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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.

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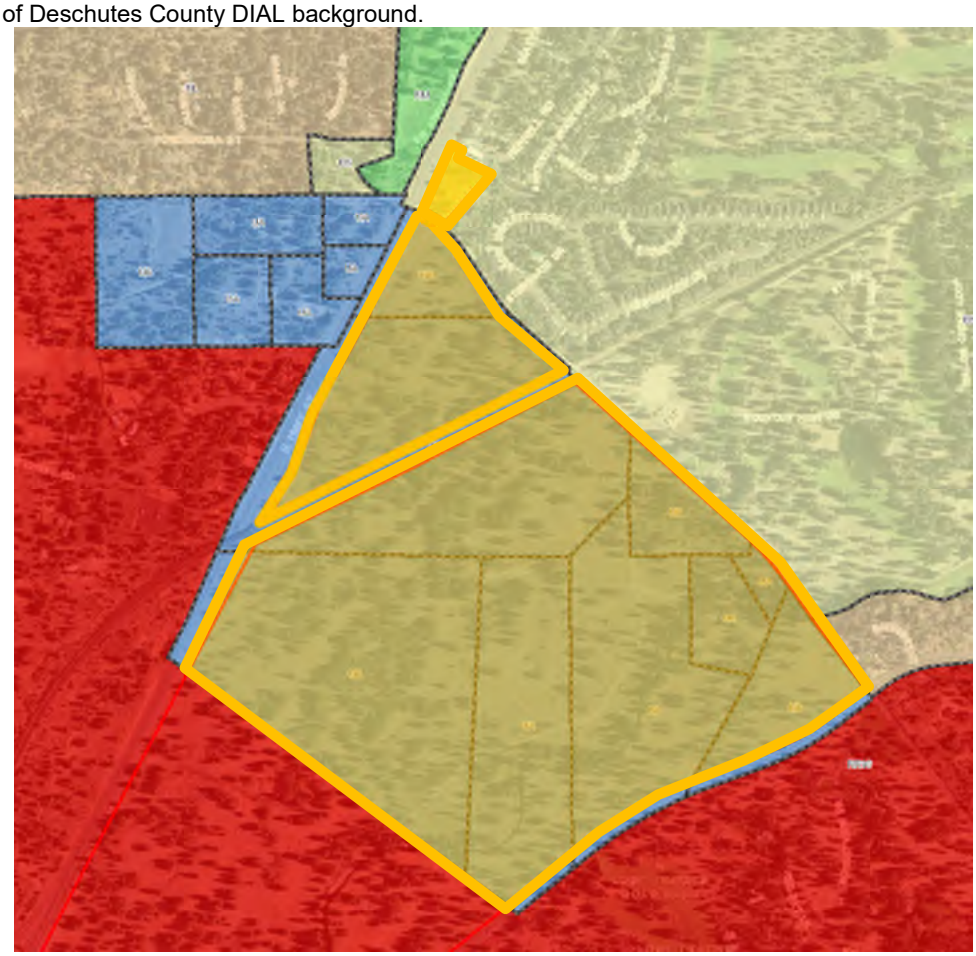
Figure 2: The Ward Property zoned UA east of Highway 97 that may be sewered through the Atwood Drive sewer highlighted in orange on top of Deschutes County DIAL background.



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.

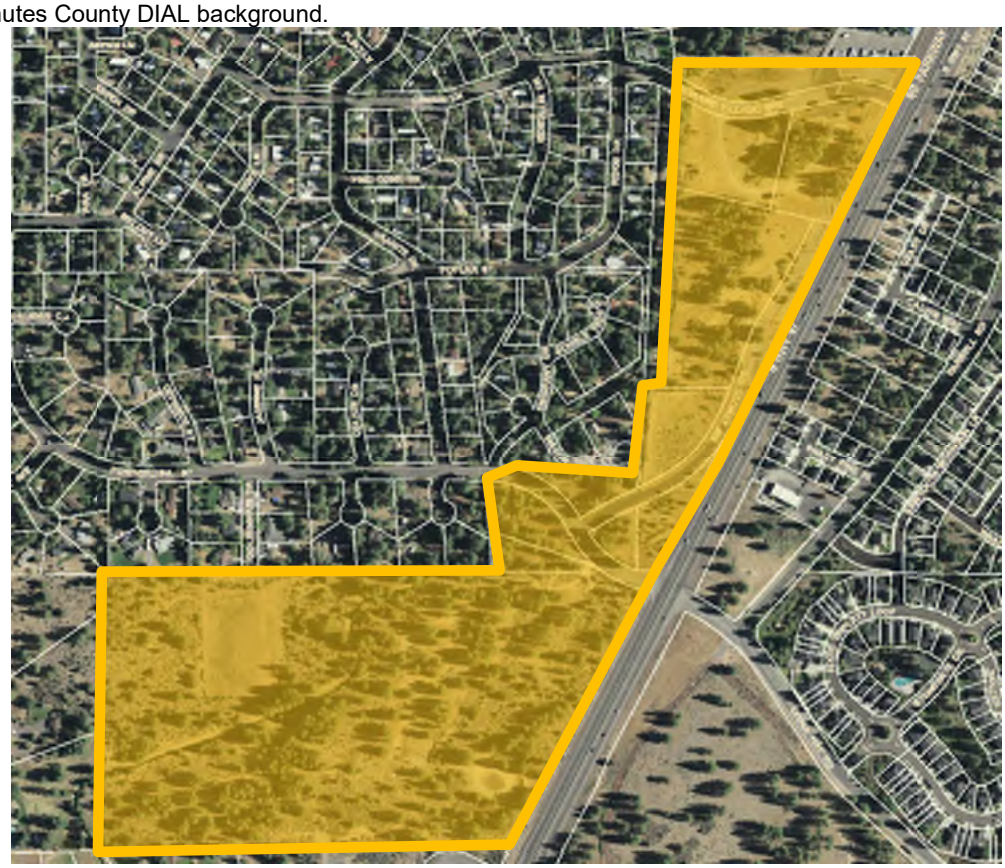
Given these parameters, a 12" at minimum grade will flow 76.7% full at 896.3gpm, which is right up against the 80% full maximum (COBDS 4.1.5). The sewer feasibility profile assumes a 12" pipe minimum grade (0.0019ft/ft) parallel to China Hat Road until it turns south at the low area east of the railroad 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.

