APPENDIX F: INFRASTRUCTURE PLAN

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Technical Memorandum

Date:	November 8, 2022
Project:	Wilsonville Frog Pond East and South Master Plan
To:	Andrew Parish – APG/MIG Joe Dills – APG/MIG
From:	Mike Carr, PE – Consor Julia King, EIT – Consor Joshua Owens, PE – Consor
Re:	Proposed Infrastructure Plans - Water, Wastewater, Stormwater Systems

Introduction

This technical memorandum provides a summary of new water, wastewater, and stormwater infrastructure necessary for the development of Wilsonville Frog Pond East and South areas, to be documented in the area's Master Plan. Analyses were performed to estimate sizes and propose layouts of the proposed systems, using applicable City standards for the systems. The planned infrastructure will also be used for cost estimates and preparation of infrastructure funding strategies.

Background

In 2015, the Frog Pond Area Plan (FPAP) was adopted by the City of Wilsonville. The Frog Pond area consists of three separate neighborhoods: West, East, and South. A master plan for Frog Pond West was developed in 2017 and development in Frog Pond West began soon after. Based on current information from the City, it is estimated that 80% of the parcels in Frog Pond West are currently, or soon to be, under development.

In 2018, the Frog Pond East and South areas were brought into the regional Urban Growth Boundary (UGB). The City initiated master planning in 2020. To date, the master plan process has prepared a draft preferred land use plan. The preferred alternative identifies residential uses of varied housing types, a neighborhood commercial area, streets and trails, and parks and open space. For the purpose of this infrastructure analysis, the plan is assumed to include 1,800 total housing units in the combined East and South neighborhoods. Infrastructure plans were developed for the preferred alternative and are further described in the individual sections below.

The City has also identified a higher-density scenario which calls for 2,384 total units (20 units per net residential acre) in the combined East and South neighborhoods. This scenario represents a

very robust buildout of housing, especially middle housing. Infrastructure needs for the higher-density alternative were estimated to determine the difference in needs between the two alternative plans. These are also described below.

Proposed Water System

The water purveyor for the Frog Pond area is the City of Wilsonville. The City's *Water System Master Plan* (WSMP), adopted September 6, 2012, is the current basis for domestic water and fire system planning within the Frog Pond East and South. The recommendations provided in the 2015 FPAP for water system improvements still apply for the recommended development concepts for Frog Pond East and South. These areas will be extensions of water pressure Zone B which operates in an elevation range from 100 feet to 285 feet and has a hydraulic grade of 400 feet.

Distribution System

Figure 1 shows the proposed preliminary water system layout for the East and South neighborhoods, including off-site improvements needed to serve the area. The existing 12-inch waterline in Boeckman Road is the primary backbone connection for Frog Pond East and South to the City's water supply and storage system. A looped system consisting of 12-inch and 8-inch distribution mains is proposed for supply of domestic water to Frog Pond East and South. The 12-inch main network provides a redundant capacity of 1,500 gallons per minute (gpm) for fire flow to all areas. In accordance with City Public Works Standards, 12-inch mains are also required for the commercial main street area proposed along Brisband Road in Frog Pond East. For all residential zones, 8-inch mains are required, with all lines interconnected as a network to minimize dead ends.

The plan calls for new 12-inch waterlines extending north in Stafford Road and east in Advance Road to extend the distribution system into Frog Pond East and South, connecting to the existing 12-inch waterlines in Boeckman Road and Advance Road. Additional points of connection will also be made to proposed waterlines planned to be installed in Frog Pond Lane and Brisband Road as part of the Frog Pond West development.

The northernmost neighborhoods in Frog Pond East along SW Kahle Road need to be connected to the City's existing water system with a 12-inch loop that connects to the south side of the BPA easement in two locations, one being a connection at the intersection of Stafford Road and SW Kahle Roads, and the other to the 12-inch waterline in the commercial main street. The loop could be constructed across the BPA easement either in the proposed road extending northeast from Frog Pond Lane, or it could cross the BPA easement further to the east via the proposed pedestrian bridge over the main fork of the Newland Creek. The decision on where to route the loop will depend on what areas are developed first and whether the pedestrian bridge is built. In either scenario the 12-inch mainline along SW Stafford Road and SW Kahle Road will be required.

The WSMP recommended two additional connections to the existing distribution system to reliably serve Frog Pond East and South through buildout. The first is a 12-inch connection to the Canyon Creek Road waterline via a crossing of Boeckman Creek at the west end of Frog Pond Lane,

for connection to the Stafford Road waterline in conjunction with development in Frog Pond East. The second is a crossing of Meridian Creek with a 12-inch main, south of the Meridian Creek Middle School, installed in conjunction with development of Frog Pond South. Both creek crossings are assumed to be below grade directionally drilled pipelines; however, they may be installed on future pedestrian bridges where under consideration by the City.

Storage System

The WSMP identified an overall water storage deficiency in the City which will be further increased by development in Frog Pond East and South. The WSMP proposed a 3.0-million-gallon West Side Tank and 24-inch transmission main project to provide sufficient storage for the City. The City has this project budgeted in the City's current 5-Year Capital Improvement Program, with design expected to begin in FY2022/23. The project is anticipated to be completed in 2025.

The extent of the storage deficiency and its impact on development of Frog Pond East and South is unknown at this time, since the WSMP is 10 years old and significant development has occurred in the City in that period. Additional analysis may be conducted to determine what, if any, impact any development in Frog Pond East and South prior to implementation of the new water tank would have on the existing water system and its customers.

The water system layout and sizing are primarily dependent on the street network to distribute fire flow to the designated land use types. Given the higher-density scenario using the same land use pattern and street plan, it is estimated that waterline sizes and costs would remain the same as with the preferred water system layout.

Proposed Wastewater System

The City of Wilsonville will provide sanitary sewer service for the Frog Pond East and South area as an extension of the City's existing collection system. The City's *Wastewater Collection System Master Plan* (WCSMP), adopted in 2014, is the current basis for wastewater system planning within the City. The 2015 FPAP and subsequent studies provide the specific framework for wastewater system planning in the Frog Pond East and South area, along with design criteria from the 2017 Public Works Standards.

