Hydraulic Report

Hills and Dales – Dean Lake Flood Mitigation Study

Prepared for

Kent County Drain Commissioner

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2200548

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1 INTRODUCTION

Flooding has been frequent in Plainfield Charter Township over recent years as rainfall has far exceeded historical averages. Specifically, the Hills and Dales neighborhood has been subject to local flooding. To the southeast, these significant volumes of rain have caused flooding of Dean Lake, which rose to 2.5 feet above the legal lake level. Currently, Dean Lake does not have a positive outlet to provide relief, so lake-front homes are at risk of flooding during such long periods of high rainfall.

This study served to analyze the capacity of the existing Hills and Dales County Drain to determine whether flow could be conveyed into the drain from the Hills and Dales neighborhood as well as from Dean Lake. The Drainage District is shown in Map 1 along with Dean Lake and the Hills and Dales neighborhood tributary areas.

2 HILLS AND DALES NEIGHBORHOOD FLOOD MITIGATION

2.1 History

The sub-division area commonly referred to as the Hills and Dales neighborhood was developed in the early 1950's. The neighborhood encompasses approximately 135 acres and is bounded by Woodworth Street and Westwood Drive on the south, Hunsberger Avenue on the east, Woodbury and Ambrose Avenues on the west, and Northview Public Schools property on the north. The original drainage system for the neighborhood was constructed as a series of roadside ditches and driveway culverts that acted as an in-place leaching system, but it had no positive outlet.

Over the decades, the roadside ditches have filled in with yard waste, leaves, sand, and gravel, all of which have reduced or eliminated the off-road infiltration capacity. This has led to more on-road flooding even during the short-duration, higher-intensity rainfall events that previously may have been handled adequately in the off-road ditches. In several areas, leaching/infiltration basins have been constructed in an effort to restore drainage capacity. See Map 2 for the location of existing leaching basins. These basins can provide relief during low-intensity rain events, but they can quickly become overwhelmed during heavy rains. And they require regular maintenance to maintain drainage capacity.

2.2 Problem

Because there is no positive storm water drainage outlet for this neighborhood, multiple areas continue to flood during heavy rain events. There are two types of drainage problem areas in the neighborhood: 1) Larger/deeper "pothole" areas, where the low point could be five feet or more below a positive outlet and houses are located below any potential outlet; and 2) smaller areas where loss of roadside ditches causes minor ponding primarily in the road but possibly in garages. Both types of drainage problems were investigated in this study, with improvements to address all identified problem areas.

2.3 Analysis

A field topographic survey was conducted in areas of known or potential flooding. The survey consisted of identifying locations and elevations of low points, elevations of potential overflow points (and the resultant depth of flooding), and elevations of houses or other structures that could be impacted by flooding. The survey also located all existing storm sewer facilities in the neighborhood.

Using this survey information, potential storm sewer outlets were identified for the various problem areas. For the flooding areas south of Eldon, the outlet alternatives primarily centered around extending storm sewer branches northward from the existing Hills and Dales County Drain storm sewer in Westwood Drive. For the flooding areas near Eldon Street, a deeper trunk storm sewer was analyzed due to the deeper "pothole" areas that would need to be served.

2.4 Improvement Alternatives

Three alternatives were developed to mitigate the flooding in the Hills and Dales Neighborhood. The first two included construction of storm sewers to collect and convey the runoff to the Hills and Dales Drain. The third option is the construction of leaching systems in the local areas of flooding.

2.4.1 Conveyance System

See Map 3 for the layout of storm sewer improvement projects that would be necessary to provide drainage relief for the flooding areas.

Drainage improvements in the north "half" of the neighborhood would be extensive projects to address the several low "pothole" areas. The project (labeled Project #1a/#1b – Eldon Trunk) would consist of a larger diameter trunk storm sewer along Huntington Avenue and Eldon Street. It would also include several branch sewers to pick up low areas north and south of Eldon in Costa, Bell, and Lester Avenues. Two alternatives exist for the Eldon Trunk project. The first alternative is a shallower trunk sewer – at most 17 feet deep – that would serve all areas except the lowest area in Bell Avenue north of Eldon Street. The second alternative is a much deeper trunk sewer that would be designed to provide a positive outlet for all the low areas, including the lowest elevation area in Bell Avenue north of Eldon Street. This would require storm sewer as much as 27 feet deep; comparatively this would be 4-10 feet deeper than the existing sanitary trunk sewer in Eldon Street.

Storm sewer improvements in the south "half" of the neighborhood generally are simpler infrastructure projects that could be constructed in conjunction with Plainfield Charter Township's other planned water and wastewater system capital improvements. These projects consist of the following:

1. Project #2: Providence Street and Chadwick Avenue. Approximately 400 LF of 12-inch storm sewer in Providence Street from just east of Chadwick to a new outlet into Ambrose Pond, plus approximately 100 LF of 12-inch storm sewer in Chadwick from Providence to the north.

2. Project #3: Hillsdale Avenue. Approximately 700 LF of 12-inch storm sewer from Westwood Drive to the low point just south of Providence Street.

3. Project #4: Costa Avenue. Approximately 600 LF of 12-inch storm sewer from Westwood Drive to the low point south of Providence Street.

4. Project #5: Lester Avenue. Approximately 980 LF of 12-inch and 18-inch storm sewer from Westwood Drive to the low point just north of Providence Street.

These storm sewers have been sized to convey the 10-year event without surcharging the pipe. This approach will significantly reduce the potential for and frequency of flooding in these new collection areas.

2.4.2 Leaching System

A less costly alternative to reduce the flooding potential is a leaching system, which could include leaching basins or an underground leaching system. These types of mitigation provide relief for smaller flood events, but surface flooding can remain for extended periods for larger storm events.

There are primarily 8 areas of local flooding that could be addressed as shown on Map 2. Each of these areas was analyzed for both a 1-inch (1") and a 1-year event to determine the needs of the leaching system to collect runoff. Table 1 provides the results. This shows that an underground system would not be prudent to provide mitigation for even a 1-year event.

Table 1: Leaching System Needs

Location #	Tributary Area (acres)	1-inch Stormwater Volume			1-yr Stormwater Volume		
		Volume of Runoff (cu ft)	***No. of Leaching Basins [1]***	***Length of Storage Unit [2]***	***Volume of Runoff (cu ft)***	***No. of Leaching Basins [1]***	***Length of Storage Unit [2]***
1	0.17	134	2	11	267	3	21
2	4.82	3,476	35	277	7,754	78	617
3	4.63	3,342	34	266	7,486	75	596
4	2.22	1,604	16	128	3,609	36	287
5	2.47	1,738	18	138	4,010	40	319
6	3.57	2,540	26	202	5,748	58	457
7	2.04	1,471	15	117	3,342	34	266
8	2.48	1,738	18	138	4,010	40	319

[1] – Number of Leaching basins needed for no surface flooding based on 4' diameter and 8-foot deep basin.

[2] - Length of 48" perforated storage piping unit for no surface flooding.

3 DEAN LAKE FLOOD MITIGATION

3.1 History

Dean Lake is an roughly 100-acre lake located primarily in Plainfield Charter Township, southeast of the previously mentioned Hills and Dales neighborhood. There are approximately 100 homes adjacent to the lake, with all or nearly all the residents living there year-round.

Dean Lake has a tributary area of approximately 377 acres. There is no outlet to provide relief from high water levels; therefore, the lake level fluctuates based on weather patterns. In fact, an augmentation well was installed decades ago to pump water into the lake during dry periods. Dean Lake does, however, have a legal lake level of 706.2 feet (NAVD88), which is to be maintained.

3.2 Problem

In the past 5 years, annual rainfall in western Michigan exceeded maximum recorded levels, including four of the highest recorded annual rainfall volumes in history as shown in Figure 1 (NOAA). Figure 2 shows the most recent cumulative 5-year rainfall volume far exceeds any previous successive 5-year period going back 120 years. As a result, many lakes in the area that do not have an outlet rose to flood levels. Dean Lake was one of those lakes, rising more than 2.5 feet above the legal lake level.

3.3 Analysis

Our analysis of the conditions at Dean Lake was completed to ascertain the hydrogeologic conditions and develop a mitigation action plan.

Regular water level data was collected for Dean Lake starting April 22, 2020 when the lake surface was at flood levels. Measurements were taken every few days at the outset and less often as summer season conditions saw the lake levels drop. The measurements were taken between one and 10 days apart and show the peak water level at 708.8 feet (NAVD88), or 2.6 feet above the legal lake level. Field data is provided in Figure 3, including two data points from past years that show normal levels back in 2015 and rising levels in 2019 before the peak water levels in 2020.

Fortunately, the dry summer season conditions caused the lake level to drop to 708.0 feet (NAVD88) by the end of August 2020, and the fall precipitation has been less than the average for this area.

3.3.1 Water Budget

To model the expected water levels based on typical water cycle components, a water budget was developed. The Pierce 2003 Water Budget Spreadsheet is based on Hydrology for Constructed Wetlands© 1993 by Gary J. Pierce. This was developed at the Wetland Training Institute, Inc., Poolesville, MD (WTI 93-2).

The Pierce 2003 Water Budget estimates the water levels based on rainfall, temperature, latitude, infiltration, evapo-transpiration, and groundwater flow. The Soil Conservation Service Curve Number Methodology was used to estimate runoff. Historical data was used to calibrate parameters, and the spreadsheet model was used to project water levels based on weather data.

3.3.2 Confirmation/Calibration

The Pierce 2003 spreadsheet model was developed, and model data were compared to field data. By estimating expected water levels based on typical water cycle components, a water budget was developed. The spreadsheet model was developed with the starting water level set to approximately the level in April 2020 when water level monitoring began in earnest. The spreadsheet uses monthly totals, so the approximate water level is estimated monthly. Figure 4 shows that the Pierce 2003 spreadsheet model tracks the actual lake levels very consistently with calibration.

3.3.3 Pumping Impacts

Because there is no positive outlet for Dean Lake, this study was tasked with evaluating the impact of pumping out of the lake when the lake is at higher-than-normal levels. Using the Theis Equation, drawdown was simulated for pumping at various rates. Many assumptions were made including conductivity, porosity, and aquifer thickness to estimate the drawdown over time. Recharge will enter the lake from higher gradient groundwater as water is pumped out of the lake.

Figure 5 shows the approximate lake level drop over time if the pumps were operated now with average rainfall over the tributary area. The pump setting will allow for operation when the pump exceeds the legal lake level nominally and is still significantly below flood stage. Pumps capacities of 200 gpm, 400 gpm, 600 gpm, and 1000 gpm were considered and are shown in Figure 5.

3.4 Improvement Alternatives

Flood mitigation alternatives were considered to minimize the risk of flooding the structures on Dean Lake. The alternatives are limited based on the site conditions. Options include the following:

1. Pump to Stream or Drain – Capacity must be available to carry the flow.
2. Gravity Outlet – Not financially feasible based on the elevation of the lake. Deep sewer would need to be constructed over some of the 2.3 miles of gravity storm sewer.
3. Pump and Haul – Not financially feasible. This requires 100 loads per day continuously a week in a 5,500-gallon tanker truck to drop the levels 1 inch.
4. Pump into Sanitary Sewer – Not financially feasible. All water would be treated at the Clean Water Plant, and also would reduce the available capacity in the sewer system.

Alternative 1 is the only feasible alternative. This option requires a SMART System to limit pumping to periods when the water level in the County Drain is at a base flow rate and capacity is available in the drain. The depth could be monitored near the discharge into the drain.

Several forcemain and discharge locations were considered as shown in Map 4. The recommended alternative is to discharge to the Hills and Dales Drain at Plainfield and Vineyard, which is the closest outlet and is a County Drain that extends to the Grand River. There is an open lot, owned by Plainfield Charter Township, that the County Drain Commissioner's office potentially could acquire, or an easement could be obtained. This lot provides access to the lake on the west side of Dean Lake at the intersection of Miramar Avenue and Dade Street.

3.4.1 Pump Station and Forcemain

Flood mitigation would include pumping from Dean Lake through approximately 2,650 feet of forcemain to the Hills and Dales Drain at the intersection of Plainfield Avenue and Vineyard Avenue. The pump station and forcemain would need to be under public ownership as part of the lake level (Part 307) for Dean Lake because the Kent County Road Commission will not permit a private utility for the lake in the public road right-of-way.

System curves were developed for various size forcemains to size the pump. These are provided in Figure 6. Based on the projections provided by the water budget for a design of back-to-back 100-year annual rainfall volumes, the pump should be rated for at least 400 gpm. From the system curves, we performed a cost-benefit analysis for four (4) pumping rate options. The following table provides the expected time for lake lowering for different flow rates, and the associated cost of each option.

Table 2: Cost Benefit Analysis for Dean Lake Pumping

Alternatives	Pumping Rate (gpm)	Estimated Pump TDH (ft)	Forcemain Diameter (in)	Lake Drawdown (days per inch of drawdown) [1]	Opinion of Cost [2] Pump Station & Forcemain
1	200	100	4	16	$ 860,000
2	400	62	6	7	$ 890,000
3	600	45	8	5	$ 920,000
4	1,000	70	8	3	$940,000

[1] – Drawdown assumes average rainfall, evaporation, runoff. Based on first 12 inches using Theis Method.
[2] – Includes SMART Monitoring System. Operation Cost are relatively insignificant.
[3] – These estimates are based on many assumptions and should be considered very approximate. Also, it is important to note that the pumps must continue to operate to maintain the drawdown level – some recharge will likely occur when the pump stops operating.

It is important to note that pumping from Dean Lake is a flood mitigation measure. That is, the lowered lake level achieved during pumping protects personal property and provides time for the site weather conditions to improve, thereby lowering the recharge rate. If the water balance continues on the same trend (e.g., high precipitation), the lake level will rise again when the pump is turned off due to groundwater recharge from a higher gradient. The pumps lower the lake level when operating, similar to the cone of influence of a well, but recharge will occur when the pumps are turned off. As a result, the impact of pumping on the water levels is a few inches to fractions of an inch over a month.

