Gray & Osborne, Inc.
CONSULTING ENGINEERS

TECHNICAL MEMORANDUM

TO:	ANDREW SILVIA, P.E.
FROM:	KERRI SIDEBOTTOM, P.E. ROGER KUYKENDALL, P.E.
DATE:	APRIL 20, 2023
SUBJECT:	35TH AVENUE DRAINAGE CITY OF LAKE FOREST PARK, KING COUNTY, WASHINGTON G&O #22462.00

EXECUTIVE SUMMARY

An existing stormwater outfall ("middle outfall") located at 16518 35th Avenue NE discharges runoff onto private property into the head of a steep, incised ravine. The conveyance piping is damaged and undersized for the estimated flows. In addition, the outfall manhole is severely undermined and at risk of falling into the ravine. Two alternative outfall locations have been identified to the north and south of the existing outfall, both of which discharge to the same surface waterbody (Sheridan Creek). The north alignment alternative would impact several private properties and is anticipated to have greater construction challenges. The south alignment alternative collects and conveys runoff from additional areas and can be constructed within the existing right-of-way and a small easement area at the outfall, but requires a longer length of new piping and larger pipe sizes. Replacing the existing outfall would be the least expensive, but it too has challenges.

This Memo provides information regarding our analysis of alternatives to correct the drainage deficiencies in the area, and assesses the feasibility and costs of those alternatives. The four following alternatives are to be considered.

1. Replacing the existing drainage system that conveys runoff from 35th Avenue NE to the middle outfall, and extending the middle outfall pipe to the bottom of the steep ravine to reduce erosion.

2. Diverting all of the runoff tributary to the middle outfall to the north outfall. This option includes abandoning the middle outfall.

3. Diverting all of the runoff tributary to the middle outfall to the south outfall. This option includes abandoning the middle outfall.

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4. Diverting a portion of the runoff tributary to the middle outfall to the south outfall and replacing and extending the middle outfall pipe to the bottom of the steep ravine to reduce erosion.

Water quality treatment for stormwater runoff is not currently provided within the basin. Two levels of treatment are reviewed in this Memo; treatment of runoff from the entire tributary basin, and treatment of runoff from road areas along the alternative alignment only. Runoff treatment could be provided as part of the Project but is not required from a regulatory standpoint.

Table 1 summarizes the estimated planning-level construction cost of the alternatives with the addition of either of the two treatment options.

TABLE 1

Summary of Estimated Construction Costs

Alternative	Conveyance Alone	Conveyance and Full Basin Treatment	Conveyance and Road Treatment
1 – Replace Middle Outfall	$357,000	$921,000	$436,000
2 – Diversion to North Outfall	$910,000	$1,474,000	$989,000
3 – Diversion to South Outfall	$822,000	$1,417,000	$910,000
4 – Hybrid/Partial Diversion to South Outfall and Replace Middle Outfall	$796,000	$1,391,000	$884,000

Replacing the existing conveyance system serving the middle outfall is the alternative with the least cost and is recommended; however, this alternative requires both temporary and permanent easements to be acquired and has construction access challenges. Similar challenges exist for the hybrid alternative, albeit at a lesser extent, and is the second choice. Diversion to the south outfall has the highest cost and would cause the greatest temporary disruption to the public and is the third choice. Access challenges, easement requirements for three separate properties, and significant construction impacts associated with the second option (diversion to the north outfall), are the most onerous and make that option the highest risk and is not recommended.

BACKGROUND

The City of Lake Forest Park has contracted with Gray & Osborne to investigate drainage system problems in the Sheridan Heights neighborhood. The study area lies west of

Bothell Way NE, also known as State Route 522 (SR 522), on a hill overlooking Lake Washington (see Figure 1). This residential area generally drains to the north and west, discharging into a tributary to McAleer Creek, commonly known as Sheridan Creek. Discharge into the creek occurs in three locations; the north, the middle, and the south outfalls.

- The north conveyance system drains a very small drainage basin (1.44 acres) located north of NE 166th Place and conveys runoff east from 35th Avenue NE to the creek via 10-inch and 12-inch pipes that cross three private properties. There are no known problems with the 10-inch outfall pipe.

- The middle conveyance system drains a large basin (36.29 acres) located west of 35th Avenue NE, from NE 166th Street to NE 158th Street. Runoff is conveyed north and south along 35th Avenue NE within ditches and 12-inch pipes to an existing manhole located on the west side of the street. From this manhole, runoff is conveyed east across the street through 12-inch pipes, and through private property (16518 35th Avenue NE). The pipe is routed around the existing house and discharges onto the top of a steep slope, into a ravine near the rear property line. The ravine conveys runoff down to the creek through an adjacent property (16512 35th Avenue NE). The existing outfall manhole (due to erosion and a small landslide that occurred in 2021), is poorly supported by the underlying soils and is at risk of falling into the ravine (see photos at the end of the Memo). In addition, it is suspected that the 12-inch conveyance system through the property is insufficient to convey extreme peak runoff flows.

- The south conveyance system drains a small basin (10.28 acres) located between 35th Avenue NE and 36th Avenue NE, and north of NE 158th Street. The conveyance system consists of ditches and 12-inch pipes that convey runoff to the creek, discharging into the creek immediately south of NE 162nd Street, at the upstream end of a 24-inch culvert that conveys Sheridan Creek beneath the street. There are no known problems with this outfall.

The City seeks to replace the existing pipes serving the middle outfall, or redirect some or all of the stormwater runoff currently routed to the middle outfall, into a more suitable conveyance system to the other two outfalls.

EXISTING CONDITIONS – MIDDLE OUTFALL

The middle outfall is located on private property at 16518 35th Avenue NE. Conveyance restrictions have caused flooding and ponding within the right-of-way. A closed-circuit television inspection of the pipe system in 2021 reveals that the existing pipe crossing beneath 35th Avenue NE is a 12-inch concrete pipe that is damaged in several locations. Generally, the joints are poorly assembled and large gaps (several inches) are evident in most. The horizontal alignment of the pipe appears straight; however, there are several significant grade changes that have contributed to the joint separations. In addition, there is a broken section in the top of the pipe that has been poorly repaired with rocks and concrete. If this conveyance component is to remain in service, it should be replaced.

The remainder of the pipe system consists of 4 storm drain manholes and 4 segments of 12-inch PVC pipe that is routed around the north side of the home. The last manhole has been undermined due to erosion and slope failure, leaving less than half the foundation support for the structure. The outfall pipe, only 5 feet in length, discharges runoff into the head of the ravine. The ravine runs east-west to the creek and varies in width and depth, up to 40 feet and 15 feet, respectively. The ravine is partially vegetated with shrubs and groundcover and several large trees have fallen in or across the ravine.

Peak Flow

An estimate of the peak flow to the middle outfall was determined using the Santa Barbara Unit Hydrograph (SBUH) method, which is a 24-hour, single-event runoff computation typically used for sizing conveyance systems. The SBUH method requires specific input data such as tributary area, land cover (and the associated curve numbers), time of concentration, and precipitation amounts for each storm event. All conveyance systems within the City are required to be designed to convey the 25-year peak runoff event.

Tributary Area

The basin and subbasins tributary to the middle outfall were delineated using a topographic survey and LiDAR topographic data for King County and the City's stormwater GIS data. Invert elevations, rim elevations, structure sizes, and other details are not included in the GIS data for the stormwater system in the Project vicinity. For any areas not included in the topographic survey, rim elevations were estimated based on the LiDAR surface elevations, and invert elevations for the existing pipes are assumed to be approximately 5 feet below grade. The middle basin was subdivided into 4 subbasins

(Subbasin 1 through Subbasin 4). The basin and delineated tributary subbasins are indicated on Figure 1.

Land Cover

Table 2 includes the estimated land cover within the basin that is tributary to the middle outfall. The total basin area is approximately 36.29 acres. The designated zoning within the basin is residential R-7200, which results in a density of approximately six homes per acre. The zoning regulations allows a maximum impervious lot coverage of 45 percent, and a maximum roof area per lot of 35 percent. From aerial imagery, the approximate impervious coverage along the right-of-way within the basin is 66 percent, including the roadway, sidewalks, gravel shoulders, and driveway aprons. The *Stormwater Management Manual for Western Washington* (Ecology Manual) notes that a reasonable assumption of impervious land cover for this housing density is 52 percent. The estimated land cover based on the assumptions in Table 2 is 50.5 percent impervious, which is in line with the Ecology guidance, and was used for each of the subbasins to calculate the peak flow rates. Curve numbers for impervious surfaces (98) and pervious areas (86) are taken from the Ecology Manual, based upon the soil type(s) within the basin.

TABLE 2

Land Cover Tributary to Middle Outfall

Land Cover Type	Area (acres)	Assumption
Roof	9.39	Maximum 35 percent roof area per lot, as allowed by LFPMC, 18.22.050.
Driveway/Patio	2.68	Maximum 45 percent impervious coverage per lot, as allowed by LFPMC, 18.22.080.
Cleared/Lawn	14.76	55 percent of lot, per LFPMC, 18.22.080.
Impervious ROW	6.24	Assumes 66 percent of ROW is paved, driveway, gravel, or sidewalk.
Cleared ROW	3.22	Assumes 34 percent of ROW is landscaped/lawn.
Total	**36.29**	

Time of Concentration

The time of concentration was determined for each of the subbasins, based on the length of the overland flow path (up to 300 feet), channelized surface flow path, and piped conveyance length to the outfall. The Manning Kinematic Equation for overland sheet flow, the Natural Resources Conservation Service (NRCS) method for shallow concentrated flow, and Manning's equation for closed pipe flow were used to calculate the overall time of concentration based on the land slope derived from topographic GIS data. Table 3 indicates the assumptions of the parameters used in the runoff flow calculation.

