Southern Flood Mitigation Feasibility Study

TOWN OF LITTLE CREEK, DELAWARE

March 2024

Prepared For:

Town of Little Creek
P.O Box #298
Little Creek, Delaware 19961

Prepared By:

Verdantas LLC
1060 S. Governors Avenue, Suite 101,
Dover, Delaware 19904

This report was prepared by Verdantas LLC using Federal funds under awards NA20NOS4190170 from the Delaware Coastal Management Program and the Office for Coastal Management (OCM), National Oceanic and Atmospheric Administration (NOAA), U.S. Department of Commerce. The statements, findings, conclusions, and recommendations are those of the author(s) and do not necessarily reflect the views of the OCM NOAA or the U.S. Department of Commerce.

GT:mjr
DNREC\18040 - Little Creek Southern Flood Mitigation F\Working\Existing Conditions and Flood Evaluation Report\Report\Rpt-18040-Little Creek Southern Flood Mitigation-20240329.docx

TABLE OF CONTENTS

SECTION **PAGE**

TABLE OF CONTENTS (continued)

FIGURES

APPENDICES

1.0 INTRODUCTION

Little Creek is a small, rural community located in Eastern Kent County, Delaware between the City of Dover and the Delaware Bay. Little Creek was settled in the early 1800's and developed a thriving oyster business which led to its growth as a community with homes and businesses. Today its primary features are its location on the Delaware Bayshore Byway, the Little Creek Wildlife Area, the Little River Boat Ramp and Fishing Pier, and the Little Creek Dog Park. The population of Little Creek has reduced but a number of historic buildings still remain in the town. The Town of Little Creek was named to the National Register of Historic Places in 1984.

The Town has experienced recurring flooding events in recent years which threaten both the existing and future use of roads and public, commercial, and residential properties within the Town limits. The area in front of the Little Creek Grill and the intersection of Main Street (DE-9) and Lowe Street are frequently flooded during even the smaller storm events experienced as well as during times of high tide and strong northeasterly winds. The Department of Natural Resources and Environmental Control (DNREC) contracted with Verdantas to perform a flood mitigation feasibility study for the southern portion of the Town with the focus on the intersection of Main Street and Lowe Street as well as the tidal influences affecting the existing system. A map showing the Town limits and the area of the study is provided as Figure 1. Verdantas has previously conducted a similar study on the northern portion of the Town's stormwater system under contract with the Town.

For this study of flooding in the southern portion of the town, Verdantas performed a natural resources and existing conditions evaluation of the study area and modeled flooding during various storm events. The model provides limits, depths, and duration of flooding, considering surface and subsurface drainage features. Then flood mitigation alternatives were identified and evaluated. An Engineer's estimate of probable construction cost was developed for the recommended alternatives.

The results of the modeling indicate that significant flooding occurs which impacts Main Street and Lowe Street on a frequent basis in an area already impacted by tidal conditions from the Little River and the Delaware Bay. The drainage infrastructure in and immediately adjacent to the Town was installed between the 1930s and 1960s and not designed to handle current rainfall events. The existing drainage infrastructure of the southern portion of Town consists of a combination of inlets, storm drain piping, culverts, a shallow farm ditch to the west of Bell Street, as well as a tidal channel on the eastern limit of the Town, connecting the system to the Little River. The existing drainage infrastructure is undersized to manage current rainfall and tidal conditions. Due to the nature of the water table and soils in Little Creek, components of the system have settled and are not performing as designed. Action is needed to reduce the frequently occurring flooding impacts to the Town.

2.0 NATURAL RESOURCES EVALUATION

Verdantas identified and delineated the approximate boundaries of wetlands and other "waters of the United States" (WOUS), the 100-year floodplain, and other protected natural resources associated with the Town of Little Creek (the "project site") and the surrounding watershed. Refer to Figure 1 for the location of the project site. The natural resource evaluation involved a desktop review of available maps and a field reconnaissance of the project site.

2.1 DESKTOP REVIEW

The boundaries of the project site were approximated on the U.S. Geologic Survey (USGS) Topographic On-line map [1], the U.S. Department of the Interior Fish and Wildlife Service (USFWS) National Wetlands Inventory (NWI) [2], and the U.S. Natural Resource Conservation Service On-line Soil Survey [3], and the NOAA Fisheries Essential Fish Habitat Mapper. Tidal Wetlands regulated by the State of Delaware were identified using the Department of Natural Resources and Environmental Control (DNREC) State Wetlands Online Mapping.

The project site is located in a rural area in Little Creek, Delaware and is located within the Little River watershed. The area evaluated was limited to the southern portion of Little Creek. See Figure 1 for the project site location.

The USGS Map (Figure 1) indicates that the latitude and longitude for the approximate center of the project site is N. 39° 10' 01.5" and W. 75° 26' 54.1." The map additionally indicates that study area is situated approximately 10-feet above mean sea level and slopes downward towards Little River.

The USFWS online NWI Map indicates that several wetland areas are located in Little Creek (Figure 2). There are four different NWI wetlands that are mapped within the project site. An Estuarine, Intertidal, Emergent, Phragmites australis, Regularly Flooded, Partially Drained/Ditched (E2EM5Pd) wetland is on both sides of Maine Street and directly abutting other wetlands that are mapped. The majority of southeast corner of the project site is mapped as an Estuarine, Intertidal, Emergent, Persistent, Regularly Flooded (E2EM1N) wetland. Two different wetlands are mapped on the southwest side of the project site. The E2EM5Pd directly abuts both a small Palustrine, Forested, Broad-Leaved Deciduous, Temporary Flooded (PFO1S) wetland and an Estuarine, Intertidal, Emergent, Persistent, Regularly Flooded, Partially Drained/Ditched (E2EM1Nd) wetland. The NWI Map classified Little River as an Estuarine, Subtidal, Unconsolidated Bottom, Subtidal (E1UBL) wetland.

The DNREC State Wetlands Online Mapping indicates that tidal marshes are located in the southern and eastern portions of Little Creek. See Appendix A for the limits of the Delaware Tidal Wetlands.

The Web Soil Survey (Figure 3) indicates that the majority of Little Creek is underlain by several soil map units, including the Unicorn loam, 0 to 2 percent slopes (UlA), the Unicorn loam, 2 to 5 percent slopes (UlB), the Carmichael loam, 0 to 2 percent slopes (CaA), the Broadkill-Appoquinimink complex, very frequently flooded, tidal (Ba), and the Mattapex silt loam, 0 to 2 percent slopes, Mid-Atlantic Coastal Plain (MtcA) units. The CaA and Ba map units are both classified as hydric soil. The areas underlain by these soils generally correspond with lands identified as wetlands by the NWI Map (Figure 2). Broadkill and Appoquinmink soil series are both mapped as Sulfaquent which is typical for tidal marsh soils.

Essential fish habitats (EFH) for several fish species are mapped near the project site by the NOAA Fisheries EFH Mapper. These species are listed in the table provided in Appendix B.

IPaC tool (US Fish and Wildlife Services) stated that there is no critical habitat at the project site, however, the IPaC showed that within the project site there is one endangered species, Eastern Black Rail, and one candidate species, Monarch Butterfly. There are also Bald Eagle present at the project site. Twenty-two migratory birds are listed. A small portion of the project site is also identified as a coastal barrier resources system.

2.2 NATURAL RESOURCE EVALUATION RESULTS

The identification and delineation of wetlands was based upon the methods outlined in U.S. Army Corps of Engineers' Wetlands Delineation Manual (1987) as modified by the Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region (2010). Evidence of the Ordinary High-Water Line were used to delineate the boundaries around watercourses when no wetlands were found. The limits of the floodplain were obtained from FEMA floodplain maps.

The limits of the WOUS and floodplains are shown on the Wetlands and Floodplain Map (Figure 4). The limits of the WOUS shown on the plans were approximated based on the field observations described above and the interpretations of LIDAR topography, aerial photographs, and the NWI Map, and the DNREC State Wetlands Online Mapping.

2.2.1 WOUS Resources

The WOUS resources identified on the project site included a perennial river (Little River), an intermittent stream, and Palustrine Forested, Palustrine Emergent and Estuarine Emergent wetlands. The non-tidal Palustrine Forested wetlands drain to an intermittent stream, which leads to tidal Palustrine Emergent and Estuarine Emergent wetlands. A portion of this stream is piped. The locations of the wetlands on the project site generally correlate to those depicted in the NWI maps.

2.2.2 Floodplain Resources

According to the FEMA Flood Maps, 100-year floodplain areas are located in the southern portion of the Town of Little Creek. The project area is located within the FEMA Flood Map 10001C0187J, effective July 7, 2014. The limits of the floodplain are shown on Figure 4.

3.0 EXISTING CONDITIONS EVALUATION

An existing conditions evaluation was performed to understand and model existing drainage and flooding conditions in the study area. This included a review of aerial imagery, topographic data, tidal data, and storm sewer and drainage data. The EPA SWMM software package was used to simulate flooding conditions in the study area.

3.1 DATA

Publicly available information from the Federal Emergency Management Agency (FEMA), the National Oceanic and Atmospheric Administration (NOAA), DNREC, Kent Conservation District (KCD) and DelDOT was supplemented with field observations and DelDOT Survey to create the existing conditions model.

3.1.1 Aerial Imagery

This study utilized medium resolution satellite imagery available from Earthstar Geographics, providing 15-meter resolution.

3.1.2 Topography and Floodplain Mapping

Studies of this nature rely on accurate elevation data for the evaluation area to provide a proper relationship between the various drainage components within the area. The elevation data utilized for this study is a composite of both field survey data received from DelDOT and LiDAR data obtained from First Map-Delaware open data source. The elevations were obtained from a 2014 LiDAR DEM which was flown for the State of Delaware using the North American Vertical Datum of 1988 (NAVD88) and referenced to the horizontal datum of NAD83 state plane coordinate system. The accuracy of the LiDAR is 6.3 cm vertically although the accuracy is considerably less in heavily vegetated areas or beneath surface water. While the LiDAR is accurate to a degree, field obtained survey data is the primary topographic data source used for modeling purposes. The topography for Little Creek is provided in Figure 5.

The elevations range from elevation 4 feet on the north side of the Little Creek Grill to elevation 12 feet as referenced to the NAVD88 datum near the intersection of Bell Street and Wilson Lane. According to the Federal Emergency Management Agency (FEMA) Firm Rate Map 10001C0187J, effective date July 7, 2014, the project area lies within three separate flood zones; AE10, X Shaded, and X unshaded. Zone AE10 is an area that lies within the 100-year floodplain with an associated flood elevation of 10. Zone X Shaded is an area that lies within the 500-year floodplain and is subject to flooding only during the most extreme storm events, such as hurricanes. Zone X Unshaded is an area that does not lie within the mapped floodplain. The floodplain limits for Little Creek are provided in Figure 4.

3.1.3 Tidal Influence

With its location on the Little River and in close proximity (less than 2 miles) to the Delaware Bay, both surface water and groundwater elevations within the town are influenced by the fluctuations of the tides. These tidal impacts, coupled with the low-lying nature of the town, exacerbate flooding during even the more typical storm events.

The nearest NOAA tide stations are at Reedy Point (Delaware City) and Lewes, to the north and south of Little Creek respectively. Assuming an average value between the two stations, the mean higher high water (MHHW) elevation in the vicinity of Little Creek is elevation 2.44 feet, while the mean lower low water (MLLW) elevation is -2.80 feet. Mean sea level (MSL) lies at elevation -0.22 feet at this location. All elevations are referenced to NAVD88 datum. While the surface elevations for the roadways and surrounding properties are higher than the MHHW elevation, the inverts of the existing drainage infrastructure at the downstream portion of the system are below this elevation. This allows the tide to frequently flow up into the storm drain system and create a backwater condition.

3.1.4 Storm Sewer and Drainage System

We reviewed information regarding the existing storm sewer system. This included 1) a DelDOT archive plan for Little Creek Streets, as-built plan, dated May 8, 1968; 2) University of Delaware Coastal Resilience Design Studio site analysis report for the Town of Little Creek, dated August 3, 2020 (excerpt attached as Figure 6); 3) Field reconnaissance on August 24, 2023; 4) System walkthrough with the mayor and a councilwoman on December 8, 2023; and 5) DelDOT survey of catch basins and street centerlines, dated December 18, 2023.