3.4.2 Temporary Pump Station and Forcemain

One alternative to potentially reduce the flood mitigation costs is to purchase or rent a portable pump rather than construct a more costly permanent pump station. This was considered simply because of the unknown need for pumping in the future. History indicates that rainfall patterns fluctuate, thus the pumping station may sit idle for many years.

The selection of a solution is dependent on priorities. To help with that determination, cost estimates were prepared for each of the three pump alternatives. To enable a comparison among constructing a permanent pump station, owning a portable pump, or renting a portable pump, a 50-year present value calculation was prepared. The results are provided in Table 3 with details in Appendix C.

Table 3: Opinion of Costs for Pumping Alternatives

Alternatives	Capital Costs: Pump & Forcemain[2]	Operation and Maintenance Costs[3]	Upgrade Costs[4]	50-Year Present Value[1]
Permanent Pump Station	$ 940,000	$ 3,200	$190,000	$ 1,130,000
Purchase Portable Pumps[5]	$ 550,000	$ 23,800	$ 40,000	$ 1,100,000
Rent Portable Pumps[5,6]	$ 380,000	$ 26,100	$ 0	$ 940,000

1 – Costs represent a 50-year present value, which covers the life cycle for the pumps. It also assumes an average of 8 weeks of continuous pumping annually.
2 - Forcemain and pump sizing based on operate at a rate of 1,000 gpm through an 8-inch forcemain.
3 – Operation and Maintenance Costs include electrical or diesel fuel costs, labor and mileage for daily checks, insurance, and rental costs.
4 – Includes pumps as well as electrical/controls.
5 – Includes sound dampening.
6 – Capital costs for the forcemain, suction piping and screen; O&M costs include the rental costs.

This information is then incorporated into the table comparing the advantages and disadvantages of the three options. Table 4 presents these pros and cons for each alternative.

Table 4: Pros and Cons of Dean Lake Pumping Alternatives

Permanent Pumping Station	Purchase Portable Pump[1]	Rent Portable Pump[1]
Own Pump	Own Pump	Do Not Own Pump
Higher Initial Capital Cost[2]	Lower Initial Capital Cost[3]	Lowest Initial Capital Cost[4]
No Periodic Rental Fees	No Periodic Rental Fees	Periodic Rental Fees[5]
High O&M Needs[6]	Periodic O&M Needs[7]	No Maintenance Needs[8]
Fully Automated	Minimal Automation - Owner Monitoring & Operation	Minimal Automation
Electric Powered	Diesel Powered	Diesel Powered
SMART System	Manual Tracking of Storms	Manual Tracking of Storms
Negligible Sound	Minimal Sound w/ Enclosure	Minimal Sound w/ Enclosure

1 – Trailer-Mounted Portable Pump
2 – Includes permanent pumping station costs and forcemain costs.
3 – Includes trailer mounted pumps, suction piping and screen, and forcemain costs.
4 – Includes forcemain, suction piping and screen costs.
5 – Rental costs are substantial but are emergency event based only. This is most cost effective if needed less frequently and least cost effective if needed more frequently.
6 – Pump Station must be operated monthly and maintained by owner.
7 – Pump must be maintained by owner.
8 – Rental Supply Company performs Maintenance Activities. Owner provides operation activities.
9 – SMART system determines if the pipe is empty. Manual tracking requires manually shutting down pumps when rain begins.

4 HILLS AND DALES DRAIN

The existing Drainage District is in Kent County on the north side of the City of Grand Rapids as shown on Map 5. Dean Lake is located near 4 Mile Road just southeast of the Hills and Dales Drain. This Drain conveys stormwater to the west through conduit and then open channel, discharging into the Grand River.

The existing tributary area at the outlet into the Grand River is approximately 0.57 square miles. The drain is approximately 2.9 miles long with 1.9 miles of conduit (2 branches) discharging into 1.0 mile of open channel.

The analysis of the system capacity was limited to the enclosed conduit portion of the drain. The downstream open channel is not be the limiting factor for the 10-year event and thus was not analyzed.

Pipe data were obtained from Regional Geographic Information System (REGIS). Data included pipe diameter, pipe length, and inverts. No survey data was available for Dean Lake or Ambrose Pond. Lake area was estimated using 2-foot contours available in REGIS. The sewer layout and ponds are shown in Map 5.

4.1 Capacity Analysis

A detailed analysis of the Hills and Dales Drain was completed to determine the available capacity in the drain based on a Level of Service, both with and without the addition of flow from the Hills and Dales Neighborhood.

Storm sewer flows were simulated using InfoSWMM®, a hydrologic and hydraulic modeling software. The program's core analysis tool is the Storm Water Management Model (SWMM), originally developed for the United States Environmental Protection Agency and later refined with commercial software improvements and extensions. The storm sewer system model was developed based on the Township's Geographic Information System (GIS) database with elements for all pipes, open drains, catch basins, manholes, and detention ponds. The model was populated with the physical properties of those system components such as:

- pipe diameter, material, and slope
- manhole rim and invert elevations
- open drain and pond characteristics

The model layout is shown in Appendix A.

This study utilized the Modified Horton method to model infiltration and the EPA SWMM method to model runoff. The National Oceanic and Atmospheric Administration (NOAA) Atlas 14 precipitation frequency estimates were applied to simulate design storm events.

4.1.1 Standards

In evaluating the capacity of the system, three common Level of Service goals were utilized:

1. 5-year storm – 100% in-pipe conveyance with no pipe surcharging
2. 10-year storm – Pipe surcharging allowed but no surface flooding

3. 25-year storm – Pipe surcharging allowed but no surface flooding greater than 30 minutes.

Evaluation of the existing infrastructure is based on meeting the Level of Service goals. However, sizing of new storm sewer exceeds the Level of Service goals and is based on no surcharging of the storm sewer during a 10-year event. The hydraulic model is also used to evaluate the remaining capacity in each pipe during the 10-year storm event. Any recommended improvements must meet this standard as well as ensure no adverse impact on any property owner downstream.

4.1.2 Results for Existing Conditions

The hydraulic analysis evaluates the 5, 10, and 25-year storm events. Peak flows were estimated using the model and are summarized at various locations for different events in Table 5.

Table 5: Peak Flows in Hills and Dales Drain

Location	Contributing Tributary Area (ac)	50% Frequency (cfs)	10% Frequency (cfs)	4% Frequency (cfs)	1% Frequency (cfs)
Fuller Avenue	248.3	33.7	53.1	66.8	111.2
Benjamin Avenue	217.4	23.3	37.8	48.4	59.9
Mayfield Avenue	145.2	19.6	33.1	36.2	45.1
Woodworth Branch					
Ambrose & Woodworth	65.3	116.3	157.5	188.9	235.4
Costa & Woodworth	30.9	66.3	77.3	83.2	98.9
Hunsberger & Westwood	13.1	16.0	19.3	23.1	35.6
Hunsberger & Plainfield	5.3	12.4	13.6	13.7	13.9
Westwood Branch					
Lindberg & Westwood	32.2	15.6	23.6	30.9	35.3
Costa & Westwood	21.4	10.3	15.9	20.6	29.0
Bell & Westwood	10.5	5.1	8.0	14.0	33.6

The analysis determined where surface flooding and hydraulic restrictions are likely to occur during rain events of various intensities. The 5-year, 10-year and 25-year design storms represent events of specified rainfall depth and return frequency (e.g. a 5-year design storm has a 20% chance of occurring in any given year). The model output was used to generate Level of Service (LOS) maps based on storm events with various return intervals (5, 10, and 25), as seen from Maps 6, 7 and 8. These maps show the maximum flow versus the full flow capacity of each pipe, identifying capacity limitations and surface flooding duration.

Results show Level of Service results for various events are all within the acceptable limits under existing conditions for the drain. Some tributary storm sewers do exceed Level of Service goals.

Table 6: Existing Level of Service Results

Drain Location	5-Year Surcharging	10-Year Surface Flooding	25-Year Flooding Duration
Fuller Avenue	No	No	none
Benjamin Avenue	No	No	none
Mayfield Avenue	No	No	none
Woodworth Branch			
Ambrose & Woodworth	No	No	none
Costa & Woodworth	No	No	none
Hunsberger & Westwood	No	No	none
Plainfield & Hunsberger	Yes	No	none
Westwood Branch			
Lindberg & Westwood	No	No	none
Costa & Westwood	No	No	0 – 15 Minutes
Bell & Westwood	No	No	none

4.1.3 Results with Additional Hills and Dales Neighborhood Flows

Simulations were performed with the addition of stormwater from the Hills and Dales neighborhood that is not currently collected. Map 9 shows the flooding duration in the system with the recommended storm sewers in place.

The hydraulic analysis evaluates the 5, 10, and 25-year storm events. With these results, the Level of Service parameters were compared as shown in Table 7.

Table 7: Level of Service Results with Recommendations in Hills & Dales Neighborhood

Drain Location	5-Year Surcharging	10-Year Surface Flooding	25-Year Flooding Duration
Fuller Avenue	No	No	none
Benjamin Avenue	No	No	none
Mayfield Avenue	No	No	none
Woodworth Branch			
Ambrose & Woodworth	No	No	none
Costa & Woodworth	No	No	none
Hunsberger & Westwood	No	No	none
Plainfield & Hunsberger	Yes	No	none
Westwood Branch			
Lindberg & Westwood	No	No	none
Costa & Westwood	No	No	15 – 30 Minutes
Bell & Westwood	No	No	none

The analysis also compared the water surface elevation for each of these events at various locations:

Table 8: 10-Year Floodplain Elevations: Existing and with Recommended Improvements

Intersection	Distance (ft)	Invert Elevation (ft)	Existing WSEL (ft)	Proposed WSEL with H&D addition (ft)	Difference in WSEL (ft)
Fuller, south of Woodworth	720	658.96	662.00	662.12	0.12
Benjamin, South of Woodworth	1,480	660.23	663.05	663.21	0.16
Woodworth & Mayfield	2,950	663.10	665.37	665.50	0.13
Ambrose Pond	3,770	660.00	666.82	667.00	0.18

Note: 1. WSEL = Water Surface Elevation
2. Distance represents the length from the conduit outlet of Hills and Dales Drain. The Drain further extends via open channel to the Grand River.

The analysis indicates that the addition of stormwater flow from the northern Hills and Dales neighborhood does not adversely impact the system, meeting Level of Service objectives in the drain and only minimally increasing the water surface elevations.

4.1.4 Results with Additional Dean Lake Flows

The Hills and Dales Drain operates at base flows most of the time (99% frequency). The design of the pump station includes only operation when the drain is at base flows. These will be monitored and used to automatically stop and start the pump.

Thus, the drain will be "activated" more frequently during long periods of high rainfall, but the capacity of the drain will not be impacted at all by the addition of flow from Dean Lake.

5 COST OPINIONS

An Opinion of Project Costs has been prepared for both the storm sewer additions in the Hills and Dales neighborhood as well as a Dean Lake Flood Relief Pump Station. Costs for projects of similar size and scope that have been constructed in west Michigan were reviewed for relevant information.

The Cost Opinions have been prepared including an allowance of approximately 30% above the estimated construction cost. This allowance is intended to include the cost of construction contingencies (issues which are presently unknown), legal fees, engineering design and construction services (including preliminary and final design, soil borings, topographic survey, bidding assistance, construction staking, compaction testing, construction inspection and project administration during the entire project) and administrative expenses related to the project. It has been assumed that land is available for construction of the described improvements.

Cost Opinions for recommended projects are included in Table 9. Detailed Estimates of Probable Cost for each project can be found in Appendix B.

Table 9 - Cost Opinions for Recommended Projects

Project	Project Description	Opinion of Cost
A	Hills and Dales Neighborhood Storm Sewer	
	Project 1a – 4,340 LF of 12-inch to 42-inch Storm Sewer	$1,450,000
	OR	
	Project 1b – 4,870 LF of 12-inch to 42-inch Storm Sewer	$2,096,000
	Project 2 – 700 LF of 12-inch & 18-inch Storm Sewer	$106,000
	Project 3 – 700 LF of 12-inch Storm Sewer	$113,000
	Project 4 – 600 LF of 12-inch Storm Sewer	$134,000
	Project 5 – 980 LF of 12 & 18-inch Storm Sewer	$180,000
B	Dean Lake Flood Relief Pump Station	
	Alt 1 – 1,000 gpm Permanent Pump Station on Dean Lake near Miramar Ave with 2,650 LF of 8-inch HDPE Forcemain	$1,130,000[3]
	Alt 2 – 1,000 gpm Portable Pump on Dean Lake (purchased) near Miramar Ave with 2,650 LF of 8-inch HDPE Forcemain	$1,100,000[3]
	Alt 3 – 1,000 gpm Portable Pump to be rented when needed. Also, with 2,650 LF of 8-inch HDPE Forcemain	$940,000[3]

Notes:
1. Opinion of Cost includes 30 percent allowance for legal and administrative costs, engineering and contingencies.
2. The Opinion of Cost is based on current dollars.
3. 50-Year Present Value costs (see Appendix B for more details)

6 CONCLUSIONS

This report has addressed flooding issues in the Hills and Dales neighborhood and at Dean Lake. The Hills and Dales neighborhood has localized flooding which Plainfield Charter Township would like to mitigate. In addition, several years of high annual rainfall has caused Dean Lake to exceed the legal lake level by more than 2.5 feet.

Based on this evaluation, the solution to mitigate the flooding in the Hills and Dales neighborhood is to direct the flood flows to the Hills and Dales Drain. The Drain was determined to meet level of service objectives for the 5-year, 10-year and 25-year rainfall events in the drain. The addition of flow from the Hills and Dales neighborhood area is attenuated by Ambrose Pond and has a minimal impact on peak drain flows and water surface elevations. As a result, the level of service objectives for the 5-year, 10-year and 25-year are all still met with the addition of the stormwater from the neighborhood.

The Dean Lake flooding concerns are due to rainfall exceeding average annual volumes for multiple years. To limit the flooding potential, Dean Lake could install a pumping system which discharges into the Hills and Dales Drain. This pump would operate continuously, except when rain events occur. Three options were considered for pumping.