TABLE 3

Runoff Parameters

Parameter	Value	Notes
Pervious Area Curve Number	86	Applies to good-condition grassed area with underlying Type C soils.
Impervious Area Curve Number	98	Standard value.
2-Year Rainfall	1.6 inches	From Ecology Manual Volume III, Appendix III-A, Isopluvial Maps.
25-Year Rainfall	2.8 inches	From NOAA Atlas 2, Volume IX.
100-Year Rainfall	3.5 inches	From Ecology Manual Volume III, Appendix III-A, Isopluvial Maps.
Overland Flow Manning's Roughness	0.045	Applies to good-condition grassed area.
Piped Conveyance Manning's Roughness	0.013	Conservative value for plastic pipe, typical value for concrete pipe.

Peak runoff rates for each subbasin are estimated to determine conveyance deficiencies and potential replacement strategies. The estimated peak runoff for each subbasin as well as the subbasin areas and times of concentration for each subbasin are included in Table 4.

TABLE 4

Middle Basin Peak Runoff

Subbasin	Total Area (acres)	Impervious Area (acres)	Pervious Area (acres)	Time of Concentration (minimum)	25-Year Peak Flow (cfs)
B1	8.11	4.10	4.01	12.4	3.92
B2	7.23	3.65	3.58	7.1	3.77
B3	9.10	4.60	4.50	12.9	4.37
B4	11.86	5.99	5.87	12.0	5.79
Total	**36.29**	**19.23**	**17.06**		**17.85**

The total 25-year peak flow to the middle outfall is estimated at 17.85 cfs.

Existing Conveyance Capacity

The City's GIS information indicates piped conveyance along 35th Avenue NE in the Project vicinity, with some ditches along the roadside. The GIS information indicates that the conveyance pipes in this location are all 12-inch in diameter, and are either CMP, concrete, or PVC. Field observations found that some pipes in this area are also CPEP. The middle outfall receives runoff from the 36.29-acre basin through a network of pipes and ditches along NE 163rd Street, NE 160th Street, NE 158th Street, 33rd Avenue NE, 34th Avenue NE, and 35th Avenue NE.

A topographic survey on 35th Avenue NE and the two parcels containing the middle outfall identified the system's manhole/catch basin rim and pipe invert elevations, and this data was used to calculate the slope and length of the existing pipes, and the capacity of each. Pipe slopes varied from about 6 percent to 36 percent. Manning's equation was used to determine the capacity of the existing pipes. Assuming a roughness coefficient value of 0.013, which is on the conservative side for plastic pipe, the capacity of the existing outfall system is less than the estimated 25-year flow to the outfall, as indicated in Table 5. Therefore, the conveyance from 35th Avenue NE to the middle outfall is undersized for the expected peak flow and that flooding within the right-of-way is possible during high-flow events.

TABLE 5

Current Middle Outfall Pipe Deficiencies

Pipe Segment ID	Pipe Diameter (inches)	Capacity (cfs)	Deficiency for 25-Year Storm (cfs)
P1	12	8.70	9.15
P2	12	21.20	N/A(1)
P3	12	16.30	1.55
P4	12	18.82	N/A(1)
P5	12	13.17	4.68

(1) Pipe has sufficient capacity.

ALTERNATIVES

Four alternatives, described in the following analyses, were considered to either replace the existing middle outfall, or to divert runoff away from the middle outfall to the north and south outfalls. All alternatives involve challenges with respect to construction including potential utility conflicts, traffic control, space for equipment and materials storage, proximity to existing private improvements, land disturbance, and easement acquisitions. These constraints are discussed in more detail under each alternative.

Alternative 1 – Replace Middle Outfall

This alternative proposes to replace the pipes and structures of the middle outfall from 35th Avenue NE to the ravine, to convey the 25-year storm peak flow. See Figure 2 for the location of each pipe segment and Table 6 for the potential pipe layout.

TABLE 6

Replace Middle Outfall Conveyance Data

Pipe ID	From Structure(1)	To Structure(1)	Length (feet)	Diameter (inches)	Slope (ft/ft)	Pipe Capacity (cfs)	25-Year Flow (cfs)
P1	CB-0852	MMH1	48	18	0.061	25.9	17.85
P2	MMH1	MMH2	24	18	0.367	63.8	17.85
P3	MMH2	MMH3	83	18	0.208	48.0	17.85
P4	MMH3	New Outfall	115	18	0.302	57.9	17.85

(1) All structures noted in the table, if existing, would be replaced with new ones.

Temporary access for construction equipment to the north side and rear portions of the parcels (address 16518 and address 16512) is limited due to the presence of large trees and a deck along the northern property boundary, and a 10-foot tall, rock wall crossing the southern boundary between the homes (see photos at the end of the Memo). Segment P1 is damaged and requires replacement regardless of its capacity deficiencies. Replacing P3 through P5 requires the removal/replacement of approximately 250 square feet of the existing deck that lies within the building setback. The City would need to acquire both a temporary construction and a permanent drainage easement from the property owner of address 16518. Another option for construction access would be to negotiate for access through the property to the north (address 16522), although this may require a greater restoration effort, with no benefit to that property.

Regardless of the access problems, it is anticipated that in replacing the outfall, the new pipe would be extended towards the stream near the bottom of the ravine. This would require a new permanent easement to be acquired from the property to the south (address 16512), as the new outfall pipe would stretch into their property. This new outfall pipe would be a flexible fuse-welded, high density, polyethylene pipe (HDPE) that would extend from manhole MMH3 initially underground until it daylighted in the ravine and would then lay in the bottom of the ravine.

According to the *Stream Delineation Report*, dated January 26, 2023, prepared by The Watershed Company, Sheridan Creek is classified as a Type-F stream and therefore requires a 115-foot buffer from the ordinary high-water mark (OHWM), according to Lake Forest Park Municipal Code (LFLMC), Chapter 16.16.355. The existing outfall pipe is located approximately 14 feet landward of the buffer boundary. At this location within the ravine, the ravine slope is very steep at over 40 percent, which would be a risky location to terminate the new outfall. Therefore, it is proposed to extend the outfall pipe down the ravine into the buffer approximately 60 feet, where the ravine slope flattens to around 10 percent. LFLMC, Chapter 16.16.350.F allows stormwater discharges so long as the discharge does not increase the rate of flow or decrease the water quality of the stream. For this alternative, the rate of flow would not be increased and water quality would be improved due to the decrease in soil erosion by moving the outfall to a flatter location of 75 feet downstream of the existing outfall. Energy dissipation, in the form of a perforated HDPE tee, would be provided at the proposed outfall to further reduce erosion.

If all current manholes and pipes on the property are replaced, pipe slopes can be adjusted and the new pipes would be able to convey the peak flows with a minimum pipe diameter of 18 inches.

Alternative 2 – Diversion to North Outfall

The second alternative includes diverting the flow in 35th Avenue NE away from the middle outfall to the north outfall. The existing north outfall pipe crosses three private residential properties; address 16580, 16816, and 16930 35th Avenue NE. It is feasible to divert runoff through a new piped conveyance system; however, construction access onto private property is limited and new easements would be required. The existing middle outfall would be plugged at CB-0852 and abandoned in place. It is believed that the homeowner at 16518 35th Avenue NE has at least one private pipe connected to this system.

Existing Conditions – North Outfall

The existing north conveyance system is indicated on the City's GIS database and consists of ditches and pipes along the west side of 35th Avenue NE, north of NE 166th Place. The conveyance eventually crosses to the east side of the road before entering private property. Topographic survey found that this conveyance consists of ditches and 12-inch CPEP, concrete, and CMP pipe, while the final outfall pipe appears to be 10-inch concrete.

North Outfall Peak Flow

The peak runoff from the area that currently drains to the north outfall was estimated using the SBUH method, with the runoff parameters noted in Table 3.

North Tributary Area

Similar to the middle outfall analysis, the basin tributary to the existing north outfall was delineated using topographic survey and LiDAR topographic data for King County and the City's stormwater GIS data. Invert elevations, rim elevations, structure sizes, and other details are not included in the GIS data. For any areas not included in the topographic survey, rim elevations were estimated based on the LiDAR surface elevations, and invert elevations for the existing pipes are assumed to be approximately 5 feet below grade. The delineated basin is indicated on Figure 1.

North Area Land Cover

Currently, the north conveyance system conveys runoff from a residential area of approximately 1.44 acres. This area includes the cul-de-sac at the north end of 35th Avenue NE, as well as several upslope properties to the west. The designated zoning

is the same as the middle outfall's tributary area. The estimated impervious land cover, based on the assumptions in Table 2 is 47.3 percent. Coverages are shown in Table 7.

TABLE 7

Land Cover Tributary to North Outfall

Land Cover Type	Area (acres)	Assumption
Roof	0.12	Maximum 35 percent roof area per lot, as allowed by LFPMC, 18.22.050.
Driveway/Patio	0.03	Maximum 45 percent impervious coverage per lot, as allowed by LFPMC, 18.22.080.
Landscaped/Lawn	0.49	55 percent of lot, per LFPMC, 18.22.080.
Impervious ROW	0.53	Assumes 66 percent of ROW is paved, driveway, gravel, or sidewalk.
Landscaped ROW	0.27	Assumes 34 percent of ROW is landscaped/lawn.
Total	**1.44**	

Time of concentration was calculated in the same manner as for the middle outfall's basin. The estimated peak runoff and the time of concentration for the north basin are included in Table 8.

TABLE 8

North Basin Peak Runoff

Subbasin	Total Area (acres)	Impervious Area (acres)	Pervious Area (acres)	Time of Concentration (minimum)	25-Year Peak Flow (cfs)
N1/Total	1.44	0.75	0.69	4.7	0.80

The total 25-year peak flow to the north outfall is estimated at 0.80 cfs. If runoff to the middle outfall is diverted to the north outfall, the conveyance piping would need to be sized to convey a peak 25-year flow of 17.85 cfs from the middle outfall basin, plus the existing peak 25-year flow of 0.80 cfs, for a total of 18.65 cfs.