An analysis of the existing wastewater infrastructure system conducted for this Master Plan and was documented in the *Existing Conditions Analysis - Water, Wastewater, Stormwater Infrastructure Technical Memorandum* dated May 31, 2022. The analysis confirmed the Frog Pond Area Plan's conclusion that the topography of the area relative to the City's existing wastewater infrastructure necessitated four lift stations.

Figure 1 – Preliminary Water System Layout

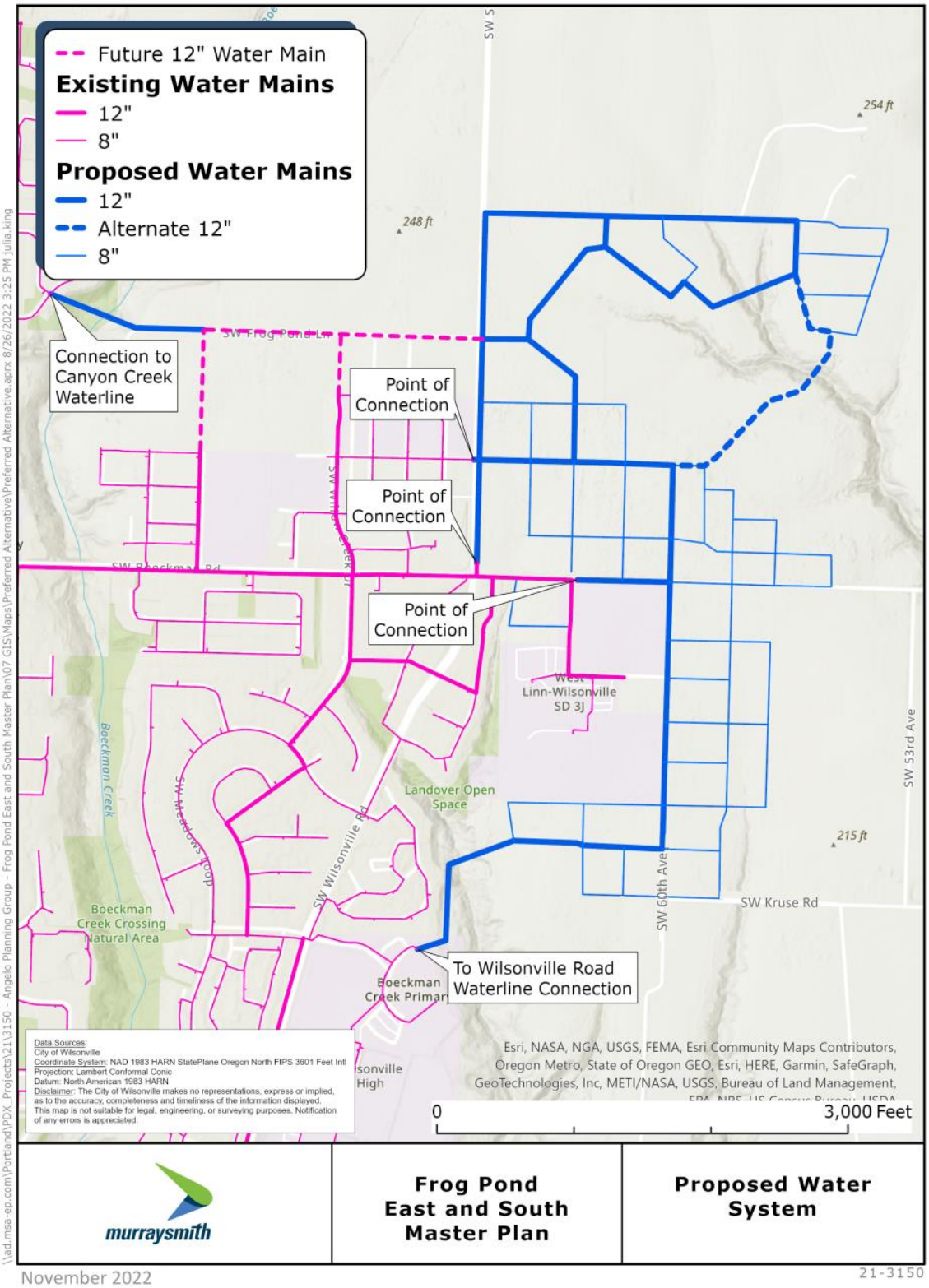


Figure 2 shows the proposed preliminary wastewater system layout for the Frog Pond East and South neighborhoods. The area was divided into five sewer basins, one for each of the four wastewater lift stations required and one that flows by gravity out of the Frog Pond area. The four lift stations are briefly described as follows:

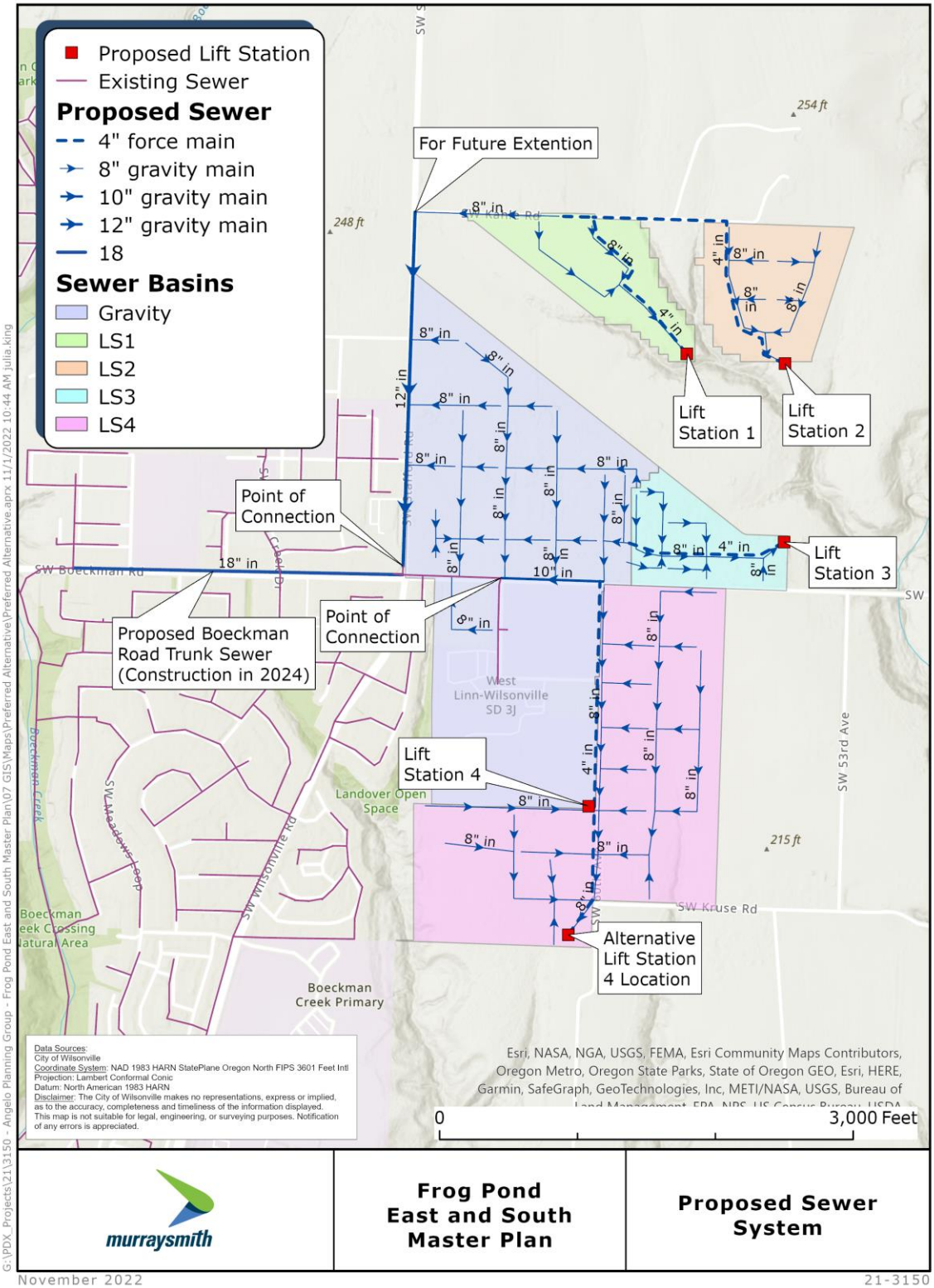
Lift Stations LS1 and LS2 are needed for the two Frog Pond East neighborhoods north of the BPA Easement along Kahle Road. The neighborhoods slope toward Newland Creek which also serves as a topographic barrier to connecting to the City's existing gravity sewer system. Each lift station will require a force main to convey wastewater to the gravity system in Kahle Road that would be extended east from Stafford Road. The force main for LS1 is estimated at 1,000 feet long, and 2,000 feet long for LS2.

Lift Station LS3 is needed to serve the far eastern portion of Frog Pond East where topography of the neighborhood slopes easterly toward Newland Creek. The lift station will pump wastewater to an extension of the existing gravity sewer system in SW Advance Road via a 1,200-foot-long force main.

Lift Station LS4 is needed in the southern portion of the Frog Pond South area due to topography, which generally runs from north to south away from the City's existing gravity wastewater sewer system in SW Advance Road. The Plan identifies two potential locations of LS4. The preferred location is along existing SW 60th Avenue in the southeast corner of the school district property. This location is advantageous because it is adjacent to the SW 60th right-of-way which is likely to be improved as part of the first phase of development, and because it can be co-located with a regional stormwater facility that is also needed for the area. An alternative lift station location was also identified further to the south, which may advantageous because it can reduce the depth, and therefore the cost, of lift station construction. However, development timing for the far south portion of Frog Pond South may not facilitate implementation at the time it is needed for the northern portion. In either case, the lift station will need to be constructed with depth sufficient to serve all properties designated within the station’s service area.

Basin peak flows were calculated using preliminary land use data provided by MIG and unit flow values determined from the WCSMP. Residences were assumed to have 2.48 people per unit and an average sewer production rate of 67 gallons per person per day. Commercial sectors were assumed to generate 1,000 gallons per acre per day and schools were estimated to generate 25 gallons per day per person. Average dry weather flows were used with a peaking factor of 2 to estimate the peak dry weather flows. Wet weather flows were estimated to have an infiltration and inflow rate of 1,800 gallons per acre per day over the entire basin. Detailed calculations can be found in Appendix A.

Figure 2 – Preliminary Wastewater System Layout



Each basin was analyzed for both the preferred housing scenario of 1,800 total units, and the higher-density scenario of 2,384 total units. The four lift station basins will each require an 8-inch gravity pipe to convey wastewater to the lift station at an assumed slope of 0.5%, and a 4-inch force main discharge to the downstream basin. These requirements are the same for both housing scenarios. Table 1 shows the peak wet weather flow for each lift station basin and the required pipe sizes.

Table 1 - Lift Station Basins

Basin	Total Peak Flow for 1,800 Units (cfs)	Total Peak Flow for 1,800 Units (gpm)	Total Peak Flow for 2,384 Units (gpm)	Recommended Lift Station Design Capacity (gpm)	Force Main Size (in)	Gravity Sewer Size (in)
LS1	0.13	58	70	135	4	8
LS2	0.16	71	86	135	4	8
LS3	0.126	55	67	135	4	8
LS4	0.49	220	260	260	4	8

Table 1 shows that the recommended capacity for LS1, LS2 and LS3 lift stations is 135 gpm, which is the minimum pumping capacity required to meet design criteria for 4-inch sewage force mains. This is the same for both housing scenarios. Capacity of LS4 would increase somewhat, from 220 gpm in the preferred scenario, to 260 gpm in the higher-density scenario. This change is estimated to be relatively insignificant in the overall cost of constructing the wastewater facilities for LS4 basin.