Thus, to summarize:

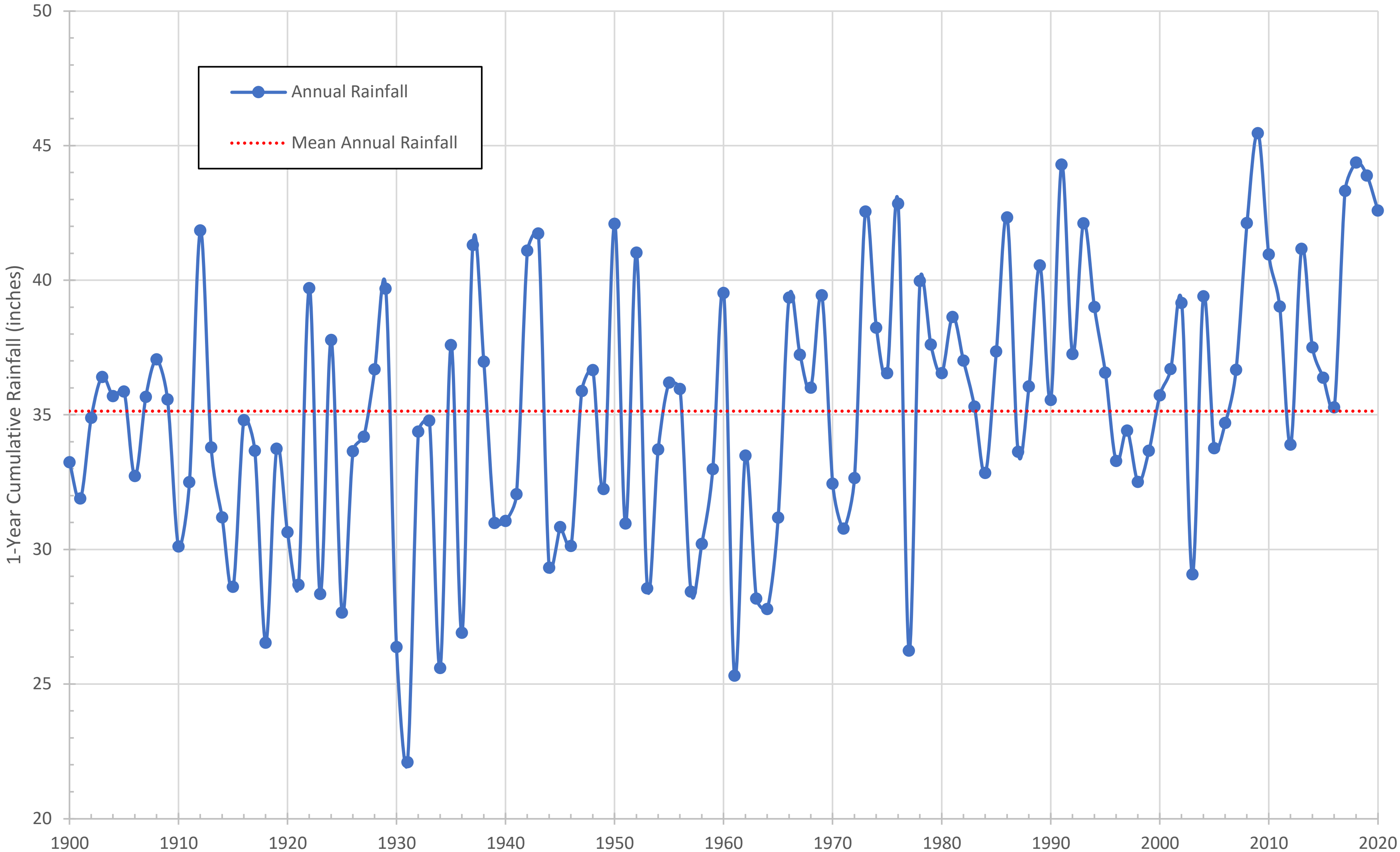
1. New storm sewer could be constructed in the Hills and Dales neighborhood to reduce the frequency of localized flooding. Alternatively, a leaching system could be constructed in multiple areas at lower cost than a gravity outlet, but such a system would provide minimal benefit except for very small rain events.

2. A pump station could be constructed to provide emergency relief for Dean Lake flooding while not operating during rain events. Three alternatives were evaluated: (1) a permanent station, (2) portable pumps owned by the Kent County Drain Commissioner, and (3) portable pumps rented when flooding exists. It is important to understand that pumping from Dean Lake is a flood mitigation measure. The lowered lake level achieved during pumping protects personal property and provides time for the site weather conditions to improve, and consequently reduces the recharge rate. If the water balance continues as before (high precipitation), the lake will rise when the pump is turned off due to groundwater recharge.

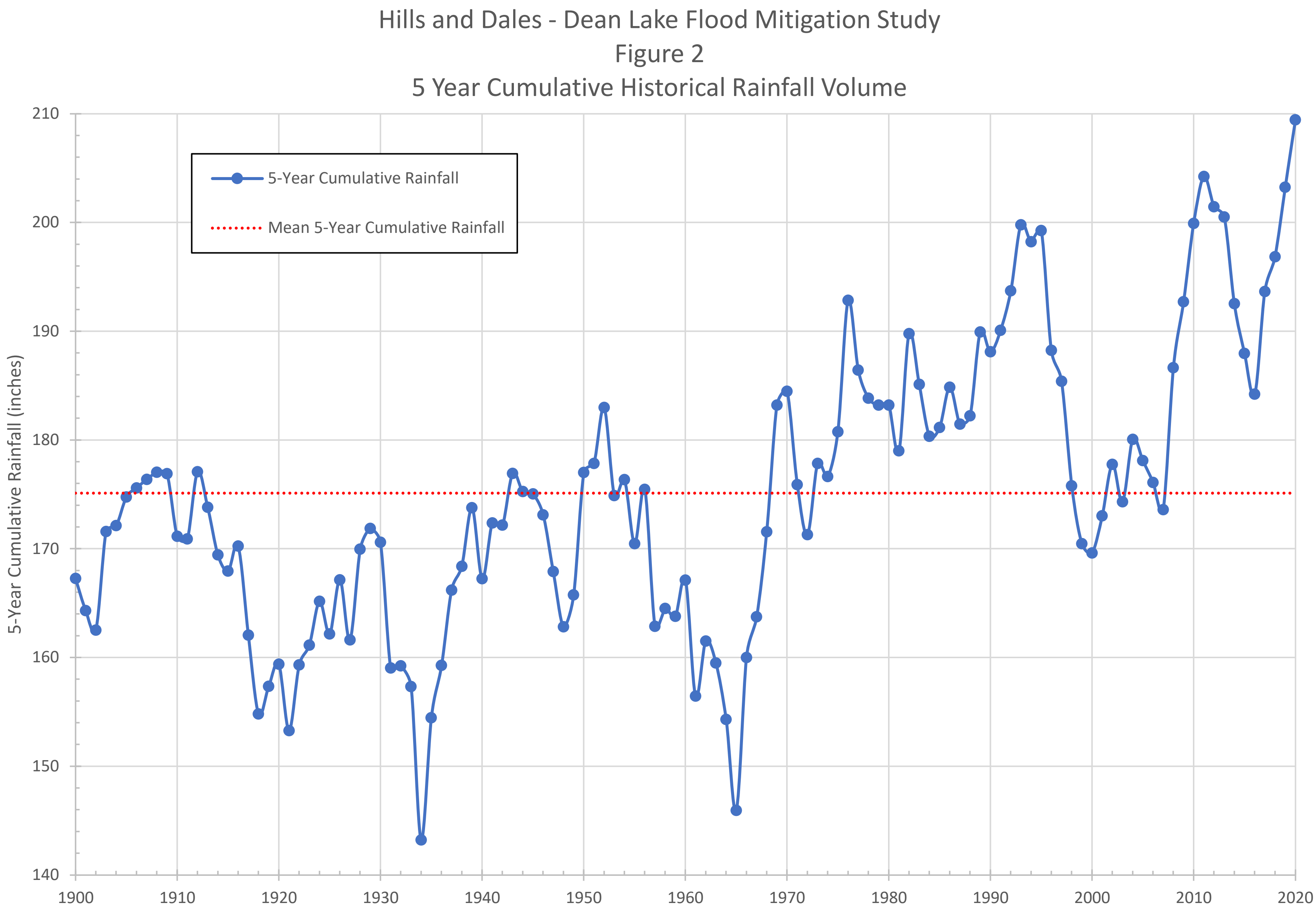
3. The Hills and Dales Drain has the capacity to convey the 10-year flood without surface flooding and meet all Level of Service objectives. The proposed recommendations have been designed to have no adverse impact downstream.

Figures

Hills and Dales - Dean Lake Flood Mitigation Study
Figure 1
Historical Annual Rainfall Volumes