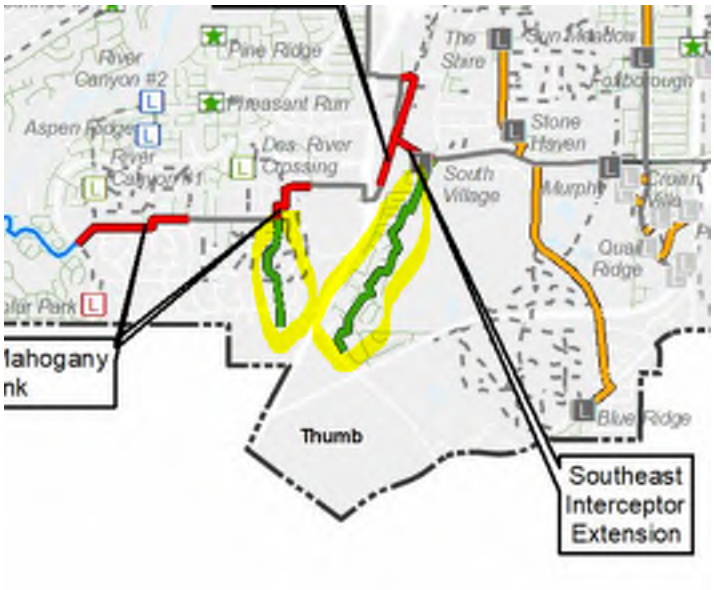


Figure 6b: PFP Capital Improvement Program showing Thumb Gravity Trunks, project 206-n.

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
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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
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FUTURE CONSTRUCTION COST TO SEWER IN PONDEROSA FROM ATWOOD TO HWY 97 (excludes engineering and adminstrative costs)				QTY	UNIT	UNIT COST	TOTAL COST
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Class 4 , Low Estimate (-30%):	$116,092.26	$116,100.00
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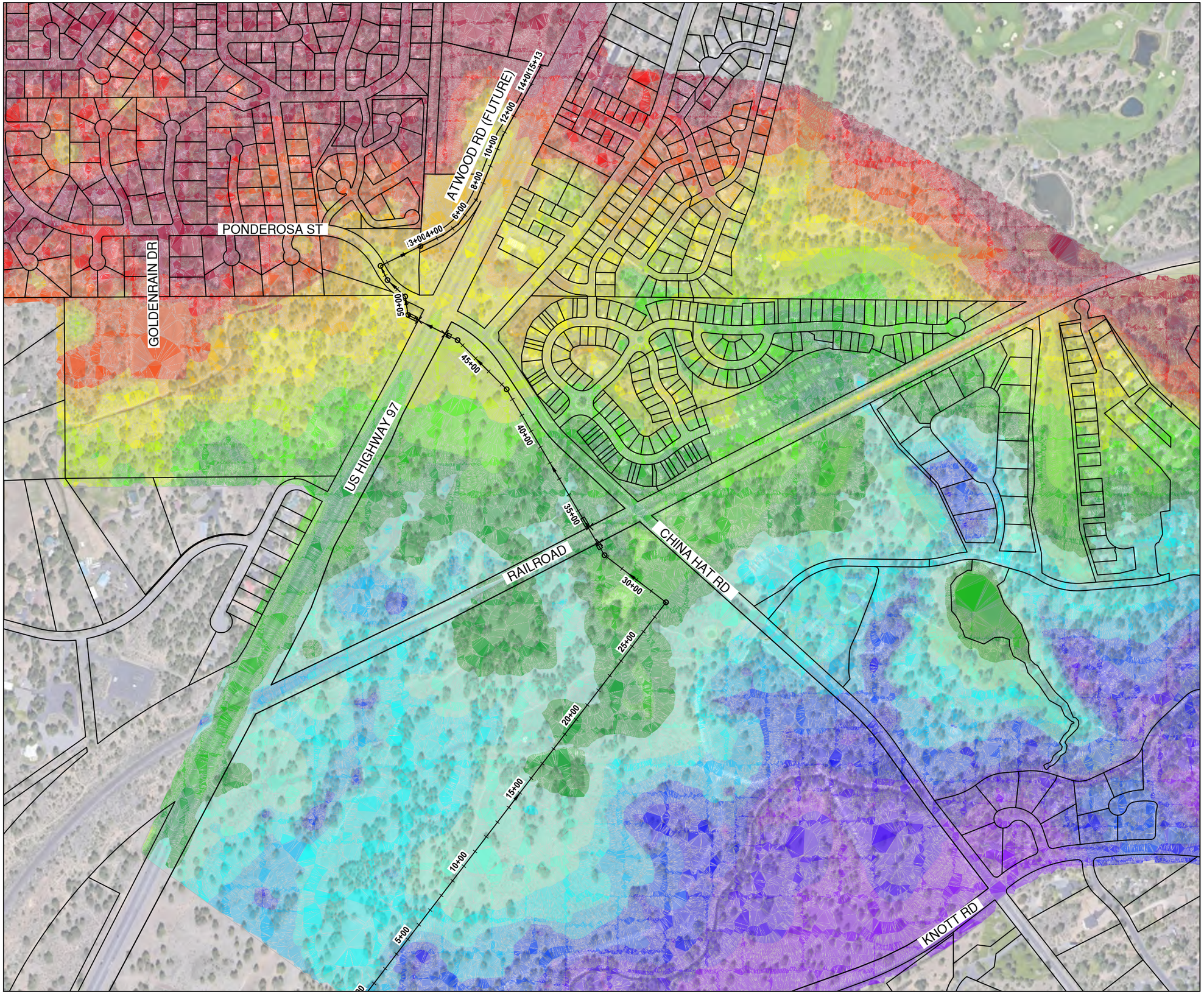
TRAFFIC CONTROL				1	LS	$10,000.00	$10,000.00
15 INCH SANITARY SEWER PIPE, 10 FT				301	FT	$261.00	$78,561.00
60" CONCRETE MANHOLE				1	EA	$10,100.00	$10,100.00
BORE PIT & RECEIVING PIT				1	LS	$27,500.00	$27,500.00
AUGER BORE, COMPLETE (183 LF)				1	ea	$346,310.00	$346,310.00
						SUBTOTAL=	**$529,167.52**