The majority of the storm sewer system was installed in 1968, making the system 56 years old. The as-built plans indicate that 274 ft. of the pipes under Main Street are reinforced concrete pipe (RCP) and 379 ft. are asbestos bonded corrugated metal pipe (CMP). Although the average lifespan of RCP and CMP are both around 75-100 years, recent field survey data from DelDOT indicate that portions of the stormwater system have sunk over time, likely due to a high-water table. The sunken components may be inhibiting flow of stormwater out of the system, can lead to pipe fracturing and groundwater infiltration, and result in some of the catch basins being partially filled with water at all times. This was field verified by both Verdantas and DelDOT during the various surveys and site visits.

Using a combination of DelDOT survey and Verdantas storm drain measure down distances, the bottom elevation of each catch basin was identified or estimated. Using this data, a model was created to simulate the existing conditions of the subsurface drainage system in different scenarios. Using rainfall inputs, tidal influence data, and surface cover data obtained by aerial imagery, flooding events were modeled to see how the existing storm sewer system handled different scenarios. Our existing condition results were reviewed with the mayor and councilwoman on December 8, 2023 to verify the results of the existing conditions model.

3.2 MODELING

Flood depths were simulated for various storm events using one-dimensional dynamic hydrologic and hydraulic (H&H) modeling of storm sewer and surface flow. The model considers tidal influence on the system. The model of existing conditions was developed in the EPA SWMM 5.2 software package.

Hydraulic Parameters

All parts of the storm sewer network serving the southern portion of the Town as shown in Figure 6 have been included in the H&H model. Additionally, the farm drainage ditch running parallel to the western edge of Bell Street was added to the model network. The ditch was broken into two segments: one representing the grass and high weeds cover condition north of Lowe Street with an assumed slope of 2%, and the other representing the heavy brush and wooded condition between Lowe Street and the outlet to riparian wetlands of Little River with an assumed slope of 0.5%. The cross-sectional shape of both ditch segments is based on field measurements of top width and depth. It is assumed to be trapezoidal with a three-foot depth, 2.25-foot bottom width, and 1 ½:1 side slope.

All catch basin grate elevations are based on DelDOT survey. Catch basin invert elevations have been determined through a combination of invert elevations provided by DelDOT survey and field measurements from known grate elevations. Catch basin invert elevations are assumed to match the inverts of connected pipes. For pipe junctions without an identified structure, estimated junction invert elevations were based on assumed pipe slopes providing positive network drainage. Information on existing pipe size and material has been synthesized from DelDOT record plans, DelDOT field survey, and the Little Creek Conceptual Resilience Plan prepared by the University of Delaware Coastal Resilience Design Studio (CRDS), dated August 2020. Additionally, DelDOT record plans indicate that a surface swale once connected pipes P-43 and P-44 upstream to pipe P-42 downstream prior to the development of the residence at 14 Bell Street. It is assumed for modeling purposes that an approximately 146 linear feet buried 15 inch RCP pipe has replaced the surface swale since the lot has been developed. However, additional site investigation may be required to confirm these assumptions.

Surface drainage was modeled in addition to and in conjunction with the subsurface storm sewer. Overflow from the Bell Street ditch is assumed to exit the ditch near the intersection of Bell and Lowe Streets and flow down Lowe Street toward Main Street. Surface links are provided in the model between Lowe Street and catch basins CB-34 and CB-32 to allow the water surface elevation to equalize freely. Catch basins CB-32, CB-33, CB-34, and CB-35 are assumed to be in a sump condition and do not use an inlet capacity calculation. Surface bypass from Lowe Street is directed toward the downstream Main Street inlets.

Street cross-section data for Main Street was provided by DelDOT. Inlet capture capacity was also modeled for the Main Street inlets. For simplicity, all inlets were modeled as combination inlets of the same size, though some inlets south of Lowe Street appear to be grate-only. All Main Street inlets are assumed to be on-grade, which is the conservative assumption; in reality, CB-26 and CB-28 could be considered in a sag condition based on grate elevations. The curb inlets on the east side of the street are assumed to bypass from north to south, with any uncaptured flow directed to the wetlands. The curb inlets on the west side of the street are assumed to bypass from CB-23 to CB-30. The road cross-section on Main Street south of Lowe Street is assumed to transition from a crowned roadway to a superelevated roadway directed toward the east curbline. In the model, surface bypass from CB-30 is routed toward CB-26 to simulate this transition.

Ponding areas were assigned to most catch basin locations in the model to extend flooding depths. For the Main Street inlets, this would allow flood depths above the top of curb. Ponding areas were estimated from topography.

Tidal backwater influence at the downstream outlets from the storm sewer system into the marsh were included in the model. The tidal curve used for modeling purposes represents a full-moon tidal cycle and is an average value based on the NOAA tide station records at Reedy Point and Lewes. Stage values are given in Table 1, referenced to the NAVD88 datum.

Table 1. Full-moon Tidal Curve

Hour of Day	Stage (ft)
3.63	-2.80
9.58	2.45
16.30	-2.70
21.85	1.55

3.2.1 Hydrologic Parameters

Four rainfall events were simulated in the existing conditions model: the one-, five-, 10-, and 25-year recurrence interval, 24-hour duration storm. The rainfall depths for each event are provided below in Table 2. A NOAA Type C rainfall distribution with a 24-hour duration was used for each event.

Table 2. Rainfall Event Depths (DNREC)

Event	Total Rainfall Depth (inches)
1-year, 24-hour	2.71
5-year, 24-hour	4.29
10-year, 24-hour	5.16
25-year, 24-hour	6.46

The EPA SWMM runoff process model was used to simulate hydrology. Infiltration losses were modeled using the modified NRCS curve number method within the EPA SWMM software package. Drainage areas drawn to individual catch basins were used in the model, as well as a drainage area for direct discharge to wetlands and separate drainage areas to the two Bell Street drainage ditch segments (Figure 5). The curve number for most drainage areas varied between 82 and 94, due to majority Hydrologic Soil Group (HSG) C and D soils and varying levels of impervious cover. The wetlands direct drainage area was an outlier, with a curve number of 73 and zero impervious cover.

3.2.2 Model Scenarios

Two existing conditions scenarios were modeled for each of the four rainfall events (one-, five-, 10- and 25-year storms). The first scenario used a tidal downstream boundary condition at the model outfalls, following the tidal curve in Table 1. Additionally, the rainfall event timing was shifted to the "worst-case" timing, in which peak runoff coincides with the higher high tide. The second scenario used a fixed downstream boundary condition at the model outfalls at elevation 2.45, representing a constant elevation at MHHW stage.

3.3 RESULTS

The tables in Appendix C show maximum gutter flow depth and spread along Main Street, as well as maximum flood elevations at all catch basin elevations, for the one- through 25-year storm events. On Main Street, gutter flow near catch basin CB-26 is predicted to overtop the curb for all storm events, and gutter flow near catch basin CB-28 is predicted to overtop the curb for the 25-year storm as well. Along Lowe Street, grates are predicted to be surcharged for catch basins CB-32 and CB-34 for all storm events. Along Bell Street, catch basin CB-35 is predicted to be surcharged for the five- through 25-year event.

Figure 7 shows mapped flood areas corresponding to the flood elevations given in Appendix C. Results show general agreement with frequently flooded locations as reported by town residents and officials. For example, Figure 7 shows significant surface flooding on Lowe Street, Bell Street, and adjacent properties for the 10- and 25-year events due to overtopping of the drainage ditch along Bell Street. This is supported by witness accounts that the drainage ditch overtops in large storm events, with overflow ultimately draining eastward down Lowe Street toward Main Street. Additionally, the full width of Main Street is predicted to be inundated in the vicinity of catch basins CB-26 and CB-30, just south of Lowe Street, for all storm events. This location has been observed to flood frequently, even in small events, which matches the model result.

It should be noted that flooding appears to be exacerbated by deficiencies in the storm sewer network, including undersized pipes, standing water in pipes and catch basins due to tidal conditions and settling of storm sewer components, and insufficient capacity in the Bell Street drainage ditch.

4.0 EVALUATION OF POTENTIAL FLOOD MITIGATION OPTIONS

A set of strategies to reduce roadway flooding in Little Creek were identified and evaluated. The strategies involve a combination of improving conveyance through the stormwater system, reducing tidal backflow, and diverting flow around the most flood prone. Specific flood mitigation measures evaluated include 1) drainage network improvements 2) restoration of the Bell Street ditch, 3) surface and subsurface volume storage options, 4) tide gates, 5) pumping, and 6) wetland restoration.

Based on the existing conditions modeling and preliminary mitigation modeling, the most viable options appeared to be some combination of subsurface storm sewer improvements, surface drainage improvements, and Bell Street ditch restoration. These alternatives were modeled in combination to identify recommended solutions. Section 5 of the report provides EPA SWMM 5.2 model results from two of the recommended combinations of these mitigation measures. Other mitigation measures were evaluated qualitatively and/or through limited modeling.

4.1 DRAINAGE NETWORK IMPROVEMENTS

Several drainage network improvements were investigated, including improvements to the subsurface storm sewer network as well as improvements to the on-street surface drainage network to improve capture efficiency and reduce gutter flow spread.

4.1.1 Subsurface Storm Sewer Improvements

Storm sewer improvements aim to improve capacity in the system and reduce ponding in the roadways. They include replacement pipes and catch basins sized to collect and convey the current 10-year storm, as recommended by the DelDOT Road Design Manual for local roads and streets as well as collectors (like Main Street/DE-9) [9]. The Manual also recommends that the resulting hydraulic grade line (HGL) be a minimum of one foot below any manhole cover or inlet grate elevations, but it does not appear that meeting this requirement will be feasible for this location due to high tidal backwater conditions. Components of the new system are to be located in the same location as existing components where feasible, to minimize replacement costs, though it is desirable to disconnect and abandon off-street pipes flowing through private property; they are difficult to maintain and potentially impossible to replace in their existing location, since it appears that in some cases, structures have been subsequently constructed above them. The existing system is mostly made up of 12-, 15-, and 18-inch pipes made of reinforced concrete or asbestos-bonded bituminous-coated corrugated metal. The existing catch basins CB-27, CB-28, CB-29, CB-30, CB-32, CB-33, CB-34, and CB-35 have grate-only tops, while the remainder of the catch basins in Main Street are curb inlets with a combination open mouth grate style top. In modeling the improvements, 15-, 18-, and 24-inch reinforced concrete pipes were utilized. In some cases, double barrel pipes were utilized to add capacity where pipes are anticipated to be too shallow to increase pipe diameter. Larger catch basin structures may be required to accommodate double barrel pipes.

Pipe P-37 is beneath the private property at 111 Main Street ("Little Creek Grill") and would be recommended to be replaced, since records indicate that it is a 12-inch pipe. It is good engineering practice to avoid downstream reductions in pipe size, and records indicate that upstream pipes are 15 inches. However, it is believed that the pipe runs near or beneath a portion of the Little Creek Grill building. P-37 can be disconnected and abandoned if alternate pipes are constructed within the public rights-of-way of Lowe and Main Streets to convey drainage to the downstream network. It is recommended that a new structure be placed at the southwest corner of Main and Lowe Streets and connected to catch basins CB-32, CB-30, and CB-31 with new pipes. Existing pipe P-36 would be replaced with two new pipes in the same location, on either side of the new structure.

Pipes P-41, P-42, P-43, P-44 and the buried former swale pipe are believed to run beneath private residential properties adjacent to the north side of Lowe Street (14 Bell Street, 39 Lowe Street, and possibly 135 Main Street), including possibly beneath structures. The condition, size, and slopes of these pipes is largely unknown. It is recommended that these pipes be disconnected from the drainage network and abandoned or removed. Abandonment of these pipes would remove the hydraulic connection from the Bell Street ditch and catch basin CB-35 to the downstream storm sewer network. It is recommended that the drainage area to CB-35 be redirected via a new pipe to the Bell Street ditch, though survey is needed to confirm that positive drainage is feasible with adequate slope and cover on the pipe.

In the existing condition, pipes P-30, P-31, and P-32 have a low or wrong-way slope, likely due to sinking of system components over time. To rectify this, at a minimum, pipes P-30, P-31, P-32, and P-33 should be replaced, with inverts at catch basin locations CB-26, CB-27, CB-28, and CB-29 lowered to provide a minimum 0.5% slope on all pipes.