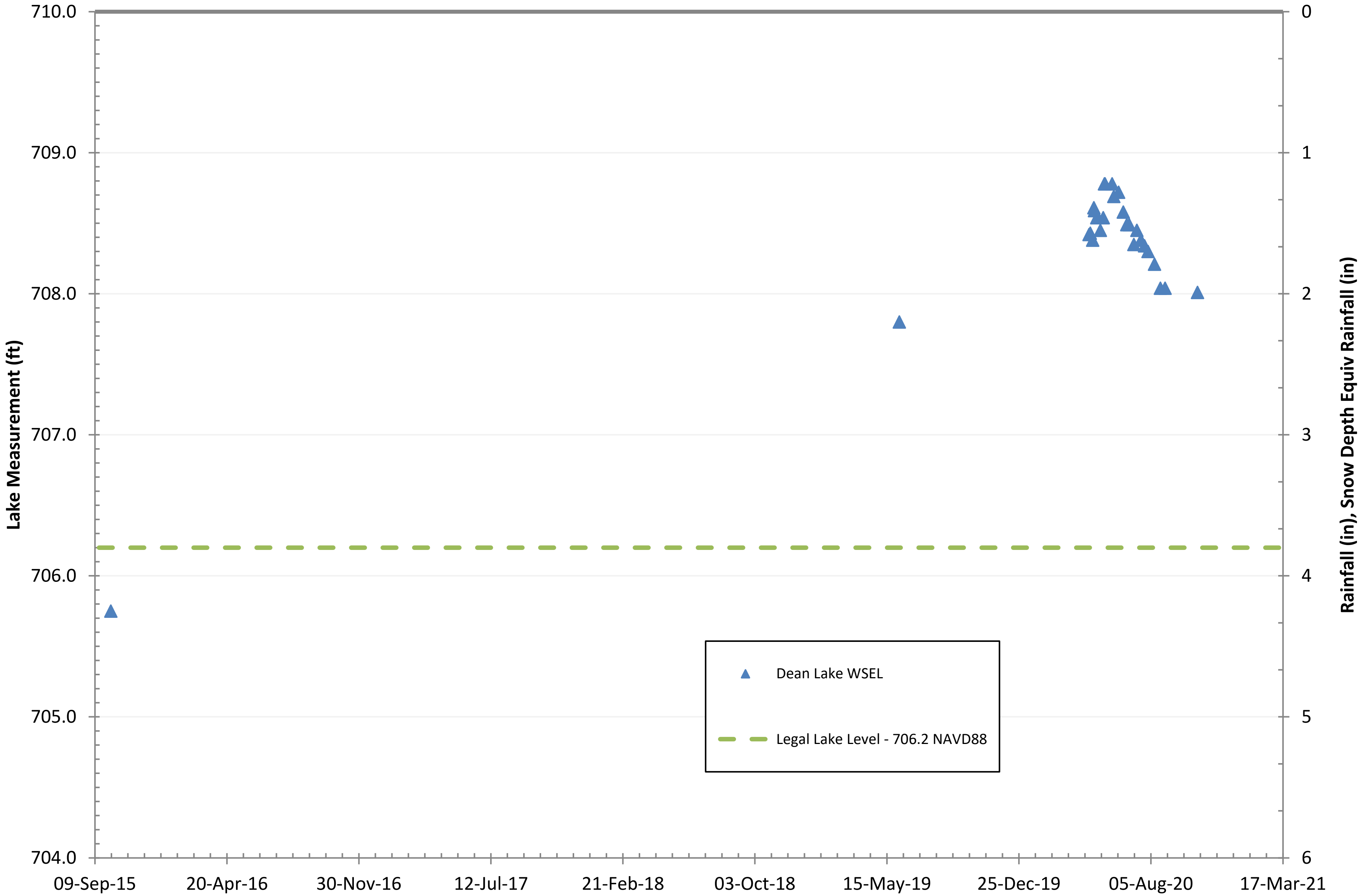


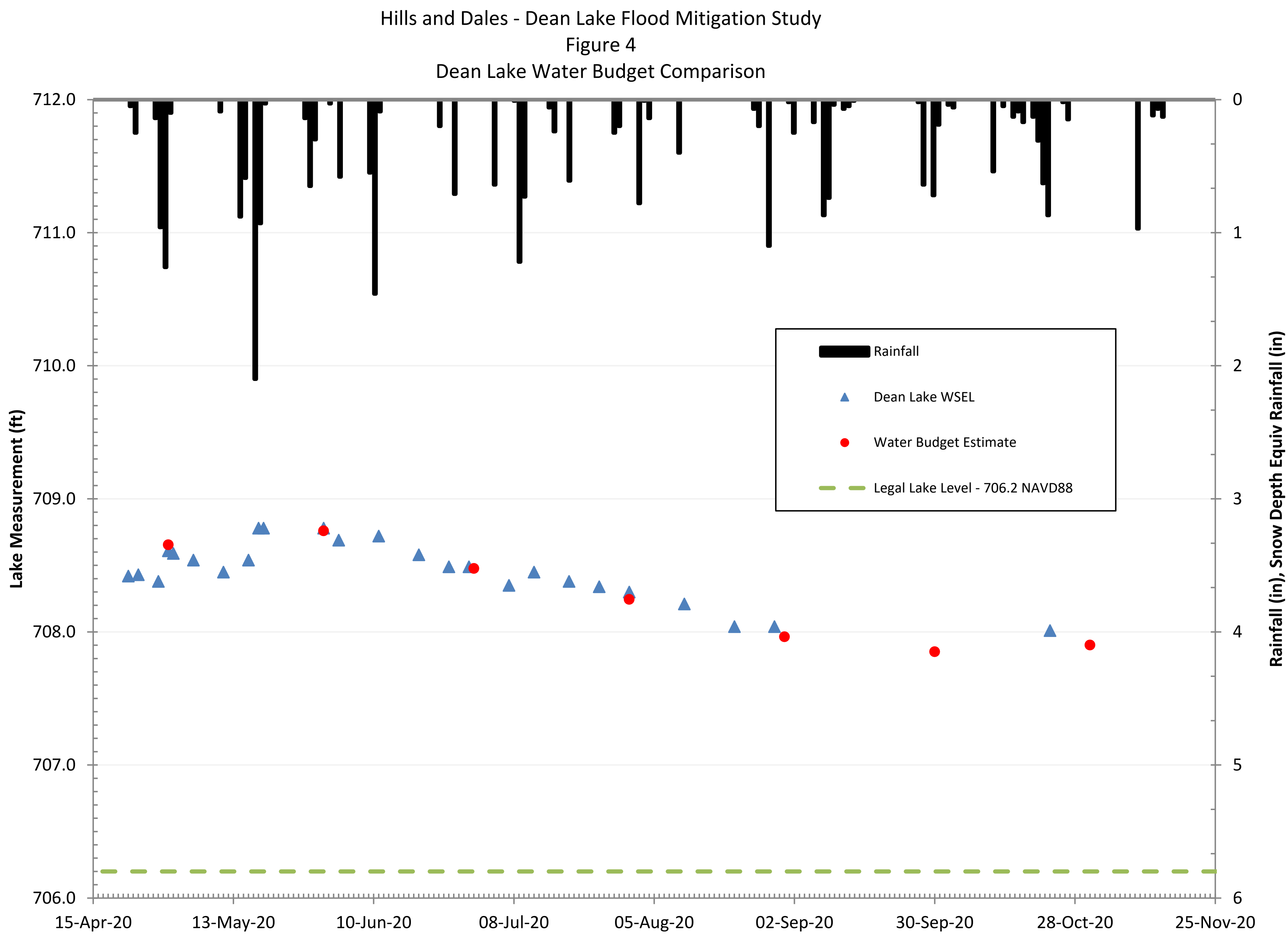
Source: NOAA National Centers for Environmental Information for Lower Southwest Michigan

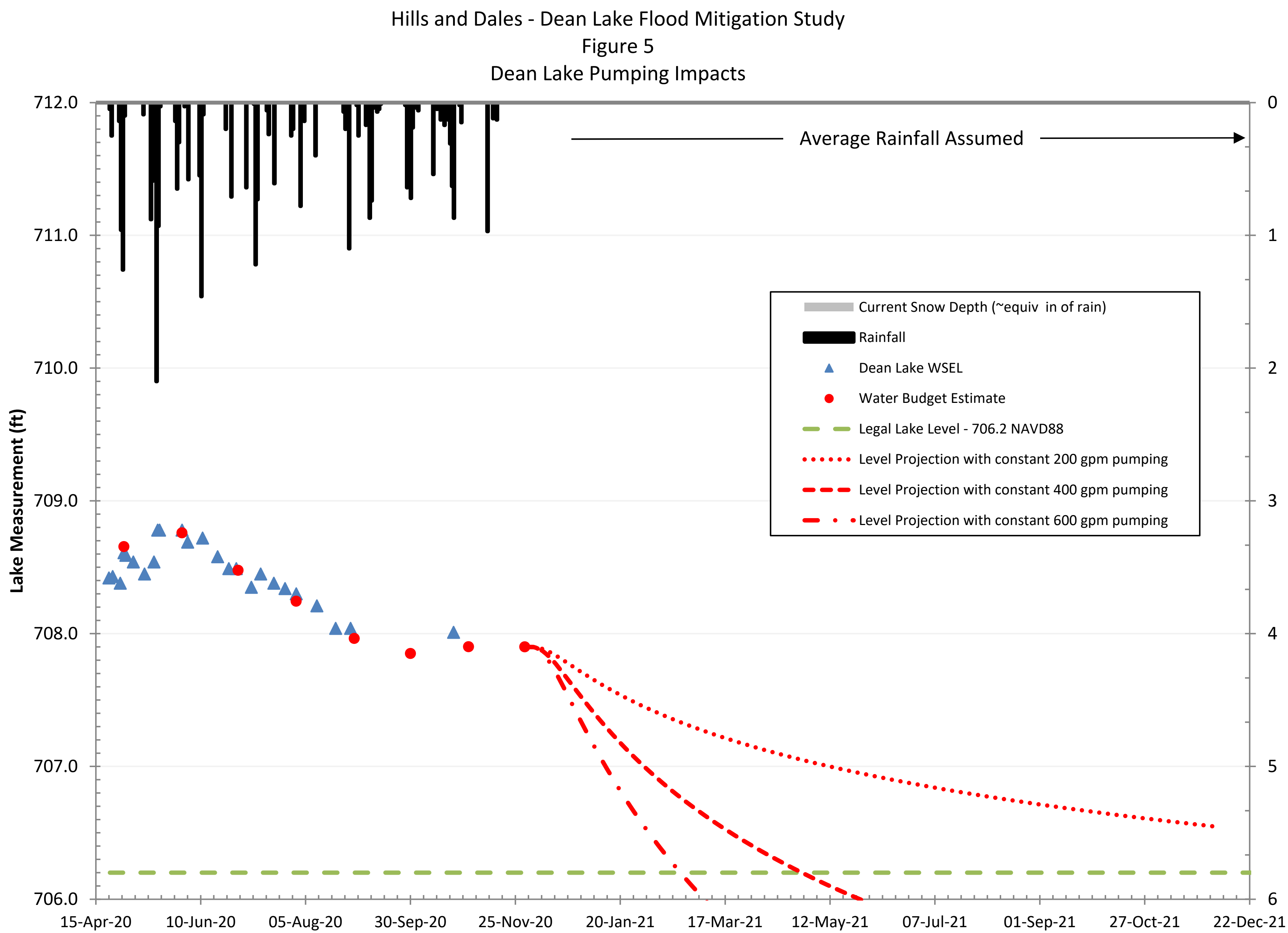


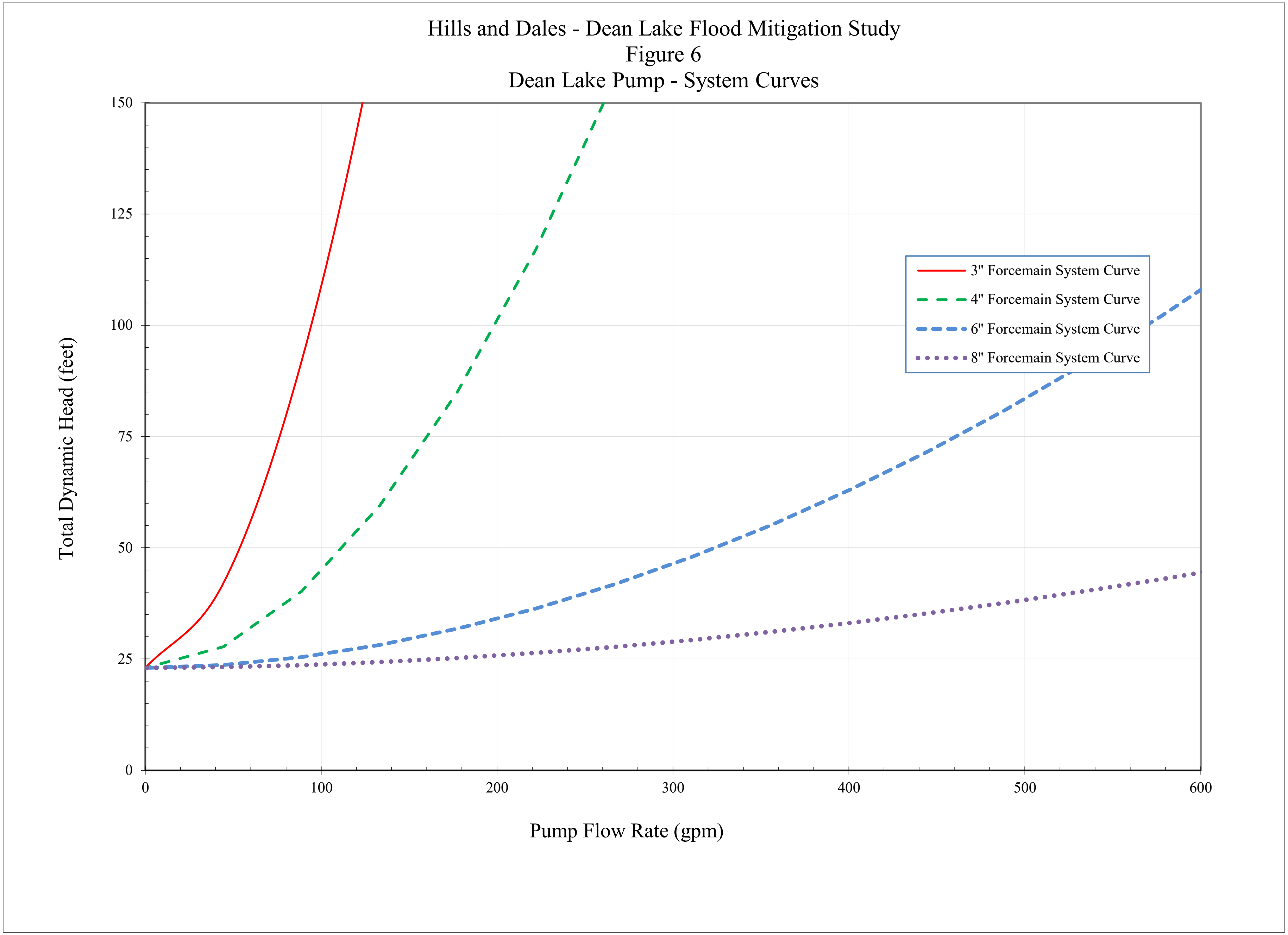
Source: NOAA National Centers for Environmental Information for Lower Southwest Michigan

Hills and Dales - Dean Lake Flood Mitigation Study
Figure 3
Dean Lake Monitoring Results through October 23, 2020




Hills and Dales - Dean Lake Flood Mitigation Study
Figure 4
Dean Lake Water Budget Comparison
Lake Measurement (ft)
Rainfall (in), Snow Depth Equiv Rainfall (in)
712.0
711.0
710.0
709.0
708.0
707.0
706.0
0
1
2
3
4
5
6
15-Apr-20
13-May-20
10-Jun-20
08-Jul-20
05-Aug-20
02-Sep-20
30-Sep-20
28-Oct-20
25-Nov-20
Rainfall
Dean Lake WSEL
Water Budget Estimate
Legal Lake Level - 706.2 NAVD88

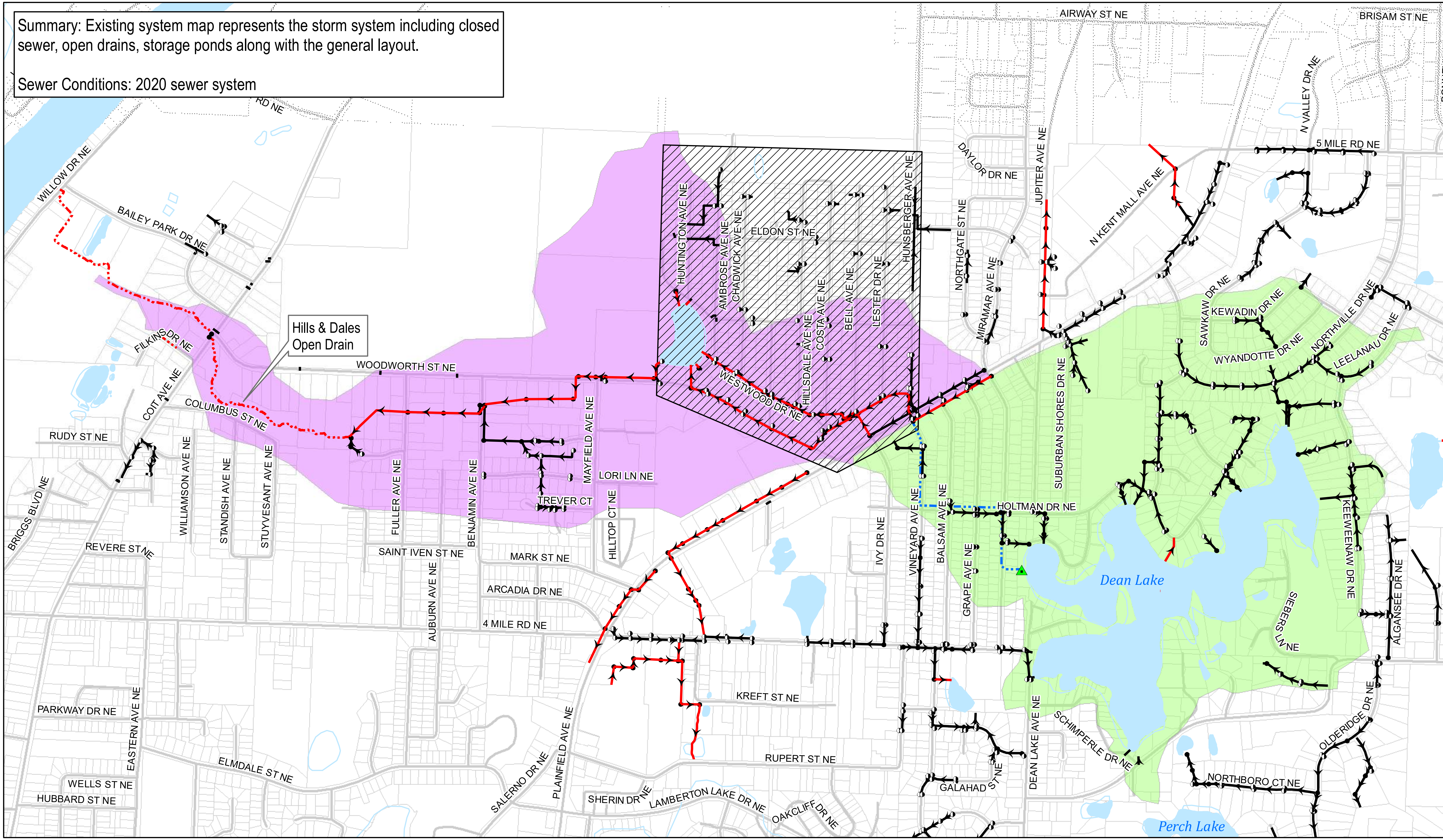

Hills and Dales - Dean Lake Flood Mitigation Study
Figure 5
Dean Lake Pumping Impacts
Average Rainfall Assumed
Current Snow Depth (~equiv in of rain)
Rainfall
Dean Lake WSEL
Water Budget Estimate
Legal Lake Level - 706.2 NAVD88
Level Projection with constant 200 gpm pumping
Level Projection with constant 400 gpm pumping
Level Projection with constant 600 gpm pumping
Lake Measurement (ft)
Rainfall (in), Snow Depth Equiv Rainfall (in)
712.0
711.0
710.0
709.0
708.0
707.0
706.0
0
1
2
3
4
5
6
15-Apr-20
10-Jun-20
05-Aug-20
30-Sep-20
25-Nov-20
20-Jan-21
17-Mar-21
12-May-21
07-Jul-21
01-Sep-21
27-Oct-21
22-Dec-21