North Basin Existing Conveyance Capacity

Diverting runoff to the north outfall from 35th Avenue NE would require approximately 475 feet of new conveyance piping to connect to the existing north conveyance system, which begins north of NE 166th Street. However, the existing system is not deep enough,

nor do the existing 12-inch pipes have the capacity to convey the peak runoff. Therefore, an entirely new conveyance system would be required.

Topographic survey and field observations were used to evaluate the feasibility of diverting flow to the north outfall. The topographic survey data was used to establish the rim elevations of existing and proposed structures. A minimum depth to invert of 5 feet was assumed, in order to provide sufficient cover over the storm pipes. Figure 3 indicates the potential stormwater conveyance that would be required to divert runoff to the north outfall. In order to convey the flow, 18-inch pipes would be necessary at a minimum slope of 1.8 percent. The deepest invert elevation is estimated at approximately 12 feet below ground level, at the proposed new manhole labeled "NMH2." Table 9 includes the pipe diameters, lengths, slopes, and capacities for this potential diversion. The existing structure IDs are provided as noted in the City's GIS. All existing structures with an ID noted would be replaced with a new structure.

TABLE 9

Diversion to North Outfall Conveyance Data

Pipe ID	From Structure(1)	To Structure(1)	Length (feet)	Diameter (inches)	Slope (ft/ft)	Pipe Capacity (cfs)	25-Year Flow (cfs)
N1	CB-0852	CB-0488	80	18	0.018	14.13	13.93
N2	CB-0488	CB-0489	100	18	0.018	14.13	13.93
N3	CB-0489	New NMH1	37	18	0.030	18.16	17.85
N4	New NMH1	New NMH2	65	18	0.029	18.01	17.85
N5	New NMH2	New NMH3	130	18	0.055	24.79	17.85
N6	New NMH3	CB-0497	63	18	0.162	42.38	18.65
N7	CB-0497	CB-0496	24	18	0.108	34.67	18.65
N8	CB-0496	CB-0495	81	18	0.119	36.26	18.65
N9	CB-0495	CB-0494	80	18	0.109	34.73	18.65
N10	CB-0494	CB-0493	60	18	0.060	25.80	18.65
N11	CB-0493	CB-1449	87	18	0.143	39.76	18.65
N12	CB-1449	Outfall 1159	300	18	0.221	49.55	18.65

(1) All structures noted in the table, if existing, would be replaced with new ones.

This alternative would require 12 new structures (assuming that the existing structures are replaced) and approximately 1,110 feet of 18-inch pipe.

North Treatment Options (Also for Alternative 1 – Replace Middle Outfall)

The Department of Ecology's Western Washington Hydrology Model (WWHM) was used to determine the potential size of a treatment facility that could be located at the downstream end of the potential north conveyance route, just upstream of the outfall. It is assumed that a proprietary treatment system or vault could be installed in an offline configuration, which requires a slightly lower treatment flow rate than an online configuration. Traditional treatment options such as a biofiltration swale or a wetpond would require a much larger footprint compared with vault-based or manhole-based systems.

The offline water quality flow rate determined in WWHM for the full flow to the north outfall is 1.47 cfs, or 659 gpm. The required facility size was determined for several different proprietary systems, and this is noted in Table 10.

TABLE 10

North Outfall Treatment Sizes – Full Basin

System	Size of Treatment System	Vault Configuration	Total Footprint (square feet)(5)
Contech Filterra	362 square feet(1)	Three 8 feet by 16 feet	459
Contech StormFilter	59 cartridges(2)	10 feet by 26 feet	225
Oldcastle BioPod	412 square feet(3)	Three 8 feet by 16 feet, plus 6 feet by 6 feet	508
BioClean Modular Wetlands	659 square feet(4)	Two 8 feet by 24 feet, plus 4 feet by 8 feet	495

(1) Based on an filtration rate through the Filterra media of 175 inches per hour.
(2) Each 18-inch tall cartridge can treat 11.25 gpm.
(3) Based on an filtration rate through the BioPod media of 1.6 gpm per square foot.
(4) Based on a supplier-specified treatment flow rate, depending on vault size.
(5) Assumes 6-inch thickness on all vault walls.

There is a large amount of private open space available just upslope of the north outfall location, which may be suitable for installation of a large vault or series of vaults. The City would need to acquire land in order to use this area, and would need to acquire additional easements for the conveyance and maintenance access. These facilities would also need to be permitted for inclusion within the stream buffer.

Alternatively, if the City chooses to treat runoff only from the road area that will be disturbed as part of the conveyance improvement, the facility size becomes much smaller. A road section with two 12-foot travel lanes and two 5-foot sidewalks is assumed, with a total length of approximately 820 feet. The offline water quality flow rate determined in WWHM for the disturbed road area is 0.051 cfs, or 23 gpm. The required facility size was determined for several different proprietary systems, and this is noted in Table 11.

TABLE 11

North Outfall Treatment Sizes – 35th Avenue Road Basin Only

System	Size of Treatment System	Vault Configuration	Total Footprint (square feet)(5)
Contech Filterra	13 square feet(1)	4 feet by 4 feet	25
Contech StormFilter	2 cartridges(2)	48-inch MH	25
Oldcastle BioPod	14 square feet(3)	4 feet by 4 feet	25
BioClean Modular Wetlands	16 square feet(4)	4 feet by 4 feet	25

(1) Based on an filtration rate through the Filterra media of 175 inches per hour.
(2) Each 18-inch tall cartridge can treat 11.25 gpm.
(3) Based on an filtration rate through the BioPod media of 1.6 gpm per square foot.
(4) Based on a supplier-specified treatment flow rate, depending on vault size.
(5) Assumes 6-inch width on all vault walls.

These smaller facility sizes can be easily installed within the 35th Avenue NE right-of-way. A flow splitter manhole would be installed just upstream to divert the required treatment flow rate to the treatment structure.

North Outfall Site Constraints

During a field visit in April 2022, a number of constraints were observed along the route to the north outfall location. The existing conveyance system and easement appears to run alongside several existing houses, and is adjacent to or below an existing rock wall. There is limited space within the existing conveyance alignment to construct a new conveyance pipe, and the cost of shoring and supporting the adjacent structures during excavation could be substantial. Because of the close spacing of the houses at the north end of the 35th Avenue NE cul-de-sac, it is likely to be difficult to install the final run of pipe to a treatment facility and outfall. The construction of the pipe to the outfall will also require additional easements beyond the area of the existing easements.

Alternative 3 – Diversion to South Outfall

The third alternative includes diverting the flow in 35th Avenue NE away from the middle outfall to the south outfall. The existing south outfall pipe serves the area located south of NE 162nd Street, and east of 35th Avenue NE. The conveyance system resides within the NE 162nd Street right-of-way, discharging into Sheridan Creek just upstream of a culvert crossing beneath NE 162nd Street, in the backyard of 16066 NE 36th Avenue NE. It is unknown if an easement exists for this outfall pipe. It is feasible to divert runoff through a new piped conveyance system, to this location. The existing middle outfall would be plugged at CB-0852 and abandoned in place. It is believed that the homeowner at 16518 35th Avenue NE has at least one private pipe connected to this system.

Existing Conditions – South Outfall

The existing south conveyance system is indicated on the City's GIS database and consists of ditches and pipes along the south side of NE 162nd Street and along 36th Avenue NE, to the outfall. Much of the piped conveyance consists of 12-inch to 18-inch CMP, CPEP, concrete, or PVC pipes.

South Outfall Peak Flow

The peak runoff from the area that currently drains to the south outfall was estimated using the SBUH method, with the runoff parameters noted in Table 3.

South Tributary Area

Similar to the middle and north outfall analyses, the basin tributary to the existing south outfall was delineated using topographic survey and LiDAR topographic data for King County and the City's stormwater GIS data. Invert elevations, rim elevations, structure sizes, and other details are not included in the GIS data. For any areas not included in the topographic survey, rim elevations were estimated based on the LiDAR surface elevations, and invert elevations for the existing pipes are assumed to be approximately 5 feet below grade. The delineated basin is indicated on Figure 1.

South Area Land Cover

Currently, the south conveyance system conveys runoff from an area of approximately 10.28 acres. This area includes 35th Avenue NE and 36th Avenue NE (and the properties in between), from NE 158th Place to NE 162nd Street. The designated zoning is the same

as the middle and north's outfall tributary area. The estimated impervious land cover (based on assumptions in Table 2) is 51.9 percent. Coverages are shown in Table 12.

TABLE 12

Land Cover Tributary to South Outfall

Land Cover Type	Area (acres)	Assumption
Roof	2.42	Maximum 35 percent roof area per lot, as allowed by LFPMC, 18.22.050.
Driveway/Patio	0.69	Maximum 45 percent impervious coverage per lot, as allowed by LFPMC, 18.22.080.
Landscaped/Lawn	3.80	55 percent of lot, per LFPMC, 18.22.080.
Impervious ROW	2.22	Assumes 66 percent of ROW is paved, driveway, gravel, or sidewalk.
Landscaped ROW	1.14	Assumes 34 percent of ROW is landscaped/lawn.
Total	**10.28**	

Time of concentration was calculated in the same manner as for the middle and north outfalls. The estimated peak runoff for each subbasin as well as the subbasin areas and times of concentration for each subbasin are included in Table 13.

TABLE 13

South Basin Peak Runoff

Subbasin	Total Area (acres)	Impervious Area (acres)	Pervious Area (acres)	Time of Concentration (minimum)	25-Year Peak Flow (cfs)
S1	2.27	1.25	1.02	6.1	1.22
S2	8.00	4.40	3.60	9.7	4.09
Total	**10.27**	**5.65**	**4.62**		**5.31**

The total 25-year peak flow to the south outfall is estimated at 5.31 cfs. If runoff to the middle outfall is diverted to the south outfall, the conveyance piping would need to be sized to convey a peak 25-year flow of 17.85 cfs from the middle outfall basin, plus the existing peak 25-year flow of 5.31 cfs, for a total of 23.16 cfs.