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



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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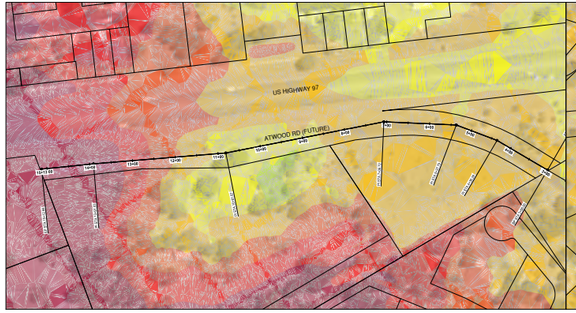
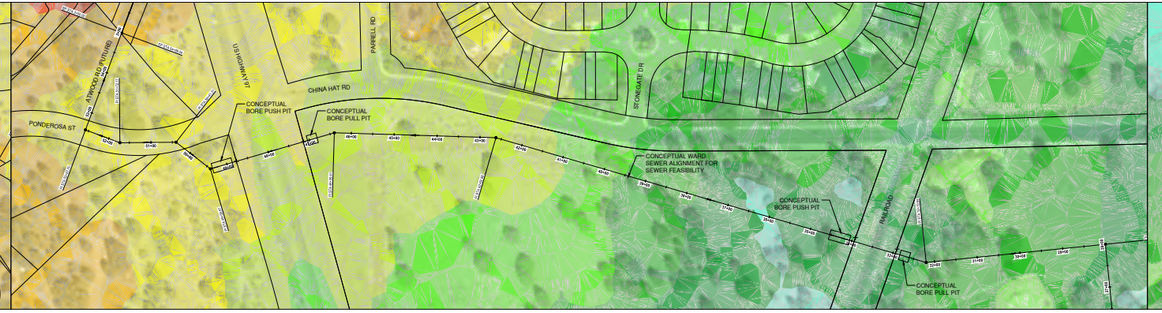
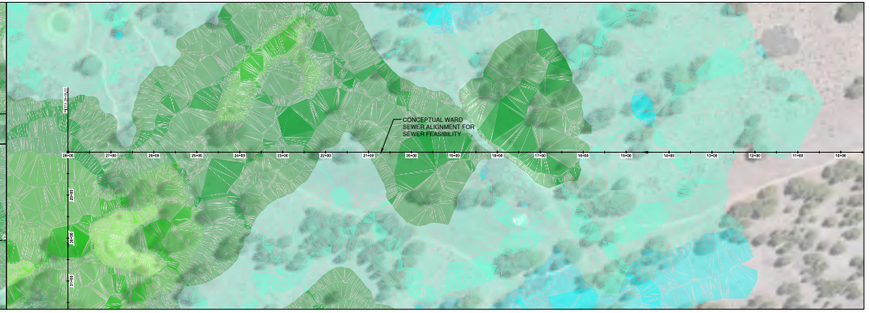
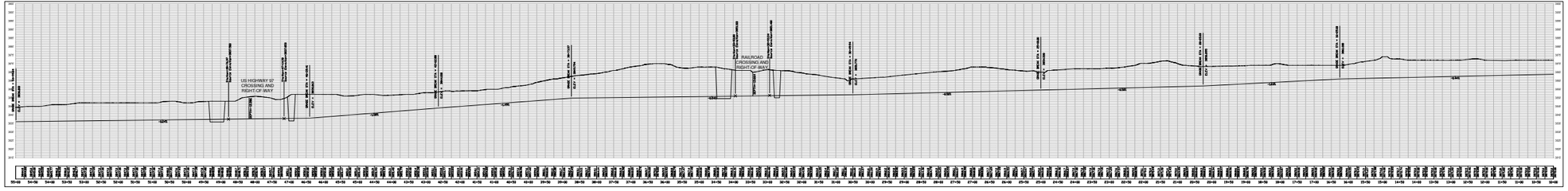






APPROXIMATE PROPOSED
ATWOOD SEWER - PROFILE
SCALE: H: 1" = 30' V: 1" = 6'



CONCEPTUAL WARD SEWER
FEASIBILITY - PROFILE
SCALE: H: 1" = 50' V: 1" = 10'

