3,495,200
	ROUNDED TOTAL COST:	$3,496,000

Width (ft)	Length (ft)
54	220

	Superstr	Cost/ft^2	$	113
Includes MSE walls ===>	Substr	Cost/ft^2	$	101
	MSE walls and coping	Cost/ft^2	$	77

Does not include Mobilization or Contingency (includes retaining walls) :	Total	Cost/ft^2	$	214
Does not include Mobilization or Contingency (Does not include retaining walls) :	Total	Cost/ft^2	$	137
Includes Mobilization and Contingency (includes retaining walls) :	**Total**	**Cost/ft^2**	**$**	**294**

Preliminary Estimate Sheet

Bridge Name: BNSF Railroad Undercrossing Bridge — Br. No.:
Section — Co.Br.No. — Station:
Highway: Murphy Road - Segment 3 — M.P. — City: Bend — Loading: HL-93
Description: Precast Prestressed Concrete 48" Deep Box Beams
Three span (110', 110', 60'), 40 foot roadway, 2 - 6 foot sidewalks, 54 foot o-o

Estimate Made By: D. Wagner — Date: 4/20/2009 — Calc.Book No.:
Checker: G. Conner — Date: 4/20/2009 — Calc.Book No.:
Estimate From: ☐ No Plans ☐ Sketch ☐ Plans, Dwgs. Nos.:

ITEMS	UNIT	QUANTITIES			COST	
		Substr.	Superstr.	Total	Rate	Amount
Structure Excavation	cy	300		300	$ 40	$ 12,000
Granular Structure Backfill	cy	210		210	$ 50	$ 10,500
Reinforcement	lbs	95000	30000	125000	$ 1.25	$ 156,250
Structural Concrete, Class 3600	cy	340		340	$ 500	$ 170,000
Structural Concrete, Class 4350	cy	170	330	500	$ 800	$ 400,000
Reinforced Concrete Bridge End Panels	SY		240	240	$ 250	$ 60,000
48" Deep Precast Prestressed Box Beams	ft		3640	3640	$ 300	$1,092,000
Concrete Parapet with Pedestrian Railing	ft		644	644	$ 245	$ 157,780
Type C Protective Fencing	ft		220	220	$ 50	$ 11,000
HMAC	ton		450	450	$ 80	$ 36,000
Waterproof Membrane	ft^2		11280	11280	$ 4.00	$ 45,120
Asphaltic Plug Joint Seal	ft		216	216	$ 100	$ 21,600
MSE Retaining Wall	ft^2	12000		12000	$ 55	$ 660,000

	Rounded Subtotal	$2,832,000
Plus 10 %	Mobilization	$ 283,200
	Subtotal	$3,115,200
Plus 25 %	for Contingencies	$ 779,000
	TOTAL COST	$3,894,200
	ROUNDED TOTAL COST:	$3,895,000

Width (ft)	Length (ft)
54	280

	Superstr	Cost/ft^2	$	114
Includes MSE walls ===>	Substr	Cost/ft^2	$	73
	MSE walls and coping	Cost/ft^2	$	44

Does not include Mobilization or Contingency (includes retaining walls) :	Total	Cost/ft^2	$	187
Does not include Mobilization or Contingency (Does not include retaining walls) :	Total	Cost/ft^2	$	144
Includes Mobilization and Contingency (includes retaining walls) :	**Total**	**Cost/ft^2**	**$**	**258**

Email communication between CH2M HILL and BNSF Railroad

Note: Attached to the email request from CH2M HILL to BNSF were 3 attachments, two of which were vicinity and project site maps identifying the project location and a third attachment, an 11x17 inch drawing entitled "Railroad Clearance Section, December 4, 2006, included herein with this documentation.

From: Olson, Rusty G [mailto:Rusty.Olson@BNSF.com]
Sent: Tuesday, February 06, 2007 3:06 PM
To: Katko, Steve/PDX
Cc: Stilley, John R
Subject: Bend, OR proposed overcrossing

Proposed overpass in Bend, OR (see attachments x 3) is acceptable to BNSF.

thanks

Rusty Olson

Project Engineer
BNSF Railway

2454 Occidental Ave So
Ste 1A
Seattle WA 98134-1439

206.625.6189 Office
206.625.6115 Fax

From: Stilley, John R
Sent: Monday, December 18, 2006 2:04 PM
To: Lozano, Donald E; Olson, Rusty G
Cc: Stilley, John R
Subject: FW: Bend, OR proposed overcrossing

Gentlemen,

The City of Bend, Oregon is proposing to extend SE Murphy Road and build an overpass over our Main Line. Attached are a Topographic Map, a Street Vicinity Map and the Proposed Column Location for their new Structure. They have also added a future track in their design. Do either of you have a problem with their design and especially their Column Locations?

There will also be a Sanitary Sewer Line installed at this location but I don't think that the Final size and design have been determined yet. I will sent them the Utility Accommodation Policy to address this issue,

The Proposed Overpass is located at approximately MP 2.3 Z on Line Segment 54 on the Oregon Trunk.

As information, on the Track Charts and the Delorme Maps a Murphy Street is shown at MP 3.26 Z (DOT# 066834P) on the Oregon Trunk, but that road is County Club Drive not Murphy Street. Thanks

John Stilley
Manager Public Projects
909-386-4474

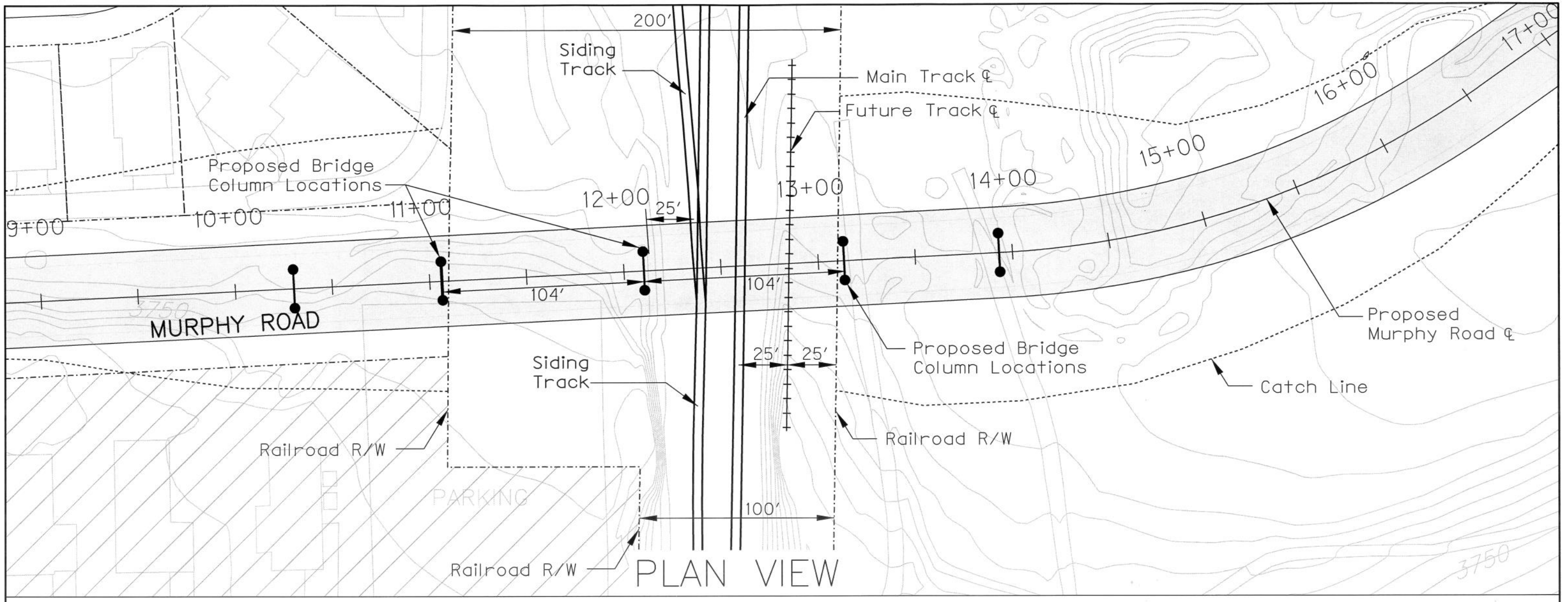
From: Steve.Katko@CH2M.com [mailto:Steve.Katko@CH2M.com]
Sent: Monday, December 11, 2006 2:15 PM
To: Stilley, John R
Subject: Bend, OR proposed overcrossing

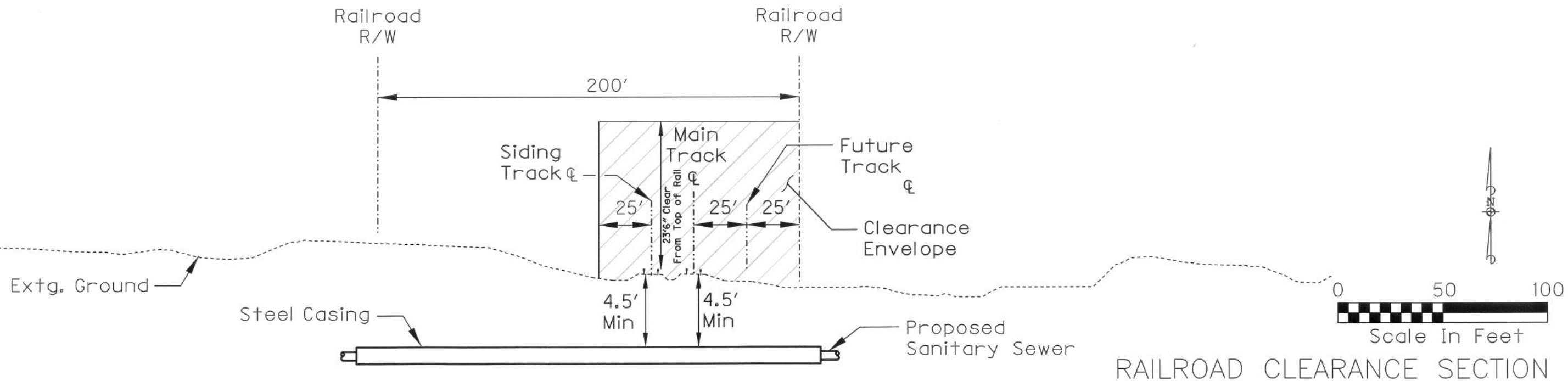
John-
We had talked a few weeks back about a project in Bend, Oregon that would have a new overcrossing over BNSF right-of-way. The right-of-way width at this location is 200'. We are hoping to cross the right-of-way with two spans by placing columns about midway in the right-of-way (25' from centerline of existing siding). Also, the City is planning on extending a sanitary sewer line beneath the tracks (size still not known).

