TECHNICAL MEMORANDUM

DATE: December 11, 2019

PROJECT: On-Call Modeling, Wastewater Collection

TO: City of Bend, Oregon

FROM: Sven MacAller, P.E.
Shad Roundy, P.E.

RE: Southeast Area Plan, Sewer Concept Plan

Background

The Southeast Area (also known as "The Elbow") in the City of Bend, Oregon (City) was identified in the 2016 Urban Growth Boundary (UGB) Expansion Study as a priority growth area. The area is approximately 480 acres and includes High Desert Park and High Desert Middle School. Boundaries of the Southeast Area include Knott Road to the south, 27th Street to the east, and the existing City limits to the north and west.

An area plan is being developed that includes land use/zoning, roadways, and sewer infrastructure. This technical memo outlines a concept for sewer infrastructure including gravity sewer and force main alignments and the location of a regional pump station. Preliminary sizing of infrastructure is also summarized. The sewer concept is based on land use data and roadway planning adopted by the Southeast Area Plan Advisory Committee (SEAPAC) on September 26, 2019 and verified with residential and employment data from the City's 2016 UGB Expansion Study.

Summary

The Southeast Area sewer infrastructure concept plan documented in this technical memorandum is summarized in Figure 1 and Table 1. The infrastructure plan includes six gravity collector sewers ranging in size from 8 to 18-inches, one regional pump station, and one 12-inch force main. Local neighborhood sewers are excluded from the plan. Based on topography, approximately 50-percent of the service area will be served by the regional pump station. Preliminary cost estimates are presented in Table 1. The cost estimates associated with the gravity sewer alignment 1 located in 15th Street are not discounted for work currently being performed by the Bend LaPine School District to extend gravity sewer service to future schools adjacent to 15th Street.

Figure 1- Sewer Concept Plan

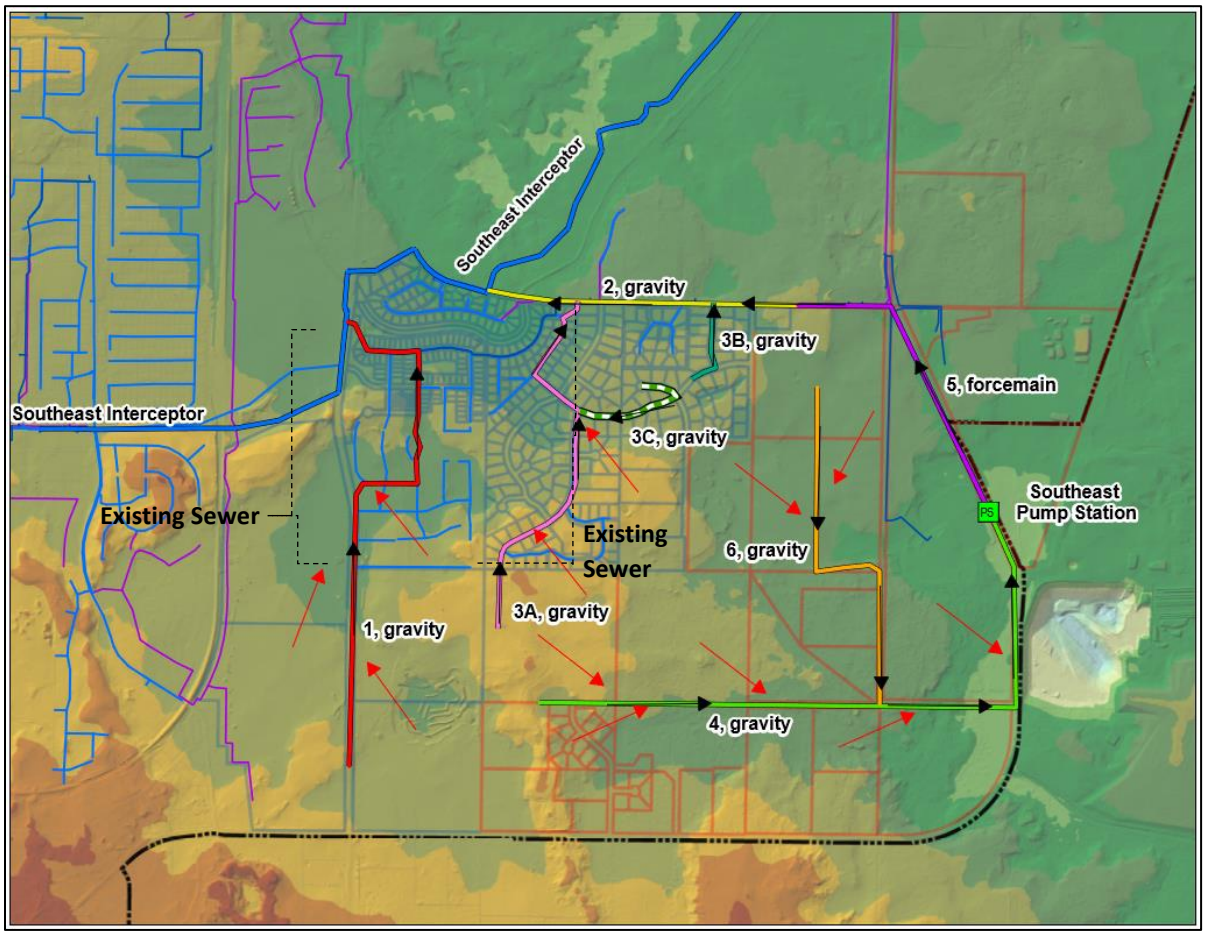


Table 1 - Sewer Infrastructure Summary and Costs

New Infrastructure	Preliminary Sizing (inches or gallons per minute, gpm)	Length (feet)	Cost Estimate, Low Markup ($million)[1]	Cost Estimate, High Markup ($million)[1]
1, gravity[2, 3]	8-inch, 12-inch	1,650 8-inch, 1,500 12-inch	1.2	1.8
2, gravity	18-inch	3,100	1.3	1.9
3A, gravity[3]	8-inch	750	0.29	0.43
3B, gravity[3]	8-inch	940	0.36	0.53
4, gravity	8-inch, 12-inch	3,350 8-inch, 3,550 12-inch	2.8	4.1
5, force main	12-inch	3,200	1.3	1.8
6, gravity	12-inch	4,100	1.8	2.7
Pump Station	1,250 gpm	n/a	3.5	5.1
Total			12.6	18.4

Table 1 Notes:

Note 1. All cost estimates are Class 5 budget estimates in millions of dollars, as established by the *American Association of Cost Engineers*. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +30 to +100 percent on the high end. The cost estimates are consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035. Cost estimates are intended to be used as guidance in establishing funding requirements at the project planning level based on information available at the time of the estimate. Estimates exclude land acquisition, financing, and inflation. Low markup is a factor of 2.1 times labor and material costs. High markup is a factor of 3.1 times labor and material costs. Cost estimates were performed in 2019 dollars based on The Engineering News Record Construction Cost Index (ENR CCI) basis of 12026.45 (February 2019).