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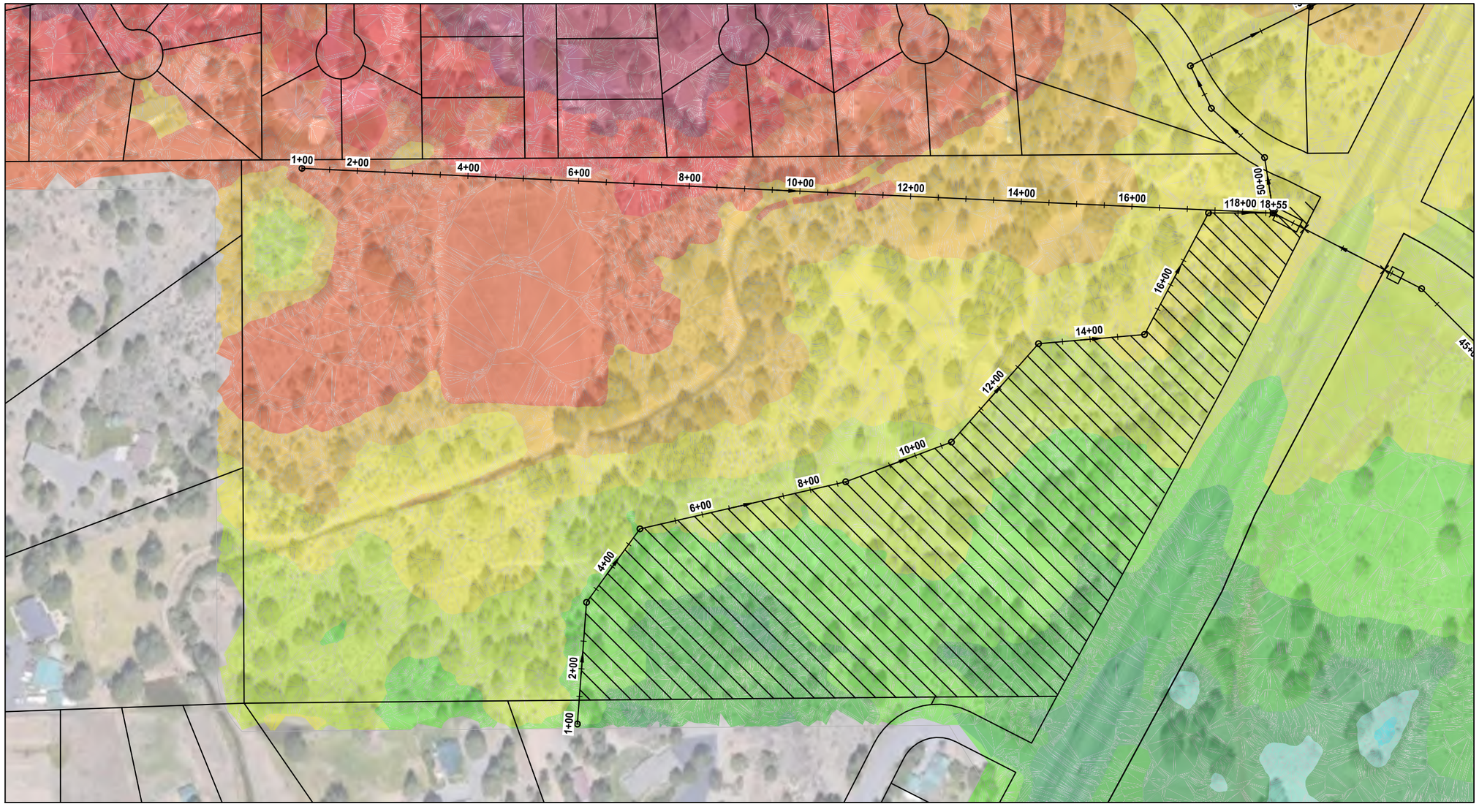
WARD SEWER FEASIBILITY REVIEW



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	

CONCEPTUAL MAVERICK SEWER OVERVIEW: 1"=100'

0 50' 100' 200'
SCALE: 1" = 100'

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TECHNICAL MEMORANDUM

Draft Print
08/14/2020 1:55:26 PM

For Review
08/14/2020 1:55:18 PM

DATE: August 14, 2020
TO: Jake Sherman
FROM: Niall Boggs
SUBJECT: Highway 97 Subsurface Explorations
CC:
PROJECT NUMBER: 297-2763-024
PROJECT NAME: SW Sewer Basin

Parametrix staff met TaylorNW onsite for preliminary subsurface explorations to be used to check for feasibility of a future boring under the highway to provide sewer service for the Ward Property through the proposed Atwood Drive sewer. The results are as follows:

Table 1. Field exploration data

Exploration Hole No.	East or West of Hwy 97	Depth to Refusal	Description
#1	East	4.3’	Appears to be rubble fill. No bed rock observed.
#2	East	3.7’	Appears to be weathered basalt bedrock
#3	West	4.3’	Appears to be weathered basalt bedrock

Holes #1 and #2 on the east side of Highway 97 were in an area of previous surface disturbance, evidenced by the weeds and lack of well-established brush.

Hole #1 is the more northerly of the east side holes. It appears that Hole #1 may be located in an area of rubble fill. To know how deep bedrock is at the Bore Hole #1 location, additional exploration work would need to be done with a backhoe as the vactor truck couldn’t go any deeper than the 4.3’.

Hole #2 is the more southerly of the east side holes. There was some initial topsoil encountered in the top 12” or so, then a mix of soil and what appeared to be rubble fill. What appeared to be weathered basalt bedrock was encountered at 3.7’.

Hole #3 is located on the west side of Highway 97 south of Ponderosa Street. The exploration encountered refusal on what appeared to be weathered basalt bedrock at 4.3 below existing ground surface.

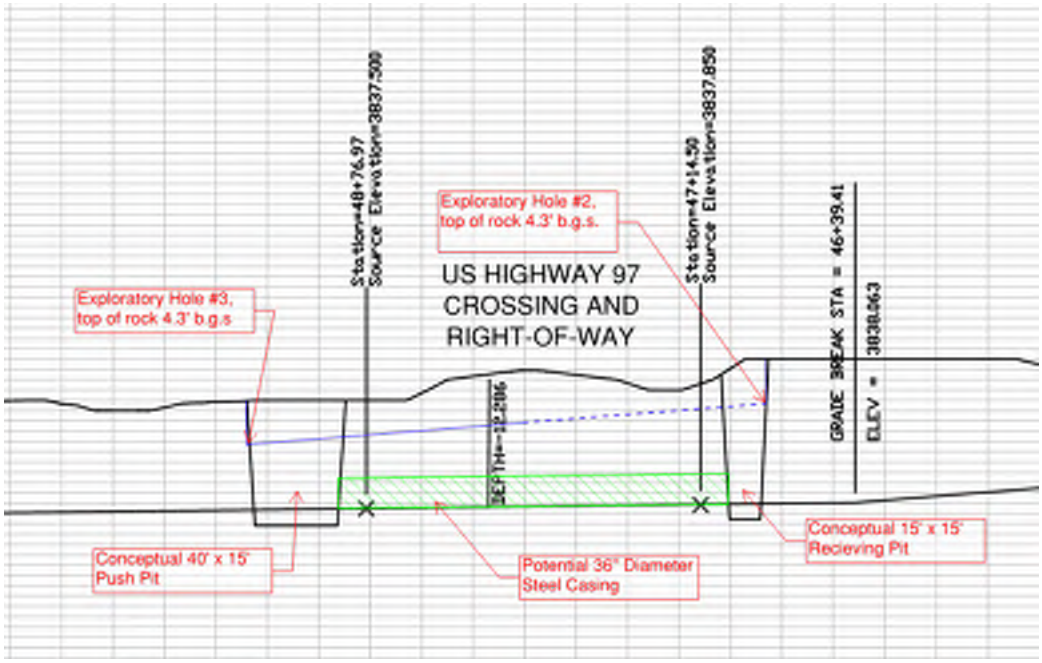
All three holes were backfilled with ¾”-0” base rock and lath were left at each hole.