The main trunk traveling north to south on SW Stafford Road conveys sewage from Lift Stations 1 and 2 and a portion of the gravity basin. This pipe has the capacity to carry both housing density scenarios at an 8-inch size; however, this pipe should be sized at 12-inch diameter as identified in the WCSMP to accommodate future extension to the north.

Extension of the Boeckman Road Trunk Sewer east on Advance Road is needed to convey sewage from both Lift Stations 3 and 4 and a portion of the gravity basin. A 10-inch size is required to provide capacity necessary for both housing density scenarios.

All wastewater from Frog Pond East and South is to be conveyed to the wastewater treatment plant through connection to the existing Boeckman Road Trunk Sewer, which flows west to the existing Boeckman Creek Interceptor Sewer and the Memorial Park Pump Station. The Boeckman Road Trunk Sewer is being upsized to 18-inch diameter as part of improvements to Boeckman Road, including Boeckman Dip Bridge, with completion anticipated for 2024.

The Boeckman Creek Interceptor Sewer is a 12-inch to 18-inch diameter pipe extending from Boeckman Road to the Memorial Park Pump Station. Capacity of the Boeckman Interceptor was determined to be sufficient for full buildout of Frog Pond West but will be insufficient to serve full

build-out of Frog Pond East and South. The WCSMP recommends the Boeckman Creek Interceptor Sewer be upsized for buildout of Frog Pond East and South. The City is currently planning to upsize the Boeckman Interceptor in conjunction with a regional trail in the creek corridor. Design of the project will begin in 2022, with construction anticipated to be completed in the fall of 2025.

Though the Boeckman Creek Interceptor will not have sufficient capacity for full buildout of Frog Pond East and South, there will be some capacity available for initial development in the area, depending on how much capacity has been taken up by Frog Pond West. A specific amount has not been calculated. With the Frog Pond West area nearing full development, it is recommended the City reevaluate the remaining capacity in the downstream Boeckman Creek system to estimate how many new dwelling units in Frog Pond East and South can be reliably connected before the planned interceptor improvements are complete.

The WCSMP estimated that the sewer line on SW Kahle Road would need to be a 10-inch pipeline; however based on updated loading conditions, calculations show an 8-inch pipe provides adequate capacity to convey the flow from the areas tributary to the Kahle Road sewer line.

Proposed Stormwater System

The City of Wilsonville will be the regulatory authority for design and construction of stormwater facilities for the Frog Pond East and South area, in accordance with the City's current Phase I Multiple Separate Storm Systems (MS4) National Pollution Discharge Elimination System (NPDES) permit.

The City is currently preparing an update to their 2012 Stormwater Management Plan (SWMP) to address new post-construction stormwater permit requirements. City staff note that significant changes are not anticipated to the stormwater design standards as a result of the new permit. Therefore, the current design standards and user's guides are assumed to be valid for this proposed stormwater system plan. These include and are referenced as:

- 2015 Stormwater and Surface Water Design and Construction Standards, Section 3 – Public Works Standards, Revised December 2015 (PWS 2015)
- User's Guide for the BMP Sizing Tool, Revised December 2017 (BMPST 2015)

The intent of this proposed stormwater system plan is to provide recommendations for laying out the stormwater conveyance system and to identify potential locations for regional facilities to manage water quality treatment and flow control (Figure 3). The plan provides the City with a basis to phase and implement stormwater infrastructure needed to meet the goals and vision of the Frog Pond East & South Master Plan. The plan provides preliminary sizing for stormwater infrastructure for the entire Frog Pond East and South Area using area-wide parameters. Final design and implementation will require more detailed analyses to incorporate the following information as it becomes available:

- Variability in the physical attributes of the development site as determined with Site Assessment and Planning[1];
- Housing Variety Policy as adopted within the Frog Pond East & South Master Plan;
- Implementation of the Housing Variety Policy as determined at the time of development;
- Phasing and implementation of transportation and other infrastructure;
- Development sequencing and phasing;
- Owner willingness to provide property for off-site stormwater facilities through easement or acquisition (e.g., school district, City park, etc.);
- Updates to the City's Stormwater Management Plan; and
- Changes to the Design and Construction Standards, analysis methods, and/or permitting requirements.

Stormwater Basins

Oregon Drainage Law[2], the City's Design Standards[3], and regulatory agencies such as National Marine Fisheries Service (NMFS)[4] all require that collected stormwater runoff remain within its natural drainage basin[5]. The drainage basins for Frog Pond East are Newland Creek in the northeast portion and Meridian Creek in the southwest portion. The drainage basins for Frog Pond South are Meridian Creek in the western portion and an unnamed tributary in the eastern portion that drains south directly into the Willamette River. For the purposes of this memo this unnamed tributary is referred to as Kruse Creek.

The three drainage basins were further delineated into subbasins based on topography with each subbasin designated with a single outfall to the receiving stream. The basins and subbasins are shown in Figure 3 and the corresponding areas are summarized in Table 1, and further described in the paragraphs below.

Newland Creek Basin

The 68-acre Newland Creek Basin basin includes the northeast portion in the Frog Pond East area. The basin was delineated into five subbasins, described as N1 through N5. Subbasins N1 and N2 are located to the south of the BPA easement. Stormwater from these subbasins will need to be conveyed across the Bonneville Power Administration (BPA) easement to discharge to Newland Creek. Subbasins N3 and N4 are for the two distinct neighborhoods north of the BPA easement along SW Kahle Road. They are separated by a fork of Newland Creek and require separate

[1] PWS 2015 Section 301.2.00
[2] Oregon Drainage Law is established by case law, for discussion see Oregon Department of Transportation 2014 Hydraulics Design Manual, Chapter 2 – Legal Aspects.
[3] PWS 2015 Section 301.1.10(a)
[4] NMFS SLOPES for Stormwater, Transportation, and Utilities, 2014 section 1.3.1.1.36.g.i
[5] PWS 2015 Section 301.1.09(c)

outfalls. Subbasin N5 is the northernmost portion of SW Stafford Road within the Frog Pond East and South Area that is also a tributary to Newland Creek.