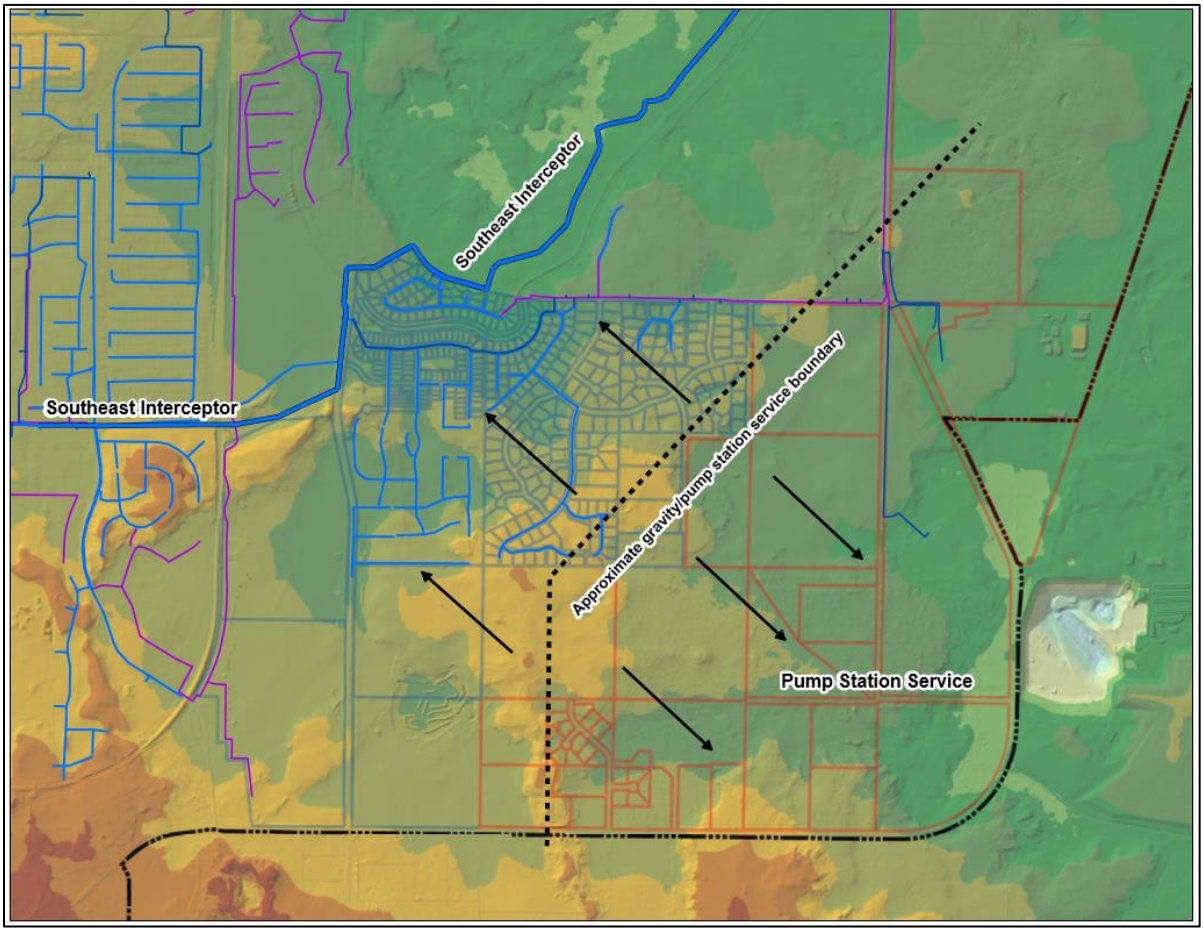
Note 2. The cost estimates associated with the gravity sewer alignment 1 located in 15th Street are not discounted for work currently being performed by the Bend LaPine School District to extend gravity sewer service to future schools adjacent to 15th Street.

Note 3. Alignments 1 and 3 connect to existing piping. The existing piping is excluded from the length and cost estimates unless an upsize is required. Alignments 3C is part of the City's septic to sewer conversion project on Cabin Ct and Via Sandia. Costs for 3C are excluded.

Topography and Sewer Service Overview

The Southeast Area will be served by the Southeast Interceptor. Due to topography, some of the area will be served via gravity while other portions will be served by a regional pump station. A ridge splits the area approximately in half from the southwest corner to the northeast corner. Areas north and west of this boundary can be served via gravity sewers while areas to the south and east of the boundary will be served via pump station. Figure 2 illustrates the general ground surface topography and approximate boundary between gravity and pump station service areas.

Figure 2 – Topography and Service Overview



Sewer Infrastructure

Sewer infrastructure will utilize the road corridors approved by SEAPAC on September 26th 2019. Figure 3 shows the sewer infrastructure concept with numbering for each sewer alignment. Sewer alignments 1 and 3 will serve the area via gravity. Alignment 1 currently connects to the Southeast Interceptor. An extension of the existing gravity pipeline will serve the future middle and high schools as well as any other development along 15th Street. The Bend LaPine School District is responsible for funding a portion of Alignment 1 and the concept presented in this plan should be coordinated with their work. Alignment 3 will serve existing properties on Sky Harbor Drive and future development south of

Miramar Drive. The sewer improvement will connect to existing 8-inch piping in Sky Harbor Drive extending the pipeline further south by approximately 500 feet. The sewer improvement also includes new piping on Via Sandia Street and Cottonwood Drive connecting the existing Sky Harbor Drive pipeline to the new collector sewer on Ferguson Road (alignment 2).

Alignment 2 will be a gravity sewer that extends from the high elevation point on Ferguson Road to King Solomon Lane where it will connect to the South East Interceptor. This sewer will convey flow from sewer alignment 2 as well as flow from the South East Area Pump Station. The Ferguson Road sewer will also be used to decommission the existing Camden and Ridgewater Pump Stations.