Note that the vactor truck potholes provide limited information about subsurface geotechnical conditions. No rock sampling was performed, so strength and integrity of existing bedrock is unknown. The holes were

approximately 18" wide, so the sample is limited and vertical variations in the rock surface are not observed. This exploratory work was done only as a check on feasibility for a bore and is not intended to be used as a geotechnical data report.

Conclusion:

Holes #2 and #3 indicate top of bedrock at approximately 4 feet below existing ground surface. Hole #1 appeared to be in rubble fill, and depth to bed rock is unknown. Preliminary profile data for serving the Ward Property through the Atwood sewer had sewer invert over 12 feet below ground surface at the highway 97 shoulder. A 36" casing was assumed, top of casing approximately would be approximately nine (9) below top of asphalt at the highway shoulder. Based on the limited potholing data and the conceptual design completed for the highway crossing, it appears that a bore would be under the soil rock interface by approximately four to six feet.



Please note the following:

- Natural variation in the top surface of the bedrock is to be expected. For example, the observed weathered bedrock at four feet b.g.s. in Holes #2 and #3 could have been outcrops and may not necessarily be representative of conditions overall. Geotechnical investigations on the new proposed Avion office site approximately 600 feet north of Hole #1 showed a great deal of variation in elevation of bedrock - up to 11 feet difference.
- Rubble fill can be problematic for boring, so the exact site of a bore will need to be evaluated and carefully selected based on what appeared to be rubble fill in Hole #1.
- Additionally, any utility installations in the area that were hammered or blasted into the bedrock can cause problems when boring under them. Final boring design will need to coordinate with utility providers on what facilities exist in the area, especially Century Link, which has fiber optic duct banks.
- To provide additional assurance of a workable bore, some additional depth in the Atwood sewer could be considered.
- Prior to any horizontal auger boring work, a geotechnical exploration should undertaken to provide data on the rock and recommendations on boring methodology.
- A qualified auger boring consultant is recommended when determining final bore pit locations, recommended methods, and development of engineering plans and specifications.

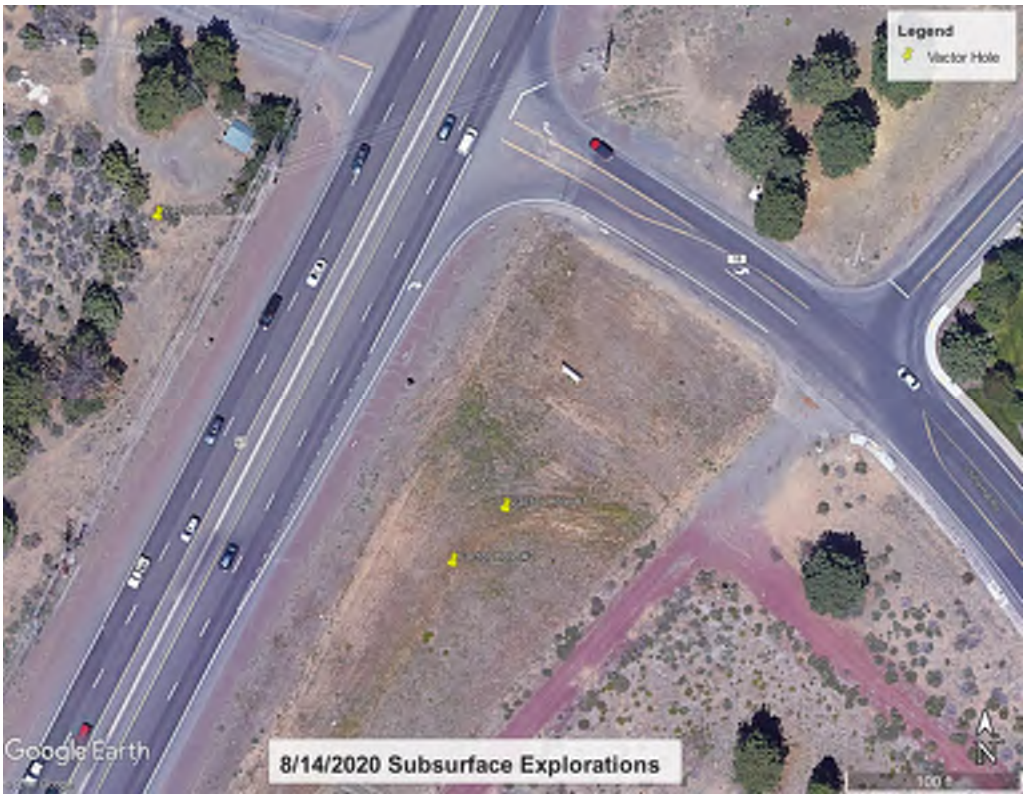


Figure 1. Location map of subsurface explorations.