Additionally, pipe elevations should be lowered at catch basin location CB-30 to provide adequate positive drainage for the upstream network. In addition to previously mentioned pipes, P-35, P-38, P-39, and P-40 would need to be replaced. It may not be feasible to provide minimum 0.5% slope on all pipes due to flat conditions and pipe cover restrictions, but slopes should be maximized to be as close to 0.5% as possible.

4.1.2 Surface Drainage Improvements

Surface drainage improvements are recommended to increase capture of surface flow into the subsurface drainage system and to decrease spread of street gutter flow to acceptable widths. The DelDOT Road Design Manual recommends that spread be limited to no more than half of the driving lane for local roads and streets as well as collectors (like Main Street/DE-9) [9]. For the northbound side of Main Street, the allowable spread is 14 feet from the face of curb (eight-foot parking lane, plus half of the 12-foot travel lane). For the southbound side of Main Street, the allowable spread is six feet (half of the 12-foot travel lane).

The following improvements are recommended, as supported by proposed conditions modeling:

- Replace catch basin CB-26 with a high-capacity inlet with a defined sump
- Regrade the southbound lane of Main Street to reduce spread at catch basins CB-23, CB-30, CB-30A, and CB-31, which may include the following measures:
    - Increase the cross-slope in Main Street to 2.5%
    - Construct a depressed gutter section. For modeling purposes, the gutter section was assumed to be two feet wide and have a two-inch depression at the bottom of curb.
    - Regrade the intersection of Main and Lowe Streets to make CB-31 be in a localized sag condition.
- Construct double inlets at the existing location of catch basins CB-23 and/or CB-31. Alternatively, extend the storm sewer along the western curbline of Main Street to place an additional inlet upstream of CB-23, effectively subdividing its existing drainage area into two areas.

Additionally, Green Stormwater Infrastructure (GSI) measures, such as a sidewalk planter, curb extension (“bumpout”) planter, or off-street rain garden could be utilized to increase surface capture and provide temporary surface storage of small runoff volumes. These measures tend to also provide traffic calming benefits and could be coordinated with a larger traffic calming plan for Main Street, if desired.

4.2 RESTORATION OF BELL STREET DITCH

The DelDOT Road Design Manual recommends that roadside ditches along local roads and streets be designed to convey a 10-year frequency event [9]. The drainage ditch along Bell Street currently conveys a maximum flow that is less than the 10-year storm. Overflow from the ditch for 10-year and larger events contributes to increased flooding downstream. Ditch restoration was evaluated to increase capacity and reduce overflow to the storm sewer system and surface drainage. Flow managed by the ditch drains southward toward the Little River, avoiding the storm sewer system and the flood-prone portion of the study area.

Detailed survey is required to design the ditch restoration to meet the 10-year standard, but possible restoration measures could include:

- Regrading of the wooded portion of the ditch to have consistent positive drainage (minimum 0.5% slope recommended)
- Conversion of the wooded portion of the ditch to a vegetated swale, similar to the upstream section
- Widening/resizing of the ditch cross-section to increase conveyance

For modeling purposes, the Manning's n-value of the ditch was calibrated to convey the 10-year storm without overtopping, so that the effects of ditch restoration in conjunction with storm sewer network improvements could be evaluated.

Restoration of the ditch may be dependent on the acquisition of private land through which the wooded portion of the ditch flows (Parcel ID #4-14-07808-01-2400-00001, owned by Sharon Brown), and/or the permission of the adjacent farm owner to the west of Bell Street.

4.3 ADDITIONAL FLOOD MITIGATION OPTIONS

Additional flood mitigation options that were evaluated include surface or subsurface detention, tide gates, pumping, and wetlands restoration.

4.3.1 Tide gates, detention, and pumping

Tide gates were considered as a mitigation measure to add system capacity, since the downstream portion of the storm sewer network is inundated daily by the tides. As one option, flap gates on both wetland outfalls were considered as an addition to the storm sewer network improvements. Flap gates prevent backflow when the outlet pipe is submerged by high tide but allow upstream flow to exit the system. However, when modeled using EPA SWMM 5.2, they were not found to provide significant capacity improvements to the system.

Another option would be to utilize control gates, which are held fully closed during the high portion of the tidal cycle. However, these must be used in conjunction with detention storage areas or pumping, because additional system capacity is required if a storm event occurs while the gates are closed. Surface detention options were considered, including detention basins and rain gardens; subsurface detention is unlikely to be feasible due to a predicted high-water table in the area. Multiple adjoining vacant parcels along the east side of Main Street (south of the residence at 110 Main Street) were considered as a potential site for detention storage. However, the parcels are likely not suitable for detention storage because large portions are mapped as wetlands and would require extensive permitting for significant alterations. Another option would be multiple small streetside planters or rain gardens. However, an annual maintenance program would need to be established for the surface features, and landowner permission would be required if constructed partially or fully outside of the public right-of-way. Pumping could be used instead of detention storage to increase drainage system capacity but would require additional capital costs as well as ongoing operations and maintenance costs.

The implementation of tide gates may need to be reevaluated in the future to prevent significant backflow into the system under predicted future higher sea level conditions.

4.3.2 Wetlands Restoration

At the outset of this study, a major mitigation alternative identified involved significant wetlands restoration and conveyance improvements on the Jarmin property. This work would require acquisition of the property. As the study progressed, the potential to acquire the property was in question, and this alternative was set aside for future consideration. Further, an increase in downstream wetlands storage is not anticipated to have a significant effect on upstream pluvial-driven flooding. The conveyance benefits of this alternative can be revisited in the future if this property becomes available for a restoration project. In addition to potential flood mitigation benefits, this alternative could result in significant ecological and water quality benefits.

5.0 RECOMMENDATION

Based on proposed conditions modeling using the EPA SWMM 5.2 software package, two recommended alternatives were identified. Alternative 2 is preferred if the necessary private property acquisitions can be made. If not, Alternative 1 is recommended. Refer to Figures 8 and 9 for the recommended storm sewer network layout for Alternatives 1 and 2, respectively.

5.1 IMPROVEMENTS RECOMMENDED ACROSS ALL ALTERNATIVES

The following improvements are recommended in any case:

- All storm sewer network improvements as described in Section 4.1.1(see Sections 5.2 and 5.3 for scenario-specific changes to pipe sizes)
- All inlet and surface drainage improvements as recommended in Section 4.1.2

5.2 ALTERNATIVE 1 RECOMMENDED IMPROVEMENTS

This alternative assumes that rehabilitation of the Bell Street ditch is not feasible, due to issues with acquisition of private property or other unforeseen issues. In addition to the improvements outlined in 5.1, the pipes noted in Table 3 should be upsized from existing conditions (or upsized from surrounding existing pipes, in the case of new pipes) to convey the 10-year storm. Double-barrel pipes are recommended in cases where pipe cover would likely not be sufficient for a larger pipe.

Table 3. Alternative 1 Pipe Size Summary

Pipe	Existing Diameter (in)	Proposed Diameter (in)
P-29	18	24
P-35	18	18 (double barrel)
P-36B	18 (existing pipe P-36)	18 (double barrel)
P-37A	12 (existing pipe P-37)	15 (double barrel)

Appendix D provides tables of the model results for the 10-year storm, using both a tidal and fixed MHHW downstream boundary condition. Results show that gutter spread in Main Street has been reduced to acceptable widths (half of the travel lane or less), and less than four inches of ponding results for off-street catch basins CB-32, CB-33, CB-34, and CB-35; maximum HGLs at these locations indicate no significant on-street or private property ponding. This alternative is expected to result in minimal roadway flooding up through the 10-year storm.

5.3 ALTERNATIVE 2 RECOMMENDED IMPROVEMENTS

This scenario assumes that the Bell Street ditch can be rehabilitated such that it conveys the 10-year storm without overtopping. In addition to the improvements outlined in 5.1, only one pipe would need to be upsized from existing conditions for the storm sewer to convey the 10-year storm, as shown in Table 4 below.

Table 4. Alternative 2 Pipe Size Summary

Pipe	Existing Diameter (in)	Proposed Diameter (in)
P-29	18	24

Similar to Alternative 1, results tables are provided in Appendix D. Results show similar reductions in gutter spread to acceptable widths, and up to four inches of ponding for off-street catch basins CB-32, CB-33, CB-34, and CB-35, which results in no significant on-street or private property ponding.

This is the preferred alternative, since pipe sizes will remain the same as existing for the shallow, cover-limited pipes along Lowe and Main Streets. During the final design process, we recommend that detailed topographic survey be obtained for the existing ditch and proposed extension area. It may be feasible to upsize the ditch to convey more than the 10-year storm flow. It may also be feasible to divert additional flow from the storm sewer network into the ditch to further reduce the potential flooding in the town. This may provide a level of protection against climate change which will impact the town via more frequent and higher tidal flooding and more frequent and intense precipitation events. The ditch restoration is a nature-based solution that is expected to provide water quality and habitat benefits in addition to flood reduction.

6.0 PERMITTING

6.1 DELDOT

Any work performed to the existing storm drain infrastructure within any state maintained rights-of-way will require coordination with DelDOT. The Town owns and maintains the inlets and pipes under Main Street, Lowe Street, and Bell Street, while DelDOT owns the and maintains the roads. Upgrades to the existing storm drainage infrastructure within the state-owned right-of-way will require a DelDOT utility permit.

6.2 ENVIRONMENTAL

The low-lying nature of the Town creates a hub for environmental resources, many of which are regulated by different agencies. Because of this, the following permits will be required from the following agencies for the work being performed:

1. Kent Conservation District (KCD) – The State of Delaware Sediment and Stormwater Regulations require that a person shall not disturb land without an approved Sediment and Stormwater Management Plan. A Sediment and Stormwater Management Plan Approval is required from the Kent Conservation District.

2. Delaware Department of Transportation (DelDOT) – Since a portion of the proposed infrastructure lies within the rights-of-way of state owned and maintained roads, an approval from DelDOT's Stormwater Engineer will be required. A Record plan approval will also be needed to establish easements and maintenance responsibilities for the green infrastructure.

3. Department of Natural Resources and Environmental Control (DNREC) – All construction projects with land disturbance over 1 acre are required to submit a Notice of Intent (NOI) as part of the NPDES General Permit for Storm Water Discharges associated with Construction Activity.

4. Kent County Planning – All construction projects wholly within, partially within, or in contact with any identified special flood hazard area are required to obtain a Permit to Construct from Kent County.

6.3 WETLANDS

Because the storm system and the Bell Street ditch both discharge to federally recognized wetlands, the following permits will be required from the following agencies for the work being done near or in wetlands:

1. U.S. Army Corps of Engineers (USACE) - The USACE Permitting requires the completion of a ENG Form 4345 (latest edition), and notifications of the following agencies: U.S. Fish and Wildlife Service; U.S. Environmental Protection Agency; National Marine Fisheries Service; the Delaware Department of Natural Resource and Environmental Control, Division of Water and Division of Watershed Stewardship; National Park Service, and the Delaware State Historic Preservation Office.

2. Department of Natural Resources and Environmental Control (DNREC) – The DNREC permitting process requires the preparation and submission of an application for a Subaqueous Permit to DNREC. The permit application will require the completion of the Basic Application Form and the appropriate Appendices. This application will include a description of the proposed activity, a written statement that describes measures used to avoid impacts to protect resources, and plans of the project site, including cross-sections, showing existing and proposed conditions.

7.0 ENGINEER'S OPINION OF PROBABLE COST

A preliminary opinion of probable cost has been prepared for both the design and construction of the provided flood mitigation options based on our knowledge of similar projects.

7.1 ALTERNATIVE 1

The Alternative 1 estimate of probable cost is $1.70M. This estimate is itemized and provided in Appendix E.

7.1.1 Engineering Cost

Engineering costs associated with design of the conceptual improvements and construction related services have been estimated based on actual costs of recent projects. The Total Engineering Cost of approximately $383,400 includes design, permitting, bid services, and construction and project administration. The permitting portion of the cost estimate includes all permits mentioned in section 6.0.

7.1.2 Construction Cost

The Engineer's Opinion of Probable Construction Cost (EOPCC) is a Class 4 estimate based on criteria of the Association for the Advancement of Cost Engineering (AACE). A Class 4 estimate is typically used for project screening, determination of feasibility, concept evaluation and preliminary budget approval.

The EOPCC is based on both conceptual level designs prepared with this study. The EOPCC, provided in Appendix E, is approximately $1,320,700 and is summarized below.

