HYDROLOGIC AND HYDRAULIC ANALYSIS

Town of Maxton
Kincaid Street Drainage Analysis
WKD Project #20190254.00.WL

Maxton, North Carolina
September 9, 2019
Revised November 5th, 2019

PREPARED BY:

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NC LICENSE NO. F-0374

11/5/19
NORTH CAROLINA PROFESSIONAL SEAL 045331 ENGINEER ALEXANDER A. ADEKOYA

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1. PROJECT NARRATIVE

Per the request of the Town of Maxton, an analysis of the following conveyance systems was completed:

- The closed drainage system between McNair Street and Kincaid Street; and
- The open channel from Kincaid Street to the railroad ditch west of the Malloy Street culvert crossing.

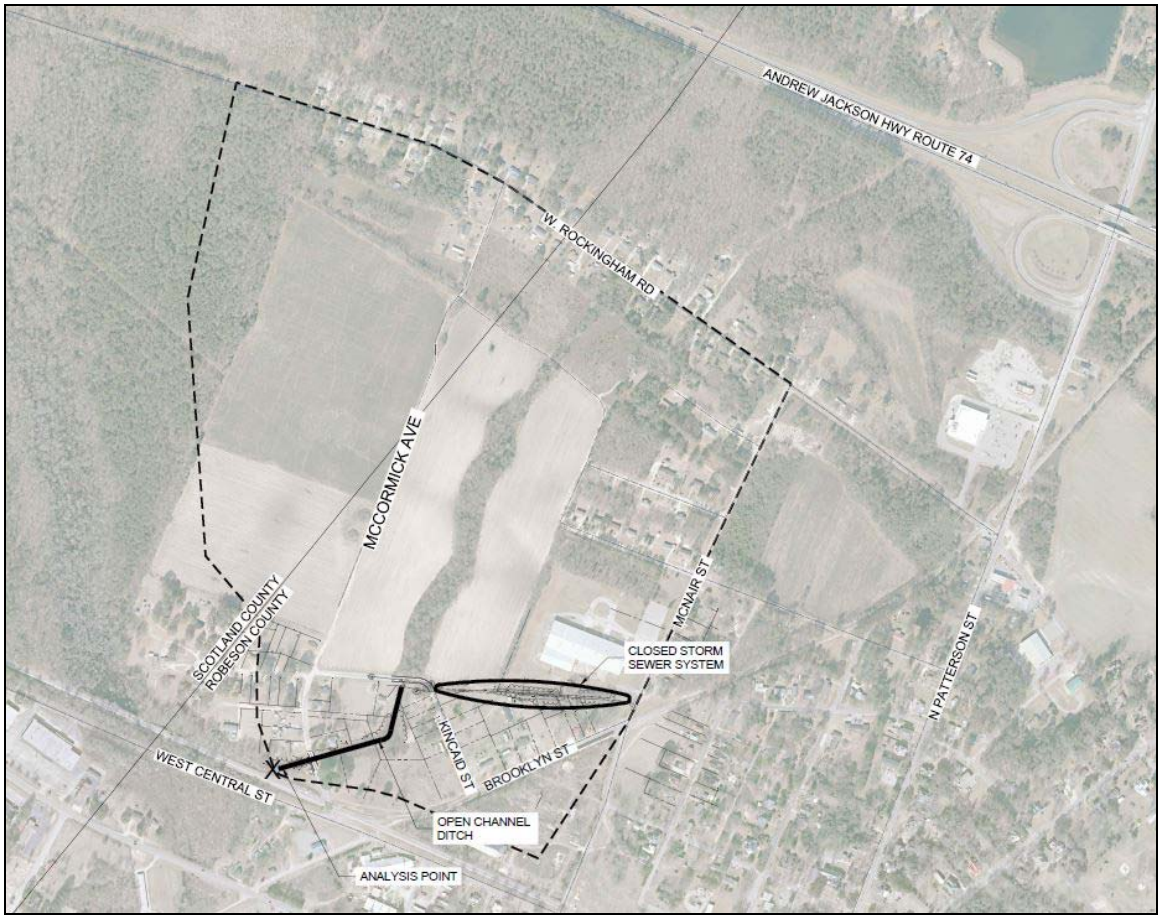


Figure 1 – Project Area Map

The existing conditions level of service will be determined to see if improvements need to be made to the existing systems.

2. EXISTING CONDITIONS HYDROLOGY

To evaluate hydrologic conditions, an analysis point was established at the culvert outlet. The drainage area to the analysis point was delineated using Robeson and Scotland County GIS LiDAR information combined with topographic survey of the storm sewer and ditch area. The topographic survey was performed between 7/5/19

and 8/5/19. The parameters required to calculate stormwater runoff are area, curve number, and time of concentration. Each drainage area is evaluated using the guidelines described in USDA Soil Conservation Service's TR-55 to determine the curve number and time of concentration. The drainage area map has been provided as Attachment A.

The runoff curve number (CN) is based on a weighted average of ground cover and soil type. The underlying soil types are described in County soil maps. The existing ground cover is assumed to remain unchanged for future conditions. If the area use, zoning or ground cover is planned to change, additional information would be needed to reanalyze the area. The CN values for each soil type within the drainage areas are determined from the tables presented in TR-55 (See Worksheet 2 of the Hydrologic Calculations in Attachment B).