Table 1: Basin and Subbasin Areas

Basin	Area (ac)
Newland Creek	**67.7**
N1	15.2
N2	15.4
N3	16.5
N4	19.6
N5	1.0
Meridian Creek	**75.4**
M1-A	4.7
M1-B	30.5
M2	5.1
M3	35.1
Kruse Creek	**69.5**
K1	60.9
K2	8.6

Meridian Creek Basin

The Meridian Creek Basin is the largest of the three drainage basins at 75 acres. It includes the southwest portion of Frog Pond East and the western portion of Frog Pond South. The basin was delineated into three separate subbasins.

Subbasin M1 is 35.2 acres in size and includes areas in Frog Pond East. It was further divided based on land use: Subbasin M1-A consists of SW Stafford Road and the westernmost portion of SW Advance Road, and Subbasin M1-B is the land north and east of the public streets. The public roadway improvements in subbasin M1-A and the private development tract in subbasin M-1B should share a combined outfall on the south side of Stafford Road.

Subbasin M2 is the area south of SW Advance Road that will require its own outfall to keep its storm system separated from the Meridian Creek Middle School property, which has already been developed and has an existing outfall to Meridian Creek.

Subbasin M3 is a 35-acre portion of Frog Pond South located on the west side of SW 60th Avenue, adjacent to and south of the middle school property. It is intended that stormwater facilities constructed for this basin will be separate from the middle school's drainage system.

Kruse Creek Basin

Kruse Creek Basin is approximately 70 acres in size, comprising the southeastern portion of the Frog Pond East and South Area. It was subdivided into two subbasins, K1 and K2.

Subbasin K1 is a 61-acre area that extends north from the creek and includes lands abutting SW 60th Avenue, the City-owned parcel along SW Advance Road designated for park use, and the southern portion of Frog Pond East. The subbasin topography features an existing shallow draw that directs water south by southeast to Kruse Creek. The shallow draw does not become channelized until about 1,800 feet south of Advance Road where the outfall is located. The City reports localized flooding at properties along SW 60th Avenue and south of SW Advance Road due to existing topography and lack of a defined drainage channel. This flooding issue will need to be addressed as part of the stormwater system needed for development within this subbasin. The basin outfall is proposed to be located at the head of the channel so that the northernmost portion of the channel is not dewatered and the riparian habitat is more fully protected.

Subbasin K2 is the remainder of the Kruse Creek Basin that is considered too far south of the K1 outfall and will therefore require a separate outfall.

Proposed Stormwater Conveyance System

Conveyance System Description

The proposed stormwater conveyance system designates a primary stormwater trunk "main" for each subbasin extending from the designated outfall into the basin, and local stormwater conveyance facilities connecting runoff-generating areas to the stormwater main.

The establishment of subbasin outfalls with stormwater mains to guide development activities has the following advantages:

- Limiting the total number of outfalls reduces impacts to the stream corridor;
- Stormwater mains provide a publicly-owned conveyance connection point for developments which would otherwise not be allowed to concentrate flow to neighboring properties[6]. This is most advantageous for subbasins that are unlikely to develop as a single large tract, such as subbasin K2;
- Stormwater mains can positively influence the location of privately-owned stormwater facilities based on locating the stormwater main within street rights-of-way. This can discourage the establishment of multiple small outfall locations with water quality and flow control facilities located at the rear of the developments, which is not acceptable to the City; and
- Stormwater mains can be constructed in conjunction with other infrastructure (transportation, water, sewer) at the time of development.

[6] PWS 2015 301.1.09.a.

The proposed stormwater conveyance system is shown in Figure 3. The proposed stormwater main locations for each subbasin conform with the preferred street plan and the subbasin's specific topographic characteristics. The mains should be installed at a depth that provide the hydraulic drop necessary for the connection of upstream stormwater treatment and/or flow control facilities. The hydraulic drop necessary will vary depending on the stormwater management facilities used in the subbasin, ranging from approximately four feet for a rain garden to seven feet for a detention pond to accommodate the underdrains. Given the significant change in elevation from the developable area to the creeks, ranging from 10 to 50 feet, there is minimal risk of backwater flooding expected with the installation of appropriately sized pipes.

The outfall locations shown are for illustrative purposes only and will be determined based on the development layout and presence of wetlands and stream and geomorphic corridor conditions at the time of design and development. Installation of outfalls will be at ordinary high water[7] or lower to prevent erosion of the banks. An acceptable point of discharge must be approved by the City[8]. The applicant is responsible for acquiring approval from any other agency having jurisdiction or permitting authority related to the activity[9].

Once the stormwater main and outfall are constructed, connection to the main would be provided by the developer at the time of development. Connecting to an established conveyance system generally requires less permitting than establishing a new outfall or other point of discharge for each development. Individual developments will be required to implement water quality treatment and flow control before connecting to the stormwater main.

Design of conveyance systems will need to comply with the Stormwater Systems Design Criteria[10] to resolve any existing capacity deficiencies and flooding such as the known flooding issue along SW 60th Avenue south of SW Advance Road. Detailed analyses will be required to determine final pipe locations, depths, and sizes at the time of development or as part of a further studies to determine the implementation strategy of regional facilities.

