City of Bend – SW Sewer Basin Study

Prepared for

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ACRONYMS AND ABBREVIATIONS

CI	Cast Iron
COB	City of Bend
CSMP	Collection System Master Plan
DI	Ductile Iron
GIS	Geographic Information System
GPD	Gallons per Day
GPM	Gallons per Minute
HDPE	High-Density Polyethylene
I/I	Infiltration/Inflow
LF	Linear Feet
LiDAR	Light Detection and Ranging
MH	Manhole
NE	Northeast
NW	Northwest
O&M	Operational and Maintenance
PFP	Public Facility Plan
PVC	Polyvinyl Chloride
ROW	Right-of-Way
SE	Southeast
SW	Southwest
UGB	Urban Growth Boundary
WWTF	Wastewater Treatment Facility

1. EXECUTIVE SUMMARY

This report is intended to review the existing SW Sewer Basin for the City of Bend and review alternatives that can achieve key sewer service objectives for the basin. The key objectives of this study include addressing existing capacity deficiencies and pump station issues, relieving on-site septic system issues, and opening up critically needed development lands to assist with relieving affordable housing shortages. Recommendations to the City are included for the best ways to serve the SW Sewer Basin based on cost estimates, potential service areas, and feasibility to help determine the recommended routing of proposed alignments. There are also some long-term decision points needed from the City on routes and depths needed to meet primary and secondary project goals.

Existing sewer infrastructure in the SW Sewer Basin includes private on-site septic systems, City-owned sewer pressure systems with individual pump stations serving one or two lots, City-owned gravity sewers that discharge to regional pump stations with force mains, and existing gravity sewer mains that drain to the recently upgraded City system. The basin evaluation was broken down into four subbasins served by larger collection mains that warranted detailed analysis which include the North Trunk Main, South Trunk Main, Jasmine Focus Area, and the Thumb properties. An additional routing alternatives analysis was completed for the downstream receiving sewer, and this sewer has been constructed.

The North Trunk routes were analyzed for the most cost-effective service of the north region of the basin. Two alternatives for the North Trunk were considered, with the upstream portions being the same, and the downstream ends diverging at the Lodgepole/Mahogany intersection. The primary goal of the North Trunk alternatives is to eliminate the individual Romain Village individual pump stations (accomplished along the mainline as well as with future construction of tributary sewers), and the alternatives were also analyzed for potential to remove the existing River Canyon #1 Pump Station by deepening the alignments. Each North Trunk alternative horizontal alignment was reviewed for cost and identifying decision point location(s) for alignment and depth to accomplish the project goals.

The South Trunk was reviewed for service area coverage, cost, tie-in locations of mains, and the potential to remove the existing Poplar Park pump station in the southwest corner of the basin. Two alternatives for the South Trunk were reviewed which differed only by additional depth needed for the removal of the pump station. The primary goal of the South Trunk area is to provide gravity sewer service to the septic system lots and individual pumped lots south of Amethyst and Mahogany Streets, with the secondary considerations being to decommission the existing Poplar Pump Station, and tying in one of the Jasmine focus area options. The South Trunk vertical alternatives were reviewed for cost and identifying decision point location(s) to accomplish project goals.

Three alternatives in the Jasmine focus area were evaluated to serve the southeast region of the basin. Two alternatives were reviewed for The Thumb review area which consists of two undeveloped parcels currently known as the Ward Property and the Maverick Property. The goal of the review of this area is to provide services to the largest number of properties while limiting the construction depth of the connected main.

The main focus of the North Trunk Alternative Evaluation is to provide services to the northern edge of the SW Sewer Basin and to decide whether it is feasible to include the decommissioning of the existing River Canyon #1 pump station. Alternative 2 has a decreased length of approximately 200 feet but due to the overall deeper depths required the cost of the project is roughly the same. The larger item to be

considered when choosing the north alternative is the effect on the surrounding public. This review also needs to look at the limited access points to the neighborhood and increased complexities needed for the detouring of Mahogany Street vs the detour routes needed for Lodgepole, which could maintain and utilize the existing access points to the north and west end of the neighborhood. Although, since both options will utilize a portion of Mahogany Street the effects will need to be reviewed for the anticipated duration of the detour which will have the largest impact to the public.

The primary goal in reviewing the South Trunk Alternatives can be narrowed down to the inclusion, or not, of decommissioning the existing Poplar Pump Station since both alternatives can provide gravity service to the entire southern sub-basin. Although Alternative 2 is longer, the run of main and design will be the same through the west end of Poplar Street and the extra piping, along with the decommissioning, would be an added cost/line item and not an alternative design cost. When coming to a determination on these alternatives, the City needs to consider if the long-term effects of the pump station and associated hydrogen sulfide effect as well as the long-term operations and maintenance associated outweigh the additional costs. This review does not have as big of a factor when it comes to the effect on the public due to the fact that the majority of the main is similar in design when looking at both alternatives.

Three alternatives in the Jasmine focus area were evaluated to serve the southeast region of the basin. The main area of focus for this alternative review is the ability to serve the largest number of future properties to best serve this area and its residents. Based on the evaluations of this region, the entire Jasmine Focus Area is not likely able to be served due to the existing topography without installing a significantly deep sewer main.

These three alternatives have very different positive and negative aspects to their design and the decision will not be as straight forward as the other review areas. Although Alternative 3 is one of the lower alternative costs, this option can only be used if planned properly with the South Trunk project. If the Jasmine area needs to be serviced before the South Trunk is installed, another alternative will need to be used or the South Trunk segments will need to be shifted to this project area. Alternative 2 is the shortest route, and cheapest when the effects on the South Trunk are factored in, but this alternative is only possible if the City is able to get easements through the affected properties, and the pipe is feasibly constructable at their property lines. Additional review and coordination between the City and the affected properties will be needed before the full effects are known on this alternative.

This report evaluated options to serve the properties referred to as Ward (east side of Highway 97) and Maverick (west side of Highway 97). Sewering the Ward property by a Highway 97 auger bore crossing and upsizing the currently planned Atwood sewer or the current Collection System Master Plan and Public Facilities Plan proposal of sewering Ward north in Parrell Road to Murphy Road.

The City of Bend and the Stillwater Crossing development upsized the sewer as recommended, so the upsized sewer is constructed in place to the southern limit of the Stillwater Crossing property on Atwood Drive. The decision to sewer the Ward property through Atwood (Option 1) has mostly been decided, but the option to construct a more expensive sewer down Parrell Road is still an option for sewering the Ward property. Since the Phase 1 and 2A designs previously constructed already accounted for the upsizing of the line through the Stillwater Crossing development, the City is in the process of pursuing this alternative. Sewering the Ward property by a Highway 97 crossing and the upsized sewer construction offers significant cost savings as compared to the current Collection System Master Plan and Public Facilities Plan.

2. PROJECT OVERVIEW

The purpose of this report is to provide a comprehensive study of sewer improvement alternatives to the City of Bend (COB) for sewering the SW Sewer Basin. As stated previously, The key objectives of this study are addressing existing capacity deficiencies and pump station issues, relieving on-site septic system issues, and opening up critically needed development lands to assist with relieving affordable housing shortages. This sewer study will provide recommendations to the City for the best ways to serve the SW Sewer Basin based on cost estimates, potential service areas, and feasibility to help determine the recommended routing of proposed alignments. The SW Sewer Basin is bounded on the east by US Highway 97, on the south by the Urban Growth Boundary (UGB)/City Limits, on the west by Brookswood Boulevard, Elk Meadow School, as well as Hollygrape Park, and on the north by Brookswood Boulevard and Murphy Road.

Existing sewer infrastructure in the SW Sewer Basin was identified in the 2018 Public Facility Plan (PFP) to have deficient gravity sewer segments. Additionally, the City has identified the existing aging pump stations serving areas of pressure sewer to have outdated electrical systems near the end of their useful life, requiring excessive maintenance. Existing sewer infrastructure in the SW Sewer Basin includes private on-site septic systems, City-owned sewer pressure sewer systems with individual pump stations serving one or two lots, City-owned gravity sewers that discharge to regional pump stations with force mains, and existing gravity sewer mains that drain to the recently upgraded Amethyst-Mahogany diversion manhole on S. 3rd Street. In addition, future new developments within the City limits and in the Urban Growth Boundary (UGB) were also considered in the overall study. Possible areas for development include Murphy's Crossing, the Jasmine Area along with the Maverick and Ward Properties, both of which make up an area referred to as "The Thumb".

See Figures 1 and 2 below as well as Appendix A - SW Sewer Basin Area and Appendix B – Existing Topographic Information for additional existing site information.

Figure 1: Overall Existing Conditions Map

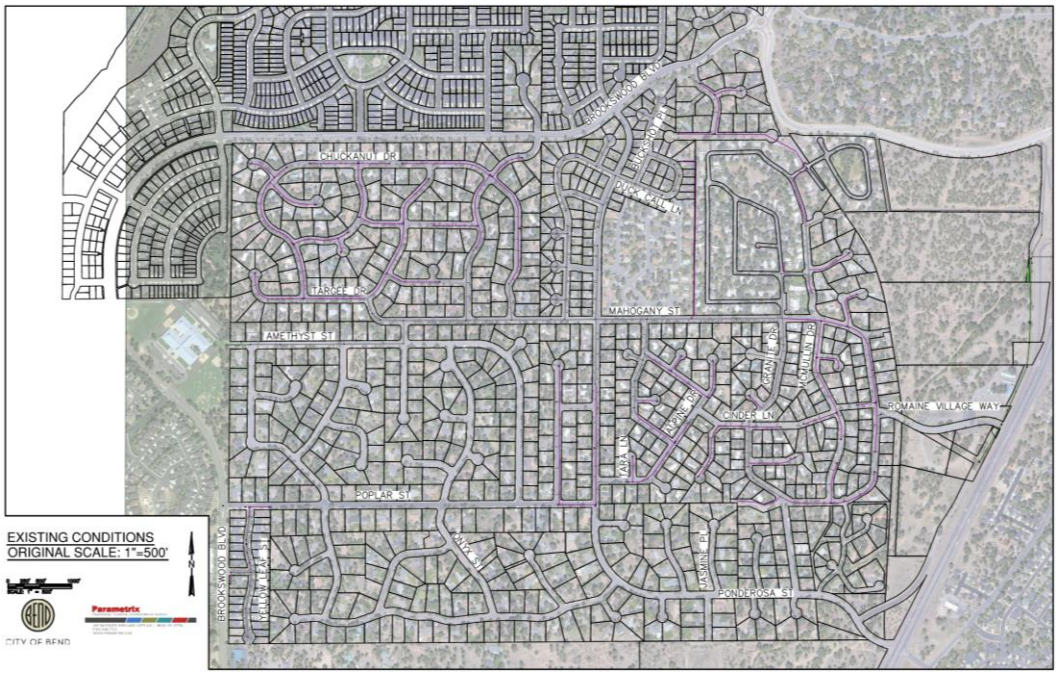
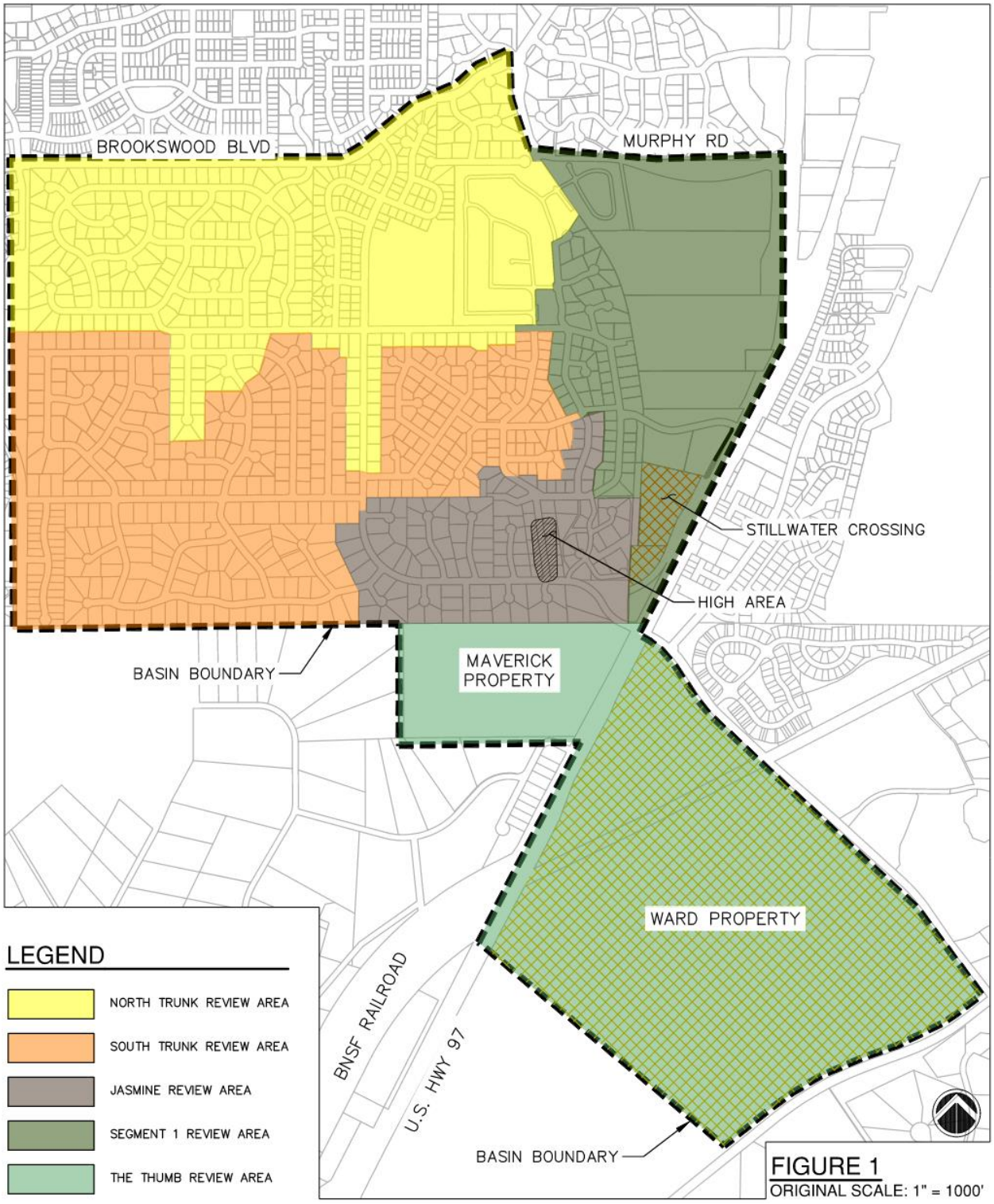


Figure 2: Overall Basin Map



3. CURRENT CONDITIONS

The existing main collection line serving the SW Sewer Basin, known as the Amethyst/Mahogany Sewer, is located within multiple City streets as well as a cross country portion in a City sewer easement. Multiple deficiencies along the Amethyst/Mahogany sewer line have been identified in the 2014 Collection System Master Plan (CSMP) and the 2018 Public Facilities Plan (PFP). Additional deficiencies have also been identified by the City of Bend Utility Department regarding the City-owned and maintained sewer pressure system in the Romaine Village area that includes approximately 240 individual pumps. This area, known as the Romaine Village Common Pressure area, includes three separate areas that feed into the Amethyst/Mahogany Sewer trunk main.

The northwestern portion (generally north of Mahogany and Targee, west and south of Chuckanut) of the Romaine Village Common Pressure area includes approximately 100 pump stations, the southeastern portion (generally south of Mahogany, east of Ashford, north of Poplar and west of Romaine Village subdivision) includes approximately 114 pump stations, and the northeastern portion (generally north of Mahogany on Driftwood, Sugarbush, Terrace, Cypress, Dovewood and Finchwood) includes approximately 23 pump stations. The PFP also provided comments by the City of Bend Operations & Maintenance (O&M) staff associating these smaller pumping units with harsh wastewater environments, which leads to hydrogen sulfide generation and corrosion. Additionally, the existing electrical components for these pumps are outdated, with some even considered unsafe environments for the City O&M staff.

As of the date of this report, multiple segments of the SW Sewer Basin have already been reviewed, evaluated and are currently in or have recently completed construction. The first section that was evaluated was Phase 1 which included the replacement of 200 feet of an existing sewer main along Amethyst Street that was undersized for current sewer flows. This segment has been fully constructed and was completed on July 2, 2021. In addition to Phase 1, Phase 2A was also previously constructed and included the installation of approximately 1,700 feet of a new 18-inch gravity sewer main, multiple manhole structures and reconstruction of an existing Oregon Department of Transportation (ODOT) multi-use path. Phase 2A was completed on October 7, 2021. These phases will help serve future construction in SW Bend as well as provide sewer for a new affordable housing development (The Stillwater Development).

See Appendix C – Phase 1 and 2A Record Drawings for additional information on the design and construction of these phases.

Phase 2B of the study includes the installation of approximately 2,300 feet of new 15-inch gravity sewer main, multiple manhole structures as well as the decommission of existing drill hole facilities and sewer pump stations. Additionally, this project will install upgraded storm water facilities, concrete curbs, full street reconstruction to address drainage and alignment/right-of-way issues, and the reconstruction of an existing canal crossing. This sewer will alleviate deficiencies in the existing sewer system as well as provide capacity for future septic-to-sewer conversions. This phase is currently under construction and is anticipated to be completed by May 31, 2022.

See Appendix D – Phase 2B Construction Plans for additional Phase 2B scoping and information.

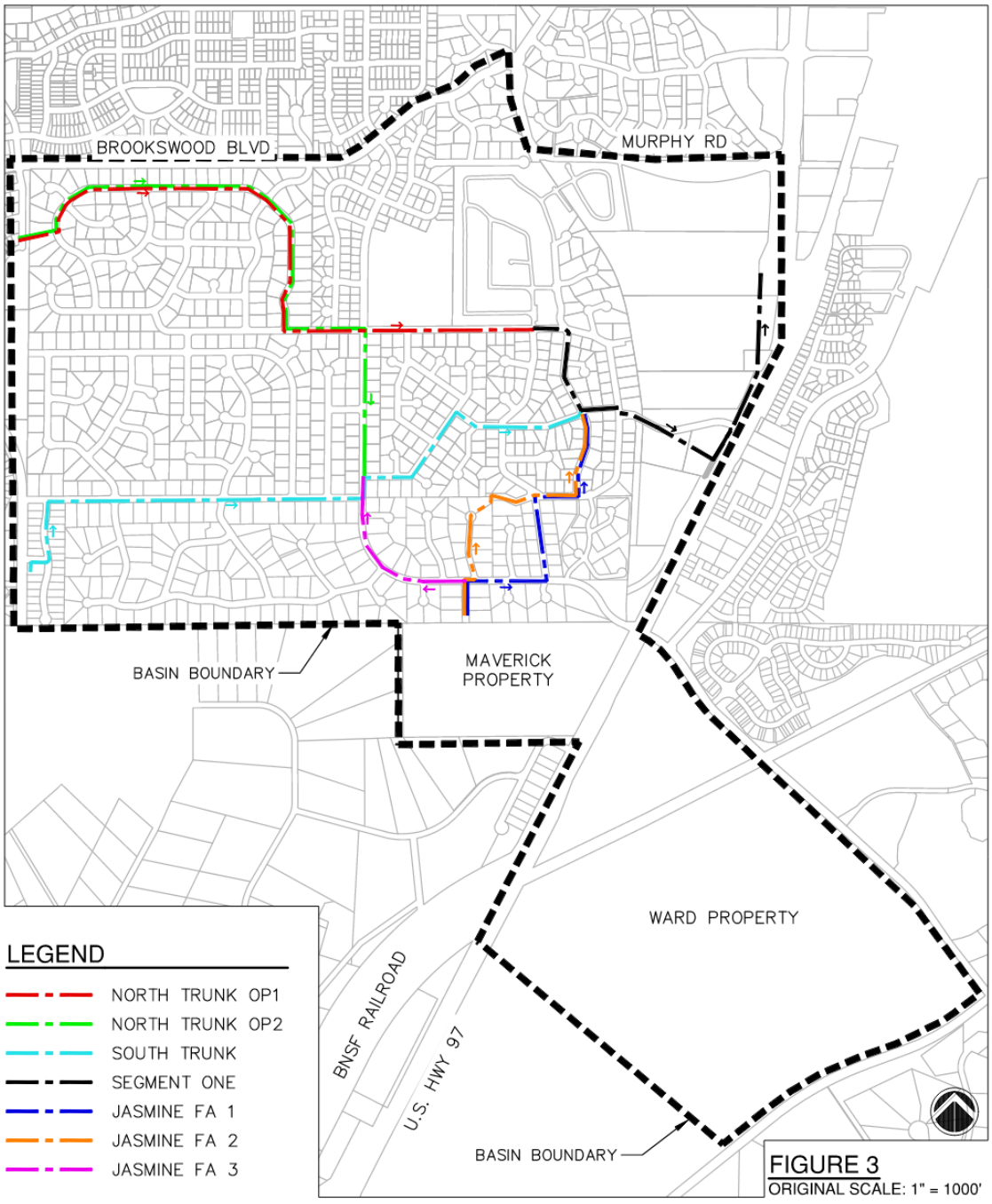
All additional and future phases of this study will be reviewed and analyzed as part of this report. See sections below for additional information and recommendations for future phases of the SW Sewer Basin.

4. DESIGN ALTERNATIVES

This document is used to evaluate several alternative alignments for various segments of collection mains that will provide gravity sanitary service to the SW Sewer Basin in Bend.

See Figure 3 and Appendix E - SW Sewer Basin Alternative for more information on the proposed route alternatives.

Figure 3: Overall Routing Map



Ultimately, it is the City's intent to provide a comprehensive concept to address existing capacity deficiencies, pump station issues, septic issues, and open up critically needed development lands to assist with relieving affordable housing shortages, and the initial phase of SW Sewer Basin construction need to satisfy these requirements. When reviewing the sewering of the SW Sewer Basin, there are four route locations that warranted detailed analysis for route selection and decision points by the City. The areas of detailed review include the North Trunk Main, South Trunk Main, Jasmine Focus Area, and the Thumb properties. The Murphy Crossing area was also reviewed in past designs of the previous phases. Due to this, the Murphy Crossing development will not be covered in detail in this report.

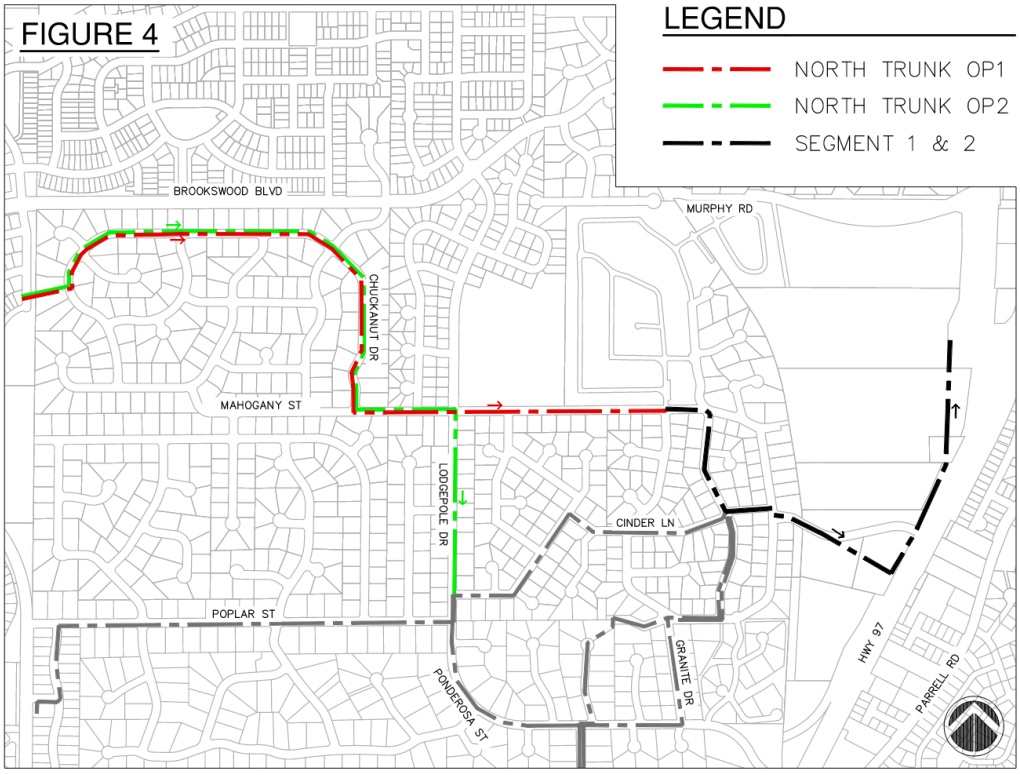
See Appendix F – Previous Design Reports for additional information on the previous reviews and phases. See Appendix G – Alternative Review Areas for additional layout and location information on the reviewed properties.

4.1 North Trunk Alternatives

Two parallel routes, tying into the existing Mahogany Street sewer main, were evaluated to provide gravity sewer services on the north and south ends of the basin. The North Trunk routes were determined to serve most of the north region of the basin. Two alternatives for the North Trunk were considered. Each North Trunk alternative was reviewed for the ability to remove the existing River Canyon #1 pump station, along with identifying decision point location(s). These alternatives both will be able to drain into the manhole at Granite and Mahogany constructed with Phase 2B construction being completed in May 2022.

See Figure 4 and Appendix H – North Trunk Alternatives for additional routing information.

Figure 4: North Alternative Routing Map



4.1.1 North Trunk Alternative 1

The North Trunk Alternative 1 is routed through Mahogany Street, replacing existing sewer east of Chuckanut Drive and drains into segment 1, manhole 19. This deeper replacement sewer alternative could provide the City with new corrosion resistant sewer manholes on Mahogany to prevent hydrogen sulfide corrosion from the existing pump stations discharging into this segment of the system. This option can have the ability to decommission the existing River Canyon #1 pump station but would require the majority of the vertical design to be lowered 3.5 to 4 feet.

4.1.2 North Trunk Alternative 2

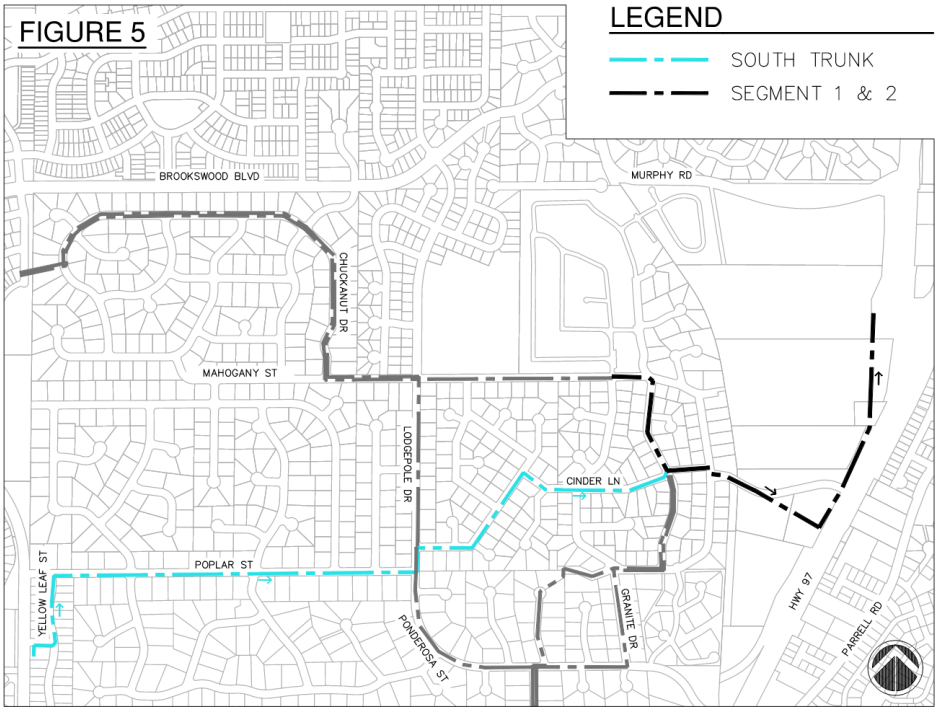
North Trunk Alternative 2 is shown splitting from Alternative 1 at Lodgepole Drive and intersecting with the South Trunk and heading east to segment 1 manhole 13. This alternative will limit the reconstruction of the existing Mahogany sewer main thus preserving the existing asset. Similar to Alternative 1, this alternative can have the ability to also decommission the existing River Canyon #1 pump station. This would also require the line to be lowered in elevation by approximately 3.5 to 4 feet.

4.2 South Trunk Alternatives

The South Trunk can be designed to allow for removal of the existing Poplar Park pump station in the southwest corner of the basin. The existing topography conveniently has a downward slope and intersects the North Trunk Alternative 2 at Lodgepole Drive and Alpine Drive, or can continue on to drain into a segment 1 manhole if the North Trunk Alternative 2 is not utilized.

See Figure 5 and Appendix I – South Trunk Alternatives for additional routing information.

Figure 5: South Alternative Routing Map



4.2.1 South Trunk Alternative 1

The South Trunk Alternative 1 is to extend the main to the west to allow for the decommissioning of the Poplar Pump Station. This alternative would require additional pipe depth south of the Poplar Street Right-of-Way (ROW). Unlike the North Trunk Alternatives, the extra depth needed to remove the pump station would only happen near the end of Alternative 2 and would be a complete additional cost vs having to lower the entire run. Although, it should be noted that extra depth on the South Trunk Alternatives may be needed, depending on the alternative design chosen for the Jasmine Focus Area. Specifically, if Alternative 3 is used for the Jasmine Focus Area, approximately 700 feet of piping would need to be lowered roughly 3 feet at a minimum. Additional depth may also be required if additional areas are to be served by the Jasmine Alternatives.

4.2.2 South Trunk Alternative 2

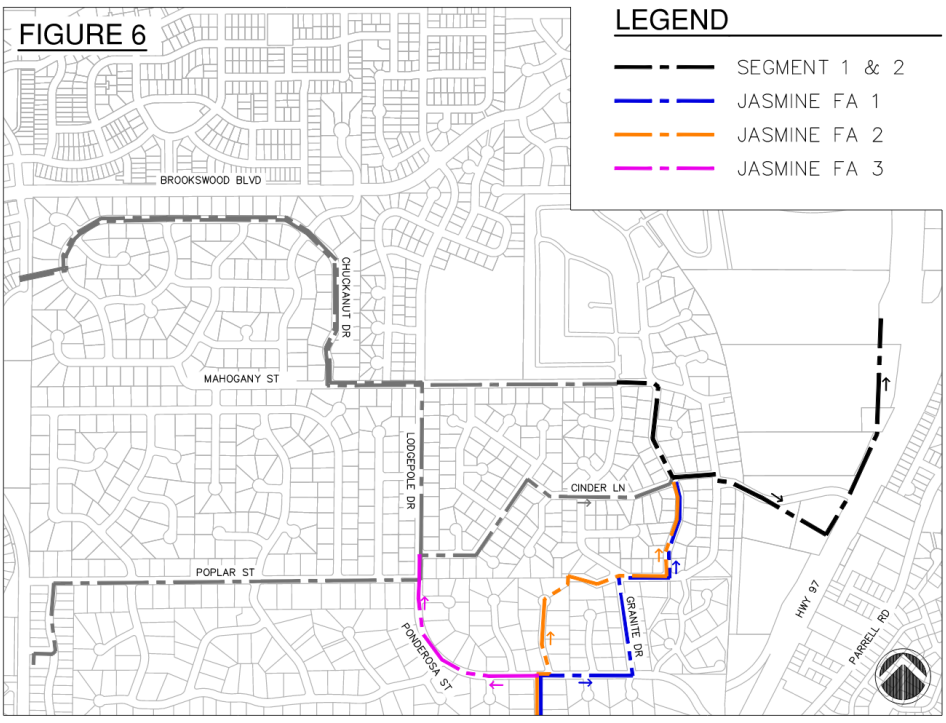
The South Trunk Alternative 2 is to also extend the main to the west but stop at the west end of Poplar Street to save on additional pipe depth and material, as noted above. This alternative will also exclude the pump decommissioning of the pump station at Poplar Park.

4.3 Jasmine Area Alternatives

Three alternatives in the Jasmine focus area were evaluated to serve the southeast region of the basin. Each of these alternatives has their advantages and disadvantages for finding ways to serve the largest area of land.

See Figure 6 and Appendix J – Jasmine Area Alternatives for additional routing information.

Figure 6: Jasmine Alternative Routing Map



4.3.1 Jasmine Area Alternative 1

Alternative 1 for the Jasmine Area has a route that starts heading east on Ponderosa Street and north on Granite Drive before connecting into segment 1 of the design. An existing high point on Granite Drive increases the depth of the sewer over twenty feet for approximately 600+ lineal feet of sewer pipe. This option ends with one of the lower initial designed connection elevations at the southern terminus but deals with the deepest pipe run along its length, compared to the other alternatives for this area.

4.3.2 Jasmine Area Alternative 2

Alternative 2 will require an access easement between tax lot 181218DC05000 and tax lot 181218DC05100. The proposed main will also need to go through a road with unknown ownership. Further exploration will be required to understand the ownership of this road. This alternative follows the same start and end points as Alternative 1, but removes the need for the deep sewer main required with that alternative. Between the three alternatives, this alternative results with one of the lower initial designed connection elevations at the southern terminus and will have less direct construction cost but would require a large amount of outreach to the affected properties. If these properties were to give push back this alternative may become infeasible.

4.3.3 Jasmine Area Alternative 3

As noted previously, Alternative 3 for the Jasmine Area will require the deepening of the South Trunk near the intersection of Ponderosa Street and Poplar Street. This alternative has the shortest route and also has the highest initial designed connection elevation at the southern terminus. Although it is the shortest route of the three alternatives, the effect on the South Trunk options and the cost per foot are increased with the utilization of this alternative. In addition, if the line is lowered to the same south connection elevation as the other alternatives, or lower, the effect on the South Trunk alternatives will greatly increase and require additional depth of the designed mains in this area back to the initial connection.

4.4 The Thumb Alternatives

The Thumb consists of two undeveloped parcels, tax lot 1812000004404, currently known as the Ward Property, and tax lot 181219A000100, currently known as the Maverick Property. Ward's ownership totals approximately 223 acres and the Maverick properties totals approximately 38 acres.

4.4.1 The Thumb Area Alternative 1

Alternative 1 is the alternative of sewering the properties through an upsized Atwood Sewer and through the SW Sewer Basin West of the highway. The Stillwater Crossing development plans include the upsizing and lowering of the main through their property to achieve the ability to serve these areas. Additional main would be needed between the Stillwater Development and Ponderosa Street before a connection could be made to the Thumb.

See Appendix F – Previous Design Reports for additional information on the previous reviews and analysis.

For this alternative there is also the added issue of having to take the sewer mains across Highway 97 at, or near, the Ponderosa/China Hat Road crossing. This additional coordination effort with ODOT needs to

also be considered when determining the final alternative to use. Although, even with this added coordination time and effort, the overall cost reduction compared to Alternative 2 is significant. This crossing location also hinders the possibility of sewering the Maverick area but this can be achieved through other routing like the Jasmine Alternatives.

4.4.2 The Thumb Area Alternative 2

To assess whether sewering the Ward and Maverick Properties through the SW Sewer Basin provides a long-term advantage to the City, it needs to be compared to the construction of a sewer main down Parrell Road as identified in the 2018 City of Bend Collection System Public Facility Plan (PFP). Ultimately, either long-term alternative would put flows into the 18-inch Southeast Interceptor (SEI) at the Parrell/Murphy roundabout.

Alternative 2 for providing services to the Thumb properties includes sewering the properties through a new Parrell Road Sewer extension. This alternative does not have all the cost and time advantages of the Atwood upsizing alternative and would likely need to be a completely separate City project due to the construction and closures needed for a new main down Parrell Road.

4.5 Side Street Connection Information

To fully evaluate the alternatives discussed above, all the connecting side streets to each of these alternatives required a full review to verify the pipe depths needed to service this area of the City. Complete design profiles were developed to determine the minimum pipe elevations at the connections to each of these trunk alternatives.

See Appendix K – Side Street Profiles for additional information on the side street design depths to provide gravity services to the area.

5. PROJECT DESIGN DRIVERS

To review the alternative design areas, as outlined in the previous section, Parametrix had to determine the correct design drivers to use when completing the alternative analyses. These drivers are listed and outlined in depth throughout this section.

5.1 Topographic and Pipe Elevation

For the alternative review, Parametrix was provided with two-foot interval LiDAR surface contours by the City of Bend to analyze the existing topography. The LiDAR surface was compared to the segment one surveyed surface to validate the accuracy and less than 1 foot of difference was calculated between the two surfaces. The elevations used for the River Canyon #1 and Poplar Park pump stations were calculated by subtracting field depth measurements of the manholes immediately upstream of the wet well(s) from the City LiDAR surface. An additional foot of depth was assumed and added to the sewer invert depth to mitigate any surface discrepancies and provide an additional safety factor.

Parametrix used AutoCAD Civil 3D to profile the invert elevations of the proposed sewer main alternatives. A constant slope of 0.50% and 0.25% were used for 8- and 12-inch sewer mains, respectively. These slopes

are used for preliminary planning/design and represent the minimum slope requirements by the City of Bend accounting for elevation drop at manhole locations without designing all manholes in the system.

Table 5.1 summarizes the minimum slope requirements for the pipes modeled based on the City of Bend Standards and Specifications. A minimum of seven feet between existing grade and invert elevation of the profiled sewer main was used to allow for sewer service connections. A 12-inch-diameter sewer main was modeled for the trunk lines and 8-inch-diameter pipes were used for the side streets that connect to the sewer trunk.

Table 5.1: City of Bend minimum slope requirements based on pipe size

Pipe Size	Minimum Slope
8”	0.40%
12”	0.19%

While evaluating the proposed routes, Parametrix also modeled sewer inverts on the side streets that would connect to the sewer trunk. The depths used for the trunk mains can allow for service of the side streets and ultimately, serving most of the SW Sewer Basin.

5.2 Pipe Flow and Capacity

CIP Consulting (CIPC) is a sub-consultant to Parametrix assisting in this alternative review effort. CIPC helped complete the calculations of the anticipated existing and future proposed sewer flows for the SW Sewer Basin. These flows have been used in the design of the initial Phase 2A and 2B segments but were also used to verify sizing of the future sewer mains in the basin for the alternative reviews. See the following Flow Estimation section (Section 6) in this report for additional information.

5.3 Construction Costs

Many areas/topics are being evaluated when looking at these alternative designs, but one of the most important factors to be considered is the economic impact to the City and its population. Although the City’s goal is to provide gravity options to the largest number of properties, these projects can only be feasible with the correct amount of funding. The City and its Council are held to a bi-annual budget that must be followed and planned correctly to achieve its goals. See the following Economic Evaluation section for additional information and review on this subject.

5.4 Construction Feasibility

Another aspect of the overall review of the proposed alternatives includes the construction feasibility review. This review includes items such as property access availability, ROW availability, existing system conditions, infrastructure crossings, Boring, and working in existing neighborhoods.

5.5 Public Impacts

In addition to the previous review topics, the study also has to consider the effect these alternatives will have on the overall public. Some of these effects are also covered in the previous review items but will also include items such as near-term effectiveness, affordable housing possibilities, sewering of Septic to Sewer areas along with the effectiveness of sewering the highest number of future lands.

The criteria for selecting the final chosen alternative may include solutions to short-term problems (such as alleviating noted system capacity deficiencies, sewering critically needed affordable housing project and development lands) as well as solutions to long-term problems (such as providing future service to take Romaine Village pump stations and force mains offline, providing future service to on-site septic system areas within the UGB, and potentially taking regional City pump stations offline).