A pump station is required to serve the southeastern portions of the area. Two gravity sewers will contribute flow to the Southeast Pump Station, alignment 6 and alignment 4. The pump station will be located just east of the High Desert Middle School on SE 27th Street. The force main will continue north on SE 27th and turn west on Ferguson Road before connecting to the gravity sewer (alignment 2) on Ferguson Road. This pump station location may also serve portions of the DSL property, another UGB expansion area.

An overview of sewer alignments is shown in Figure 3. Figure 3 includes the transportation infrastructure plan as a background layer, while Figure 4 includes a ground surface elevation background layer. Black arrows on both figures indicate flow direction, while the red arrows on Figure 3 indicate general direction of sewer service.

Figure 3 – Preliminary Sewer Service Overview

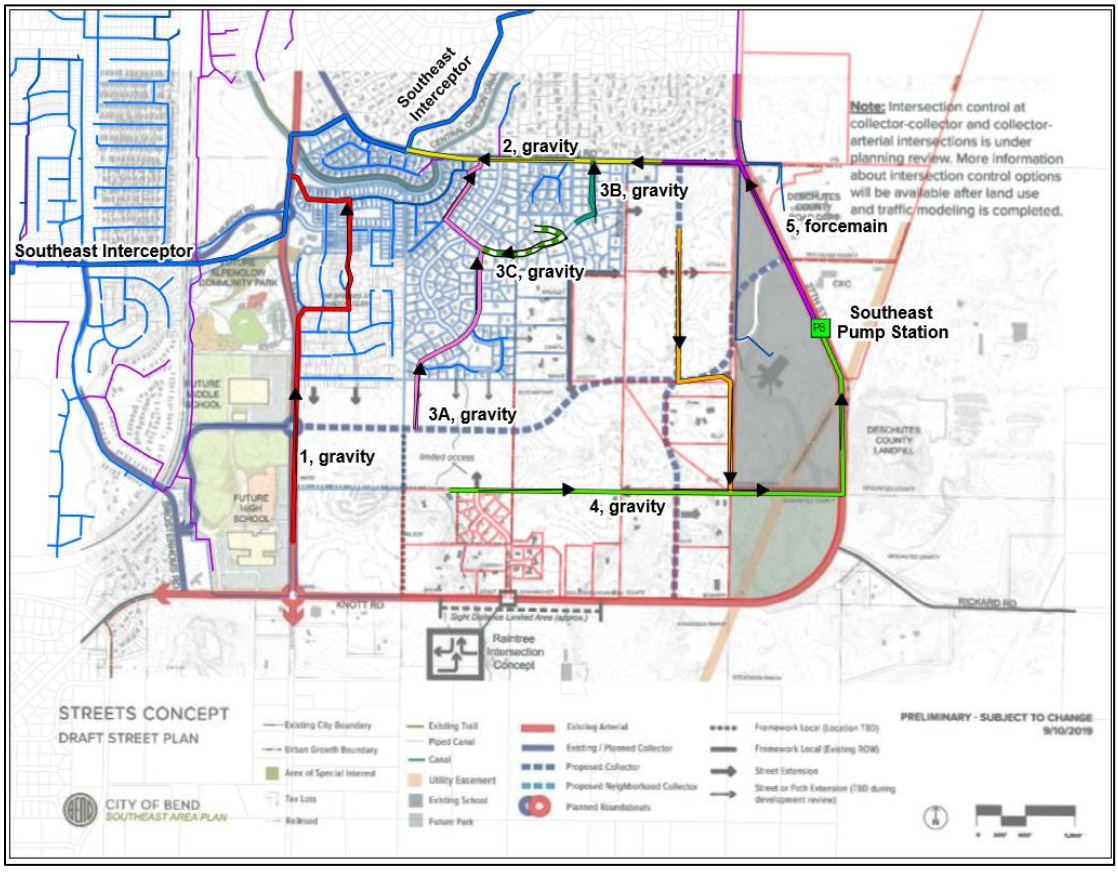
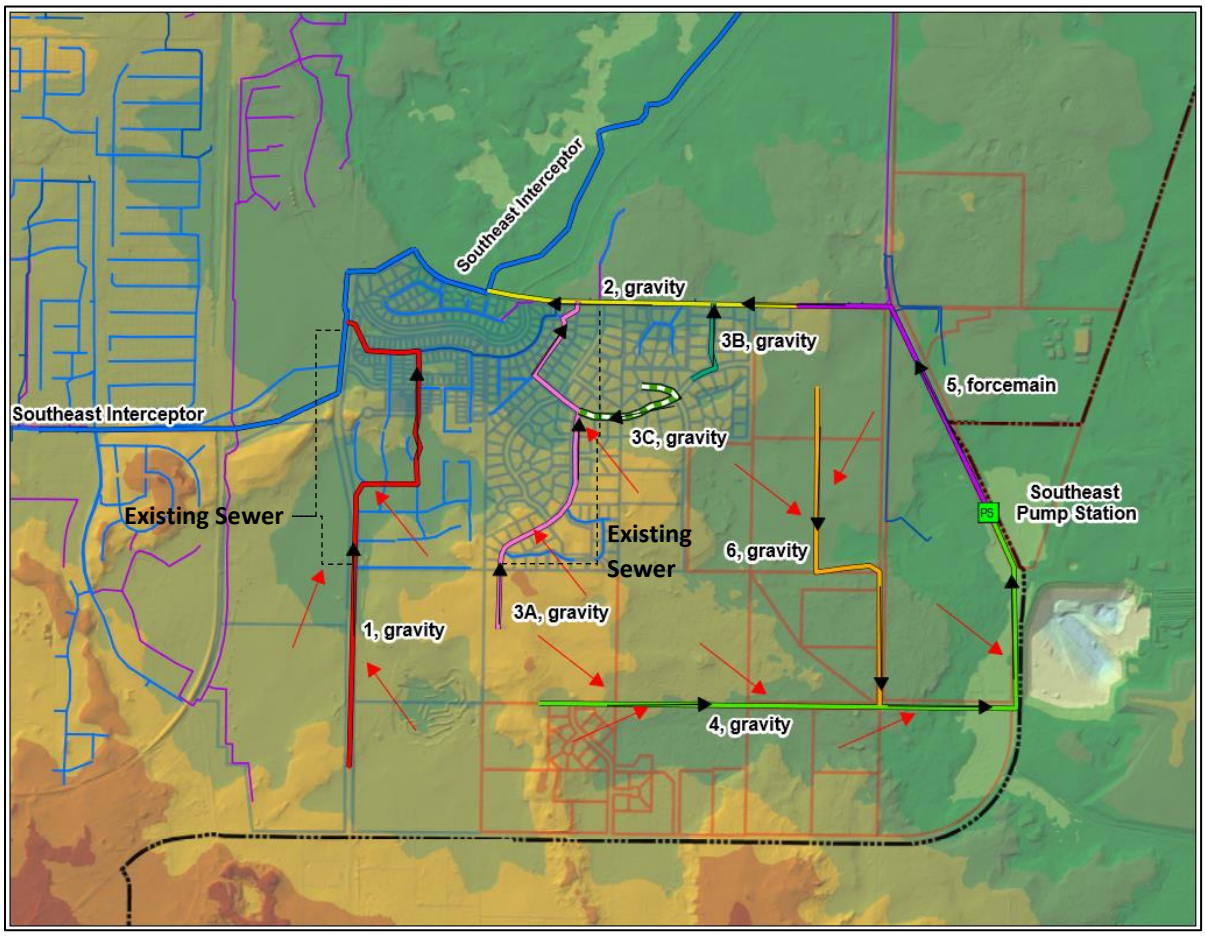