Conveyance System Sizing Analysis

The Design and Construction Standards require conveyance facilities to be sized for the 25-year[11] design storm and emergency overflow structures to be designed for the 100-year[12] storm. Post-development peak flow rates used for conveyance sizing were estimated using methodology described by the PWS. For each subbasin, peak flow rates for the 25-year and 100-year storm events were calculated using the Santa Barbara Urban Hydrograph (SBUH) method with a Type

[7] NMFS SLOPES for Stormwater, Transportation, and Utilities, 2014 section 1.3.1.1.36.g.iii
[8] PWS 2015 301.1.09.b.
[9] PWS 2015.301.1.09.e.
[10] PWS 2015 301.1.05.a
[11] PWS 2015 301.1.05.g
[12] PWS 2015 301.1.10.e

1A-24 hour storm event. The following area-wide assumptions were used to represent the proposed condition of the basins for purposes of estimating peak flow:

- Basin Impervious Percent = 70%
- Impervious Area Curve Number = 98
- Impervious Area Time of Concentration = 5 minutes
- Pervious Area Curve Number = 79
- Pervious Area Time of Concentration = 20 minutes

Pipe size calculations were developed using the Manning's equation assuming a roughness value of n=0.012 and with full-pipe flow. The topographic slope in the area ranges from 1.5 % to 10% with typical slopes in the 3% to 6% range. A typical pipe slope of 3% was used to determine recommended pipe capacity since it approximates the overall topography and will yield a relatively conservative estimate.

Storm main pipe size analysis results are presented in Table 2. The recommended pipe sizes were selected to convey the estimated 25-year peak flow storm event to reduce the risk of overland flow eroding the steep hillsides and streambanks during those storm events. The peak flow for the 25-year and 100-year storm events are provided in the table for reference.

Table 2: Preliminary Storm Main Pipe Size Recommendations

Basin	Area (ac)	25-yr Peak Flow (cfs)	100-yr Peak Flow (cfs)	Recommended Pipe Size (inches)	Pipe Capacity (cfs)
Newland Creek					
N1	15.2	11.1	13.1	18	19.7
N2	15.4	11.3	13.4	18	19.7
N3	16.5	12.1	14.3	18	19.7
N4	19.6	14.4	17.0	18	19.7
N5	1.0	0.8	0.9	12	6.7
Meridian Creek					
M1-A	4.7	3.9	4.5	12	6.7
M1-B	30.5	22.4	26.4	24	42.5
M2	5.1	3.8	4.4	12	6.7
M3	35.1	25.8	30.4	24	42.5
Kruse Creek					
K1	60.9	44.7	52.8	30	77.0
K2	8.6	6.3	7.5	12	6.7

Stormwater Water Quality Treatment and Flow Control

LID Implementation Strategies

The City's NPDES permit and PWS require the implementation of Low Impact Development (LID) facilities for providing stormwater management (i.e., water quality treatment and flow control) to the "maximum extent practicable". "Maximum extent practicable" is defined by the City's PWS as installing LID facilities with a surface area of at least 10% of the total new or redeveloped impervious area[13]. LID facilities are herein defined as decentralized water quality treatment and flow control facilities implemented where runoff is generated (e.g. green roofs) and/or collected (e.g. rain gardens), prior to entering the conveyance system.

To promote the use of decentralized vegetated facilities, this plan considers decentralized filtration facilities that require underdrain systems "due to limiting conditions for LID facilities"[14] to be an LID facility that counts toward the maximum extent practicable. Underdrain systems are generally recommended for locations with poor infiltration and other geotechnical concerns, which is expected to be the case in many areas of Frog Pond East and South due to existing soil characteristics. It is recommended these be permitted for use in the implementation of LID in these areas.

If when using LID to the maximum extent practicable, onsite infiltration and retention of up to the 10-year event is not possible due to limited infiltration conditions, then additional facilities must be provided to meet the flow control requirement.[15]

The City understands that there will be significant competition for space along street frontages where LID facilities are typically provided. The Frog Pond East and South Area is anticipated to develop with higher densities and a greater variety of residential types than past developments within the City, potentially leading to additional driveways, walkways, and utility connections that cross the planter strips where LID is typically implemented. Street frontages must also accommodate other necessary improvements such as on-street parallel parking, street trees, fire hydrants, etc. that may not be compatible with LID facilities.

Allowing the implementation of LID at less than the maximum extent practicable to meet competing requirements for space will be at the discretion of the City. To maximize the implementation of LID in Frog Pond East and South, the City requires LID facilities be provided in the following locations:

- Collector and arterial street planter strips where parallel on-street parking is not permitted, such as SW Stafford Road and SW Advance Road;
- Alleys, greenways, and other midblock opportunities (e.g. curb extensions);

[13] PWS 2015 301.2.03.4
[14] PWS 2015 301.2.02.4.c
[15] 301.1.04.d

- Parks and open space buffers;
- Areas between buildings and roadways/other buildings within a development (e.g. common areas, courtyards, greenspaces, pocket parks); and
- Planters adjacent to buildings to treat roof runoff.

LID Limitations and Alternatives

The Frog Pond East and South Area predominantly consists of soils with hydrologic soil groups of C and C/D, meaning the soils have limited infiltration capacity. LID facilities installed in areas with limited infiltration capacity typically have decreased performance in meeting flow control standards because more water is conveyed to the downstream outfall after filtration. This means that the implementation of LID facilities to the "maximum extent practicable" may not be sufficient to meet water quality and flow control requirements. It is therefore anticipated that additional facilities will be required for flow control. These can be provided through larger LID facilities in tracts, or through additional LID alternatives such as impervious area reduction methods[16], or through regional facilities.

Impervious area reduction methods are permeable surfaces, such porous pavers or green roofs, that provide water quality and flow control at the point of runoff generation. These areas are subtracted from the total impervious area requiring water quality treatment and flow control, thereby reducing the overall LID footprint required.

Regional facilities are centralized water quality and flow control facilities, such as detention ponds, implemented at a downstream location to receive collected and conveyed stormwater. Regional facilities typically serve multiple properties to manage a larger catchment area than LID facilities and generally require less total area because they provide a larger storage volume per area of facility. Regional facilities may be used to meet water quality and flow control requirements, or flow control requirements only if water quality requirements are met upstream of the regional facility.