6. FLOW ESTIMATIONS

CIP Consulting, LLC (CIPC) has estimated sewer flow for undeveloped properties within the basin which areas are shown on Table 6.1 below;

Table 6.1: Undeveloped Properties Sewer Flows

Tax Lot #	Owner	Special Planning Area
18-12-17 TL 1601	1601 Murphy Crossing LLC	Murphy Crossing Refinement Area
18-12-17 TL 1700	1700 Murphy Crossing LLC	Murphy Crossing Refinement Area
18-12-17 TL 1800 & 1900	ODOT	Murphy Crossing Refinement Area
18-12-17 TL 2001	Mayfield	Murphy Crossing Refinement Area
18-12-17 TL 2004, 2005 & 2006	Bell	Murphy Crossing Refinement Area
18-12-17 TL 2000, 2003 & 2500	2000 & 2500 Stillwater Housing Assoc. LTD	See Land Use Decision
18-12-18DD TL 6800 & 6900	Ponderosa Pine LLC	Murphy Crossing
18-12-18DD TL 6801 & 6802	ODOT	Murphy Crossing
18-12-19AO TL 100	100 Ponderosa Pine Estates LLC	Southwest UGB Expansion Area
18-12-17 TL 2215	Ward	N/A
18-12-00 TL 4404	Ward	Southwest UGB Expansion Area

See Appendix F – Previous Design Reports for additional flow information.

Ultimately, based on their review of the flows, CIPC recommends extending the largest pipe size as may be feasible based on cost, downstream system constraints, and other relevant factors as determined by the City of Bend. This will help with future flows as much as possible before any future upsizing or additional improvements are needed. CIPC estimated future sewer flows, ranging from low to high, for

each property based on its respective Comprehensive Plan zoning designation and applicable Development Code requirements for properties within that boundary.

The methodology used for determining sewer flow estimates for each property is generally described in this section below. To quantify gross acreage for each zoning designation, CIPC utilized City and County geographic information systems to estimate zoning designation areas. Peak flows are estimated by multiplying the number of EDU's for each zoning designation by 130 gallons per EDU per day and a peaking factor of 3.0 in accordance with Table 4-1 of the City's Design Standards.

6.1 Residential Flow Estimation Background

Flow estimations for residential development start by calculating total dwelling units by multiplying gross acreage by the allowable density for each zone.

Estimate development yield by converting dwelling units into equivalent dwelling units (EDU's). Single-family dwellings equate to 1.0 EDU, two-family dwellings equate to 2.0 EDU's (or 1.0 EDU each), and Multi-family dwellings equate to 0.8 EDU's each per Table 4-1 of the City's Design Standards. It should also be noted that these calculations do not include potential accessory dwelling units.

6.2 Commercial and Industrial Flow Estimation Background

Density for non-residential development is expressed as finished floor area per gross acre. The assumed finished floor area ratios (FARs), ranging from 0.20 to 0.30, are based on professional judgment as there is no direct Code requirement for these. This assumption is more conservative than the "non-residential" classification in Table 4-1 of the City's Design Standards (427 gallons per acre per day) and is considered a more accurate means of estimating of flows in this scenario.

Estimate development yield by multiplying FARs by gross acreage, then dividing by the assumed value of 1,000 square feet per 1.0 EDU of finished floor area. This assumption is based on a rough average of values for various uses which are listed in Table 4-1 of the City's Design Standards. Also assumes no residential development.

6.3 Mixed Use Flow Estimation Background

This zoning assumes a mix of commercial/office and residential uses. It also assumes that commercial/office uses occupy the floor area equivalent of the entire ground floor of the mixed-use development which is the minimum required by Development Code.

Lastly, the calculations assume 50% of the gross acreage will develop as multi-family residential which can be done in a variety of configurations including both vertical and horizontal mixed-use. There is potential for a wide variation in both commercial and residential development within the ME and MN zones. 50% of gross acreage is assumed as a reasonably likely scenario for medium and high-density residential development. Density assumptions and development yield calculations are the same as those described above.

6.4 Public Facilities/Institutional Use Flow Estimation

Overall, these areas assume one elementary school that will facilitate between 600-800 people (students, teachers, and staff) in accordance with Comprehensive Plan Policies and one public park with a restroom facility.

Estimate EDU's per Table 4-1 of the City's Design Standards which is 0.08 EDU per person for elementary school and 1.0 EDU per park with restroom.

7. ECONOMIC EVALUATION

The pricing shown in this section was determined by comparing similar sewer projects recently constructed in the City of Bend.

Table 7.1: Cost Breakdown of Items

Pipe Design Classifications	Cost per Linear Foot
0-10' Depth	$750
0-10' Depth Over Existing Pipe	$650
10-20' Depth	$960
10-20' Depth Over Existing Pipe	$850
Over 20' Depth	$1,000

Table 7.2: Estimated Alternative Costs

Design Alternative	Average Cost *(per linear foot)*	Length of Pipe *(feet)*	Low Cost (-20% Contingency)	Design Cost (0% Contingency)	High Cost (50% Contingency)
North Trunk Alternative 1A with Pump Decommission	$880	5,760	$4,060,000	$5,075,000	$7,612,500
North Trunk Alternative 1B without Pump Decommission	$785	5,460	$3,440,000	$4,300,000	$6,450,000
North Trunk Alternative 2A with Pump Decommission	$940	5,560	$4,180,000	$5,225,000	$7,837,500
North Trunk Alternative 2B without Pump Decommission	$860	5,260	$3,620,000	$4,525,000	$6,787,500
South Trunk Alternative 1 with Pump Decommission	$910	5,210	$3,800,000	$4,750,000	$7,125,000
South Trunk Alternative 2 with Pump Decommission	$925	5,910	$4,380,000	$5,475,000	$8,212,500

Table 7.2: Estimated Alternative Costs (Cont.)

Design Alternative	Average Cost *(per linear foot)*	Length of Pipe *(feet)*	Low Cost (-20% Contingency)	Design Cost (0% Contingency)	High Cost (50% Contingency)
Jasmine Focus Area Alternative 1	$910	2,820	$1,980,000	$2,475,000	$3,712,500
Jasmine Focus Area Alternative 2	$800	2,700	$1,740,000	$2,175,000	$3,262,500
Jasmine Focus Area Alternative 3	$945	1,850	$1,400,000	$1,750,000*	$2,625,000
The Thumb Area Alternative 1	N/A**	N/A**	$740,360	$925,450***	$1,388,175
The Thumb Area Alternative 2	$1,130	5,400	$4,885,800	$6,107,250***	$9,160,875

*It should be noted that this pricing is for the install of the Jasmine Focus Area Alternative 3 only. An additional $100,000 should be added to the South Trunk Alternative cost if this alternative is to be used due to the extra pipe depth required. This would lead to a total cost for the Jasmine Focus Area Alternative 3 to be closer to $1,850,000.
**This option includes pipe upsizing only.
***Average Total Cost was taken from a previous review, see Appendix F – Previous Design Reports for the SW Sewer Basin Technical Memo dated August 7, 2020.

The presented cost estimates were developed to compare routes for the main trunk lines for specific areas of interest and are not comprehensive cost estimates for extending tributary sewers to serve the entire basin. Projects used as a reference for the pricing include the North Area Force Main, Desert Woods Septic to Sewer Conversion, and Southeast Interceptor Improvements. In addition to those project estimates, the bids for Phase 1 and 2A were also used to verify the assumed pricing. Comparable projects used for cost estimating the sewer extension into the SW Sewer Basin were for the construction of new sewer mains in existing City of Bend mature neighborhoods.

An average of the total project price per lineal foot of sewer was used to determine the price of construction for the alternatives. Price adjustments were made to separate construction costs based on depth, and an inflation factor of 4% over three years was added to the construction cost. Sewer that is shown to be constructed over existing sewer will have a lower price per lineal foot due to the reduction in trenching and backfill efforts. The prices include all related bid items in the referenced projects and no contingency.

8. ALTERNATIVES EVALUATIONS

Based on the review factors listed in the previous sections, this section is meant to provide the City with a comprehensive overview of all the criteria to help make a final decision for how they would like to move forward for the future of the sewer design within the basin.

8.1 North Trunk Evaluation

The main focus of the North Trunk Alternative Evaluation is to provide services to the northern edge of the SW Sewer Basin. In addition, a decision needs to be made as to whether it is feasible to include the decommissioning of the existing River Canyon #1 pump station. Both alternatives being reviewed will have the same end location, at or near the pump station, and will ultimately deliver its flow demand into the Phase 1 section of the project, previously installed.

Unlike some of the other alternatives being reviewed, the overall cost is not the primary design criteria to be considered when looking at these alternatives. This is due to the alternatives being only a difference in cost of about 3-5% depending on whether the pump station decommissioning is included or not. The larger review when it comes to the cost saving is if the City prefers to include the pump station decommissioning or not. The decommissioning of the pump station would be priced at roughly $700,000.

Even though the overall price is not as large of a factor in this review, the piping elevations should be considered. Alternative 2 has a decreased length of approximately 200 feet but due to the overall deeper depths required the cost of the project is roughly the same. This highlights the additional depth and construction issues that may be encountered when completing the construction of the deeper sections. Going deeper with the pipe trenching may require wider excavations, additional effects to the ROW/private properties and time frames for the pipe installation. These deeper sections with Alternative 2 will also be installed where there is no current piping, unlike the majority of Alternative 1.

The larger item to be considered when choosing the north alternative is the effect on the surrounding public. Alternative 1 is routed through Mahogany Street which would require the reconstruction of a heavily trafficked roadway vs the alternative of installing the main down the less used Lodgepole Drive (Alternative 2). This review also needs to look at the limited access points to the neighborhood and increased complexities needed for the detouring of Mahogany Street vs the detour routes needed for Lodgepole, which could maintain and utilize the existing access points to the north and west end of the neighborhood. Although, since both options will utilize a portion of Mahogany Street the effects will need to be reviewed for the anticipated duration of the detour which will have the largest impact to the public.

8.2 South Trunk Evaluation

The primary goal in reviewing the South Trunk Alternatives can be narrowed down to the inclusion, or not, of decommissioning the existing Poplar Pump Station. Otherwise, the start and end locations of the South Trunk Alternatives are approximately the same, Alternative 2 is about 700 feet longer. Although Alternative 2 is longer, the run of main and design will be the same through the west end of Poplar Street and the extra piping, along with the decommissioning, would be an added cost/line item and not an alternative design cost.

When coming to a determination on these alternatives the City needs to consider if the long-term effects of the pump station and associated hydrogen sulfide effect as well as the long-term operations and maintenance associated outweigh the additional cost of approximately $775,000. This cost would include the decommissioning of the station and the extra piping needed to connect and reverse flows as well as removal of electrical and structural components.

Poplar Park PS is noted as “Expected to require pump replacement in the near future” in the 2014 Collection System Public Facility Plan. Estimated cost for rehabilitation in 2014 was estimated at $100,000.

To account for annual price escalation of 3% per year for six years plus 10%/year for one year, the estimated current replacement pump station rehabilitation cost is estimated to be $130,000. Annual estimated O&M costs are estimated at $10,000/year. 20-year life cycle cost is estimated at $330,000. It is estimated that the pay off period is 40 years.

Unlike the North Alternatives above, this review does not have as big of a factor when it comes to the effect on the public. Ultimately, this is due to the fact that the majority of the main is similar in design when looking at both alternatives when it comes to pipe depth/design, detouring construction, and effects on the ROW/private properties. The main effect to evaluate comes from the long-term decision of decommissioning the pump station.

8.3 Jasmine Focus Area Evaluation

Three alternatives in the Jasmine focus area were evaluated to best feasibly serve the southeast region of the basin. The main area of focus for this alternative review is the ability to serve the largest number of future properties to best serve this area and its residents. Based on the evaluations of this region, the entire Jasmine Focus Area is not likely able to be served due to the existing topography without installing a significantly deep sewer main. The NW portion of the Jasmine Focus Area has lower elevations than the rest of the properties which make serving this area much more difficult trying to reverse grades of the piping against the natural grades of the existing surface. Due to this, that portion of the properties will need to be served by a pressure system no matter what alternative is decided upon for this review.

Unlike the other alternative reviews that are reduced down to mostly a single design element or two for review, these three alternatives have very different positive and negative aspects to their design and the decision will not be as straight forward. Ultimately, the decision for the Jasmine Focus Area will come down to properties serviced, construction schedule, and ROW/private property access and availability.

The first item to review will be the possibility for future properties to be serviced by this sewer main. As noted previously, the NW corner of this area is at a lower elevation making it infeasible to services all the properties in this area. Due to this, the goal in this area is to get the sewer main to the lowest feasible elevation to open up the greatest number of properties to be served. As is evident in the included profiles, Alternatives 1 and 2 result in the lowest initial designed invert elevations with Alternative 3 being the highest elevation at the terminus. Although, these elevations are all the lowest inverts needed to serve the connecting side streets for the routing to the Jasmine Area and all can be lowered to serve more of the focus area. Without a design plan for this region, Parametrix is unable to put a hard number to the properties served by these alternatives but can show the order of magnitude between the invert of each option.

The next item to review is the effects that the construction schedule will have on the alternatives. As noted above, Alternative 3 has the shortest routing, but this alternative is only possible during or after the construction of the South Trunk main. In addition, this option will require the South Trunk to increase its depth at the connection point and downstream of the connection to the Jasmine Focus area main. This additional depth would also add roughly $100,000 minimum to the South Trunk Alternative chosen due to the extra depth and trenching requirements. Although Alternative 3 is one of the lower alternative costs, this option can only be used if planned properly with the South Trunk project. If the Jasmine area needs to be serviced before the South Trunk is installed, another alternative will need to be used or the South Trunk segments will need to be shifted to this project area.

Lastly, ROW and private property access and availability is another aspect that needs to be reviewed in detail. Similar to the previous discussion of construction schedule, this topic greatly affects one of the design alternatives: Alternative 2. This alternative is only possible if the City is able to get easements through the affected properties, and the pipe is feasibly constructable at their property lines. Additional review and coordination between the City and the affected properties will be needed before the full effects are known on this alternative. If the layout is feasible, this alternative would allow for the cheapest construction cost, a larger amount of future properties being able to be served and the possibility of being able to install this main on an independent timeframe and schedule.

8.4 The Thumb Area Evaluation

A technical memorandum entitled Sewer Service of Southern UGB Expansion Areas Through Atwood Drive dated August 7, 2020, was completed by Parametrix and submitted to the City of Bend on October 2, 2020, and is included as an attachment in Appendix F. This report evaluated options to serve the properties referred to as Ward (east side of Highway 97) and Maverick (west side of Highway 97). This technical memorandum contained the following:

- Sewering the Ward property by a Highway 97 auger bore crossing and upsizing the currently planned Atwood sewer construction project planned for late 2020 offers significant cost savings as compared to the current Collection System Master Plan and Public Facilities Plan proposal of sewering Ward north in Parrell Road to Murphy Road.
- It was recommended the sewer main being constructed to serve the Stillwater Crossing affordable housing development be upsized to serve the entirety of the Ward property as well as a portion of the Maverick property.

The City of Bend and the Stillwater Crossing development upsized the sewer as recommended, so the upsized sewer is constructed in place to the southern limit of the Stillwater Crossing property on Atwood Drive. The decision to sewer the Ward property through Atwood (Option 1) has mostly been decided, the option to construct a more expensive sewer down Parrell Road is still an option for sewering the Ward property. Ultimately, either long-term alternative would put flows into the 18-inch Southeast Interceptor (SEI) at the Parrell/Murphy roundabout.

Since the Phase 1 and 2A designs previously constructed already accounted for the upsizing of the line through the Stillwater Crossing development, the City is in the process of pursuing this alternative. Additional main will be needed between the Stillwater Development and Ponderosa Street before a connection could be made to the Thumb. In addition, there is the added issue of having to take the sewer mains across Highway 97 at, or near, the Ponderosa/China Hat Road crossing. There will be additional coordination and permitting required with ODOT. Additionally, the highway boring will need to be specifically assessed by a geotechnical engineer and qualified boring consultant. Note that Parametrix completed a cursory evaluation of a bore by finding depth to bedrock as part of the Southern UGB Expansion Areas memo and it appears that a bore under Highway 97 is feasible. Additionally, a conservative approach to grade was used and needs to also be considered when determining the final alternative to use. Although, even with this added coordination time and effort, the overall cost reduction compared to Alternative 2 is significant.

Alternative 1 for sewering the Ward and Maverick Properties through the SW Sewer Basin provides a long-term advantage to the City vs Alternative 2 of a sewer main down Parrell Road as identified in the 2018 City of Bend Collection System Public Facility Plan (PFP). Sewering the Ward property by a Highway 97

crossing and the upsized sewer construction offers significant cost savings as compared to the current Collection System Master Plan and Public Facilities Plan. A conservative estimate shows a cost saving of over 5 million dollars.

9. ENGINEERING CONCLUSION

Based on the information provided within this report, the City of Bend has the background information to make the most educated decisions when finalizing the proposed design and project to service the SW Sewer Basin. The alternatives provided can feasibly serve the SW Sewer Basin with the pipe sizes and slopes modeled by Parametrix. These improvements will help relieve an old system, increase the properties within the City on gravity systems and provide a better designed and planned system to service the area into the future.

Appendix A

SW Sewer Basin Area

APPENDIX A

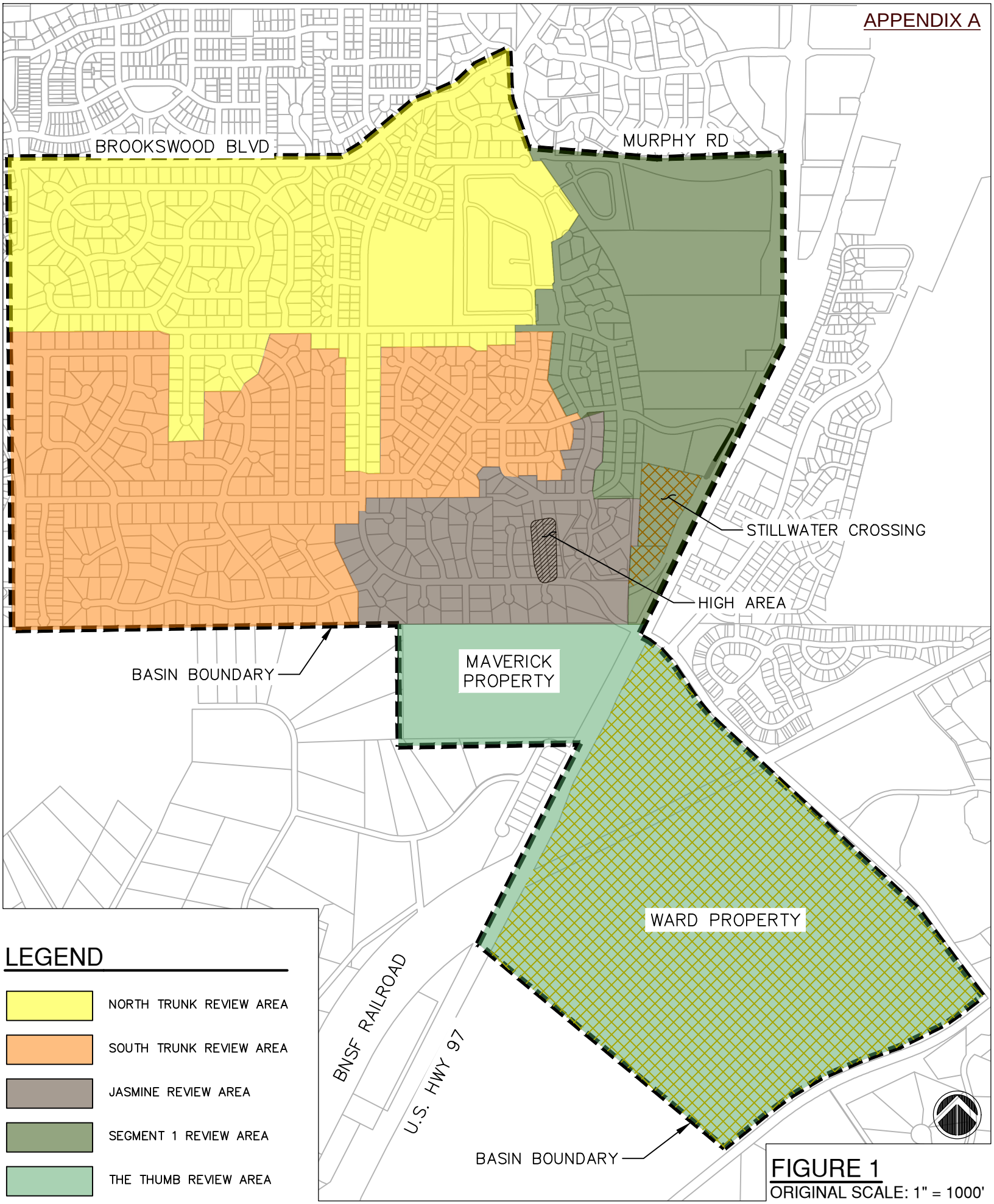


FIGURE 1
ORIGINAL SCALE: 1" = 1000'

Appendix B

Existing Topographic Information

EXISTING TOPOGRAPHY
SCALE: 1"=250'

0 125' 250' 500'
SCALE: 1" = 250'

Elevations Table				
Number	Minimum Elevation	Maximum Elevation	Area	Color
1	3780.00	3815.00	9504332.04	
2	3815.00	3820.00	2976462.88	
3	3820.00	3825.00	3826713.47	
4	3825.00	3830.00	5581919.71	
5	3830.00	3835.00	7349404.30	
6	3835.00	3840.00	8325014.84	
7	3840.00	3845.00	6721757.25	
8	3845.00	3850.00	6966873.05	
9	3850.00	3855.00	6398336.39	
10	3855.00	3880.00	10543352.16	

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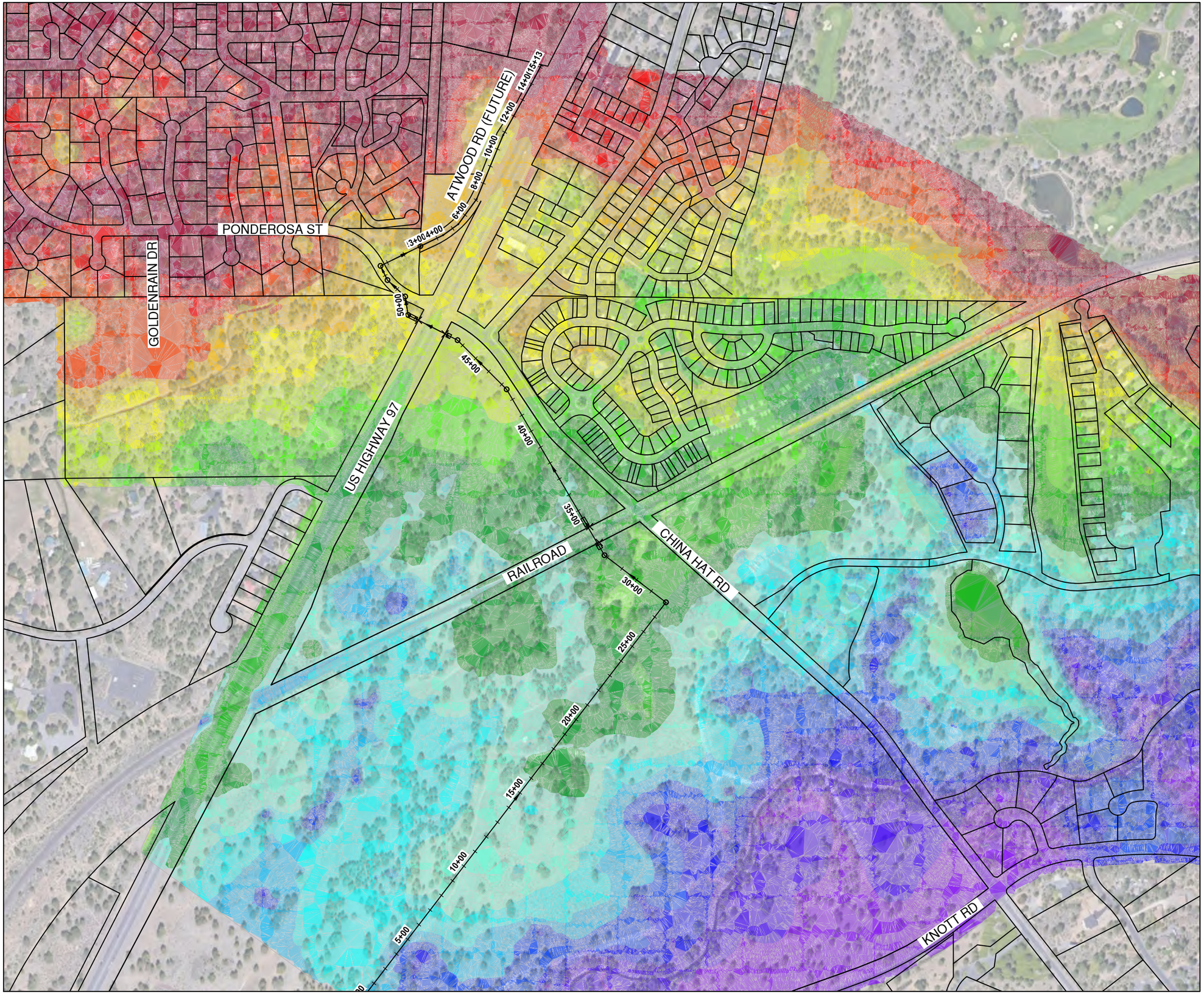

CONCEPTUAL WARD SEWER OVERVIEW: 1"=250'

0 125' 250' 500'
SCALE: 1" = 250'

Elevations Table			
Number	Minimum Elevation	Maximum Elevation	Color
1	3679	3830	
2	3830	3835	
3	3835	3840	
4	3840	3845	
5	3845	3850	
6	3850	3855	
7	3855	3860	
8	3860	3865	
9	3865	3870	
10	3870	3875	
11	3875	3880	
12	3880	3885	
13	3885	3890	
14	3890	3895	
15	3895	3900	
16	3900	3918	

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Appendix C

Phase 1 and 2A Record Drawings

APPENDIX C

SW SEWER PHASES 1 & 2A

FEBRUARY 2021

PROJECT #1SAMM

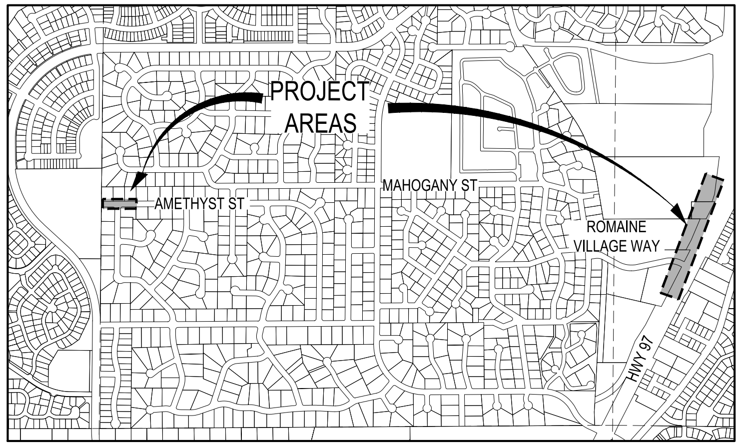
CITY OF BEND

DESCHUTES COUNTY, OREGON

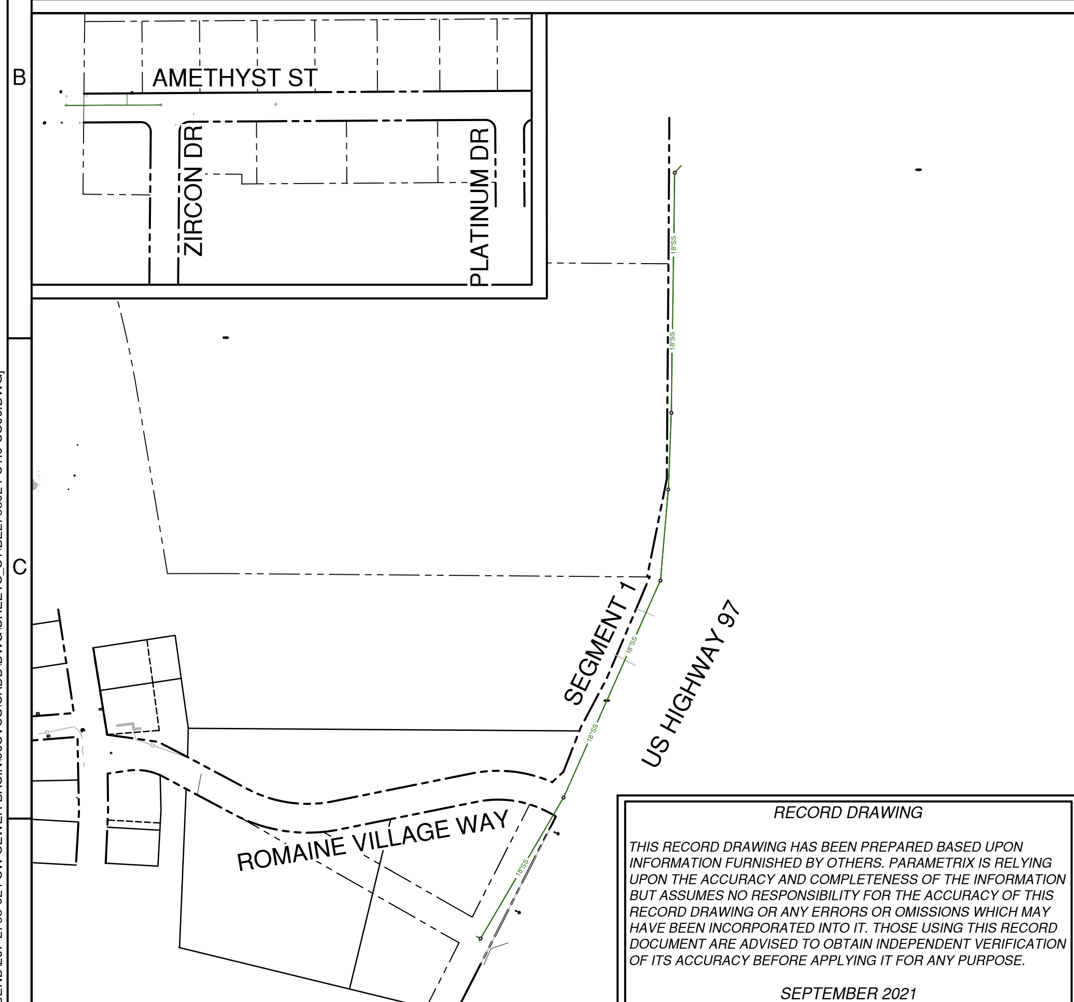
CITY OF BEND

OWNER:

CITY OF BEND
710 SW WALL STREET
BEND, OREGON, 97701
(541) 388-5505



PROJECT LOCATION
SCALE: 1" = 1000'



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SEPTEMBER 2021

VICINITY MAP
SCALE: 1" = 200'

HORIZONTAL DATUM:
HORIZONTAL DATUM FOR THIS SURVEY IS NAD 1983(91).

PROJECTION IS CENTRAL OREGON COORDINATE SYSTEM (COCS), INTERNATIONAL FEET.

VERIFICATION TIE TO CENTRAL OREGON COORDINATE SYSTEM CONTROL POINT B012, PUBLISHED BY THE DESCHUTES COUNTY SURVEYORS OFFICE.

POINT DESIGNATION B012
NORTHING: 370481.63
EASTING: 3290848.45

VERTICAL DATUM:
VERTICAL DATUM IS NGVD29 BASED ON THE CENTRAL OREGON OREGON COORDINATES SYSTEM (COCS).

VERIFICATION TIE TO CENTRAL OREGON COORDINATE SYSTEM CONTROL POINT B012, PUBLISHED BY THE DESCHUTES COUNTY SURVEYORS OFFICE.

POINT DESIGNATION B012
ELEVATION: 3791.85

LEGEND:

EXISTING / PROPOSED
BENCHMARK (FOUND)
BENCHMARK (SET)
CATCH BASIN (CB)
CLEANOUT (CO)
CONCRETE
CONIFEROUS TREE (TO BE REMOVED)
CONTROL MON
DECIDUOUS TREE
DITCH INLET
GAS METER (GM)
GAS VALVE (GV)
GRAVEL
GUY WIRE
MAILBOX
MONUMENT (FOUND)
MONUMENT (SET)
SANITARY MANHOLE
SIGN

EXISTING / PROPOSED
TELEPHONE RISER
TELEPHONE MANHOLE
UTILITY POLE
UTILITY POLE/LIGHT
UTILITY VAULT W/ MANHOLE
WATER AIR RELEASE VALVE
WATER FIRE DEPT CONNECTION
WATER FIRE HYDRANT
WATER VALVE
WATER METER (WM)

EXISTING / PROPOSED
BANK (BOTTOM)
BANK (TOP
CABLE TV
CANAL
CENTERLINE
DITCH (CENTER)
EDGE OF CONCRETE
EDGE OF GRAVEL
EDGE OF PAVEMENT
EASEMENT
FENCE (OTHER)
FENCE (SILT)
FENCE (STEEL)
FENCE (WOOD)
FIBER OPTICS
FORCE MAIN
GAS
GRADE BREAK
GUARDRAIL
IRRIGATION
JERSEY BARRIER
PAVEMENT REPAIR
PROPERTY BOUNDARY

EXISTING / PROPOSED
POWER
POWER (OVERHEAD)
RAILROAD
CANAL
PRESSURE SEWER
SANITARY SEWER
SANITARY SEWER SERVICE IN ROW
SANITARY SEWER SERVICE- PRIVATE
STORM DRAIN
TELEPHONE
WATER

PARAMETRIX PRIMARY STATIC CONTROL

POINT NO.	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	367629.51	3284029.45	3855.24	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 1
2	371467.51	3283996.00	3843.66	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 2
3	372352.85	3288214.83	3837.26	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 3
4	370537.93	3290845.50	3793.84	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 4
5	367474.04	3289429.32	3847.49	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 5
6	369971.76	3288430.31	3815.44	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 6
7	369955.07	3285401.20	3846.54	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 7

APPROVALS:

EIPD DIRECTOR:
NOTE: SIGNATURE DOES NOT GRANT APPROVAL TO COMMENCE CONSTRUCTION.