Figure 4- Preliminary Sewer Service Overview



Flow Rates and Infrastructure Sizing

Flow rates are based on land use/zoning approved by SEAPAC on September 26th 2019 and confirmed with assumptions from the City's 2016 UGB Expansion Study and 2018 Collection System Public Facility Plan Update. Average dry weather flow rates are calculated based on household or employment density per acre multiplied by unit flow factors of 130 gallons per housing unit per day and 45 gallons per employee per day. School properties were reviewed to ensure a minimum of 350 gallons per acre per day flow rate. Household and employment densities were adjusted to comply with total households and employees identified for the Elbow from the City's 2016 UGB Expansion Study (820 households and 2,290 employees). A peaking factor of 1.7 was used for average flow to peak dry weather flow, and a factor of 4 was used for average flow to peak wet weather flow. In addition to the design peak wet weather flow rate, a low flow dry weather and maximum build-out peak wet weather flow were developed to evaluate sewer infrastructure under low and high flow scenarios. The low dry weather flows were developed using planned vacancy within the service area. The high wet weather flow was developed using maximum zoning densities. The low and high flow scenarios are used for a sensitivity analysis to check for low scour velocities and surcharging of infrastructure during peak wet flow conditions. Table 2 provides a summary of flow rates and sizing calculated for each sewer line and the force main. Pipes were sized to convey the design peak wet weather flow without surcharging.

Table 2 – Flow and Sizing Summary

Alignment	Sizing (inches or total dynamic head, TDH)	Average Flow (gpm)	Peak Dry Weather Flow (gpm)	Design Peak Wet Weather Flow (gpm)	Low Dry Weather Flow (gpm)	Buildout Max Peak Wet Weather Flow (gpm)
1, gravity[1]	8-inch and 12-inch	100	180	400	155	425
2, gravity (includes flow from Pump Station and Profile 3)	18-inch	325	590	1,300	615	1,990
3A, gravity[1]	8-inch	44	77	176	88	176
3B, gravity[1]	8-inch	4	7	16	8	16
4, gravity	8-inch	60	100	225	150	200
4, gravity (downstream of 6)	12-inch	130	240	5,300	255	1,030
5, force main[2,3]	12-inch	280	500	1,250	520	1,800
6, gravity	12-inch	75	140	300	105	840
Pump Station[2]	67-77 feet TDH[4]	280	500	1,250	520	1,800

Note:
1, Sizing refers to new infrastructure, existing infrastructure remains “as-is”
2, Includes additional flow from DSL property
3, Force main sized to convey 1,250 gpm at 3.5 feet per second
4, Total dynamic head may vary based on wet well depth

Sewer Profiles

Sewer profiles have been developed for each sewer alignments. Profiles include a ground surface and hydraulic grade line for peak dry and peak wet weather flow. Profiles have been developed to reduce overall depth while still meeting minimum slope requirements and allow for connections to existing infrastructure or pump station decommissioning. Profiles are shown for each alignment in Appendix 1.

Preliminary Cost Estimates

Cost estimates for the sewer infrastructure were developed. Preliminary costs are planning-level estimates using the approach from the Public Facility Plan Update (2018) and UGB Expansion Study (2016). All cost estimates are Class 5 budget estimates, as established by the *American Association of Cost Engineers*. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +30 to +100 percent on the high end. The cost estimates are consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035. Cost estimates are intended to be used as guidance in establishing funding requirements at the project planning level based on information available at the time of the estimate. Estimates exclude land acquisition, financing, and inflation. Cost estimates were performed in 2019 dollars based on *The Engineering News Record Construction Cost Index* (ENR CCI) basis of 12026 (February 2019).

Unit cost rates include materials, installation, and surface restoration in three categories (arterial, local, and dirt). Unit installation and material costs vary by both pipe diameter and depth. Unit cost markups are included for design and administration costs, mobilization, traffic control, erosion control, and contractor's overhead.

Some capital projects include significant unknowns at a planning level assessment. To account for unknowns related to canal crossings, and rock blasting, capital projects are given a cost estimate range representing standard and above average markups. These markups are presented in Table 3.

Table 3
Unit Cost Markups

Markup Category	Markup
Design and Administration	30%
Construction Mobilization	10%
Traffic Control and Erosion	9%
Contractor Overhead and Profit	15%
Subtotal	64%
Construction Contingency Low End	30%
Construction Contingency High End	80%
Overall Markup	2.1 (low) to 3.1 (high)

Preliminary cost estimate ranges for the Southeast Area sewer infrastructure concept are presented in Table 4. The cost estimates associated with the gravity sewer alignment 1 located in 15th Street are not discounted for work currently being performed by the Bend LaPine School District to extend gravity sewer service to future schools adjacent to 15th Street.