Take a look at what we've laid out here and let us know if there are issues from the Railroad's standpoint that we should be aware of.

Thanks
Steve

Steve Katko
CH2M HILL
2020 SW 4th Avenue
Portland, OR 97201
(503) 736-4278





RAILROAD CLEARANCE SECTION
December 4, 2006

CH2MHILL

APPENDIX C

Drainage Technical Memorandum

Murphy Road Preliminary Drainage Design Memorandum

PREPARED FOR: City of Bend

PREPARED BY: Jeff Stallard,
Rick Attanasio, P.E.

DATE: April 28, 2009

PROJECT NUMBER: 348153.A2.07

Introduction

Upon completion of the Murphy Road Refinement Plan, the City of Bend (COB) requested CH2M HILL to advance with the preliminary design of Murphy Road from Brookswood Boulevard to 15th Street. The preliminary design for the stormwater system was to evaluate water quality and water quantity control options, and develop conceptual level plans based on these results. This memorandum summarizes the analysis performed.

To simplify discussion, the Murphy Road corridor was broken into three separate segments:

- Segment 1: Includes Murphy Road from Brookswood Boulevard to Parrell Road.
- Segment 2: Includes Murphy Road from Parrell Road to Brosterhous Road
- Segment 3: Includes Murphy Road from Brosterhous Road to 15th Street

Design Criteria

To establish the design criteria, the City of Bend Design Standards, the Central Oregon Stormwater manual and the Oregon Department of Transportation Hydraulic Manual were referenced. See Table 1 for a summary of the design standards utilized.

TABLE 1
Design Standards

Design Feature	Design Criteria	Reference
Road Classification	Major Collector	City of Bend
Spread Design	ODOT Standards per City Requirement 8' max (2' into traveled way) with 6' Target. This 6' target was based upon a 6' bike lane and the desire to keep the spread out of the traveled way.	ODOT Hydraulics Manual Appendix D
Drainage Inlets	25-yr design storm and 50-yr for design storm sag inlets	COSM Chapter 8
Storm Pipe Type	Concrete pipe 2' minimum cover from top of pipe to bottom of pavement. Bottom of pavement refers to the asphalt or concrete	COSM Chapter 8

	above the base.	
Conveyance	25 year flow	COSM Chapter 8
Culvert	50-yr design storm HW/D = 2 max	COSM Chapter 8
Water Quality	6-month 24-hr Type I storm which is calculated as 67% of the 2-yr 24-hr Type I Storm.	COSM Chapter 6
Water Quantity	$Q25_{pre} = Q25_{post}$ peak analysis	COSM Chapter 7
Inlet Type	Type CG-3 Inlet	ODOT
Drywells	Design Capacity (CF)= Vb+9.5*Vr+Vs=k*0.1A Vb= Barrell Volume, Vr=Rock Volume, k=1 A= Impervious Area 0.1' is rainfall depth required for sizing drywells	City of Bend Design Standard 2.A.13.B

Water Quality and Drywell Disposal Evaluation

The water quality evaluation approach was based on an October 9, 2008 meeting with City staff; Hardy Hanson, Ollie Fick and David Buchanan. The City expressed a strong preference for vegetative treatment as opposed to mechanical treatment (i.e. Storm Filters). Each segment was first evaluated for treatment options based on the available space within the City right-of-way to incorporate natural treatment. If natural treatment wouldn't fit within the proposed right-of-way, a mechanical form of treatment was sized. Water quality flows were generated utilizing the Santa Barbra Urban Hydrograph (SBUH) methodology with a 6-month 24-hr storm event. Drywell disposal capacity calculations follow the methodology in the COB Design Standard. See Appendix A for the water quality and drywell disposal calculations.

Segment 1

Station 38+00 Natural Water Quality Facility

The road profile for Segment 1 identified an approximate sag location at Station 38+00. The exact location for this water quality facility will be determined as the

Segment 1 design moves forward. The Segment 1 water quality facility is preliminarily sized to treat and dispose of runoff from 2.3-acres of roadway from the project. The system utilizes an infiltration swale and discharges flows above the water quality flow into drywells for disposal. The total water quality volume, based on SBUH methodology is 6,207 CF with a peak runoff of 0.39 CFS. This type of water quality facility allows for a reduction of the required volume to be disposed of through the use of drywells. The drywell disposal calculation were completed assuming a 20-foot drywell depth and identifies the requirement of 6 new drywells for disposal of all flows above the water quality flow.

Segment 2

Station 317+10 Mechanical Water Quality Facility at Mel Ct

The facility being proposed at Mel Ct. uses mechanical treatment (Storm Filters) to provide water quality treatment. A Storm Filter vault with multiple filter cartridges will discharge into new drywells. The mechanical facility is proposed at this location because there is no readily available land for construction of a vegetative natural treatment facility. This facility is preliminarily sized to treat and dispose of runoff from 1.4-acres of the roadway project, which generates a peak water quality flow of 0.24 CFS and a total water quality volume of 3,778 CF. This system is comprised of a 6-foot x 12-foot concrete vault housing 9 filter cartridges for treatment. Since space for open detention is not available at this location, the entire water quality volume is proposed to be disposed of utilizing 15 new drywells.

Station 340+62 Vegetative Water Quality Facility with Drywells

The location for the vegetative water quality facility (WQF) is the south side of Murphy Road at station 340+62. This is across from the Jewel School property. This facility is preliminarily sized to treat and dispose of runoff from 4-ac of roadway from the project. The system is comprised of an infiltration swale that discharges flows exceeding the water quality flow. The total water quality flow based on SBUH methodology is 10,794 Cubic Feet (CF) with a peak runoff of 0.75 Cubic Feet per Second (CFS). The vegetative WQF allows for a reduction of the required volume to be disposed of through the use of drywells. The drywell disposal calculation were completed assuming a 20-foot drywell depth and identifies the requirement of 4 new drywells for disposal of all flows above the water quality flow. The discharge depth of the storm system in relation to the adjacent land will result in a deep facility that will require extensive excavation for construction.

Segment 3

Station 376+99 Vegetative Water Quality Facility

The road profile for Segment 3 identifies one sag location at Station 376+99. The water quality facility location has been proposed for the north side of Murphy Road at this location. The Segment 3 water quality facility is preliminarily sized to treat and dispose of runoff from 1.4-acres of roadway from the project. The system utilizes an infiltration swale and then discharges flows exceeding the water quality flow into drywells for disposal. The total water quality volume, based on SBUH methodology, is 3,778 CF with a peak runoff of 0.26 CFS. The vegetative WQF allows for a reduction of the required volume to be disposed of through the use of drywells. The drywell disposal calculation was completed assuming a 20-foot dry well depth and identifies the requirement of 3 new drywells for disposal of all flows above the water quality flow.

Conveyance and Inlet Locations

The inlet spacing has been calculated, for an allowable spread of 6-feet, utilizing the 25-yr return event for all at grade inlets, and the 50-yr return event for all sag inlets. The allowable spread for safety considerations was limited to the 6-foot bike lane. This will allow the spread to remain within the proposed bike lane and out of any vehicular travel lanes. The conveyance system was design utilizing the Rational method, maintaining the hydraulic grade line within the pipe for a 25-yr return event. See Appendix B for all inlet spacing calculations completed, and Appendix C for all conveyance calculations.

Special design considerations

The bridge over the railroad in Segment 3 is superelevated with 2% shed section to the north. The road then transitions to a 2% superelevation to the south. Due to this transition from north to south an increased number of inlets were required to minimize the runoff crossing over Murphy Road from north to south. The amount of water transitioning across Murphy Road needs to be minimized as it would have the potential to create a safety hazard due to icing in the winter months.

Future Work Items

As this design effort described above preliminary, below are work items identified for the future design efforts on the Murphy Road Corridor.

1. The four corridor roundabouts located at Country Club Drive, Brookswood Boulevard, Brosterhous Road, and 15th Street at this time have not been graded in detail. Therefore, drainage design was not completed. For the cost estimate, it was assumed that each roundabout would require 12 inlets, 4 Manholes, and 200 lineal feet of 12-inch storm pipe.

2. The bridge over Bend Parkway was not completed as part of this study. Due to the winter weather conditions in Bend, the bridge drainage features should be analyzed closely to minimize the potential icy conditions typically associated with bridges.