Sheet List Table

Sheet Number	Sheet Number	Sheet Title
1	C1.0	COVER SHEET
2	C1.1	GENERAL NOTES
3	C2.0	KEY MAP
4	C3.1	DEMOLITION PLAN
5	C3.2	DEMOLITION PLAN
6	C3.3	DEMOLITION PLAN
7	C4.0	EROSION & SEDIMENT CONTROL COVER SHEET
8	C4.1	EROSION & SEDIMENT CONTROL PLAN
9	C4.2	EROSION & SEDIMENT CONTROL PLAN
10	C4.3	EROSION & SEDIMENT CONTROL DETAILS
11	C5.0	BYPASS PLANS
12	C6.1	PLAN & PROFILE - STA 5+00 TO 11+50
13	C6.2	PLAN & PROFILE - STA 11+50 TO 19+00
14	C6.3	PLAN & PROFILE - STA 1+00 TO 3+20
15	C6.4	PLAN & PROFILE - STA 19+00 TO 22+50
16	C7.0	TYPICAL SECTIONS
17	C7.1	ROADWAY PLAN & PROFILE
18	C7.2	ROADWAY PLAN & PROFILE
19	C7.3	ROADWAY PLAN & PROFILE
20	C7.4	ROADWAY PLAN & PROFILE
21	C8.0	CITY OF BEND DETAILS
22	C9.0	HWY 97 TRAFFIC CONTROL PLAN
23	C9.1	PEDESTRIAN DETOUR PLAN
24	C10.0	EASEMENT & CONSTRUCTION LAYDOWN

RECORD DRAWINGS

SW SEWER BASIN
PHASES 1 & 2A
COVER SHEET
BEND, OREGON

CITY OF BEND

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DESIGNED BY: JEF/NWB
DRAWN BY: BAE
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FILE: BE2763024-C1.0-CS00.dwg
DATE: 9/28/2021

VERIFY SCALES
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BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C1.0

1 OF 24

COB # 1SAMM

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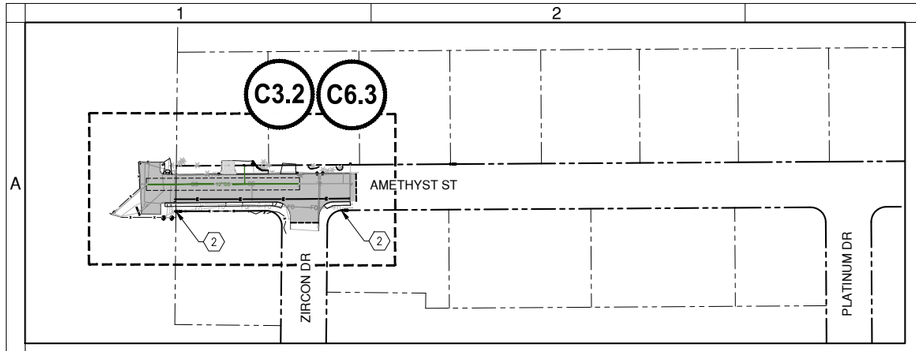
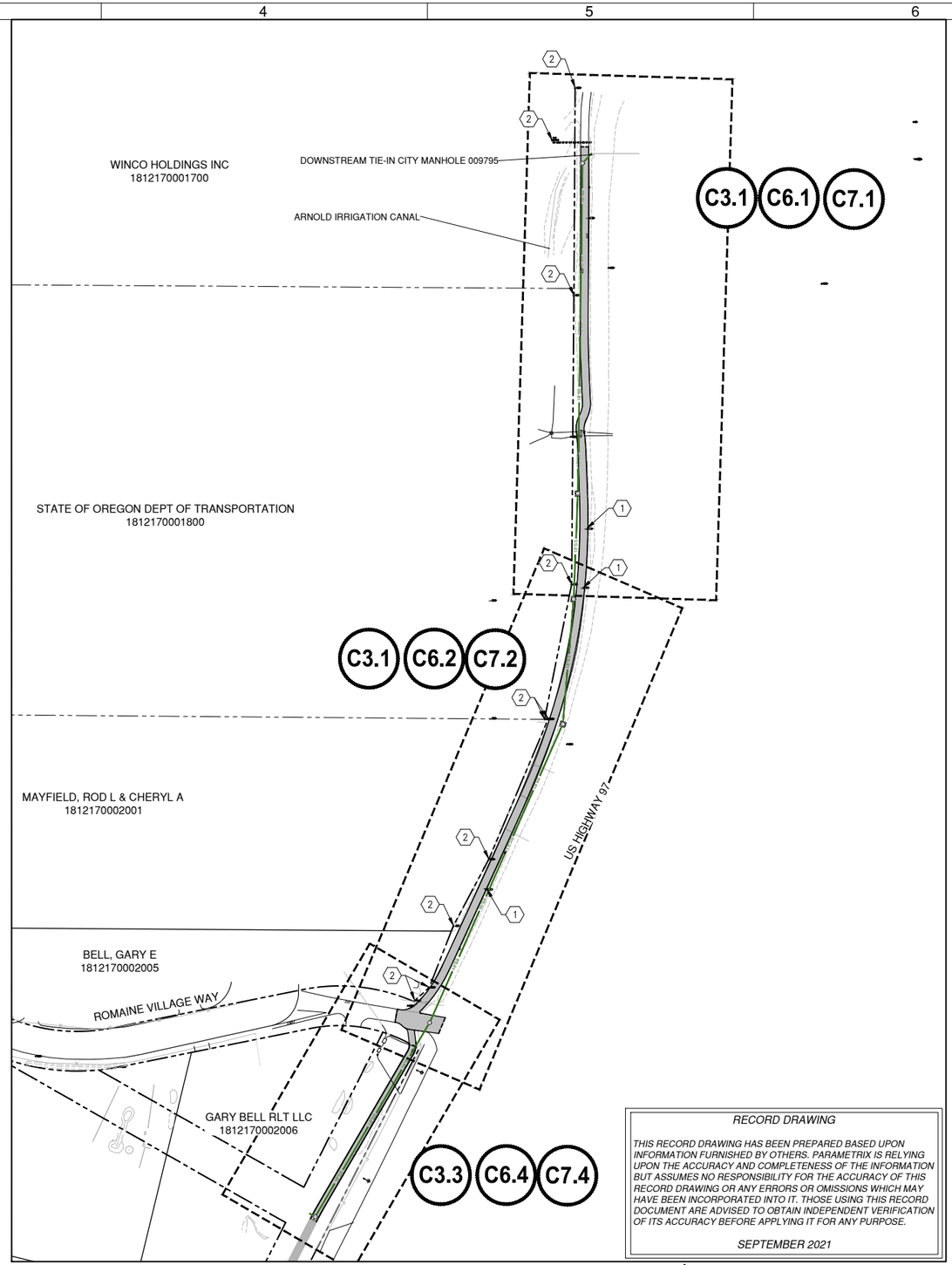


PHASE 1 OVERVIEW MAP

SCALE: 1" = 100'



CONSTRUCTION NOTES

1. SURVEY MONUMENT TO BE RESET BY OTHERS
2. SURVEY MONUMENT, PROTECT IN PLACE

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SEPTEMBER 2021

PHASE 2A OVERVIEW MAP

SCALE: 1" = 100'

N

RECORD DRAWINGS

SW SEWER BASIN
PHASES 1 & 2A
KEY MAP

BEND, OREGON

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DESIGNED BY: JEF/NWB
DRAWN BY: BAE
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DATE: 9/28/2021

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3 OF 24

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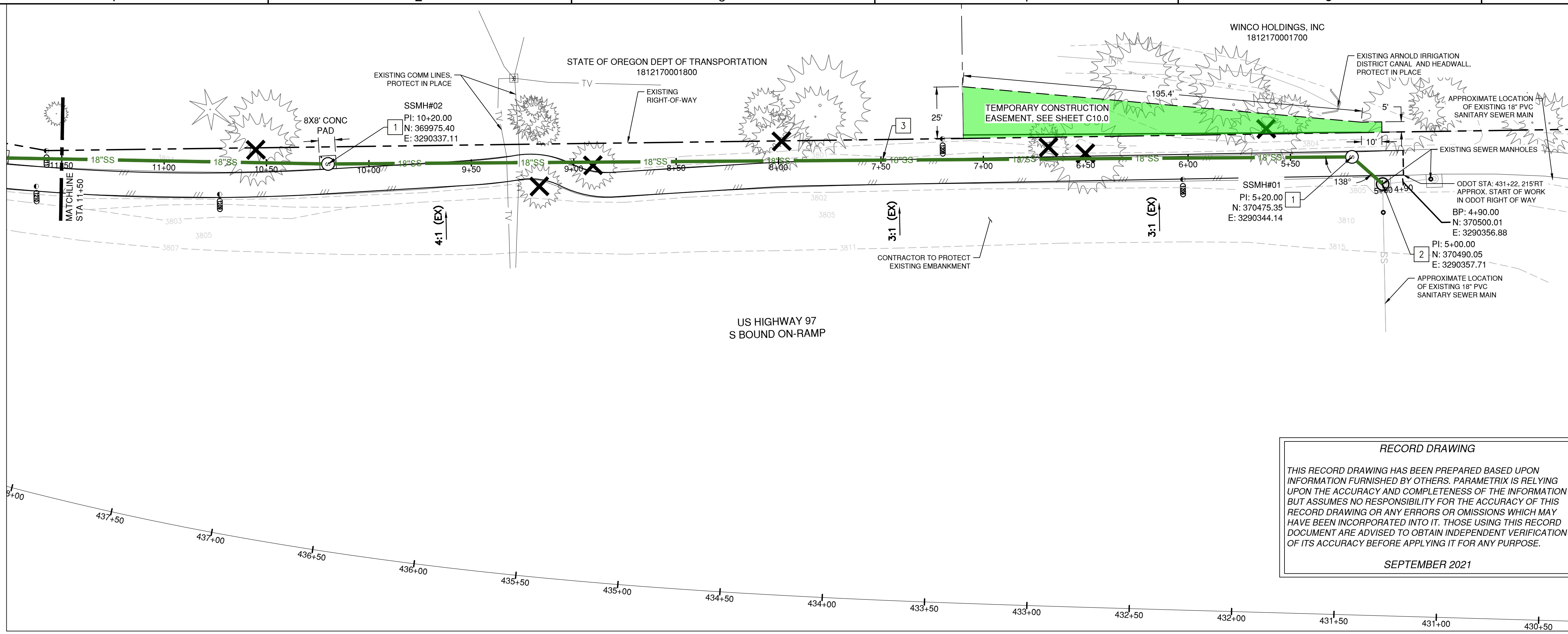

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SEPTEMBER 2021

SEWER CONSTRUCTION NOTES

1. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE
2. CONNECT TO EXISTING 60"Ø HDPE MANHOLE PER DETAIL ON SHEET ####
3. INSTALL 18" SEWER MAIN PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.0

PROPOSED SEWER PLAN

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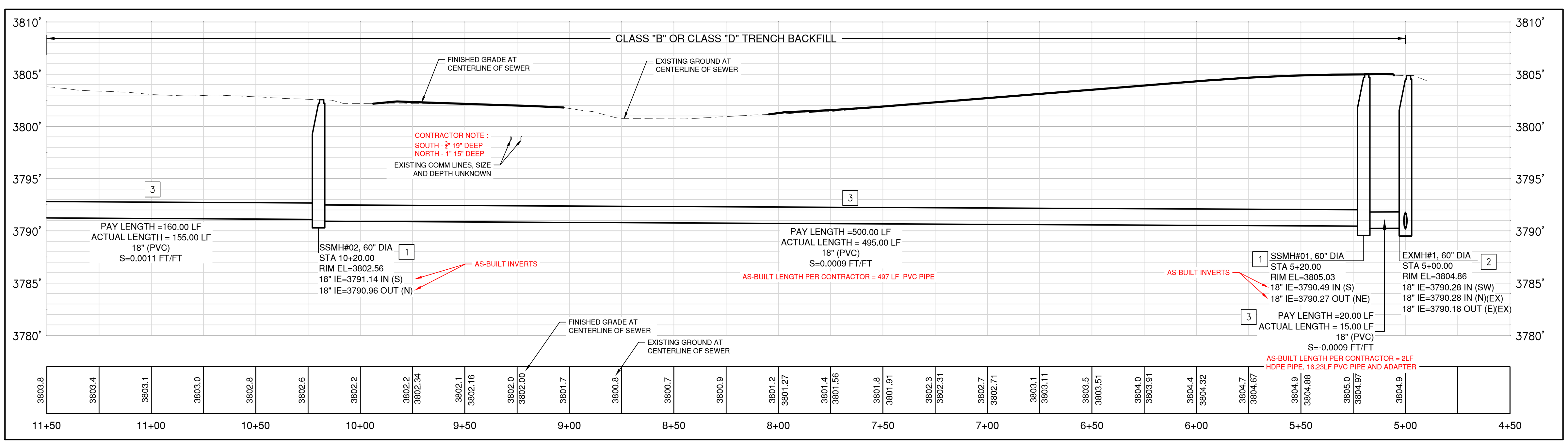
0 15' 30' 60'
SCALE: 1" = 30'



PROPOSED SEWER - PROFILE

SCALE: H: 1" = 30 V: 1" = 6

0 15' 30' 60'
HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'

RECORD DRAWINGS

SW SEWER BASIN
PHASE 2A
PLAN & PROFILE - STA 5+00 TO 11+50
BEND, OREGON

CITY OF BEND

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DESIGNED BY: JEF/NWB
DRAWN BY: BAE
SCALE: AS SHOWN
FILE:
DATE: 9/28/2021

VERIFY SCALES
0 1"
BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.1

12 OF 24

COB # 1SAMM

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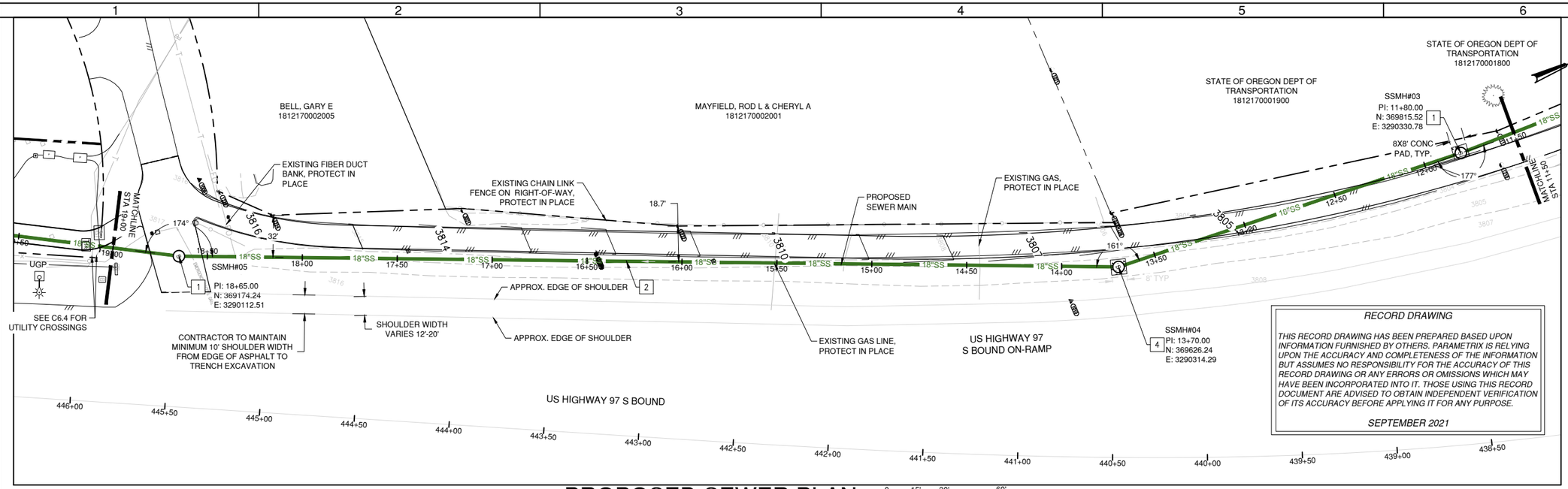


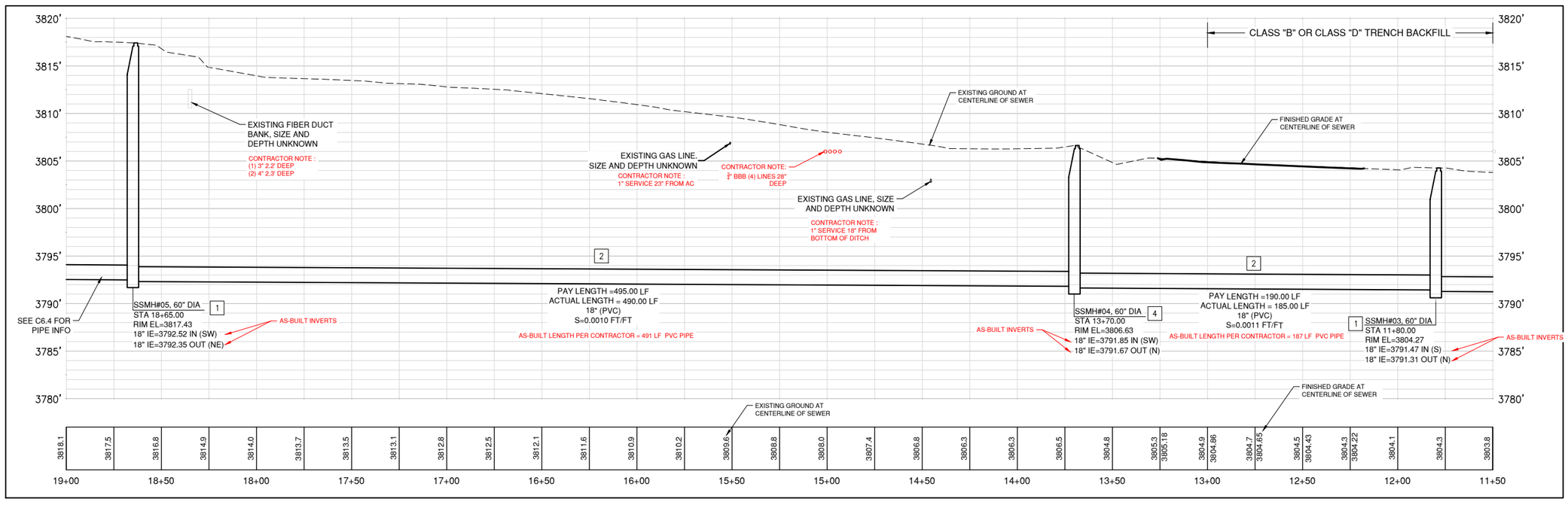
SEWER CONSTRUCTION NOTES

1. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE
2. INSTALL 18" SEWER MAIN PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.0
3. NOT USED
4. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE AND LOCKING LID

PROPOSED SEWER PLAN

SCALE: 1" = 30'

SCALE: 1" = 30'



PROPOSED SEWER - PROFILE

SCALE: H: 1" = 30 V: 1" = 6

HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'

RECORD DRAWINGS

SW SEWER BASIN
PHASE 2A

PLAN & PROFILE - STA 11+50 TO 19+00

BEND, OREGON

CITY OF BEND

REVISIONS:

Parametrix
ENGINEERING | PLANNING | ENVIRONMENTAL SCIENCES
350 NW PACIFIC PARK LANE, SUITE 110 | BEND, OR 97701
P 541.508.7710
WWW.PARAMETRIX.COM

DESIGNED BY: JEF/NWB
DRAWN BY: BAE
SCALE: AS SHOWN
FILE: IE\278324-09.3.PPP00.dwg
DATE: 9/28/2021

VERIFY SCALES
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BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.2
13 OF 24

COB # 1SAMM

[DATE: 9/28/2021 12:05:21 PM] [AUTHOR: LUC FRIEDENFELS] [STYLE: PMX BW.CTB]
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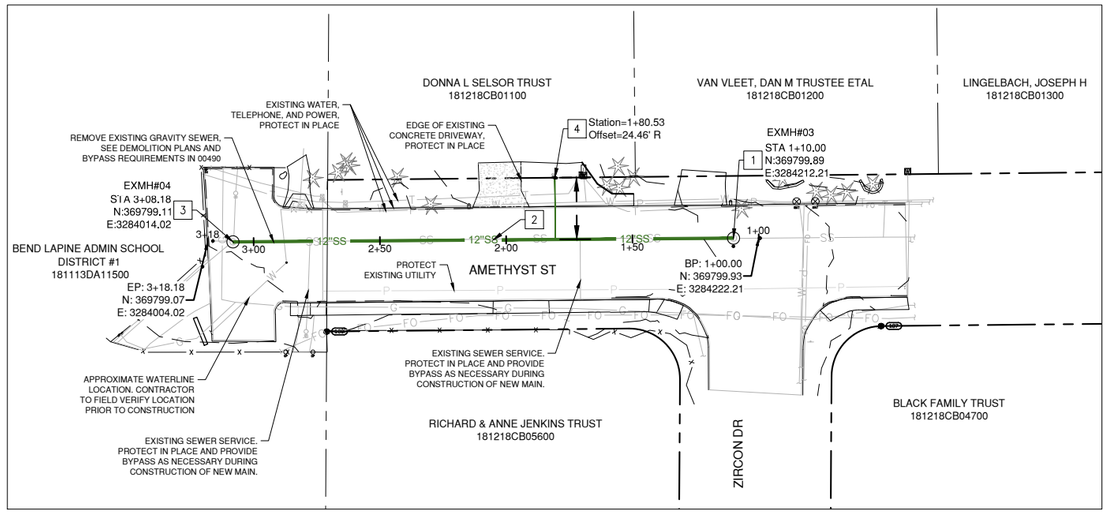


PROPOSED SEWER PLAN

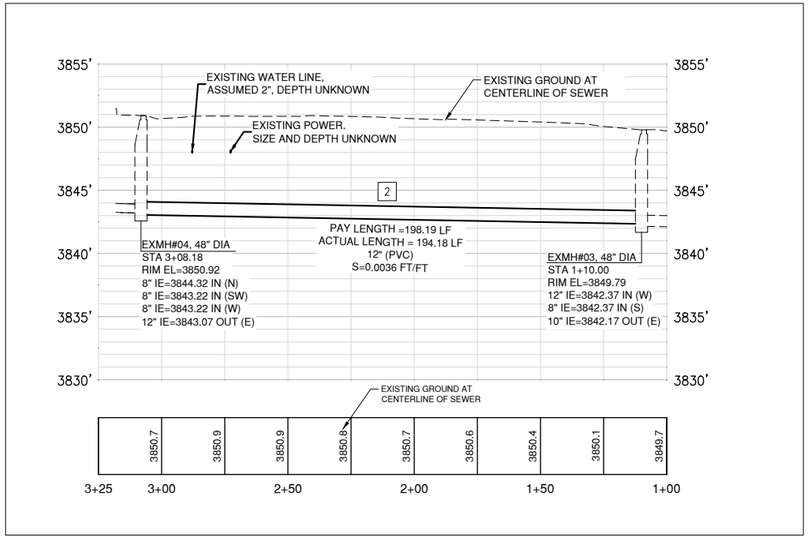
SCALE: 1" = 30'

0 15' 30' 60'

SCALE: 1" = 30'

SEWER CONSTRUCTION NOTES

1. REMOVE EXISTING SEWER MAIN AND CORE EXISTING 48" MANHOLE FOR NEW 12" PIPE. CHIP EXISTING CHANNEL AND REFORM FOR NEW PIPE
2. INSTALL 12" PIPE PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.0
3. REMOVE EXISTING SEWER MAIN AND CORE EXISTING 48" MANHOLE FOR NEW 12" PIPE. CHIP EXISTING CHANNEL AND REFORM FOR NEW PIPE
4. INSTALL SEWER SERVICE PER COB STD. DWG. S-2 AS MODIFIED BY PARAMETRIX ON C8.3. 5" STUB IE AT PROPERTY LINE =3844.5



PROPOSED SEWER - PROFILE

SCALE: H: 1" = 30 V: 1" = 6

0 15' 30' 60'

0

3'

6'

HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'

RECORD DRAWING

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SEPTEMBER 2021

RECORD DRAWINGS

SW SEWER BASIN
PHASE 1
PLAN & PROFILE - STA 1+00 TO 3+20
BEND, OREGON

CITY OF BEND

REVISIONS:

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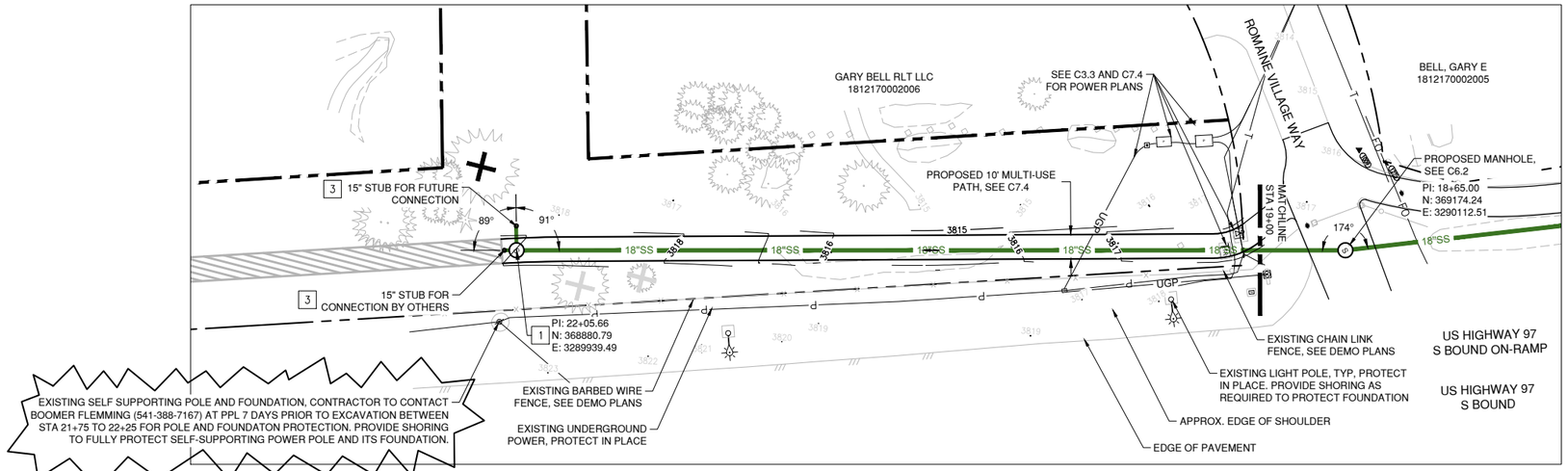
DRAWN BY: BAE
SCALE: AS SHOWN
FILE: 182763024-C6.3-PP00.dwg
DATE: 9/28/2021

VERIFY SCALES
0 1"
BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.3

14 OF 24

COB # 1SAMM



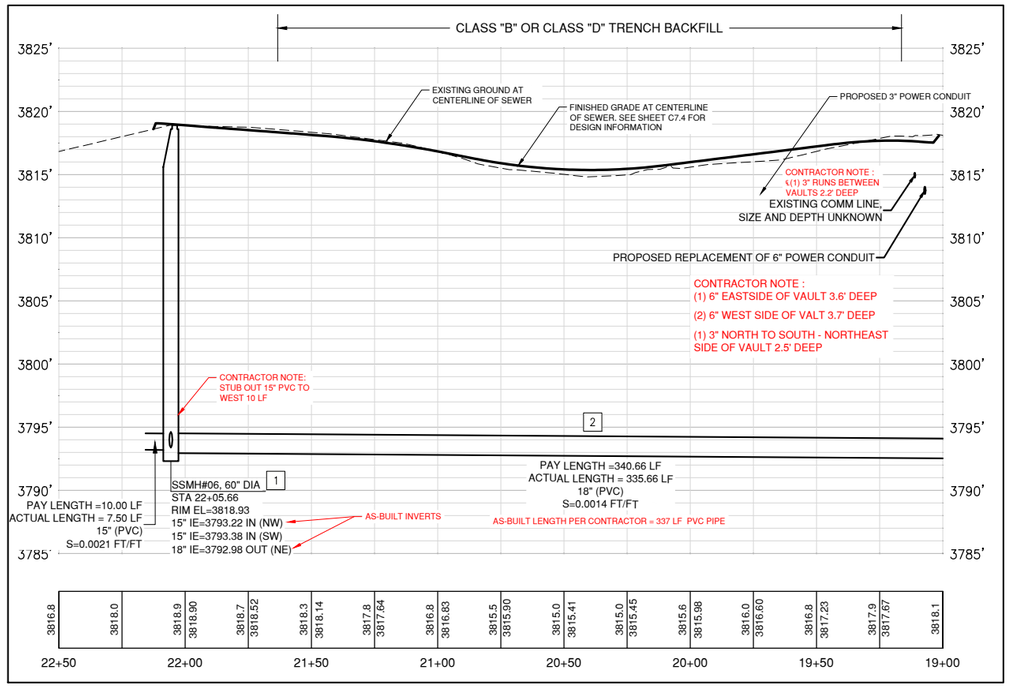
SEWER CONSTRUCTION NOTES

1. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE
2. INSTALL 18" SEWER MAIN PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.0
3. INSTALL 15" SEWER MAIN STUB PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.0

PROPOSED SEWER PLAN

SCALE: 1" = 30'

0 15' 30' 60'
SCALE: 1" = 30'



PROPOSED SEWER - PROFILE

SCALE: H: 1" = 30 V: 1" = 6

0 15' 30' 60'
0
3'
6'
HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'

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SEPTEMBER 2021

RECORD DRAWINGS

SW SEWER BASIN
PHASE 2A
PLAN & PROFILE - STA 19+00 TO 22+50
BEND, OREGON

CITY OF BEND

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DRAWN BY: BAE
SCALE: AS SHOWN
FILE: 8623024-C6.4-PP00.dwg
DATE: 9/28/2021

VERIFY SCALES
0 1"
BAR EQUALS ONE INCH
ON ORIGINAL DRAWING

SHEET: C6.4

15 OF 24

COB # 1SAMM

[DATE: 9/28/2021 1:07:18 PM] [AUTHOR: LUC FRIEDENFELS] [STYLE: PMX BW.CTB]
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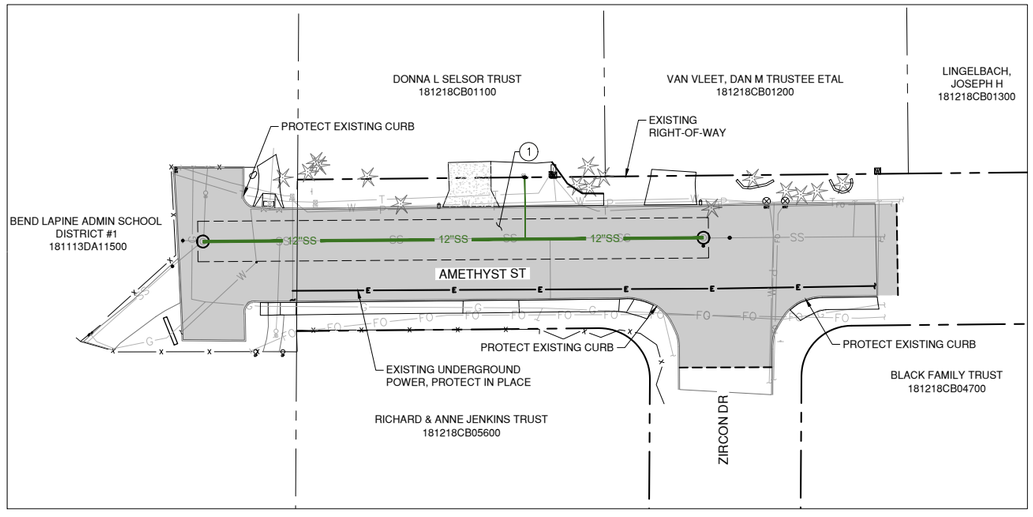

AMETHYST ST PLAN

SCALE: 1" = 30'

0 15' 30' 60'

SCALE: 1" = 30'

N

LEGEND

- EXISTING ROW
- EXISTING 1' CONTOUR
- PROPOSED 1' CONTOUR
- SAWCUT
- ASPHALT: SEE WCD08
- ASPHALT: SHARED-USE-PATH SEE SHEET C7.0

CONSTRUCTION NOTES

1. PAVING AND RESTORATION AREA PER WCD 08

RECORD DRAWING

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SEPTEMBER 2021

RECORD DRAWINGS

SW SEWER BASIN
PHASE 1
ROADWAY PLAN & PROFILE
BEND, OREGON

CITY OF BEND

REVISIONS:

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DESIGNED BY: JEF/NWB
DRAWN BY: KE
SCALE: AS SHOWN
FILE: BE2763024-C7.3-PP00.dwg
DATE: 9/28/2021

VERIFY SCALES
0 1"
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SHEET: C7.3

19 OF 24

COB # 1SAMM

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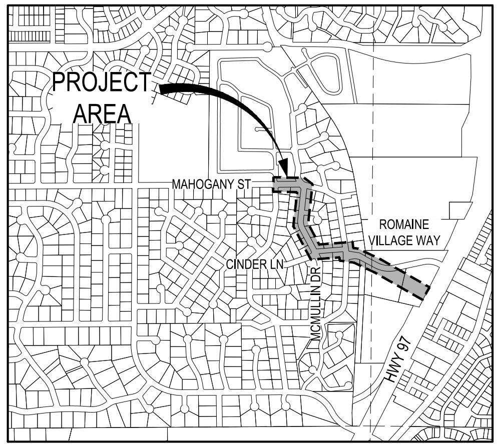
Appendix D

Phase 2B Construction Plans

SW SEWER BASIN PHASE 2B



PROJECT LOCATION

SCALE: 1" = 1000'

CITY OF BEND

JUNE 2021

PROJECT #1SAMM

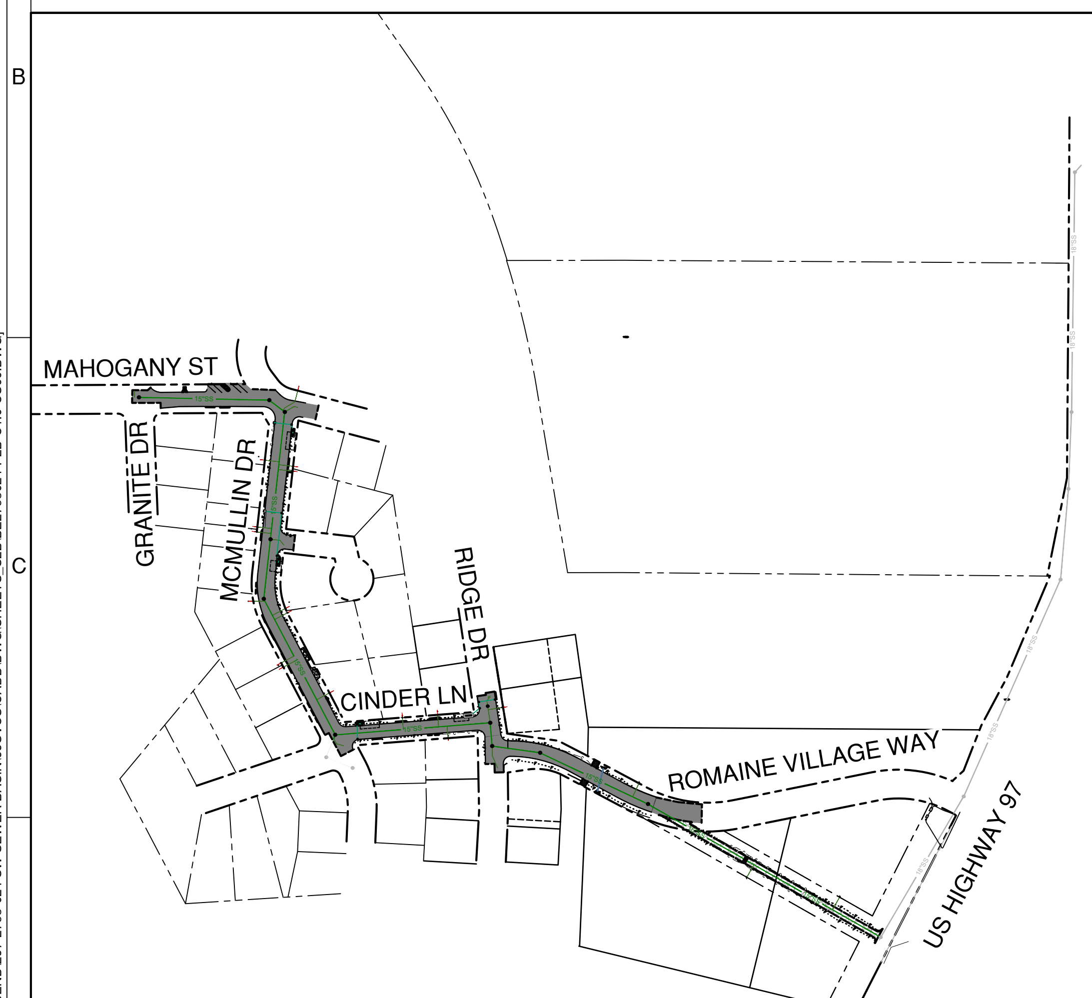
CITY OF BEND

DESCHUTES COUNTY, OREGON

OWNER:

CITY OF BEND

710 SW WALL STREET
BEND, OREGON, 97701
(541) 388-5505



VICINITY MAP

SCALE: 1" = 200'

HORIZONTAL DATUM:
HORIZONTAL DATUM FOR THIS SURVEY IS NAD 1983(91).

PROJECTION IS CENTRAL OREGON COORDINATE SYSTEM (COCS), INTERNATIONAL FEET.

VERIFICATION TIE TO CENTRAL OREGON COORDINATE SYSTEM CONTROL POINT B012, PUBLISHED BY THE DESCHUTES COUNTY SURVEYORS OFFICE.

POINT DESIGNATION B012
NORTHING: 370481.63
EASTING: 3290848.45

VERTICAL DATUM:
VERTICAL DATUM IS NGVD29 BASED ON THE CENTRAL OREGON OREGON COORDINATES SYSTEM (COCS).

VERIFICATION TIE TO CENTRAL OREGON COORDINATE SYSTEM CONTROL POINT B012, PUBLISHED BY THE DESCHUTES COUNTY SURVEYORS OFFICE.

POINT DESIGNATION B012
ELEVATION: 3791.85

LEGEND:

EXISTING / PROPOSED

- BENCHMARK (FOUND)
- BENCHMARK (SET)
- CATCH BASIN (CB)
- CLEANOUT (CO)
- CONCRETE
- CONIFEROUS TREE (TO BE REMOVED)
- CONTROL MON
- DECIDUOUS TREE
- DITCH INLET
- GAS METER (GM)
- GAS VALVE (GV)
- GRAVEL
- GUY WIRE
- MAILBOX
- MONUMENT (FOUND)
- MONUMENT (SET)
- SANITARY MANHOLE
- SIGN

EXISTING / PROPOSED

- TELEPHONE RISER
- TELEPHONE MANHOLE
- UTILITY POLE
- UTILITY POLE/LIGHT
- UTILITY VAULT W/ MANHOLE
- WATER AIR RELEASE VALVE
- WATER FIRE DEPT CONNECTION
- WATER FIRE HYDRANT
- WATER VALVE
- WATER METER (WM)

EXISTING / PROPOSED

- BANK (BOTTOM)
- BANK (TOP
- CABLE TV
- CANAL
- CENTERLINE
- DITCH (CENTER)
- EDGE OF CONCRETE
- EDGE OF GRAVEL
- EDGE OF PAVEMENT
- EASEMENT
- FENCE (OTHER)
- FENCE (SILT)
- FENCE (STEEL)
- FENCE (WOOD)
- FIBER OPTICS
- FORCE MAIN
- GAS
- GRADE BREAK
- GUARDRAIL
- IRRIGATION
- JERSEY BARRIER
- PAVEMENT REPAIR
- PROPERTY BOUNDARY

EXISTING / PROPOSED

- POWER
- POWER (OVERHEAD)
- RAILROAD
- CANAL
- PRESSURE SEWER
- SANITARY SEWER
- SANITARY SEWER SERVICE IN ROW
- SANITARY SEWER SERVICE- PRIVATE
- STORM DRAIN
- TELEPHONE
- WATER

PARAMETRIX PRIMARY STATIC CONTROL

POINT NO.	NORTHING	EASTING	ELEVATION	DESCRIPTION
1	367629.51	3284029.45	3855.24	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 1
2	371467.51	3283996.00	3843.66	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 2
3	372352.85	3288214.83	3837.26	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 3
4	370537.93	3290845.50	3793.84	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 4
5	367474.04	3289429.32	3847.49	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 5
6	369971.76	3288430.31	3815.44	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 6
7	369955.07	3285401.20	3846.54	SET 1 INCH COPPER PLUG STAMPED PARAMETRIX 7

APPROVALS:

EIPD DIRECTOR:

NOTE: SIGNATURE DOES NOT GRANT APPROVAL TO COMMENCE CONSTRUCTION.