Preliminary evaluation of whether the implementation of LID to the maximum extent practicable can be performed by comparing the site-specific LID sizing factor to the maximum extent practicable, where:

LID Sizing Factor[17] = (Total LID Area / Total Contributing Impervious Area) x 100%

LID sizing factors may be determined using the City's Best Management Practice Sizing Tool[18] (BMP Sizing Tool). The tool determines the area required for LID best management practices based on

[16] PWS 2015 301.2.03.3.d
[17] BMPST 2017 9.2
[18] BMPST 2017

the contributing impervious area, the pre-developed soil and land cover, and the site infiltration capacity based on the soil type found within the facility footprint.

Implementing LID to the maximum extent practicable corresponds to an LID sizing factor of 10%. Therefore, an LID sizing factor greater than 10% may require require larger LID facilities or additional LID alternatives, such as impervious area reduction.

For the Frog Pond East and South Area analysis, the sizing factors provided in the BMP Sizing Tool User Guide in Appendix B were used. These sizing factors consider the post-developed land cover to be impervious, and the other parameters as summarized below:

- Pre-developed pervious – Forest, C
- Soil type under facility footprint - C1, C2, C3, D1, Lined

The sizing factors for providing water quality treatment and flow control facilities using rain garden filtration, planter filtration, or vegetated swale filtration range from 10% to 23%[19]. Because this range is equal to or greater than the 10% maximum extent practicable, it is recommended that additional LID or LID alternatives be anticipated and planned for in the majority of the Frog Pond East and South Area. In these cases, the strategy for meeting water quality and flow control requirements should follow the stormwater management hierarchy below, with the order of preference being from Category 1 as the most preferred to Category 3 as the least preferred:

Category 1. LID facilities are used to meet all water quality treatment and flow control requirements.

Category 2. LID facility areas are used in combination with impervious area reduction methods[20] and/or regional facilities to meet all water quality and flow control requirements. The implementation of LID at less than the maximum extent practicable is at the discretion of the City.

Category 3. Regional facilities[21] are used to meet all water quality treatment and flow control requirements.

All basins must provide stormwater management onsite using Category 1 or Category 2 of the stormwater management hierarchy, with the following exceptions considered at the discretion of the City:

Subbasins N1, N2: Regional facilities may be constructed in the BPA easement as allowed to reduce the amount of buildable land dedicated to stormwater management.

[19] BMPST 2017 Appendix B Table B-1
[20] PWS 2015 301.4.03
[21] PWS 2015 301.4.02.b

Subbasin K1: Regional facilities are an option for providing water quality treatment and flow control. Regional facilities may partially treat or fully treat the basin depending on site suitability and feasibility.

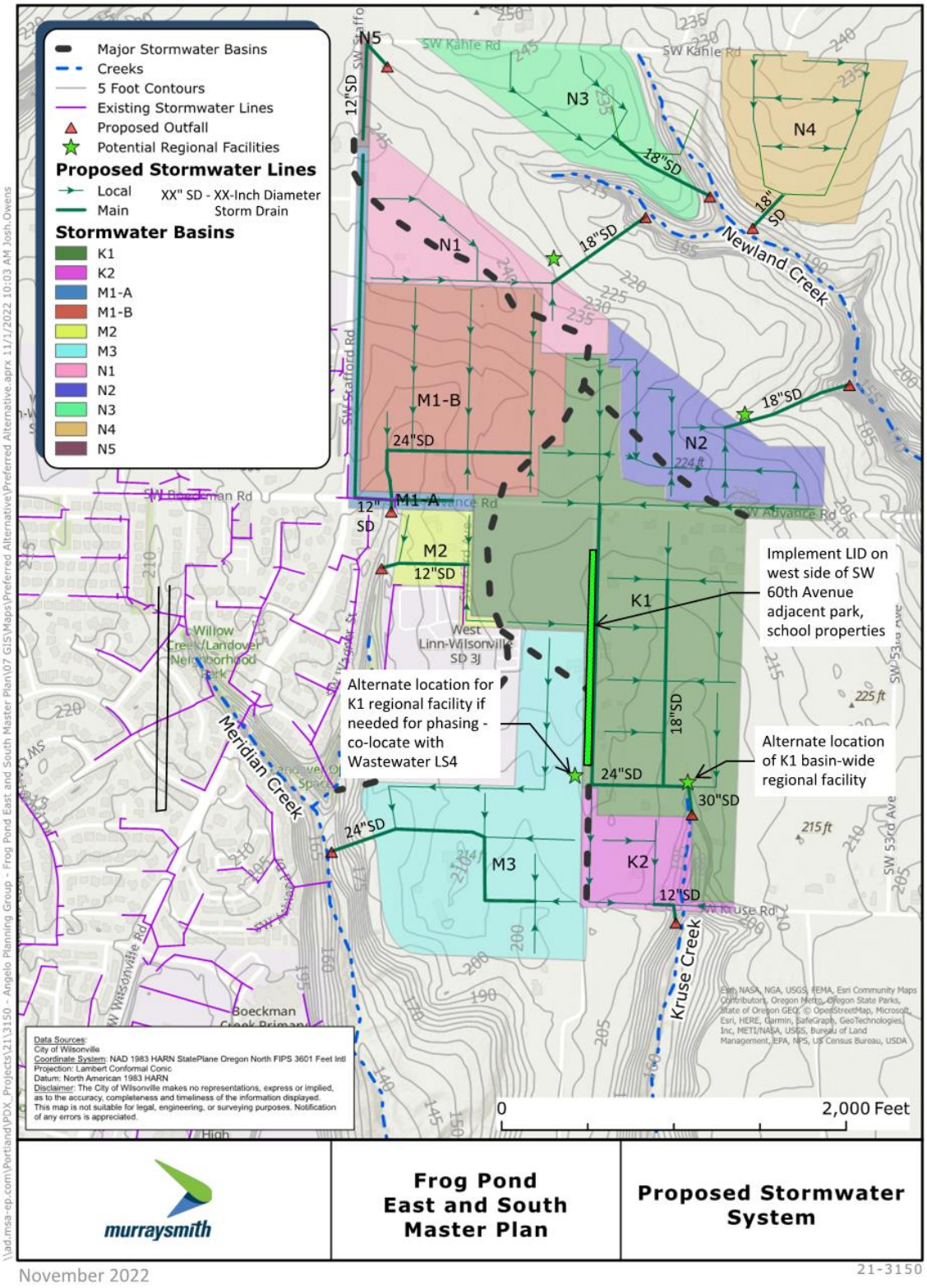
Proposed locations for the regional facilities identified above are shown in **Figure 3**.