Time of concentration (Tc) represents the amount of time it takes for runoff to travel from the hydraulically most distant point of the watershed to the point of analysis. Surface roughness, slope, channel shape and flow patterns are the factors that affect the time of concentration. Stormwater runoff flows through the drainage area as sheet flow, shallow concentrated flow, open channel flow, or concentrated flow (such as in storm sewers or open channels). The sum of the travel times over the various surfaces within the assumed flow path for a specific drainage area determines that area's time of concentration. The figures and formulas in TR-55 are employed to compute travel times for sheet flow and shallow concentrated flow.

A. <u>Watershed</u>

The drainage area to the Malloy Street culvert is delineated to be 174.35 acres of forest area and farmland (See Attachment A). The watershed area has a composite CN of 61 and a time of concentration of 78 minutes (See Attachment B for detailed calculations). Rainfall data was obtained from the NOAA website for Maxton, NC (See Attachment B). The entire analysis area is located outside of any FEMA delineated floodplain. The existing hydrologic conditions and characteristics within the drainage area are not expected to change. Any changes to area site characteristics within the drainage area must be approved by the Town of Maxton prior to implementation.

SCS TR-20 Methodology is used in the hydrologic model to calculate runoff into the reservoir. The model results were compared to a TR-55 calculation for verification. The model reports a peak flow of 107.37 cfs during the 1/10 annual chance event as summarized in Table 1.

Table 1 - Peak Flow		
STORM EVENT	RAINFALL	RUNOFF
1 / 10 Storm Annual Frequency	5.89"	107.37 CFS
1 / 25 Storm Annual Frequency	7.16"	160.34 CFS
1 / 100 Storm Annual Frequency	9.25"	259.11 CFS

B. Hydraulic Model

To model the open channel section from Kincaid Street to the railroad ditch, a hydraulic analysis was performed by using 1-foot contours from the topographic survey along the ditch line combined with 2-foot LiDAR obtained from the Robeson and Scotland County GIS departments. The U.S. Army Corps of Engineers' HEC-RAS model (Version 5.0.7) was used to create cross sections based on the available topographic information. Three (3) different scenarios were run to evaluate the performance of the culvert and flow characteristics of the site. They are as follows:

- Scenario 1 models the existing conditions of the watershed and the existing 36" RCP culvert crossing at Malloy Street including existing sediment deposition;
- Scenario 2 models the ditch and existing culvert assuming no obstructions with sediment cleared out from the drainageway to eliminate blockage of flow through the culvert; and
- Scenario 3 models a proposed condition with an additional 36" RCP at the Malloy Street crossing.

The model was run as steady flow with both the upstream and downstream boundary conditions set to normal depth. The design storm for this analysis is the 1/10 Year annual chance event.

C. Results

The model shows that under existing conditions the culvert does not pass the design storm and water overtops Malloy Street. In Scenario 2, clearing out sediment from the ditch and regrading between Kincaid Street and the railroad ditch, the 36" RCP culvert still cannot handle the design flow and water overtops Malloy Street. For Scenario 3, the increased capacity provided by the additional 36" RCP allows water to pass the 1/10 and the 1/25 storm events; however, water still overtops Malloy Street during the 1/100 annual chance event. The proposed actions in Scenarios 2 and 3 above, will result in "no net rise" conditions within the contributing upstream watershed and in the downstream conveyance area as compared to existing conditions. Further analysis during final design will evaluate the proposed scenarios and determine what, if any, flooding impacts

will occur and if modifications to the proposed scenarios can be made to eliminate or reduce these impacts

The HEC-RAS results are summarized in Table 2 and provided as Attachment C.

Table 2 - Summary of Malloy Street Culvert Performance

RAS MODEL	DESIGN STORM CULVERT OPERATION	PEAK WATER SURFACE ELEVATION (FEET NAVD 1988)[1]		
		1/10 ANNUAL FREQUENCY STORM	1/25 ANNUAL FREQUENCY STORM	1/100 ANNUAL FREQUENCY STORM
EXISTING SCENARIO 1 (CULVERT 1)	OUTLET	**186.66**	**186.81**	**187.02**
PROPOSED SCENARIO 2 (CULVERT 1)	INLET	**186.63**	**186.77**	**187.05**
PROPOSED SCENARIO 3 (CULVERT 1)	OUTLET	184.66	185.96	**186.75**
PROPOSED SCENARIO 3 (CULVERT 2)	INLET	184.66	185.96	**186.75**

[1] Malloy Street Begins to overtop at elevation 186.00 feet. Bold text indicates Malloy Street overtopping.

As shown in Table 2, in order to pass the stormwater runoff underneath the Malloy Street culvert for the 1/10 and 1/25 annual chance events, an additional 36" drainage pipe would be needed. The additional culvert would need to be installed with a slope equal to or greater than the existing culvert slope. Additional drainage options to provide greater flow are available but would require more space and would add cost to the design and construction.

3. STORM SEWER SYSTEM

Stormwater runoff conveyance through the closed storm sewer system was not evaluated as many parts of the system are completely submerged or buried. The land survey and attempted video inspection of the storm sewer did not provide conclusive details of the existing storm sewer system.

Based on the best available information provided by the surveyor (Stewart Engineering), the storm sewer system was modeled as straight lines between assumed inlet locations with the outlet centered on the spring line of the 36" RCP culvert underneath Kincaid Street. The drainage system accepts flow from two sub-drainage areas of the overall watershed (See DR-2 in Attachment A). A Hydraflow Hydrographs model of the system was run to appropriately size the drainage system based upon these drainage areas. The time of concentration was set to 15 minutes for each sub-basin and the runoff coefficient is 0.35. Hydraflow Storm Sewers uses Manning's equation to determine flow conveyance through pipes and structures. Tailwater conditions within the model were set to 184.16 feet due to the submerged conditions of the culvert under Kincaid Street.