Stormwater System Improvements	**$ 354,200**
Road Work	**$ 549,400**
Earthwork and Mobilization	**$ 417,100**
EOPCC Total	**$1,320,700**

7.2 ALTERNATIVE 2

The Alternative 2 estimate of probable cost is $1.76M. It is itemized and provided in Appendix F.

7.2.1 Engineering Cost

Engineering costs associated with design of the conceptual improvements and construction related services have been estimated based on actual costs of recent projects. The Total Engineering Cost of approximately $409,800 includes design, permitting, bid services, and construction and project administration. The permitting portion of the cost estimate includes all permits mentioned in section 6.0.

7.2.2 Construction Cost

The Engineer's Opinion of Probable Construction Cost (EOPCC) is a Class 4 estimate based on criteria of the Association for the Advancement of Cost Engineering (AACE). A Class 4 estimate is typically used for project screening, determination of feasibility, concept evaluation and preliminary budget approval.

The EOPCC is based on both conceptual level designs prepared with this study. The EOPCC, provided in Appendix F, is approximately $1,354,300 and is summarized below. This EOPCC does not include any easement or land acquisition costs that may be required to implement this alternative.

Stormwater System Improvements	**$ 321,400**
Road Work	**$ 549,400**
Earthwork and Mobilization	**$ 483,500**
EOPCC Total	**$1,354,300**

As described in Section 5.3, it may be possible to upsize the proposed Alternative 2 ditch restoration component to manage additional flow. For planning purposes, we recommend an additional $50,000 in engineering budget to be included to analyze and optimize sizing of the ditch.

7.3 ADDITIONAL INFORMATION

The EOPCCs are made by an engineer and not by a professional construction cost estimator or construction contractor. Consistent with AACE criteria, the Class 4 estimate herein includes a 20% contingency and was prepared for determination of feasibility and preliminary budget consideration.

These estimates assumes that state wages will be used for construction work because the project takes place primarily within a DelDOT Right-of-Way. Additionally, DelDOT requires RCP to be used when conveying stormwater within their R.O.W. In the Town maintained roads (Bell St. and Lowe St.) HDPE pipe could potentially be used in place of RCP, which would lower the cost of the stormwater improvements.

There are other improvements that were considered, but not included in the cost estimate. These improvements are listed below:

1. Providing ADA ramps and access – ADA improvements may be helpful if pursuing grant funding for construction projects.
2. Green Stormwater Infrastructure – GSI would assist in detention of stormwater but would require land acquisition which is unpredictable in pricing.

8.0 CONCLUSION

A combination of strategies is likely required to mitigate flood risk in the southern portion of Little Creek. Verdantas performed a natural resources and existing conditions evaluation of the study area and modeled flooding during the one-, five-, 10-, and 25-year frequency, 24-hour duration storm event to validate against observed flooding. Verdantas then evaluated several flood mitigation strategies and recommended two possible scenarios as combinations of those strategies. The first strategy (Alternative 1) involves improving and upsizing the drainage system while the second strategy (Alternative 2) involves a combination of drainage system and ditch improvements. Alternative 2 includes nature-based solutions and is anticipated to provide water quality and habitat benefits in addition to flood restoration benefits. The overall flood mitigation strategy is recommended to rely on a combination of subsurface and surface drainage network improvements. Climate change and sea level rise are expected to exacerbate flooding in Little Creek. While the proposed alternatives are designed to manage current flood conditions, they will provide a level of protection against future flooding and sea level rise. Additional system improvements may be required to manage the future 10-year storm and could be evaluated as part of a subsequent engineering design phase.

An Engineers Opinion of Probable Construction Costs was created to encapsulate the total cost of both upsizing the subsurface stormwater system as well as restoring the ditch to the west side of Little Creek. Additionally, an engineering cost estimate was provided for design, permitting, project management, bidding, and construction administration services. The total estimated cost for Alternative 1 is $1.70M and for Alternative 2 is $1.76M. Alternative 2 is expected to require land acquisition and/or easement costs in addition to this estimated cost. It may be possible to upsize the ditch restoration component to provide additional flood reduction benefits and added climate change risk management. The upsizing would likely require additional design and construction costs.

9.0 REFERENCES

1. United States Geologic Survey, Available online at http://www.fws.gov/wetlands/Data/Mapper.html, accessed August 16, 2023.

2. United States Department of the Interior, Fish and Wildlife Service, National Wetlands Inventory Map, Available online at http://www.fws.gov/wetlands/Data/Mapper.html, accessed August 16, 2023.

3. Soil Survey Staff, Natural Resources Conservation Service, United States Department of Agriculture. Web Soil Survey. Available online at http://websoilsurvey.nrcs.usda.gov/, accessed August 16, 2023.

4. Environmental Laboratory, 1987. Corps of Engineers Wetlands Delineation Manual, Technical Report Y 87 1, United States Army Engineer Waterways Experiment Station, Vicksburg, MS.

5. U.S. Army Corps of Engineers, 2010 Regional Supplement to the Corps of Engineers Wetland Delineation Manual: Atlantic and Gulf Coastal Plain Region Version 2.0 U.S. Army Engineer Research and Development Center. ERDC/EL TR 10-20.

6. Lichvar, R.W., D.L. Banks, W.N. Kirchner, and N.C. Melvin. 2016. The National Wetland Plant List: 2016 wetland ratings. Phytoneuron 2016-30: 1-17. Published 28 April 2016. ISSN 2153 733X

7. NOAA Fisheries Essential Fish Habitat Mapper, Available online https://www.fisheries.noaa.gov/resource/map/essential-fish-habitat-mapper, accessed August 16, 2021 and September 22, 2023.

8. Information of Planning and Consulting Tool, Available online https://ipac.ecosphere.fws.gov/, accessed September 21, 2023.

9. Delaware Department of Transportation, 2022. Road Design Manual, Available online https://roaddesignmanual.deldot.gov/ , accessed February 13, 2024.

FIGURES

Delaware

DISCLAIMER:
Verdantas LLC has furnished this map to the Client for its sole and exclusive use as a preliminary planning and screening tool. This map is reproduced from geospatial information compiled from third-party sources which may change over time and are not accurate as to mapping, surveying or engineering standards. Verdantas LLC makes no representation or warranty as to the content, accuracy, timeliness or completeness of any information. In no event will Verdantas LLC, its owners, officers, employees or agents, be liable for damages of any kind arising out of the use of this map by Client or any other party.

0 1,000 2,000 4,000 Feet
1 Inch = 5,464 Feet

Quadrangle: Little Creek, Delaware

Sources:

The topographic map was acquired through the National Geographic Society Web Service.

The aerial photo in the inset was acquired through the Esri Imagery Web Service dated 2015.

verdantas
PEOPLE FOCUSED FUTURE

NATURAL RESOURCES MAPS

Site Location Map

TOWN OF LITTLE CREEK
KENT COUNTY~DELAWARE

Date:
March 2024

Date Edited: 3/1/2024

GIS User: jfedetz

Figure
1

File Location: Z:\Project Files\CA-DZ\DNREC\18040 - Little Creek Southern Flood Mitigation FIGIS\18040 LittleCreek_Natural_Resources 2024.02.13.aprx

verdantas
PEOPLE FOCUSED FUTURE

DISCLAIMER:
Verdantas LLC has furnished this map to the Client for its sole and exclusive use as a preliminary planning and screening tool. This map is reproduced from geospatial information compiled from third-party sources which may change over time and are not accurate as to mapping, surveying or engineering standards. Verdantas LLC makes no representation or warranty as to the content, accuracy, timeliness or completeness of any information. In no event will Verdantas LLC, its owners, officers, employees or agents, be liable for damages of any kind arising out of the use of this map by Client or any other party.

March 2024

NATURAL RESOURCES MAPS

Figure 2

NATIONAL WETLANDS INVENTORY MAP

TOWN OF LITTLE CREEK
KENT COUNTY~DELAWARE

Produced Using Esri's ArcGIS Software

Edited: 3/1/2024 User: jfedetz

Note:
The aerial photo was acquired through the Esri Imagery Web Service.
Aerial photography dated 2015.

verdantas
PEOPLE FOCUSED FUTURE

DISCLAIMER:
Verdantas LLC has furnished this map to the Client for its sole and exclusive use as a preliminary planning and screening tool. This map is reproduced from geospatial information compiled from third-party sources which may change over time and are not accurate as to mapping, survey or engineering standards. Verdantas LLC makes no representation or warranty as to the content, accuracy, timeliness or completeness of any information. In no event will Verdantas LLC, its owners, officers, employees or agents, be liable for damages of any kind arising out of the use of this map by Client or any other party.

March 2024

NATURAL RESOURCES MAPS

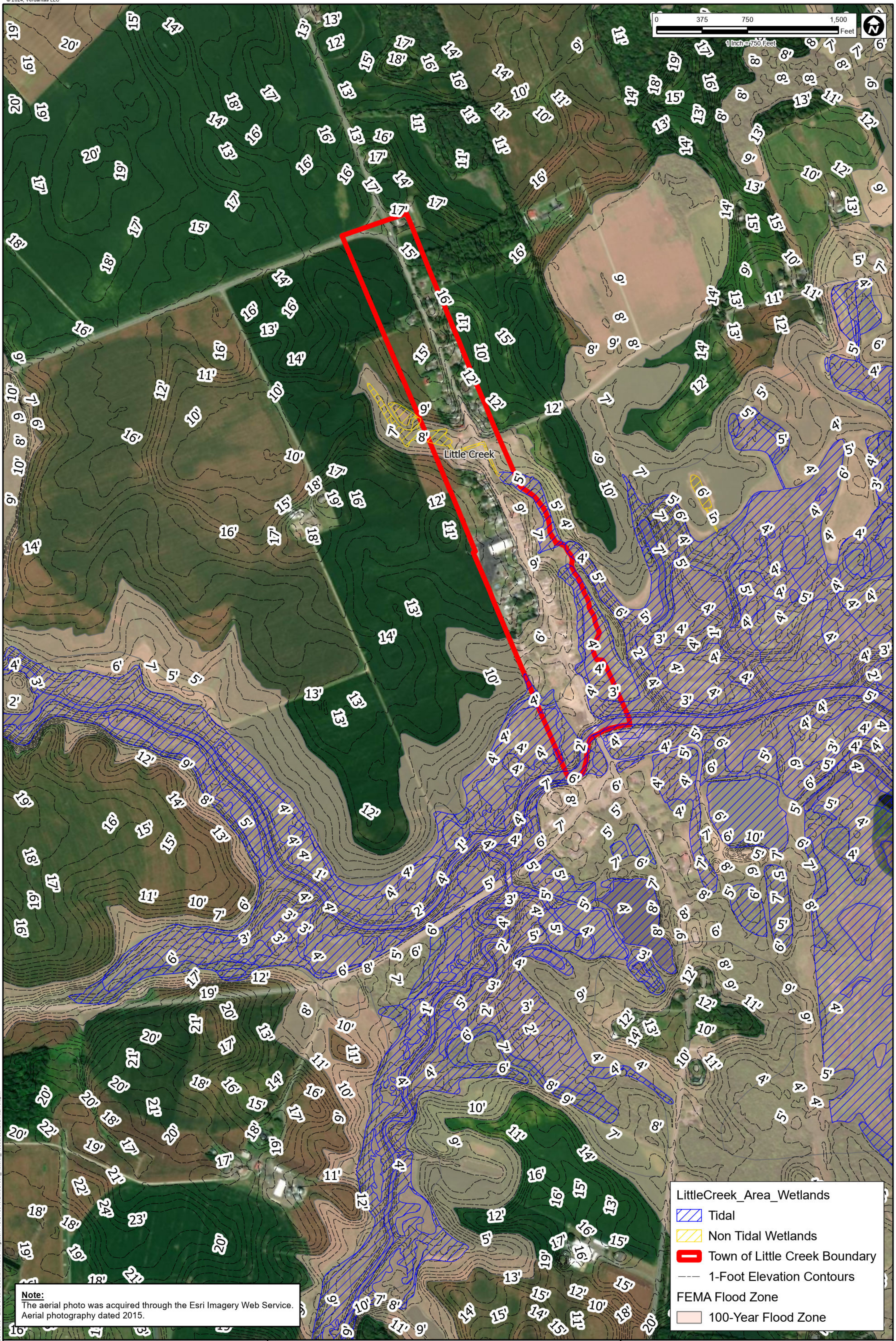
NATIONAL WETLANDS INVENTORY MAP

TOWN OF LITTLE CREEK
KENT COUNTY~DELAWARE

Figure
3

Produced Using Esri's ArcGIS Software

Edited: 3/1/2024 User: jfedetz



verdantas
PEOPLE FOCUSED FUTURE

DISCLAIMER:
Verdantas LLC has furnished this map to the Client for its sole and exclusive use as a preliminary planning and screening tool. This map is reproduced from geospatial information compiled from third-party sources which may change over time and are not accurate as to mapping, surveying or engineering standards. Verdantas LLC makes no representation or warranty as to the content, accuracy, timeliness or completeness of any information. In no event will Verdantas LLC, its owners, officers, employees or agents, be liable for damages of any kind arising out of the use of this map by Client or any other party.