Table 4
Sewer Concept Preliminary Cost Estimates

New Infrastructure	Preliminary Sizing (inches or gallons per minute, gpm)	Length (feet)	Cost Estimate, Low Markup ($million)[1]	Cost Estimate, High Markup ($million)[1]
1, gravity[2, 3]	8-inch, 12-inch	1,650 8-inch, 1,500 12-inch	1.2	1.8
2, gravity	18-inch	3,100	1.3	1.9
3A, gravity[3]	8-inch	750	0.29	0.43
3B, gravity[3]	8-inch	940	0.36	0.53
4, gravity	8-inch, 12-inch	3,350 8-inch, 3,550 12-inch	2.8	4.1
5, force main	12-inch	3,200	1.3	1.8
6, gravity	12-inch	4,100	1.8	2.7
Pump Station	1,250 gpm	n/a	3.5	5.1
Total			12.6	18.4

Table 4 Notes:

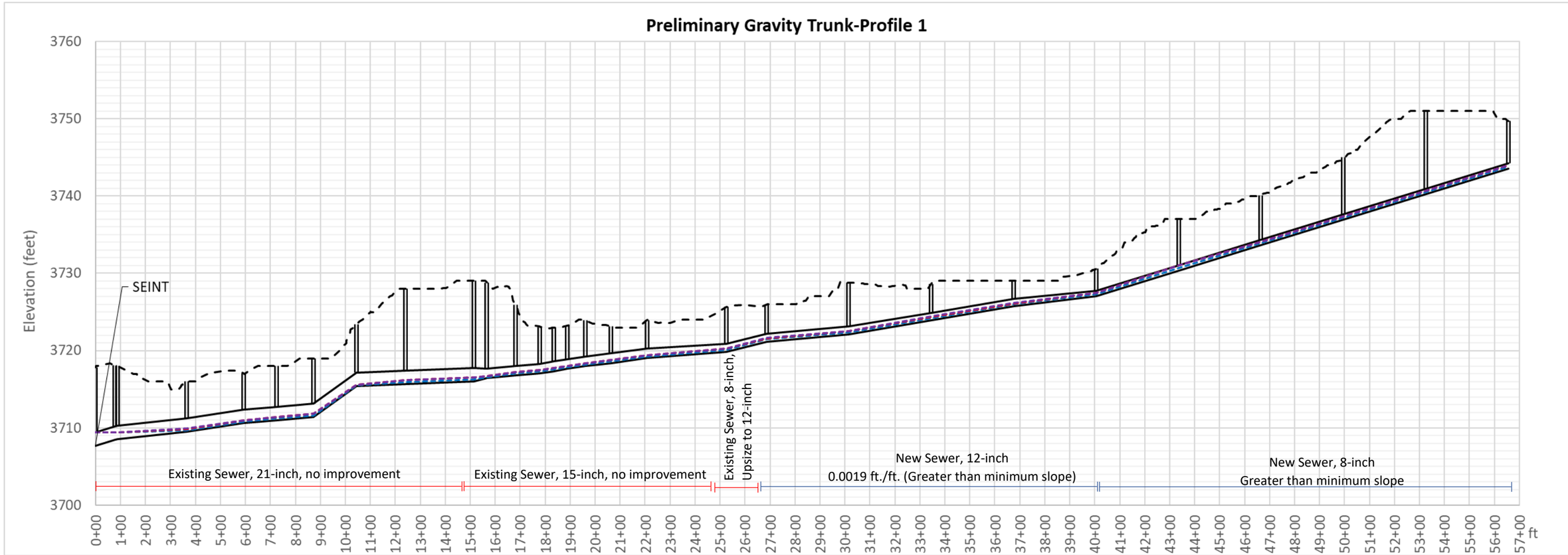
Note 1. All cost estimates are Class 5 budget estimates in millions of dollars, as established by the *American Association of Cost Engineers*. This preliminary estimate class is used for conceptual screening and assumes project definition maturity level below two percent. The expected accuracy range is -20 to -50 percent on the low end, and +30 to +100 percent on the high end. The cost estimates are consistent with the definition of OAR 660-011-0005(2) and OAR 660-011-035. Cost estimates are intended to be used as guidance in establishing funding requirements at the project planning level based on information available at the time of the estimate. Estimates exclude land acquisition, financing, and inflation. Low markup is a factor of 2.1 times labor and material costs. High markup is a factor of 3.1 times labor and material costs. Cost estimates were performed in 2019 dollars based on The Engineering News Record Construction Cost Index (ENR CCI) basis of 12026.45 (February 2019).

Note 2. The cost estimates associated with the gravity sewer alignment 1 located in 15th Street are not discounted for work currently being performed by the Bend LaPine School District to extend gravity sewer service to future schools adjacent to 15th Street.

Note 3. Alignments 1 and 3 connect to existing piping. The existing piping is excluded from the length and cost estimates unless an upsize is required. Alignments 3C is part of the City's septic to sewer conversion project on Cabin Ct and Via Sandia. Costs for 3C are excluded.