Sheet List Table

CONFORMED DRAWINGS

REGISTERED PROFESSIONAL ENGINEER
W. BOGGS
2008
NOT FOR CONSTRUCTION
EXPIRES 12-31-21

SW SEWER BASIN PHASE 2B
COVER SHEET
BEND, OREGON

CITY OF BEND

REVISIONS:

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DRAWN BY: BAE
SCALE: AS SHOWN
FILE: BE2763024-P2B-C1.0-CS00.dwg
DATE: 6/7/2021

VERIFY SCALES
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BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C1.0

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COB # 1SAMM

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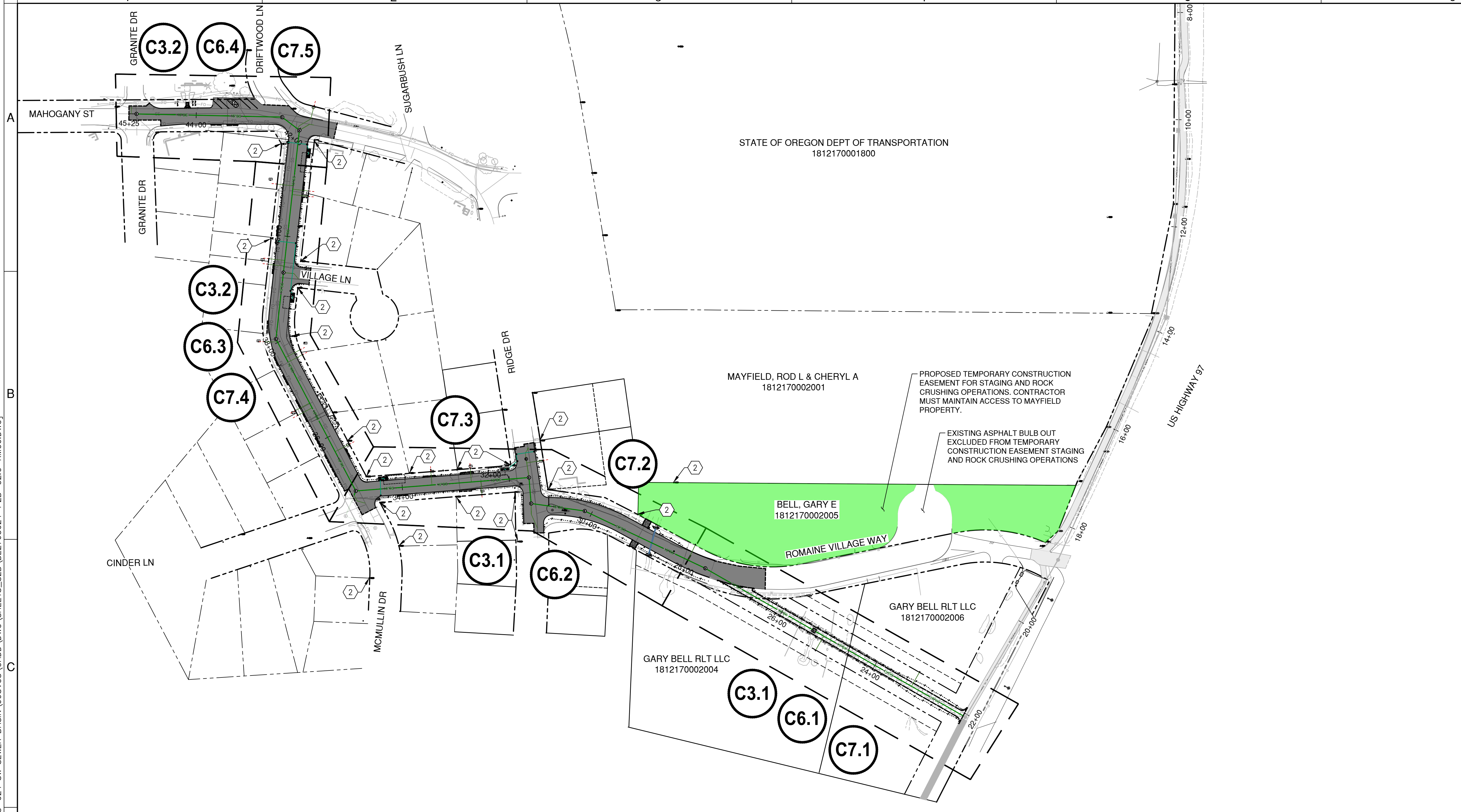

PHASE 2B OVERVIEW MAP

SCALE: 1" = 100'

CONSTRUCTION NOTES

1. SURVEY MONUMENT TO BE RESET BY OTHERS
2. SURVEY MONUMENT, PROTECT IN PLACE

CONFORMED DRAWINGS

REGISTERED PROFESSIONAL ENGINEER — W. BOGGS — NOT FOR CONSTRUCTION — EXPIRES 12-31-21

SW SEWER BASIN PHASE 2B

KEY MAP

BEND, OREGON

CITY OF BEND

REVISIONS:

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DRAWN BY: BAE
SCALE: AS SHOWN
FILE: BE2763024-P2B-C2.0-KM00.dwg
DATE: 6/7/2021

VERIFY SCALES
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BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C2.0

03 OF 33

COB # 1SAMM

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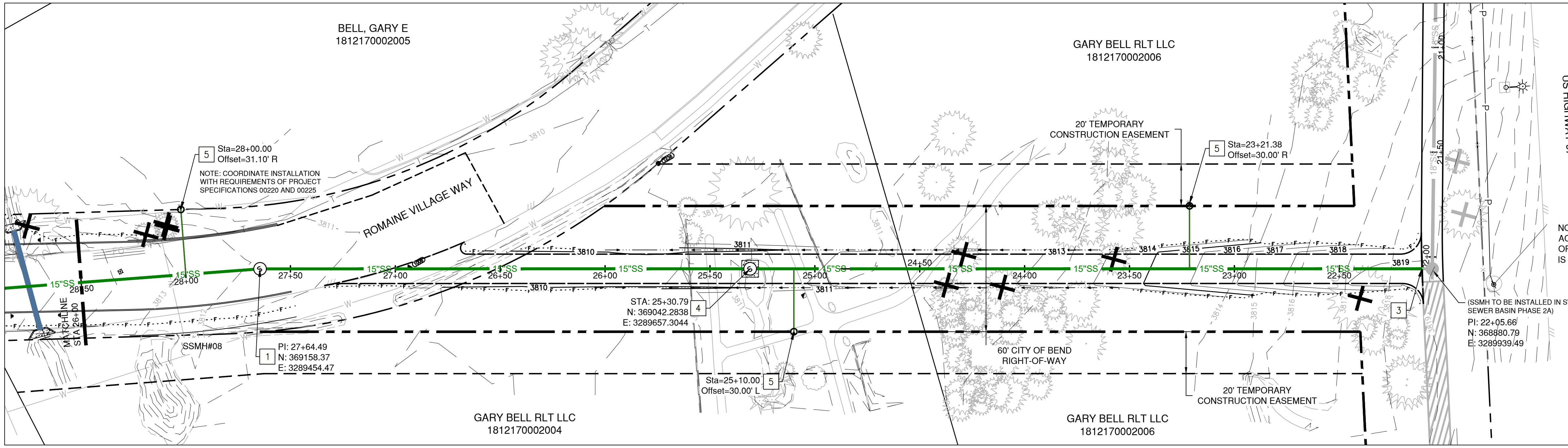


PROPOSED SEWER PLAN

SCALE: 1" = 30'

SCALE: 1" = 30'

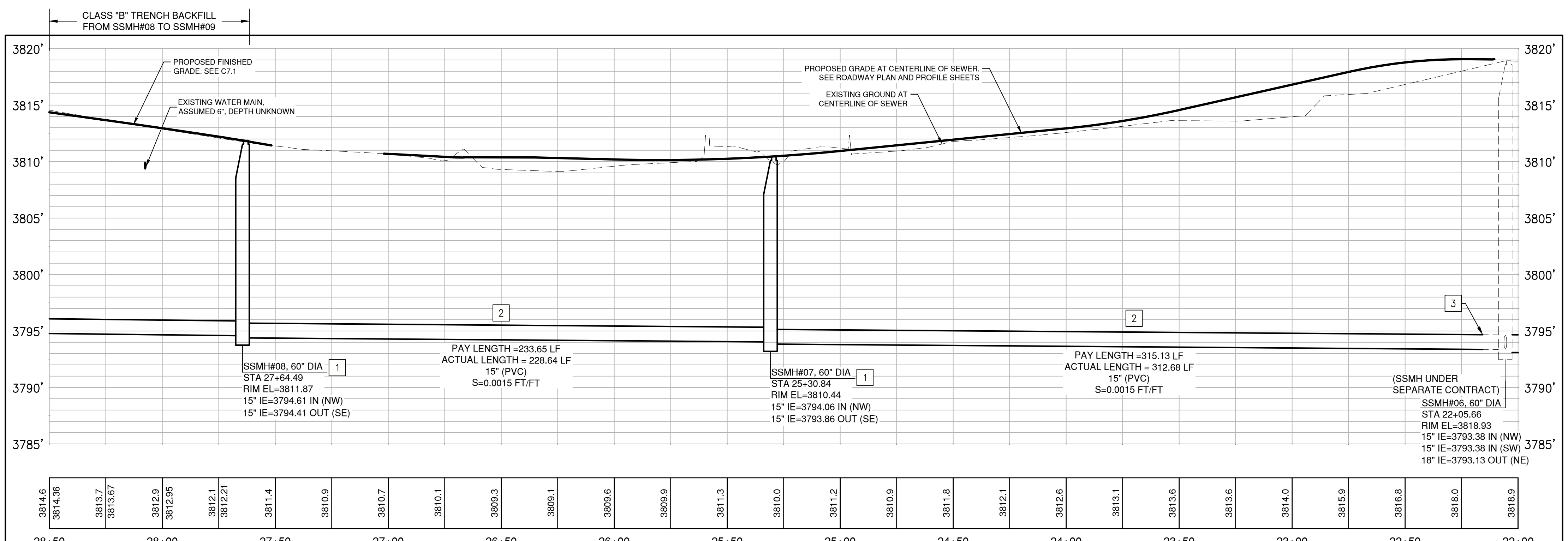
SEWER CONSTRUCTION NOTES

1. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE PER COB STD DWG S-3B
2. INSTALL 15" SEWER MAIN PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.2
3. CONNECT TO PIPE 15" STUB TO BE INSTALLED UNDER SEPARATE CONTRACT. NO PAYMENT TO BE MADE FOR CONNECTION TO EXISTING STRUCTURE AT THIS LOCATION.
4. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE AND LOCKING LID.

5. INSTALL 6" SEWER SERVICE PER COB STD. DWG. S-2 AS MODIFIED BY PARAMETRIX ON C8.3. SEWER SERVICE DEPTH TO BE 8' DEEP AT RIGHT-OF-WAY.

GENERAL NOTES

1. CONTRACTOR MUST MAINTAIN ACCESS TO 60957 S HWY 97 PER 00220. THIS MAY INCLUDE SHORT TERM ACCESS ACROSS NON-ROMAINE VILLAGE WAY PORTION OF TAX LOT 1812170002005



PROPOSED SEWER - PROFILE

SCALE: H: 1" = 30 V: 1" = 6

HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'

CONFORMED DRAWINGS

NOT FOR CONSTRUCTION
EXPIRES 12-31-21

SW SEWER BASIN PHASE 2B

PLAN & PROFILE - STA 22+00 TO 28+50

BEND, OREGON

CITY OF BEND

REVISIONS:

Parametrix
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WWW.PARAMETRIX.COM

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DRAWN BY: BAE
SCALE: AS SHOWN
FILE: BE2763024-P2B-C6.1-PP00.dwg
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VERIFY SCALES
BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.1

11 OF 33

COB # 1SAMM

[DATE: 6/7/2021 10:08:27 AM] [AUTHOR: BEN EWING] [STYLE: PMX BW CTB]
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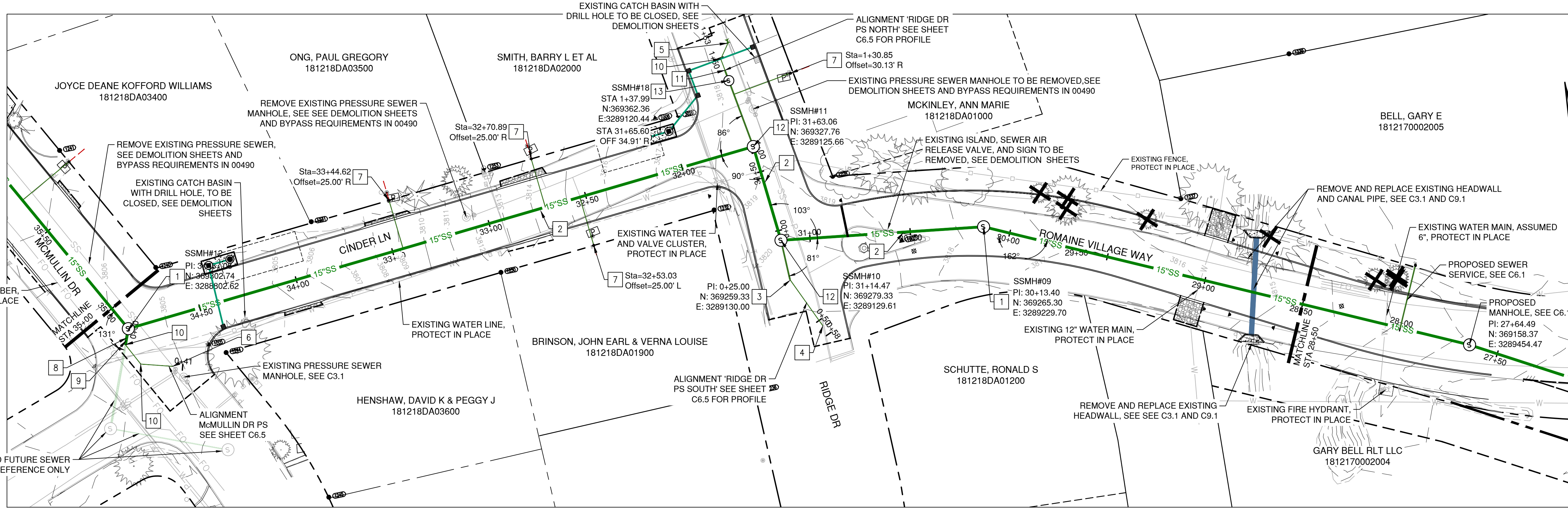
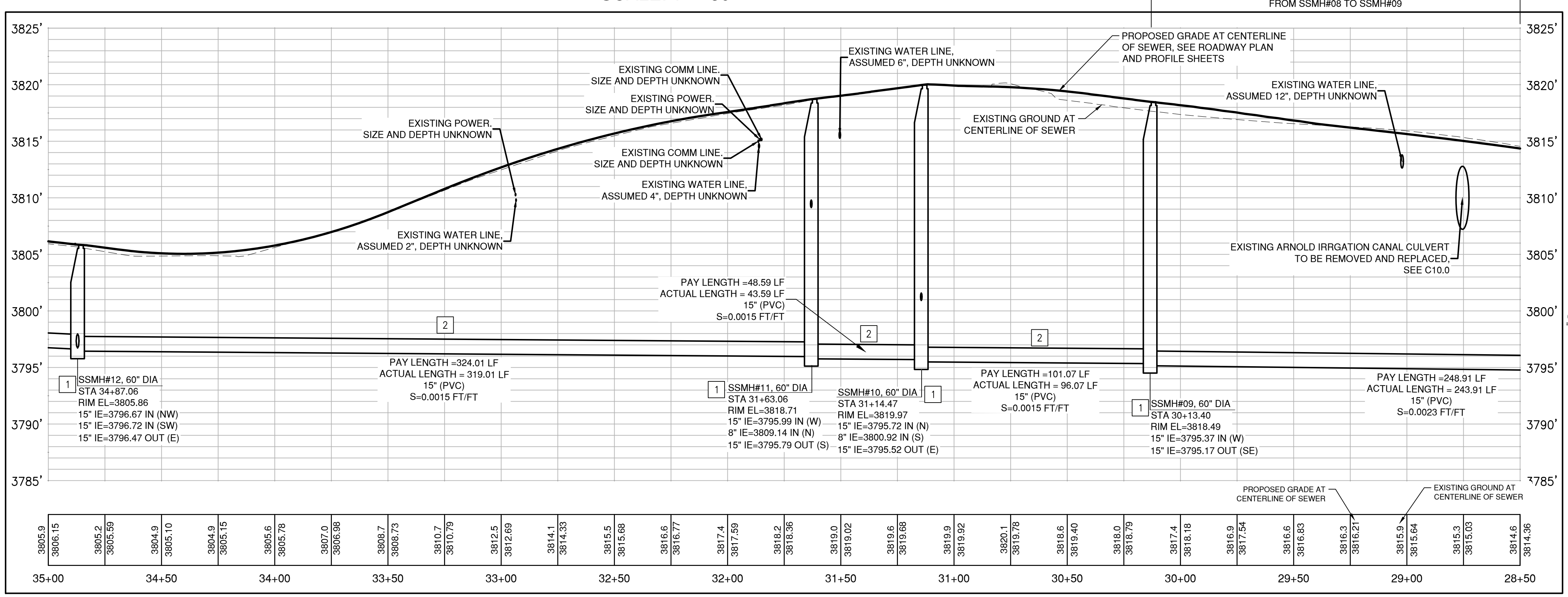


PROPOSED SEWER PLAN

SCALE: 1" = 30'



PROPOSED SEWER - PROFILE

SCALE: H: 1" = 30 V: 1" = 6

HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'

SEWER CONSTRUCTION NOTES

1. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE PER COB STD DWG S-3B
2. INSTALL 15" SEWER MAIN PER COB STD DWG S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.2
3. INSTALL 8"X3" REDUCER AND 3" 22.5 DEGREE BEND
4. CONNECT TO EXISTING PRESSURE SEWER WITH 3" 22.5 DEGREE BEND
5. INSTALL 3" PLUG VALVE, 3" 45 DEGREE BEND
6. CONNECT TO EXISTING PRESSURE SEWER WITH 3" 45 DEGREE BEND
7. INSTALL SEWER SERVICE PER COB STD DWG S-2 AS MODIFIED BY PARAMETRIX ON C8.3. CONSTRUCT PRIVATE GRAVITY SEWER SERVICE TO TIE INTO EXISTING GRAVITY SEWER. SEWER SERVICE LOCATION IS APPROXIMATE AND MAY NEED TO BE ADJUSTED FOR FIELD CONDITIONS.
8. INSTALL 15"X8" REDUCER
9. INSTALL 8"X3" REDUCER AND 3" 11.25 DEGREE VERTICAL BEND
10. INSTALL 3" 45 DEGREE BEND
11. INSTALL 8"X3" REDUCER AND 45° VERTICAL BEND
12. INSTALL STANDARD 60"Ø MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE PER COB STD DWG S-3B WITH 8" INTERIOR DROP PER INSIDE DROP MANHOLE ON SHEET C8.5
13. INSTALL STANDARD 48"Ø MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE PER COB STD DWG S-3B

GENERAL NOTES

1. CONTRACTOR MUST MAINTAIN ACCESS TO 60957 S HWY 97 PER 00220. THIS MAY INCLUDE SHORT TERM ACCESS ACROSS NON-ROMAINE VILLAGE WAY PORTION OF TAX LOT 1812170002005

CONFORMED DRAWINGS

REGISTERED PROFESSIONAL ENGINEER — W. BOGGS — NOT FOR CONSTRUCTION — EXPIRES 12-31-21

SW SEWER BASIN PHASE 2B

PLAN & PROFILE - STA 28+50 TO 35+00

BEND, OREGON

CITY OF BEND

REVISIONS:

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VERIFY SCALES — 0 — 1" — BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.2

12 OF 33

COB # 1SAMM

[DATE: 6/7/2021 10:08:46 AM] [AUTHOR: BEN EWING] [STYLE: PMX BW.CTB]
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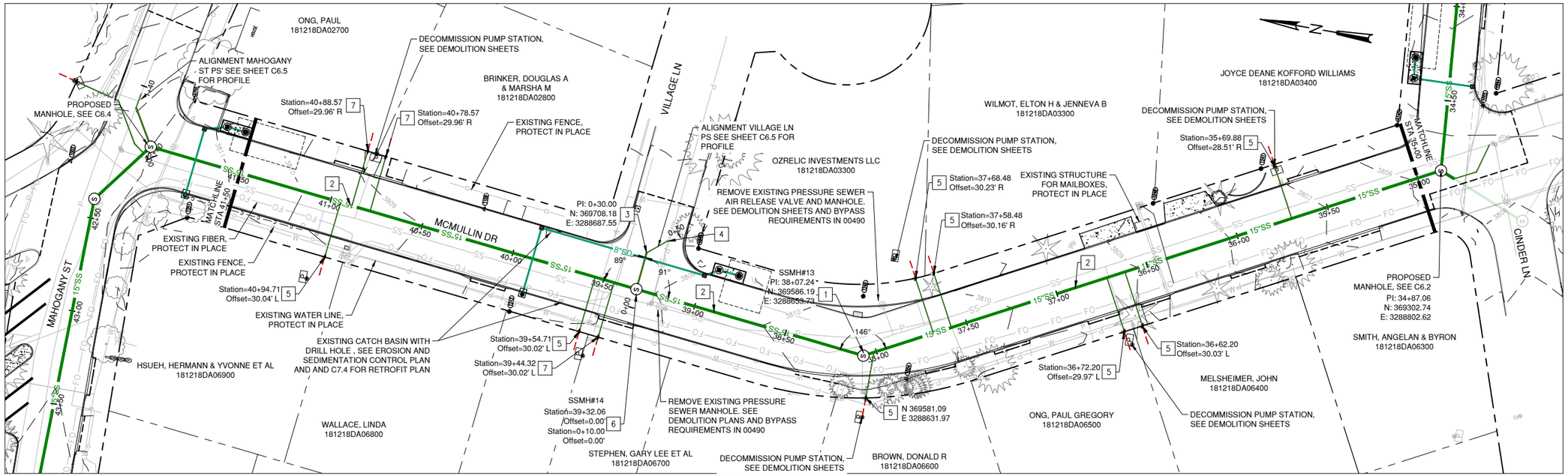


SEWER CONSTRUCTION NOTES

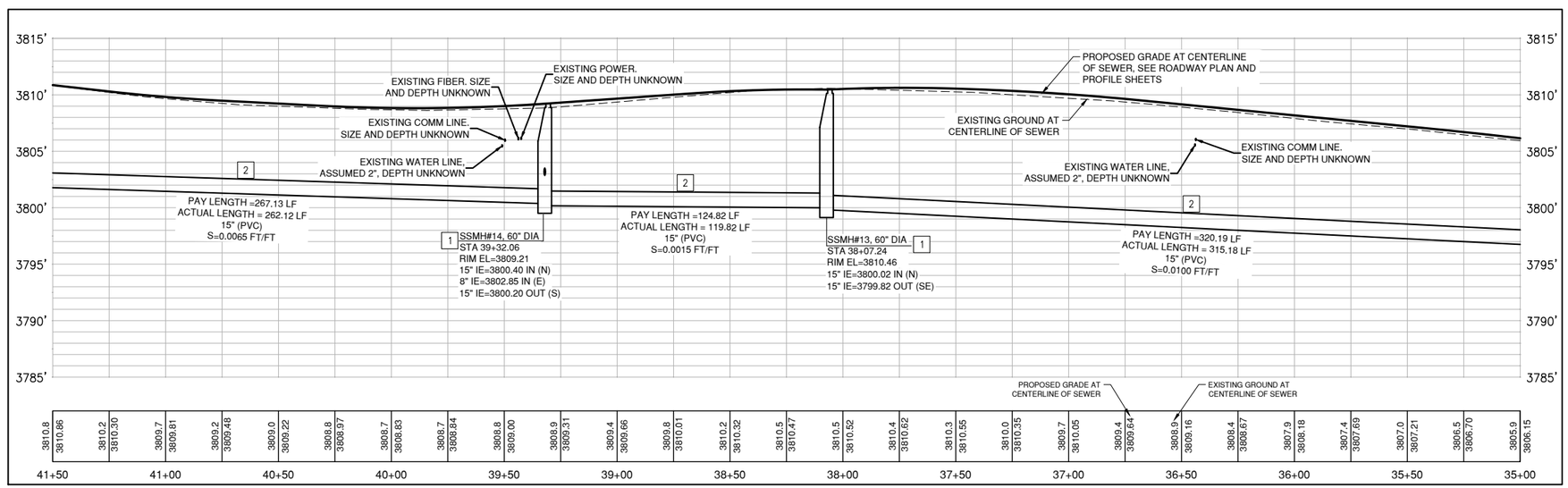
1. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE. PER COB STD DWG S-3B
2. INSTALL 15" PIPE PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.2
3. INSTALL 8"x3" REDUCER AND 3" 45 DEGREE BEND
4. CONNECT TO EXISTING PRESSURE SEWER WITH 3" 45 DEGREE BEND
5. INSTALL SEWER SERVICE PER COB STD. DWG. S-2 AS MODIFIED BY PARAMETRIX ON C8.3. CONSTRUCT PRIVATE GRAVITY SEWER SERVICE TO TIE INTO EXISTING GRAVITY SEWER. SEWER SERVICE LOCATION IS APPROXIMATE AND MAY NEED TO BE ADJUSTED FOR FIELD CONDITIONS.
6. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE WITH 8" INTERIOR DROP PER INSIDE DROP DETAIL ON SHEET C8.5
7. INSTALL SEWER SERVICE WITH TRAFFIC RATED CLEANOUT PER COB STD. DWG. S-2 AS MODIFIED BY PARAMETRIX ON C8.3. CONSTRUCT PRIVATE GRAVITY SEWER SERVICE TO TIE INTO EXISTING GRAVITY SEWER. SEWER SERVICE LOCATION IS APPROXIMATE AND MAY NEED TO BE ADJUSTED FOR FIELD CONDITIONS.

PROPOSED SEWER PLAN

SCALE: 1" = 30'

0 15' 30' 60'

SCALE: 1" = 30'



PROPOSED SEWER - PROFILE

SCALE: H: 1" = 30 V: 1" = 6

0 15' 30' 60'

0

3'

6'

HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'

CONFORMED DRAWINGS

NOT FOR CONSTRUCTION
REGISTERED PROFESSIONAL ENGINEER
OREGON
JULY 26, 2005
BRADLEY W. BOGGS
EXPIRES 12-31-21

SW SEWER BASIN
PHASE 2B

PLAN & PROFILE - STA 35+00 TO 41+50

BEND, OREGON

CITY OF BEND

REVISIONS:

Parametrix
ENGINEERING · PLANNING · ENVIRONMENTAL SCIENCES
150 NW PACIFIC PARK LANE, SUITE 110 | BEND, OR 97701
P 541.508.7710
WWW.PARAMETRIX.COM

DESIGNED BY: JEF/NWB
DRAWN BY: BAE
SCALE: AS SHOWN
FILE: I:\BEND\PROJECTS\CLIENTS\2763-CITYOFBEND\297-2763-024 SW SEWER BASIN\99SVCS\CADD\DWG\SHEETS_S2B\BE2763024-P2B-C6.3-PP00.DWG
DATE: 6/7/2021

VERIFY SCALES
0 1"
BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.3

13 OF 33

COB # 1SAMM

[DATE: 6/7/2021 10:09:10 AM] [AUTHOR: BEN EWING] [STYLE: PMX BW.CTB]
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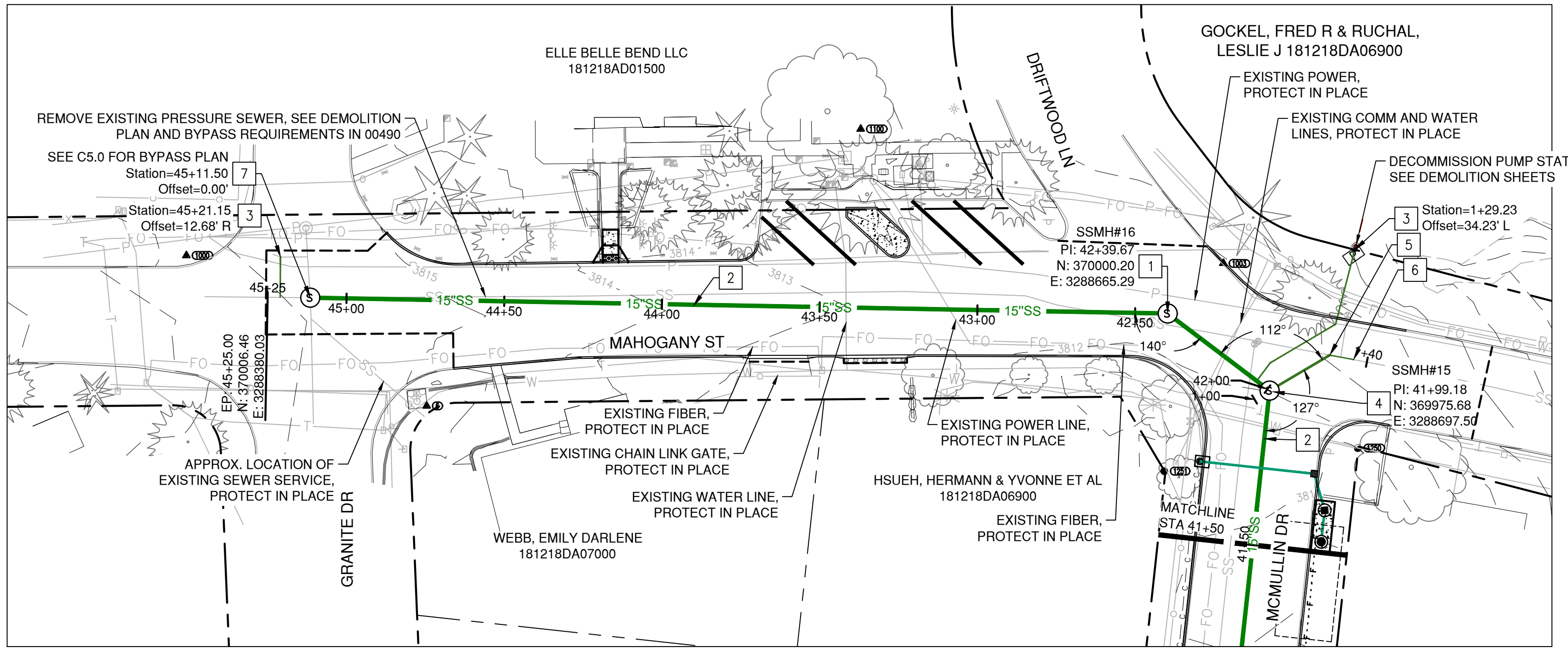


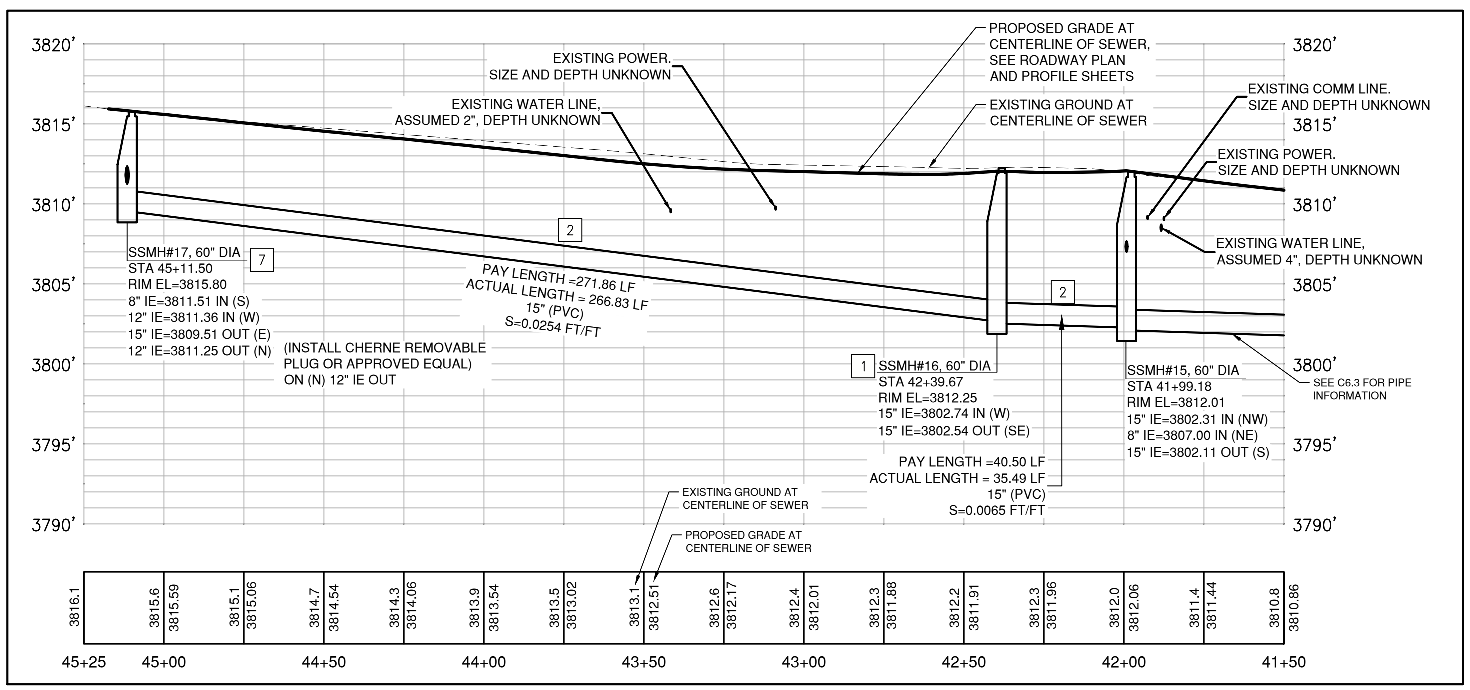
PROPOSED SEWER PLAN

SCALE: 1" = 30'

SCALE: 1" = 30'

SEWER CONSTRUCTION NOTES

1. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE PER COB STD. DWG S-3B.
2. INSTALL15" PIPE PER COB STD. DWG. S-10 AND R-1 AS MODIFIED BY PARAMETRIX ON C8.0
3. INSTALL SEWER SERVICE PER COB STD. DWG. S-2 AS MODIFIED BY PARAMETRIX ON C8.3. CONSTRUCT PRIVATE GRAVITY SEWER SERVICE TO TIE INTO EXISTING GRAVITY SEWER. SEWER SERVICE LOCATION IS APPROXIMATE AND MAY NEED TO BE ADJUSTED FOR FIELD CONDITIONS.
4. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE WITH 8" INTERIOR DROP PER INSIDE DROP DETAIL ON SHEET C8.5
5. INSTALL 8"X3" REDUCER AND 3" 45° HORIZONTAL BEND
6. CONNECT TO EXISTING PRESSURE SEWER WITH 3" 45° BEND
7. INSTALL STANDARD 60"Ø CONCRETE MANHOLE WITH CRYSTALLINE WATERPROOFING ADMIXTURE PER COB STD DWG S-3B. GROUT BEAVER SLIDE CHANNELS PER DETAIL THIS SHEET



PROPOSED SEWER - PROFILE

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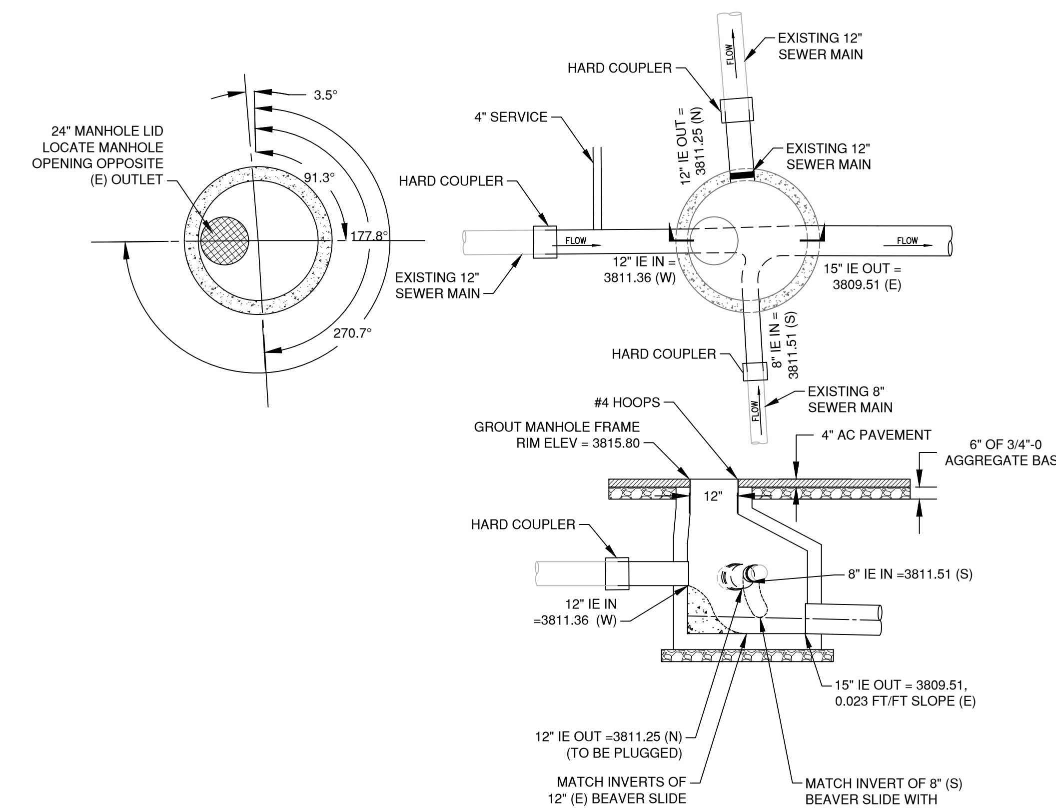
HORIZ SCALE: 1" = 30'
VERT SCALE: 1" = 6'



SSMH#17 BEAVER SLIDE DETAIL

N.T.S

CONFORMED DRAWINGS

NOT FOR CONSTRUCTION
EXPIRES 12-31-21

SW SEWER BASIN
PHASE 2B
PLAN & PROFILE - STA 41+50 TO 45+25
BEND, OREGON

CITY OF BEND

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DESIGNED BY: JEF/NWB
DRAWN BY: BAE
SCALE: AS SHOWN
FILE: BE2763024-P2B-C6.4-PP00.dwg
DATE: 6/7/2021

VERIFY SCALES
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BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.4

14 OF 33

COB # 1SAMM

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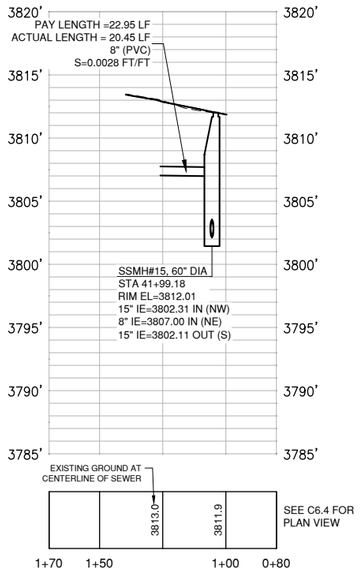
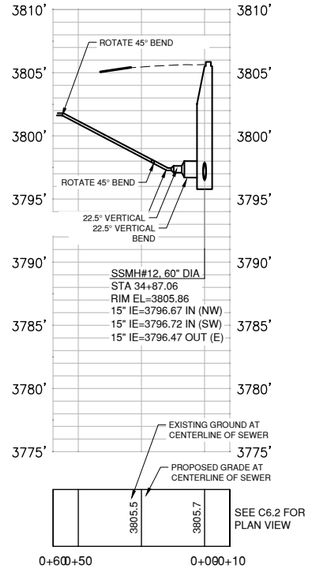


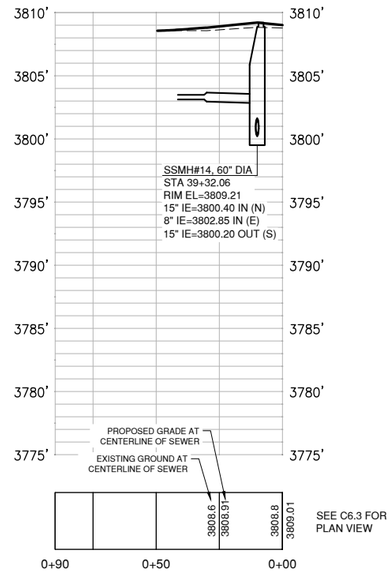
MAHOGANY ST PRESSURE SEWER PROFILE

SCALE: H: 1" = 30 V: 1" = 6



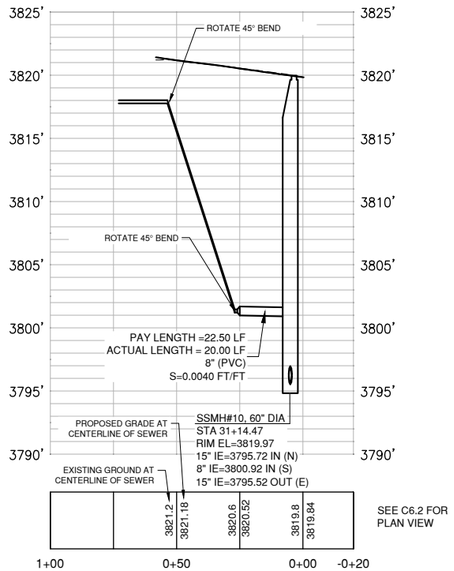
MCMULLIN DR PRESSURE SEWER PROFILE

SCALE: H: 1" = 30 V: 1" = 6



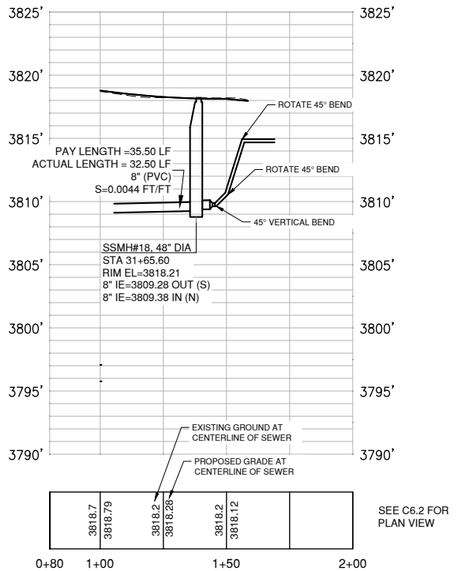
VILLAGE LN PRESSURE SEWER PROFILE

SCALE: H: 1" = 30 V: 1" = 6



RIDGE DR PRESSURE SEWER SOUTH PROFILE

SCALE: H: 1" = 30 V: 1" = 6



RIDGE DR PRESSURE SEWER NORTH PROFILE

SCALE: H: 1" = 30 V: 1" = 6

CONFORMED DRAWINGS

NOT FOR CONSTRUCTION
REGISTERED PROFESSIONAL ENGINEER
OREGON
JULY 27, 2005
BENJAMIN W. BOGGS
EXPIRES 12-31-21

SW SEWER BASIN PHASE 2B

PRESSURE SEWER TIE-IN PROFILES

BEND, OREGON

CITY OF BEND

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DESIGNED BY: JEF/NWB
DRAWN BY: BAE
SCALE: AS SHOWN
FILE: I:\BEND\2763024-P2B\C6.5-PP00.dwg
DATE: 6/7/2021

VERIFY SCALES
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BAR EQUALS ONE INCH ON ORIGINAL DRAWING

SHEET: C6.5

15 OF 33

COB # 1SAMM

Appendix E

SW Sewer Basin Alternative

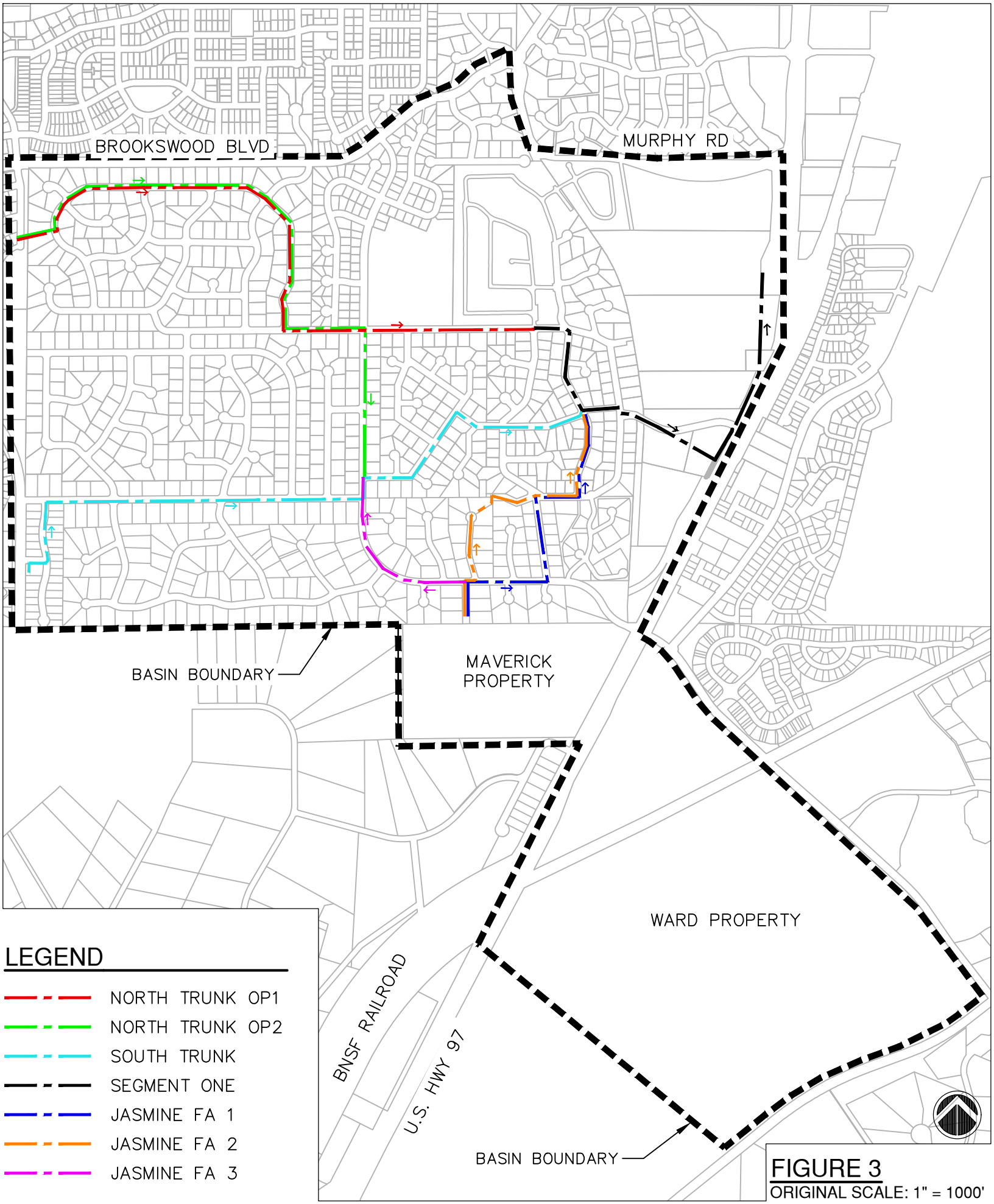


FIGURE 3
ORIGINAL SCALE: 1" = 1000'

Appendix F

Previous Design Reports

150 NW PACIFIC PARK LANE, SUITE 110 | BEND, OR 97701 | P 541.508.7710

TECHNICAL MEMORANDUM

DATE:	August 7, 2020
TO:	Jake Sherman, PE
FROM:	Niall Boggs, PE, CWRE
SUBJECT:	Sewer Service of Southern UGB Expansion Areas Through Atwood Drive
CC:	Eric Forster Jim Frost Jeff England
PROJECT NUMBER:	297-2763-024
PROJECT NAME:	SW Sewer Basin

Executive Summary

The proposed Stillwater Crossing development is planning to construct an 8" sewer main in Atwood Drive. This Atwood sewer alignment can feasibly serve the Ward property located on the east side of Highway 97 if the sewer is upsized to a 15" sewer. Grades will need to be modified slightly from the 85% progress design plans for Stillwater Crossing.