February 2024

NATURAL RESOURCES MAPS

WETLANDS AND FLOODPLAIN MAP

TOWN OF LITTLE CREEK
KENT COUNTY~DELAWARE

Figure
4

Produced Using Esri's ArcGIS Software

Edited: 2/14/2024 User: jfedetz

150' 0 150' 300'
DRAWING SCALE 1" = 150'

verdantas
PEOPLE FOCUSED FUTURE
1060 S. GOVERNORS AVE, SUITE 101
DOVER, DE 19904-6920
TEL. 302.674.9280
FAX 302.674.1099

GINA L. TONN, P.E.
STATE: DE
P.E. #XXXX

DESIGNED BY: PJM/EPP
DRAWN BY: PJM/EPP
CHECKED BY: GLT
PROJECT NO. 18040

No.	REVISION	CHK'D BY DATE
	PRELIMINARY NOT FOR CONSTRUCTION	

LITTLE CREEK ~ KENT COUNTY ~ DELAWARE
SOUTHERN FLOOD MITIGATION FEASIBILITY STUDY
DRAINAGE AREA MAP

APPLICATION NO.
DATE: MARCH 5, 2024
SCALE: 1' = 150'
SHEET: FIGURE 5

CRDS
COASTAL RESILIENCE DESIGN STUDIO

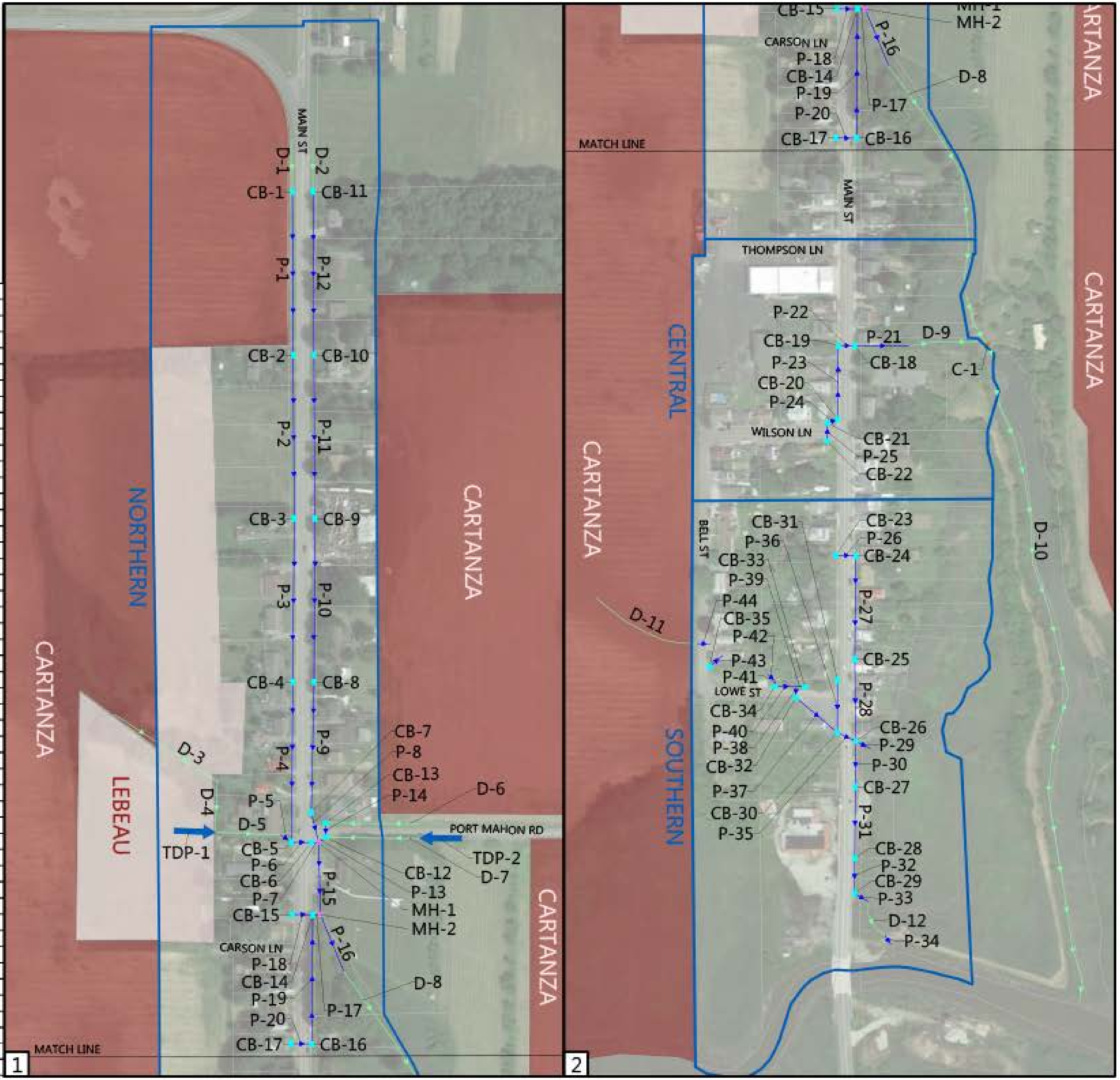
Existing Stormwater Infrastructure

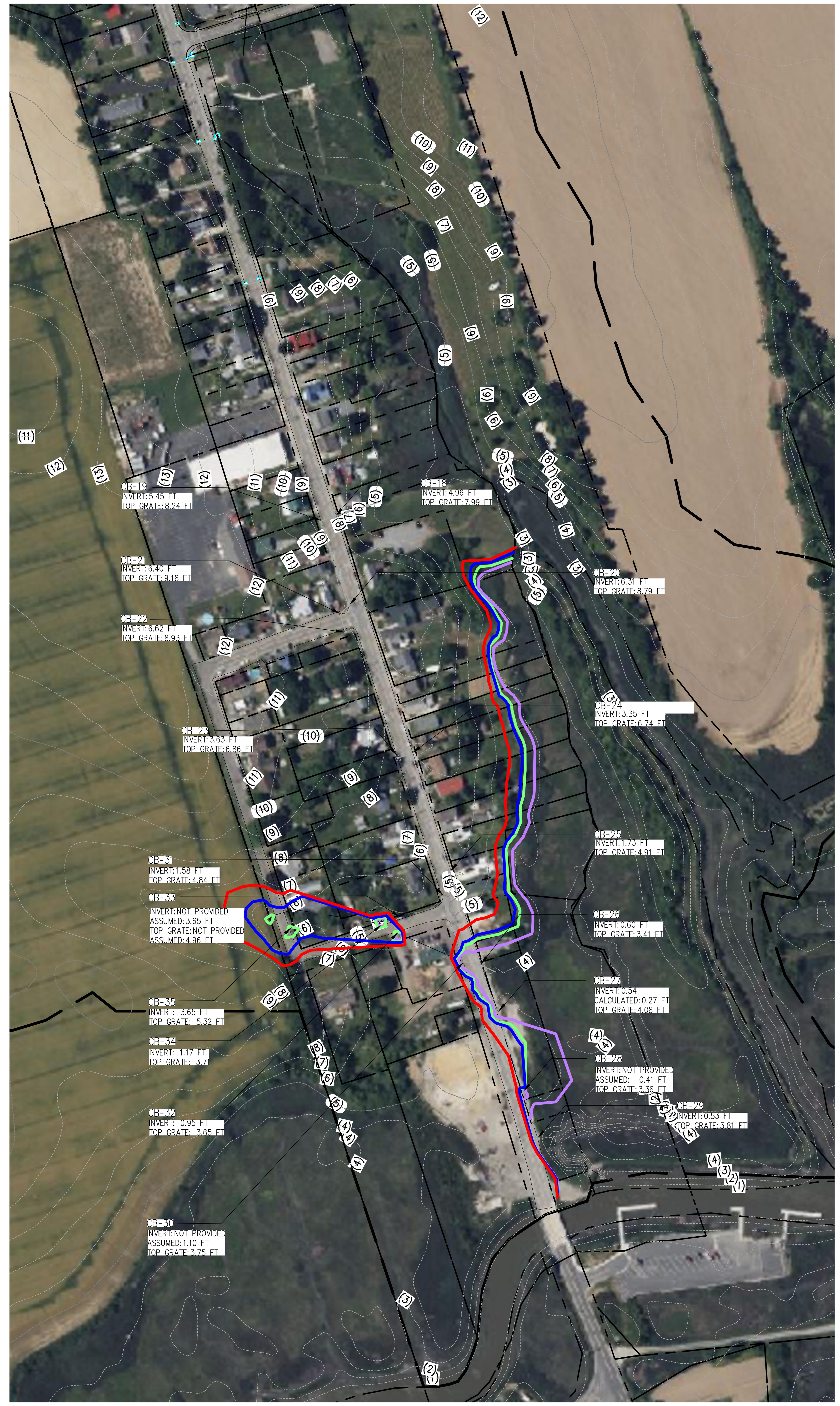
Little Creek, Delaware

0 180 360
Scale: 1" = 180'

Little Creek Stormwater Pipe Inventory

	Pipe	Diameter (in.)	Length (L.F.)	Type	Notes
Northern	P-1	-	~400	-	Assumed connections; Possibly inaccurate
	P-2	-	~400	-	Assumed connections; Possibly inaccurate
	P-3	-	~400	-	Assumed connections; Possibly inaccurate
	P-4	-	~395	-	Assumed connections; Possibly inaccurate
	P-5	~36	~32	CMP	Info from DelDOT Contract 65-10-011
	P-6	24	~30	RCP	Info from DelDOT Contract 65-10-011
	P-7	24	~5	RCP	Info from DelDOT Contract 65-10-011
	P-8	18	75	RCP	Info from DelDOT Contract 65-10-011
	P-9	-	~320	-	Assumed connections; Possibly inaccurate
	P-10	-	~400	-	Assumed connections; Possibly inaccurate
	P-11	-	~400	-	Assumed connections; Possibly inaccurate
	P-12	-	~400	-	Assumed connections; Possibly inaccurate
	P-13	18	32	RCP	Info from DelDOT Contract 65-10-011
	P-14	18	40	RCP	Info from DelDOT Contract 65-10-011
	P-15	30	~170	RCP	Info from DelDOT Contract 65-10-011
	P-16	30	150	RCP	Outlet ditch (D-8) silted-in
	P-17	-	12	ACCMP	Info from DelDOT Contract 65-10-011
	P-18	18	30	RCP	Info from DelDOT Contract 65-10-011
	P-19	22"x13"	307	ACCMP	Info from DelDOT Contract 65-10-011
	P-20	18	30	RCP	Info from DelDOT Contract 65-10-011
	TDP-1	~8	-	PVC	Tile Drainage Pipe (Cartanza); LeBeau lawsuit
	TDP-2	-	-	-	Tile Drainage Pipe (Unknown)
	C-1	18	25	ABBC-CMP	Culvert; Two pipes, same size; Partially Collapsed
Central	P-21	18	133	RCP	Info from DelDOT Contract 65-10-011
	P-22	18	~30	RCP	Info from DelDOT Contract 65-10-011
	P-23	15	186	RCP	Info from DelDOT Contract 65-10-011
	P-24	15	24	RCP	Info from DelDOT Contract 65-10-011
	P-25	15	34	RCP	Info from DelDOT Contract 65-10-011
Southern	P-26	15	30	RCP	KCD inspected; Joint Offset; Debris
	P-27	18	244	RCP	KCD inspected; Infiltration runner; Debris
	P-28	18	189	ABBC-CMP	KCD inspected; Significant corrosion
	P-29	18	20	ABBC-CMP	KCD inspection incomplete; Backflow from marsh
	P-30	18	~103	RCP	KCD inspected; Infiltration runner/ring broken
	P-31	18	~173	RCP	KCD inspected; Infiltration runner/dripper; Debris
	P-32	-	~100	-	-
	P-33	~18	~32	CMP	-
	P-34	~30	-	HDPE-DWCP	-
	P-35	18	~33	ABBC-CMP	KCD inspected; Lost BC
	P-36	18	~138	ABBC-CMP	KCD inspection incomplete
	P-37	12	~147	RCP	KCD inspection incomplete
	P-38	15	-	RCP	KCD inspected; Blind Junction w/ P-39, P-40
	P-39	-	-	-	KCD inspected; Blind Junction w/ P-38, P-40
	P-40	-	-	RCP	KCD inspected; Blind Junction w/ P-38, P-39
	P-41	15	-	RCP	KCD inspected
	P-42	15	-	RCP	KCD inspected; Unknown connection
	P-43	-	-	-	KCD inspected; Unknown connection
	P-44	12	-	RCP	Unknown connection; Possibly removed