APPENDIX A

Water Quality and Drywell Disposal Calculations

CH2MHILL

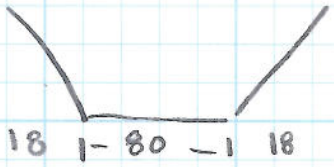
SUBJECT Murphy Road Seg 1 WQF @ STA 38+00 Drywell Disposal

BY JSS

SHEET NO. 1 of 4 DATE 4-27-09

PROJECT NO. 348153

Foot Print of WQF



Size = 80' wide x 100' Long

So 9" WQ Storage ≈ 8000 CF

Drywell Calculation

2.3 Acres Runoff Area = A = 100,188 ft²

20' Deep Drywells so h = 18

From Manual

$$\#wells\left[V_b + 9.5V_R + V_S\right] = 0.1A - WQ\ Storage$$

$V_b = \pi r^2 h = 3.14(2)^2(18) = 226$ CF

$V_R = 20$ CY From Manual type B standard

$V_S = 0$

This Gives us

$$\#\ wells\left[226 + 9.5(20) + (0)\right] = 0.1(100188) - 8000$$

$$\#wells = \frac{2018}{416} = 4.85 \rightarrow 5\ \text{Drywells For Disposal}$$

WQF will Be A 6' x 12' Storm Filter VAULT with 9 Filter CARTRIDGES So WQ STORAGE = 0

So Dry well Disposal

1.4 Acres of Runoff AREA = A = 60,984 ft^2

20' Deep wells So h = 18

From Bend MANUAL

$$\#\text{ wells}\left[V_b + 9.5\,V_R + V_S\right] = 0.1\,A - \text{WQ STORAGE}$$

$V_b = \pi R^2 h = 3.14(2)^2(18) = 226$ CF

V_R = 20 Cy From MANUAL type B STANDARD

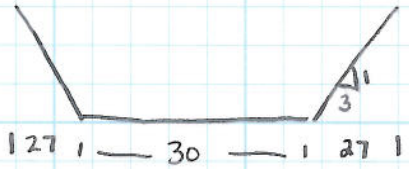
$V_S = 0$

This Gives us

$$\#\text{ wells}\left[226 + 9.5(20) + 0\right] = 0.1(60,984) - 0$$

#wells = 14.65 → 15 Dry wells For Disposal

Foot Print of WQF



Size 30' wide x 500' Long

So 9" WQ Depth Volume $\approx$ 15,000 ft^3 = WQ Storage

Drywell Calculation

4 Acres of Run off AREA = A = 174,240 ft^2

20' Deep wells, so h = 18

From Bend Manual

$$\#_{wells}\left[Vb + 9.5\,VR + Vs\right] = 0.1\,A - WQ\ Storage$$

$Vb = \pi r^2 h \rightarrow 3.14(2)^2(18) = 226$ CF

Vr = 20 CY From Manual Type B (Standard)

Vs = 0

This Gives us

$$\#_{wells}\left[226 + (9.5)(20) + 0\right] = 0.1\,(174{,}240) - 15{,}000$$

$$\#_{wells} = \frac{2424}{416} = 5.8 \rightarrow 6 \text{ Dry wells for Disposal}$$

Foot Print of WQF

Size = 70' wide x 75' Long

So 9" WQ Storage ≈ 5100 CF

Dry well Calculation

1.4 Acres Runoff Area = A = 60,984 ft²

20' Deep wells, so h = 18

From Bend Manual

$$\#\text{wells}\left[V_b + 9.5\,V_R + V_S\right] = 0.1\,A - \text{WQ Storage}$$

$V_b = \pi r^2 h = 3.14\,(2)^2(18) = 226$ CF

$V_r = 20$ CY From Manual type B standard

$V_S = 0$

This gives us

$$\#\text{wells}\left[226 + 9.5(20) + 0\right] = 0.1(60{,}984) - 5100$$

$$\#\text{wells} = \frac{998}{416} = 2.4 \rightarrow$$ 3 Dry wells for Disposal

SBUH DESIGN WORKSHEET

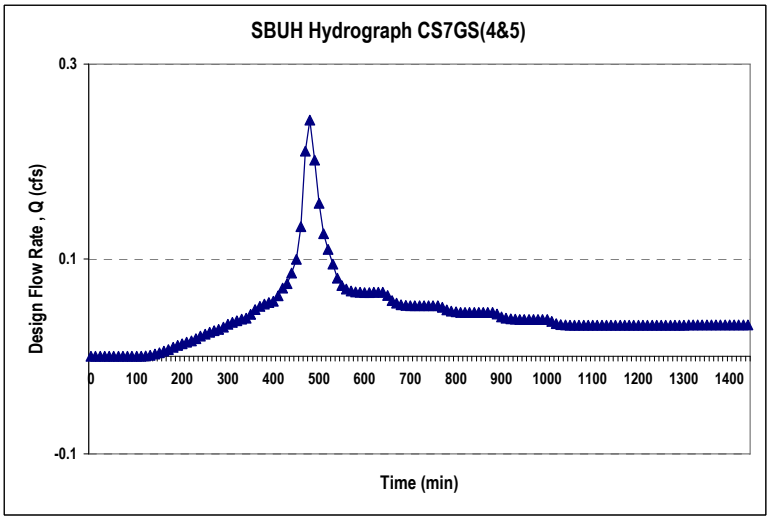
PROJECT:	Murphy Road	
BASIN	Bend, OR	
OUTFALL:		
LOCATION:	Sta 317+10	
TREATMENT FACILITY:	Mechanical	
FACILITY NAME:		
TOTAL IMPERVIOUS AREA	60,984	sq ft
	1.40	acre

Parameters		**Units**			**Comments**			
Total length of Flow	1740	ft						
Sheet Flow Segment								
Length	30	ft						
Slope of hydraulic Grid Line - S_o	0.02	ft/ft						
n_s - Sheet flow Manning' Effective roughness coeff.	0.25				*[City of Portland Stormwater Management Manual 2004 page 2-74]*			
Travel time (sheet Flow Segment) $T_1 = 0.42\ (n_sL)^{0.8}/((1.58*(S_o)^{0.4})$	6.4	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Shallow Concentrated Flow Segment								
Length	0	ft						
S_o	0.005	ft/ft			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Velocity V = 20.3282(S_o)^0.5	1.44	ft/s			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
T_2 = L/(60*V)	0.0	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Pipe Flow Segment								
Length	1710	ft			Assume sheet flows empty into inlets connected to pipes.			
T_3 = L/(60*V)	9.5	min			Assume pipe flow velocity of 3fps			
Given Area	1.4	acres						
P_t Depth of Rainfall	0.94	in			67% of 2 year at 1.4			
d_t	10	min						
T_c	15.9	min			From Conveyance Spreadsheet			
Routing Constant w= $d_t/(2T_c+d_t)$	0.240							
Pervious Area (acres)	0.0		CN	85	S = (1000/CN)-10	1.7647059	0.2*S	0.352941
Impervious Area (acres)	1.4		CN	98	S = (1000/CN)-10	0.2040816	0.2*S	0.040816
Inputs								

Summary Results

Santa Barbara Urban Hydrograph (SBUH) Method Using SCS Type 1A Storm Distribution

Peak Design Flow Rate	0.24	cfs
Total Runoff	0.74	in
Total Runoff Volume	3,778	cf



SBUH DESIGN WORKSHEET

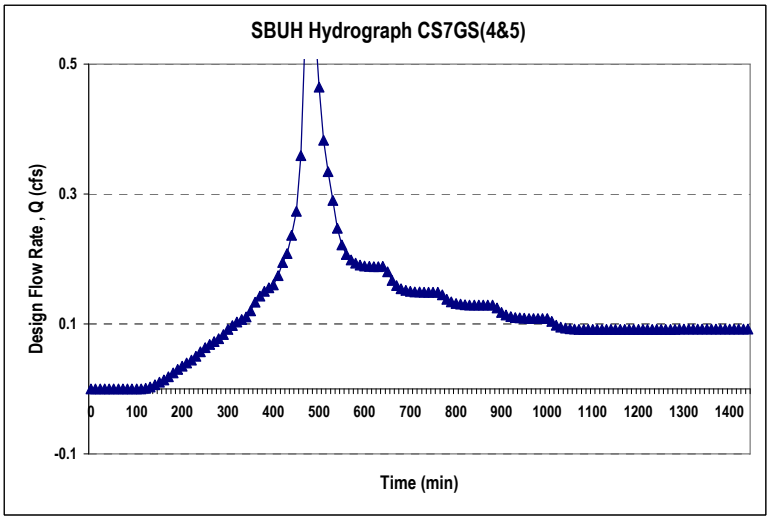
PROJECT:	Murphy Road	
BASIN	Bend, OR	
OUTFALL:		
LOCATION:	Sta 340+62	
TREATMENT FACILITY:	Grassy Swale	
FACILITY NAME:		
TOTAL IMPERVIOUS AREA	174,240	sq ft
	4.00	acre

Parameters		**Units**			**Comments**			
Total length of Flow	1658	ft						
Sheet Flow Segment								
Length	58	ft						
Slope of hydraulic Grid Line - S_o	0.02	ft/ft						
n_s - Sheet flow Manning' Effective roughness coeff.	0.25				*[City of Portland Stormwater Management Manual 2004 page 2-74]*			
Travel time (sheet Flow Segment) $T_1 = 0.42 (n_sL)^{0.8}/((1.58*(S_o)^{0.4})$	10.8	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Shallow Concentrated Flow Segment								
Length	0	ft						
S_o	0.005	ft/ft			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Velocity V = 20.3282(S_o)^0.5	1.44	ft/s			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
T_2 = L/(60*V)	0.0	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Pipe Flow Segment								
Length	1600	ft			Assume sheet flows empty into inlets connected to pipes.			
T_3 = L/(60*V)	8.9	min			Assume pipe flow velocity of 3fps			
Given Area	4.0	acres						
P_t Depth of Rainfall	0.94	in			67% of 2 year which is 1.4			
d_t	10	min						
T_c	19.7	min			From Conveyance Spreadsheet			
Routing Constant w= $d_t/(2T_c+d_t)$	0.203							
Pervious Area (acres)	0.0		CN	85	S = (1000/CN)-10	1.7647059	0.2*S	0.352941
Impervious Area (acres)	4.0		CN	98	S = (1000/CN)-10	0.2040816	0.2*S	0.040816
Inputs								