Elevations adjusted down 7" to maintain as-designed top of pipe elevations in the Atwood sewer will additionally allow sewer service to approximately 11 acres of the Maverick parcel of the Southwest UGB expansion area. To serve the entirety of the Maverick parcel through the Atwood sewer alignment, the sewer would need to be dropped significantly.

Sewering the Ward property by a highway 97 crossing and upsizing the currently planned Atwood sewer construction project planned for late 2020 offers significant cost savings as compared to the current Collection System Plan and Public Facilities Plan.

Introduction

The planned Stillwater Crossing development plans to construct a standard 8" gravity sewer in Atwood Drive, ultimately sewering north to the SW Sewer Segment 1 main at the eastern terminus of Romaine Village Way at Highway 97. As part of the SW Sewer basin project, Parametrix is reviewing the potential to serve the Urban Growth Boundary (UGB) expansion areas known as "The Thumb" in an upsized sewer main using the Atwood Drive sewer alignment. The Thumb consists of two undeveloped parcels, taxlot 1812000004404, currently known as the Ward Property, and taxlot 181219A000100, currently known as the Maverick Property. (Note: TL 1812000002215 north of China Hat was owned by Ward and was sold to Avion Water Company, Inc. on August 11, 2020. Avion is currently planning to construct a new water service center on a portion of this property, with the remainder to remain undeveloped at the current time. This change occurred after initial drafts of this report. The potential contributing flows are considered unchanged for the purposes of this report.) Ward totals approximately 223 acres and Maverick totals approximately 38 acres. The intent is to serve these parcels through the planned Atwood sewer alignment and provide recommendations on pipe sizing and depths to serve these areas.

Design Drivers

To check the feasibility of sewering the property known as The Thumb through the proposed Stillwater Crossing development's sewer in Atwood Drive, there are several critical crossings, service areas and constraints that need to be verified, including:

- The geometry and size of the Atwood sewer that this future sewer would tie into.
- Highway 97 crossing
- BNSF Railway crossing
- Ensure gravity sewer service of the entire Ward property within the Urban Growth Boundary
- Flow estimation, Pipe Sizes, and Minimum Pipe Slopes

Atwood Sewer:

Datum correlation

The City 2019 one-foot aerial surface was utilized along with Deschutes County Tax Map in AutoCAD, a pdf of Atwood plans was then imported into the AutoCAD file, and finally the two maps were aligned using property boundaries. The existing surface from Atwood profiles matched well with City aerial surface elevations, with a discrepancy of 0.1 to 0.4 feet depending on location.

Tie-in Elevation

Ward Property:

To evaluate feasibility of sewering the Thumb through an upsized Atwood sewer, Parametrix modeled the sewer profile tying into Atwood SSMH 7 at an invert elevation (IE) 0.36ft higher than Ashley & Vance's design IE out. This provides a small amount of room for error. If this sewer is selected to be redesigned to accommodate projected flows from the UGB expansion areas, the top of pipe elevation should be held at SSMH 7, dropping the invert out by seven inches (0.58ft) and doing some minor grade adjustments downstream as described below. Doing this will ensure that all utility crossings and sewer services designed by Ashley & Vance over the top of the sewer will still work, eliminating redesign work for the other utilities. The sewer feasibility profile starting 0.36ft above the design i.e. out at SSMH 7 shows that this elevation works for upstream critical design drivers.

Recommendation: To serve the Ward property of the Thumb, hold top of pipe elevation at SSMH 7 and upsize to 15-inch sewer main, dropping this invert by approximately 0.58 feet.

Maverick Property:

Utilizing the existing top of pipe elevation at the Atwood SSMH 7 as the tie-in and progressing at minimum grade with a 15" main to Ponderosa Street, the service area for the approximate 40-acre parcel is limited to approximately the southeast 11 acres, see Concept Overview exhibit. Under this scenario the remainder would need to be served by a gravity sewer at the natural low point on the parcel, where it abuts against Goldenrain Drive. This would then sewer either through a future Jasmine Place sewer main or Granite Drive sewer main.

The entire Maverick Property could conceivably be served through a deepened version of the proposed Atwood sewer. However, this would require that the Atwood sewer be deepened significantly. Approximately 1,000 linear feet (LF) of the currently planned Atwood sewer and approximately 560LF of sewer in Atwood Drive and Ponderosa Drive would need to be deepened by 18.5 feet. With a portion of the proposed Atwood sewer currently shown at 17 feet deep, lowering the proposed sewer to serve the entire Maverick Property would result in a portion of Atwood sewer being 30+ feet deep.

A third option would be to drop the Atwood sewer by a reduced amount to serve more of the Maverick property. For example, a drop of 10 feet would provide service to all of the Maverick parcel east of the Arnold canal.

Recommendation: Approximately 11 acres of the Maverick parcel could be served without significant deepening of the existing Atwood design. The Maverick parcel naturally drains to a low point at Goldenrain Drive, which can be served by a future gravity sewer. The entire Maverick parcel can be served through the Atwood sewer by dropping the design by 18.5 feet, adding significant cost.

Drop Manholes

The Ashley & Vance design drawings for the proposed Atwood sewer show the two northerly-most manholes (SSMH 1 and 2), to be drop manholes. These may be included in the design to keep velocities below 8 feet per second (ft/s) per City of Bend Design Standards (COBDS) 4.1.10. The City typically does not allow the use of drop manholes within their system to avoid odor and hydrogen sulfide release. Drop manholes are also more expensive due to additional piping and concrete backfill required around the outside drop pipe. With the proposed upsize to serve the Thumb, The City would require evaluation of the design to see if the two northern manholes can be standard manholes instead of drop manholes. The potential upstream flows from the Ward Property, the Maverick Property, the Stillwater Crossing development, and smaller ODOT and Ponderosa Pines, LLC parcels is projected at 1102gpm. This flow in a 15" Atwood pipe will reach 8ft/s velocity at a slope of 1.85%.

Recommendation: Evaluate if the drop manholes can be replaced with standard manholes, maintaining pipe slopes below 1.85% to keep velocity below 8ft/s, or waive the 8ft/s requirement.

Missing Section of Sewer

The Ashley & Vance design drawings for the proposed Atwood sewer shows the pipe extending to the southern property line of tax lot 181217 2006 (Gary Bell RLT LLC). Note that this location is approximately 500 feet south of the proposed SW Sewer Segment 1 sewer alignment located in Romaine Village Way. There is a gap that is approximately 500 LF without sewer across Bell TL 2006. This 500 LF of pipe across the Bell property will need to be completed by the Stillwater Crossing developer and not included in SW Sewer Segment 1 design. The northernmost Atwood sewer drop manhole has proposed IE out of 3807.22. The conceptual design for SW Sewer Segment 1 has a manhole located near the fire gate on the east extend of Romaine Village Way with a 15" IE out of 3793.37. The IE in from the south would need to be 0.2ft higher in a 60" manhole for an IE in of 3793.57. There is a drop of 13.65 feet from the northernmost Atwood manhole IE out to the IE in of the SW Sewer Segment 1 tie-in manhole in Romaine Village Way, with a resulting slope of 2.73% in the 500 foot gap. Although the sewer design for the Bell gap hasn't yet been designed/resolved, the connection appears to be easily feasible.

Recommendation: Stillwater Crossing to design and build 500LF of sewer main across Bell TL 2006.

Atwood Flow in Oversized Sewer Main

If the Atwood sewer is upsized to a 15" pipe to accommodate the Ward and Maverick properties in the future, there will be an indeterminate time period where just the Stillwater Crossing project is contributing flows. Per the land use decision, there will be 240 units. Using the City design standards of 130 gallons / unit / day x 0.8 equivalent dwelling unit (EDU) / unit for multifamily x 3.0 peaking factor yields a design flow of 52gpm (see COBDS 4.1.3 Table 4-1). If the 15" sewer is installed at a minimum slope of 0.0015ft/ft, the 52gpm will have a velocity of 1.35 ft/s, which is below preferred design velocity of 2ft/s. If the current proposed design slopes for the 8" Atwood pipe are maintained in a 15" main, the minimum slope of 0.004ft/ft will result in a velocity of 1.90ft/s. To obtain 2ft/s, a minimum slope of 0.0046ft/ft is required.

Recommendation: Slightly steepen Atwood sewer to 0.0046ft/ft min. slope to achieve scour velocity during Atwood only contribution period.

Manhole Size

With an upsize of the Atwood sewer to 15" from 8", manholes will need to be increased in size from 48" diameter to 60" per COBDS 4.2. Currently Atwood manholes SSMH 3-7 are 48".

Recommendation: Upsize all Atwood sewer manholes to 60".

South Tie-In Location

The Stillwater Crossing project upstream termination manhole (SSMH 7) is located where Atwood Drive crosses the western property boundary of the Atwood property tracts (TL 181217 2500 & 2003). This is about 225LF north of where Atwood Drive intersects with Ponderosa Street. The Stillwater Crossing project includes improvements (grading, paving, curbs, walks) to this southerly 225 LF of Atwood Drive to Local Road standards. With the proposed roadway improvements, it would be beneficial to extend the sewer to Ponderosa Street. This will eliminate future construction on the newly paved road.

Recommendation: Propose to construct additional +/-225LF of sewer main to Ponderosa.

Highway 97:

Oregon Department of Transportation has specific requirements for highway crossings under OAR 734-055-0015. District offices also have their own specific restrictions that need to be followed.

- Pipes need to be cased in steel or ductile iron casing.
- The shallowest the top of the casing pipe can be is 5' below finish grade of paved roadway.
- Bore pits need to be protected by barriers with traffic control/warning to MUTCD standards.
- Bore pits be outside of the prism on the roadbed or off the shoulder so it is not compromised.
- All crossings need to be coordinated with ODOT and a permit obtained.

On a similar crossing of Highway 97 on the north end of Bend (North Area Sewer Capacity Improvements), Parametrix utilized a 15" carrier pipe within a 36" casing. This will be the assumption for checking the feasibility of the Thumb sewer crossing. To be conservative and ensure clearances are met, we will assume the carrier pipe is on the bottom of the casing, making the sewer invert to be a minimum of eight (8) feet below the lowest asphalt grade, which is the shoulder on a typical crown section.

The sewer feasibility profile was run starting at Atwood SSMH 7 at an invert elevation 0.36ft higher than Ashley & Vance's design IE out, then running 15" minimum slope of 0.0015ft/ft to and through the Hwy 97 crossing location. Using this profile, there was approximately 12 feet of vertical separation from the highway shoulder to sewer invert at the crossing location. This provides approximately four (4) vertical feet that the sewer can be raised above what is shown in the feasibility profile.

Depth to rock is unknown at this point, but future potholing is planned at the Hwy. 97 / China Hat / Ponderosa intersection to find depth of bedrock. The main design driver on a bore at this location will likely be to avoid a bore located at the interface between rock and soil.

Recommendation: Tying in while maintaining the as-designed top of pipe elevation at Atwood SSMH 7, provides a feasible highway crossing with approximately four (4) vertical feet that it could be raised. Soil rock interface is unknown. Once it is known, there may be a desire to adjust the elevation of the Atwood sewer down to stay within rock.

BNSF Railway:

Railroads have specific requirements for crossing geometry. The critical geometric constraints required by the railroad are as follows:

- Plastic pipe must be encased in a steel casing pipe the full width of the railroad right-of-way.
- Minimum vertical separation from base of rail to top of casing pipe is 5.5 feet.
- Minimum ground cover on railroad property is 3.0 feet.
- The crossing will need to be permitted through BNSF.

The following chart is an excerpt from the BNSF Railway "Application for Pipeline or Wire Line – Crossing and/or Longitudinal" right of crossing.

Figure 1: Excerpt from BNSF "Application for Pipeline or Wire Line – Crossing and/or Longitudinal"

PIPELINE:
(Note: For wire line see pg. 2)

Contents to be handled through pipeline: [ ]

	CARRIER	CASING
Length of pipe on RR property (plastic pipe must be encased full width of ROW)	[ ] ft.	[ ] ft.
Inside diameter of pipe	[ ] in.	[ ] in.
Pipe Material	[ ]	[ ]
Specification & grade (Minimum yield strength casing 35,000 psi)	[ ]	[ ]
Wall thickness (minimum wall thickness of casing pipe under 14 in. – 0.188 in E-80 Loading)	[ ]	[ ]
Actual working pressure	[ ]	[ ]
Type of Joint	Mechanical [ ] Welded [ ]	Mechanical [ ] Welded [ ]
Coating	[ ]	[ ]
Distance from base of rail to top of pipe (Flammable contents, steam, water or non-flammable – minimum 5 ½ ft. under main track) (uncased gaseous products – minimum 10' under track)	[ ]	[ ]
Minimum ground cover on RR property (minimum 3 ft.)	[ ]	[ ]
Cathodic protection casing (flammable substance)	[ ]	[ ]

The sewer feasibility profile shows that the railroad crossing isn't the controlling factor – there is a low area east of the railroad tracks that requires the sewer to be deeper than the minimums required by the railroad. The sewer invert driven by the low area to the east is 13.6 feet below the low point within the railroad right of way. Assuming a 36" casing, there will be greater than 10 feet of vertical separation between the low point in the railroad right of way and the top of casing. Note that no subsurface explorations are being completed for the railroad crossing with this sewer feasibility study.

Recommendation: The railroad crossing appears feasible based on project service elevations and railroad crossing requirements. The railroad is significantly higher in elevation than the highway or tie-in to the Atwood SSMH 7 and doesn't require minimum slopes up from the highway to work.

Sewer Service for the Ward property:

To ensure sewer service for the entire Ward property that is within the UGB, a conceptual profile was run parallel to China Hat Road, to a point east of the railroad crossing to a natural drainage area, then turned southwest, running the assumed sewer trunk line up the drainage. From the turning point east of the railroad track, the sewer is run at a grade of 0.004ft/ft or more, assuming 8" pipe. A larger 12" could be run at a flatter grade if

necessary. A projected sewer service area off this main was considered assuming minimum grade for 8" tributary mains to ensure service all the way east to Knott Road and south to the UGB. The grades shown in the profile are approximate highest working invert elevation of an 8" main in this location heading to the southwest serving as a trunk. Note that Parametrix does not currently have any road alignments or development designs for the Ward property. Ultimate roadway and sewer alignments, as well as building and lot design will affect required grades. There are portions of the 8" line headed south that are able to exceed minimum grade to provide some additional working elevation. Additionally, as noted above, between Highway 97 and the BNSF railway crossing, the ground rises considerably higher than minimum grade, providing nearly ten vertical feet of additional vertical grade to work with.

Recommendation: Sewer service to the entire Ward parcel within the UGB appears feasible based on existing ground elevations and the conceptual alignment. There is significant additional vertical grade to work with between Highway 97 and BNSF railway.

Sewer Service for the Maverick property:
See above discussion on sewering Maverick through Atwood.

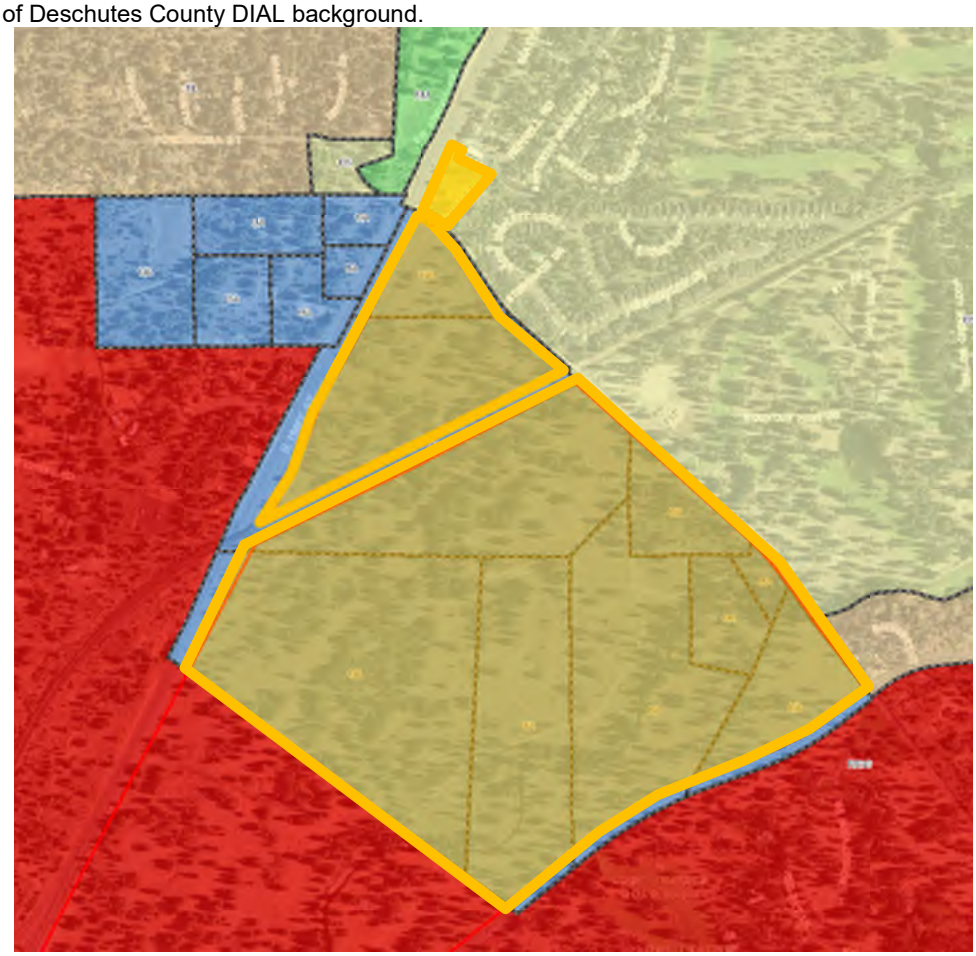
Flows, Pipe Sizing, Design Grades:
City of Bend Design Standards include the following:

- Use Manning's "n" of 0.009 for PVC (COBDS 4.1.4)
- Minimum velocity of 2ft/s (COBDS 4.1.5)
- Maximum velocity of 8ft/s (COBDS 4.1.5)
- Minimum grade for 12" sewer is 0.0019ft/ft (COBDS 4.1.6)
- Minimum grade for 16" sewer is 0.0014ft/ft (COBDS 4.1.6)
- Note that ASTM 3034 sewer pipe doesn't come in 16"; it comes in 15"; using interpolation a 15" sewer minimum design grade is 0.0015ft/ft.

East of Highway 97
The properties east of Highway 97 that may potentially sewer through the future Atwood sewer are both owned by the Ward family, taxlots 181217000**2215** & 181200000**4404**. The only portion of taxlot 4404 that is under consideration is that within the UGB zoned UA, and not the RR-10 zoned land. Note that this excludes any other properties including any potential future redevelopment of Mountain High Golf Course because it is at the top of the Basin #9 with no future capital projects identified to add capacity to the existing pressure sewer system in the long-term or to serve the Thumb.

Continued next page

Figure 2: The Ward Property zoned UA east of Highway 97 that may be sewered through the Atwood Drive sewer highlighted in orange on top of Deschutes County DIAL background.



Development plans and the associated potential flows for the undeveloped UA lands are unknown, but Parametrix has utilized CIP Consulting to develop flow projections, and they are as follows:

Figure 3: Projected flows summary for The Ward Property east of Highway 97.

Tax Lot #	Owner	Special Planning Area	Comp Plan Zoning Designation	Estimated Peak Flow [GPM]		
				Minimum	Mid-Range	Maximum
18-12-17 TL 2215	Ward	N/A	RS - Residential Standard Density	2.4	3.6	4.4
			Ward 1 Sub-Totals	**2.4**	**3.6**	**4.4**
18-12-00 TL 4404	Ward	The Thumb UGB Expansion Area	RS - Residential Standard Density	48.4	56.9	69.5
			RM - Residential Medium Density	19.7	27.3	32.9
			RH - Residential High Density	9.4	15.2	18.6
			ME - Mixed Employment: Commercial	73.1	91.4	109.7
			ME - Mixed Employment: Multi-Family Residential	72.9	117.5	144.4
			CG - Commercial General	155.7	194.7	233.6
			CC - Commercial Convenience	47.2	59.0	70.8
			IL - Industrial Light	141.6	177.0	212.4
			Ward 2 Sub-Totals	**568.1**	**738.9**	**891.9**

Estimated maximum flows for the east side of the highway are 896.3gpm. See appendix for more detail on flow projections.

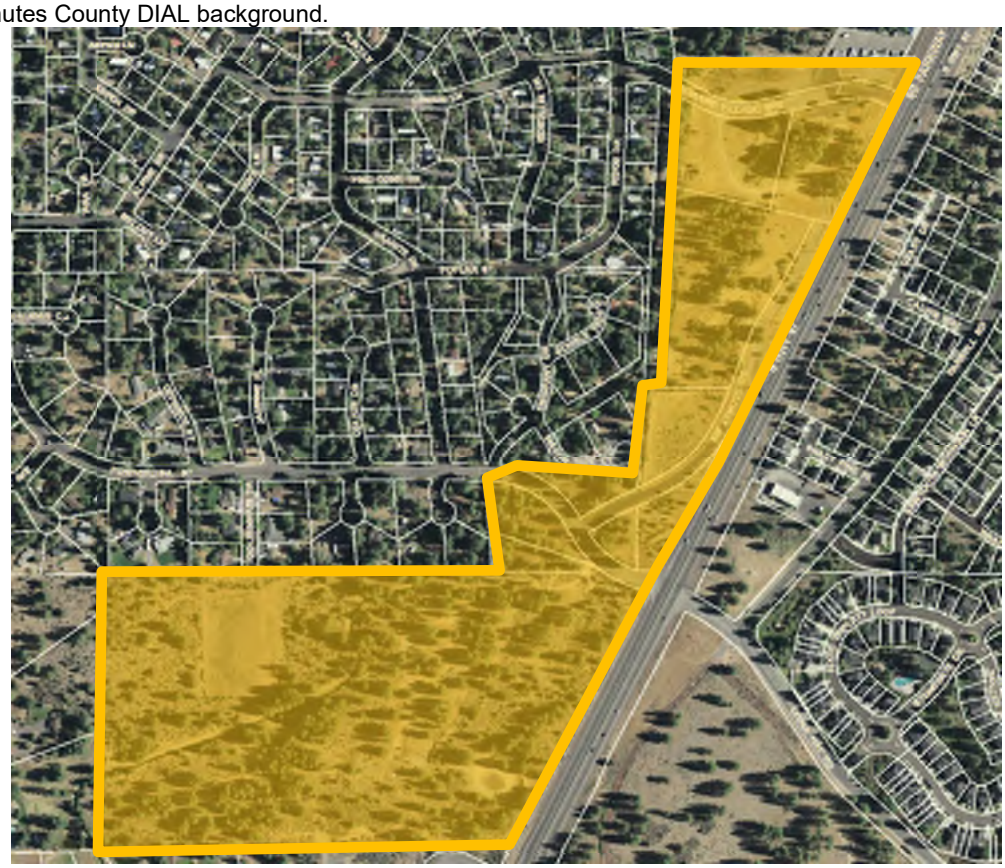
Given these parameters, a 12" at minimum grade will flow 76.7% full at 896.3gpm, which is right up against the 80% full maximum (COBDS 4.1.5). The sewer feasibility profile assumes a 12" pipe minimum grade (0.0019ft/ft) parallel to China Hat Road until it turns south at the low area east of the railroad tracks. It then assumes an 8" pipe minimum grade (0.004ft/ft) heading south serving the project interior. Parametrix used the steeper grades of smaller pipes to ensure the project can be served. These pipe sizes need to be evaluated with actual development plans.

Recommendation: Final pipe sizing east of Highway 97 to be completed with development plans for the Ward property. We anticipate a 12" or 15" trunk main with smaller 8" tributary mains.

West of Highway 97

West of Highway 97, the conceptual sewer alignment would potentially pick up flows from parcels owned by Maverick Properties, LLC (TL 181219A000100), Ponderosa Pine Estates, LLC (TL 181218DD06800 & 6900), ODOT (181218DD06801 & 6802), Jim A. Atwood Trust et al (181217000**2500**, **2003**, & **2000**), and Gary Bell RLT LLC (181217000**2006** & **2004**) prior to connecting with SW Sewer Segment 1. These tracts are all currently undeveloped. The Atwood properties are the only lots with development plans, which are being developed under the Stillwater Crossing site plan.

Figure 4: The potential land west of Highway 97 that may be sewered through the Atwood Drive sewer highlighted in orange on top of Deschutes County DIAL background.



Flows from other properties are estimated by CIP Consulting are as follows:

Figure 5: Projected flows summary for land west of Highway 97.

Tax Lot #	Owner	Special Planning Area	Comp Plan Zoning Designation	Estimated Peak Flow [GPM]		
				Minimum	Mid-Range	Maximum
18-12-17 TL 2004, 2005, & 2006	Bell	Murphy Crossing Refinement Area	RS - Residential Standard Density	0.2	0.5	0.7
			RM - Residential Medium Density	1.8	3.3	4.0
			ME - Mixed Employment: Commercial	6.4	8.0	9.6
			ME - Mixed Employment: Multi-Family Residential	2.9	5.3	6.3
			CG - Commercial General	9.0	11.2	13.4
			Bell Sub-Totals	**20.3**	**28.3**	**34.0**
18-12-17 TL 2000, 2003, & 2500	Atwood	See Land Use Decision	RM - Residential Medium Density	52.0	52.0	52.0
			Atwood Sub-Totals	**52.0**	**52.0**	**52.0**
18-12-18DD TL 6800 & 6900	Ponderosa Pine LLC	Murphy Crossing	RS - Residential Standard Density	1.3	3.4	4.1
			Ponderosa Pine Properties Sub-Totals	**1.3**	**3.4**	**4.1**
18-12-18DD TL 6801 & 6802	ODOT	Murphy Crossing	RS - Residential Standard Density	0.5	1.4	1.7
			RM - Residential Medium Density	0.8	1.4	1.7
			ODOT 2 Sub-Totals	**1.4**	**2.7**	**3.4**
18-12-19A0 TL 100	Maverick	Southwest UGB Expansion Area	RS - Residential Standard Density	19.4	22.8	27.8
			RM - Residential Medium Density	16.9	23.4	28.2
			PF - Public Facilities [Elementary School]	13.0	15.2	17.3
			RH - Residential High Density	23.5	37.9	46.6
			CL - Commercial Limited	7.1	8.8	10.6
			MN - Mixed Neighborhood: Commercial	4.7	5.9	7.1
			MN - Mixed Neighborhood: Multi-Family Residential	4.7	7.6	9.3
			Maverick Sub-Totals	**89.3**	**121.6**	**146.9**

Estimated flow contributions for the west side of the highway into the Atwood main total 240.4gpm. The combined flows in the Atwood sewer are therefore 1137 gpm. The additional projected flows require a 15" diameter sewer. At minimum slope of 0.0015ft/ft, a 15" sewer will flow 66.29% full with 1137gpm. See above discussion with initial Atwood development only, low flow velocities will occur and a steeper slope is recommended. To stay below the City's maximum velocity of 8ft/sec, the slope should be less than 1.85 ft/ft. **Recommendation: A 15" sewer is recommended for the Atwood combined sewer on the west side of the Highway 97 crossing.**

Segment 1 Pipe Sizing

SW Basin Residential

- Unknown if entire basin will flow through the Segment 1 sewer, but assume it will.

In-Study Area Flows

- 508 lots south of Mahogany Street not on gravity today (combination of Romaine Village Pressure Area & future septic-to-sewer conversions)
- 32 lots in Poplar Park, currently on pump station
- 184 lots north of Mahogany Street on pressure sewer
- 69 lots in Deschutes River Crossing and 62 homesites in Fox Hills Mobile Home Park that gravity into Deschutes River Crossing Pump Station for a total of 131 lots
- 111 lots currently on gravity
- Approximately 170 homes located within the Romaine Village Mobile Home Park
- Assume 77 lots with RL zoning subdivide (10% of (508+184+111-36 lots)=767)
- In-Basin Subtotal = 329gpm (130gpd/lot*3PF*1213 lots/1440=329gpm)

Out-of-Study Area Contributing Pump Stations

- River Rim Pump Station = 170gpm[1], 150gpm[2] current (proposed PFP project 29 for 400gpm)
- River Canyon #1 Pump Station = 330gpm[1], 280gpm[2], 130gpm[3] current (PFP project 125, add VFD)
- River Canyon #2 Pump Station = 150gpm[1], 140gpm[2], 85gpm[3] current
- Aspen Ridge Pump Station = 180gpm[1], 190gpm[2], 90gpm[3] current
- Out-of-Basin Potential Subtotal = 475gpm with all pump stations operating (170gpm + 130gpm + 85gpm + 90gpm)
- Note potential addition of 230gpm additional with PFP project 29 at River Rim Pump Station. Status of this project is unknown, but conceivably could have 705gpm. This estimate is likely too high, see notes below regarding pump station operations and system attenuation.

Combined In-Study Area and Out-of-Study Area Upstream of Romaine Village Way

- Total potential combined flow, *In-Study Area and Out-of-Study Area* = 804gpm (475gpm +329gpm)
- However, observed peak flow 20" HDPE Hwy 97 crossing was 574 gpm; this includes River Rim, River Canyon #1, River Canyon #2, Aspen Ridge and Deschutes River Crossing stations, hundreds of Romaine Village individual stations and gravity sewer. The system of force and gravity mains provides attenuation, pump stations have short run times, and all pump stations operating at one time is a rare occurrence. Therefore, the Out-of-Study Area Contributing Pump Stations subtotal of 574gpm is used.

1=Station Pumping Capacity (The lift station capacity with all pumps operating. Other lift stations sharing common force mains are not operating. This represents the maximum pumping capacity)

2=Station Firm Pumping Capacity (The lift station capacity with the largest pump out of service. Other lift stations sharing common force mains are not operating)

3=Station Firm Pumping Capacity Group (The lift station capacity with the largest pump out of service. Other lift stations sharing common force mains are operating. This represents the minimum pumping capacity. Some pump stations with varied size pumps will operate without simultaneous pump operation.

<u>Combined Atwood Sewer Flow (Ward, Maverick, Atwood, Bell, etc.)</u>

- See above, Subtotal = 1137 gpm

<u>Mixed Use Development between Murphy and Romaine Village Way (Bonnett, Winco, ODOT, Mayfield</u>

- Bonnett, 53.9gpm
- Winco, 63.3gpm
- ODOT, 56.8gpm
- Mayfield, 29.2gpm
- Subtotal = 203.2gpm

<u>Total Combined Flow</u>

Segment 1, Upstream of Atwood Tie-in

- Entire existing residential basin, excluding the Atwood/Ward/Maverick combined is 574gpm
- 8" at minimum slope of 0.004 flowing 80% full has a capacity of 471gpm
- 12" at minimum slope of 0.0019 flowing 80% full has capacity of 936.7gpm
- Given the current noted deficiencies in the existing 12" north of Granite Drive, a 15" main will be used.

Segment 1, Downstream of Atwood Tie-in

- Combined flows through Segment 1: 203gpm (Mixed Use) + 1137gpm (Atwood/Ward/Maverick) + 574 (Existing Basin) = 1914gpm
- Alternatively, if using 804gpm for existing basin (574 observed peak +230gpm River Rim increased capacity), Combined flows through Segment 1 = 2144gpm
- 15" at minimum slope of 0.0015 flowing 80% full has capacity of 1429gpm, undersized

- 18" at minimum slope of 0.0011 flowing 80% full has capacity of 2208gpm, therefore 18" selected
- The downstream receiving pipe mains are 18" mains installed with the SEI and Amethyst Mahogany Diversion projects. Downstream is outside of the scope of this document, however, the addition of the future Ward, Maverick, and Murphy Crossing commercial flows may trigger the construction of the East Interceptor at some point as the Interim SEI connection to the Central Interceptor may reach capacity.
- These flow projections don't account for taking any sewer pump stations outside the study area offline. Additional analysis would be required to account for that.

Recommendation: Segment 1 should be sized at a minimum of 15" upstream of the Atwood sewer tie-in, and a minimum of 18" downstream of the Atwood sewer tie-in. See below discussion of Other Alignments discussing pipe sizing between Atwood tie-in at Romaine Village Way / Hwy97 and Cinder Lane/McMullin Drive.

Cost Comparison

To assess whether sewering the Ward Property through an upsized 15" Atwood sewer main provides a long-term advantage to the City, it needs to be compared to the cost to construct a sewer main down Parrell Road as identified as project 206-n in the 2018 City of Bend Collection System Public Facility Plan (PFP). Either long-term option would put flows into the 18" Southeast Interceptor (SEI) at the Parrell/Murphy roundabout.

Figure 6a: PFP graphic showing Thumb Gravity Trunks, project 206-n.

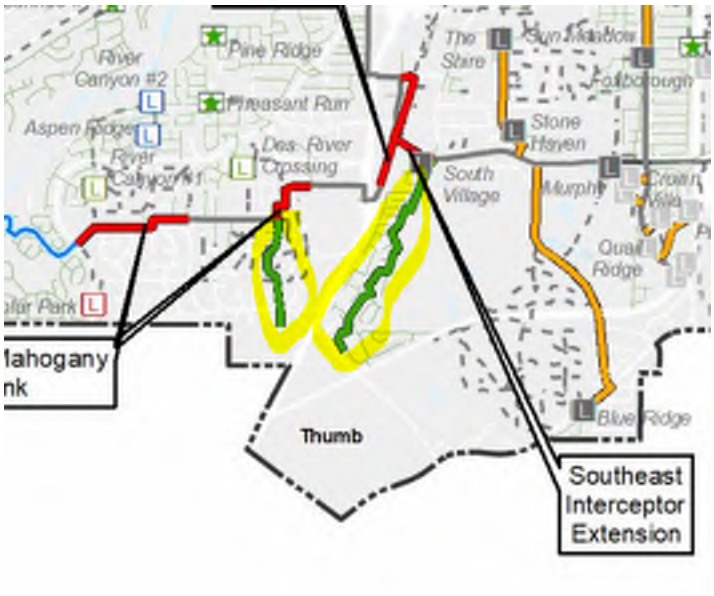


Figure 6b: PFP Capital Improvement Program showing Thumb Gravity Trunks, project 206-n.

Table 23
Capital Improvement Program

Project ID[1]	Timeframe	Project Name	Type of Improvement	Description	Project Coordination	Recommended Size	Unit, Length, or Capacity	Project Estimate[2]
204B-n	Year 1 to 5	Development-Based	Elbow Force main	New Elbow Force main	-	Sizing to be determined	7,300 LF	$2,900,000
205-n	Year 6 to 10	Development-Based	DSL Gravity Trunks	New gravity trunk sewers to serve the DSL	-	Sizing to be determined	6,600 LF	$4,300,000
206-n	Year 1 to 5	Development-Based	Thumb Gravity Trunks	New and upsized gravity trunk sewers to serve the Thumb	-	Sizing to be determined	8,700 LF	$5,700,000
207-n	Year 1 to 5	Development-Based	West Gravity Trunks	New and upsized gravity trunk sewers to serve the West	-	Sizing to be determined	11,000 LF	$7,000,000

Option 1 is the option of sewering the Ward Property through an upsized Atwood Sewer:

- Item 1.1: The estimated costs for upsizing are based on maintaining top of pipe elevation, dropping IE by 7" and upsizing manholes from 48" to 60".
- Item 1.2: The current plans for the Atwood sewer show a terminating manhole (SSMH 7). The Stillwater Crossing plans show resurfacing of Atwood drive all the way south to Ponderosa Street. Therefore, it is worth considering the inclusion of the 15" sewer connection from Atwood Manhole SSMH 7 to Ponderosa St with the Stillwater Crossing project to avoid tearing up a road surface installed in year 2021 to install this segment of sewer.
- Items 1.3 and 1.4 are assumed to be future costs borne by the developer of the Ward Property.
- The highlighted columns represent Parametrix's opinion of most probable cost range.