Water quality treatment and flow control facility sizing and configuration will be determined at the time of development using the BMP Sizing Tool Method[22] or the Engineered Method[23]. Design and implementation will require further detailed site assessment and analyses to determine the final pipe and regional facility locations.

The implementation of regional facilities requires multi-stakeholder coordination. Due to this, it is often beneficial to construct regional facilities in conjunction with other infrastructure, such as roads, waterlines, and sewer infrastructure. In the case of Frog Pond South, the location proposed for a regional stormwater facility on SW 60th Avenue to serve the K1 subbasin has also been identified as a preferred site for the wastewater lift station LS4 required for Frog Pond South.

[22] PWS 2015 301.4.05.a
[23] PWS 2015.301.4.05.b

Figure 3 – Proposed Stormwater Pipe Locations and Potential Regional Facilities



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Appendix A

Project: 21-3150 Frog Pond Master Plan
Date: 8/26/2022
Author: JK
Decription: Frog Pond East and South sewer basin land use and flow calculations for 1,800 total residential units

Assumptions		
Category	Average Sewer GPD	
Person	67	gallons/person/day
Commercial	1000	gallons/acre/day
School	25	gallons/person/day
I&I	1800	gallons/acre/day

Gravity Pipe Assumptions	
Slope	0.005
Manning's n	0.013

Diameter	Max Flow in Pipe (cfs)
4	0.135
6	0.398
8	0.857
10	1.553

Basin	Total Area (ac)	MF Units	SFA Units	SFD Units	Total Residentital Units	Commecial Area (ac)	School Area (ac)	School Students and Employees	Park/Street Area (ac)	Residential Area (ac)
Gravity	105.0	174	308	274	756	4.9	27.1	1305	27.9	45.0
LS1	18.1	0	63	93	155	0.0	0.0	0	0.4	17.7
LS2	20.7	0	86	111	197	0.0	0.0	0	1.0	19.7
LS3	15.4	0	72	84	156	0.0	0.0	0	1.4	14.0
LS4	76.7	48	212	276	536	0.0	0.0	0	25.1	51.6
Totals	235.9	222	740	837	1,800	4.9	27.1	1305	55.9	148.0

Basin	Average Dry Weather Flow (gpm)	Peak Average Dry Weather Flow (gpm)	Peak I&I Flow (gpm)	Total Peak Flow (gpm)	Total Peak Flow (cfs)	Force Main Size (in)	Force Main Velocity	Does Gravity Flow fit in 8in	Does Gravity Flow fit in 10 in
Gravity	96.6	193.3	131.3	324.5	0.723	N/A	N/A	Yes	Yes
LS1	17.9	35.9	22.6	58.5	0.130	4	1.49	Yes	Yes
LS2	22.7	45.4	25.8	71.2	0.159	4	1.82	Yes	Yes
LS3	18.0	36.0	19.2	55.2	0.123	4	1.41	Yes	Yes
LS4	61.8	123.6	95.9	219.5	0.489	4	5.61	Yes	Yes

Trunk	Total Peak Flow (cfs)	Does Gravity Flow fit in 8in	Does Gravity Flow fit in 10in
SW Stafford Road Trunk (cfs)	0.651	Yes	Yes
Boeckman Trunk Extension (cfs)	0.974	Pipe Overcapacity	Yes

Project: 21-3150 Frog Pond Master Plan
Date: 8/26/2022
Author: JK
Decription: Frog Pond East and South sewer basin land use and flow calculations for 2,384 total residential units

Flow Assumptions		
Category	Average Sewer GPD	
Person	67	gallons/person/day
Commercial	1000	gallons/acre/day
School	25	gallons/person/day
I&I	1800	gallons/acre/day

Pipe Assumptions	
Slope	0.005
Manning's n	0.013

Diameter	Max Flow in Pipe (cfs)
4	0.135
6	0.398
8	0.857
10	1.553

Basin	Residential Units (32% increase)	Commercial Area	School Students and Employees
Gravity	1,001	4.9	1305
LS1	206	0.0	0
LS2	261	0.0	0
LS3	207	0.0	0
LS4	709	0.0	0
Total	2,384	4.9	1305

Basin	Average Dry Weather Flow (gpm)	Peak Average Dry Weather Flow (gpm)	Peak I&I Flow (gpm)	Total Peak Flow (gpm)	Total Peak Flow (cfs)	Force Main Size (in)	Force Main Velocity	Does Gravity Flow fit in 8in	Does Gravity Flow fit in 10in
Gravity	124.9	249.9	131.3	381.1	0.849	N/A	N/A	Yes	Yes
LS1	23.7	47.5	22.6	70.1	0.156	4	1.79	Yes	Yes
LS2	30.1	60.1	25.8	86.0	0.192	4	2.19	Yes	Yes
LS3	23.8	47.7	19.2	66.9	0.149	4	1.71	Yes	Yes
LS4	81.9	163.7	95.9	259.7	0.579	4	6.63	Yes	Yes

Trunk	Total Peak Flow (cfs)	Does Gravity Flow fit in 8in	Does Gravity Flow fit in 10in
SW Stafford Road Trunk (cfs)	0.772	Yes	Yes
Boeckman Trunk Extension (cfs)	1.152	Pipe Overcapacity	Yes