The system should be designed with a minimum pipe slope of 0.50% and a minimum size of 24" diameter. It is recommended that a smooth interior drainage pipe such as high density polyethylene or reinforced concrete pipe be used. To better assess the storm sewer, the Town would need to provide a temporary diversion and blockage downstream to dewater the entire storm sewer system. Additionally, drainage structure inlets should be located with the assistance of record drawings of the original system. In the dewatered condition, existing drainage system inverts and video of the storm sewer interior will provide adequate information to determine if the pipes are appropriately sized.

4. CONCLUSIONS AND RECOMMENDATIONS

A. Watershed Conveyance

The ditch from Kincaid Street to the railroad ditch west of Malloy Street appears to be adequately sized. The culvert constriction at Malloy Street causes overbank flooding of the ditch immediately around Malloy Street and upstream for approximately 250-feet.

The stormwater runoff flowing to the Kincaid Street ditch and the Malloy Street crossing cannot pass through the culvert without overtopping Malloy Street or causing overbank flooding for the design storm event (1/10 annual chance event). Cleaning out the sediment from the ditch increases the overall flow area; however, it does not affect the overtopping of Malloy Street due to the inlet conditions at the culvert. By increasing the capacity with the addition of a 36" drainage pipe, overtopping of the roadway is only mitigated during the 1/10 and 1/25 annual chance events. Flooding at Malloy Street and overbank flooding still occurs during the 1/100 annual chance event.

It is recommended that the Town explore options to remove and replace the culvert at Malloy Street with a fully designed larger drainage structure or install

an additional designed 36" drainage pipe. In the interim, it is recommended that the Town monitor the flooding that occurs during various storm events to determine whether the corrective action of adding another culvert or adjusting the type of culvert provided at Malloy Street is warranted. A flood risk assessment should be performed for the residences near Malloy Street.