LEGEND

- 1-YEAR FLOOD EXTENTS
- 5-YEAR FLOOD EXTENTS
- 10-YEAR FLOOD EXTENTS
- 25-YEAR FLOOD EXTENTS

150' 0 150' 300'
DRAWING SCALE 1" = 150'

verdantas
PEOPLE FOCUSED FUTURE
1060 S. GOVERNORS AVE, SUITE 101
DOVER, DE 19904-6920
TEL. 302.674.9280
FAX 302.674.1099

GINA TONN
STATE: DE
P.E. P.E. #XXXX

DESIGNED BY:	DRAWN BY:	CHECKED BY:	PROJECT NO.
EPP	PJM/EPP	GLT	18040

No.	REVISION	CHK'D BY DATE
	PRELIMINARY NOT FOR CONSTRUCTION	

LITTLE CREEK ~ KENT COUNTY ~ DELAWARE

SOUTHERN FLOOD MITIGATION FEASIBILITY STUDY

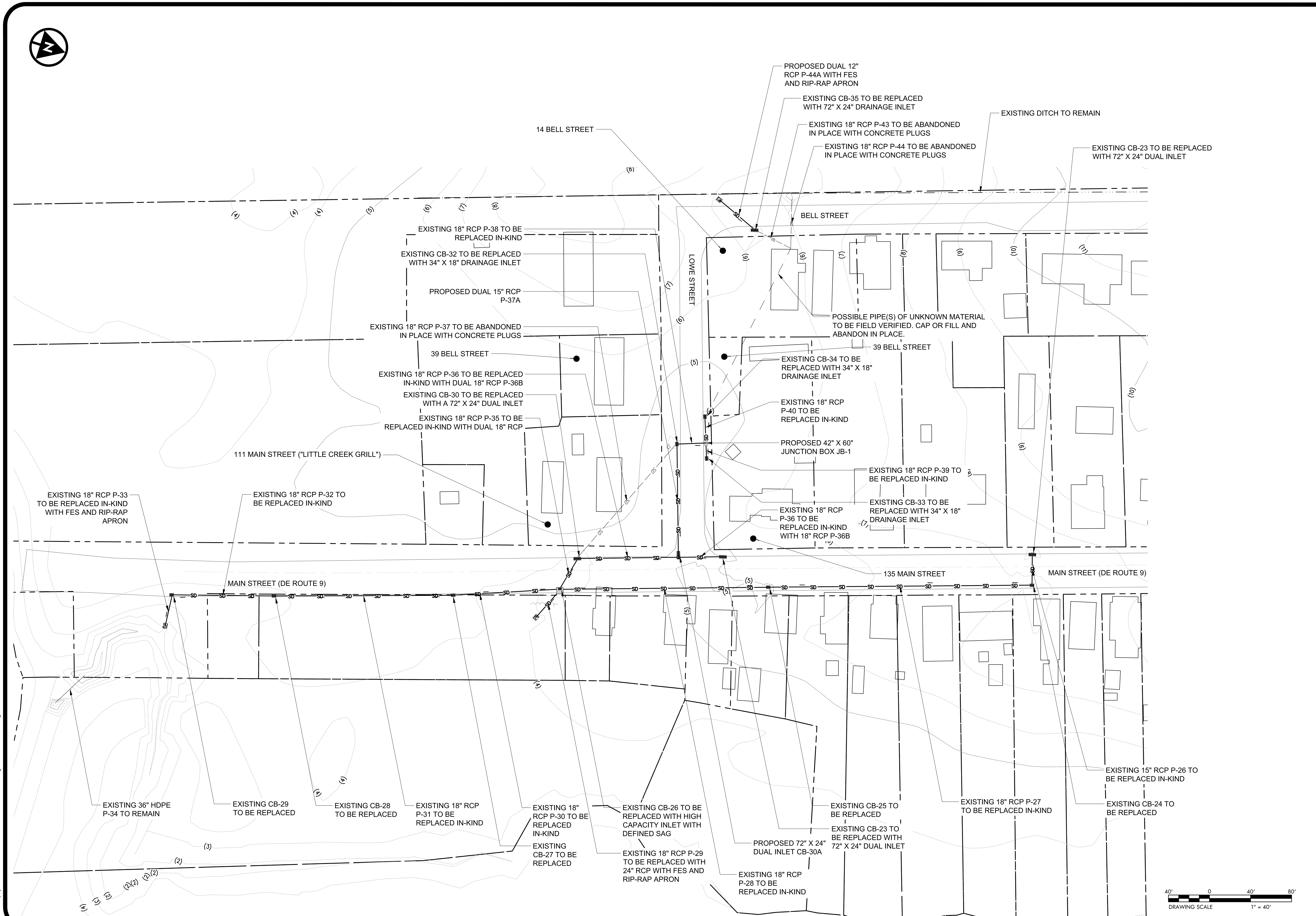
EXISTING CONDITIONS MODEL RESULTS MAP

APPLICATION NO.

DATE: FEBRUARY 29, 2024

SCALE: 1' = 150'

SHEET: FIGURE 7



verdantas
PEOPLE FOCUSED FUTURE

1060 S. GOVERNORS AVE, SUITE 101
DOVER, DE 19904-6920
TEL. 302.674.9280
FAX 302.674.1099

GINA TONN
P.E. #XXXXX
STATE: DELAWARE

DESIGNED BY:	DRAWN BY:	CHECKED BY:	PROJECT NO.
EPP	PJM	GLT	18040

No.	REVISION	CHK'D BY DATE

PRELIMINARY NOT FOR CONSTRUCTION

TOWN OF LITTLE CREEK ~ KENT COUNTY ~ DELAWARE

LITTLE CREEK SOUTHERN FLOOD MITIGATION FEASIBILITY STUDY

DNREC

ALTERNATIVE 1 CONCEPT DESIGN

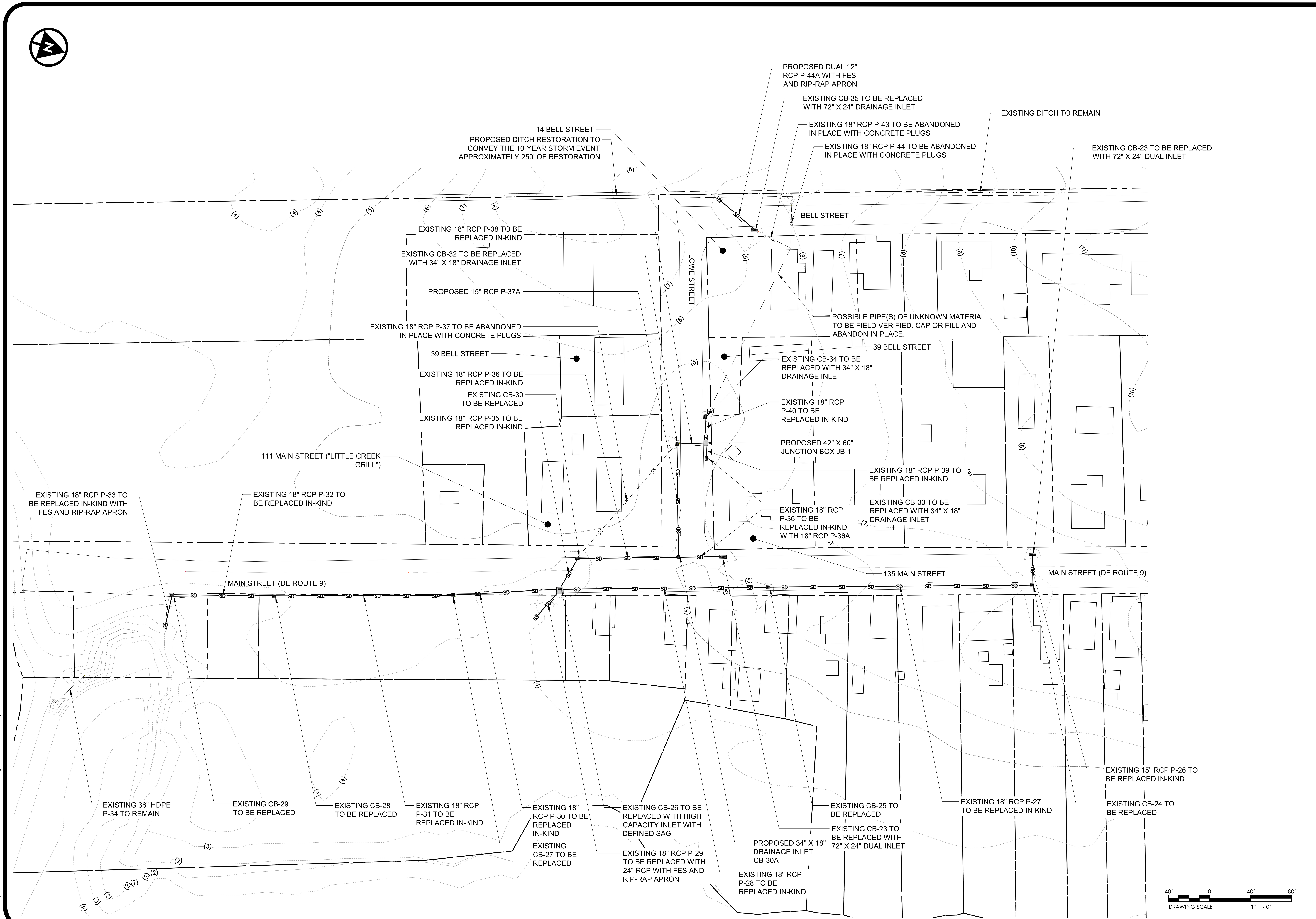
APPLICATION NO.

DATE: FEBRUARY 29, 2024

SCALE: 1" = 40'

SHEET: FIGURE 10

z:\project files\ca-dz\dnrec\18040 - little creek southern flood mitigation fcad\18040-con.dwg



verdantas
PEOPLE FOCUSED FUTURE
1060 S. GOVERNORS AVE, SUITE 101
DOVER, DE 19904-6920
TEL 302.674.9280
FAX 302.674.1099

GINA TONN
P.E. #XXXXXX
STATE: DELAWARE

DESIGNED BY: EPP
DRAWN BY: PJM
CHECKED BY: GLT
PROJECT NO. 18040

No. | REVISION | DATE | CHK'D BY

PRELIMINARY NOT FOR CONSTRUCTION

TOWN OF LITTLE CREEK ~ KENT COUNTY ~ DELAWARE

LITTLE CREEK SOUTHERN FLOOD MITIGATION FEASIBILITY STUDY

DNREC

ALTERNATIVE 2 CONCEPT DESIGN

APPLICATION NO.