Summary Results

Santa Barbara Urban Hydrograph (SBUH) Method Using SCS Type 1A Storm Distribution

Peak Design Flow Rate	0.65	cfs
Total Runoff	0.74	in
Total Runoff Volume	10,794	cf



SBUH DESIGN WORKSHEET

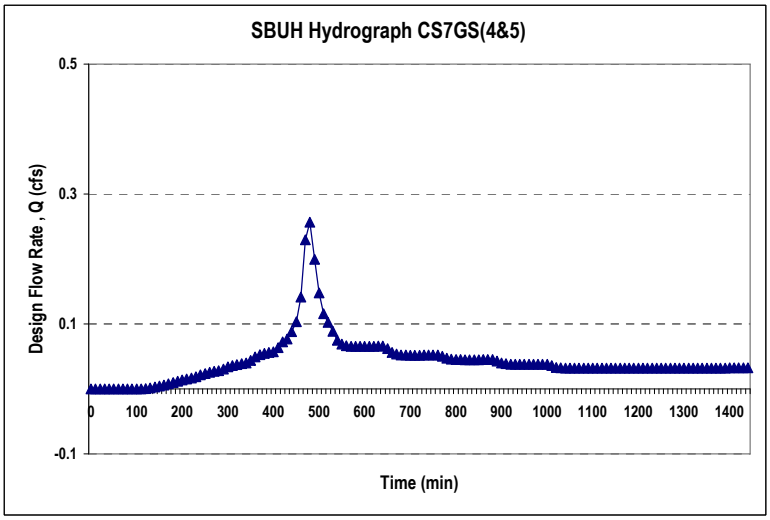
PROJECT:	Murphy Road	
BASIN	Bend, OR	
OUTFALL:		
LOCATION:	Sta 376+99	
TREATMENT FACILITY:	Grassy Swale	
FACILITY NAME:		
TOTAL IMPERVIOUS AREA	60,984	sq ft
	1.40	acre

Parameters		**Units**			**Comments**			
Total length of Flow	1130	ft						
Sheet Flow Segment								
Length	30	ft						
Slope of hydraulic Grid Line - S_o	0.02	ft/ft						
n_s - Sheet flow Manning' Effective roughness coeff.	0.25				*[City of Portland Stormwater Management Manual 2004 page 2-74]*			
Travel time (sheet Flow Segment) $T_1 = 0.42\ (n_sL)^{0.8}/((1.58*(S_o)^{0.4})$	6.4	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Shallow Concentrated Flow Segment								
Length	0	ft						
S_o	0.005	ft/ft			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Velocity V = 20.3282(S_o)^0.5	1.44	ft/s			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
T_2 = L/(60*V)	0.0	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Pipe Flow Segment								
Length	1100	ft			Assume sheet flows empty into inlets connected to pipes.			
T_3 = L/(60*V)	6.1	min			Assume pipe flow velocity of 3fps			
Given Area	1.4	acres						
P_t Depth of Rainfall	0.94	in			67% of 2 year at 1.4			
d_t	10	min						
T_c	12.5	min			From Conveyance Spreadsheet			
Routing Constant w= $d_t/(2T_c+d_t)$	0.286							
Pervious Area (acres)	0.0		CN	85	S = (1000/CN)-10	1.7647059	0.2*S	0.352941
Impervious Area (acres)	1.4		CN	98	S = (1000/CN)-10	0.2040816	0.2*S	0.040816
Inputs								

Summary Results

Santa Barbara Urban Hydrograph (SBUH) Method Using SCS Type 1A Storm Distribution

Peak Design Flow Rate	0.26	cfs
Total Runoff	0.74	in
Total Runoff Volume	3,778	cf



SBUH DESIGN WORKSHEET

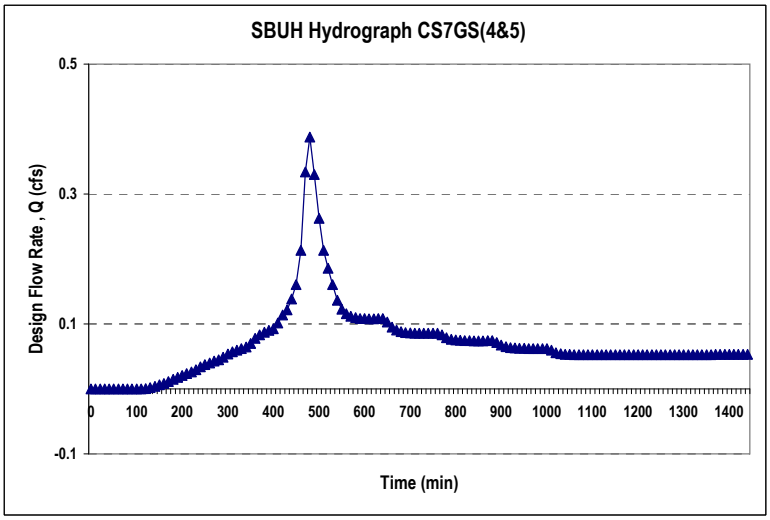
PROJECT:	Murphy Road	
BASIN	Bend, OR	
OUTFALL:		
LOCATION:	Sta 38+00	
TREATMENT FACILITY:	Grassy Swale	
FACILITY NAME:		
TOTAL IMPERVIOUS AREA	100,188	sq ft
	2.30	acre

Parameters		**Units**			**Comments**			
Total length of Flow	0	ft						
Sheet Flow Segment								
Length	30	ft						
Slope of hydraulic Grid Line - S_o	0.02	ft/ft						
n_s - Sheet flow Manning' Effective roughness coeff.	0.25				*[City of Portland Stormwater Management Manual 2004 page 2-74]*			
Travel time (sheet Flow Segment) $T_1 = 0.42\ (n_sL)^{0.8}/((1.58*(S_o)^{0.4})$	6.4	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Shallow Concentrated Flow Segment								
Length	0	ft						
S_o	0.005	ft/ft			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Velocity V = 20.3282(S_o)^0.5	1.44	ft/s			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
T_2 = L/(60*V)	0.0	min			*[City of Portland Stormwater Management Manual 2004 page C-2]*			
Pipe Flow Segment								
Length	2000	ft			Assume sheet flows empty into inlets connected to pipes.			
T_3 = L/(60*V)	11.1	min			Assume pipe flow velocity of 3fps			
Given Area	2.3	acres						
P_t Depth of Rainfall	0.94	in			67% of 2 year at 1.4			
d_t	10	min						
T_c	17.5	min			From Conveyance Spreadsheet			
Routing Constant w= $d_t/(2T_c+d_t)$	0.222							
Pervious Area (acres)	0.0		CN	85	S = (1000/CN)-10	1.7647059	0.2*S	0.352941
Impervious Area (acres)	2.3		CN	98	S = (1000/CN)-10	0.2040816	0.2*S	0.040816
Inputs								

Summary Results

Santa Barbara Urban Hydrograph (SBUH) Method Using SCS Type 1A Storm Distribution