Hills and Dales - Dean Lake Flood Mitigation Study
Figure 6
Dean Lake Pump - System Curves
Total Dynamic Head (feet)
150
125
100
75
50
25
0
0
100
200
300
400
500
600
Pump Flow Rate (gpm)
3" Forcemain System Curve
4" Forcemain System Curve
6" Forcemain System Curve
8" Forcemain System Curve

Maps

Summary: Existing system map represents the storm system including closed sewer, open drains, storage ponds along with the general layout.

Sewer Conditions: 2020 sewer system



N

Feet
1,000 500 0 1,000

LEGEND

- Manhole
- Catch Basin
- Local Storm Sewer
- County Drain Storm Sewer
- Open Drain

Tributary Area
- Hills and Dales
- Dean Lake

- Hills and Dales Neighborhood
- Recommended Pump Station
- Recommended Force Main

KENT COUNTY DRAIN COMMISSION
KENT COUNTY, MI

MAP 1: TRIBUTARY AREAS

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2200548

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MAP 2: EXISTING STORM SEWER IN THE HILLS AND DALES NEIGHBORHOOD

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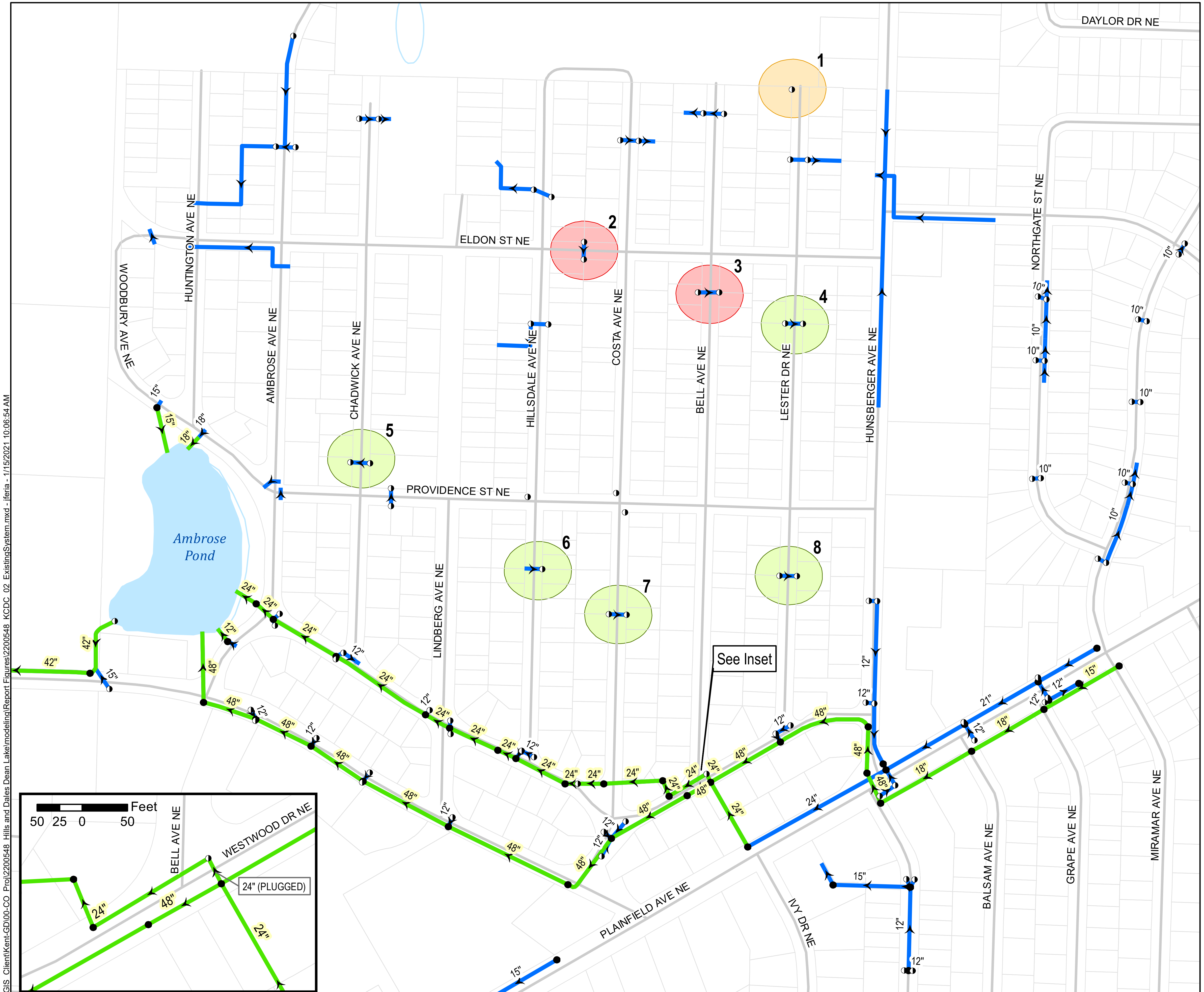


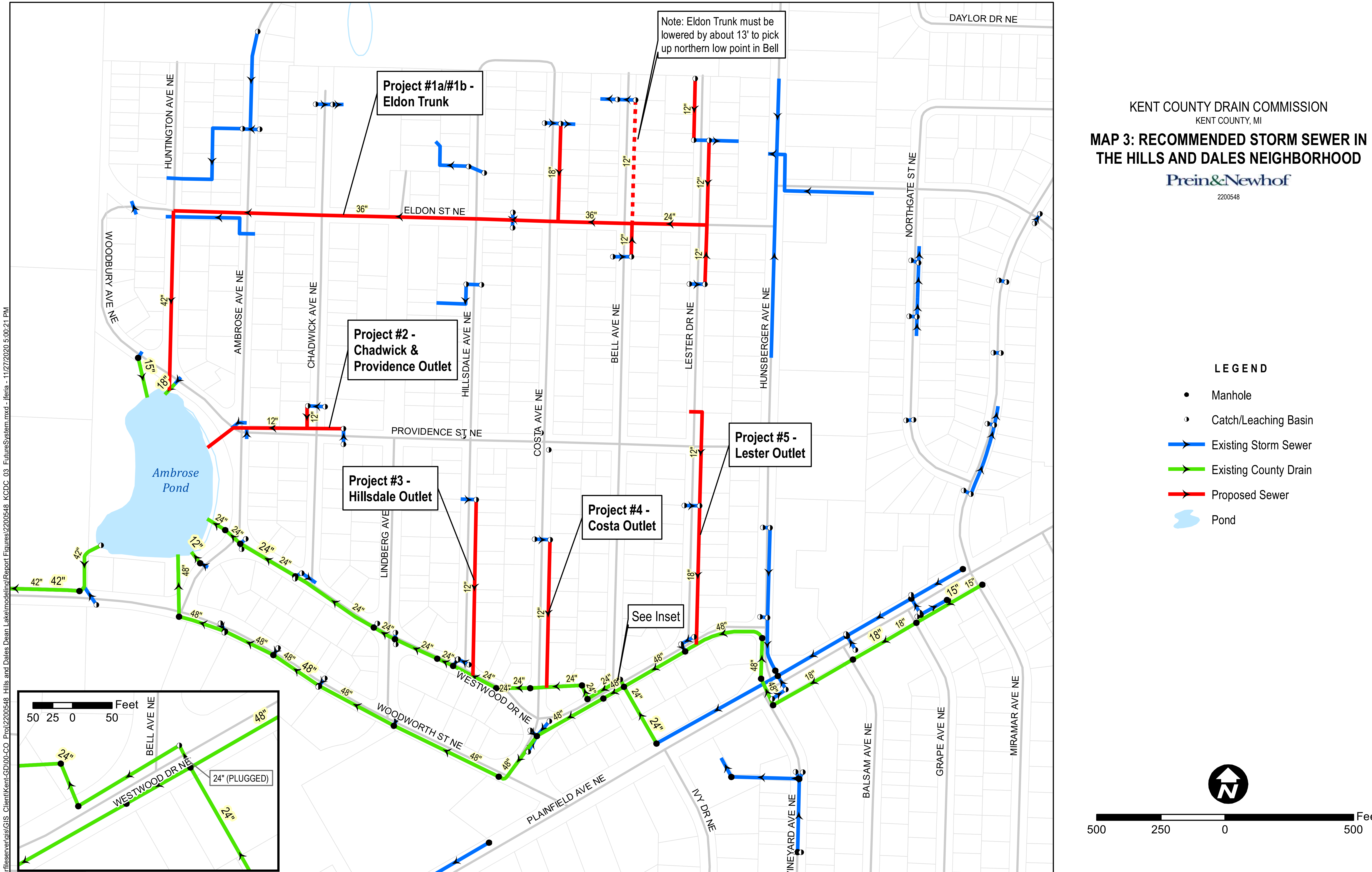
LEGEND

- Manhole
- Catch/Leaching Basin
- Hills and Dales County Drain
- Storm Sewer
- Pond

Current Flooding Areas

- Pothole - Road Surface Flooding
- Pothole - Garage Flooding
- Pothole - Road Surface & Garage Flooding

Feet
500 250 0 500



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MAP 3: RECOMMENDED STORM SEWER IN THE HILLS AND DALES NEIGHBORHOOD

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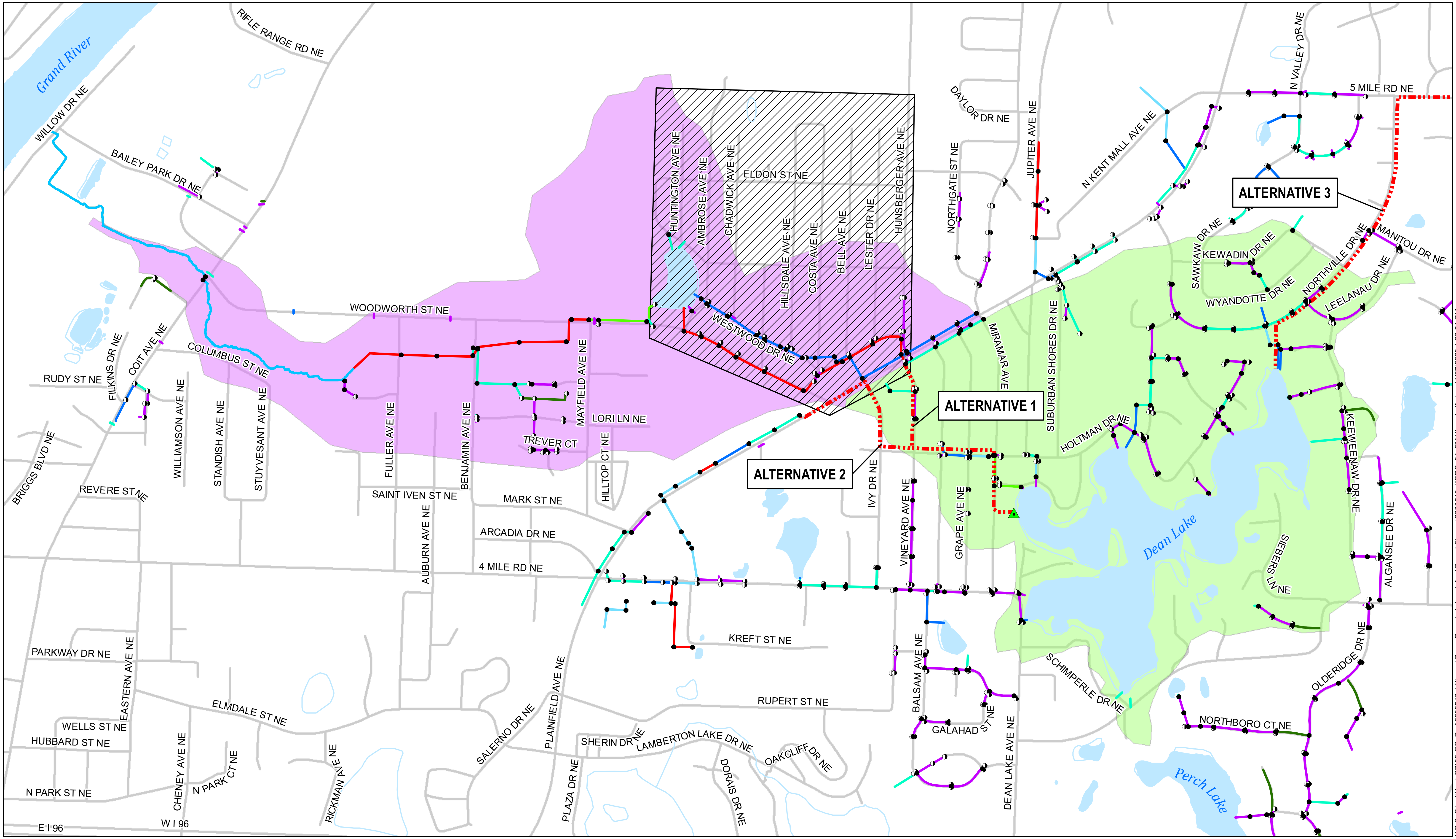