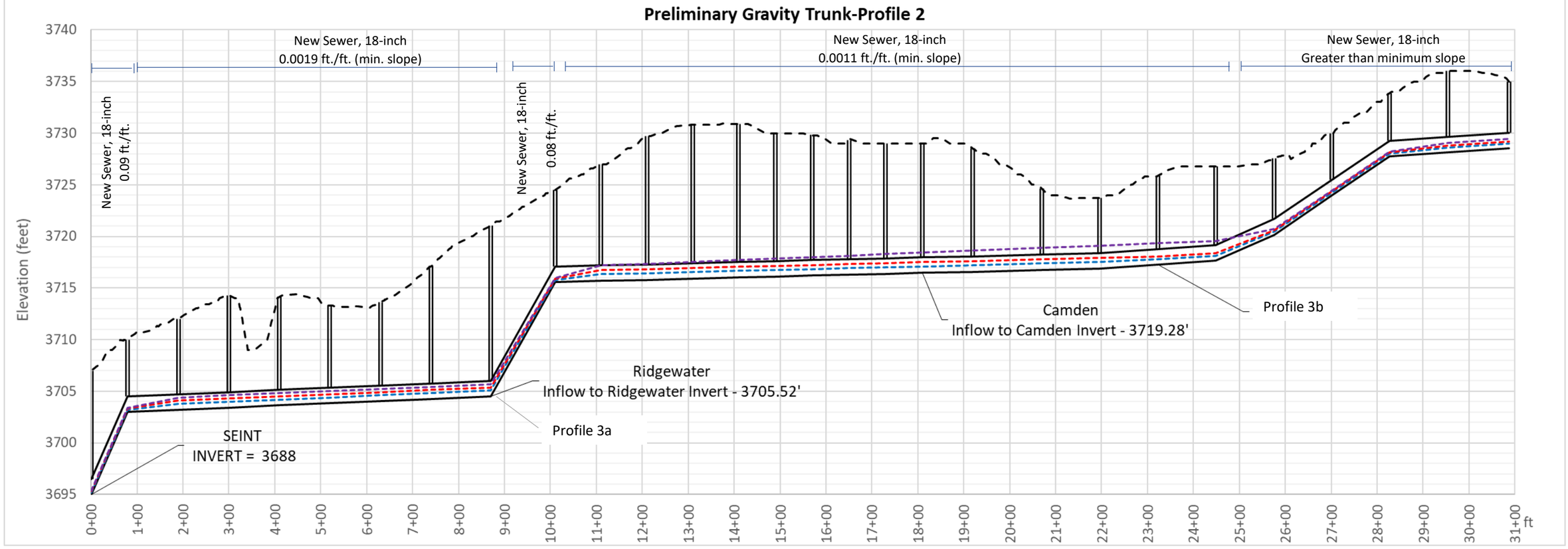
Appendix 1 – Sewer Profiles

Red line indicates design peak wet weather flow hydraulic grade line
Blue line represents low flow dry weather hydraulic grade line, used for scour velocity sensitivity analysis
Purple line represents a full build out condition, used for sizing sensitivity analysis



Flow Scenario	Min d/D	Max d/D	Min Vel. (fps)	Max Vel. (fps)
DWF	0.1	0.4	1.3	3.0
Peak WWF	0.1	0.6	1.8	4.3
Build Out Sensitivity Analysis	0.1	0.7	1.8	4.5

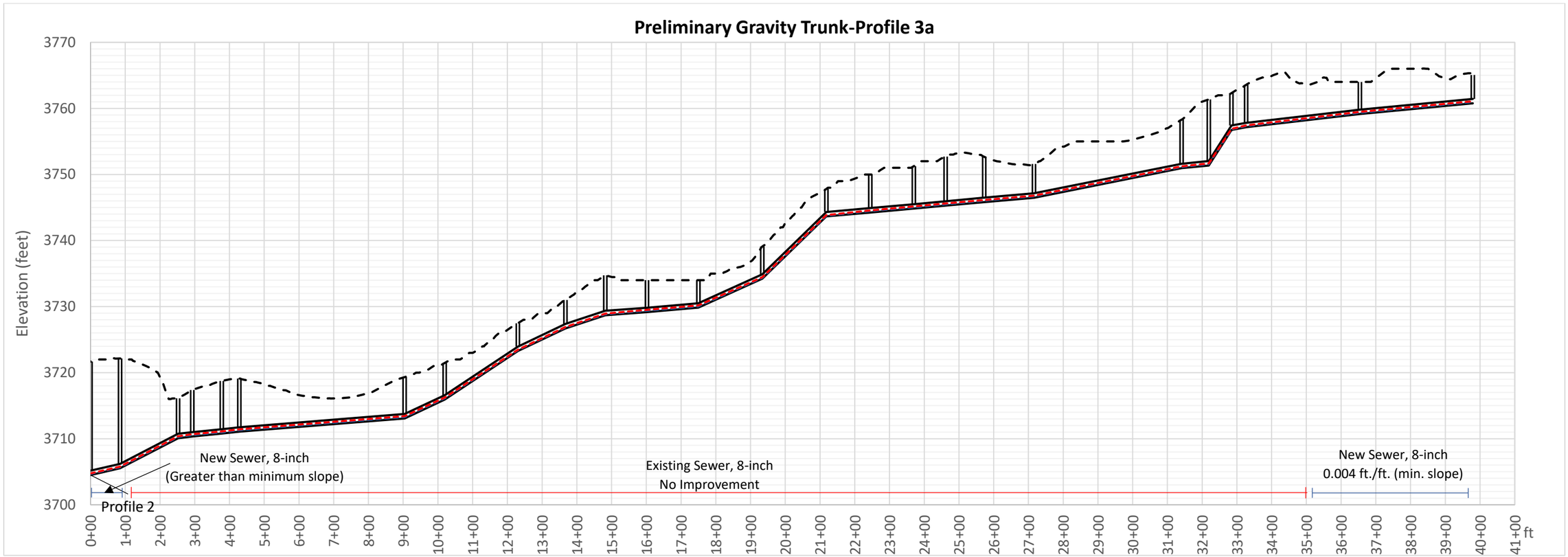
Comments- Low velocities are in the existing portion of this alignment sized at 21-inches. New infrastructure has velocity of 2.5 to 3 fps under peak dry weather flow conditions. Gravity alignment 1 will serve future middle and high schools as well as any other development along 15th Street. The Bend LaPine School District is responsible for funding a portion of Alignment 1 and the concept presented in this plan should be coordinated with their work.



Flow Scenario	Min d/D	Max d/D	Min Vel. (fps)	Max Vel. (fps)
DWF	0.1	0.4	1.8	8.6
Peak WWF	0.2	0.7	2.2	11.8
Build Out Sensitivity Analysis	0.3	d/D > 1.0, surcharging < 1 ft	2.5	13.5

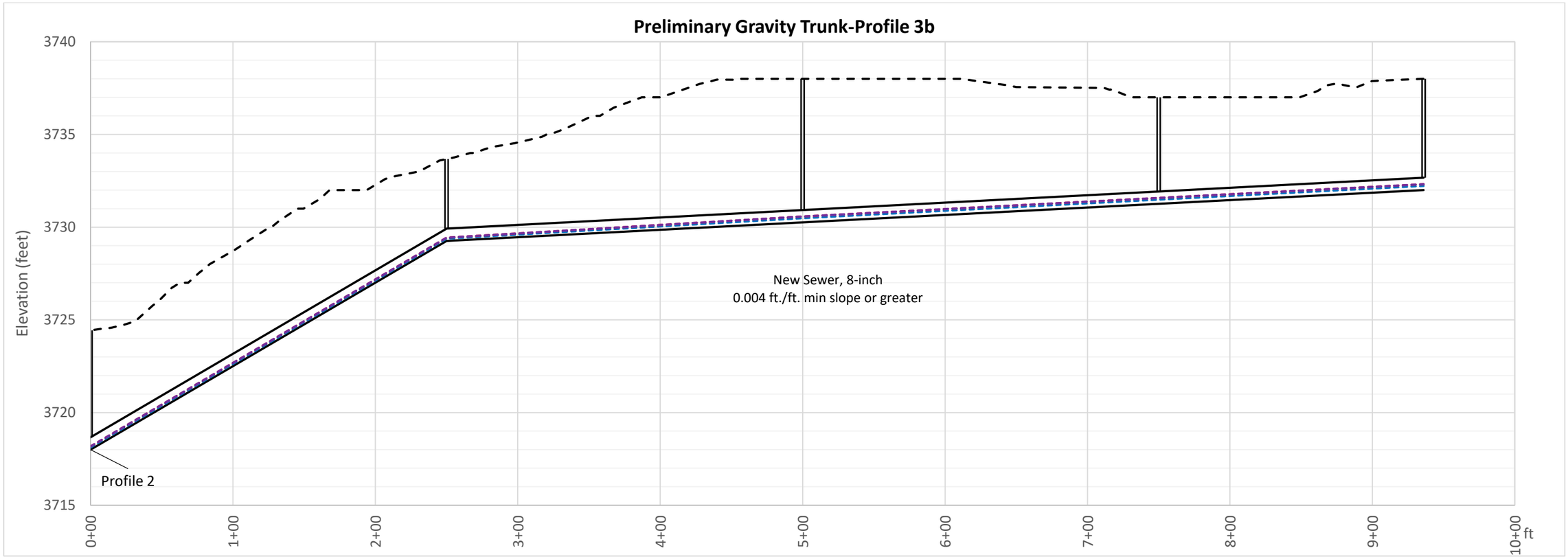
Comments- Alignment is driven by decommissioning of Ridgewater lift station and trying to minimize depth. Low velocities are in the middle section of the profile with slope of 0.0011 ft./ft. Slope could be increased but would result in increased depth (greater than 15 ft.).