Peak Design Flow Rate	0.39	cfs
Total Runoff	0.74	in
Total Runoff Volume	6,207	cf



APPENDIX B
Inlet Design Calculations

Inlet Placement
Project: Murphy Road
Job Number: 348153

Side	Inlet Sta	From Sta	To Sta	Section Width (ft)	Section Length (ft)	Area (ac)	C 0.90	Time T_c (min)	Intensity I (in/hr)	Flow Q (cfs)	Pavement Long. S_L (ft/ft)	Pavement Cross S_x (ft/ft)	Equiv Cross S_e (ft/ft)	Pavement Manning's n 0.012	Prev. Bypass Q_{bp} (cfs)	Total Gutter Q_{tot} (cfs)	Flow Depth D (ft)	Spread T (ft)	Grate Width W (ft)	Opening Length L (ft)	Opening Required Lt (ft)	Gutter Velocity V_g (ft/sec)	Efficiency E	Intercepted Flow Q_i (cfs)	Bypass Flow Q_{bp} (cfs)	
Super Left Sta 36+550 to 370+60																										
L	**367+00**	36550	36700	48	150	0.165	0.9	5.0	2.7	0.402	0.034	0.04	0.110	0.012	0	0.402	0.095	2.39	2	2.5	7.893	1.80	0.50	0.20	0.20	
L	**367+50**	36700	36750	48	50	0.055	0.9	5.0	2.7	0.134	0.045	0.04	0.119	0.012	0.20	0.336	0.084	2.11	2	2.5	7.628	1.93	0.51	0.17	0.16	
L	**368+00**	36750	36800	48	50	0.055	0.9	5.0	2.7	0.134	0.056	0.04	0.126	0.012	0.16	0.298	0.077	1.94	2	2.5	7.493	2.06	0.52	0.15	0.14	
L	**368+50**	36800	36850	48	50	0.055	0.9	5.0	2.7	0.134	0.067	0.04	0.131	0.012	0.14	0.278	0.073	1.82	2	2.5	7.484	2.19	0.52	0.14	0.13	
L	**369+00**	36850	36900	48	50	0.055	0.9	5.0	2.7	0.134	0.079	0.04	0.135	0.012	0.13	0.267	0.070	1.75	2	2.5	7.578	2.30	0.51	0.14	0.13	
L	**369+40**	36900	36940	48	40	0.044	0.9	5.0	2.7	0.107	0.075	0.04	0.139	0.012	0.13	0.237	0.067	1.68	2	2.5	7.001	2.38	0.55	0.13	0.11	
L	**369+80**	36940	36980	48	40	0.044	0.9	5.0	2.7	0.107	0.070	0.04	0.141	0.012	0.11	0.214	0.066	1.64	2	2.5	6.487	2.43	0.58	0.13	0.09	
L	**370+20**	36980	37020	48	40	0.044	0.9	5.0	2.7	0.107	0.096	0.04	0.151	0.012	0.09	0.196	0.060	1.50	2	2.5	6.617	2.84	0.57	0.11	0.08	
L	**370+40**	37020	37040	48	20	0.022	0.9	5.0	2.7	0.054	0.061	0.04	0.157	0.012	0.08	0.137	0.057	1.42	2	2.5	4.858	2.94	0.73	0.10	0.04	
L	**370+50**	37040	37050	48	10	0.011	0.9	5.0	2.7	0.027	0.060	0.04	0.195	0.012	0.04	0.064	0.043	1.08	2	2.5	3.079	10.07	0.95	0.06	0.00	
Super Right Sta 370+60 to 377+34																										
R	**373+00**	37050	37300	48	250	0.275	0.9	5.0	2.7	0.669	0.045	0.02	0.059	0.012	0.00	0.669	0.084	4.22	2	2.5	15.426	1.42	0.27	0.18	0.49	
R	**375+50**	37300	37550	48	250	0.275	0.9	5.0	2.7	0.669	0.022	0.02	0.055	0.012	0.49	0.669	0.096	4.81	2	2.5	13.180	1.38	0.32	0.21	0.46	
R	**376+50**	37550	37650	48	100	0.110	0.9	5.0	2.7	0.268	0.008	0.02	0.060	0.012	0.46	0.268	0.084	4.18	2	2.5	6.139	1.29	0.61	0.16	0.10	
Sag at Sta 376+99 Right Side																										
R	**376+99**	37650	37801	Varies	151	0.129	0.9	5.0	3	0.348	0.000	0.02			0.15	0.453	0.067	3.34								Spread From Flow Master
R	**377+09**																									
Crown Section at Sta 377+34 to 378+01																										
L	377+34	37801	37734	48	67	0.074	0.9	5.0	2.7	0.179	0.005	0.02	0.063	0.012	0.00	0.179	0.077	3.86	2	2.5	4.484	1.21	0.77	0.14	0.04	
Sag at Sta 349+01																										
L	**362+50**	36550	36250	24	300	0.165	0.9	5.0	2.7	0.402	0.015	0.02	0.059	0.012	0.00	0.402	0.086	4.29	2	2.5	8.999	1.35	0.44	0.18	0.22	
L	**359+50**	36250	35950	24	300	0.165	0.9	5.0	2.7	0.402	0.039	0.02	0.059	0.012	0.22	0.625	0.085	4.23	2	2.5	14.365	1.41	0.29	0.18	0.44	
L	**356+50**	35950	35650	24	300	0.165	0.9	5.0	2.7	0.402	0.008	0.02	0.046	0.012	0.22	0.845	0.129	6.44	2	2.5	11.628	1.37	0.35	0.30	0.55	
L	**353+50**	35650	35350	24	300	0.165	0.9	5.0	2.7	0.402	0.008	0.02	0.045	0.012	0.44	0.948	0.135	6.73	2	2.5	12.383	1.38	0.33	0.32	0.63	
L	**350+50**	35350	35050	24	300	0.165	0.9	5.0	2.7	0.402	0.008	0.02	0.044	0.012	0.55	1.033	0.139	6.95	2	2.5	12.977	1.39	0.32	0.33	0.70	
L	**349+61**	35050	34961	24	89	0.049	0.9	5.0	2.7	0.119	0.005	0.02	0.044	0.012	0.63	0.822	0.138	6.88	2	2.5	10.405	1.36	0.39	0.32	0.50	
L	**349+30**	35050	34930	24	120	0.066	0.9	5.0	2.7	0.161	0.003	0.02	0.042	0.012	0.70	0.864	0.153	7.67	2	2.5	9.528	1.37	0.42	0.36	0.50	
L	**349+01**	34930	34700	24	230	0.127	0.9	5.0	2.7	0.308		0.02			0.63	0.902	0.144	7.19								Spread From Flow Master
L	**348+91**																									
L	**346+75**	34505	34700	24	195	0.107	0.9	5.0	2.7	0.261	0.006	0.02	0.059	0.012	0.00	0.261	0.086	4.29	2	2.5	5.800	1.27	0.64	0.17	0.09	
L	**345+05**	34452	34505	24	53	0.029	0.9	5.0	2.77	0.073	0.002	0.02	0.072	0.012	0.00	0.073	0.064	3.21	2	2.5	2.223	0.82	1.00	0.07	0.00	
Sag at Sta 340+62																										
L	**340+62**	34452	34062	24	626	0.345	0.9	5.0	3	0.931		0.02			0.27	1.197	0.144	7.20								Spread From Flow Master
L	**340+52**																									
L	**332+26**	32926	33226	24	300	0.165	0.9	5.0	2.7	0.402	0.016	0.02	0.060	0.012	0.00	0.402	0.084	4.21	2	2.5	9.184	1.36	0.44	0.17	0.23	
L	**335+26**	33226	33526	24	300	0.165	0.9	5.0	2.7	0.402	0.007	0.02	0.049	0.012	0.23	0.628	0.116	5.78	2	2.5	9.850	1.35	0.41	0.26	0.37	
L	**337+43**	33743	33774																							
L	**337+75**	33526	33811	24	285	0.157	0.9	5.0	2.7	0.382	0.006	0.02	0.046	0.012	0.37	0.753	0.129	6.43	2	2.5	10.354	1.36	0.39	0.29	0.46	
L	**338+11**	33775	33811	24	36	0.020	0.9	5.0	2.7	0.048	0.006	0.02	0.050	0.012	0.46	0.506	0.111	5.54	2	2.5	8.318	1.32	0.47	0.24	0.27	
Sag at Sta 325+72																										
L	**Roundabout to be designed in the future**			24	0	0.000	0.9	5.0	3	0.000		0.02			0.00	0.000	0.078	3.89								Spread From Flow Master
L																										
Sag at Sta 317+07																										
L	**320+56**	32226	32056	24	170	0.094	0.9	5.0	2.7	0.228	0.025	0.02	0.073	0.012	0	0.228	0.063	3.14	2	2.5	7.284	1.41	0.53	0.12	0.11	
L	**320+10**	32056	32010	24	46	0.025	0.9	5.0	2.7	0.062	0.025	0.02	0.107	0.012	0.11	0.062	0.038	1.92	2	2.5	3.353	1.52	0.91	0.06	0.01	
L	**317+30**	32010	31730	24	280	0.154	0.9	5.0	2.7	0.375	0.025	0.02	0.064	0.012	0.01	0.375	0.076	3.79	2	2.5	9.724	1.39	0.41	0.16	0.22	
L	**317+07**	31730	31707	24	23	0.013	0.9	5.0	3	0.034		0.02			0.63	0.550	0.079	3.97								Spread From Flow Master
L	**316+97**																									
L	**311+57**	30857	31157	24	300	0.165	0.9	5.0	2.7	0.402	0.015	0.02	0.059	0.012	0.00	0.402	0.086	4.30	2	2.5	8.958	1.35	0.45	0.18	0.22	
L	**314+57**	31157	31457	24	300	0.165	0.9	5.0	2.7	0.402	0.024	0.02	0.056	0.012	0.00	0.625	0.093	4.64	2	2.5	12.826	1.39	0.32	0.20	0.42	
L	**316+57**	31457	31657	24	200	0.110	0.9	5.0	2.7	0.268	0.006	0.02	0.047	0.012	0.00	0.691	0.124	6.21	2	2.5	9.915	1.35	0.41	0.28	0.41	
Sag at Sta 305+54																										
L	**305+54**	30857	30554	24	303	0.167	0.9	5.0	3	0.451		0.02			0.00	0.451	0.066	3.28								Spread From Flow Master
L	**305+44**																									
TO BE COMPLETED WITH SEGMENT 1																										