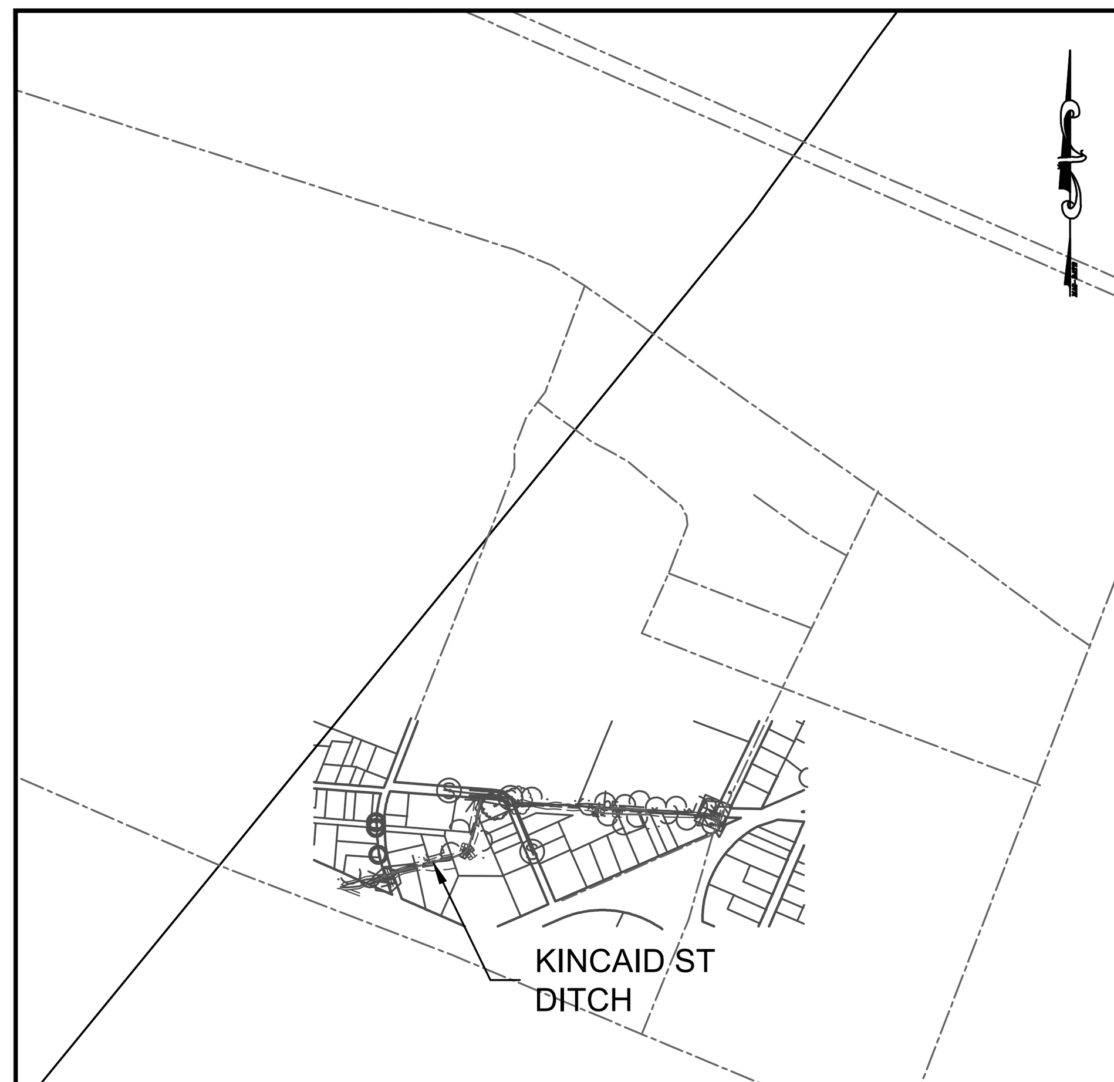
B. Storm Sewer

Given the existing conditions at the site, the storm sewer system could not be properly inspected and surveyed. Surveyors noted standing water in drainage structures and several structures were inaccessible from the ground. The structures were either covered with earth and debris or had collapsed. Additional effort and resources are needed to be able to block/divert flows from entering the drainage system, to survey and inspect the pipes and structures. It is recommended that the Town plan to replace the storm sewer system due to the deficiencies noted previously. During design of the new storm sewer system, the Town should arrange to dewater the drainage system for inspection. Following this detailed inspection, additional attempts to locate inverts of pipes and determine the pipe condition should be made. If our assumptions and inputs for the storm sewer system are correct and the storm sewer is in disrepair and undersized, it is recommended that the existing storm sewer system be replaced with 24" smooth interior drainage pipe. The Town should attempt to locate record drawings to assess original design parameters used for the drainage system between McNair and Kincaid Streets.

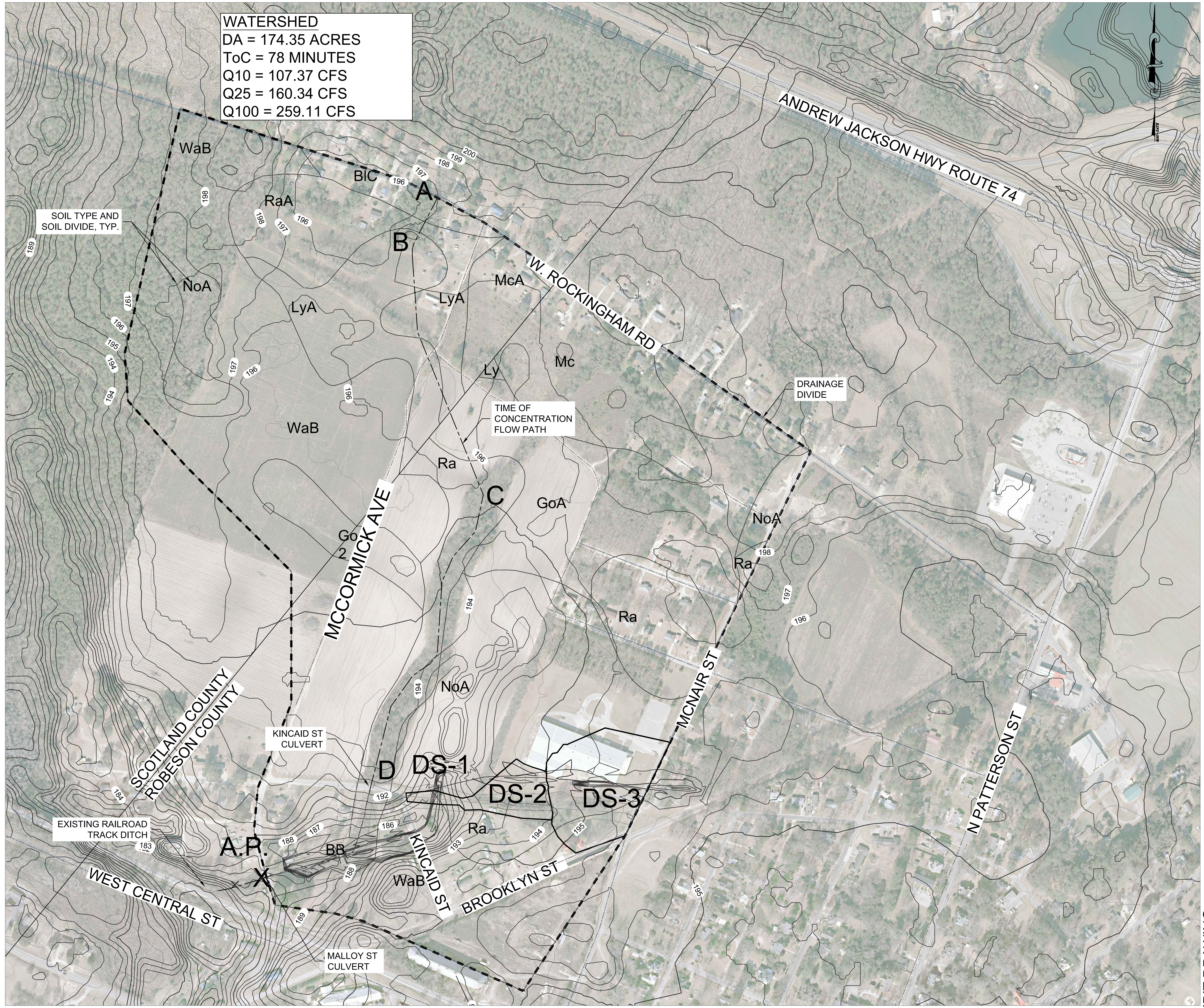
If the Town can obtain right-of-way along this storm sewer corridor or an existing easement exists, an open channel may be a better option to convey flow to the Kincaid Street culvert. A comprehensive inspection of the overall storm sewer system would be needed to determine the suitability of an open channel system.