DATE: FEBRUARY 29, 2024

SCALE: 1" = 40'

SHEET: FIGURE 10

APPENDIX A

DELAWARE TIDAL WETLANDS

PHOTO # 18-019

N

FILENAME - DNR220

300 0 300 600 900 1200 1500 1800 2100 Feet

SCALE 1:3600

DELAWARE DEPARTMENT OF NATURAL RESOURCES AND ENVIRONMENTAL CONTROL

SALISBURY STATE UNIVERSITY MARYLAND

State of Delaware Wetlands
KENT COUNTY, DELAWARE

(in Accordance with the Delaware Wetlands Act # 6607)
Approximate Scale (1:3600)

Prepared for: DEPARTMENT OF NATURAL RESOURCES
and ENVIRONMENTAL CONTROL

Produced by: SALISBURY STATE UNIVERSITY
IMAGE PROCESSING & REMOTE SENSING CENTER
SALISBURY, MARYLAND

Legend for Delaware Tidal Wetland Delineations:

B - Beach
DF - Disturbed Forested Swamp
DM - Disturbed Marsh (vegetation removed for agricultural activities)
F - Tidal Forested Swamp
IF - Impounded Forested Wetland
ILM - Impounded Low Marsh
IM - Impounded Marsh
IS - Impounded Scrub-Shrub Wetland
IW - Impounded Water
LM - Low Marsh
M - Marsh
MS - Marsh in spoil areas
N - Non-tidal wetlands (400 acres+ , including tidal forested swamps)
O - Other (Upland or Non-tidal wetlands less than 400 acres)
S - Tidal Scrub-Shrub Swamps
SS - Areas flooded by tidal storm surges
SS* - Areas flooded by storm surges at a higher flood plain elevation
T - Tidal Mudflats (in some cases vegetated)/ sand bars
W - Water
WS - Water in a spoil area
/ - complexes among different commmunity types (ex. M/S)

Map Change See Box File + Violation File

APPENDIX B

ESSENTIAL FISH HABITAT LIST

EFH Data Notice: Essential Fish Habitat (EFH) is defined by textual descriptions contained in the fishery management plans developed by the regional Fishery Management Councils. In most cases mapping data can not fully represent the complexity of the habitats that make up EFH. This report should be used for general interest queries only and should not be interpreted as a definitive evaluation of EFH at this location. A location-specific evaluation of EFH for any official purposes must be performed by a regional expert. Please refer to the following links for the appropriate regional resources.

Greater Atlantic Regional Office
Atlantic Highly Migratory Species Management Division

Query Results

Degrees, Minutes, Seconds: Latitude = 39º9'34" N, Longitude = 76º33'49" W
Decimal Degrees: Latitude = 39.16, Longitude = -75.44

The query location intersects with spatial data representing EFH and/or HAPCs for the following species/management units.

*** W A R N I N G ***

Please note under "Life Stage(s) Found at Location" the category "ALL" indicates that all life stages of that species share the same map and are designated at the queried location.

EFH

Show	Link	Data Caveats	Species/Management Unit	Lifestage(s) Found at Location	Management Council	FMP
			Little Skate	Juvenile Adult	New England	Amendment 2 to the Northeast Skate Complex FMP
			Atlantic Herring	Juvenile Adult	New England	Amendment 3 to the Atlantic Herring FMP
			Red Hake	Adult	New England	Amendment 14 to the Northeast Multispecies FMP
			Windowpane Flounder	Adult Juvenile	New England	Amendment 14 to the Northeast Multispecies FMP
			Winter Skate	Adult Juvenile	New England	Amendment 2 to the Northeast Skate Complex FMP
			Clearnose Skate	Adult Juvenile	New England	Amendment 2 to the Northeast Skate Complex FMP
			Longfin Inshore Squid	Eggs	Mid-Atlantic	Atlantic Mackerel, Squid,& Butterfish Amendment 11
			Bluefish	Adult Juvenile	Mid-Atlantic	Bluefish
			Atlantic Butterfish	Larvae Adult	Mid-Atlantic	Atlantic Mackerel, Squid,& Butterfish Amendment 11
			Scup	Juvenile Adult	Mid-Atlantic	Summer Flounder, Scup, Black Sea Bass
			Summer Flounder	Juvenile Adult	Mid-Atlantic	Summer Flounder, Scup, Black Sea Bass
			Black Sea Bass	Juvenile Adult	Mid-Atlantic	Summer Flounder, Scup, Black Sea Bass

HAPCs

No Habitat Areas of Particular Concern (HAPC) were identified at the report location.

EFH Areas Protected from Fishing

No EFH Areas Protected from Fishing (EFHA) were identified at the report location.

Spatial data does not currently exist for all the managed species in this area. The following is a list of species or management units for which there is no spatial data. ****For links to all EFH text descriptions see the complete data inventory: open data inventory -->**
All spatial data is currently mapped for this region

APPENDIX C

EXISTING NODE FLOODING SUMMARY

Main Street Inlets														
				Tidal (storm peak aligned with high-high tide)						Fixed Stage (at high-high tide)				
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth
CB-23	6.86	3.63	N/A	7.544	0.177	NO	0	7.02	0.16	7.544	0.177	NO	0	7.02	0.16
CB-24	6.74	3.35	N/A	6.601	0.154	NO	0	6.90	0.16	6.601	0.154	NO	0	6.90	0.16
CB-25	4.91	1.73	730	6.148	0.159	NO	0	5.07	0.16	6.147	0.159	NO	0	5.07	0.16
CB-26	3.41	0.60	5060	12.005	0.364	YES	0.116	4.10	0.69	12.126	0.367	YES	0.223	4.21	0.80
CB-27	4.08	0.27	1560	15.818	0.316	NO	0	4.21	0.13	15.818	0.316	NO	0	4.21	0.13
CB-28	3.36	-0.41	4215	8.922	0.357	NO	0	3.94	0.58	8.922	0.357	NO	0	3.94	0.58
CB-29	3.81	0.53	4350	11.443	0.355	NO	0	3.94	0.13	11.443	0.355	NO	0	3.94	0.13
CB-30	3.75	1.10	8050	13.000	0.211	NO	0	4.10	0.35	13.000	0.258	NO	0	4.21	0.46
CB-31	4.84	1.58	2500	13.000	0.173	NO	0	5.04	0.20	13.000	0.168	NO	0	5.03	0.19

Lowe/Bell Street Inlets									
				Tidal (storm peak aligned with high-high tide)			Fixed Stage (at high-high tide)		
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max HGL	Flooded?	Max Surface Depth (ft)	Max HGL	Flooded?	Max Surface Depth (ft)
CB-32	3.65	0.95	7750	4.10	YES	0.45	4.21	YES	0.56
CB-33	4.96	3.65	1600	4.10	NO	N/A	4.21	NO	N/A
CB-34	3.71	1.17	3100	4.10	YES	0.39	4.21	YES	0.50
CB-35	5.32	3.65	880	5.01	NO	N/A	5.03	NO	N/A

Existing Model Results **5-year Event** **Created By: EPP 2/22/2024**

Main Street Inlets															
				Tidal (storm peak aligned with high-high tide)						Fixed Stage (at high-high tide)					
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth
CB-23	6.86	3.63	N/A	9.387	0.220	NO	0	7.05	0.19	9.387	0.220	NO	0	7.05	0.19
CB-24	6.74	3.35	N/A	8.284	0.194	NO	0	6.94	0.20	8.284	0.194	NO	0	6.94	0.20
CB-25	4.91	1.73	730	7.847	0.202	NO	0	5.11	0.20	7.847	0.202	NO	0	5.11	0.20
CB-26	3.41	0.60	5060	12.865	0.390	YES	0.332	4.32	0.91	12.865	0.390	YES	0.378	4.36	0.95
CB-27	4.08	0.27	1560	18.383	0.368	NO	0	4.32	0.24	19.000	0.390	NO	0	4.36	0.28
CB-28	3.36	-0.41	4215	10.030	0.401	NO	0	3.97	0.61	10.916	0.437	NO	0	3.97	0.61
CB-29	3.81	0.53	4350	12.442	0.386	NO	0	3.97	0.16	12.442	0.386	NO	0	3.97	0.16
CB-30	3.75	1.10	8050	13.000	0.331	NO	0	4.32	0.57	13.000	0.347	NO	0	4.36	0.61
CB-31	4.84	1.58	2500	13.000	0.209	NO	0	5.07	0.23	13.000	0.209	NO	0	5.07	0.23

Lowe/Bell Street Inlets									
				Tidal (storm peak aligned with high-high tide)			Fixed Stage (at high-high tide)		
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max HGL	Flooded?	Max Surface Depth (ft)	Max HGL	Flooded?	Max Surface Depth (ft)
CB-32	3.65	0.95	7750	4.32	YES	0.67	4.36	YES	0.71
CB-33	4.96	3.65	1600	4.32	NO	N/A	4.36	NO	N/A
CB-34	3.71	1.17	3100	4.32	YES	0.61	4.37	YES	0.66
CB-35	5.32	3.65	880	5.76	YES	0.44	5.77	YES	0.45

Main Street Inlets															
				Tidal (storm peak aligned with high-high tide)						Fixed Stage (at high-high tide)					
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth
CB-23	6.86	3.63	N/A	10.242	0.240	NO	0	7.07	0.21	10.242	0.240	NO	0	7.07	0.21
CB-24	6.74	3.35	N/A	9.050	0.212	NO	0	6.96	0.22	9.050	0.212	NO	0	6.96	0.22
CB-25	4.91	1.73	730	8.637	0.223	NO	0	5.14	0.23	8.637	0.223	NO	0	5.14	0.23
CB-26	3.41	0.60	5060	13.213	0.400	YES	0.412	4.40	0.99	13.213	0.400	YES	0.441	4.43	1.02
CB-27	4.08	0.27	1560	19.000	0.406	NO	0	4.39	0.31	19.000	0.420	NO	0	4.42	0.34
CB-28	3.36	-0.41	4215	11.678	0.467	NO	0	3.99	0.63	12.257	0.490	NO	0	4.00	0.64
CB-29	3.81	0.53	4350	12.906	0.400	NO	0	3.98	0.17	13.286	0.412	NO	0	3.99	0.18
CB-30	3.75	1.10	8050	13.000	0.373	NO	0	4.40	0.65	13.000	0.374	NO	0	4.43	0.68
CB-31	4.84	1.58	2500	13.000	0.229	NO	0	5.09	0.25	13.000	0.229	NO	0	5.09	0.25

Lowe/Bell Street Inlets									
				Tidal (storm peak aligned with high-high tide)			Fixed Stage (at high-high tide)		
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max HGL	Flooded?	Max Surface Depth (ft)	Max HGL	Flooded?	Max Surface Depth (ft)
CB-32	3.65	0.95	7750	4.40	YES	0.75	4.43	YES	0.78
CB-33	4.96	3.65	1600	4.40	NO	N/A	4.43	NO	N/A
CB-34	3.71	1.17	3100	4.40	YES	0.69	4.43	YES	0.72
CB-35	5.32	3.65	880	6.16	YES	0.84	6.17	YES	0.85

Existing Model Results **25-year Event** **Created By: EPP 2/22/2024**

Main Street Inlets															
				Tidal (storm peak aligned with high-high tide)						Fixed Stage (at high-high tide)					
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth
CB-23	6.86	3.63	N/A	11.379	0.266	NO	0	7.10	0.24	11.379	0.266	NO	0	7.10	0.24
CB-24	6.74	3.35	N/A	10.052	0.235	NO	0	6.99	0.25	10.052	0.235	NO	0	6.99	0.25
CB-25	4.91	1.73	730	9.682	0.250	NO	0	5.16	0.25	9.682	0.250	NO	0	5.16	0.25
CB-26	3.41	0.60	5060	13.678	0.414	YES	0.705	4.69	1.28	13.678	0.414	YES	0.708	4.69	1.28
CB-27	4.08	0.27	1560	19.000	0.500	NO	0	4.65	0.57	19.000	0.500	NO	0	4.65	0.57
CB-28	3.36	-0.41	4215	18.128	0.725	YES	0.014	4.25	0.89	18.156	0.726	YES	0.101	4.34	0.98
CB-29	3.81	0.53	4350	16.683	0.517	NO	0	4.16	0.35	17.402	0.539	NO	0	4.21	0.40
CB-30	3.75	1.10	8050	13.000	0.389	NO	0	4.70	0.95	13.000	0.389	NO	0	4.70	0.95
CB-31	4.84	1.58	2500	13.000	0.257	NO	0	5.12	0.28	13.000	0.257	NO	0	5.12	0.28