South Basin Existing Conveyance Capacity

Diverting runoff to the south outfall from 35th Avenue NE would require approximately 325 feet of new conveyance piping to connect to the existing south conveyance system, which begins at the intersection of NE 166th Street and 35th Avenue NE. However, the existing system is not deep enough, nor do the existing pipes have the capacity to convey the peak runoff. Therefore, an entirely new conveyance system would be required.

Topographic survey and field observations were used to determine the feasibility of routing flow to the south outfall. The topographic survey data was used to establish the rim elevations of existing and proposed structures. A minimum depth to invert of 5 feet was assumed, to provide sufficient cover over the storm pipes. Figure 4 indicates the potential stormwater conveyance that may be feasible to divert runoff to the south outfall. In order to convey the flow, 18-inch pipes would be necessary at slopes of 0.3 percent or greater. The deepest invert elevation is estimated at 16 feet below ground level, at the proposed manhole labeled "SMH 2." Table 14 includes the pipe diameters, lengths, slopes, and capacities for this potential diversion. The existing structure IDs are provided, as noted in the City's GIS. All existing structures with an ID noted would be replaced with a new structure.

TABLE 14

Diversion to South Outfall Conveyance Data

Pipe ID	From Structure(1)	To Structure(1)	Length (feet)	Diameter (inches)	Slope (ft/ft)	Pipe Capacity (cfs)	25-Year Flow (cfs)
S1	CB-0852	CB-0487	51	18	0.0039	6.60	5.81
S2	CB-0487	CB-0486	90	18	0.0034	6.08	5.81
S3	CB-0486	MH1	89	18	0.0056	7.89	7.69
S4	MH1	MH2	44	18	0.030	18.10	17.85
S5	MH2	CB-0510	51	18	0.029	18.06	17.85
S6	CB-0510	MH3	152	18	0.030	18.12	17.85
S7	MH3	MH4	118	18	0.031	18.40	17.85
S8	MH4	MH5	47	18	0.062	26.16	17.85
S9	MH5	CB-0512	131	18	0.074	28.66	19.07
S10	CB-0512	CB-0514	78	18	0.100	33.31	19.07
S11	CB-0514	MH6	35	18	0.049	23.21	23.16
S12	MH6	CB-1894	87	18	0.076	29.08	23.16
S13	CB-1894	Outfall 0879	20	18	0.414	67.73	23.16

(1) All structures noted in the table, if existing, would be replaced as new.

This alternative would require 13 new structures (assuming that the existing structures are replaced), and approximately 990 feet of 18-inch pipe. Also, this option assumes that runoff would be piped from the south side of NE 162nd Street to the north side of the road, in order to reduce the amount of runoff entering the inlet side of the existing NE 162nd Street culvert.

South Treatment Options

WWHM was used to determine the potential size of a treatment facility that could be located at the downstream end of the proposed conveyance route, just upstream of the outfall. It is assumed that a proprietary treatment system or vault could be installed in an offline configuration, which requires a slightly lower treatment flow rate than an online configuration. Traditional treatment options such as a biofiltration swale or a wetpond would require a much larger footprint when compared with vault-based or manhole-based system, and land is not readily available for these facilities.

The offline water quality flow rate determined in WWHM for the full flow to the outfall is 1.52 cfs, or 683 gpm. The required facility size was determined for several different proprietary systems, and this is noted in Table 15.

TABLE 15

South Outfall Treatment Sizes – Full Basin

System	Size of Treatment System	Vault Configuration	Total Footprint (square feet)(5)
Contech Filterra	454 square feet(1)	Three 8 feet by 20 feet	567
Contech StormFilter	73 cartridges(2)	Two 8 feet by 16 feet	306
Oldcastle BioPod	516 square feet(3)	Four 8 feet by 16 feet, plus 4 feet by 4 feet	637
BioClean Modular Wetlands	512 square feet(4)	Two 8 feet by 24 feet, plus 8 feet by16 feet	603

(1) Based on an filtration rate through the Filterra media of 175 inches per hour.
(2) Each 18-inch tall cartridge can treat 11.25 gpm.
(3) Based on an filtration rate through the BioPod media of 1.6 gpm per square foot.
(4) Based on a supplier-specified treatment flow rate, depending on vault size.
(5) Assumes 6-inch width on all vault walls.

There is very limited area available at the south outfall location to install a large facility, and the parcels adjacent to the right-of-way are all developed. If the vault is installed within the right-of-way, it would occupy approximately half of the right-of-way, below

the road, and shoulder. It is assumed that the facility would need to be installed partially within the right-of-way and partially within the adjacent private property.

Alternatively, if the City chooses to treat runoff only from the road area that will be disturbed as part of the conveyance improvement, the facility size becomes much smaller. A road section with two 12-foot travel lanes and two 5-foot shoulders is assumed, with a total length of approximately 990 feet. The offline water quality flow rate determined in WWHM for the road area is 0.047 cfs, or 21 gpm. The required facility size was determined for several different proprietary systems, and this is noted in Table 16.

TABLE 16

South Outfall Treatment Sizes – 35th Avenue Road Basin Only

System	Size of Treatment System	Vault Configuration	Total Footprint (square feet)(5)
Contech Filterra	11 square feet(1)	4 feet by 4 feet	25
Contech StormFilter	2 cartridges(2)	48-inch MH	25
Oldcastle BioPod	13 square feet(3)	4 feet by 4 feet	25
BioClean Modular Wetlands	16 square feet(4)	4 feet by 4 feet	25

(1) Based on an filtration rate through the Filterra media of 175 inches per hour.
(2) Each 18-inch tall cartridge can treat 11.25 gpm.
(3) Based on an filtration rate through the BioPod media of 1.6 gpm per square foot.
(4) Based on a supplier-specified treatment flow rate, depending on vault size.
(5) Assumes 6-inch width on all vault walls.

These facility sizes can easily be installed along the side of the right-of-way (possibly with some easements), with a flow splitter manhole installed just upstream, in order to divert the required treatment flow rate to the treatment structure.

Alternative 4 – Hybrid/Partial Diversion to South Outfall and Replace Middle Outfall

The fourth alternative is a hybrid solution that combines portions of Alternative 1 and Alternative 3 and includes diverting a portion of the flow in 35th Avenue NE away from the middle outfall to the south outfall, and then replacing the middle outfall pipe. By diverting runoff from Subbasin B3 and Subbasin B4 at the intersection of 35th Avenue NE and NE 162nd Street, the improvements to the south conveyance system would be reduced in scope, avoiding the large pipe sizes and deep excavation that would be required under Alternative 3. At the same time, by reducing the peak flows to the middle outfall, only the outfall pipe (connected to the existing manhole MMH3) would

require replacement (in addition to Segment P1, which must be replaced due to damage). Replacing the outfall could be accomplished with smaller equipment and removal of the existing deck may not be required.

Estimated Flows with Hybrid

As summarized in previous sections, Subbasins B3 and B4 discharge (for the 25-year storm event) 4.37 and 5.79 cfs, respectively, to the middle outfall. Diverting this runoff to the south outfall would reduce the flows at the middle outfall by 10.16 cfs. In addition, 25 percent of Subbasin B2 would also be diverted, reducing the peak flow at the middle outfall by another 0.94 cfs. Therefore, the total 25-year peak flow to the middle outfall would be reduced to about 6.75 cfs, which is near the existing system's maximum capacity. Therefore, only the two damaged pipes (P1 and P5, the outfall pipe) would need to be replaced at the middle outfall.

The runoff diverted to the south conveyance system would be decreased (from the amounts in Alternative 3) from 23.16 cfs to 16.41 cfs, but would still require replacement of the south system; however, the pipes would be smaller (12 and 18 inches) and would generally not have to be installed nearly as deep (only 4.5 feet deep), thereby saving a significant amount of cost and disturbance regarding the improvements to NE 162nd Street, as compared to Alternative 3.

Diverting a portion of runoff to the south outfall from the intersection would require approximately 720 feet of new conveyance piping to Sheridan Creek, at NE 162nd Street. In order to convey the flow to the south outfall, 18-inch pipes would be necessary at slopes of 3.7 percent or greater. Table 17 includes the pipe diameters, lengths, slopes, and capacities for this potential diversion. The existing structure IDs are provided as noted in the City's GIS. All existing structures with an ID noted would be replaced with a new structure.

TABLE 17

Hybrid Conveyance Data

Pipe ID	From Structure(1)	To Structure(1)	Length (feet)	Diameter (in)	Slope (ft/ft)	Pipe Capacity (cfs)	25-Year Flow (cfs)
P1	CB-0852	EX SDMH	48	12	0.060	8.80	6.75
P5	EX SDMH	New Outfall	125	12	0.250	17.9	6.75
S4	CB-0509	CB-0510	30	12	0.122	12.48	12.32
S5	CB-0510	CB-0511	20	12	0.245	17.86	12.32
S6	CB-0511	SMH3	152	18	0.055	24.76	12.32
S7	SMH3	SMH4	118	18	0.053	24.34	12.32
S8	SMH4	SMH5	47	18	0.136	38.84	12.32
S9	SMH5	CB-0512	131	18	0.074	28.66	12.32
S10	CB-0512	CB-0514	78	18	0.100	33.31	12.32
S11	CB-0514	SMH6	35	18	0.037	20.30	16.41
S12	SMH6	CB-1894	87	18	0.080	29.88	16.41
S13	CB-1894	Outfall 0879	20	18	0.050	23.55	16.41

(1) All structures noted in the table, if existing, would be replaced as new except for structures at the middle outfall.

This alternative would require no new structures at the middle outfall (but would include an anchor block) and 10 new structures (assuming that the existing structures are replaced), with approximately 50 feet of 12-inch pipe and 670 feet of 18-inch pipe. This is indicated on Figure 5.