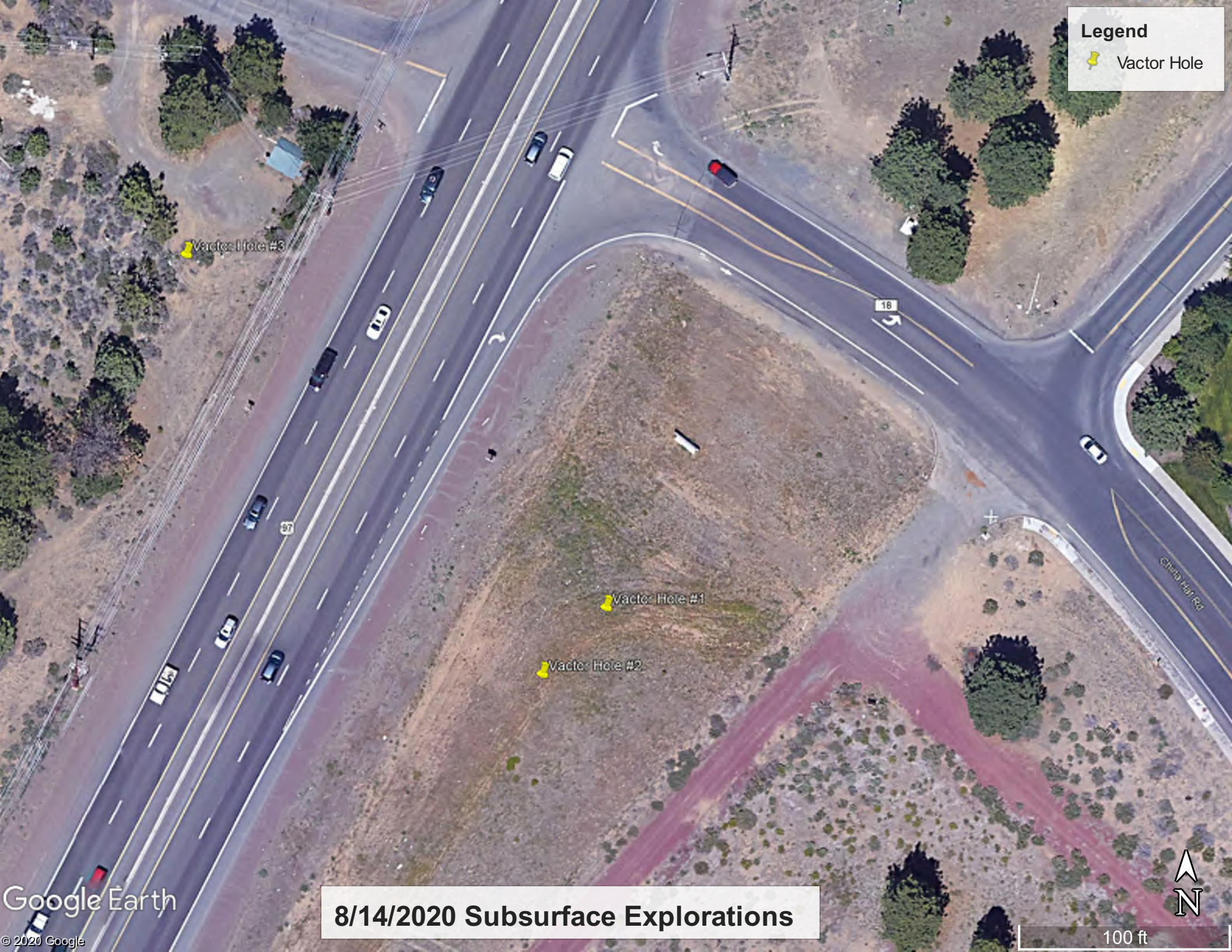
Figure 2. Holes #1 (right) and #2 (left), looking west toward Highway 97.

Figure 3. Hole #3, looking northeast toward intersection of Ponderosa Street and Highway 97.

Figure 4. Hole #1 with what appears to be rubble fill.

Figure 5. Hole #2 with what appears to be weathered basalt bedrock in bottom.

Figure 6. Hole #3, with what appears to be weathered basalt bedrock in bottom.