Infrastructure is sized to prevent surcharging using flow rates developed from planned population and employment for the Elbow (red hydraulic gradeline). The buildout sensitivity scenario includes flow rates generated assuming maximum population and employment density within the service area. This scenario is used to verify that infrastructure is sized adequately to prevent excessive surcharging for any potential redevelopment in the future (purple hydraulic gradeline).



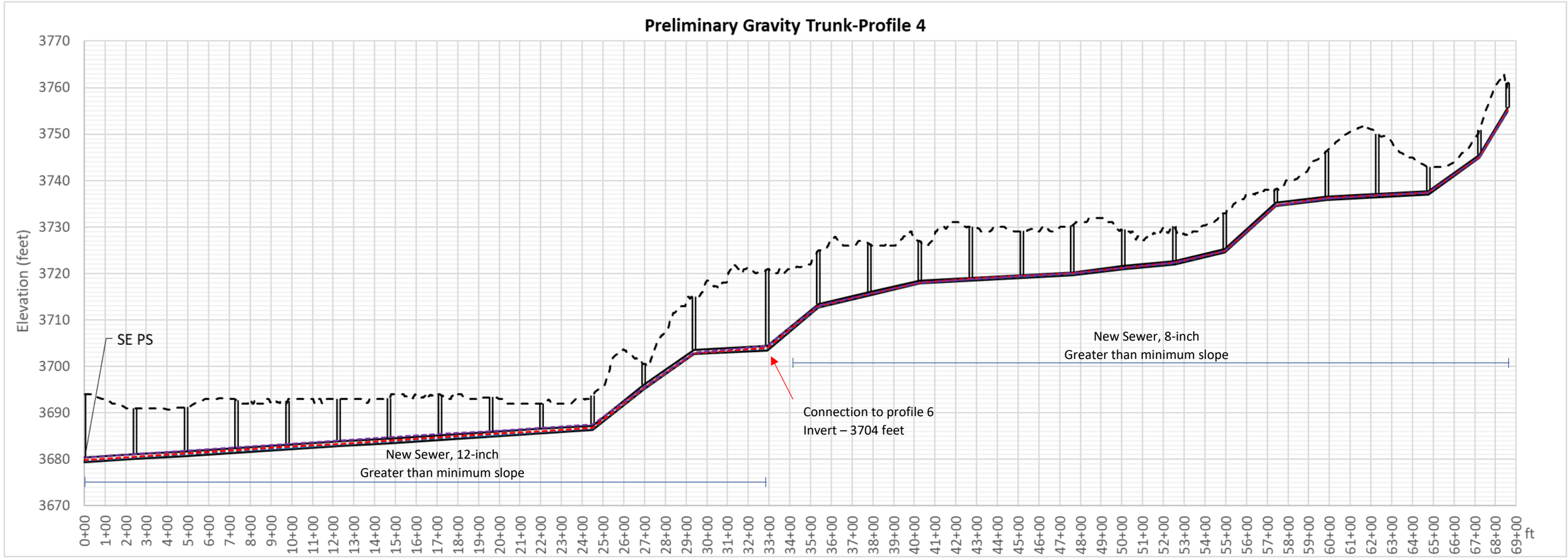
Flow Scenario	Min d/D	Max d/D	Min Vel. (fps)	Max Vel. (fps)
DWF	0.14	0.3	1.8	5.0
Peak WWF	0.24	0.5	1.8	6.8
Build Out Sensitivity Analysis	0.24	0.5	1.8	6.8

Comments- Low velocities are in the existing portion of this alignment sized at 8-inches.



Flow Scenario	Min d/D	Max d/D	Min Vel. (fps)	Max Vel. (fps)
DWF	0.04	0.1	2	1.3
Peak WWF	0.1	0.1	2	2
Build Out Sensitivity Analysis	0.1	0.1	2	2