Hybrid Treatment Options

Treatment options for this alternative would be similar but slightly smaller than those for Alternative 3, since the disturbed area would be slightly smaller.

COST ESTIMATE

For the purpose of estimating costs, the Contech Filterra system was assumed as the selected treatment facility. It is likely that the other types of treatment facilities would be similar in cost, as they generally consist of similarly sized vaults.

The estimated planning-level construction costs are provided in Table 18. The cost of only installing the new conveyance is provided and the costs of additionally including a treatment vault for the entire basin or for the equivalent road area are also noted.

TABLE 18

Summary of Estimated Construction Costs

Alternative	Conveyance Alone	Conveyance and Full Basin Treatment	Conveyance and Road Treatment
Replace Middle Outfall	$357,000	$921,000(1)	$436,000(1)
Diversion to North Outfall	$910,000	$1,474,000	$989,000
Diversion to South Outfall	$822,000	$1,417,000	$910,000
Hybrid/Partial Diversion to South Outfall and Replace Middle Outfall	$796,000	$1,391,000	$884,000

CONCLUSIONS AND RECOMMENDATIONS

In its current configuration, the middle outfall system is not adequate to convey the runoff flowing to it, and there is damage to the pipe crossing 35th Avenue NE, and damage to the outfall manhole. The City should either replace the outfall system, or divert runoff to another location. Selecting the best option from the four considered is difficult due to the many variables. Selection must consider initial capital costs, operation and maintenance costs, construction access and restoration, and the ability to acquire necessary easements, both temporary and permanent. In addition, the City must decide what level of treatment, if any, is desired for the alternative selected.

If temporary construction and permanent easements can be obtained for Alternative 1 – Replace Middle Outfall, the capital costs would be significantly less than the other options and the construction disturbance to the neighborhood would be minimal. Alternative 1is the preferred choice. Similar easements are needed for Alternative 4 – Hybrid/Partial Diversion to South Outfall and Replace Middle Outfall and would be the second choice.

However, if easements are not straight-forward for Alternative 1 or Alternative 4, Alternative 3 – Diversion to South Outfall would be the third choice, even though it is the most expensive. Alternative 2 – Diversion to North Outfall has significant and difficult construction access and easement requirements and would be the least favorable option.

FIGURES

Existing North Outfall Location

Existing Middle Outfall Location

Existing South Outfall Location

Sheridan Creek

Lake Washington

Sub-Basin N1

Sub-Basin B1

Sub-Basin B2

Sub-Basin B3

Sub-Basin B4

Sub-Basin S1

Sub-Basin S2

NE 174TH ST
BROOKSIDE BLVD NE
44TH AVE NE
HAMLIN RD NE
NE 170TH PL
NE 170TH ST
NE 169TH CT
39TH PL NE
41ST AVE NE
45TH AVE NE
SHORE DR NE
BOTHELL WAY NE
BEACH DR NE
39TH AVE NE
NE 167TH ST
30TH AVE NE
HILLSIDE DR NE
33RD AVE NE
35TH AVE NE
32ND PL NE
32ND AVE NE
NE 166TH ST
NE 163RD ST
NE 162ND ST
34TH AVE NE
36TH AVE NE
NE 160TH ST
NE 161ST ST
NE 158TH LN
NE 158TH PL
NE 157TH LN
NE 157TH PL
NE 157TH ST
NE 156TH ST
NE 155TH PL
NE 155TH ST

Source: Relevant City & County Sources;

Legend

- CatchBasins
- Manholes
- Outfalls
- Pipes
- Ditches
- 5-ft Contour
- Water Bodies
- Parcels

Basins

- Middle Basins
- North Basin
- South Basins

N

0 100 200 400 Feet

CITY OF LAKE FOREST PARK

35TH AVENUE NE DRAINAGE

FIGURE 1
STUDY AREA

Gray & Osborne, Inc.
CONSULTING ENGINEERS

L:\Lake Forest Park\22462 35th Drainage\03 Design\GIS\APRX\Summation of Alternatives\Summation of Alternatives.aprx

16615 35TH AVE NE
16564 35TH AVE NE
16556 35TH AVE NE
16575 35TH AVE NE
16548 35TH AVE NE
16549 35TH AVE NE
16540 35TH AVE NE
16539 35TH AVE NE
16533 35TH AVE NE
16524 35TH AVE NE
16289 36TH AVE NE
16525 35TH AVE NE
16522 35TH AVE NE
16283 36TH AVE NE
16519 35TH AVE NE
16518 35TH AVE NE
16515 35TH AVE NE
16512 35TH AVE NE
16273 36TH AVE NE
16509 35TH AVE NE
16503 35TH AVE NE
16504 35TH AVE NE
16359 35TH AVE NE
3500 NE 162ND ST

250
125
150
200
175
225

Sub-Basin N1
Sub-Basin B1
Sub-Basin B2

NE 166TH PL
35TH AVE NE
NE 162ND ST

Sheridan Creek

Existing CB-0852
P1
P2
P3
P4
P5
New MMH1 Rim = 218 IE = 214.39
New MMH2 Rim = 214 IE = 205.38
New MMH3 Rim = 190 IE = 184.71
Manhole Removed
New Middle Outfall (extends from New MMH3)

Source: Relevant City & County Sources,

Legend

- CatchBasins
- Manholes
- Outfalls
- Pipes
- Ditches
- 5-ft Contour
- Water Bodies
- Parcels

Basins
- Middle Basins
- North Basin
- South Basins
- New Pipes
- New Storm Structures

N

0 25 50 100 Feet

CITY OF LAKE FOREST PARK

35TH AVENUE NE DRAINAGE

FIGURE 2
MIDDLE OUTFALL REPLACEMENT ALTERNATIVE 1

Gray & Osborne, Inc.
CONSULTING ENGINEERS

L:\Lake Forest Park\22462 35th Drainage\03 Design\GIS\APRX\Summation of Alternatives\Summation of Alternatives.aprx

North Outfall = 90

CB-0493
Rim = 173.33
IE = 168.8

CB-1449
Rim = 160.86
IE = 156.4

CB-0494
Rim = 176.89
IE = 172.4

CB-0495
Rim = 185.64
IE = 181.1

CB-0496
Rim = 195.23
IE = 190.7

CB-0497
Rim = 197.77
IE = 193.3

New NMH3
Rim = 208
IE = 203.5

New NMH2
Rim = 222.7
IE = 210.7

New NMH1
Rim = 221.1
IE = 212.6

CB-0489
Rim = 221.57
IE = 213.7

CB-0488
Rim = 220.87
IE = 215.5

CB-0852
Rim = 221.41
IE = 216.9

Plug and Abandon

Middle Outfall

Sheridan Creek

Sub-Basin N1

Sub-Basin B1

Sub-Basin B2

Sub-Basin S1

33RD AVE NE
NE 167TH ST
NE 166TH PL
35TH AVE NE
34TH AVE NE
NE 165TH ST
NE 162ND ST
36TH AVE NE

16930 35TH AVE NE
16816 35TH AVE NE
16635 35TH AVE NE
16625 35TH AVE NE
16615 35TH AVE NE
16575 35TH AVE NE
16556 35TH AVE NE
16548 35TH AVE NE
16549 35TH AVE NE
16540 35TH AVE NE
16539 35TH AVE NE
16533 35TH AVE NE
16525 35TH AVE NE
16519 35TH AVE NE
16515 35TH AVE NE
16509 35TH AVE NE
16503 35TH AVE NE
16359 35TH AVE NE
16351 35TH AVE NE
16343 35TH AVE NE
16335 35TH AVE NE
16328 35TH AVE NE
16580 35TH AVE NE
16572 35TH AVE NE
16564 35TH AVE NE
16524 35TH AVE NE
16522 35TH AVE NE
16518 35TH AVE NE
16512 35TH AVE NE
16504 35TH AVE NE
3531 NE 166TH ST
16289 36TH AVE NE
16283 36TH AVE NE
16273 36TH AVE NE
3500 NE 162ND ST
3502 NE 162ND ST
3504 NE 162ND ST

125
250
225
200
275
300
100
150
175

Source: Relevant City & County Sources.

Legend

- CatchBasins
- Manholes
- Outfalls
- Pipes
- Ditches
- 5-ft Contour
- Water Bodies
- Parcels

Basins
- Middle Basins
- North Basin
- South Basins
- New Pipes
- New Manholes
- Catch Basins

N

0 50 100 200 Feet

CITY OF LAKE FOREST PARK

35TH AVENUE NE DRAINAGE

FIGURE 3
DIVERSION TO NORTH OUTFALL
ALTERNATIVE 2

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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Sub-Basin N1

Sub-Basin B1

Sub-Basin B2

Sub-Basin B3

Sub-Basin B4

Sub-Basin S1

Sub-Basin S2

Plug and abandon

CB-0852
Rim = 221.41
IE = 216.9

CB-0487
Rim = 222.61
IE = 216.7

CB-0486
Rim = 226.01
IE = 216.4

New SMH1
Rim = 227.7
IE = 215.9

New SMH2
Rim = 231.0
IE = 214.6

CB-0511
Rim = 227.71
IE = 213.1

New SMH3
Rim = 219.27
IE = 208.6

New SMH4
Rim = 213.04
IE = 205.0

New SMH5
Rim = 206.56
IE = 202.1

CB-0512
Rim = 196.93
IE = 192.4

New SMH6
Rim = 187.77
IE = 182.9

CB-0514
Rim = 189.1
IE = 184.6

New SMH7
Rim = 180.77
IE = 176.3

Middle Outfall

Sheridan Creek

South Outfall = 168

NE 166TH PL

NE 165TH ST

NE 162ND ST

NE 163RD ST

34TH AVE NE

35TH AVE NE

36TH AVE NE

37TH AVE NE

Source: Relevant City & County Sources,

Legend

- CatchBasins
- Manholes
- Outfalls
- Pipes
- Ditches
- 5-ft Contour
- Water Bodies
- Parcels