N

1,000 500 0 1,000 Feet

LEGEND

Proposed Pump Station	Manhole	**Storm Sewer**	**Tributary Area**
Proposed Force Main	Catch Basin	8" or Smaller	Hills and Dales
	Open Drain	10" - 12"	Dean Lake
		15" - 18"	Hills and Dales Neighborhood
		21" - 24"	
		27"	
		30" - 36"	
		42" - 45"	
		48" - 54"	

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KENT COUNTY, MI

MAP 4: FORCEMAIN LOCATION ALTERNATIVES

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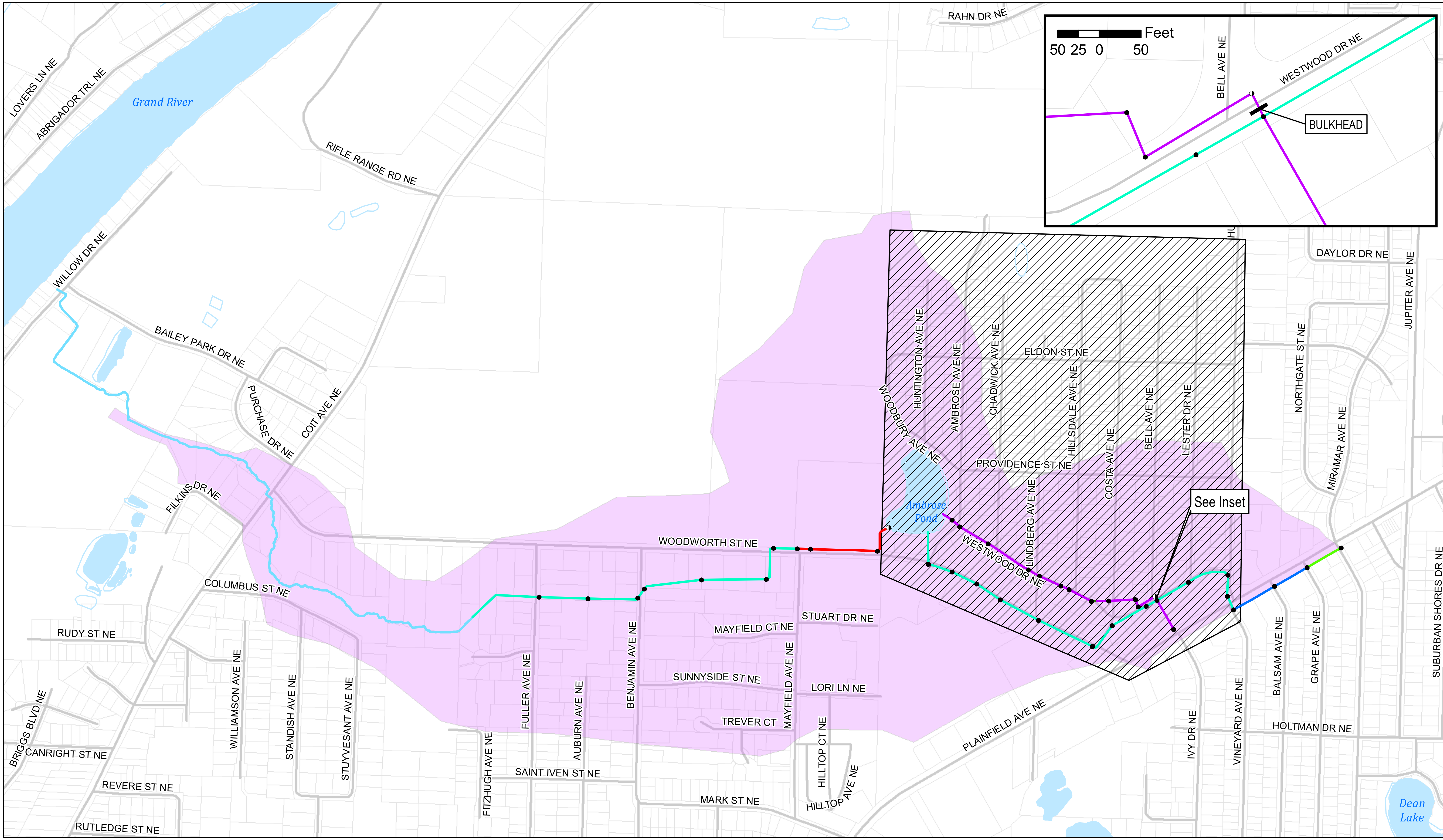

LEGEND

- Manhole
- Catch Basin
- Open Drain
- Hills and Dales Neighborhood
- Hills and Dales Tributary Area

Storm Sewer Diameter

- Unknown
- 15-inch
- 18-inch
- 24-inch
- 42-inch
- 48-inch

N

Feet

1,000 500 0 1,000

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MAP 5: HILLS AND DALES DRAIN DISTRICT

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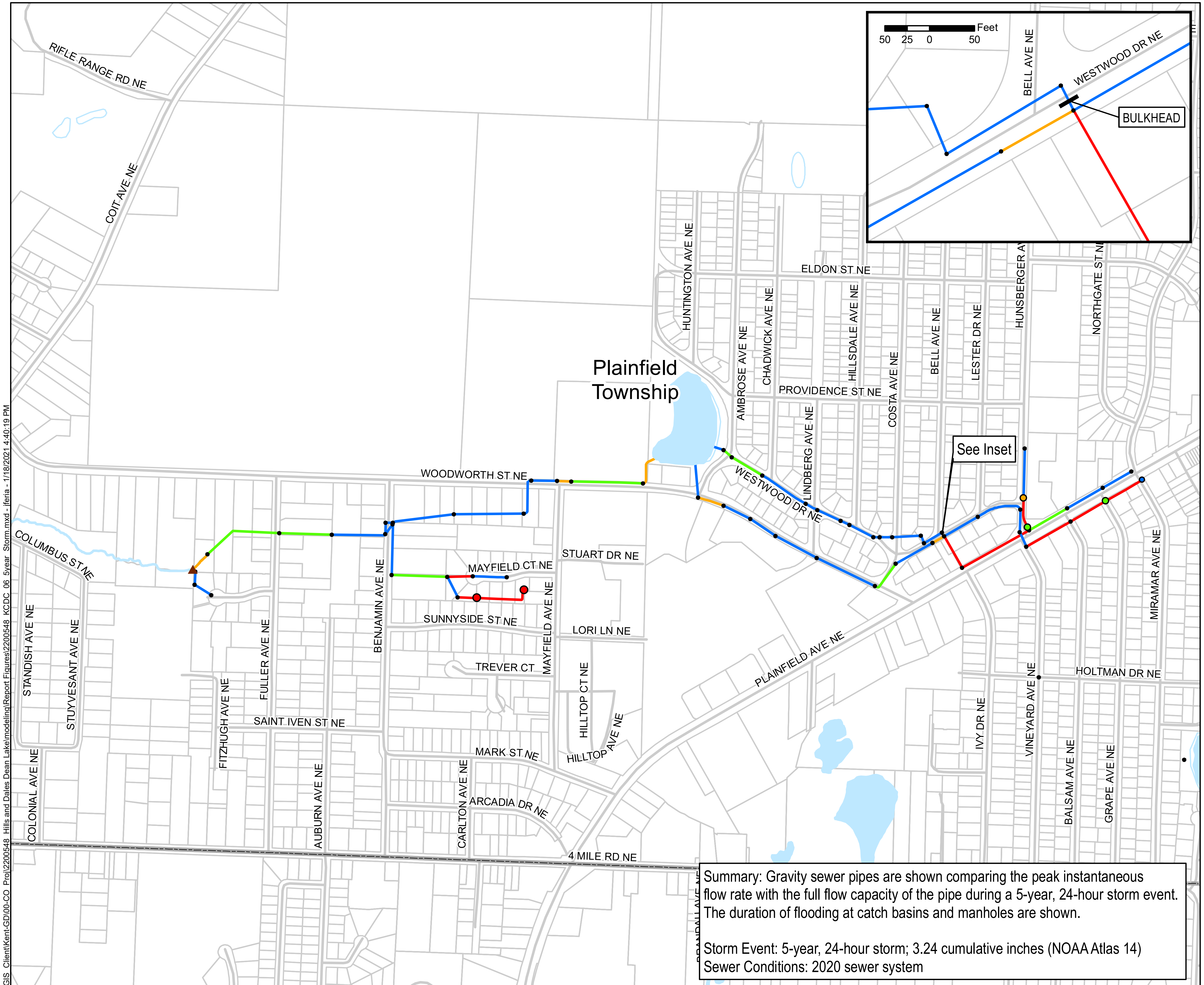
2200548



KENT COUNTY DRAIN COMMISSION

KENT COUNTY, MI

MAP 6: EXISTING DURATION OF FLOODING (5-YEAR EVENT)

Prein&Newhof

2200548

LEGEND

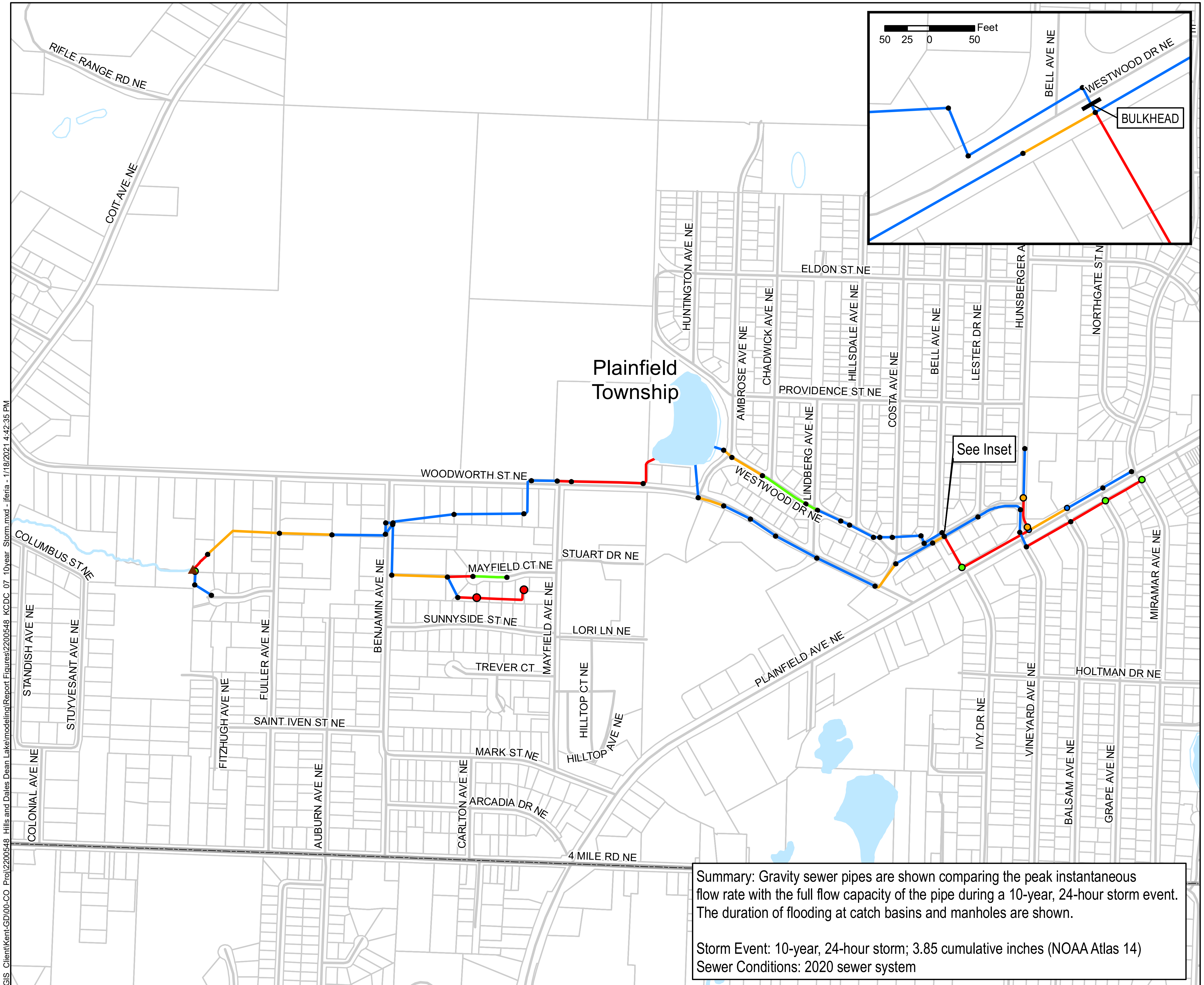
Duration of Flooding

- No Flooding
- < 15 Mins
- 15 - 30 Mins
- 30 - 60 Mins
- > 60 Mins

Gravity Sewer Percent of Capacity

- < 70% Full
- 70% - 85% Full
- 85% - 99% Full
- > 100% Full
- End of Hills&Dales Drain Conduit

Feet
500 250 0 500



Summary: Gravity sewer pipes are shown comparing the peak instantaneous flow rate with the full flow capacity of the pipe during a 10-year, 24-hour storm event. The duration of flooding at catch basins and manholes are shown.