Sag at Sta 349+01																									
R	**362+50**	36550	36250	24	300	0.165	0.9	5.0	2.7	0.402	0.015	0.02	0.059	0.012	0.00	0.402	0.086	4.29	2	2.5	8.999	1.35	0.44	0.18	0.22	
R	**359+50**	36250	35950	24	300	0.165	0.9	5.0	2.7	0.402	0.039	0.02	0.059	0.012	0.22	0.625	0.085	4.23	2	2.5	14.365	1.41	0.29	0.18	0.44	
R	**356+50**	35950	35650	24	300	0.165	0.9	5.0	2.7	0.402	0.008	0.02	0.046	0.012	0.22	0.845	0.129	6.44	2	2.5	11.628	1.37	0.35	0.30	0.55	
R	**353+50**	35650	35350	24	300	0.165	0.9	5.0	2.7	0.402	0.008	0.02	0.045	0.012	0.44	0.948	0.135	6.73	2	2.5	12.383	1.38	0.33	0.32	0.63	
R	**350+50**	35350	35050	24	300	0.165	0.9	5.0	2.7	0.402	0.008	0.02	0.044	0.012	0.55	1.033	0.139	6.95	2	2.5	12.977	1.39	0.32	0.33	0.70	
R	**349+30**	35050	34930	24	120	0.066	0.9	5.0	2.7	0.161	0.003	0.02	0.042	0.012	0.70	0.864	0.153	7.67	2	2.5	9.528	1.37	0.42	0.36	0.50	
R	**349+11**																									
R	**349+01**	34930	34700	24	230	0.127	0.9	5.0	2.7	0.308		0.02			0.63	0.928	0.144	7.19								Spread From Flow Master
R	**346+75**	34475	34700	24	225	0.124	0.9	5.0	2.7	0.301	0.006	0.02	0.057	0.012	0.00	0.301	0.090	4.52	2	2.5	6.291	1.28	0.60	0.18	0.12	
R	**345+06**	34452	34475	24	23	0.013	0.9	5.0	2.77	0.032	0.002	0.02	0.091	0.012	0.00	0.032	0.047	2.34	2	2.5	1.359	0.59	1.00	0.03	0.00	
Sag at Sta 340+62																										
R	**340+62**	34452	34062	24	626	0.345	0.9	5.0	3	0.931		0.02			0.26	1.187	0.144	7.20								Spread From Flow Master
R	**340+52**																									
R	**332+26**	32926	33226	24	300	0.165	0.9	5.0	2.7	0.402	0.016	0.02	0.060	0.012	0.00	0.402	0.084	4.21	2	2.5	9.184	1.36	0.44	0.17	0.23	
R	**335+26**	33226	33526	24	300	0.165	0.9	5.0	2.7	0.402	0.007	0.02	0.049	0.012	0.23	0.628	0.116	5.78	2	2.5	9.850	1.35	0.41	0.26	0.37	
R	**337+56**	33526	33756	24	230	0.127	0.9	5.0	2.7	0.308	0.006	0.02	0.047	0.012	0.37	0.679	0.124	6.19	2	2.5	9.785	1.35	0.41	0.28	0.40	
R	**338+26**	33756	33826	24	70	0.039	0.9	5.0	2.7	0.094	0.006	0.02	0.050	0.012	0.40	0.493	0.110	5.49	2	2.5	8.199	1.32	0.48	0.24	0.26	
Sag at Sta 325+72																										
R	**Roundabout to be designed in the future**			24	0	0.000	0.9	5.0	3	0.000		0.02			0.00	0.000	0.078	3.89								Spread From Flow Master
R																										
Sag at Sta 317+07																										
R	**320+25**	32226	32025	24	201	0.111	0.9	5.0	2.7	0.269	0.025	0.02	0.070	0.012	0	0.269	0.067	3.34	2	2.5	8.030	1.40	0.49	0.13	0.14	
R	**317+07**	32025	31657	24	368	0.203	0.9	5.0	3	0.547		0.02			0.41	1.094	0.079	3.97								Spread From Flow Master
R	**316+97**																									
R	**311+57**	30857	31157	24	300	0.165	0.9	5.0	2.7	0.402	0.015	0.02	0.059	0.012	0.00	0.402	0.086	4.30	2	2.5	8.958	1.35	0.45	0.18	0.22	
R	**314+57**	31157	31457	24	300	0.165	0.9	5.0	2.7	0.402	0.024	0.02	0.056	0.012	0.00	0.625	0.093	4.64	2	2.5	12.826	1.39	0.32	0.20	0.42	
R	**316+57**	31457	31657	24	200	0.110	0.9	5.0	2.7	0.268	0.006	0.02	0.047	0.012	0.00	0.691	0.124	6.21	2	2.5	9.915	1.35	0.41	0.28	0.41	
Sag at Sta 305+54																										
R	**305+54**	30857	30554	24	303	0.167	0.9	5.0	3	0.451		0.02			0.00	0.451	0.066	3.28								Spread From Flow Master
R	**305+44**																									
TO BE COMPLETED WITH SEGMENT 1																										
Segment 1 Sta 10+00 to Sta 30+28																										
L	**14+00**	1000	1400	18	400	0.165	0.9	5.0	2.7	0.402	0.015	0.02	0.059	0.012	0.00	0.402	0.086	4.29	2	2.5	8.999	1.35	0.44	0.18	0.22	
L	**16+00**	1400	1600	36	200	0.165	0.9	5.0	2.7	0.402	0.039	0.04	0.101	0.012	0.22	0.625	0.110	2.74	2	2.5	10.458	1.75	0.39	0.24	0.38	
L	**17+00**	1600	1700	36	100	0.083	0.9	5.0	2.7	0.201	0.008	0.04	0.086	0.012	0.22	0.583	0.145	3.63	2	2.5	6.831	1.55	0.56	0.33	0.26	
L	**18+00**	1700	1800	36	100	0.083	0.9	5.0	2.7	0.201	0.008	0.04	0.090	0.012	0.38	0.458	0.133	3.32	2	2.5	5.988	1.54	0.62	0.28	0.17	
L	**20+50**	1800	2050	36	250	0.207	0.9	5.0	2.7	0.502	0.008	0.04	0.083	0.012	0.26	0.675	0.153	3.84	2	2.5	7.391	1.56	0.52	0.35	0.32	
L	**23+50**	2050	2350	18	300	0.124	0.9	5.0	2.7	0.301	0.039	0.02	0.059	0.012	0.32	0.622	0.084	4.22	2	2.5	14.326	1.41	0.29	0.18	0.44	
L	**25+00**	2350	2500	18	150	0.062	0.9	5.0	2.7	0.151	0.008	0.02	0.050	0.012	0.32	0.591	0.113	5.64	2	2.5	9.553	1.34	0.42	0.25	0.34	
L	**26+50**	2500	2650	18	150	0.062	0.9	5.0	2.7	0.151	0.008	0.02	0.052	0.012	0.44	0.493	0.105	5.26	2	2.5	8.636	1.33	0.46	0.23	0.27	
L	**28+00**	2650	2800	18	150	0.062	0.9	5.0	2.7	0.151	0.039	0.02	0.066	0.012	0.27	0.417	0.073	3.63	2	2.5	11.392	1.42	0.36	0.15	0.27	
L	**30+28**	2800	3025	18	225	0.093	0.9	5.0	2.7	0.226	0.008	0.02	0.052	0.012	0.27	0.493	0.105	5.26	2	2.5	8.635	1.33	0.46	0.23	0.27	
Segment 1 Sta 10+00 to Sta 30+28																										
R	**14+00**	1000	1400	18	400	0.165	0.9	5.0	2.7	0.402	0.015	0.02	0.059	0.012	0.00	0.402	0.086	4.29	2	2.5	8.999	1.35	0.44	0.18	0.22	
R	**23+50**	2050	2350	18	300	0.124	0.9	5.0	2.7	0.301	0.039	0.02	0.064	0.012	0.00	0.475	0.076	3.82	2	2.5	12.280	1.42	0.34	0.16	0.32	
R	**25+00**	2350	2500	18	150	0.062	0.9	5.0	2.7	0.151	0.008	0.02	0.052	0.012	0.32	0.466	0.103	5.15	2	2.5	8.369	1.32	0.47	0.22	0.25	
R	**26+50**	2500	2650	18	150	0.062	0.9	5.0	2.7	0.151	0.008	0.02	0.054	0.012	0.25	0.397	0.097	4.85	2	2.5	7.646	1.31	0.51	0.20	0.19	
R	**28+00**	2650	2800	18	150	0.062	0.9	5.0	2.7	0.151	0.039	0.02	0.069	0.012	0.19	0.345	0.068	3.38	2	2.5	10.209	1.44	0.40	0.14	0.21	
R	**30+28**	2800	3025	18	225	0.093	0.9	5.0	2.7	0.226	0.008	0.02	0.053	0.012	0.21	0.434	0.100	5.02	2	2.5	8.042	1.32	0.49	0.21	0.22	