Lowe/Bell Street Inlets									
				Tidal (storm peak aligned with high-high tide)			Fixed Stage (at high-high tide)		
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max HGL	Flooded?	Max Surface Depth (ft)	Max HGL	Flooded?	Max Surface Depth (ft)
CB-32	3.65	0.95	7750	4.70	YES	1.05	4.7	YES	1.05
CB-33	4.96	3.65	1600	4.70	NO	N/A	4.7	NO	N/A
CB-34	3.71	1.17	3100	4.70	YES	0.99	4.7	YES	0.99
CB-35	5.32	3.65	880	6.74	YES	1.42	6.75	YES	1.43

verdantas

APPENDIX D

PROPOSED NODE FLOODING SUMMARY

Main Street Inlets															
				Tidal (storm peak aligned with high-high tide)						Fixed Stage (at high-high tide)					
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth
CB-23	6.86	3.63	N/A	8.903	0.343	NO	0	7.16	0.30	8.903	0.343	NO	0	7.16	0.30
CB-24	6.74	3.35	N/A	9.050	0.212	NO	0	6.96	0.22	9.050	0.212	NO	0	6.96	0.22
CB-25	4.91	1.73	730	8.642	0.223	NO	0	5.14	0.23	8.641	0.223	NO	0	5.14	0.23
CB-26	3.41	0.32	5060	8.333	0.252	NO	0	3.69	0.28	8.333	0.252	NO	0	3.69	0.28
CB-27	4.08	-0.19	1560	11.255	0.225	NO	0	4.25	0.17	11.254	0.225	NO	0	4.25	0.17
CB-28	3.36	-1.05	4215	9.992	0.400	NO	0	3.99	0.63	9.992	0.4	NO	0	3.99	0.63
CB-29	3.81	-1.53	4350	12.906	0.400	NO	0	3.98	0.17	12.906	0.4	NO	0	3.98	0.17
CB-30	3.75	0.48	8050	0.138	0.006	NO	0	3.75	0.00	0.139	0.006	NO	0	3.75	0.00
CB-30A	4.93	0.95	N/A	1.509	0.128	NO	0	4.94	0.01	1.508	0.128	NO	0	4.94	0.01
CB-31	4.84	1.33	2500	6.092	0.272	NO	0	5.09	0.25	6.093	0.272	NO	0	5.09	0.25

Lowe/Bell Street Inlets									
				Tidal (storm peak aligned with high-high tide)			Fixed Stage (at high-high tide)		
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max HGL	Flooded?	Max Surface Depth (ft)	Max HGL	Flooded?	Max Surface Depth (ft)
CB-32	3.65	1.4	7750	3.67	YES	0.02	3.93	YES	0.28
CB-33	4.96	3.65	1600	3.77	NO	N/A	3.94	NO	N/A
CB-34	3.71	1.64	3100	3.88	YES	0.17	3.94	YES	0.23
CB-35	5.32	3.32	880	5.38	YES	0.06	5.35	YES	0.03

Main Street Inlets																
				Tidal (storm peak aligned with high-high tide)						Fixed Stage (at high-high tide)						
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth	Max Gutter Spread (ft)	Max Gutter Depth (ft)	Flooded?	Flood Depth (ft)	Max HGL	Total Surface Depth
CB-23	6.86	3.63	N/A	8.903	0.343	NO	0	7.16	0.30	8.903	0.343	NO	0	7.16	0.30
CB-24	6.74	3.35	N/A	9.050	0.212	NO	0	6.96	0.22	9.050	0.212	NO	0	6.96	0.22
CB-25	4.91	1.73	730	8.641	0.223	NO	0	5.14	0.23	8.641	0.223	NO	0	5.14	0.23
CB-26	3.41	0.32	5060	8.333	0.252	NO	0	3.69	0.28	8.333	0.252	NO	0	3.69	0.28
CB-27	4.08	-0.19	1560	11.254	0.225	NO	0	4.25	0.17	11.254	0.225	NO	0	4.25	0.17
CB-28	3.36	-1.05	4215	9.992	0.400	NO	0	3.99	0.63	9.992	0.400	NO	0	3.99	0.63
CB-29	3.81	-1.53	4350	12.906	0.400	NO	0	3.98	0.17	12.906	0.400	NO	0	3.98	0.17
CB-30	3.75	0.48	8050	0.139	0.006	NO	0	3.75	0.00	0.139	0.005	NO	0	3.75	0.00
CB-30A	4.93	0.95	N/A	1.508	0.128	NO	0	4.94	0.01	1.507	0.128	NO	0	4.94	0.01
CB-31	4.84	1.33	2500	6.093	0.272	NO	0	5.09	0.25	6.093	0.272	NO	0	5.09	0.25

Lowe/Bell Street Inlets									
				Tidal (storm peak aligned with high-high tide)			Fixed Stage (at high-high tide)		
	Grate Elevation	Invert Elevation	Ponding Area (sf)	Max HGL	Flooded?	Max Surface Depth (ft)	Max HGL	Flooded?	Max Surface Depth (ft)
CB-32	3.65	1.4	7750	3.80	YES	0.15	3.98	YES	0.33
CB-33	4.96	3.65	1600	3.82	NO	N/A	3.98	NO	N/A
CB-34	3.71	1.64	3100	3.83	YES	0.12	3.98	YES	0.27
CB-35	5.32	3.32	880	5.30	NO	N/A	5.28	NO	N/A

APPENDIX E

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST – ALTERNATIVE 1

Little Creek South Flood Mitigation Study - Alternative 1				
	Quantity	Unit	Cost	Total Cost
Stormwater				
12" RCP, CL IV	90	LF	$ 96.00	$ 8,640.00
15" RCP, CL IV	246	LF	$ 112.50	$ 27,675.00
18" RCP, CL IV	985	LF	$ 120.00	$ 118,200.00
24" RCP, CL IV	35	LF	$ 150.00	$ 5,250.00
Inlet, 34" x 18"	10	EA	$ 5,700.00	$ 57,000.00
Inlet, 66" x 66"	1	EA	$ 12,750.00	$ 12,750.00
Inlet, 72" x 24"	3	EA	$ 9,750.00	$ 29,250.00
Junction Box, 60" x 42"	1	EA	$ 13,500.00	$ 13,500.00
12" FES and Rip-Rap	2	EA	$ 3,500.00	$ 7,000.00
18" FES and Rip-Rap	1	EA	$ 3,675.00	$ 3,675.00
24" FES and Rip-Rap	1	EA	$ 3,900.00	$ 3,900.00
Asbestos Testing and Inspection	25	DAY	$ 400.00	$ 10,000.00
Contingency (20%)	1	LS	$ 57,368.00	$ 57,368.00
Stormwater - Subtotal				**$ 354,208.00**
Roads				
Integral Curb and Gutter, Type 2	1677	LF	$ 42.25	$ 70,853.25
8" Concrete Sidewalk	28	SY	$ 200.00	$ 5,560.00
Pavement Milling	7360	SY-IN	$ 3.05	$ 22,446.64
Hot-mix trench Repaving	2453	SY	$ 146.33	$ 358,974.59
Contingency (20%)	1	LS	$ 91,566.90	$ 91,566.90
Road - Subtotal				**$ 549,401.38**
Earthwork/mobilization				
Dewatering	1	LS	$ 7,500.00	$ 7,500.00
Erosion and Sedimentation Control	1	LS	$ 65,000.00	$ 65,000.00
Traffic Control	1	LS	$ 80,000.00	$ 80,000.00
Landscaping (seed and sod)	83	SY	$ 6.00	$ 500.00
Backfill	1046	CY	$ 30.00	$ 31,384.58
Striping	1900	LF	$ 0.50	$ 950.00
Mobilization (15% of Construction Costs)	1	LS	$ 162,216.59	$ 162,216.59

Contingency (20%)	1	LS	$ 69,510.24	$ 69,510.24
Earthwork - Subtotal				**$ 417,061.41**
	Quantity	Unit	Cost	Total Cost
Engineering and Permitting				
Natural Resources Evaluation	1	LS	$ 10,000.00	$ 10,000.00
Survey	1	LS	$ 38,500.00	$ 38,500.00
Design of Drainage Improvements	1	LS	$ 75,000.00	$ 75,000.00
Permitting	1	LS	$ 50,000.00	$ 50,000.00
Bidding Services	1	LS	$ 18,000.00	$ 18,000.00
Construction Administration	1	LS	$ 128,000.00	$ 128,000.00
Contingencies (20%)	1	LS	$ 63,900.00	$ 63,900.00
Engineering and Permitting - Subtotal				**$ 383,400.00**
Total Construction Costs				**$ 1,320,670.79**
Total Project Costs				**$ 1,704,070.79**

ESTIMATE CREATED USING ACTUAL COSTS FROM SIMILAR PROJECTS

Since the Engineer has no control over the cost of labor, materials, or equipment; over the Contractor's method of determining prices; or over the competitive bidding or market conditions; the estimate of construction cost herein is made on the basis of their best judgement as a design professional familiar with the construction industry. The Engineer cannot, and does not, guarentee that bids of the project construction cost will not vary from this estimate.

APPENDIX F

ENGINEER'S OPINION OF PROBABLE CONSTRUCTION COST – ALTERNATIVE 2

Little Creek South Flood Mitigation Study - Alternative 2				
	Quantity	Unit	Cost	Total Cost
Stormwater				
12" RCP, CL IV	90	LF	$ 126.00	$ 11,340.00
15" RCP, CL IV	137	LF	$ 94.50	$ 12,946.50
18" RCP, CL IV	856	LF	$ 115.50	$ 98,868.00
24" RCP, CL IV	35	LF	$ 150.00	$ 5,250.00
Inlet, 34" x 18"	9	EA	$ 5,700.00	$ 51,300.00
Inlet, 66" x 66"	1	EA	$ 12,750.00	$ 12,750.00
Inlet, 72" x 24"	4	EA	$ 9,750.00	$ 39,000.00
Junction Box, 60" x 42"	1	EA	$ 13,500.00	$ 13,500.00
12" FES and Rip-Rap	2	EA	$ 3,500.00	$ 7,000.00
18" FES and Rip-Rap	1	EA	$ 3,675.00	$ 3,675.00
24" FES and Rip-Rap	1	EA	$ 3,900.00	$ 3,900.00
Asbestos Testing and Inspection	25	DAY	$ 400.00	$ 10,000.00
Contingency (20%)	1	LS	$ 51,905.90	$ 51,905.90
Stormwater - Subtotal				**$ 321,435.40**
Roads				
Integral Curb and Gutter, Type 2	1677	LF	$ 42.25	$ 70,853.25
8" Concrete Sidewalk	28	SY	$ 200.00	$ 5,560.00
Pavement Milling	7360	SY-IN	$ 3.05	$ 22,446.64
Hot-mix trench Repaving	2453	SY	$ 146.33	$ 358,974.59
Contingency (20%)	1	LS	$ 91,566.90	$ 91,566.90
Road - Subtotal				**$ 549,401.38**
Earthwork/mobilization				
Dewatering	1	LS	$ 7,500.00	$ 7,500.00
Erosion and Sedimentation Control	1	LS	$ 81,250.00	$ 81,250.00
Ditch Clearing and Grading	1	LS	$ 35,000.00	$ 35,000.00
Traffic Control	1	LS	$ 80,000.00	$ 80,000.00
Landscaping (seed and sod)	278	SY	$ 6.00	$ 1,666.67
Backfill	1046	CY	$ 30.00	$ 31,384.58
Striping	1900	LF	$ 0.50	$ 950.00

Mobilization (15% of Construction Costs)	1	LS	$ 165,163.20	$ 165,163.20
Contingency (20%)	1	LS	$ 80,582.89	$ 80,582.89
Earthwork - Subtotal				**$ 483,497.35**
	Quantity	Unit	Cost	Total Cost
Engineering and Permitting				
Natural Resources Evaluation	1	LS	$ 10,000.00	$ 10,000.00
Survey	1	LS	$ 45,500.00	$ 45,500.00
Design of Drainage Improvements	1	LS	$ 90,000.00	$ 90,000.00
Permitting	1	LS	$ 50,000.00	$ 50,000.00
Bidding Services	1	LS	$ 18,000.00	$ 18,000.00
Construction Administration	1	LS	$ 128,000.00	$ 128,000.00
Contingencies (20%)	1	LS	$ 68,300.00	$ 68,300.00
Engineering and Permitting - Subtotal				**$ 409,800.00**
Total Construction Costs				**$ 1,354,334.12**
Total Project Costs				**$ 1,764,134.12**

ESTIMATE CREATED USING ACTUAL COSTS FROM SIMILAR PROJECTS

Since the Engineer has no control over the cost of labor, materials, or equipment; over the Contractor's method of determining prices; or over the competitive bidding or market conditions; the estimate of construction cost herein is made on the basis of their best judgement as a design