Storm Event: 10-year, 24-hour storm; 3.85 cumulative inches (NOAA Atlas 14)
Sewer Conditions: 2020 sewer system

KENT COUNTY DRAIN COMMISSION
KENT COUNTY, MI

MAP 7: EXISTING DURATION OF FLOODING (10-YEAR EVENT)

Prein&Newhof
2200548

LEGEND

Duration of Flooding

- No Flooding
- < 15 Mins
- 15 - 30 Mins
- 30 - 60 Mins
- > 60 Mins

Gravity Sewer Percent of Capacity

- < 70% Full
- 70% - 85% Full
- 85% - 99% Full
- > 100% Full
- End of Hills&Dales Drain Conduit

Feet
500 250 0 500

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MAP 8: EXISTING DURATION OF FLOODING (25-YEAR EVENT)

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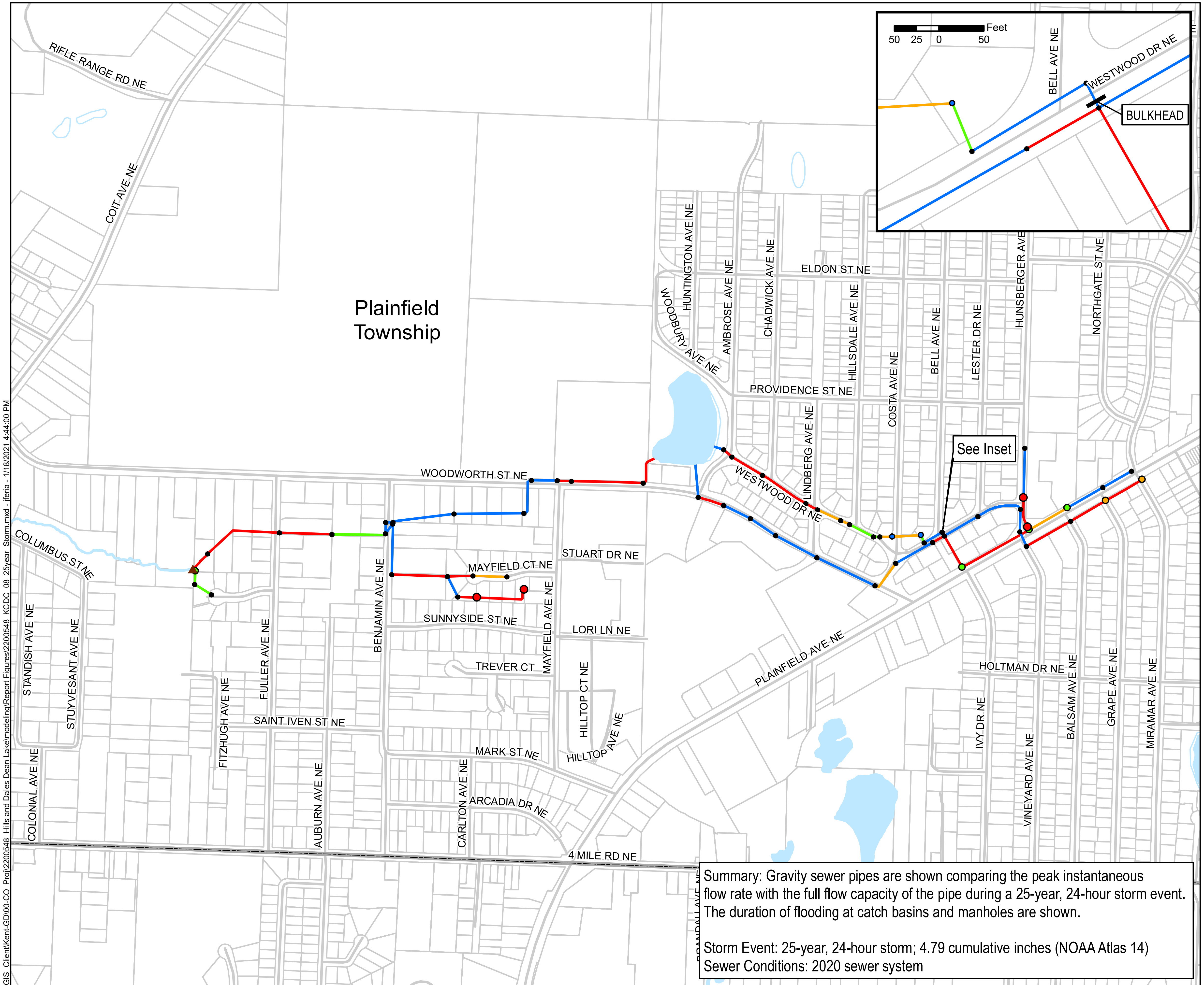
2200548



Summary: Gravity sewer pipes are shown comparing the peak instantaneous flow rate with the full flow capacity of the pipe during a 25-year, 24-hour storm event. The duration of flooding at catch basins and manholes are shown.

Storm Event: 25-year, 24-hour storm; 4.79 cumulative inches (NOAA Atlas 14)
Sewer Conditions: 2020 sewer system

LEGEND

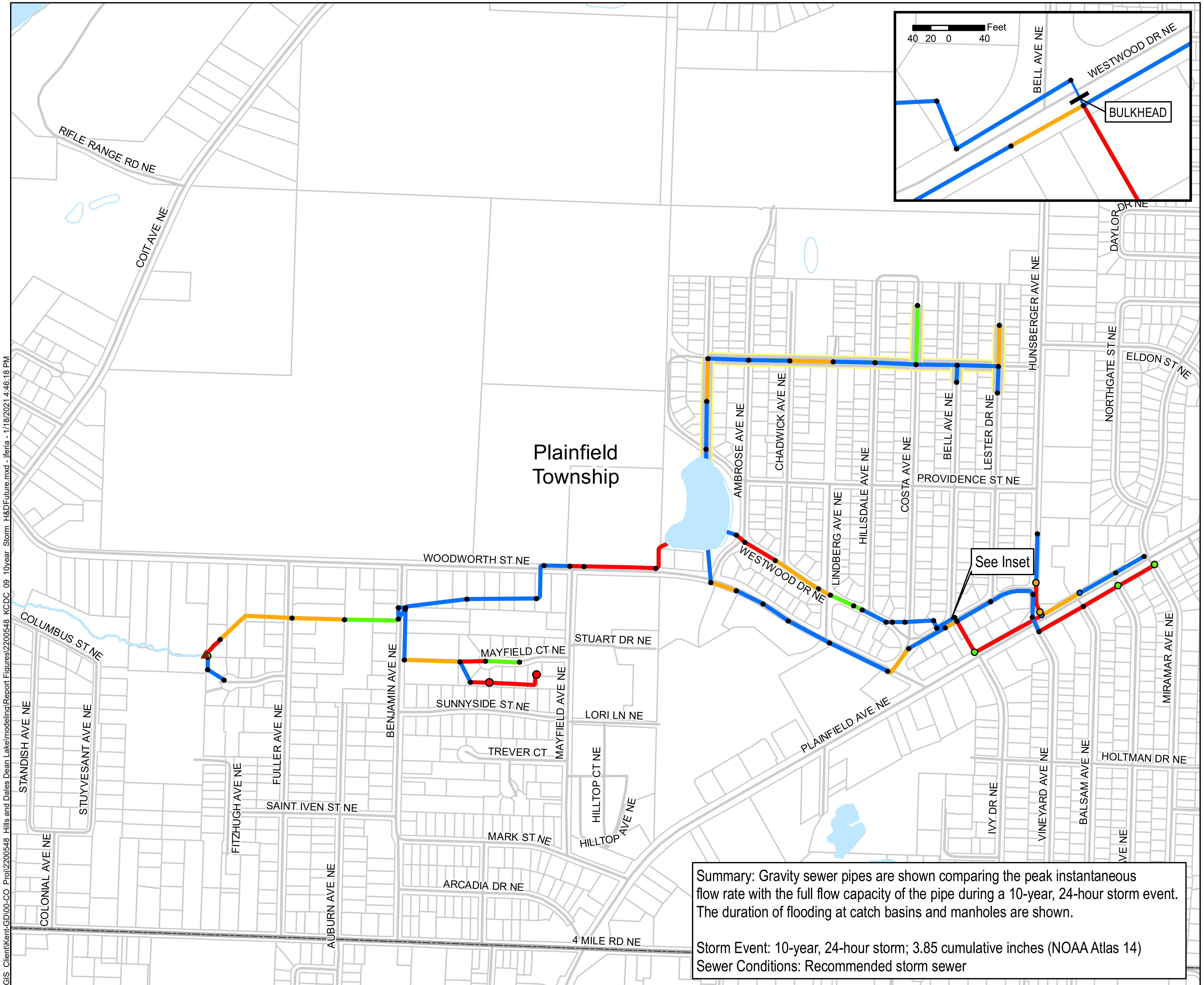
Duration of Flooding

- No Flooding
- < 15 Mins
- 15 - 30 Mins
- 30 - 60 Mins
- > 60 Mins

Gravity Sewer Percent of Capacity

- < 70% Full
- 70% - 85% Full
- 85% - 99% Full
- > 100% Full
- End of Hills&Dales Drain Conduit

Feet
500 250 0 500



KENT COUNTY DRAIN COMMISSION

KENT COUNTY, MI

MAP 9: DURATION OF FLOODING IN HILLS & DALES NEIGHBORHOOD WITH RECOMMENDED SEWERS

Prein&Newhof

2200548

LEGEND

Duration of Flooding

- No Flooding
- < 15 Mins
- 15 - 30 Mins
- 30 - 60 Mins
- > 60 Mins

Gravity Sewer Percent of Capacity

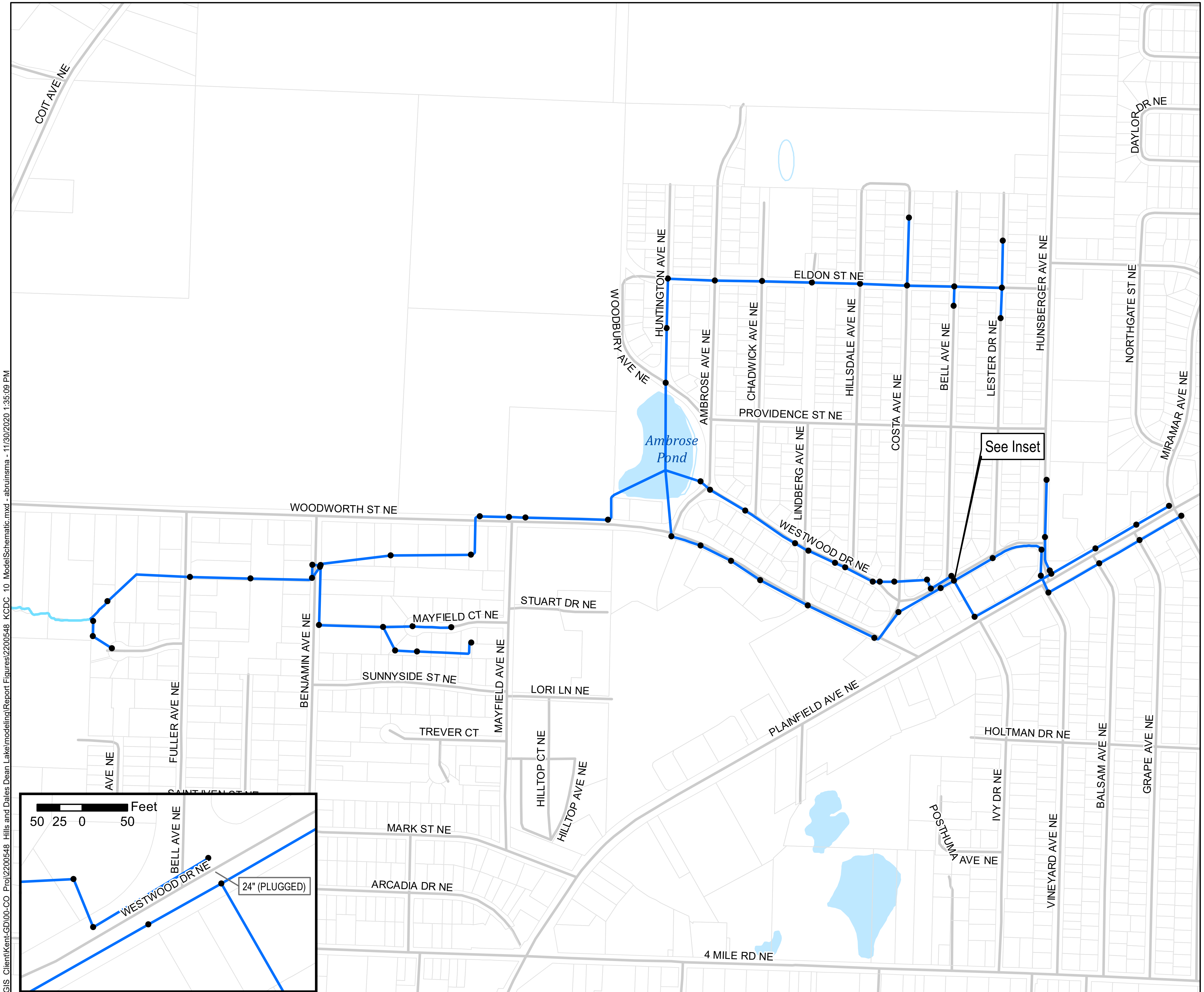
- < 70% Full
- 70% - 85% Full
- 85% - 99% Full
- > 100% Full
- Proposed Sewer
- End of Hills&Dales Drain Conduit

N

810 405 0 810 Feet

Appendix A

Schematic Drawing for Network Analysis



KENT COUNTY DRAIN COMMISSION
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APPENDIX A: INFOSWMM MODEL SCHEMATIC

Prein&Newhof

2200548

LEGEND

- Model Junctions
- Model Pipes
- Pond
- Open Drain

750 375 0 750 Feet

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Appendix B

Detailed Estimates of Probable Cost

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

Estimate of Probable Cost

Owner:
Kent County Drain Commissioner

Project Title:
Hills and Dales Neighborhood Drainage Improvements
Project #1a - Eldon Trunk (Not Deep Enough to Serve the North End of Bell Avenue)
Huntington from Ambrose Pond to Eldon & Eldon from Huntington to Lester Including Costa North of Eldon, Bell South of Eldon, and Lester North and South of Eldon

Date: October 25, 2020

Project #: 2200548

Item No.	Description	Quantity	Unit	Unit Price	Total Amount
1	42-inch Storm Sewer, Conc (10-15 feet deep)	750	LF	$300.00	$225,000.00
2	36-inch Storm Sewer, Conc (12-17 feet deep)	1,770	LF	$280.00	$495,600.00
3	24-inch Storm Sewer, Conc (17 feet deep)	300	LF	$200.00	$60,000.00
4	18-inch Storm Sewer, Conc (5-15 feet deep)	420	LF	$80.00	$33,600.00
5	12-inch Storm Sewer, Conc (5-15 feet deep)	1,100	LF	$70.00	$77,000.00
6	4-foot Dia. Storm Manhole	1	EA	$3,500.00	$3,500.00
7	5-foot Dia. Storm Manhole	6	EA	$5,000.00	$30,000.00
8	6-foot Dia. Storm Manhole	2	EA	$6,500.00	$13,000.00
9	7-foot Dia. Storm Manhole	1	EA	$8,000.00	$8,000.00
10	4-foot Dia. Storm Catch Basin	5	EA	$3,000.00	$15,000.00
11	Connect to Existing Storm Structure	5	EA	$1,000.00	$5,000.00
12	Restoration[1]	4,250	LF	$35.00	$148,750.00
				Total Construction Estimate:	$1,114,450.00
13	Engineering, Legal, Administration, & Contingencies (30% of Total Construction)	1	LS	$335,000.00	$335,000.00
				Total Estimate:	**$1,450,000.00**

Notes:

1. Some surface improvement removals and restoration (e.g. road construction) are assumed to be shared as part of a larger water and sanitary sewer capital improvement project in the Hills & Dales neighborhood. Restoration cost represents 1/3 of the overall total.