ATTACHMENT A

EXISTING CONDITIONS DRAINAGE AREA MAPS



VICINITY MAP



EXISTING CONDITIONS DRAINAGE MAP

EXHIBIT DRAWING

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PROFESSIONAL SEAL

REVISION RECORD

NO.	DATE	DESCRIPTION	BY

PROJECT NAME: TOWN OF MAXTON, NC KINCAID STREET DRAINAGE STUDY

DRAWING TITLE: EXISTING CONDITIONS DRAINAGE MAP

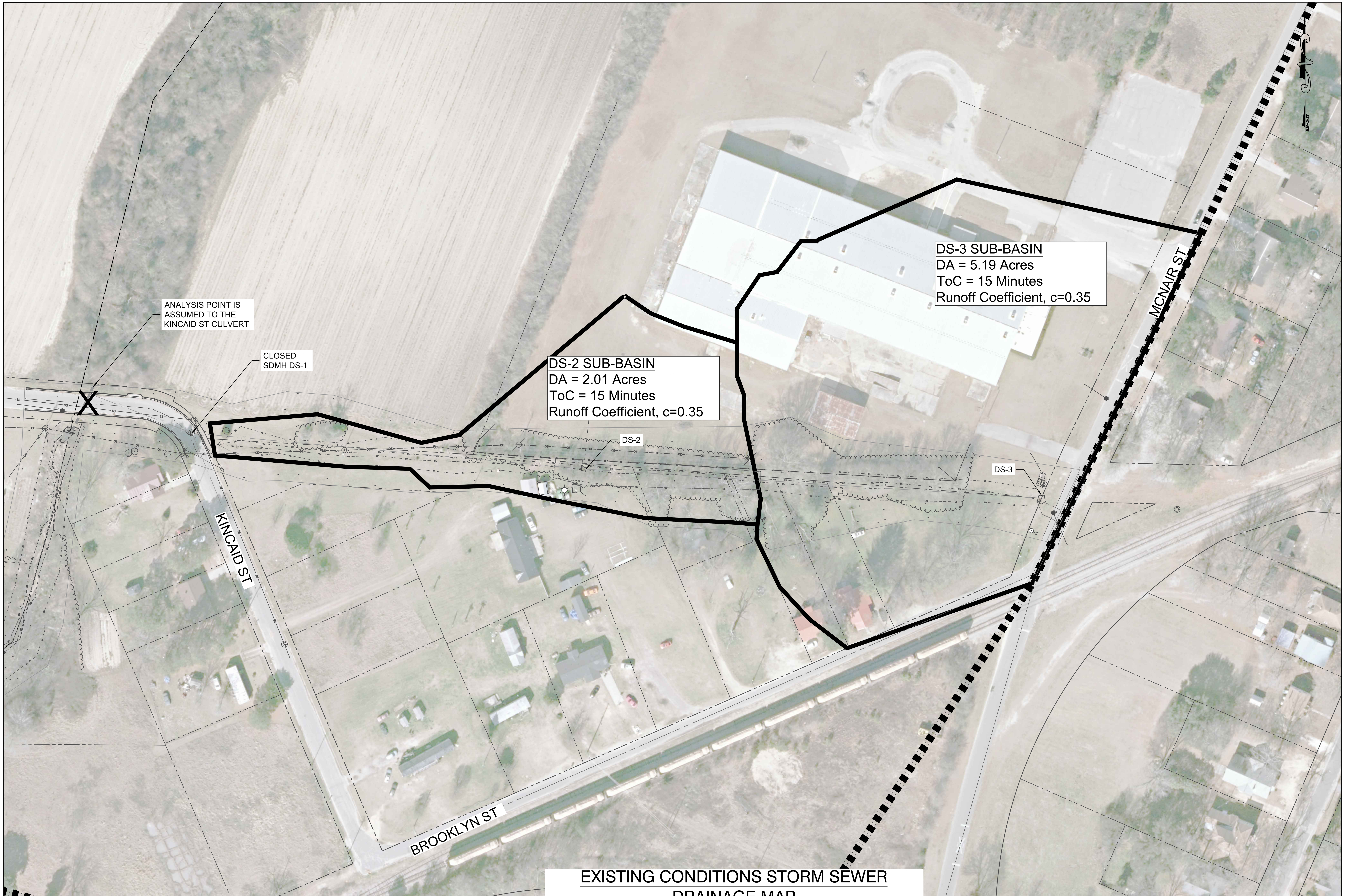
PROJ. MGR.:	KM
DESIGN BY:	AA
DRAWN BY:	AA
PROJ. DATE:	09/09/19

DRAWING NUMBER:

DR-1

WKD PROJ. NO.:

2016025400.WL



EXISTING CONDITIONS STORM SEWER DRAINAGE MAP

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PROFESSIONAL SEAL

REVISION RECORD

NO.	DATE	DESCRIPTION	BY

PROJECT NAME: TOWN OF MAXTON, NC
KINCAID STREET DRAINAGE STUDY

DRAWING TITLE: EXISTING STORM SEWER SYSTEM MAP

EXHIBIT DRAWING

PROJ. MGR.:	KM
DESIGN BY:	AA
DRAWN BY:	AA
PROJ. DATE:	09/09/19

DRAWING NUMBER:
DR-2
WKD PROJ. NO.:
2016025400.WL

ATTACHMENT B

TR-55 HYDROLOGIC ANALYSIS BACKUP

HYDROLOGIC CALCULATIONS

TR-55 Worksheet 2: Runoff curve number and runoff

Project: Kincaid Street Drainage Analysis By: AAA 8/20/2019

Location Maxton, Robeson County, NC Checked: EVH 8/29/2019

Condition (Current or Developed) Existing and Proposed Condition

Runoff Curve Number (CN)