APPENDIX C
Conveyance Design Calculations

Conveyance Calculations
Project: **Murphy Rd.**
Job Number: **348153**

Location					Hydrology												Sewer Design						ewer Profi		
Description	Pipe From	Pipe To	Length (ft)	Width (ft)	Area (ft²)	Total Area (acres)	Cf = C	1.0 CfCA	Sum CA	Tc from STA (min)	Tc in Pipe (min)	Sum Tc (min)	Intensity I (in/hr)	Flow (cfs)	Offsite Flow (cfs)	Total Flow (cfs)	Diameter D (in)	Slope S (ft/ft)	Manning's n 0.013	Capacity Qf (cfs)	Velocity V (fps)	Q/Qf	Length L (ft)	Q/Qf Check	Slope Check
Murphy Road																									
Main line																									
SAG AT STA 376+99																									
From East	**378+01.00**	**377+34.00**	67.00	48.00	3216	0.07	0.90	0.07	0.07	**5.00**	0.37	**5.4**	2.70	0.18		**0.18**	**12**	0.45%	0.013	2.38	3.04	**0.08**	67.00	ok	ok
	377+34.00	**376+99.00**	35.00	48.00	1680	0.04	0.90	0.03	0.10	**5.37**	0.17	**5.5**	2.70	0.27		**0.27**	**12**	0.57%	0.013	2.69	3.43	**0.10**	35.00	ok	ok
From West	**365+50.00**	**367+00.00**	150.00	48.00	7200	0.17	0.90	0.15	0.15	**5.00**	0.50	**5.5**	2.70	0.40		**0.40**	**12**	1.23%	0.013	3.96	5.04	**0.10**	150.00	ok	ok
	367+00.00	**367+50.00**	50.00	48.00	2400	0.06	0.90	0.05	0.20	**5.50**	0.08	**5.6**	2.70	0.54		**0.54**	**12**	4.80%	0.013	7.80	9.94	**0.07**	50.00	ok	ok
	367+50.00	**368+00.00**	50.00	48.00	2400	0.06	0.90	0.05	0.25	**5.58**	0.13	**5.7**	2.70	0.67		**0.67**	**12**	2.00%	0.013	5.04	6.42	**0.13**	50.00	ok	ok
	368+00.00	**368+50.00**	50.00	48.00	2400	0.06	0.90	0.05	0.30	**5.71**	0.08	**5.8**	2.70	0.80		**0.80**	**12**	4.80%	0.013	7.80	9.94	**0.10**	50.00	ok	ok
	368+50.00	**369+00.00**	50.00	48.00	2400	0.06	0.90	0.05	0.35	**5.79**	0.08	**5.9**	2.70	0.94		**0.94**	**12**	4.84%	0.013	7.84	9.98	**0.12**	50.00	ok	ok
	369+00.00	**369+40.00**	40.00	48.00	1920	0.04	0.90	0.04	0.39	**5.88**	0.07	**5.9**	2.70	1.04		**1.04**	**12**	4.82%	0.013	7.82	9.97	**0.13**	40.00	ok	ok
	369+40.00	**369+80.00**	40.00	48.00	1920	0.04	0.90	0.04	0.29	**5.71**	0.04	**5.8**	2.70	0.78		**0.78**	**12**	11.38%	0.013	12.01	15.31	**0.06**	40.00	ok	ok
	369+80.00	**370+20.00**	40.00	48.00	1920	0.04	0.90	0.04	0.34	**5.79**	0.05	**5.8**	2.70	0.91		**0.91**	**12**	8.62%	0.013	10.46	13.33	**0.09**	40.00	ok	ok
	370+20.00	**370+40.00**	20.00	48.00	960	0.02	0.90	0.02	0.37	**5.88**	0.05	**5.9**	2.70	0.99		**0.99**	**12**	2.50%	0.013	5.63	7.18	**0.18**	20.00	ok	ok
	370+40.00	**370+50.00**	10.00	48.00	480	0.01	0.90	0.01	0.40	**5.94**	0.02	**6.0**	2.70	1.07		**1.07**	**12**	3.80%	0.013	6.94	8.85	**0.15**	10.00	ok	ok
	370+50.00	**373+00.00**	250.00	48.00	12000	0.28	0.90	0.25	0.54	**5.75**	0.43	**6.2**	2.70	1.45		**1.45**	**12**	4.59%	0.013	7.63	9.72	**0.19**	250.00	ok	ok
	373+00.00	**375+50.00**	250.00	48.00	12000	0.28	0.90	0.25	0.59	**5.84**	0.45	**6.3**	2.70	1.58		**1.58**	**12**	4.13%	0.013	7.24	9.23	**0.22**	250.00	ok	ok
	375+50.00	**376+50.00**	100.00	48.00	4800	0.11	0.90	0.10	0.47	**5.92**	0.34	**6.3**	2.70	1.26		**1.26**	**12**	1.17%	0.013	3.85	4.91	**0.33**	100.00	ok	ok
	376+50.00	**376+99.00**	49.00	48.00	2352	0.05	0.90	0.05	0.45	**5.96**	0.23	**6.2**	2.70	1.20		**1.20**	**12**	0.61%	0.013	2.79	3.55	**0.43**	49.00	ok	ok
SAG AT STA 340+62																									
From East																									
	362+50.00	**359+50.00**	300.00	48.00	14400	0.33	0.90	0.30	0.30	**5.00**	0.55	**5.5**	2.70	0.80		**0.80**	**12**	4.03%	0.013	7.15	9.11	**0.11**	300.00	ok	ok
	359+50.00	**356+50.00**	300.00	48.00	14400	0.33	0.90	0.30	0.60	**5.55**	0.80	**6.3**	2.70	1.61		**1.61**	**12**	1.90%	0.013	4.91	6.26	**0.33**	300.00	ok	ok
	356+50.00	**353+50.00**	300.00	48.00	14400	0.33	0.90	0.30	0.89	**6.35**	1.27	**7.6**	2.70	2.41		**2.41**	**12**	0.75%	0.013	3.08	3.93	**0.78**	300.00	ok	ok
	353+50.00	**350+50.00**	300.00	48.00	14400	0.33	0.90	0.30	1.19	**7.62**	1.19	**8.8**	2.70	3.21		**3.21**	**12**	0.85%	0.013	3.28	4.18	**0.98**	300.00	ok	ok
	350+50.00	**349+61.00**	89.00	48.00	4272	0.10	0.90	0.09	1.28	**8.81**	0.31	**9.1**	2.70	3.45		**3.45**	**12**	1.12%	0.013	3.78	4.81	**0.91**	89.00	ok	ok
	349+61.00	**349+30.00**	31.00	48.00	1488	0.03	0.90	0.03	1.31	**9.12**	0.11	**9.2**	2.70	3.53		**3.53**	**12**	1.13%	0.013	3.78	4.82	**0.93**	31.00	ok	ok
	349+30.00	**349+01.00**	29.00	48.00	1392	0.03	0.90	0.03	1.34	**9.23**	0.13	**9.4**	2.70	3.61		**3.61**	**15**	0.52%	0.013	4.64	3.79	**0.78**	29.00	ok	ok
	349+01.00	**348+91.00**	10.00	48.00	480	0.01	0.90	0.01	1.35	**9.36**	0.04	**9.4**	2.70	3.64		**3.64**	**15**	0.50%	0.013	4.57	3.72	**0.80**	10.00	ok	ok
	348+91.00	**347+00.00**	191.00	48.00	9168	0.21	1.90	0.40	1.75	**9.40**	0.80	**10.2**	2.70	4.72		**4.72**	**18**	0.45%	0.013	7.00	3.97	**0.67**	191.00	ok	ok
	347+00.00	**345+05.00**	195.00	48.00	9360	0.21	2.90	0.62	2.37	**10.21**	0.76	**11.0**	2.70	6.40		**6.40**	**18**	0.51%	0.013	7.52	4.26	**0.85**	195.00	ok	ok
	345+05.00	**344+52.00**	53.00	48.00	2544	0.06	3.90	0.23	2.60	**10.97**	0.20	**11.2**	2.70	7.02		**7.02**	**18**	0.57%	0.013	7.90	4.47	**0.89**	53.00	ok	ok
	344+52.00	**340+62.00**	390.00	48.00	18720	0.43	4.90	2.11	4.70	**11.17**	1.15	**12.3**	2.70	12.70		**12.70**	**24**	0.62%	0.013	17.74	5.65	**0.72**	390.00	ok	ok
From West																									
	325+72.00	**329+26.00**	354.00	48.00	16992	0.39	0.90	0.35	0.35	**5.00**	1.96	**7.0**	2.70	0.95		**0.95**	**12**	0.44%	0.013	2.36	3.01	**0.40**	354.00	ok	ok
	329+26.00	**332+26.00**	300.00	48.00	14400	0.33	0.90	0.30	0.65	**6.96**	1.59	**8.5**	2.70	1.75		**1.75**	**12**	0.48%	0.013	2.47	3.14	**0.71**	300.00	ok	ok
	332+26.00	**335+26.00**	300.00	48.00	14400	0.33	0.90	0.30	0.95	**8.55**	1.05	**9.6**	2.70	2.55		**2.55**	**12**	1.10%	0.013	3.73	4.75	**0.68**	300.00	ok	ok
	335+26.00	**337+43.00**	217.00	48.00	10416	0.24	0.90	0.22	1.16	**9.60**	0.79	**10.4**	2.70	3.14		**3.14**	**12**	1.01%	0.013	3.59	4.57	**0.87**	217.00	ok	ok
	337+43.00	**337+75.00**	32.00	48.00	1536	0.04	0.90	0.03	1.19	**10.39**	0.13	**10.5**	2.70	3.22		**3.22**	**15**	0.66%	0.013	5.23	4.27	**0.62**	32.00	ok	ok
	337+75.00	**338+11.00**	36.00	48.00	1728	0.04	0.90	0.04	1.23	**10.52**	0.12	**10.6**	2.70	3.32		**3.32**	**15**	0.83%	0.013	5.89	4.81	**0.56**	36.00	ok	ok
	338+11.00	**340+62.00**	251.00	48.00	12048	0.28	0.90	0.25	1.48	**10.64**	0.73	**11.4**	2.70	3.99		**3.99**	**15**	1.20%	0.013	7.06	5.76	**0.57**	251.00	ok	ok
SAG AT STA 317+07																									
From East																									
	320+56.00	**320+10.00**	46.00	48.00	2208	0.05	0.90	0.05	0.05	**5.00**	0.24	**5.2**	2.70	0.12		**0.12**	**12**	0.50%	0.013	2.52	3.21	**0.05**	46.00	ok	ok
	320+10.00	**317+30.00**	280.00	48.00	13440	0.31	0.90	0.28	0.32	**5.24**	0.79	**6.0**	2.70	0.87		**0.87**	**12**	1.71%	0.013	4.66	5.94	**0.19**	280.00	ok	ok
	317+30.00	**317+07.00**	23.00	48.00	1104	0.03	0.90	0.02	0.35	**6.02**	0.04	**6.1**	2.70	0.93		**0.93**	**12**	4.35%	0.013	7.43	9.46	**0.13**	23.00	ok	ok
From West	**308+57.00**	**311+57.00**	300.00	48.00	14400	0.33	0.90	0.30	0.30	**5.00**															
	311+57.00	**314+57.00**	300.00	48.00	14400	0.33	0.90	0.30	0.60	**5.00**	0.78	**5.8**	2.70	1.61		**1.61**	**12**	2.00%	0.013	5.04	6.42	**0.32**	300.00	ok	ok
	314+57.00	**316+57.00**	200.00	48.00	9600	0.22	0.90	0.20	0.79	**5.78**	0.60	**6.4**	2.70	2.14		**2.14**	**12**	1.50%	0.013	4.36	5.56	**0.49**	200.00	ok	ok
	316+57.00	**316+97.00**	40.00	48.00	1920	0.04	0.90	0.04	0.83	**6.38**	0.17	**6.6**	2.70	2.25		**2.25**	**12**	0.72%	0.013	3.03	3.86	**0.74**	40.00	ok	ok
	316+97.00	**317+07.00**	10.00	48.00	480	0.01	0.90	0.01	0.84	**6.55**	0.01	**6.6**	2.70	2.28		**2.28**	**12**	7.10%	0.013	9.49	12.09	**0.24**	10.00	ok	ok
SAG AT STA 38+00																									
From West																									
	14+00.00	**16+00.00**	200.00	36.00	7200	0.17	0.90	0.15	0.15	**5.00**	0.73	**5.7**	2.70	0.40		**0.40**	**12**	1.00%	0.013	3.56	4.54	**0.11**	200.00	ok	ok
	16+00.00	**17+00.00**	100.00	36.00	3600	0.08	0.90	0.07	0.22	**5.73**	0.52	**6.3**	2.70	0.60		**0.60**	**12**	0.50%	0.013	2.52	3.21	**0.24**	100.00	ok	ok
	17+00.00	**18+00.00**	100.00	36.00	3600	0.08	0.90	0.07	0.30	**6.25**	0.52	**6.8**	2.70	0.80		**0.80**	**12**	0.50%	0.013	2.52	3.21	**0.32**	100.00	ok	ok
	18+00.00	**20+50.00**	250.00	36.00	9000	0.21	0.90	0.19	0.48	**6.77**	1.30	**8.1**	2.70	1.31		**1.31**	**12**	0.50%	0.013	2.52	3.21	**0.52**	250.00	ok	ok
	20+50.00	**23+50.00**	300.00	36.00	10800	0.25	0.90	0.22	0.71	**8.07**	0.88	**8.9**	2.70	1.91		**1.91**	**12**	1.58%	0.013	4.48	5.71	**0.43**	300.00	ok	ok
	23+50.00	**25+00.00**	150.00	36.00	5400	0.12	0.90	0.11	0.82	**8.95**	0.45	**9.4**	2.70	2.21		**2.21**	**12**	1.50%	0.013	4.36	5.56	**0.51**	150.00	ok	ok
	25+00.00	**26+50.00**	150.00	36.00	5400	0.12	0.90	0.11	0.93	**9.40**	0.45	**9.8**	2.70	2.51		**2.51**	**12**	1.50%	0.013	4.36	5.56	**0.58**	150.00	ok	ok
	26+50.00	**28+00.00**	150.00	36.00	5400	0.12	0.90	0.11	1.04	**9.85**	0.63	**10.5**	2.70	2.81		**2.81**	**12**	0.77%	0.013	3.12	3.97	**0.90**	150.00	ok	ok
	28+00.00	**30+25.00**	225.00	36.00	8100	0.19	1.90	0.35	1.39	**10.48**	0.79	**11.3**	2.70	3.77		**3.77**	**15**	0.82%	0.013	5.86	4.78	**0.64**	225.00	ok	ok
	30+25.00	**33+25.00**	300.00	36.00	10800	0.25	2.90	0.72	2.11	**11.26**	1.19	**12.4**	2.70	5.71		**5.71**	**18**	0.50%	0.013	7.43	4.21	**0.77**	300.00	ok	ok
	33+25.00	**36+25.00**	300.00	36.00	10800	0.25	3.90	0.97	3.08	**12.45**	0.93	**13.4**	2.70	8.32		**8.32**	**21**	0.67%	0.013	12.93	5.38	**0.64**	300.00	ok	ok
	36+25.00	**38+00.00**	175.00	36.00	6300	0.14	3.90	0.56	3.64	**13.38**	0.59	**14.0**	2.70	9.84		**9.84**	**21**	0.57%	0.013	11.97	4.98	**0.82**	175.00	ok	ok