8/14/2020 Subsurface Explorations

South Area Sewer Flow Assumptions and Estimates

Tax Lot #	Owner	Special Planning Area	Comp Plan Zoning Designation	Gross Acreage	Residential Density Assumptions [dwelling units / gross acre]			Non-Residential Assumptions [finished floor area, sf / gross acre]			Estimated Development Yield [EDU]			Estimated Peak Flow [GPM]			Notes
					Minimum	Mid-Range	Maximum	0.2 Floor Area Ratio	0.25 Floor Area Ratio	0.3 Floor Area Ratio	Minimum	Mid-Range	Maximum	Minimum	Mid-Range	Maximum	
18-12-17 TL 1601	Bonnett	Murphy Crossing Refinement Area	RM - Residential Medium Density	2.56	10	18.0	21.7	-	-	-	20.5	36.9	44.4	5.5	10.0	12.0	Murphy Crossing central core area RM zone density is 10.0 to 21.7 units per acre [Table 2.7.820B Murphy Crossing Refinemen Plan Code].
			ME - Mixed Employment: Commercial	2.05	-	-	-	8712	10,890	13,068	17.9	22.3	26.8	4.8	6.0	7.3	Assumes 1 EDU per 1,000 SF of finished floor area. See City of Bend Design Standards.
			ME - Mixed Employment: Multi-Family Residential		10	18.0	21.7	-	-	-	8.2	14.8	17.8	2.2	4.0	4.8	Assumes 50% of gross acreage is multi-family development. Maximum density is 21.7 units per acre [Table 2.7.820B Murphy Crossing Refinement Plan Code]
			CG - Commercial General	8.41	-	-	-	8712	10,890	13,068	73.3	91.6	109.9	19.8	24.8	29.8	
			Bonnett Sub-Totals	**13.02**							**120**	**166**	**199**	**32.4**	**44.8**	**53.9**	
18-12-17 TL 1700	Winco	Murphy Crossing Refinement Area	RS - Residential Standard Density	2.23	2.3	6.0	7.3	-	-	-	5.1	13.4	16.3	1.4	3.6	4.4	6,000 sf minimum lot size adjacent to RL zone per Bend Development Code Section 2.7.800 - Murphy Crossing Refinement Plan Code. Density Range is 2.3-7.3 units per gross acre per Table 2.7.820D
			RM - Residential Medium Density	2.46	10	18.0	21.7	-	-	-	19.7	35.4	42.7	5.3	9.6	11.6	Murphy Crossing central core area RM zone density is 10.0 to 21.7 units per acre [Table 2.7.820B Murphy Crossing Refinemen Plan Code].
			ME - Mixed Employment: Commercial	5.1	-	-	-	8712	10,890	13,068	44.4	55.5	66.6	12.0	15.0	18.1	Assumes 1 EDU per 1,000 SF of finished floor area.
			ME - Mixed Employment: Multi-Family Residential		10	18.0	21.7	-	-	-	20.4	36.7	44.3	5.5	9.9	12.0	Assumes 50% of gross acreage multi-family development. Maximum density is 21.7 units per acre [Table 2.7.820B Murphy Crossing Refinement Plan Code]
			CG - Commercial General	4.84	-	-	-	8712	10,890	13,068	42.2	52.7	63.2	11.4	14.3	17.1	
			PF - Public Facilities [Park / Open Space]	1.74	-	-	-	-	-	-	0.5	0.5	0.5	0.1	0.1	0.1	
			Winco Sub-Totals	**16.37**							**132**	**194**	**234**	**35.8**	**52.6**	**63.3**	
18-12-17 TL 1800 & 1900	ODOT	Murphy Crossing Refinement Area	RS - Residential Standard Density	2.3	2.3	6.0	7.3	-	-	-	5.3	13.8	16.8	1.4	3.7	4.5	6,000 sf minimum lot size adjacent to RL zone per Bend Development Code Section 2.7.800 - Murphy Crossing Refinement Plan. Density Range is 2.3-7.3 units per gross acre per Table 2.7.820D
			RM - Residential Medium Density	1.62	10	18.0	21.7	-	-	-	13.0	23.3	28.1	3.5	6.3	7.6	Murphy Crossing central core area RM zone density is 10.0 to 21.7 units per acre per Table 2.7.820B.
			ME - Mixed Employment: Commercial	3.04	-	-	-	8712	10,890	13,068	26.5	33.1	39.7	7.2	9.0	10.8	Assumes 1 EDU per 1,000 SF of finished floor area.
			ME - Mixed Employment: Multi-Family Residential		10	18.0	21.7	-	-	-	12.2	21.9	26.4	3.3	5.9	7.1	Assumes 50% of gross acreage is multi-family development. Maximum density is 21.7 units per acre [Table 2.7.820B Murphy Crossing Refinement Plan Code]
			CG - Commercial General	7.51	-	-	-	8712	10,890	13,068	65.4	81.8	98.1	17.7	22.1	26.6	
			PF - Public Facilities [Park / Open Space]	3.69	-	-	-	-	-	-	0.5	0.5	0.5	0.1	0.1	0.1	
			ODOT 1 Sub-Totals	**18.16**							**123**	**174**	**210**	**33.3**	**47.2**	**56.8**	
18-12-17 TL 2001	Mayfield	Murphy Crossing Refinement Area	RS - Residential Standard Density	1.13	2.3	6.0	7.3	-	-	-	2.6	6.8	8.2	0.7	1.8	2.2	6,000 sf minimum lot size adjacent to RL zone per Bend Development Code Section 2.7.800 - Murphy Crossing Refinement Plan. Density Range is 2.3-7.3 units per gross acre per Table 2.7.820D
			RM - Residential Medium Density	1.69	10	18.0	21.7	-	-	-	13.5	24.3	29.3	3.7	6.6	7.9	Murphy Crossing central core area RM zone density is 10.0 to 21.7 units per acre per Table 2.7.820B.
			ME - Mixed Employment: Commercial	1.87	-	-	-	8712	10,890	13,068	16.3	20.4	24.4	4.4	5.5	6.6	Assumes 1 EDU per 1,000 SF of finished floor area.
			ME - Mixed Employment: Multi-Family Residential		10	18.0	21.7	-	-	-	7.5	13.5	16.2	2.0	3.6	4.4	Assumes 50% of gross acreage is multi-family development. Maximum density is 21.7 units per acre [Table 2.7.820B Murphy Crossing Refinement Plan Code]
			CG - Commercial General	2.27	-	-	-	8712	10,890	13,068	19.8	24.7	29.7	5.4	6.7	8.0	
			Mayfield Sub-Totals	**6.96**							**60**	**90**	**108**	**16.2**	**24.3**	**29.2**	
18-12-17 TL 2004, 2005, & 2006	Bell	Murphy Crossing Refinement Area	RS - Residential Standard Density	0.33	2.3	6.0	7.3	-	-	-	0.8	2.0	2.4	0.2	0.5	0.7	6,000 sf minimum lot size adjacent to RL zone per Bend Development Code Section 2.7.800 - Murphy Crossing Refinement Plan. Density Range is 2.3-7.3 units per gross acre per Table 2.7.820D
			RM - Residential Medium Density	0.85	10	18.0	21.7	-	-	-	6.8	12.2	14.8	1.8	3.3	4.0	Murphy Crossing central core area RM zone density is 10.0 to 21.7 units per acre per Table 2.7.820B.
			ME - Mixed Employment: Commercial	2.7	-	-	-	8712	10,890	13,068	23.5	29.4	35.3	6.4	8.0	9.6	Assumes 1 EDU per 1,000 SF of finished floor area.