Soils Name and Hydrologic Group	Cover Description (cover Type, Treatment and hydrologic condition; percent impervious; Unconnected/connected impervious area ratio	Curve Number Table 2	Fig. 2-3	Fig 2-4	Area (Circle One) Acres / Miles Sq. / Percent	Product of CN x Area
Bibb soils D	Woods - Grass Combination	82			1.85	152.05
Blanton sand A	Woods - Fair	40			2.35	93.96
Goldsboro loamy sand B	Close-seeded or broadcast, C&T	65			26.51	1723.07
Lynchburg sandy loam D	Farmsteads	82			12.67	1038.81
McColl loam D	Farmsteads	82			11.56	948.07
Norfolk loamy sand A	Woods Grass Combination - Fair	43			27.11	1165.67
Pactolus loamy sand A	Woods - Good	30			0.00	0.00
Pantego loam D	Woods - Good	30			0.00	0.00
Rains sandy loam D	Woods - Good	80			31.37	2509.29
Wagram loamy sand A	Close-seeded or broadcast, SR	50			60.94	3046.86
				Total	174.354	10677.8

Cn (weighted) = Total Product 10678 61.24 **61**
Total Area 174.35

2. Runoff		Storm #1	Storm #2	Storm #3
Frequency	Yr	10	25	100
Rainfall, P (24 hour)	in	5.89	7.16	9.25
Runoff, Q	in	1.94	2.82	4.43

(Use P and CN with table 2-1 fig. 2-1 or eqs. 2-3 and 2-4.)

HYDROLOGIC CALCULATIONS

TR-55 Worksheet 3: Time of concentration (T_c) or travel time (T_t)

Project: Kincaid Street Drainage Analysis | By: AAA | Date: 8/20/2019

Location: Maxton, Robeson County, NC | Checked: EVH | Date: 8/29/2019

Condition (Existing or Developed): Existing and Proposed

Circle One: Tc Tt through subarea: Tc for SCS

Note: Space for as many as two segments per flow type can be used for each worksheet
Include a map, schematic, or description of flow segments

Sheet Flow	(applicable to Tc only)		Segment ID	A - B				
1.	Surface Description (Table 3-1)			Range (ROW)				
2.	Manning's roughness coeff., n (table 3-1)		n	0.13				
3.	Flow length, L (total L < 300 ft)		ft	300				
4.	Two-yr 24-hr rainfall, P2		in	3.65				
5.	Land slope, s		ft/ft	0.006				
6.	$Tt = \frac{0.007\,(nL)^{0.8}}{(P2)^{0.5}\,(s)^{0.4}}$	Compute Tt	hr	0.55	+		=	0.55
Shallow Concentrated Flow			Segment ID	B - C				
7.	Surface Description (paved or unpaved)			Unpaved				
8.	Flow Length, L		ft	2741.07				
9.	Watercourse Slope, s		ft/ft	0.005				
10.	Average Velocity, V (figure 3-1)		ft/s	1.15				
11.	Tt = L / 3600 * V	Compute Tt	hr	0.66	+		=	0.66
Channel Flow								
			Segment ID	C - D				
12.	Cross sectional flow area, a		sq ft	48				<--A
13.	Wetted perimeter		ft	36.00				
14.	Hydraulic radius, r = a/Pw		ft	1.33				
15.	Channel Slope		ft/ft	0.003				
16.	Manning's Roughness Coeff., n			0.04				
17.	Velocity $v = \frac{1.49\ r^{2/3}\ s^{1/2}}{n}$		ft/s	2.33				
18.	Flow Length, L		ft	672.57				
19.	Tt = L / 3600 * V		hr	0.08	+		=	0.08
20.	Watershed or Subarea Tc or Tt (add Tc in steps 6, 11, and 19)						hr	1.29

HYDROLOGIC CALCULATIONS

TR-55 Worksheet 4: Graphical Peak Discharge method

Project: Kincaid Street Drainage Analysis By AAA Date 8/20/2019

Location: Maxton, Robeson County, NC Checked EVH Date 8/29/2019

Condition (Present or Developed) Existing and Proposed

1. Data:

Drainage Area A_m = 0.272 mi^2 (acres/640)

Runoff Curve Number CN = 61 (from worksheet 2)

Time of Concentration T_c = 1.29 hr (from worksheet 3)

Rainfall Distribution Type = III (I , IA, II, III)

Pond and Swamp Factor spread throughout watershed = 0.87 percent of A_m (0 acres or mi^2 covered)

			Storm #1	Storm #2	Storm #3
2.	Frequency	yr	10	25	100
3.	Rainfall, P (24 - hour)	in	5.89	7.16	9.25
4.	Initial abstraction, I_a (use CN with table 4-1)	in	1.279	1.279	1.279
5.	Compute Ia / P		0.217	0.179	0.138
6.	Unit peak discharge, q_u (use Tc and I_a / P with exhibit 4 - III)	csm/in	234	240	247
7.	Runoff, Q (from worksheet 2)	in	1.936	2.819	4.426
8.	Pond and swamp adjustment factor, F_p (Use percent pond and swamp, area with table 4-2. Factor is 1.0 for zero percent pond and swamp area.)		0.87	0.87	0.87
9.	Peak Discharge, q_p (where $q_p = q_u * A_m * Q * F_p$)	cfs	107.37	160.34	259.11