Basins
- Middle Basins
- North Basin
- South Basins
- New Pipes
- New Manholes
- Catch Basins

N

0 62.5 125 250 Feet

CITY OF LAKE FOREST PARK

35TH AVENUE NE DRAINAGE

FIGURE 4
DIVERSION TO SOUTH OUTFALL
ALTERNATIVE 3

Gray & Osborne, Inc.
CONSULTING ENGINEERS

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CB-0852
Rim = 221.41
IE = 217.51

New MMH3

New Middle Outfall
(extends from
New MMH3)

CB-0510
Rim = 235.09
IE = 228.2 W
IE = 228.1 S

CB-0511
Rim = 227.71
IE = 223.2

Sheridan Creek

CB-0509
Rim = 236.36
IE = 231.90 E

New SMH3
Rim = 219.27
IE = 214.8

New SMH4
Rim = 213.04
IE = 208.5

New SMH5
Rim = 206.56
IE = 202.1

CB-0512
Rim = 196.93
IE = 192.4

New SMH6
Rim = 187.77
IE = 183.3

CB-0514
Rim = 189.1
IE = 184.6

South Outfall = 168

New SMH7
Rim = 180.77
IE = 176.3 NW
IE = 169.0 N

Sub-Basin B2
Sub-Basin S1
Sub-Basin B3
Sub-Basin S2
Sub-Basin B4

16525 35TH AVE NE
16519 35TH AVE NE
16515 35TH AVE NE
16509 35TH AVE NE
16503 35TH AVE NE
16359 35TH AVE NE
16351 35TH AVE NE
16343 35TH AVE NE
16335 35TH AVE NE
16329 35TH AVE NE
16328 35TH AVE NE
16321 35TH AVE NE
16314 35TH AVE NE
16522 35TH AVE NE
16518 35TH AVE NE
16512 35TH AVE NE
16504 35TH AVE NE
16283 36TH AVE NE
16273 36TH AVE NE
3500 NE 162ND ST
3502 NE 162ND ST
3504 NE 162ND ST
3556 NE 162ND ST
3606 NE 162ND ST
3525 NE 162ND ST
16067 36TH AVE NE
16066 36TH AVE NE
16201 37TH AVE NE
16061 37TH AVE NE

35TH AVE NE
NE 162ND ST
NE 163RD ST
36TH AVE NE
37TH AVE NE

150
175
200
225
250
275
300

Source: Relevant City & County Sources,

Legend

- CatchBasins
- Manholes
- Outfalls
- Pipes
- Ditches
- 5-ft Contour
- Water Bodies
- Parcels

Basins
- Middle Basins
- North Basin
- South Basins
- New Pipes
- New Manholes
- CatchBasins selection

N

0 50 100 200 Feet

CITY OF LAKE FOREST PARK

35TH AVENUE NE DRAINAGE

FIGURE 5
SOUTH OUTFALL HYBRID
ALTERNATIVE 4

Gray & Osborne, Inc.
CONSULTING ENGINEERS

L:\Lake Forest Park\22462 35th Drainage\03 Design\GIS\APRX\Summation of Alternatives\Summation of Alternatives.aprx