			ME - Mixed Employment: Multi-Family Residential		10	18.0	21.7	-	-	-	10.8	19.4	23.4	2.9	5.3	6.3	Assumes 50% of gross acreage is multi-family development. Maximum density is 21.7 units per acre [Table 2.7.820B Murphy Crossing Refinement Plan Code]
			CG - Commercial General	3.8	-	-	-	8712	10,890	13,068	33.1	41.4	49.7	9.0	11.2	13.4	
			Bell Sub-Totals	**7.68**							**75**	**104**	**126**	**20.3**	**28.3**	**34.0**	
18-12-17 TL 2000, 2003, & 2500	Atwood	See Land Use Decision	RM - Residential Medium Density	8.57	28.0	28.0	28.0	-	-	-	192.0	192.0	192.0	52.0	52.0	52.0	See Stillwater Crossing Site Plan. Density = 240 units / 8.57 acres = 28.0 units per acre.
			Atwood Sub-Totals	**8.57**							**192**	**192**	**192**	**52.0**	**52.0**	**52.0**	
18-12-17 TL 2215	Ward	N/A	RS - Residential Standard Density	2.24	4	6.0	7.3	-	-	-	9.0	13.4	16.4	2.4	3.6	4.4	Not part of any Special Planning Area.
			Ward 1 Sub-Totals	**2.24**							**9**	**13**	**16**	**2.4**	**3.6**	**4.4**	
18-12-18DD TL 6800 & 6900	Ponderosa Pine LLC	Murphy Crossing	RS - Residential Standard Density	2.08	2.3	6.0	7.3	-	-	-	4.8	12.5	15.2	1.3	3.4	4.1	6,000 sf minimum lot size adjacent to RL zone per Bend Development Code Section 2.7.800 - Murphy Crossing Refinement Plan. Density Range is 2.3-7.3 units per gross acre per Table 2.7.820D.
			Ponderosa Pine Properties Sub-Totals	**2.08**							**5**	**12**	**15**	**1.3**	**3.4**	**4.1**	
18-12-18DD TL 6801 & 6802	ODOT	Murphy Crossing	RS - Residential Standard Density	0.86	2.3	6.0	7.3	-	-	-	2.0	5.2	6.3	0.5	1.4	1.7	6,000 sf minimum lot size adjacent to RL zone per Bend Development Code Section 2.7.800 - Murphy Crossing Refinement Plan. Density Range is 2.3-7.3 units per gross acre per Table 2.7.820D
			RM - Residential Medium Density	0.52	7.3	12.0	15.0	-	-	-	3.0	5.0	6.2	0.8	1.4	1.7	Murphy Crossing south end area RM zone density is 7.3 to 15.0 units per acre per Table 2.7.820B.
			ODOT 2 Sub-Totals	**1.38**							**5**	**10**	**13**	**1.4**	**2.7**	**3.4**	
18-12-19A0 TL 100	Maverick	Southwest UGB Expansion Area	RS - Residential Standard Density	14	5.11	6.0	7.33	-	-	-	71.5	84.0	102.6	19.4	22.8	27.8	See Comp Plan Policies 11-92 through 11-99. 14 gross acres RS minimum per Comp Plan Policy #11-95.
			RM - Residential Medium Density	6	13.02	18.0	21.7	-	-	-	62.5	86.4	104.2	16.9	23.4	28.2	14 gross acres mimimum RM minus 8 gross acres minimum school site [PF Zone] per Comp Plan Policy #11-95.
			PF - Public Facilities [Elementary School]	8	-	-	-	600	700	800	48.0	56.0	64.0	13.0	15.2	17.3	8 gross acres minimum PF [elementary school site] per Comp Plan Policy #11-95. Assumed 600-800 students + staff. 0.08 EDU/person [Table 4-1 City of Bend Design Stds
			RH - Residential High Density	5	21.7	35.0	43.0	-	-	-	86.8	140.0	172.0	23.5	37.9	46.6	5 gross acres minimum RH per Comp Plan Policy #11-95.
			CL - Commercial Limited	3	-	-	-	8712	10,890	13,068	26.1	32.7	39.2	7.1	8.8	10.6	3 gross acres minimum CL per Comp Plan Policy #11-95.
			MN - Mixed Neighborhood: Commercial	2	-	-	-	8712	10,890	13,068	17.4	21.8	26.1	4.7	5.9	7.1	2 gross acres minimum MN per Comp Plan Policy #11-95. Assumes 1 EDU per 1,000 SF of finished floor area
			MN - Mixed Neighborhood: Multi-Family Residential		21.7	35.0	43.0	-	-	-	17.4	28.0	34.4	4.7	7.6	9.3	2 gross acres minimum MN per Comp Plan Policy #11-95. Assumes 50% of gross acreage is multi-family development. RH Density
			Maverick Sub-Totals	**38**							**330**	**449**	**543**	**89.3**	**121.6**	**146.9**	
18-12-00 TL 4404	Ward	The Thumb UGB Expansion Area	RS - Residential Standard Density	35	5.11	6.0	7.33	-	-	-	178.9	210.0	256.6	48.4	56.9	69.5	See Comp Plan Policies 11-85 through 11-91. 35 gross acres minimum RS per Comp Plan Policy #11-88.
			RM - Residential Medium Density	7	13.02	18.0	21.7	-	-	-	72.9	100.8	121.5	19.7	27.3	32.9	7 gross acres minimum RM per Comp Plan Policy #11-88
			RH - Residential High Density	2	21.7	35.0	43.0	-	-	-	34.7	56.0	68.8	9.4	15.2	18.6	2 gross acres minimum RH per Comp Plan Policy #11-88
			ME - Mixed Employment: Commercial	31	-	-	-	8712	10,890	13,068	270.1	337.6	405.1	73.1	91.4	109.7	31 gross acres minimum ME per Comp Plan Policy #11-87. Assumes 1 EDU per 1,000 SF of finished floor area.
			ME - Mixed Employment: Multi-Family Residential		21.7	35.0	43.0	-	-	-	269.1	434.0	533.2	72.9	117.5	144.4	31 gross acres minimum ME per Comp Plan Policy #11-87. Assumes 50% of gross acreage is multi-family development. RH Density.
			CG - Commercial General	66	-	-	-	8712	10,890	13,068	575.0	718.7	862.5	155.7	194.7	233.6	86 gross acres minimum CG+CC per Comp Plan Policy #11-87
			CC - Commercial Convenience	20	-	-	-	8712	10,890	13,068	174.2	217.8	261.4	47.2	59.0	70.8	
			IL - Industrial Light	60	-	-	-	8712	10,890	13,068	522.7	653.4	784.1	141.6	177.0	212.4	60 gross acres minimum IL per Comp Plan Policy #11-87
			Ward 2 Sub-Totals	**221**							**2,098**	**2,728**	**3,293**	**568.1**	**738.9**	**891.9**	
			Totals	**335.46**							**3,148**	**4,134**	**4,947**	**852**	**1,120**	**1,340**	

Assumes Residential Avereage Daily flow = 130 gallons/EDU/day [Table 4-1 City of Bend Design Stds]. Peak factor = 3.0
Assumes 1 multi-family unit = 0.8 EDU.
Assumes Non-Residential Average Daily flow = (1 EDU / 1,000 SF finished floor area)(130 gallons/EDU/day) is more conservative than 427 gal/ac/day [Table 4-1 City of Bend Design Stds]. Peak factor = 3.0
Assumes Non-Residential finished floor area ratios [FAR] of 0.2 to 0.3

Estimated Peak Flow at 427 gpad: (427 gpad x 1 acre) / (1 day/1440 min) x 3.0 PF = 0.9 gpm

Estimated Peak Flow at 0.2 FAR/acre: (.2 FAR x 43,560 sf) x (1 EDU / 1,000 sf) x [(130 gal/EDU/day) x (1 day / 1440 min)] x 3.0 PF = 2.4 gpm