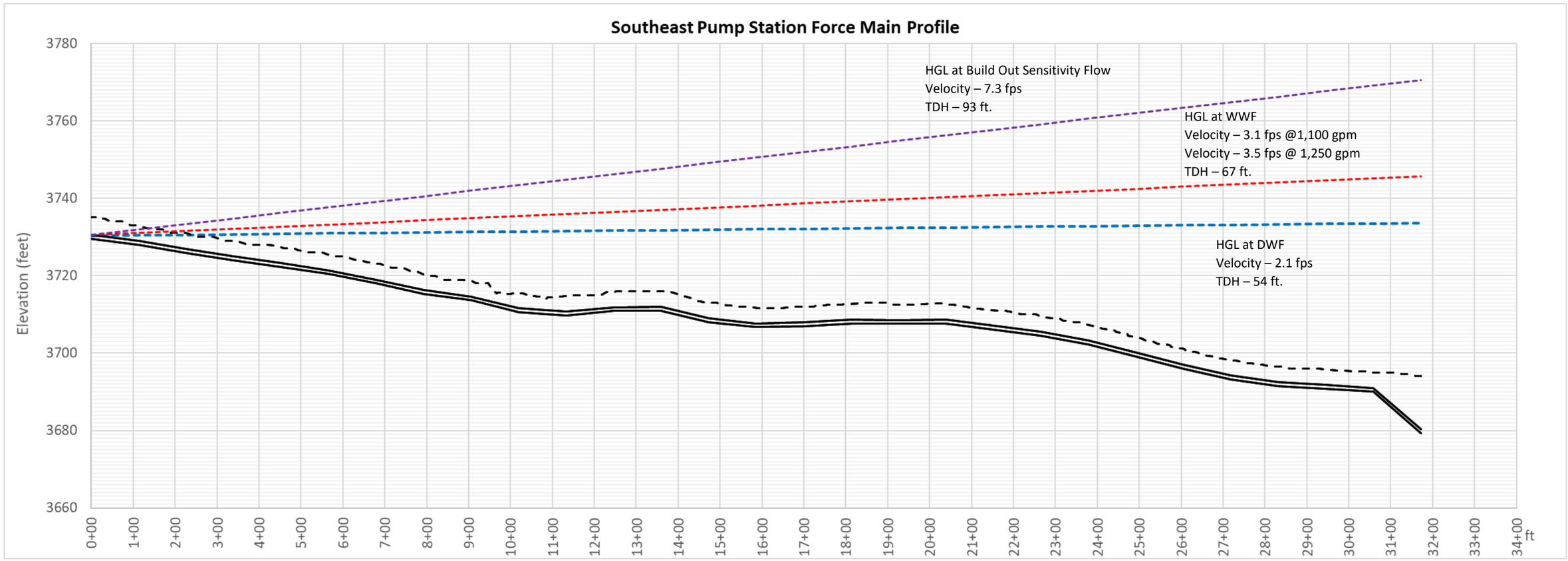
Comments- Velocity could be increased with increased slope, result would be increased depth (greater than 9 feet).



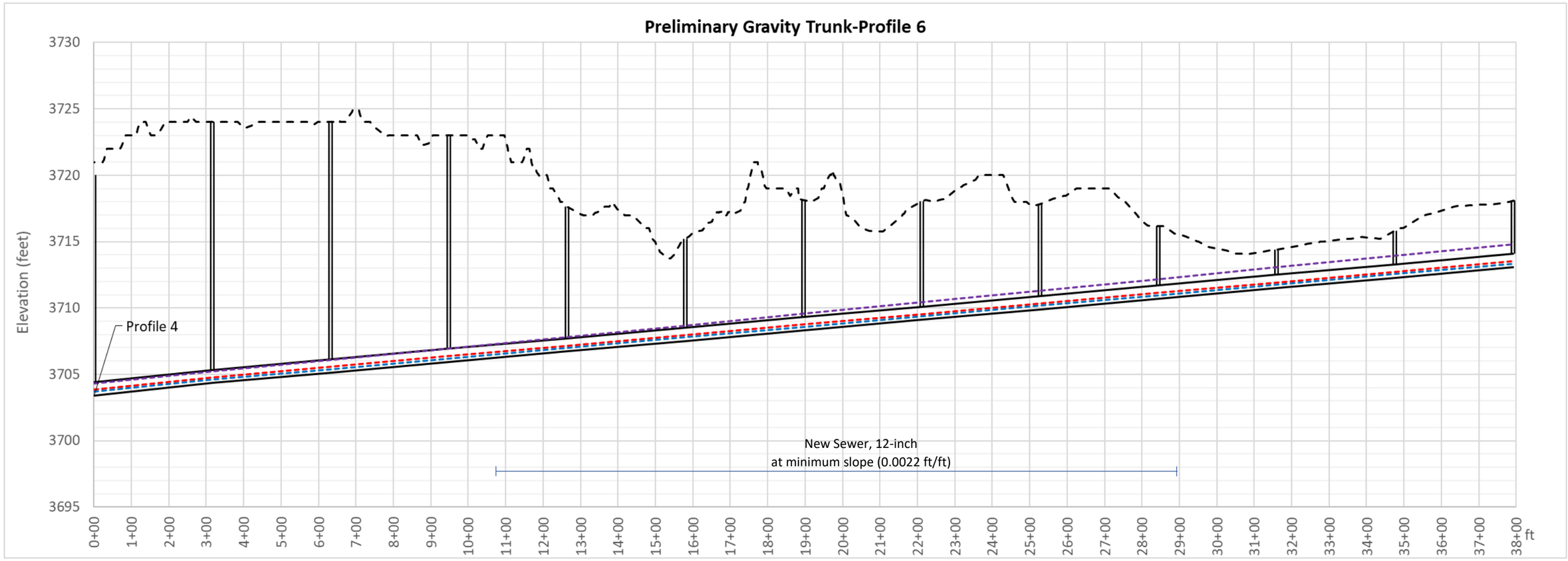
Flow Scenario	Min d/D	Max d/D	Min Vel. (fps)	Max Vel. (fps)
DWF	0.2	0.5	1.7	6.2
Peak WWF	0.3	0.7	1.8	6.8
Build Out Sensitivity Analysis	0.3	d/D > 1.0, surcharging < 1 ft	2.5	13.5

Comments- Profile is driven by need to connect with profile 6 and desire to reduce depth. Velocity could be improved in both profile 4 and profile 6, this would result in increased depth for both profiles (greater than 17 feet for profile 4)

Infrastructure is sized to prevent surcharging using flow rates developed from planned population and employment for the Elbow (red hydraulic gradeline). The buildout sensitivity scenario includes flow rates generated assuming maximum population and employment density within the service area. This scenario is used to verify that infrastructure is sized adequately to prevent excessive surcharging for any potential redevelopment in the future (purple hydraulic gradeline).



Diameter (nominal, inches)	Flow Rate (gpm)	Total Dynamic Head (TDH, ft)	Velocity (fps)
12	1250	67-77 (dependent on wet well depth)	3.5



Flow Scenario	Min d/D	Max d/D	Min Vel. (fps)	Max Vel. (fps)
DWF	0.17	0.3	2	2
Peak WWF	0.31	0.4	2	2
Build Out Sensitivity Analysis	0.52	d/D > 1.0, surcharging < 1 ft	2	3

Comments- Profile 6 could be re-routed further east, potentially along Diamondback Ln to reduce depth at downstream end.

Infrastructure is sized to prevent surcharging using flow rates developed from planned population and employment for the Elbow (red hydraulic gradeline). The buildout sensitivity scenario includes flow rates generated assuming maximum population and employment density within the service area. This scenario is used to verify that infrastructure is sized adequately to prevent excessive surcharging for any potential redevelopment in the future (purple hydraulic gradeline).