PHOTOS

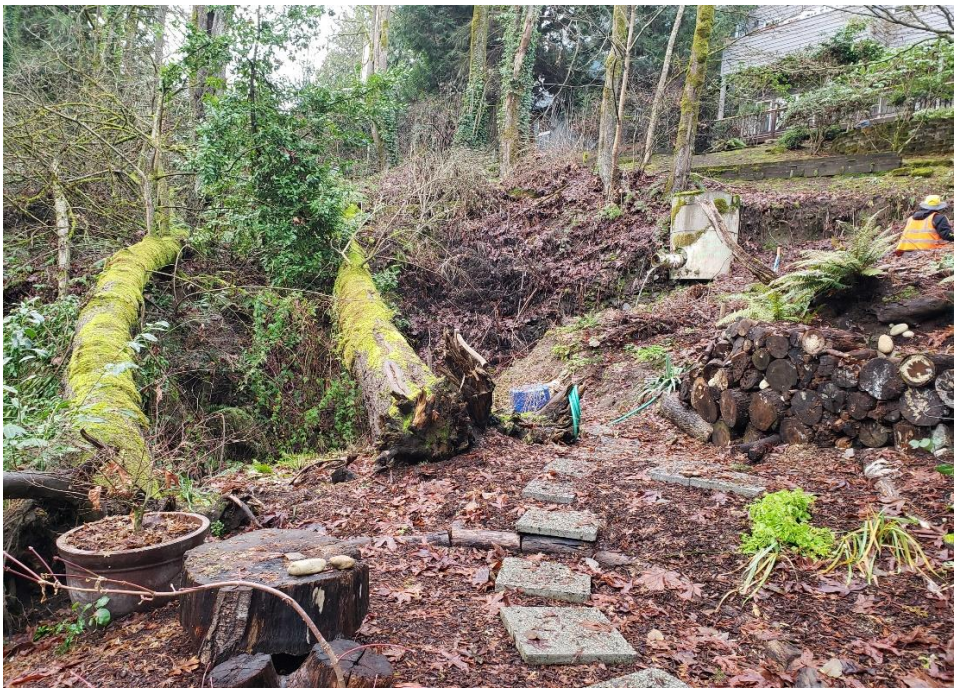

PHOTO 1

Looking Southwest at Middle Outfall Manhole MMH4

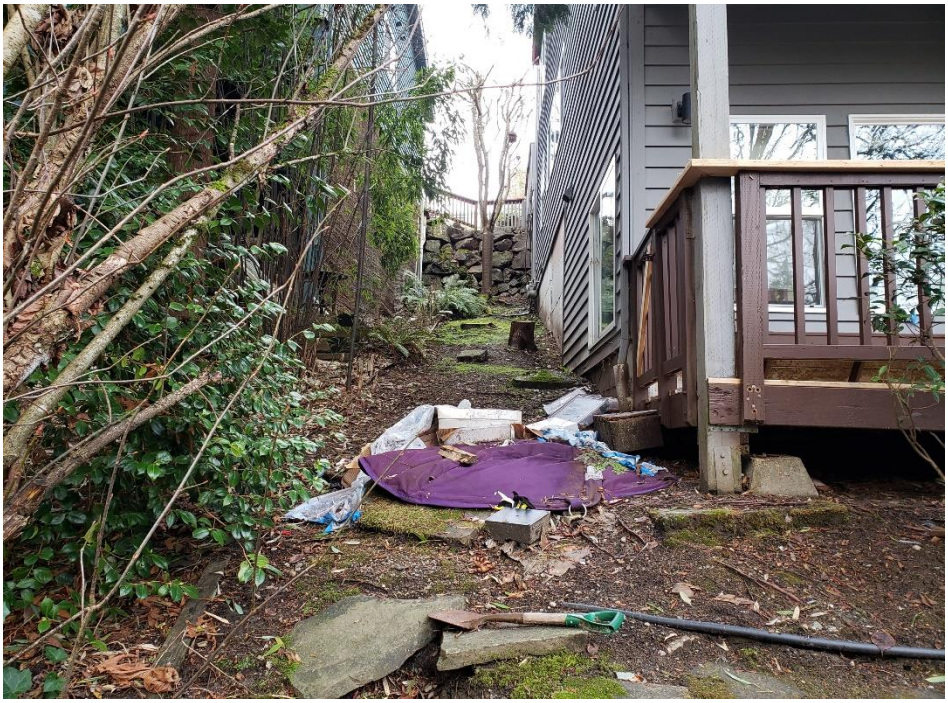

PHOTO 2

Looking West Along South Property Line of Address 16518 35th Avenue NE

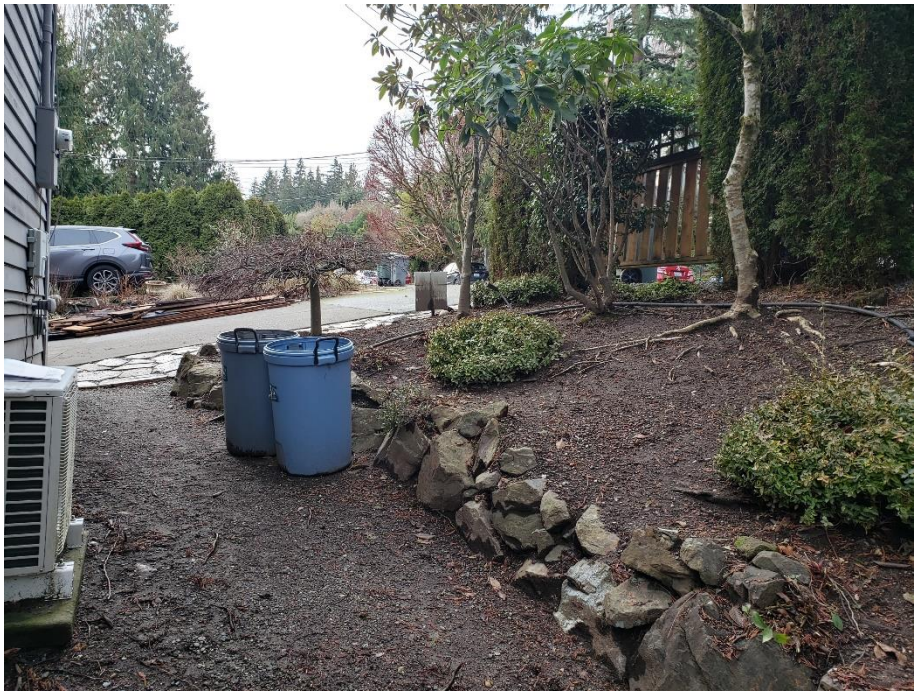

PHOTO 3

Looking South in Front Yard of Address 16518 35th Avenue NE

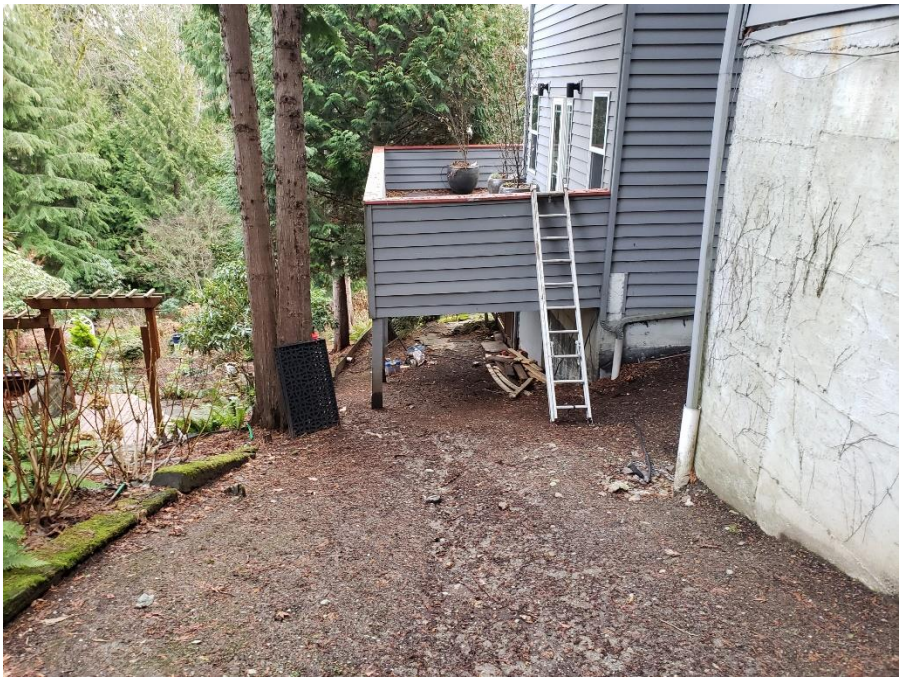

PHOTO 4

Looking East Along North Property Line of Address 16518 35th Avenue NE

COST ESTIMATES

City of Lake Forest Park
Planning Level Cost Estimate
35th Avenue Drainage - Replace Middle Outfall (Alt 1)
April 20, 2023

	Item	Quantity		Unit Cost		Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 23,000	$	23,000
2	Minor Changes	1	CALC	$ 10,000	$	10,000
3	Survey	1	LS	$ 1,000	$	1,000
4	Project Temporary Traffic Control	1	LS	$ 2,500	$	2,500
5	Clearing and Grubbing	1	LS	$ 8,000	$	8,000
6	Removal of Structure and Obstruction	1	LS	$ 7,000	$	7,000
7	Locate Existing Utilities	1	LS	$ 2,000	$	2,000
8	Bypass Storm Flow	1	LS	$ 4,000	$	4,000
9	Commercial HMA for Trench Patch	10	TN	$ 250	$	2,500
10	HMA Overlay	0	TN	$ 110	$	-
11	CPEP Storm Sewer Pipe, 12 In. Diam. (Incl. Bedding)	0	LF	$ 100	$	-
12	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	155	LF	$ 160	$	24,800
12	HDPE Storm Sewer Pipe, 18 In. O.D. (Incl. Bedding)	125	LF	$ 270	$	33,750
13	Catch Basin, Type 2, 48 In. Diam. (Basic to 8 ft)	3	EA	$ 5,500	$	16,500
14	Catch Basin, Type 1	0	EA	$ 4,000	$	-
15	Catch Basin Additional Height, 48 In. Diam (Over 8 ft)	0	VF	$ 300	$	-
16	Concrete Anchor Block	1	EA	$ 12,000	$	12,000
17	Trench Excavation Safety Systems	1	LS	$ 5,000	$	5,000
18	Bank Run Gravel for Trench Backfill	340	TN	$ 35	$	11,900
19	Erosion Control and Water Pollution Prevention	1	LS	$ 5,000	$	5,000
20	Landscaping Restoration	1	LS	$ 20,000	$	20,000
21	Tree Replacement	4	EA	$ 500	$	2,000
22	Stream Buffer Restoration	1	LS	$ 20,000	$	20,000
23	Rolled Curb and Gutter	0	LF	$ 35	$	-
24	Cement Concrete Driveway Repair	40	SY	$ 150	$	6,000
25	Crushed Surfacing Base Course	40	TN	$ 45	$	1,800
26	Crushed Surfacing Top Course	0	TN	$ 55	$	-
27	Project Documentation	1	LS	$ 1,000	$	1,000
26	Deck Restoration	1	LS	$ 25,000	$	25,000
	Subtotal				$	244,750
	Contingency (30%)				$	73,425
	Subtotal				$	318,175
	TAX EXEMPT (RULE 171)				$	-
	Easement Acquisition (Temporary and Permanent)	2850	SF	$ 10	$	28,500
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	2	EA	$ 5,000	$	10,000
	Total				$	356,675
	Total Construction Cost (Rounded)				**$**	**357,000**

City of Lake Forest Park
Planning Level Cost Estimate
35th Avenue Drainage - Diversion to North Outfall (Alt 2)
April 20, 2023

	Item	Quantity		Unit Cost		Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 60,000	$	60,000
2	Minor Changes	1	CALC	$ 25,000	$	25,000
3	Survey	1	LS	$ 5,000	$	5,000
4	Project Temporary Traffic Control	1	LS	$ 10,000	$	10,000
5	Clearing and Grubbing	1	LS	$ 20,000	$	20,000
6	Removal of Structure and Obstruction	1	LS	$ 20,000	$	20,000
7	Locate Existing Utilities	1	LS	$ 5,000	$	5,000
8	Bypass Storm Flow	1	LS	$ 15,000	$	15,000
9	Commercial HMA for Trench Patch	140	TN	$ 250	$	35,000
10	HMA Overlay	0	TN	$ 110	$	-
11	CPEP Storm Sewer Pipe, 12 In. Diam. (Incl. Bedding)	80	LF	$ 100	$	8,000
12	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	1,110	LF	$ 160	$	177,600
13	Catch Basin, Type 2, 48 In. Diam. (Basic to 8 ft)	12	EA	$ 5,500	$	66,000
14	Catch Basin, Type 1	5	EA	$ 4,000	$	20,000
15	Catch Basin Additional Height, 48 In. Diam (Over 8 ft)	5	VF	$ 300	$	1,350
16	Connection to Existing Structure	3	EA	$ 1,500	$	4,500
17	Trench Excavation Safety Systems	1	LS	$ 10,000	$	10,000
18	Bank Run Gravel for Trench Backfill	1,930	TN	$ 35	$	67,550
19	Erosion Control and Water Pollution Prevention	1	LS	$ 15,000	$	15,000
20	Landscaping Restoration	1	LS	$ 35,000	$	35,000
21	Tree Replacement	8	EA	$ 500	$	4,000
22	Stream Buffer Restoration	1	LS	$ 35,000	$	35,000
23	Rolled Curb and Gutter	0	LF	$ 35	$	-
24	Cement Concrete Driveway Repair	10	SY	$ 150	$	1,500
25	Crushed Surfacing Base Course	180	TN	$ 45	$	8,100
26	Crushed Surfacing Top Course	120	TN	$ 55	$	6,600
27	Project Documentation	1	LS	$ 2,000	$	2,000
	Subtotal				$	657,200
	Contingency (30%)				$	197,160
	Subtotal				$	854,360
	TAX EXEMPT (RULE 171)				$	-
	Easement Acquisition (Temporary and Permanent)	4500	SF	$ 10	$	45,000
	Total				$	909,360
	Total Construction Cost (Rounded)				**$**	**910,000**

North Outfall Additive Option 1

Treatment for Road Only

	Item	Quantity		Unit Cost	Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 6,000	$ 6,000
1	Treatment Vault (Filterra 4x4)	1	LS	$ 25,000	$ 25,000
2	Foundation Gravel	5	TN	$ 30	$ 150
3	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	50	LF	$ 125	$ 6,250
4	Flow Splitter MH	3	EA	$ 6,000	$ 18,000
5	Connection to Existing Structure	1	EA	$ 1,500	$ 1,500
6	Trench Excavation Safety Systems	1	LS	$ 2,500	$ 2,500
7	Trench Backfill	40	TN	$ 30	$ 1,200
				Subtotal	$ 60,600
				Contingency (30%)	$ 18,180
				Subtotal	$ 78,780
				TAX EXEMPT (RULE 171)	$ -
	Easement Acquisition (Temporary and Permanent)	0	SF	$ 10	$ -
				Total	$ 78,780
				Total Construction Cost (Rounded)	**$ 79,000**

North Outfall Additive Option 2

Treatment for Entire Basin

	Item	Quantity		Unit Cost	Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 37,000	$ 37,000
1	Treatment Vault (Filterra 8x16)	3	LS	$ 110,000	$ 330,000
2	Foundation Gravel	40	TN	$ 30	$ 1,200
3	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	150	LF	$ 125	$ 18,750
4	Connection to Existing Structure	1	EA	$ 1,500	$ 1,500
5	Trench Excavation Safety Systems	1	LS	$ 5,000	$ 5,000
6	Trench Backfill	300	TN	$ 30	$ 9,000
				Subtotal	$ 402,450
				Contingency (30%)	$ 120,735
				Subtotal	$ 523,185
				TAX EXEMPT (RULE 171)	$ -
	Easement Acquisition (Temporary and Permanent)	3000	SF	$ 10	$ 30,000
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	2	EA	$ 5,000	$ 10,000
				Total	$ 563,185
				Total Construction Cost (Rounded)	**$ 564,000**

City of Lake Forest Park
Planning Level Cost Estimate
35th Avenue Drainage - Diversion to South Outfall (Alt 3)
April 20, 2023