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

Estimate of Probable Cost

Owner:
Kent County Drain Commissioner

Project Title:
Hills and Dales Neighborhood Drainage Improvements
Project #1b - Eldon Trunk (Deep Enough to Serve the North End of Bell Avenue)
Huntington from Ambrose Pond to Eldon & Eldon from Huntington to Lester Including Costa North of Eldon, Bell North and South of Eldon, and Lester North and South of Eldon

Date: October 25, 2020

Project #: 2200548

Item No.	*Description*	*Quantity*	*Unit*	*Unit Price*	*Total Amount*
1	42-inch Storm Sewer, Conc (10-15 feet deep)	750	LF	$300.00	$225,000.00
2	36-inch Storm Sewer, Conc (16-27 feet deep)	1,770	LF	$400.00	$708,000.00
3	24-inch Storm Sewer, Conc (27-17 feet deep)	300	LF	$300.00	$90,000.00
4	18-inch Storm Sewer, Conc (5-15 feet deep)	420	LF	$80.00	$33,600.00
5	12-inch Storm Sewer, Conc (5-15 feet deep)	1,630	LF	$70.00	$114,100.00
6	4-foot Dia. Storm Manhole	1	EA	$6,500.00	$6,500.00
7	5-foot Dia. Storm Manhole	6	EA	$7,500.00	$45,000.00
8	6-foot Dia. Storm Manhole	2	EA	$6,500.00	$13,000.00
9	7-foot Dia. Storm Manhole	1	EA	$8,000.00	$8,000.00
10	4-foot Dia. Storm Catch Basin	5	EA	$3,000.00	$15,000.00
11	Connect to Existing Storm Structure	5	EA	$1,000.00	$5,000.00
12	Maintain Existing Sanitary Sewer Flows	1	LS	$200,000.00	$200,000.00
13	Restoration[1]	4,250	LF	$35.00	$148,750.00
				Total Construction Estimate:	$1,611,950.00
14	Engineering, Legal, Administration, & Contingencies (30% of Total Construction)	1	LS	$484,000.00	$484,000.00
				Total Estimate:	**$2,096,000.00**

Notes:
1. Some surface improvement removals and restoration (e.g. road construction) are assumed to be shared as part of a larger water and sanitary sewer capital improvement project in the Hills & Dales neighborhood. Restoration cost represents 1/3 of the overall total.

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

Estimate of Probable Cost

Owner:
Kent County Drain Commissioner

Project Title:
Hills and Dales Neighborhood Drainage Improvements
Project #2 - Chadwick & Providence Outlet
Providence from Ambrose Pond to 100 feet East of Chadwick and Chadwick from Providence to 130 feet North

Date: October 25, 2020

Project #: 2200548

Item No.	*Description*	*Quantity*	*Unit*	*Unit Price*	*Total Amount*
1	18-inch Storm Sewer, Conc (4-6 feet deep)	200	LF	$80.00	$16,000.00
2	12-inch Storm Sewer, Conc (4-6 feet deep)	500	LF	$70.00	$35,000.00
3	4-foot Dia. Storm Manhole	3	EA	$3,500.00	$10,500.00
4	4-foot Dia. Storm Catch Basin	1	EA	$3,000.00	$3,000.00
5	Connect to Existing Storm Structure	2	EA	$1,000.00	$2,000.00
6	Lawn Restoration	600	LF	$10.00	$6,000.00
7	Road Restoration[1]	100	LF	$80.00	$8,000.00
				Total Construction Estimate:	$80,500.00
8	Engineering, Legal, Administration, & Contingencies (30% of Total Construction)	1	LS	$25,000.00	$25,000.00
				Total Estimate:	**$106,000.00**

Notes:

1. Road Restoration costs are assumed to be born solely by storm sewer project since the water and sanitary sewer have been recently replaced. Storm sewer is assumed to be outside of the road since there are no utilities in Providence Street.

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

Estimate of Probable Cost

Owner:
Kent County Drain Commissioner

Project Title:
Hills and Dales Neighborhood Drainage Improvements
Project #3 - Hillsdale Outlet
Hillsdale from Westwood to 700 feet North

Date: October 25, 2020

Project #: 2200548

Item No.	*Description*	*Quantity*	*Unit*	*Unit Price*	*Total Amount*
1	12-inch Storm Sewer, Conc (4-6 feet deep)	700	LF	$70.00	$49,000.00
2	4-foot Dia. Storm Manhole	2	EA	$3,500.00	$7,000.00
3	4-foot Dia. Storm Catch Basin	2	EA	$3,000.00	$6,000.00
4	Restoration[1]	700	LF	$35.00	$24,500.00
				Total Construction Estimate:	$86,500.00
5	Engineering, Legal, Administration, & Contingencies (30% of Total Construction)	1	LS	$26,000.00	$26,000.00
				Total Estimate:	**$113,000.00**

Notes:

1. Some surface improvement removals and restoration (e.g. road construction) are assumed to be shared as part of a larger water and sanitary sewer capital improvement project in the Hills & Dales neighborhood. Restoration cost represents 1/3 of the overall total.

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

Estimate of Probable Cost

Owner:
Kent County Drain Commissioner

Project Title:
Hills and Dales Neighborhood Drainage Improvements
Project #4 - Costa Outlet
Costa from 24-inch County Drain at Westwood to 600 feet North

Date: October 25, 2020

Project #: 2200548

Item No.	*Description*	*Quantity*	*Unit*	*Unit Price*	*Total Amount*
1	12-inch Storm Sewer, Conc (4-6 feet deep)	600	LF	$70.00	$42,000.00
2	4-foot Dia. Storm Manhole	3	EA	$3,500.00	$10,500.00
3	Connect to Existing Storm Structure	2	EA	$1,000.00	$2,000.00
4	Lawn Restoration	600	LF	$10.00	$6,000.00
5	Road Restoration[1]	600	LF	$70.00	$42,000.00
				Total Construction Estimate:	$102,500.00
6	Engineering, Legal, Administration, & Contingencies (30% of Total Construction)	1	LS	$31,000.00	$31,000.00
				Total Estimate:	**$134,000.00**

Notes:

1. Road Restoration costs are assumed to be born solely by storm sewer project since the water and sanitary sewer have been recently replaced.

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

Estimate of Probable Cost

Owner:
Kent County Drain Commissioner

Project Title:
Hills and Dales Neighborhood Drainage Improvements
Project #5 - Lester Outlet
Lester from Westwood to 130 feet North of Providence

Date: October 25, 2020

Project #: 2200548

Item No.	*Description*	*Quantity*	*Unit*	*Unit Price*	*Total Amount*
1	18-inch Storm Sewer, Conc (4-6 feet deep)	480	LF	$80.00	$38,400.00
2	12-inch Storm Sewer, Conc (4-6 feet deep)	500	LF	$70.00	$35,000.00
3	4-foot Dia. Storm Manhole	5	EA	$3,500.00	$17,500.00
4	4-foot Dia. Storm Catch Basin	4	EA	$3,000.00	$12,000.00
5	Restoration[1]	980	LF	$35.00	$34,300.00
				Total Construction Estimate:	$137,200.00
6	Engineering, Legal, Administration, & Contingencies (30% of Total Construction)	1	LS	$42,000.00	$42,000.00
				Total Estimate:	**$180,000.00**

Notes:

1. Some surface improvement removals and restoration (e.g. road construction) are assumed to be shared as part of a larger water and sanitary sewer capital improvement project in the Hills & Dales neighborhood. Restoration cost represents 1/3 of the overall total.

Prein&Newhof
Engineers▪Surveyors▪Environmental▪Laboratory

Estimate of Probable Cost

Owner:
Kent County Drain Commissioner

Project Title:
Dean Lake Flood Mitigation Study
Dean Lake Pump Station and Forcemain

Date: October 25, 2020

Project #: 2200548

Item No.	*Description*	*Quantity*	*Unit*	*Unit Price*	*Total Amount*
Pump Station					
1	Dewatering & Soil Erosion, Sedimentation Control	1	LS	$50,000.00	$50,000.00
2	Intake Wells/Screens	1	LS	$60,000.00	$60,000.00
3	Precast Concrete Wet Well & Valve Chamber	1	LS	$40,000.00	$40,000.00
4	Pumps, Valves, and Piping (including painting)	1	LS	$80,000.00	$80,000.00
5	Control Pannel & Instrumentation	1	LS	$110,000.00	$110,000.00
6	Electrical Equipment & Wiring	1	LS	$25,000.00	$25,000.00
7	Flow Meter & Chamber	1	LS	$18,000.00	$18,000.00
8	Restoration	1	LS	$20,000.00	$20,000.00
9	Allowance for Electrical Service	1	LS	$15,000.00	$15,000.00
10	General Conditions	1	LS	$41,000.00	$41,000.00
				Pump Station Subtotal:	$459,000.00
Forcemain					
11	6-inch Forcemain, HDPE, Directional Drill	2,650	LF	$75.00	$198,750.00
12	Combination Vacuum/Air Release Valve & Structure	1	EA	$10,000.00	$10,000.00
13	Connect to Existing Storm Structure	1	EA	$1,000.00	$1,000.00
14	Forcemain Concrete Restraint	2	EA	$2,500.00	$5,000.00

Item No.	Description	Quantity	Unit	Unit Price	Total Amount
15	Restoration	1	LS	$10,000.00	$10,000.00
				Forcemain Subtotal:	$224,750.00
				Total Construction Estimate:	$683,750.00
16	Engineering, Legal, Administration, & Contingencies (30% of Total Construction)	1	LS	$206,000.00	$206,000.00
				Total Estimate:	**$890,000.00**

PUMP OPTIONS COST COMPARISON

Cost Item	Rent Portable Pump	Owning Portable Pump	Pump Station	Notes
Permits				
EGLE	$100	$100	$100	
KCRC	$100	$100	$100	
Consumers Energy	$0	$0	$400	Utility charge (assumed)
SUBTOTAL	$200	$200	$600	
Capital				
Construction	$380,000	$380,000	$940,000	Permanent infrastructure included for all Options including the 8" forcemain. Portable Options include Riverscreen and piping.
Portable Pump	$0	$170,000	$0	Portable Pump Cost
SUBTOTAL	$380,000	$550,000	$940,000	
Operation				
Rental*	$5,000	$0	$0	Assume $2500/4 wks x 8 weeks/year Avg for rental
Insurance	$300	$600	$600	Assumed annual premium.
Electric	$0	$0	$1,600	Assume $800/month when operating steady; Assume steady operation 2 months/year AVE
Diesel Fuel	$8,000	$8,000	$0	Assume $4/gallon, 39 gallon fuel tank, or $156/tank; 1 day (24hr) of operation/tank. Assume 7 days operation per month x 0.5 (12hr) operation/day x 2 months/year = 7 days/year AVE = $1,092; round up for oil and lube.
Mileage	$1,600	$1,600	$200	Assume 20 miles round trip from GR at $1/mile; For setup, daily startup and shutoff & removal assume 1 trips per day from GR, 1 trip per week for refueling, and monthly inspections for say 80 trips=$1600.
KCDC Labor	$11,200	$13,600	$800	Assume 8 weeks per year AVE at 2 hrs/days ave = 112 hrs/year for portable pump; Add'l 12 hours for misc site calls; $100/hour. Additional costs to install and remove for Portable owned (12 hrs/yr)
SUBTOTAL	$26,100	$23,800	$3,200	
Maintenance				
Annual Inspection	$0	$800	$1,000	Assume $50/month for operation + $400 annual
Parts and Repair	$0	$200	$200	Average annual budget
SUBTOTAL	$0	$1,000	$1,200	
Elec/Cntrls Repl.	$0	$0	$150,000	Electrical/Controls replaced after 15-years
Pump Replaced	$0	$40,000	$40,000	Assume pump replaced after 25-years
TOTAL-Present Va	**$940,000**	**$1,100,000**	**$1,130,000**	50-Year Present Value (4% Effective Rate of Return)

* Sunbelt Rental - SAPP44S8-3TNV84T Sound attenuated, vacuum primed, diesel driven, centrifugal pump package - 4x4x10 Solids Vac 49HP QF Contr Pump.

** Present Value estimate based on 50 year life of forcemain and pump station infrastructure, 25 year life of pumps, & 15-year life of electrical/controls. Also assumes a 6% rate of return & 2% inflation (4% effective rate of return).