Option 2 is the option of sewering the Ward Property through a new Parrell Sewer:

- The PFP lists both a Parrell trunk sewer and a Granite trunk sewer together as project 206-n. The PFP states a total of 8,700LF for a cost of $5,700,00. This equates to a unit cost for construction of $655/LF. The Parrell sewer alignment is approximately 5,100 LF, which would total $3,340,500. Based on recent City of Bend sewer construction projects, this unit cost appears to be low. However it does fall within the -50% low estimate for a Class 5 estimate.
- The highlighted columns represent Parametrix's opinion of most probable cost range.

The following summary of costs indicates that the proposed upsize provides a significant long-term cost advantage. Detailed cost estimates are included in the appendix. Costs are for construction only and do not include costs for engineering, construction management or project administration.

Figure 7: Cost Estimates for Option 1 & Option 2

Option 1: Summary of Costs to Sewer Ward Property Through Upsized Atwood Sewer

No.	Description of Improvements	Low Cost Estimate	0% Contingency Cost Estimate	High Cost Estimate	Estimate Class
1.1	Upsize pipe from 8" to 15" and manholes from 48" to 60" in Atwood Drive	$51,100	$63,900	$83,000	**Class 3**
1.2	Extend 15" Sewer from Atwood Manhole SSMH 7 to Ponderosa St (241 LF 15")	$71,500	$89,400	$116,200	**Class 3**
1.3	Extend 15" from Atwood / Ponderosa to Highway 97 (324 LF 15")	$116,100	$165,800	$248,800	**Class 4**
1.4	Bore Under Highway 97 (183 LF bore + 301 LF 15")	$370,400	$529,200	$793,800	**Class 4**
	Total=	$609,100	**$848,300**	**$1,241,800**	

vs.

Option 2: Summary of Costs to Construct new Parrell Sewer

No.	Description of Improvements	Low Cost Estimate	0% Contingency Cost Estimate	50% Contingency Cost Estimate	High Cost Estimate	Estimate Class
1.3	12" Sanitary sewer pipe, depth unknown, All Inclusive	$2,442,900	**$4,885,800**	**$7,328,700**	$9,771,600	**Class 5**

Based on the above shaded higher probability cost estimates, sewering through a deepened Atwood sewer main offers cost savings between $4.04 and $6.09 million.

Other Alignments

Other options for sewering the Ward property on the west side of the highway exist and include extending the sewer main to the west and heading north on Granite or Emigrant. These options don't have all the cost and time advantages of the Atwood upsizing proposal, but likely have advantages over constructing the Parrell sewer main. If the Atwood upsizing proposal cannot be funded, the Segment 1 main may need to be maintained as an 18" along Romaine Village Way and Cinder Drive to the intersection with McMullin Drive.

Conclusion

The Atwood sewer alignment can feasibly serve the Ward property located on the east side of Highway 97 if the sewer is upsized to a 15" sewer. The design inverts of the Atwood should be dropped by approximately 7" in the upstream portions of the alignment to allow for exiting utility crossings and sewer services to work. Upcoming potholing activities near the intersection of China Hat and Highway 97 should be used to confirm sewer depth that may be driven by rock-soil interface elevation for a future bore.

Elevations adjusted down 7" to maintain as-designed top of pipe elevations in the Atwood sewer will additionally allow sewer service to approximately 11 acres of the Maverick parcel of the Southwest UGB expansion area. To serve the entirety of the Maverick parcel through the Atwood sewer alignment, the sewer would need to be dropped significantly.

Sewering the Ward property by a highway 97 crossing and upsizing the currently planned Atwood sewer construction project planned for late 2020 offers significant cost savings as compared to the current Collection System Master Plan and Public Facilities Plan.

ATWOOD UPSIZE (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Changing from 8" to 15", 5-10' Depth				520	FT	$24.11	$12,539.01
Changing from 8" to 15", 10-20' Depth				693	FT	$27.01	$18,720.03
						SUBTOTAL=	$31,259.05

	As-Designed Depth	48" Cost		Assumed Upsized Depth**	60" Cost
SSMH 1*	13.23	$11,048.00		13.81	$13,744.00
SSMH 2*	9.97	$8,600.00		10.55	$11,011.00
SSMH 3	13.51	$11,048.00		14.09	$14,655.00
SSMH 4	8.27	$8,600.00		8.85	$10,100.00
SSMH 5	6.39	$8,600.00		6.97	$10,100.00
SSMH 6	7.46	$8,600.00		8.04	$10,100.00
SSMH 7	8.53	$8,600.00		9.11	$10,100.00
	48" Total=	$65,096.00		60" Total=	$79,810.00
				Cost to Upsize to 60" Manholes=	$14,714.00

*Assumes Standard MH, not Drop MH

**Assumes 7" Add'l Depth

Upsize Atwood Subtotal=	**$45,973.05**	$46,000.00
Class 2 , Low Estimate (-15%):	$39,077.09	$39,100.00
Class 2 , High Estimate (+20%):	**$55,167.65**	$55,200.00

ADD'L COST TO SEWER TO PONDEROSA (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Mobilization, 8%				1	LS	$6,383.76	$6,383.76
Misc. Incidentals, 4%				1	LS	$3,191.88	$3,191.88
TRAFFIC CONTROL				1	LS	$5,000.00	$5,000.00
15 INCH SANITARY SEWER PIPE, 10 FT				241	FT	$261.00	$62,901.00
60" CONCRETE MANHOLE				1	EA	$10,100.00	$10,100.00
SAWCUTTING				62	FT	$2.00	$124.00
REMOVAL OF SURFACINGS, 10" DEEP***				38	SY	$9.00	$342.00
AGGREGATE BASE, 6 INCHES THICK***				38	SY	$10.00	$380.00
LEVEL 3, 1/2 INCH DENSE MHMAC MIXTURE,				38	SY	$25.00	$950.00
						SUBTOTAL=	**$89,372.64**

***Assumes Atwood being refinished by developer per plans, only repave work being paid for with the sewer is on Ponderosa.

Class 3 , Low Estimate (-20%):	$71,498.11	$71,500.00
Class 3, High Estimate (+30%):	**$116,184.43**	$116,200.00

FUTURE CONSTRUCTION COST TO SEWER IN PONDEROSA FROM ATWOOD TO HWY 97 (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Mobilization, 8%				1	LS	$11,774.72	$11,774.72
Misc. Incidentals, 4%				1	LS	$5,887.36	$5,887.36
TRAFFIC CONTROL				1	LS	$10,000.00	$10,000.00
15 INCH SANITARY SEWER PIPE, 10 FT				324	FT	$261.00	$84,564.00
60" CONCRETE MANHOLE				3	EA	$10,100.00	$30,300.00
SAWCUTTING				248	FT	$2.00	$496.00
REMOVAL OF SURFACINGS, 10" DEEP****				496	SY	$9.00	$4,464.00
AGGREGATE BASE, 6 INCHES THICK****				496	SY	$10.00	$4,960.00
LEVEL 3, 1/2 INCH DENSE MHMAC MIXTURE, 4-INCHES THICK****				496	SY	$25.00	$12,400.00
8" Watermain Crossing				1	EA	$1,000.00	$1,000.00
						SUBTOTAL=	**$165,846.08**

****Assumes single lane replacement in Ponderosa

Class 4 , Low Estimate (-30%):	$116,092.26	$116,100.00
Class 4, High Estimate (+50%):	**$248,769.12**	$248,800.00

FUTURE CONSTRUCTION COST TO BORE UNDER HWY 97 (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Mobilization, 8%				1	LS	$37,797.68	$37,797.68
Misc. Incidentals, 4%				1	LS	$18,898.84	$18,898.84
TRAFFIC CONTROL				1	LS	$10,000.00	$10,000.00
15 INCH SANITARY SEWER PIPE, 10 FT				301	FT	$261.00	$78,561.00
60" CONCRETE MANHOLE				1	EA	$10,100.00	$10,100.00
BORE PIT & RECEIVING PIT				1	LS	$27,500.00	$27,500.00
AUGER BORE, COMPLETE (183 LF)				1	ea	$346,310.00	$346,310.00
						SUBTOTAL=	**$529,167.52**

Class 4 , Low Estimate (-30%):	$370,417.26	$370,400.00
Class 4, High Estimate (+50%):	**$793,751.28**	$793,800.00
		$830,400
		$597,100
Total Present Day Costs to Extend Sewer Across Highway 97 to Ward Parcel (excludes engineering and adminstrative costs)=	**$1,213,872**	**$1,214,000**

COMPARATIVE COST TO CONSTRUCT PARRELL SEWER MAIN (excludes engineering and adminstrative costs)		QTY	UNIT	UNIT COST	TOTAL COST
12 INCH SANITARY SEWER PIPE, DEPTH UNKNOWN, ALL INCLUSIVE		5100	LF	958	4885800
				SUBTOTAL=	**$4,885,800.00**

Class 5 , Low Estimate (-50%):	$2,442,900.00	$2,442,900.00
Class 5, High Estimate (+100%):	$9,771,600.00	$9,771,600.00
Estimated cost to sewer to Sewer Ward through Parrell, w/ 50% contingency=	**$7,328,700.00**	$7,328,700.00

ATWOOD UPSIZE (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Changing from 8" to 15", 5-10' Depth				520	FT	$24.11	$12,539.01
Changing from 8" to 15", 10-20' Depth				693	FT	$27.01	$18,720.03
Changing from 8" to 15", Depth Unknown across Bell property				500	FT	$25.00	$12,500.00
						SUBTOTAL=	$43,759.05

	As-Designed Depth	48" Cost		Assumed Upsized Depth**	60" Cost
SSMH 1*	13.23	$11,048.00		13.81	$13,744.00
SSMH 2*	9.97	$8,600.00		10.55	$11,011.00
SSMH 3	13.51	$11,048.00		14.09	$14,655.00
SSMH 4	8.27	$8,600.00		8.85	$10,100.00
SSMH 5	6.39	$8,600.00		6.97	$10,100.00
SSMH 6	7.46	$8,600.00		8.04	$10,100.00
SSMH 7	8.53	$8,600.00		9.11	$10,100.00
Unknown Bell MH	13	$11,048.00		13.58	$13,744.00
Unknown Bell MH	13	$11,048.00		13.58	$13,744.00
	48" Total=	$87,192.00		60" Total=	$107,298.00
				Cost to Upsize to 60" Manholes=	$20,106.00

*Assumes Standard MH, not Drop MH

**Assumes 7" Add'l Depth

Upsize Atwood Subtotal=	**$63,865.05**	$63,900.00
Class 3 , Low Estimate (-20%):	$51,092.04	$51,100.00
Class 3 , High Estimate (+30%):	**$83,024.56**	$83,000.00

Note: preliminary information from Engineer of Record for Stillwater Crossing indicated higher cost difference from that project's Contractor to upsize from 8" to 15". As of this writing (10/2/2020) we haven't received bidding data from them, so we don't know the magnitude or reasons for the difference.

ADD'L COST TO SEWER TO PONDEROSA (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Mobilization, 8%				1	LS	$6,383.76	$6,383.76
Misc. Incidentals, 4%				1	LS	$3,191.88	$3,191.88
TRAFFIC CONTROL				1	LS	$5,000.00	$5,000.00
15 INCH SANITARY SEWER PIPE, 10 FT				241	FT	$261.00	$62,901.00
60" CONCRETE MANHOLE				1	EA	$10,100.00	$10,100.00
SAWCUTTING				62	FT	$2.00	$124.00
REMOVAL OF SURFACINGS, 10" DEEP***				38	SY	$9.00	$342.00
AGGREGATE BASE, 6 INCHES THICK***				38	SY	$10.00	$380.00
LEVEL 3, 1/2 INCH DENSE MHMAC MIXTURE,				38	SY	$25.00	$950.00
						SUBTOTAL=	**$89,372.64**

***Assumes Atwood being refinished by developer per plans, only repave work being paid for with the sewer is on Ponderosa.

Class 3 , Low Estimate (-20%):	$71,498.11	$71,500.00
Class 3, High Estimate (+30%):	**$116,184.43**	$116,200.00

FUTURE CONSTRUCTION COST TO SEWER IN PONDEROSA FROM ATWOOD TO HWY 97 (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Mobilization, 8%				1	LS	$11,774.72	$11,774.72
Misc. Incidentals, 4%				1	LS	$5,887.36	$5,887.36
TRAFFIC CONTROL				1	LS	$10,000.00	$10,000.00
15 INCH SANITARY SEWER PIPE, 10 FT				324	FT	$261.00	$84,564.00
60" CONCRETE MANHOLE				3	EA	$10,100.00	$30,300.00
SAWCUTTING				248	FT	$2.00	$496.00
REMOVAL OF SURFACINGS, 10" DEEP****				496	SY	$9.00	$4,464.00
AGGREGATE BASE, 6 INCHES THICK****				496	SY	$10.00	$4,960.00
LEVEL 3, 1/2 INCH DENSE MHMAC MIXTURE, 4-INCHES THICK****				496	SY	$25.00	$12,400.00
8" Watermain Crossing				1	EA	$1,000.00	$1,000.00
						SUBTOTAL=	**$165,846.08**

****Assumes single lane replacement in Ponderosa

Class 4 , Low Estimate (-30%):	$116,092.26	$116,100.00
Class 4, High Estimate (+50%):	**$248,769.12**	$248,800.00

FUTURE CONSTRUCTION COST TO BORE UNDER HWY 97 (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
Mobilization, 8%				1	LS	$37,797.68	$37,797.68
Misc. Incidentals, 4%				1	LS	$18,898.84	$18,898.84
TRAFFIC CONTROL				1	LS	$10,000.00	$10,000.00
15 INCH SANITARY SEWER PIPE, 10 FT				301	FT	$261.00	$78,561.00
60" CONCRETE MANHOLE				1	EA	$10,100.00	$10,100.00
BORE PIT & RECEIVING PIT				1	LS	$27,500.00	$27,500.00
AUGER BORE, COMPLETE (183 LF)				1	ea	$346,310.00	$346,310.00
						SUBTOTAL=	**$529,167.52**

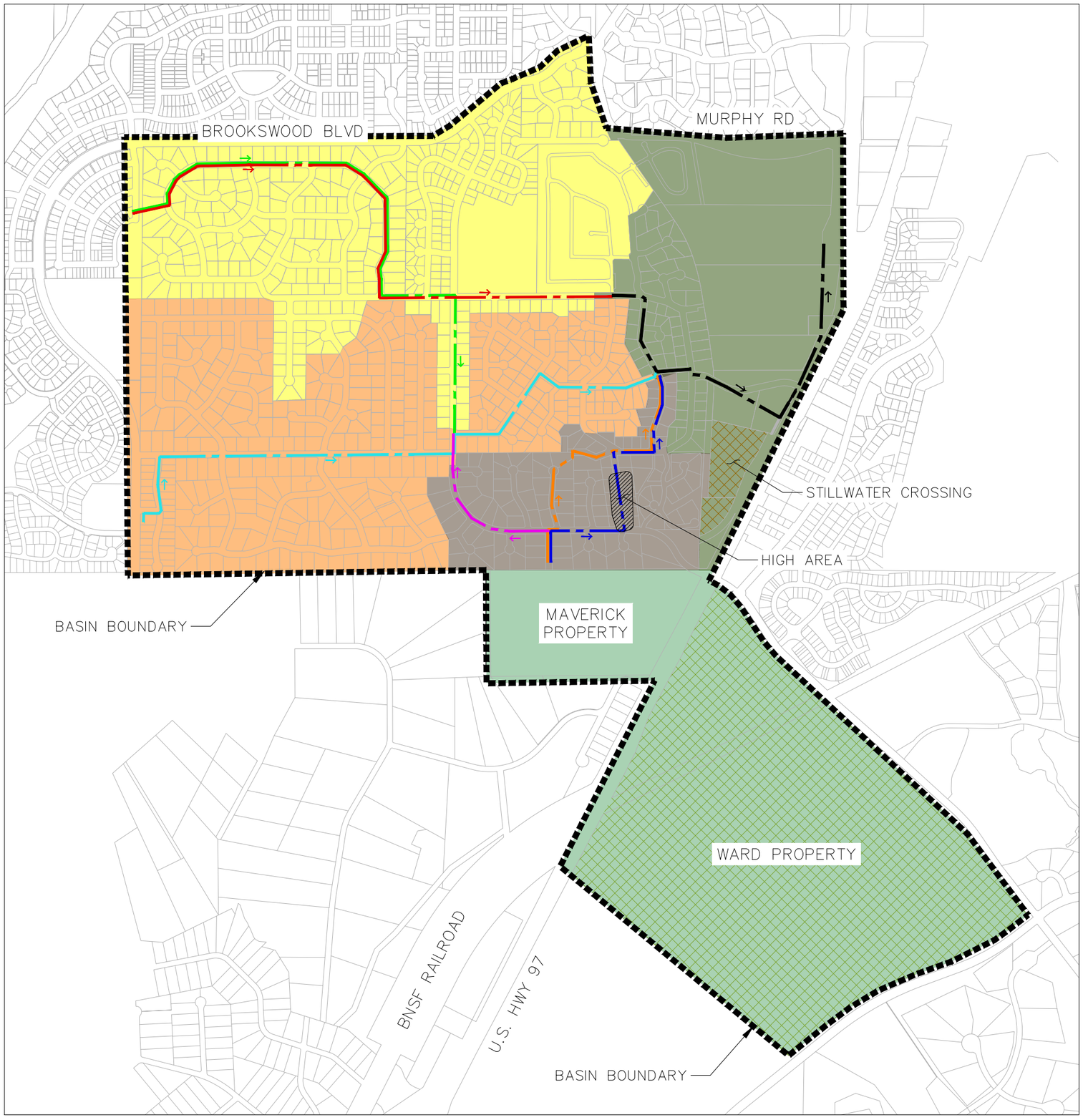
Class 4 , Low Estimate (-30%):	$370,417.26	$370,400.00
Class 4, High Estimate (+50%):	**$793,751.28**	$793,800.00
		$848,300
		$609,100
Total Present Day Costs to Extend Sewer Across Highway 97 to Ward Parcel (excludes engineering and adminstrative costs)=	**$1,241,729**	**$1,241,800**

COMPARATIVE COST TO CONSTRUCT PARRELL SEWER MAIN (excludes engineering and adminstrative costs)		QTY	UNIT	UNIT COST	TOTAL COST
12 INCH SANITARY SEWER PIPE, DEPTH UNKNOWN, ALL INCLUSIVE		5100	LF	$958	$4,885,800
				SUBTOTAL=	**$4,885,800.00**

		$4,885,800.00
Class 5 , Low Estimate (-50%):	$2,442,900.00	$2,442,900.00
Class 5, High Estimate (+100%):	$9,771,600.00	$9,771,600.00
Estimated cost to sewer to Sewer Ward through Parrell, w/ 50% contingency=	**$7,328,700.00**	$7,328,700.00

Appendix G

Alternative Review Areas



REVIEW AREA LEGEND

- NORTH TRUNK REVIEW AREA
- SOUTH TRUNK REVIEW AREA
- JASMINE REVIEW AREA
- SEGMENT 1 REVIEW AREA
- THE THUMB REVIEW AREA

ALIGNMENT LEGEND

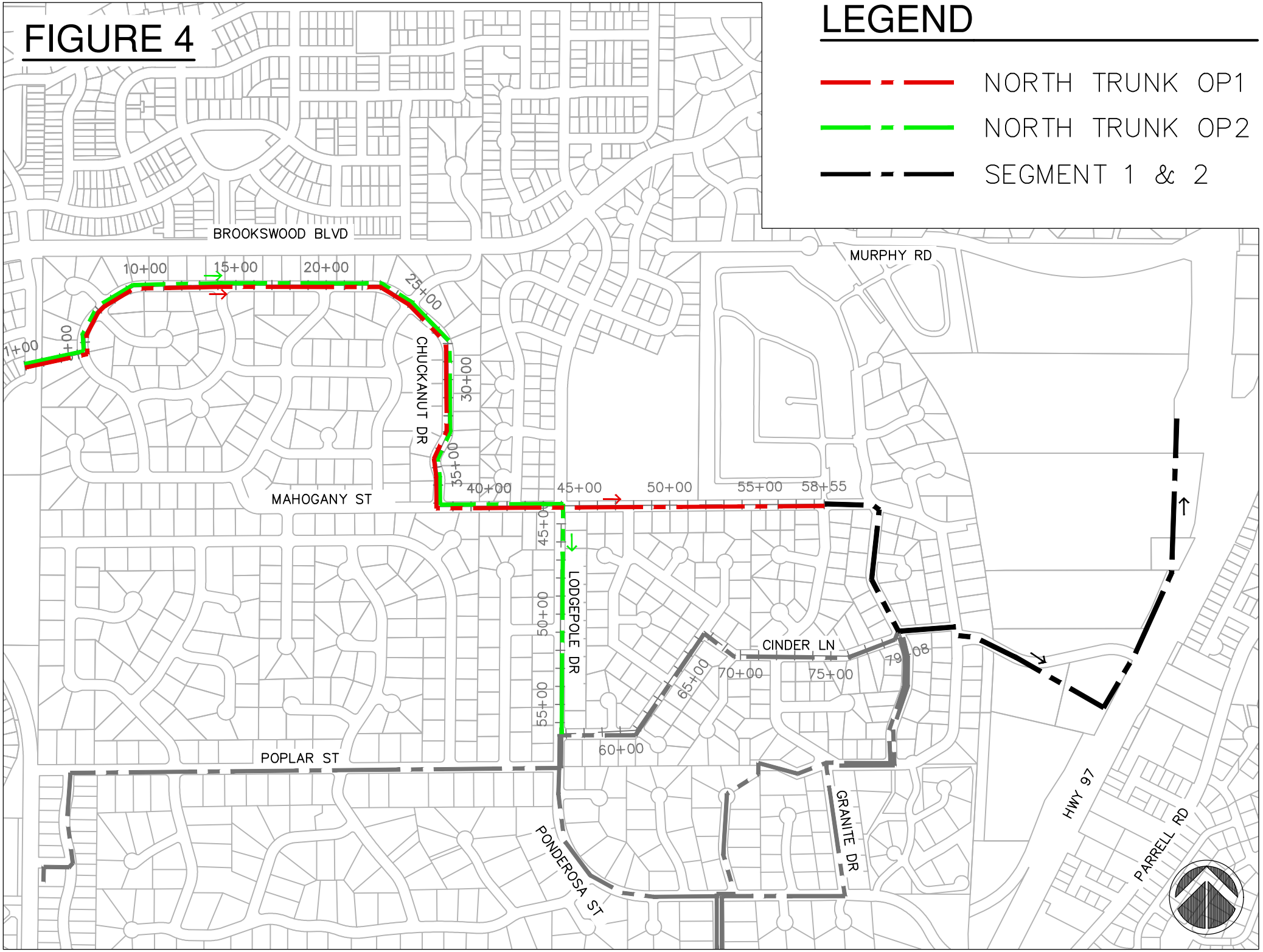
- NORTH TRUNK OP1
- NORTH TRUNK OP2
- SOUTH TRUNK
- SEGMENT ONE
- JASMINE FA 1
- JASMINE FA 2
- JASMINE FA 3

FIGURE 3
SCALE: 1" = 500'

Appendix H

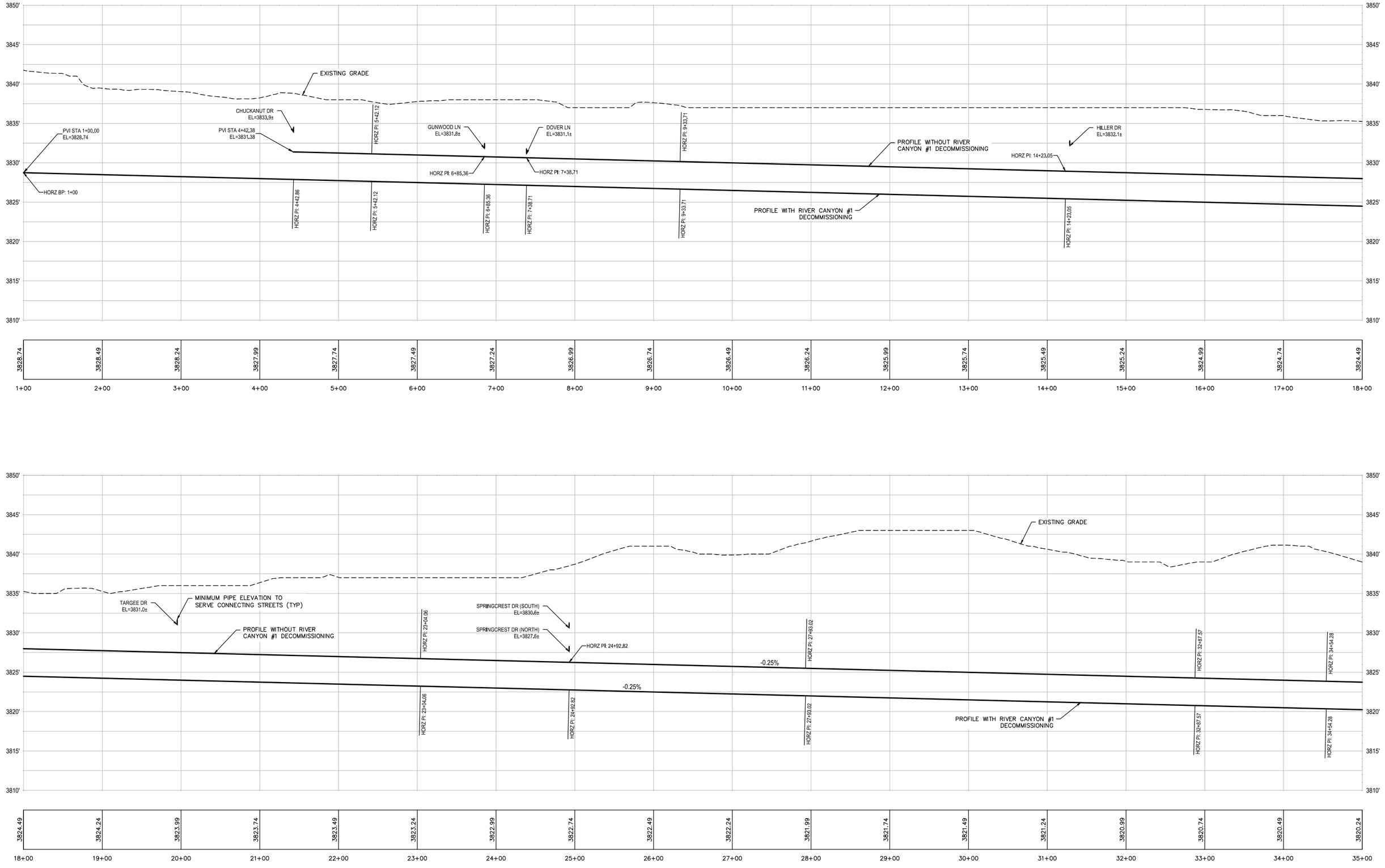
North Trunk Alternatives

FIGURE 4


LEGEND
NORTH TRUNK OP1
NORTH TRUNK OP2
SEGMENT 1 & 2
BROOKSWOOD BLVD
MURPHY RD
CHUCKANUT DR
MAHOGANY ST
LODGEPOLE DR
CINDER LN
POPLAR ST
PONDEROSA ST
GRANITE DR
HWY 97
PARRELL RD
1+00
5+00
10+00
15+00
20+00
25+00
30+00
35+00
40+00
45+00
50+00
55+00
58+55
45+00
50+00
55+00
60+00
65+00
70+00
75+00
79+08