APPENDIX D

Cost Estimates

CITY OF BEND

PROJECT NAME MURPHY ROAD PRELIMINARY DESIGN

COST ESTIMATE SEGMENT 3

MARK-UPS

	Percent	
ELEC/I&C	NOTE 1	
MECHANICAL	NOTE 2	
ALLOWANCE	10%	
MOB/BOND/INS	8%	
CONTINGENCY	NOTE 3	
ENGINEERING	NOTE 4	
CAPITALIZED INTEREST (BOND)	NOTE 5	COB PROVIDED
COB INTERNAL CHARGES	13%	COB PROVIDED
OTHER COB COSTS	NOTE 5	COB PROVIDED
ADMIN/LEGAL	5%	COB PROVIDED

Prepared By: BILLY ADAMS
Proj. Manager: DAVE SIMMONS
Project No: 348153
Date: October 7, 2009

NO.	DESCRIPTION	QTY	UNIT	Material Unit $	Installation Unit $	TOTAL	RESOURCE
A	CONSTRUCTION COST ESTIMATE						
1	MOBILIZATION	ALL	LS		10%	$516,700	
2	TEMPORARY PROTECTION AND DIRECTION OF TRAFFIC	ALL	LS		1.5%	$75,700	
3	EROSION CONTROL	ALL	LS		1.0%	$50,500	
4	REMOVALOF STRUCTURES AND OBSTRUCTIONS	ALL	LS		$1,180	$1,180	
5	CLEARING AND GRUBBING	ALL	LS		$6,550	$6,550	
6	EMBANKMENT IN PLACE	86330	CY		$11.00	$949,630	
7	SUBGRADE GEOTEXTILE	13340	SY		$1.50	$20,010	
8	12 INCH STORM SEWER PIPE, 5 FT DEPTH	2,841	LF		$60	$170,460	
9	CONCRETE STORM SEWER MANHOLES	20	EA		$3,000	$60,000	
10	CONCRETE INLETS, TYPE CG-3	26	EA		$1,700	$44,200	
11	WATER QUALITY FACILITY	ALL	LS		$93,000	$93,000	
12	DRYWELL DISPOSAL	ALL	LS		$27,000	$27,000	
13	STRUCTURE EXCAVATION	250	CY		$40.00	$10,000	
14	GRANULAR WALL BACKFILL	140	CY		$50.00	$7,000	
15	REINFORCEMENT	160,000	LB		$1.25	$200,000	
16	GENERAL STRUCTURAL CONCRETE, CLASS 3600	200	CY		$500.00	$100,000	
17	GENERAL STRUCTURAL CONCRETE, CLASS 4350	660	CY		$800.00	$528,000	
18	REINFORCED CONCRETE BRIDGE END PANELS	240	SY		$250.00	$60,000	
19	BT60 PRECAST PRESTRESSED BEAMS	1,760	LF		$300.00	$528,000	
20	CONCRETE PARAPET WITH PEDESTRIAN RAIL AND CHAIN-LINK FENCE	525	LF		$245.00	$128,625	
21	TYPE C PROTECTIVE FENCING	220	LF		$50.00	$11,000	
22	ASPHALTIC PLUG JOINT SEAL	108	LF		$100.00	$10,800	
23	RETAINING WALL, MSE	16,650	SF		$55.00	$915,750	
24	COLD PLANE PAVEMENT REMOVAL, 0 - 2 INCHES DEEP	13,340	SY		$5.00	$66,700	
25	AGGREGATE BASE (Note 6)	9,267	TON		$22.00	$203,882	
26	CONCRETE CURBS, CURB AND GUTTER	5,592	LF		$15.00	$83,880	
27	CONCRETE CURBS, MOUNTABLE CURB	252	LF		$20.00	$5,040	
28	CONCRETE ISLANDS	3,751	SF		$10.00	$37,510	
29	CONCRETE WALKS (INCL DW APRONS)	37,223	SF		$4.00	$148,892	
30	CONCRETE BARRIER	237.5	LF		$55.00	$13,063	
31	LEVEL 3, HMAC (Note 6)	ALL	LS		$371,830	$371,830	
32	SIGNING AND STRIPING	ALL	LS		$31,120	$31,120	
33	LANDSCAPING	ALL	LS		$42,770	$42,770	
34	ILLUMINATION, COMPLETE	ALL	LS		$90,000	$90,000	
35	RETAINING WALL	ALL	LS		$74,890	$74,890	
B	SUBTOTAL					**$5,684,000**	
C	ELEC/I&C	(% of B)				$0	
D	MECHANICAL	(% of B)				$0	
E	SUBTOTAL					**$0**	
F	ALLOWANCE =	(% of G)				$0	
G	MOB/BOND/INS. =	(% of G)				$0	
H	CONTINGENCY =	30%				$1,706,000	
I	SUBTOTAL					**$7,390,000**	
J	ENGINEERING	20%				$1,478,000	
	CAPITALIZED INTEREST (BOND)	(% of I)				$0	
	COB INTERNAL CHARGES	(% of I)				$0	
	OTHER COB COSTS	(% of I)				$0	
K	ADMIN/LEGAL	(% of I)				$0	
L	PROPERTY COSTS (ROW/EASEMENTS) Assumed Cost	250,700	SF		$10.00	$2,507,000	
M	UTILITIES COSTS					$0	
N	PERMIT FEES					$0	
	Total Estimated Project Cost					**$11,375,000**	

NOTES

1 Note: if this work is in the unit price bid schedule then use 0% and note this.
2 Note: if this work is in the unit price bid schedule then use 0% and note this.
3 Varies depending upon the 30%, 60% 95% design level.
4 Discuss with consultant and CIP mgr for percentage during planning.
5 This will vary by project in coordination with the funding mgr.
6 Pavement quantities are based on an assumed roadway section of 6" of HMAC and 12" of Aggregate Base.
7 Water quality facility unit cost includes seeding and limited plantings.