Kincaid Street Ditch - Hydrologic Data

https://hdsc.nws.noaa.gov/hdsc/pfds/pfds_map_cont.html?bkmrk=nc
Point precipitation frequency estimates (inches)
NOAA Atlas 14 Volume 2 Version 3
Data type: Precipitation depth
Time series type: Annual maximum
Project area: Ohio River Basin
Location name (ESRI Maps): Maxton North Carolina USA
Station Name: -
Latitude: 34.7419°
Longitude: -79.3541°
Elevation (USGS): 193.86 ft

PRECIPITATION FREQUENCY ESTIMATES

by duration for AEP:	'1/2	'1/5	**'1/10**	**'1/25**	'1/50	**'1/100**	'1/200	'1/500	'1/1000
5-min:	0.515	0.640	0.717	0.807	0.872	0.936	0.996	1.08	1.14
10-min:	0.824	1.030	1.15	1.29	1.39	1.49	1.58	1.70	1.79
15-min:	1.04	1.30	1.45	1.63	1.76	1.88	1.99	2.14	2.25
30-min:	1.43	1.84	2.10	2.42	2.65	2.88	3.10	3.41	3.64
60-min:	1.80	2.36	2.74	3.22	3.59	3.97	4.35	4.89	5.32
2-hr:	2.10	2.81	3.31	3.95	4.45	4.97	5.48	6.19	6.77
3-hr:	2.24	3.01	3.56	4.30	4.90	5.51	6.16	7.09	7.84
6-hr:	2.67	3.59	4.26	5.16	5.88	6.64	7.44	8.59	9.54
12-hr:	3.15	4.27	5.09	6.21	7.12	8.08	9.13	10.70	11.90
24-hr:	3.65	4.95	**5.89**	**7.16**	8.17	**9.25**	10.40	12.00	13.30
2-day:	4.23	5.68	6.73	8.15	9.28	10.50	11.80	13.60	15.00
3-day:	4.46	5.96	7.04	8.49	9.63	10.80	12.10	13.90	15.40
4-day:	4.70	6.25	7.34	8.82	9.98	11.20	12.50	14.30	15.80
7-day:	5.44	7.15	8.33	9.91	11.10	12.40	13.80	15.60	17.20
10-day:	6.20	8.01	9.24	10.80	12.10	13.30	14.60	16.40	17.80
20-day:	8.24	10.50	12.00	13.90	15.40	16.90	18.40	20.50	22.20
30-day:	10.20	12.70	14.30	16.40	17.90	19.40	20.90	23.00	24.60
45-day:	12.70	15.60	17.40	19.70	21.40	23.00	24.60	26.70	28.40
60-day:	15.10	18.40	20.50	23.00	24.80	26.50	28.30	30.50	32.30