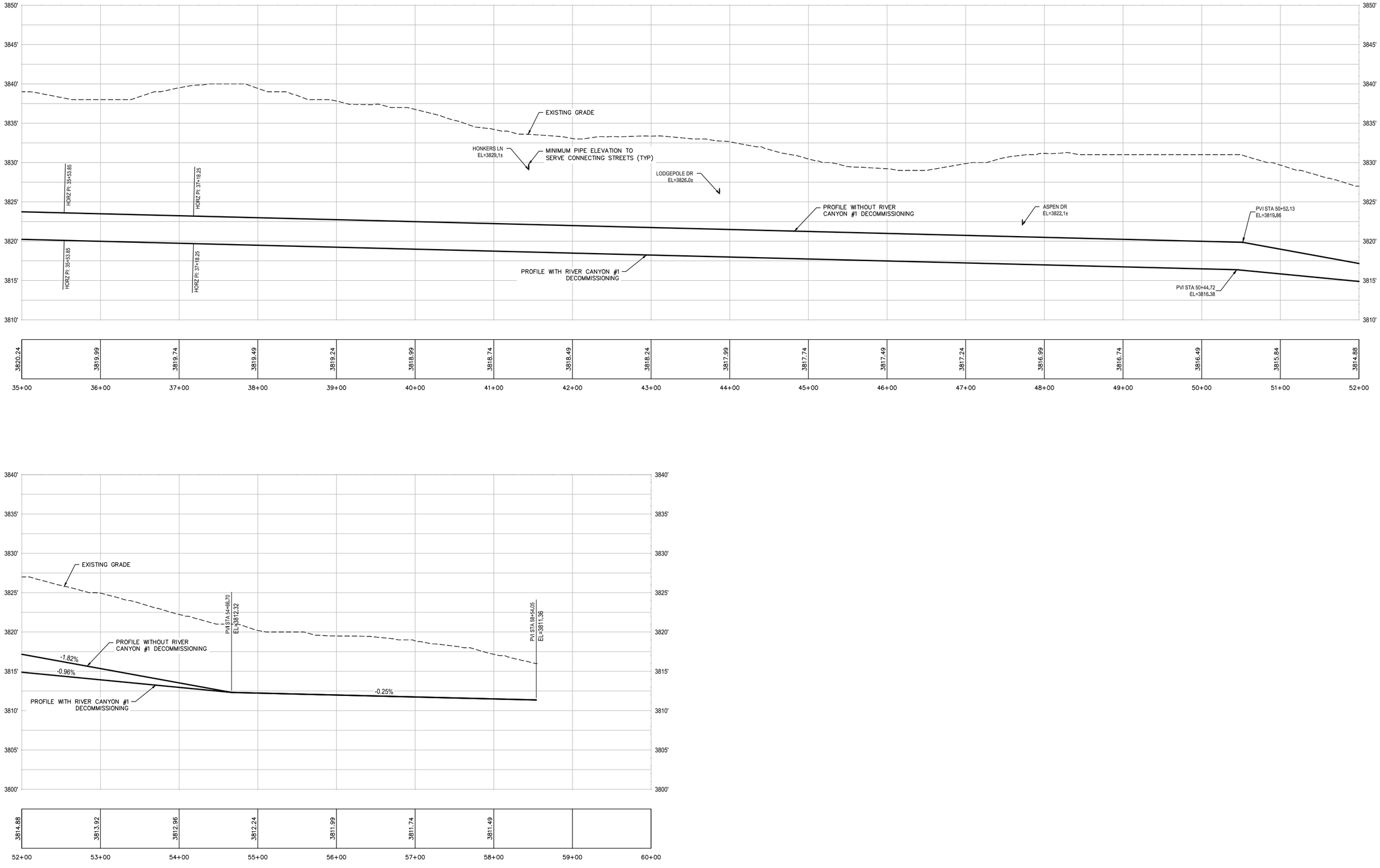
NORTH TRUNK - ALTERNATIVE 1 - PROFILE

SCALE: H: 1" = 50 V: 1" = 5



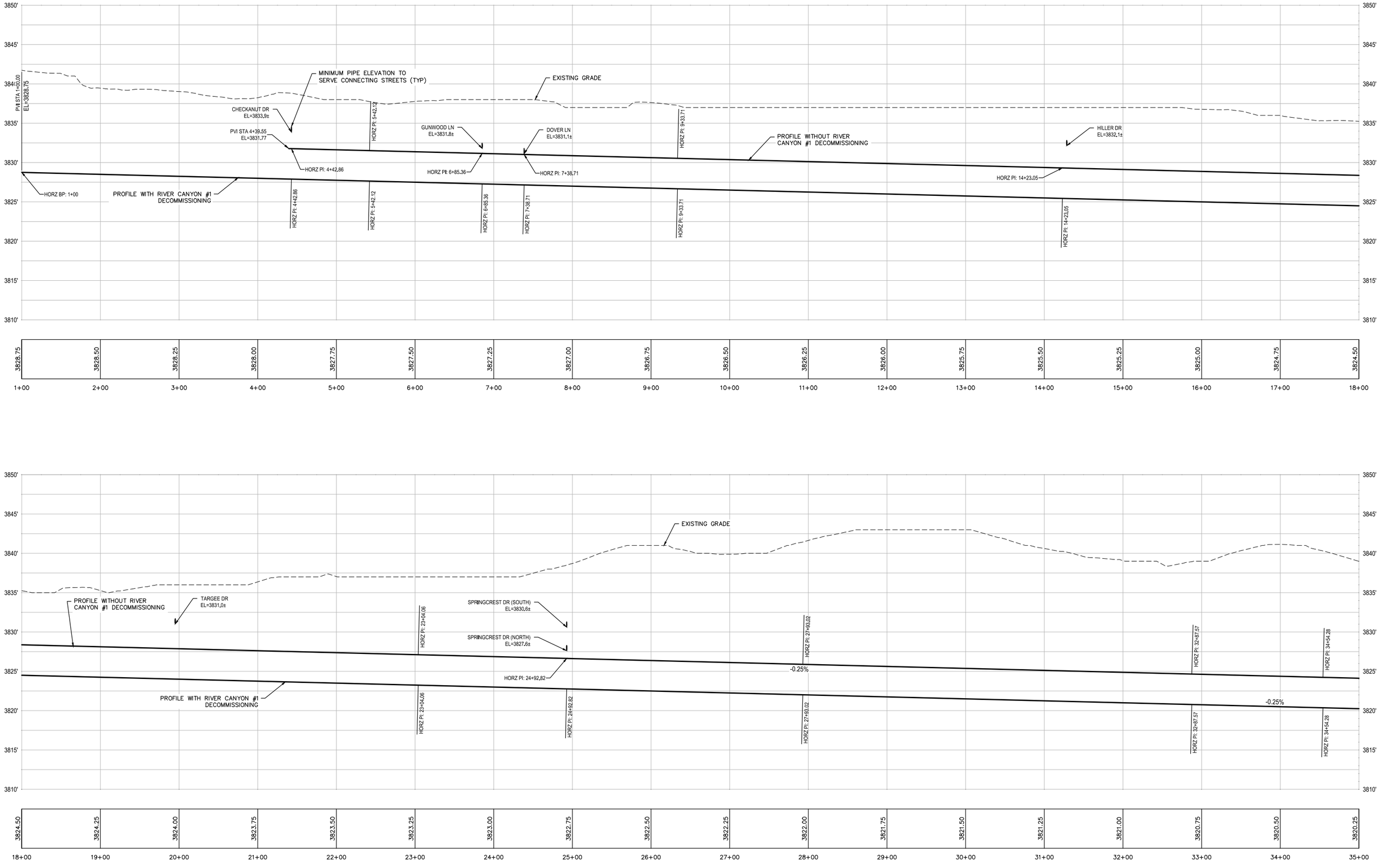
NORTH TRUNK - ALTERNATIVE 1 - PROFILE

SCALE: H: 1" = 50 V: 1" = 5



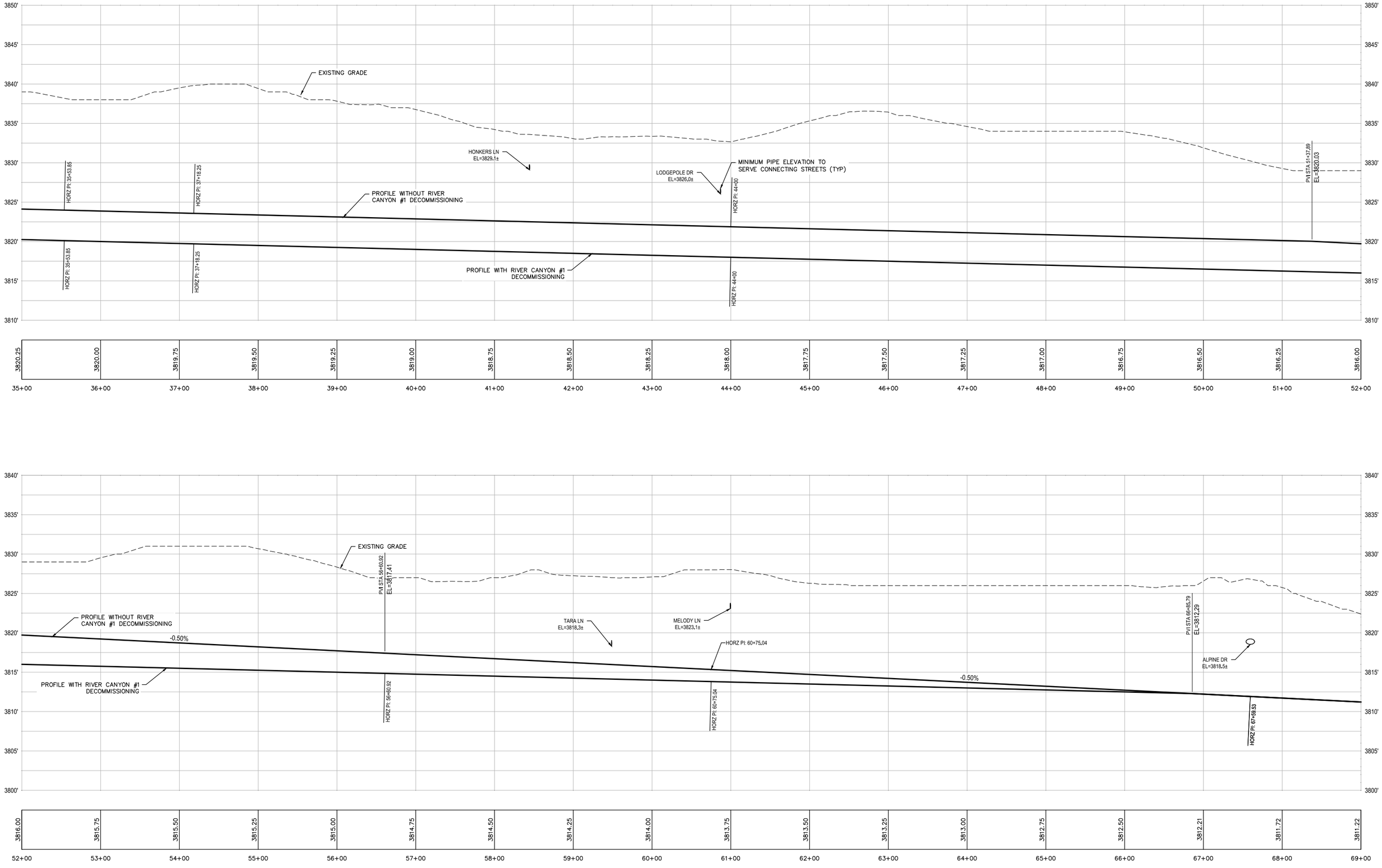
NORTH TRUNK - ALTERNATIVE 2 - PROFILE

SCALE: H: 1" = 50 V: 1" = 5



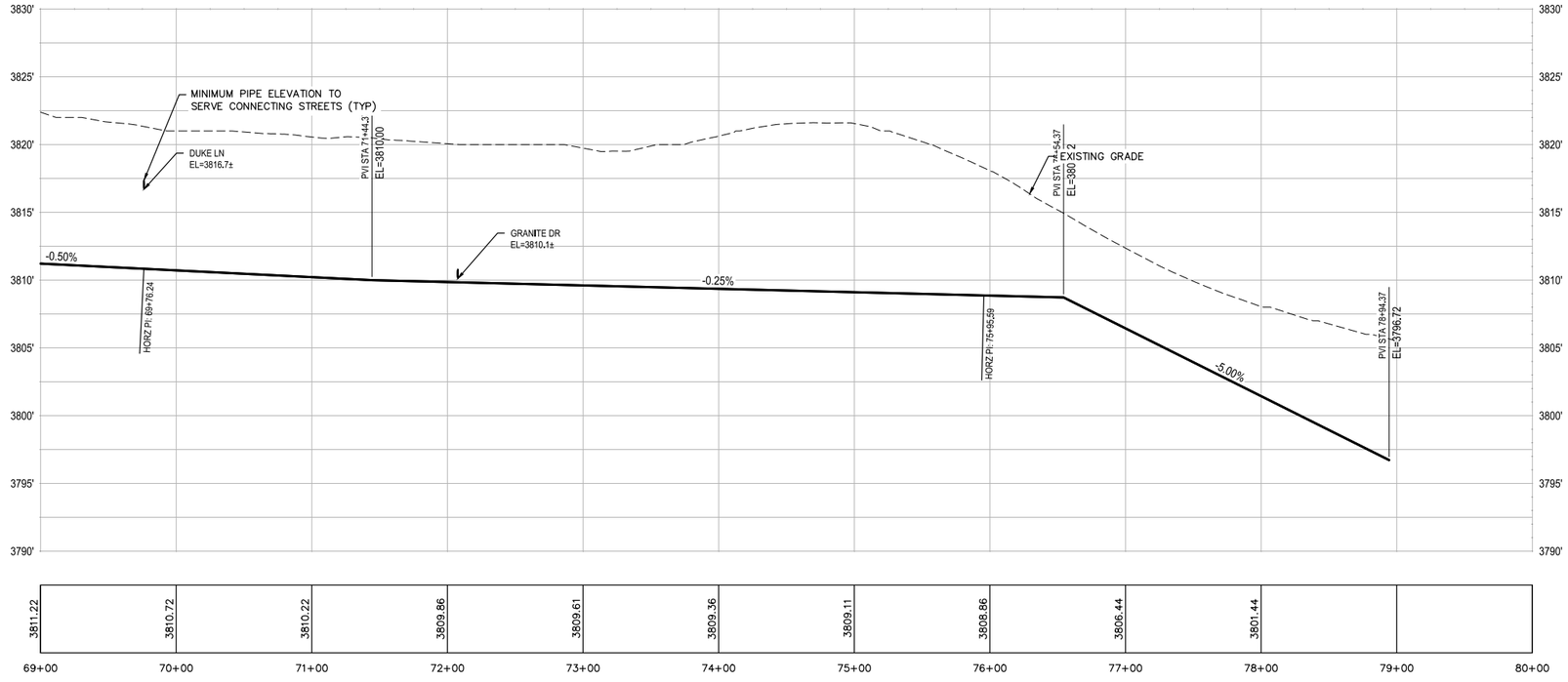
NORTH TRUNK - ALTERNATIVE 2 - PROFILE

SCALE: H: 1" = 50 V: 1" = 5



NORTH TRUNK - ALTERNATIVE 2 - PROFILE

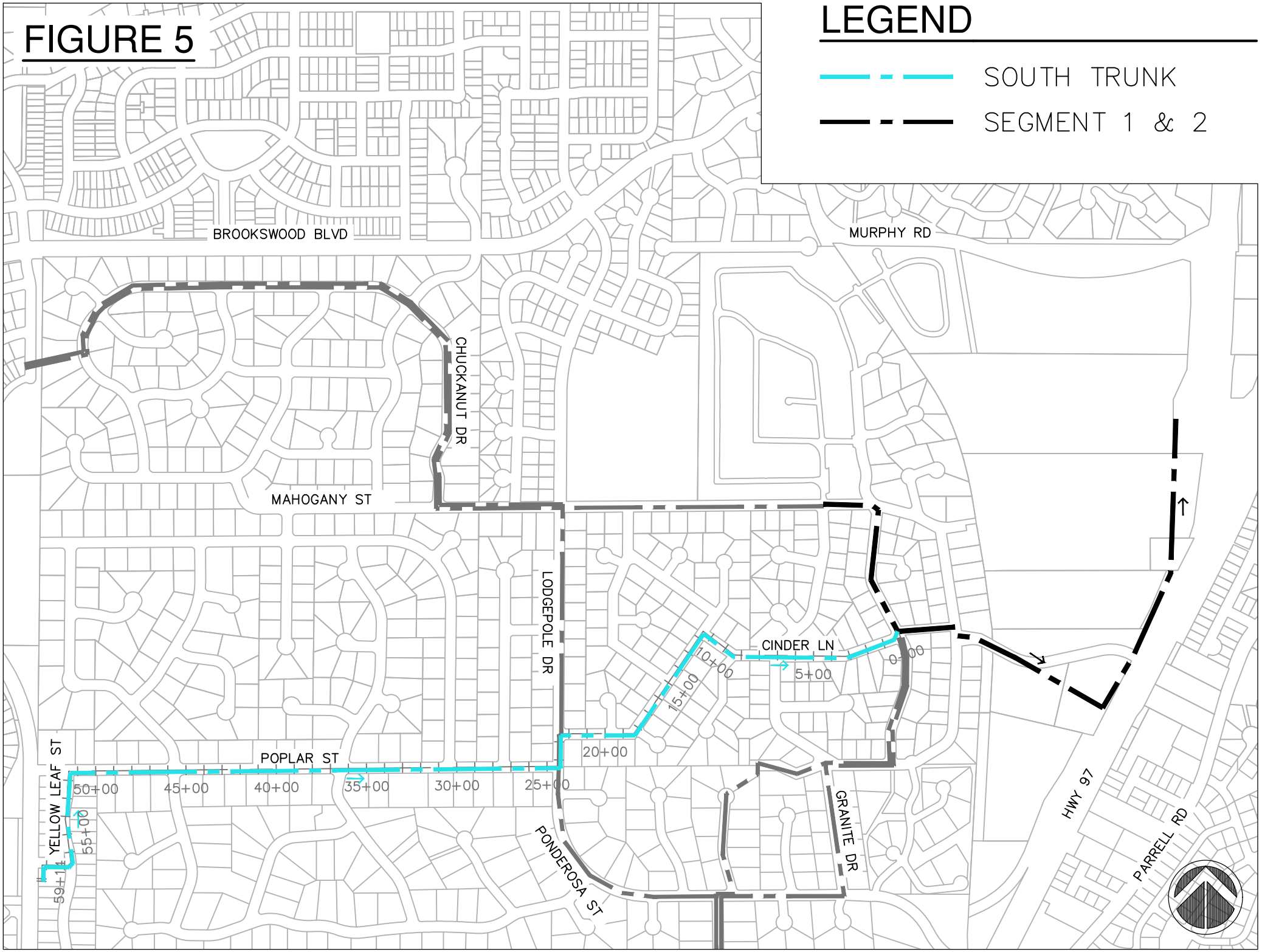
SCALE: H: 1" = 50 V: 1" = 5



Appendix I

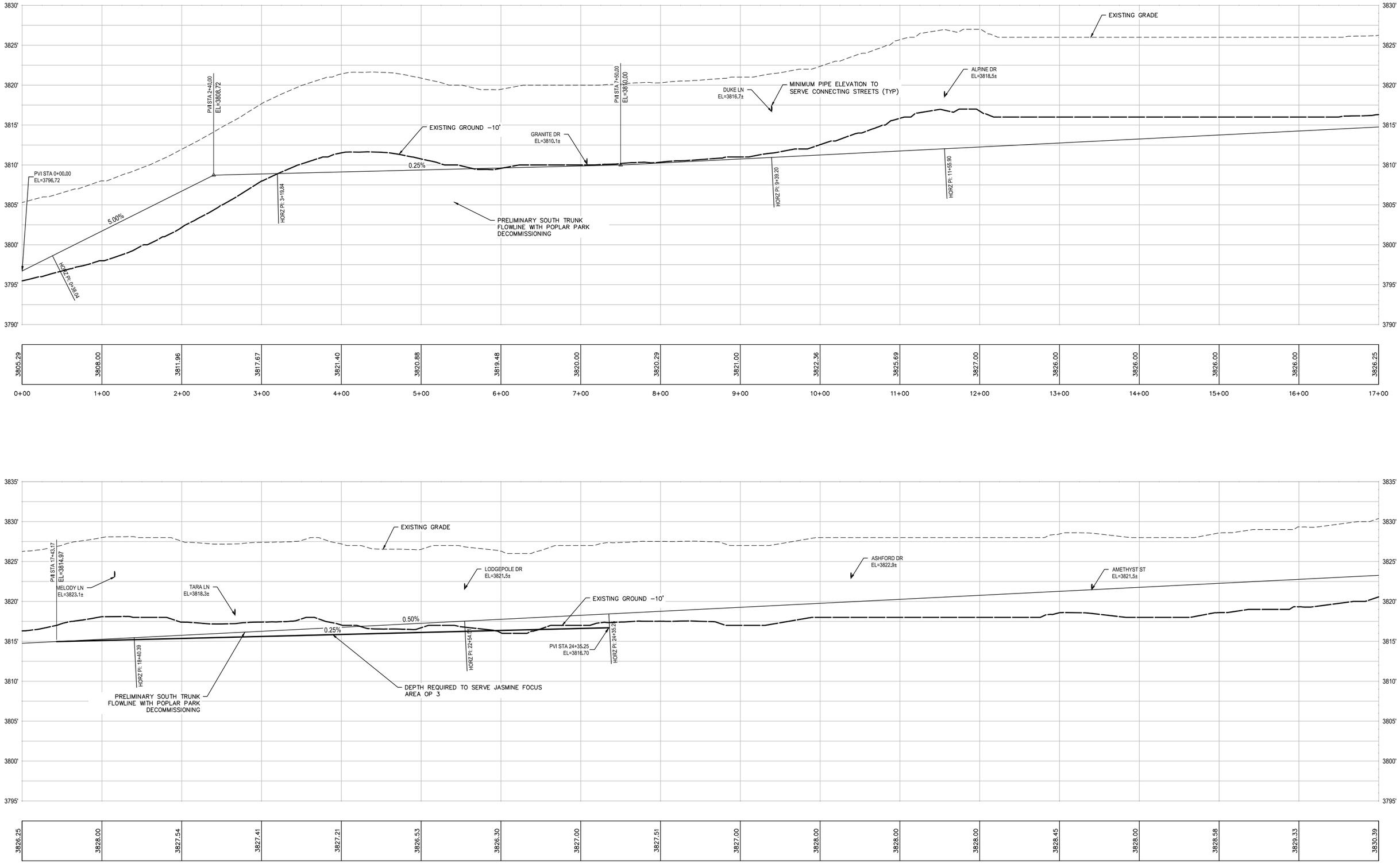
South Trunk Alternatives

FIGURE 5


LEGEND
SOUTH TRUNK
SEGMENT 1 & 2
BROOKSWOOD BLVD
MURPHY RD
CHUCKANUT DR
MAHOGANY ST
LODGEPOLE DR
CINDER LN
0+00
5+00
10+00
15+00
20+00
POPLAR ST
50+00
45+00
40+00
35+00
30+00
25+00
YELLOW LEAF ST
55+00
59+1±
PONDEROSA ST
GRANITE DR
HWY 97
PARRELL RD

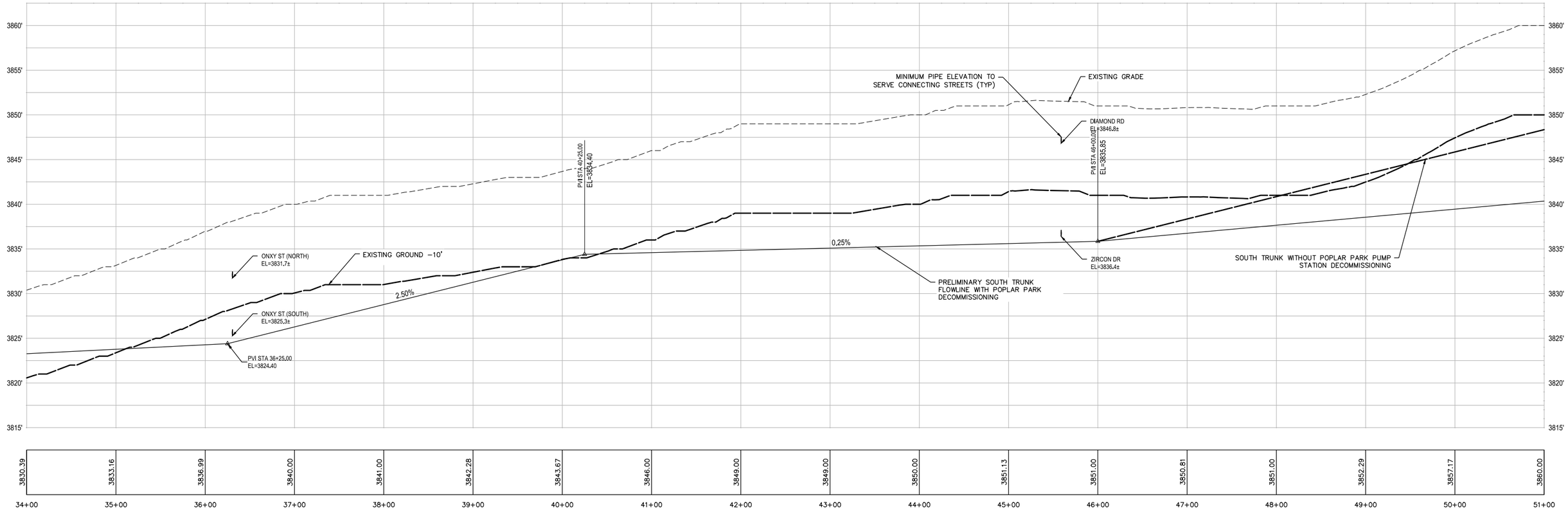
SOUTH TRUNK - PROFILE

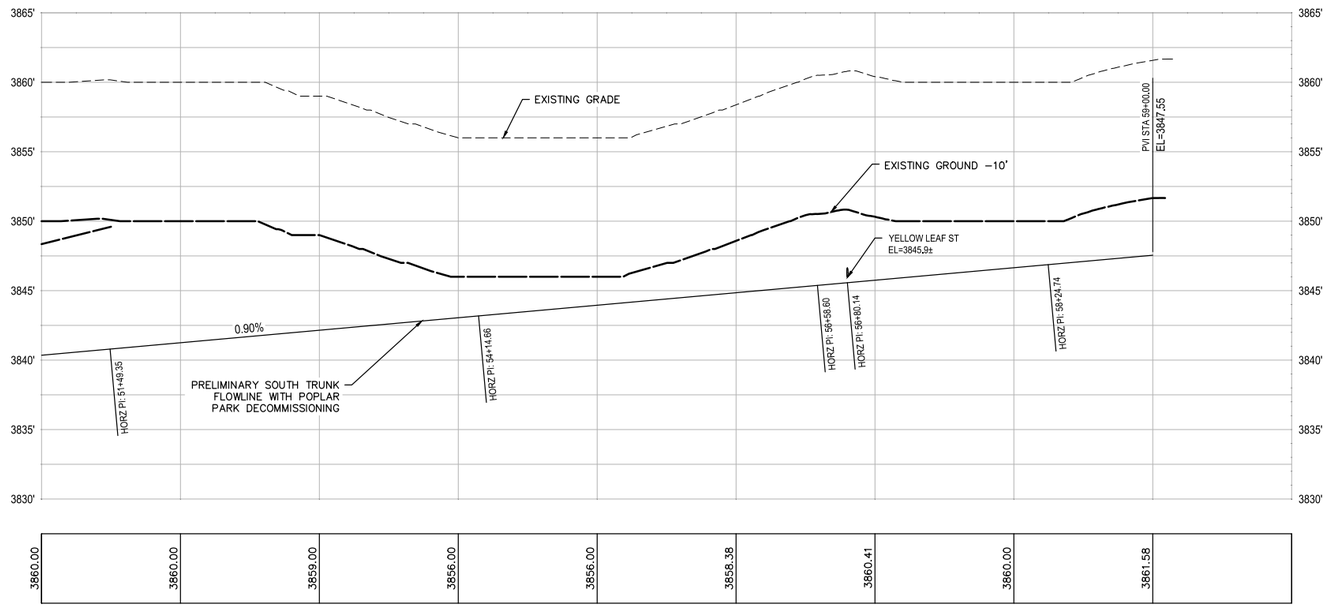
SCALE: H: 1" = 50 V: 1" = 5



SOUTH TRUNK - PROFILE

SCALE: H: 1" = 50 V: 1" = 5

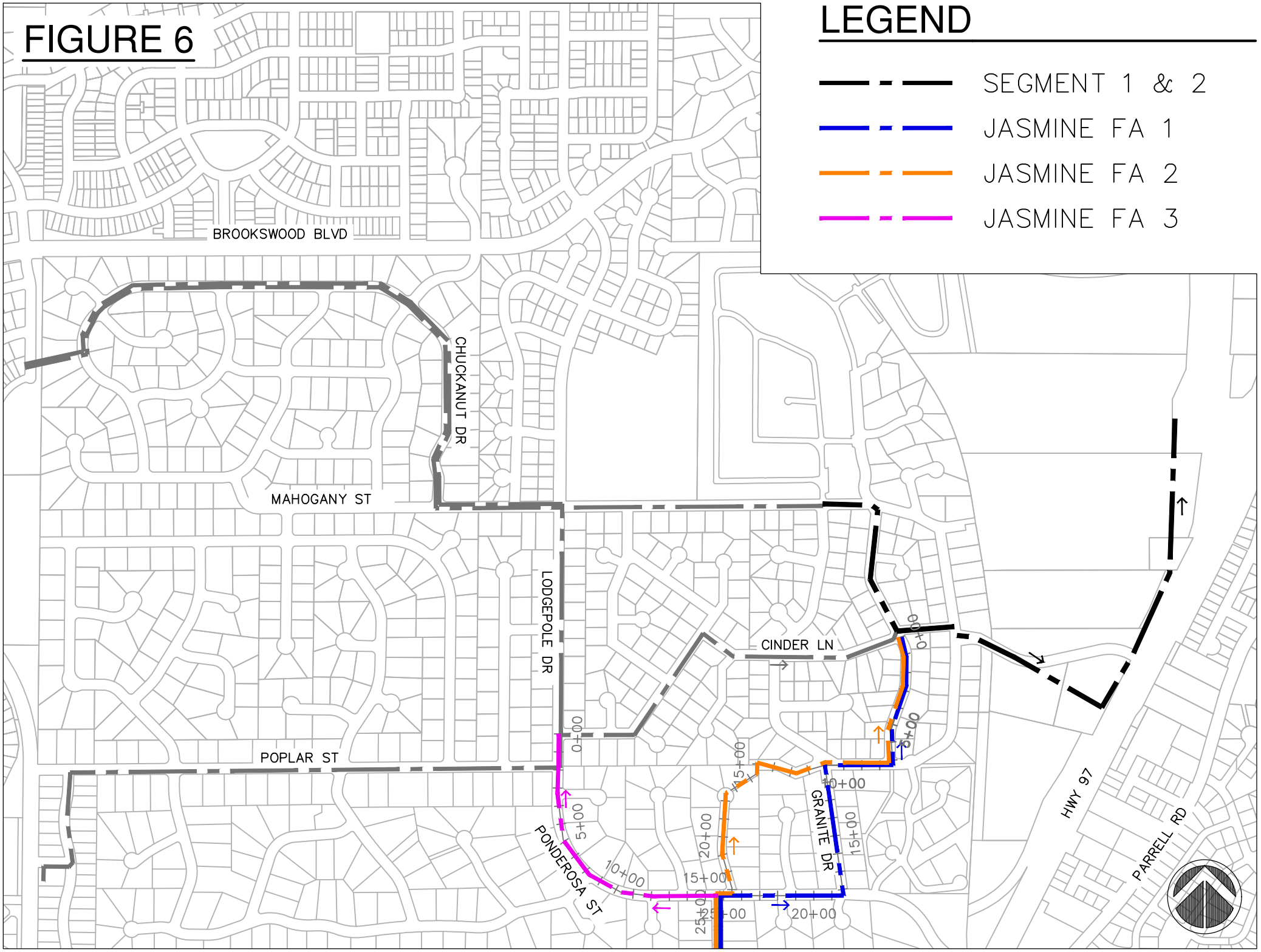




Appendix J

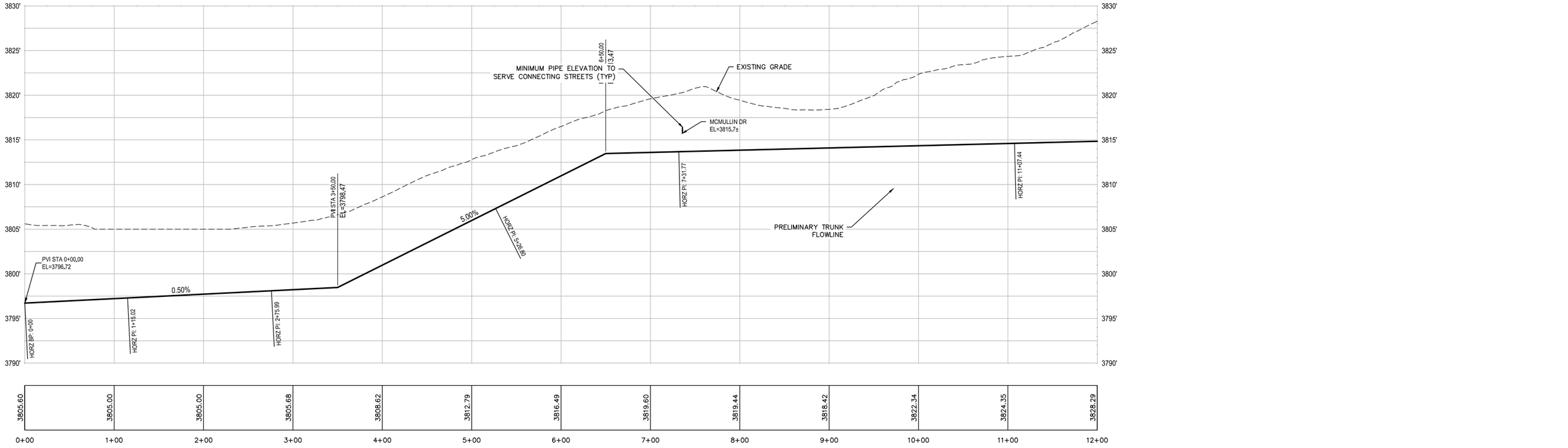
Jasmine Area Alternatives

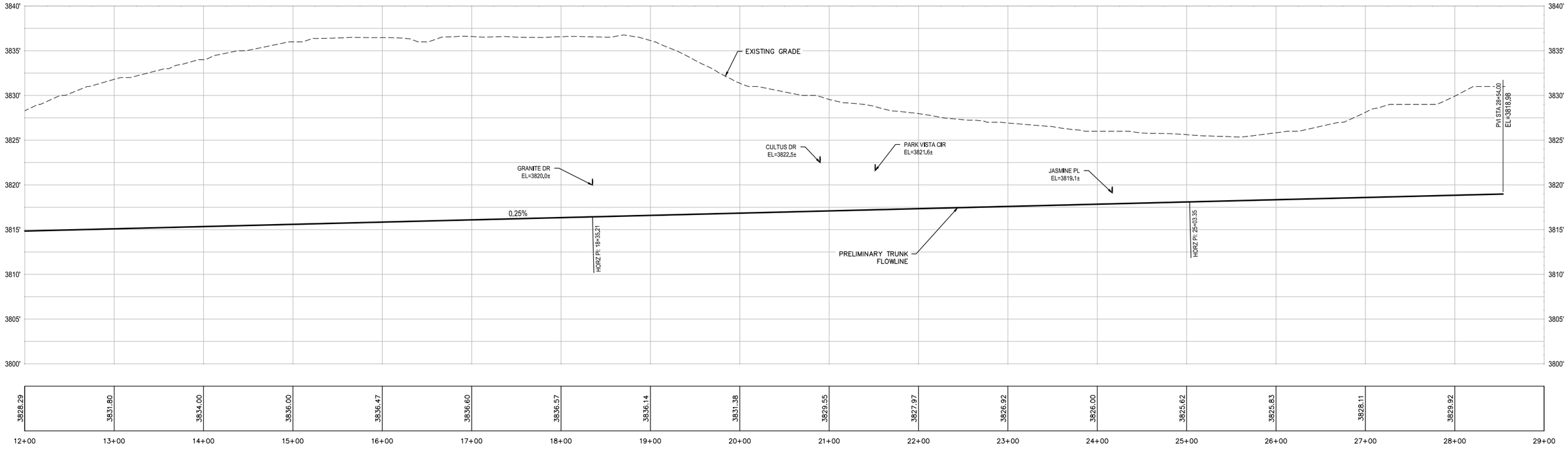
FIGURE 6


LEGEND
SEGMENT 1 & 2
JASMINE FA 1
JASMINE FA 2
JASMINE FA 3
BROOKSWOOD BLVD
CHUCKANUT DR
MAHOGANY ST
LODGEPOLE DR
CINDER LN
POPLAR ST
PONDEROSA ST
GRANITE DR
HWY 97
PARRELL RD
0+00
5+00
10+00
15+00
20+00
25+00

JASMINE AREA - ALTERNATIVE 1 - PROFILE

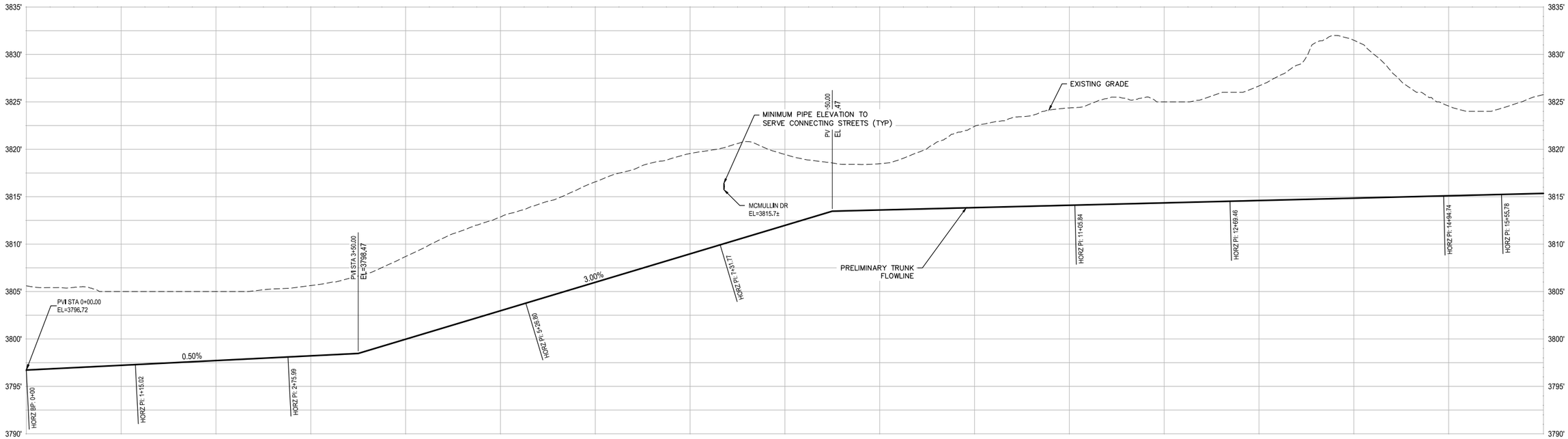
SCALE: H: 1" = 50 V: 1" = 5

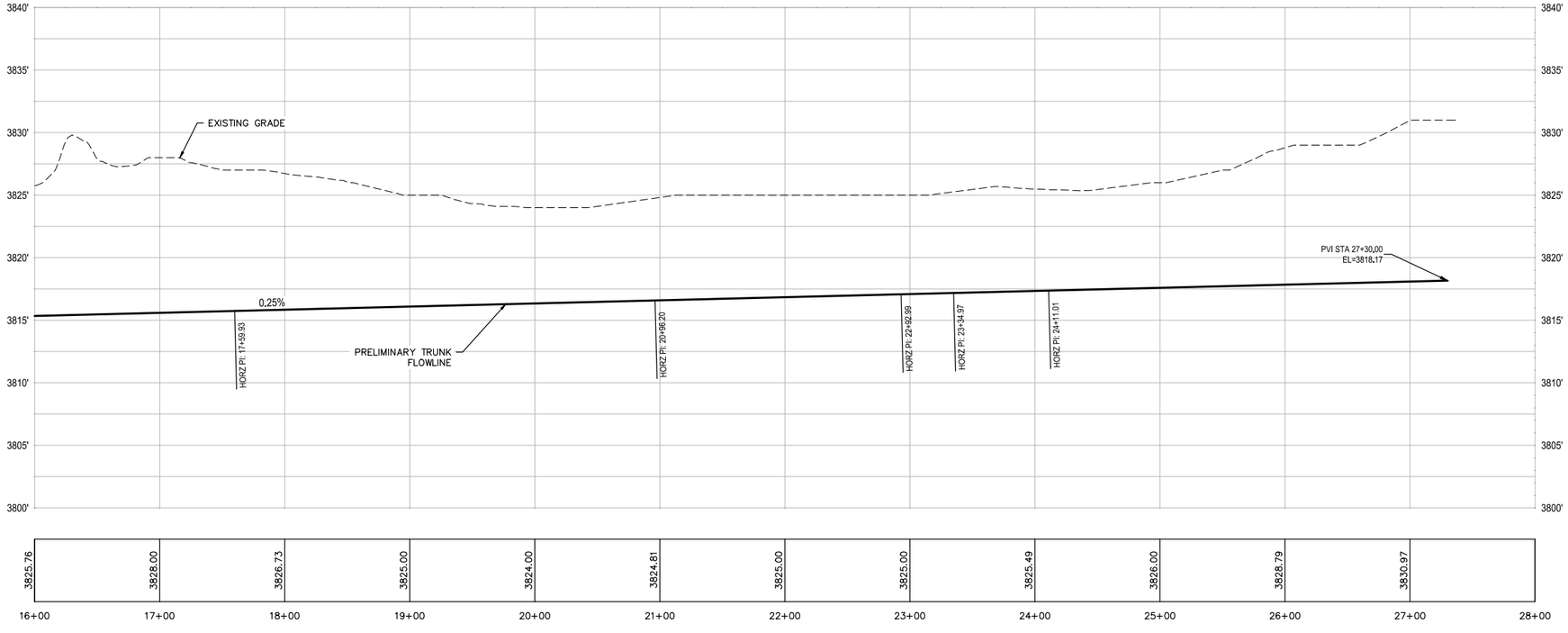




JASMINE AREA - ALTERNATIVE 2 - PROFILE

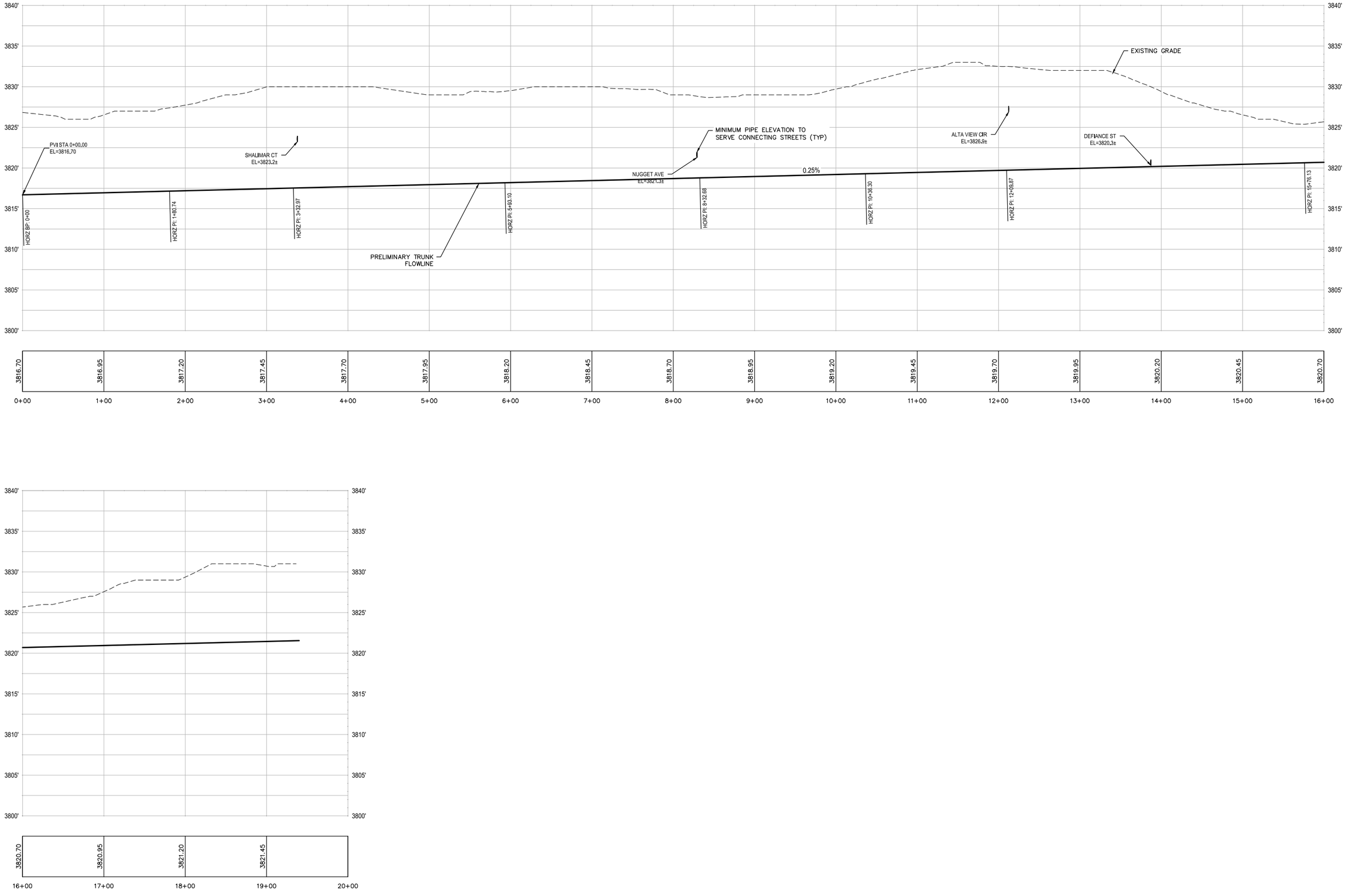
SCALE: H: 1" = 50 V: 1" = 5





JASMINE AREA - ALTERNATIVE 3 - PROFILE

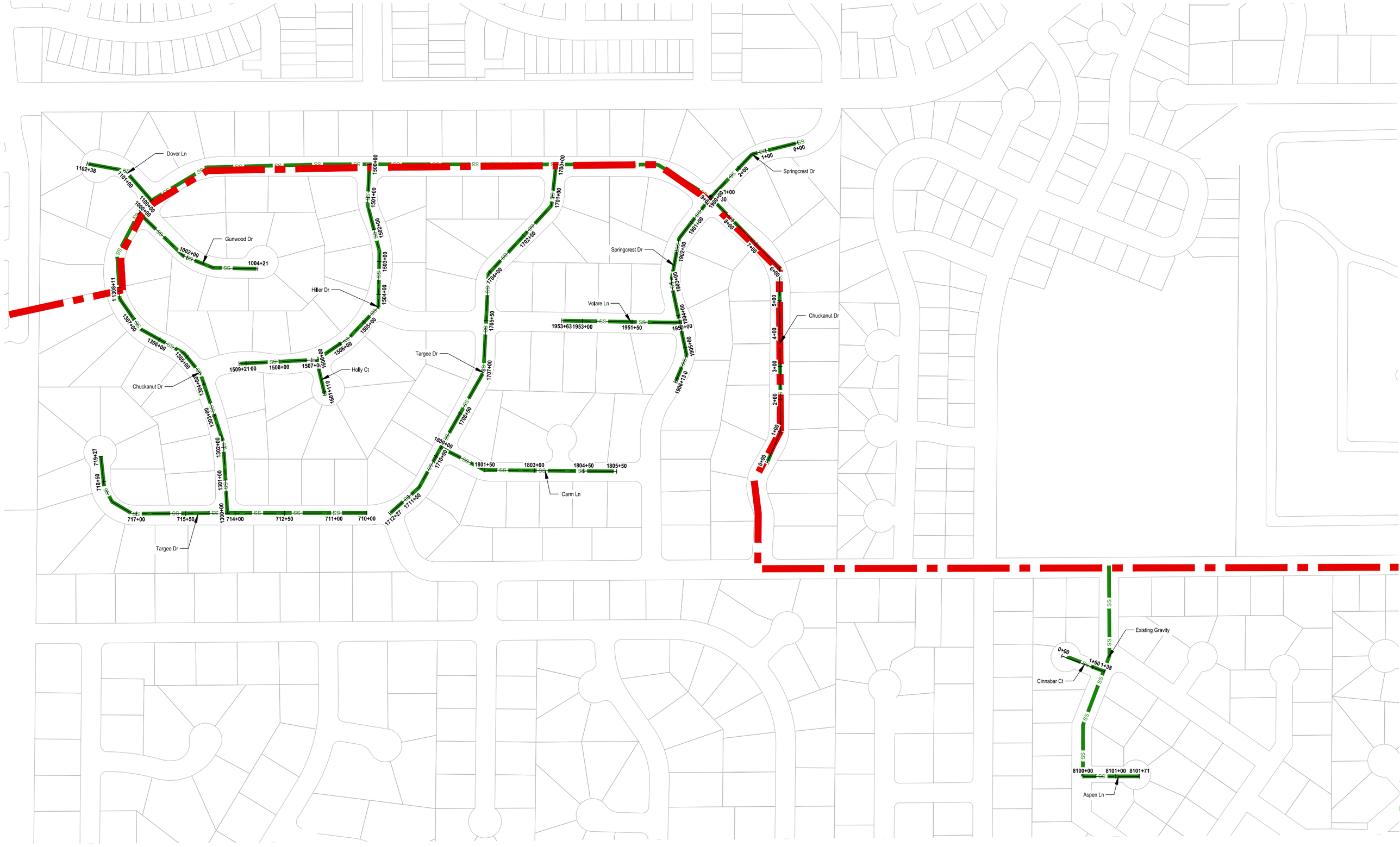
SCALE: H: 1" = 50 V: 1" = 5



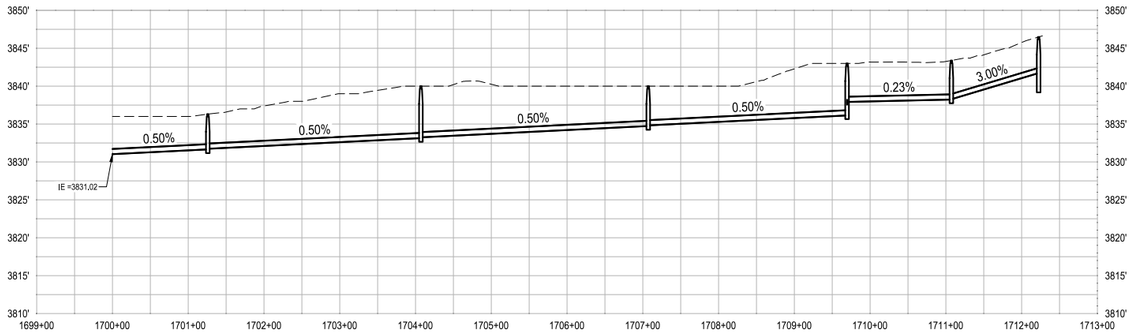
Appendix K

Side Street Profiles

NORTH TRUNK TIE IN SIDE STREETS

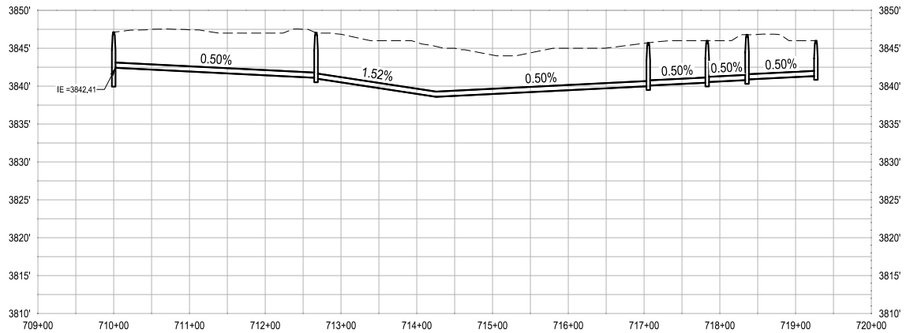


NORTH TRUNK TIE IN SIDE STREETS



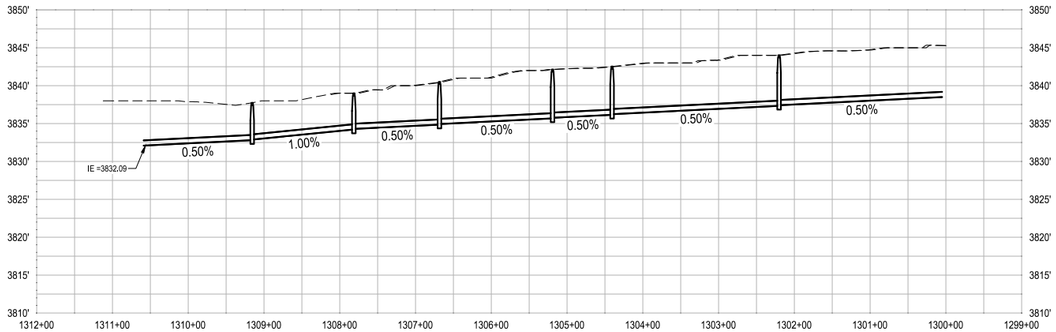
TARGEE DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