	Item	Quantity		Unit Cost		Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 57,000	$	57,000
2	Minor Changes	1	CALC	$ 15,000	$	15,000
3	Survey	1	LS	$ 5,000	$	5,000
4	Project Temporary Traffic Control	1	LS	$ 25,000	$	25,000
5	Clearing and Grubbing	1	LS	$ 10,000	$	10,000
6	Removal of Structure and Obstruction	1	LS	$ 20,000	$	20,000
7	Locate Existing Utilities	1	LS	$ 5,000	$	5,000
8	Bypass Storm Flow	1	LS	$ 15,000	$	15,000
9	Commercial HMA for Trench Patch	130	TN	$ 250	$	32,500
10	HMA Overlay	0	TN	$ 110	$	-
11	CPEP Storm Sewer Pipe, 12 In. Diam. (Incl. Bedding)	80	LF	$ 100	$	8,000
12	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	995	LF	$ 160	$	159,200
13	CPEP Storm Sewer Pipe, 24 In. Diam. (Incl. Bedding)	0	LF	$ 210	$	-
14	Catch Basin, Type 2, 48 In. Diam. (Basic to 8 ft)	13	EA	$ 5,500	$	71,500
15	Catch Basin, Type 1	5	EA	$ 4,000	$	20,000
16	Catch Basin Additional Height, 48 In. Diam (Over 8 ft)	24	VF	$ 300	$	7,200
17	Connection to Existing Structure	2	EA	$ 1,500	$	3,000
18	Trench Excavation Safety Systems	1	LS	$ 15,000	$	15,000
19	Bank Run Gravel for Trench Backfill	2,630	TN	$ 35	$	92,050
20	Erosion Control and Water Pollution Prevention	1	LS	$ 5,000	$	5,000
21	Landscaping Restoration	1	LS	$ 10,000	$	10,000
22	Tree Replacement	10	EA	$ 500	$	5,000
23	Strean Buffer Restoration	1	LS	$ 5,000	$	5,000
24	Rolled Curb and Gutter	500	LF	$ 35	$	17,500
25	Cement Concrete Driveway Repair	20	SY	$ 150	$	3,000
26	Crushed Surfacing Base Course	170	TN	$ 45	$	7,650
27	Crushed Surfacing Top Course	110	TN	$ 55	$	6,050
28	Project Documentation	1	LS	$ 2,000	$	2,000
	Subtotal				$	621,650
	Contingency (30%)				$	186,495
	Subtotal				$	808,145
	TAX EXEMPT (RULE 171)				$	-
	Easement Acquisition (Temporary and Permanent)	300	SF	$ 10	$	3,000
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	2	EA	$ 5,000	$	10,000
	Total Construction Cost (Rounded)				**$**	**822,000**

South Outfall Additive Option 1

Treatment for Road Only

	Item	Quantity		Unit Cost	Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 6,000	$ 6,000
2	Treatment Vault (Filterra 4x4)	1	LS	$ 25,000	$ 25,000
3	Foundation Gravel	5	TN	$ 30	$ 150
4	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	50	LF	$ 125	$ 6,250
5	Flow Splitter MH	3	EA	$ 6,000	$ 18,000
6	Connection to Existing Structure	1	EA	$ 1,500	$ 1,500
7	Trench Excavation Safety Systems	1	LS	$ 2,000	$ 2,000
8	Trench Backfill	40	TN	$ 30	$ 1,200
	Subtotal				$ 60,100
	Contingency (30%)				$ 18,030
	Subtotal				$ 78,130
	TAX EXEMPT (RULE 171)				$ -
	Easement Acquisition (Temporary and Permanent)	400	SF	$ 10	$ 4,000
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	1	EA	$ 5,000	$ 5,000
	Total Construction Cost (Rounded)				**$ 88,000**

South Outfall Additive Option 2

Treatment for Entire Basin

	Item	Quantity		Unit Cost	Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 40,000	$ 40,000
2	Treatment Vault (Filterra 8x20)	3	LS	$ 120,000	$ 360,000
3	Foundation Gravel	45	TN	$ 30	$ 1,350
4	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	140	LF	$ 125	$ 17,500
5	Connection to Existing Structure	1	EA	$ 1,500	$ 1,500
6	Trench Excavation Safety Systems	1	LS	$ 2,000	$ 2,000
7	Trench Backfill	300	TN	$ 30	$ 9,000
	Subtotal				$ 431,350
	Contingency (30%)				$ 129,405
	Subtotal				$ 560,755
	TAX EXEMPT (RULE 171)				$ -
	Easement Acquisition (Temporary and Permanent)	2400	SF	$ 10	$ 24,000
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	2	EA	$ 5,000	$ 10,000
	Total				$ 594,755
	Total Construction Cost (Rounded)				**$ 595,000**

City of Lake Forest Park
Planning Level Cost Estimate
35th Avenue Drainage - Partial South Diversion & Replace Middle Outfall (Alt 4)
April 20, 2023

	Item	Quantity		Unit Cost		Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 53,000	$	53,000
2	Minor Changes	1	CALC	$ 10,000	$	10,000
3	Survey	1	LS	$ 5,000	$	5,000
4	Project Temporary Traffic Control	1	LS	$ 20,000	$	20,000
5	Clearing and Grubbing	1	LS	$ 12,500	$	12,500
6	Removal of Structure and Obstruction	1	LS	$ 18,000	$	18,000
7	Locate Existing Utilities	1	LS	$ 5,000	$	5,000
8	Bypass Storm Flow	1	LS	$ 10,000	$	10,000
9	Commercial HMA for Trench Patch	100	TN	$ 250	$	25,000
10	HMA Overlay	0	TN	$ 110	$	-
11	CPEP Storm Sewer Pipe, 12 In. Diam. (Incl. Bedding)	140	LF	$ 100	$	14,000
12	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	770	LF	$ 160	$	123,200
13	HDPE Storm Sewer Pipe, 16 In. O.D. (Incl. Bedding)	125	LF	$ 250	$	31,250
14	Catch Basin, Type 2, 48 In. Diam. (Basic to 8 ft)	10	EA	$ 5,500	$	55,000
15	Catch Basin, Type 1	4	EA	$ 4,000	$	16,000
16	Catch Basin Additional Height, 48 In. Diam (Over 8 ft)	0	VF	$ 300	$	-
17	Connection to Existing Structure	2	EA	$ 1,500	$	3,000
18	Concrete Anchor Block	1	EA	$ 10,000	$	10,000
19	Trench Excavation Safety Systems	1	LS	$ 15,000	$	15,000
20	Bank Run Gravel for Trench Backfill	1,760	TN	$ 35	$	61,600
21	Erosion Control and Water Pollution Prevention	1	LS	$ 8,000	$	8,000
22	Landscaping Restoration	1	LS	$ 20,000	$	20,000
23	Tree Replacement	2	EA	$ 500	$	1,000
24	Strean Buffer Restoration	1	LS	$ 20,000	$	20,000
25	Rolled Curb and Gutter	500	LF	$ 35	$	17,500
26	Cement Concrete Driveway Repair	80	SY	$ 150	$	12,000
27	Crushed Surfacing Base Course	150	TN	$ 45	$	6,750
28	Crushed Surfacing Top Course	90	TN	$ 55	$	4,950
29	Project Documentation	1	LS	$ 2,000	$	2,000
	Subtotal				$	579,750
	Contingency (30%)				$	173,925
	Subtotal				$	753,675
	TAX EXEMPT (RULE 171)					
	Easement Acquisition (Temporary and Permanent)	3150	SF	$ 10	$	31,500
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	2	EA	$ 5,000	$	10,000
	Total Construction Cost (Rounded)				**$**	**796,000**

South Outfall Additive Option 1

Treatment for Road Only

	Item	Quantity		Unit Cost	Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 6,000	$ 6,000
2	Treatment Vault (Filterra 4x4)	1	LS	$ 25,000	$ 25,000
3	Foundation Gravel	5	TN	$ 30	$ 150
4	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	50	LF	$ 125	$ 6,250
5	Flow Splitter MH	3	EA	$ 6,000	$ 18,000
6	Connection to Existing Structure	1	EA	$ 1,500	$ 1,500
7	Trench Excavation Safety Systems	1	LS	$ 2,000	$ 2,000
8	Trench Backfill	40	TN	$ 30	$ 1,200
	Subtotal				$ 60,100
	Contingency (30%)				$ 18,030
	Subtotal				$ 78,130
	TAX EXEMPT (RULE 171)				$ -
	Easement Acquisition (Temporary and Permanent)	400	SF	$ 10	$ 4,000
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	1	EA	$ 5,000	$ 5,000
	Total				$ 87,130
	Total Construction Cost (Rounded)				**$ 88,000**

South Outfall Additive Option 2

Treatment for Entire Basin

	Item	Quantity		Unit Cost	Total
1	Mobilization, Cleanup, and Demobilization	1	LS	$ 40,000	$ 40,000
2	Treatment Vault (Filterra 8x20)	3	LS	$ 120,000	$ 360,000
3	Foundation Gravel	45	TN	$ 30	$ 1,350
4	CPEP Storm Sewer Pipe, 18 In. Diam. (Incl. Bedding)	140	LF	$ 125	$ 17,500
5	Connection to Existing Structure	1	EA	$ 1,500	$ 1,500
6	Trench Excavation Safety Systems	1	LS	$ 2,000	$ 2,000
7	Trench Backfill	300	TN	$ 30	$ 9,000
	Subtotal				$ 431,350
	Contingency (30%)				$ 129,405
	Subtotal				$ 560,755
	TAX EXEMPT (RULE 171)				$ -
	Easement Acquisition (Temporary and Permanent)	2400	SF	$ 10	$ 24,000
	Fixed Costs for Easements (Negotiations/Agent/Survey/etc.)	2	EA	$ 5,000	$ 10,000
	Total				$ 594,755
	Total Construction Cost (Rounded)				**$ 595,000**