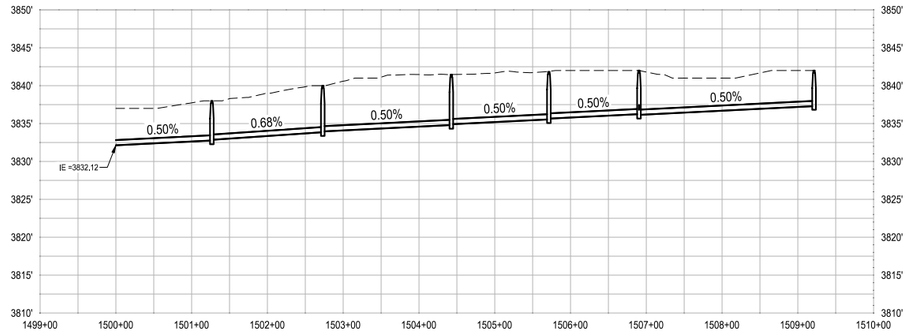
TARGEE DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



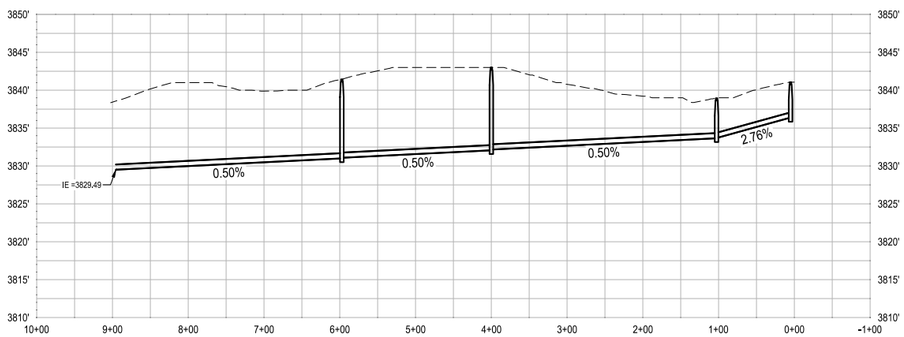
CHUCKANUT DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



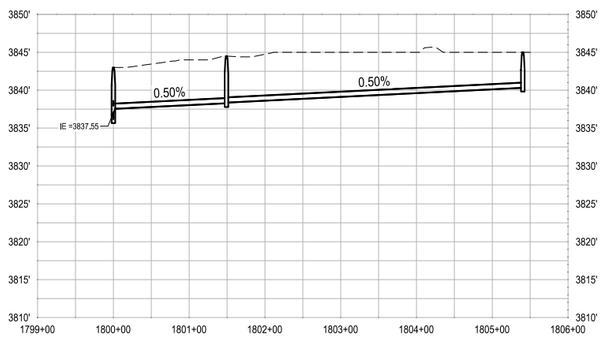
HILLER DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



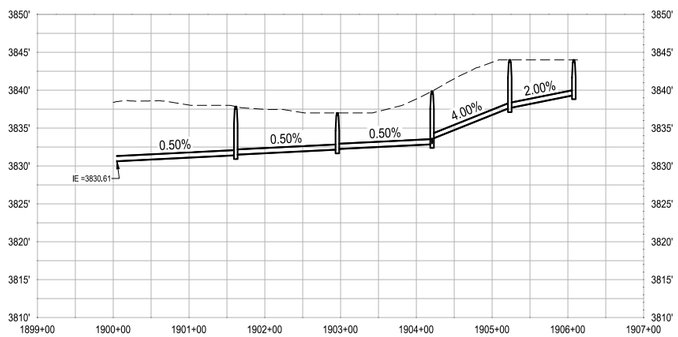
CHUCKANUT DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



CARM LN - PROFILE

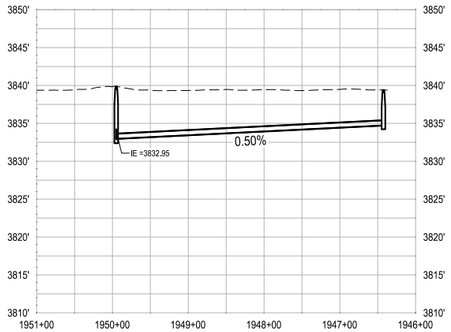
SCALE: H: 1" = 100' V: 1" = 10'



SPRINGCREST DR - PROFILE

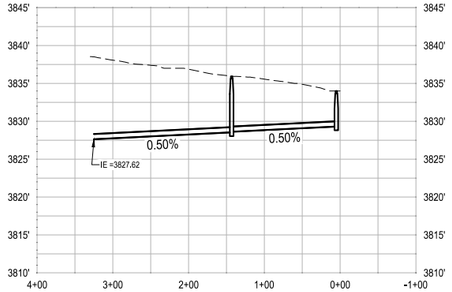
SCALE: H: 1" = 100' V: 1" = 10'

NORTH TRUNK TIE IN SIDE STREETS



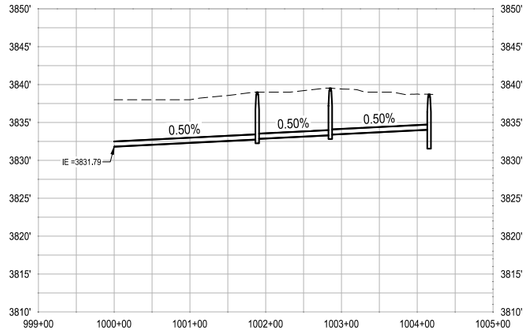
VOLARE LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



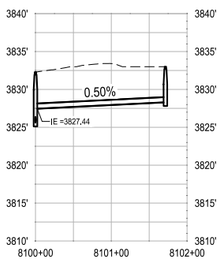
SPRINGCREST DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



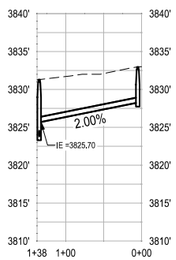
GUNWOOD LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



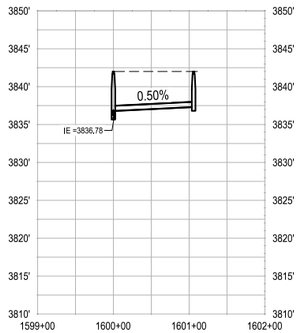
ASPEN LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



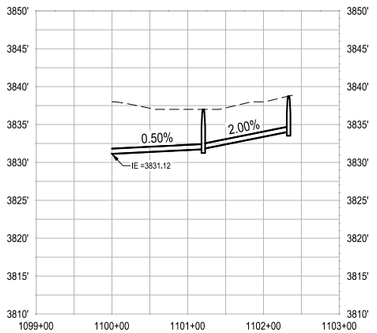
CINNABAR CT - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



HOLLY CT - PROFILE

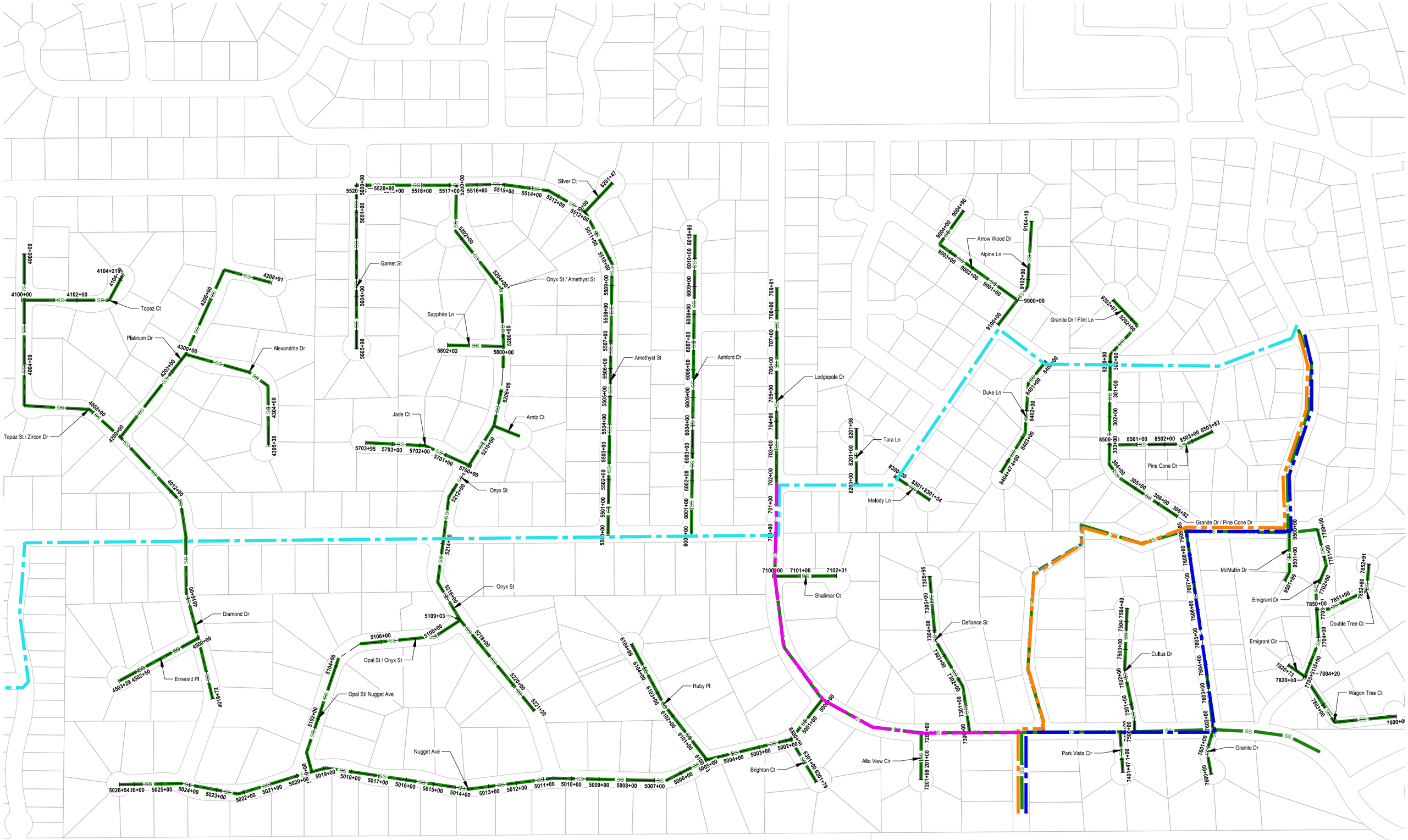
SCALE: H: 1" = 100' V: 1" = 10'



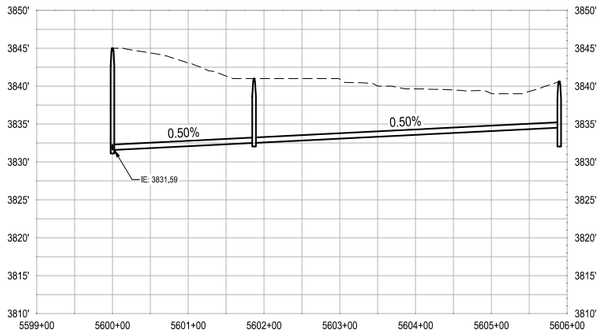
DOVER LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'

SOUTH TRUNK / JASMINE TIE IN SIDE STREETS

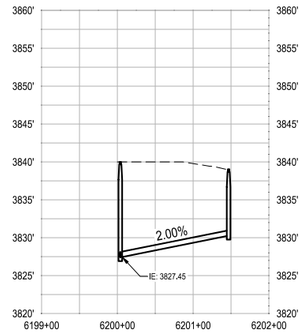


SOUTH TRUNK TIE IN SIDE STREETS



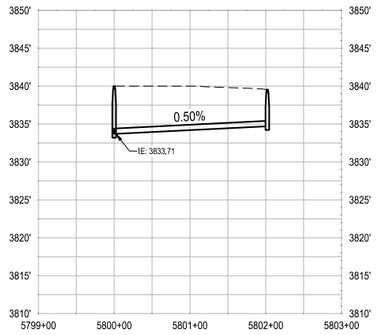
GARNET ST - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



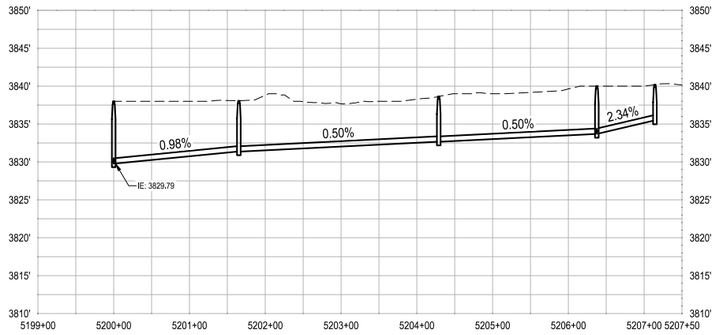
SILVER CT - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



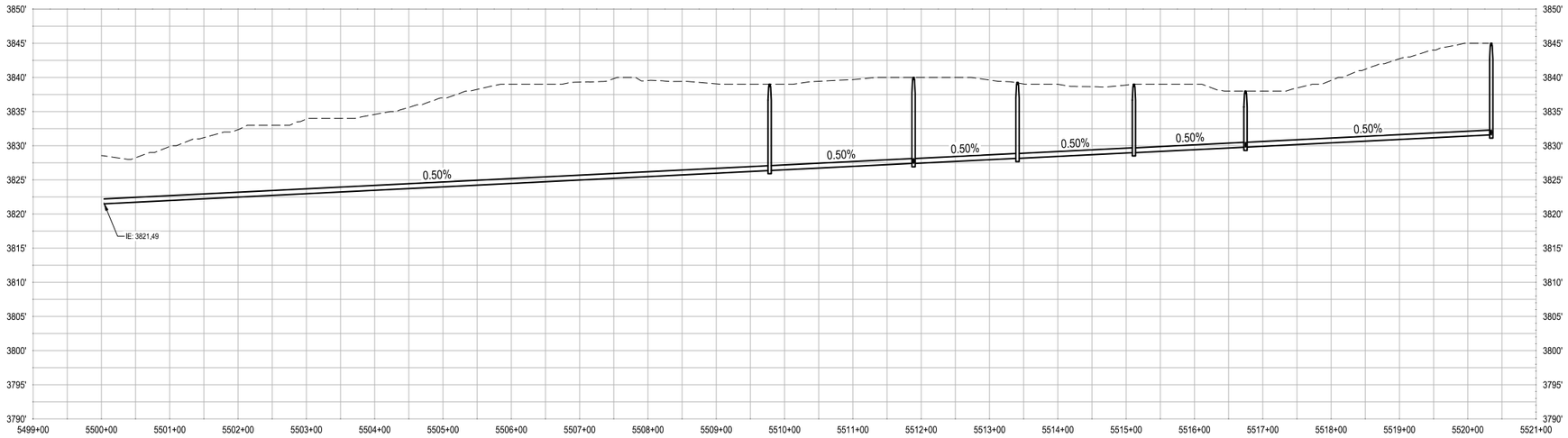
SAPPHIRE LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



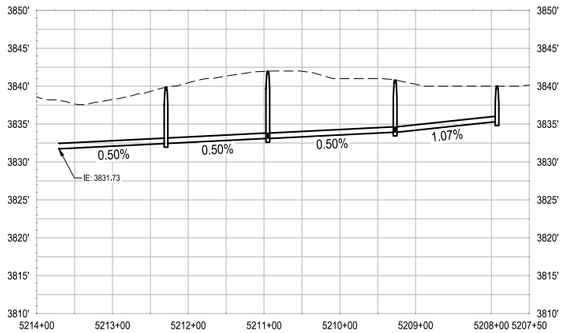
ONYX ST / AMETHYST ST - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



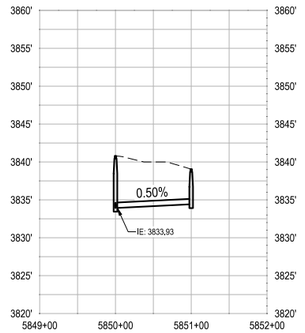
AMETHYST ST - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



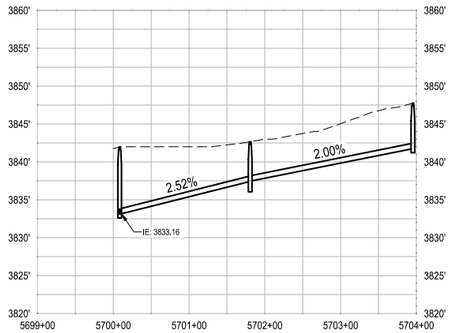
ONYX ST - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



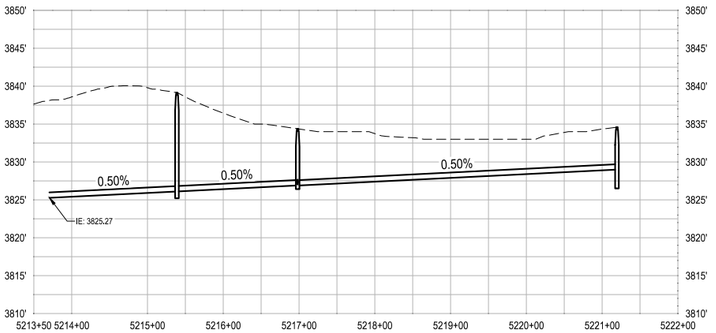
ARNTZ CT - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



JADE CT- PROFILE

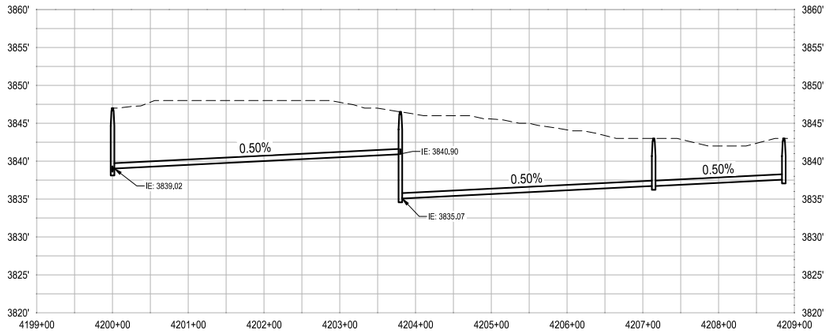
SCALE: H: 1" = 100' V: 1" = 10'



ONYX ST - PROFILE

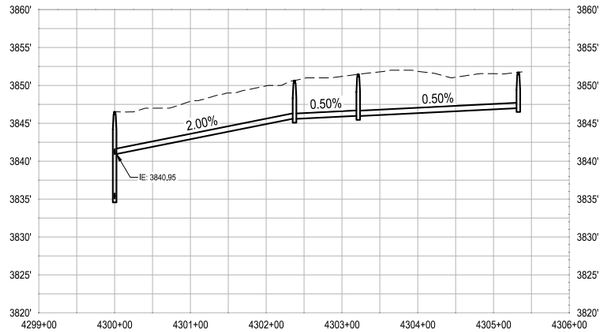
SCALE: H: 1" = 100' V: 1" = 10'

SOUTH TRUNK TIE IN SIDE STREETS



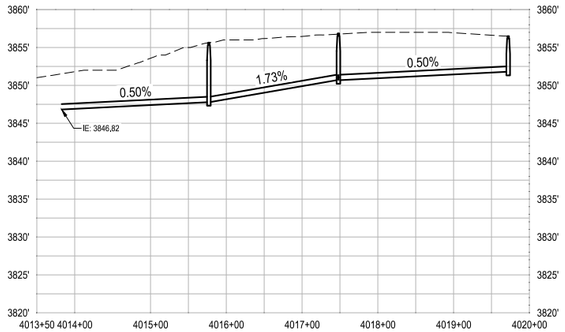
PLATINUM DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



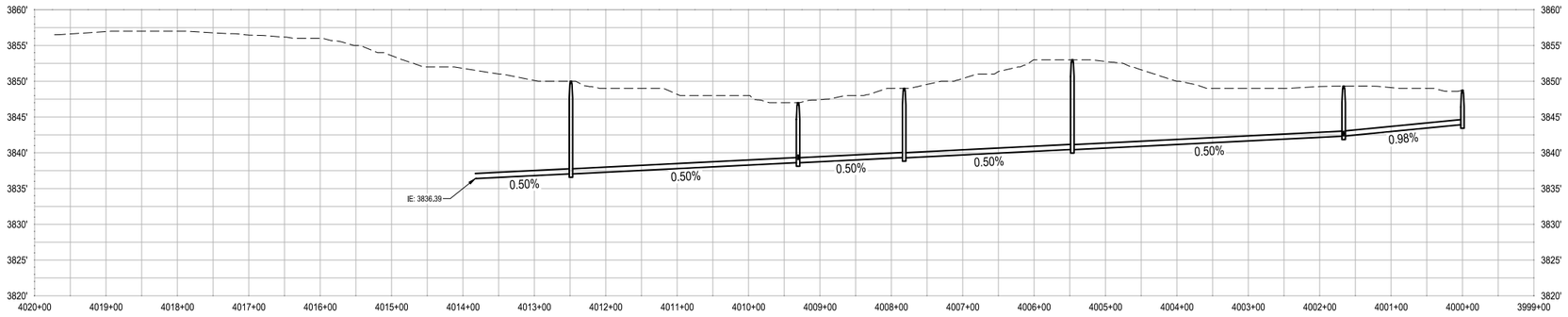
ALEXANDRITE DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



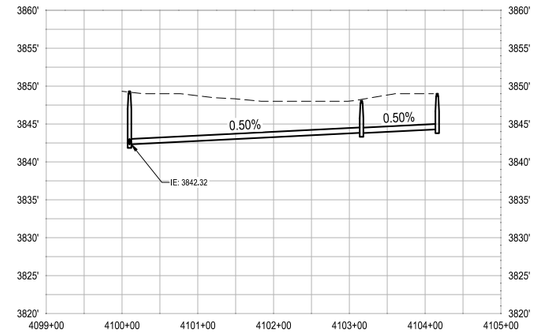
DIAMOND DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



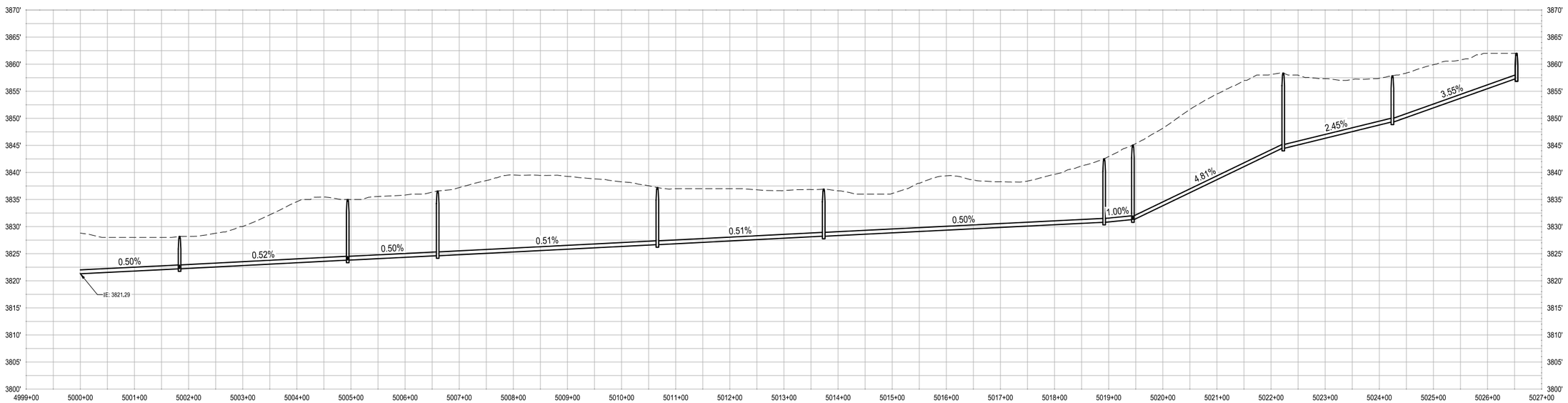
TOPAZ ST / ZIRCON DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



TOPAZ CT - PROFILE

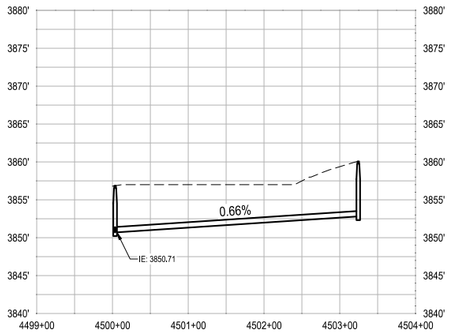
SCALE: H: 1" = 100' V: 1" = 10'



NUGGET AVE - PROFILE

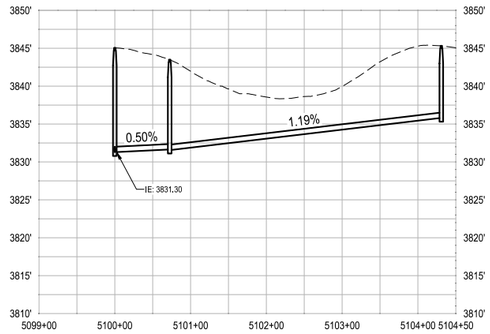
SCALE: H: 1" = 100' V: 1" = 10'

SOUTH TRUNK TIE IN SIDE STREETS



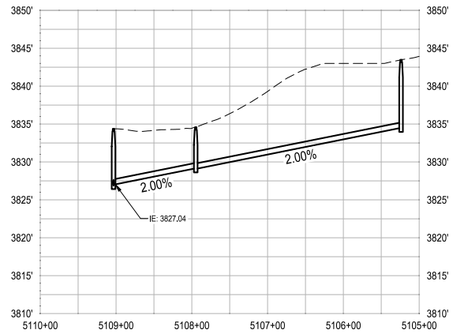
EMERALD PL - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



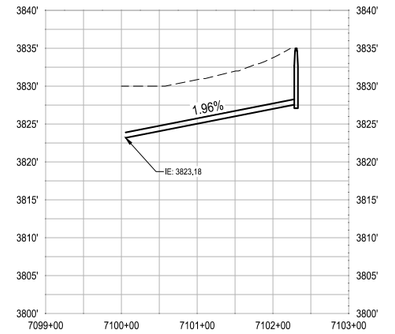
OPAL ST / NUGGET AVE - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



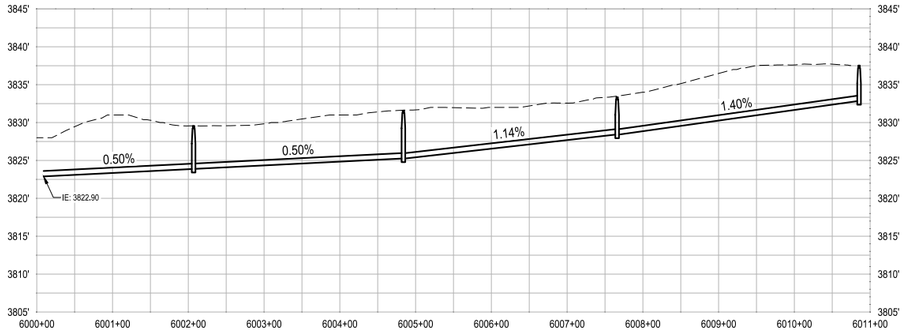
OPAL ST / ONYX ST - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



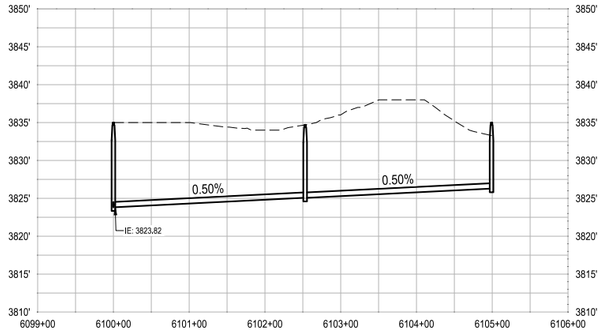
SHALIMAR CT - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



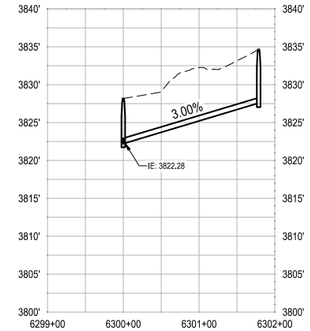
ASHFORD DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



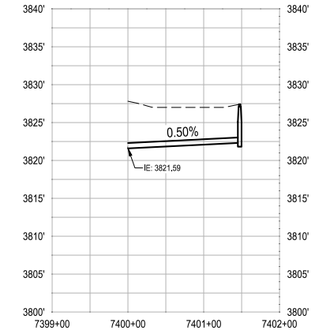
RUBY PL - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



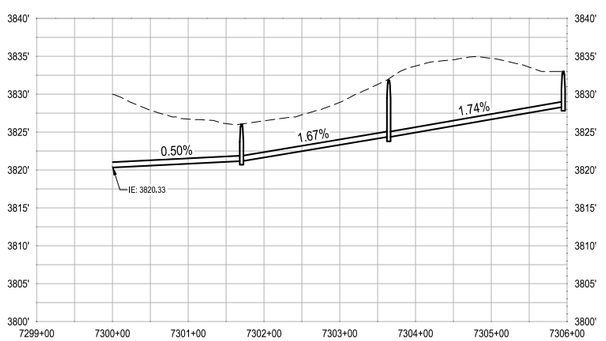
BRIGHTON CT - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



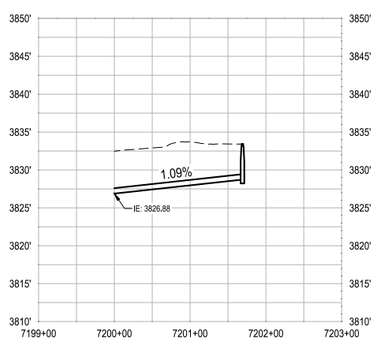
PARK VISTA CIR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



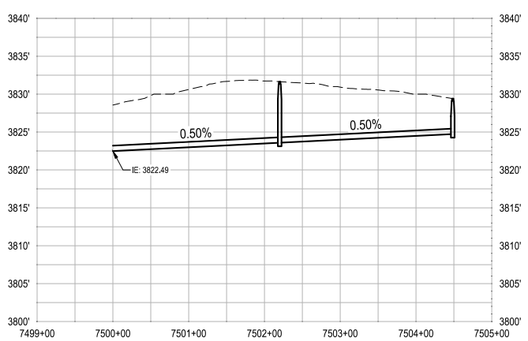
DEFIANCE ST - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



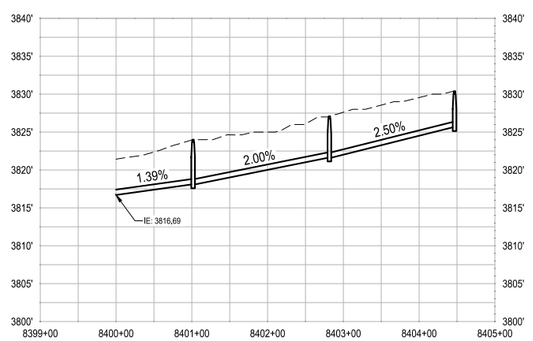
ALTA VIEW CIR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



CULTUS DR - PROFILE

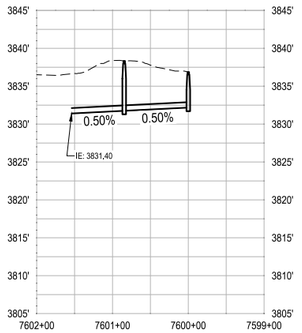
SCALE: H: 1" = 100' V: 1" = 10'



DUKE LN - PROFILE

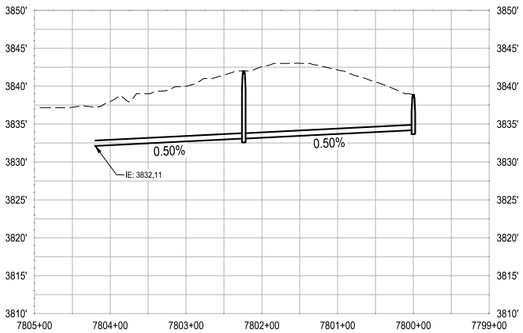
SCALE: H: 1" = 100' V: 1" = 10'

SOUTH TRUNK TIE IN SIDE STREETS



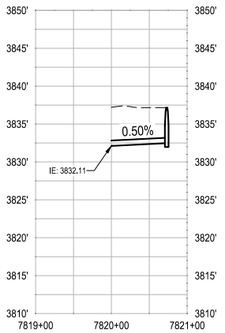
GRANITE DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



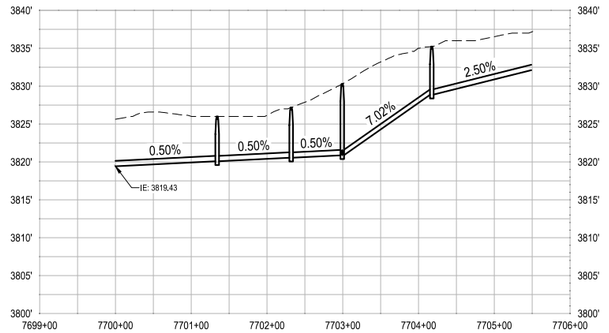
WAGON TREE CT - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



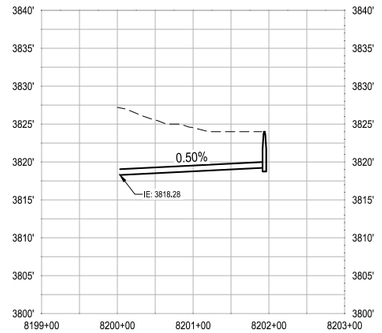
EMIGRANT CIR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



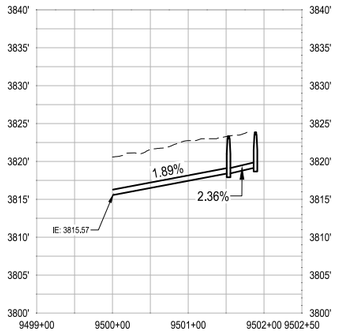
EMIGRANT DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



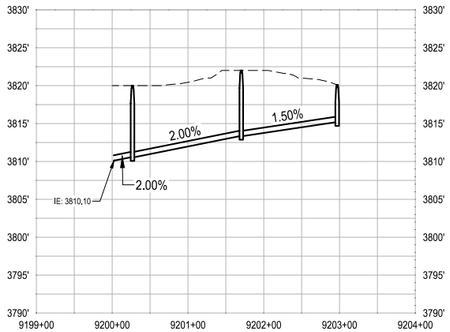
TARA LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



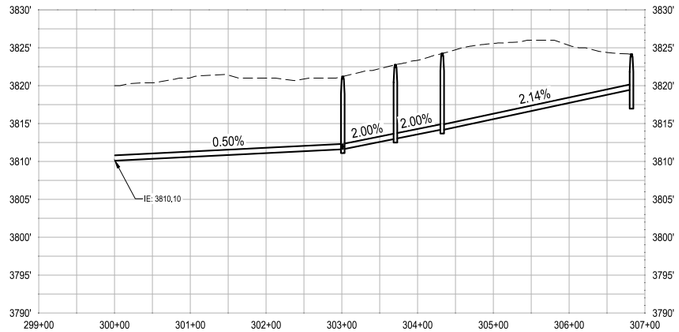
MCMULLIN DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



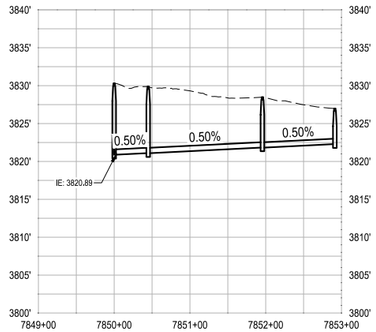
GRANITE DR / FLINT LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



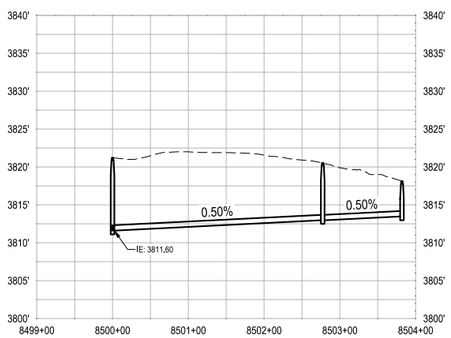
GRANITE DR / PINE CONE DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



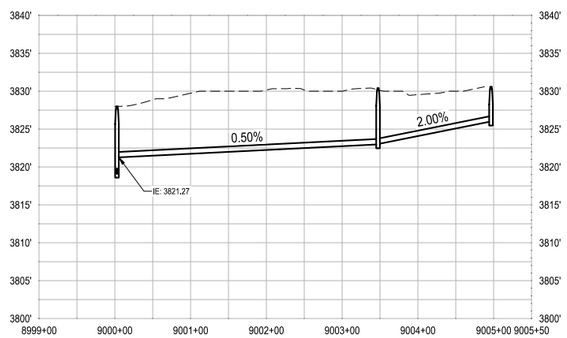
DOUBLE TREE CT - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



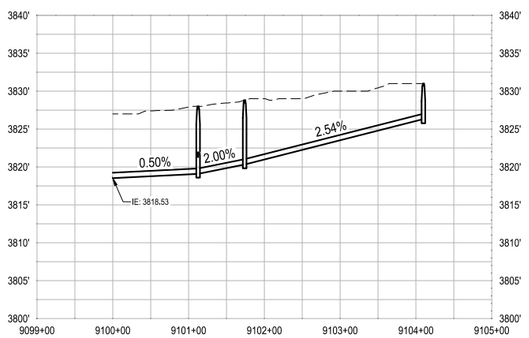
PINE CONE DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



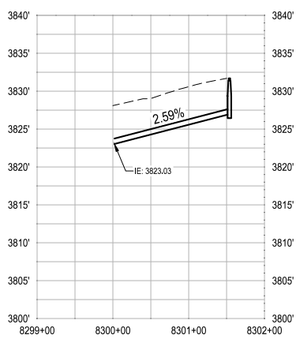
ARROW WOOD DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



ALPINE DR - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'



MELODY LN - PROFILE

SCALE: H: 1" = 100' V: 1" = 10'