Date/time (GMT): Mon Aug 12 21:02:28 2019
pyRunTime: 0.010883808136

ATTACHMENT C

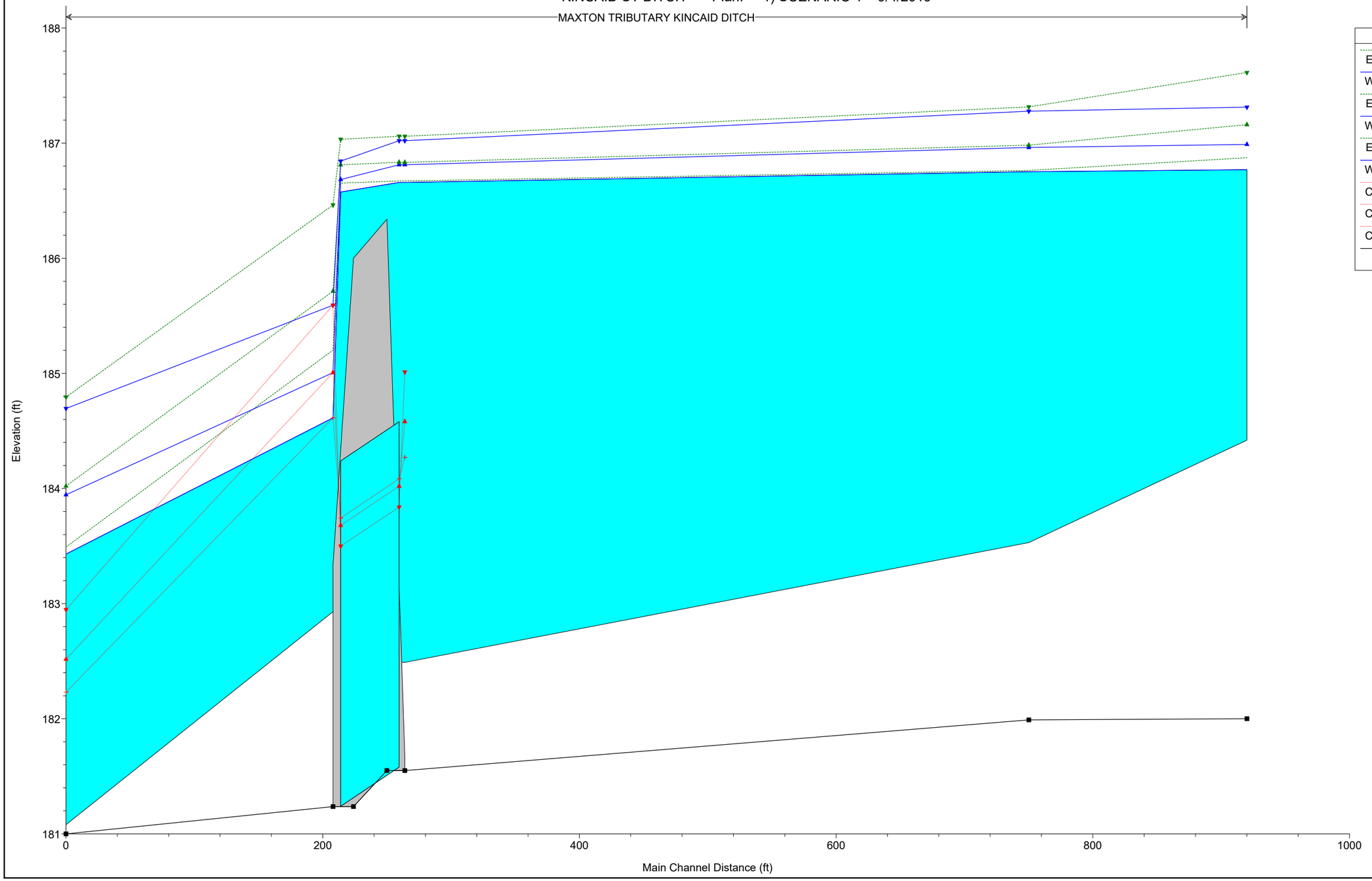
HEC-RAS OUTPUT

Kincaid Street Ditch - HEC RAS Analysis Results

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KINCAID DITCH	920	1/10 Annual Chance	107.37	184.42	186.77		186.87	0.0032	2.58	41.58	29.03	0.38
KINCAID DITCH	920	1/25 Annual Chance	160.34	184.42	186.99		187.16	0.0047	3.33	48.19	31.31	0.47
KINCAID DITCH	920	1/100 Annual Chance	259.11	184.42	187.31		187.61	0.0073	4.4	58.89	34.67	0.6
KINCAID DITCH	700	1/10 Annual Chance	107.37	183.53	186.75		186.76	0.0002	0.89	140.12	86.58	0.1
KINCAID DITCH	700	1/25 Annual Chance	160.34	183.53	186.96		186.98	0.0003	1.19	159.04	92.73	0.13
KINCAID DITCH	700	1/100 Annual Chance	259.11	183.53	187.28		187.32	0.0005	1.65	189.72	101.92	0.18
KINCAID DITCH	264	1/10 Annual Chance	107.37	182.49	186.66	184.27	186.67	0.0002	0.95	154.22	182.56	0.1
KINCAID DITCH	264	1/25 Annual Chance	160.34	182.49	186.81	184.58	186.83	0.0003	1.26	182.70	189.09	0.13
KINCAID DITCH	264	1/100 Annual Chance	259.11	182.49	187.02	185.01	187.06	0.0005	1.75	223.15	197.99	0.18
KINCAID DITCH	236		Culvert									
KINCAID DITCH	208	1/10 Annual Chance	107.37	182.93	184.61	184.61	185.2	0.0237	6.15	17.46	15.08	1.01
KINCAID DITCH	208	1/25 Annual Chance	160.34	182.93	185.01	185.01	185.71	0.0224	6.75	23.76	17.05	1.01
KINCAID DITCH	208	1/100 Annual Chance	259.11	182.93	185.59	185.59	186.46	0.0204	7.49	34.76	22.54	1.00
KINCAID DITCH	0	1/10 Annual Chance	107.37	181.08	183.43	182.23	183.49	0.0015	1.98	54.29	33.13	0.27
KINCAID DITCH	0	1/25 Annual Chance	160.34	181.08	183.95	182.52	184.02	0.0015	2.21	72.39	37.22	0.28
KINCAID DITCH	0	1/100 Annual Chance	259.11	181.08	184.69	182.95	184.79	0.0015	2.53	102.52	63.29	0.29

KINCAID ST DITCH Plan: 1) SCENARIO 1 9/4/2019

MAXTON TRIBUTARY KINCAID DITCH



Kincaid Street Ditch - HEC RAS Analysis Results

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KINCAID DITCH	920	1/10 Annual Chance	107.37	182	186.74		186.76	0.0004	1.28	83.67	37.18	0.15
KINCAID DITCH	920	1/25 Annual Chance	160.34	182	186.95		186.99	0.0007	1.75	91.71	38.96	0.2
KINCAID DITCH	920	1/100 Annual Chance	259.11	182	187.33		187.42	0.0013	2.42	107.07	42.15	0.27
KINCAID DITCH	700	1/10 Annual Chance	107.37	181.99	186.71		186.72	0.0001	0.84	147.71	85.28	0.09
KINCAID DITCH	700	1/25 Annual Chance	160.34	181.99	186.90		186.92	0.0003	1.14	164.59	90.86	0.12
KINCAID DITCH	700	1/100 Annual Chance	259.11	181.99	187.25		187.28	0.0004	1.57	198.23	101.08	0.16
KINCAID DITCH	264	1/10 Annual Chance	107.37	181.55	186.63	183.69	186.65	0.0001	0.88	161.78	181.54	0.09
KINCAID DITCH	264	1/25 Annual Chance	160.34	181.55	186.77	184.04	186.79	0.0002	1.19	187.60	187.49	0.12
KINCAID DITCH	264	1/100 Annual Chance	259.11	181.55	187.05	184.54	187.08	0.0004	1.61	240.58	199.16	0.16
KINCAID DITCH	236		Culvert									
KINCAID DITCH	208	1/10 Annual Chance	107.37	181.24	183.88		184.14	0.0077	4.08	26.31	17.88	0.59
KINCAID DITCH	208	1/25 Annual Chance	160.34	181.24	184.38		184.69	0.0075	4.46	35.92	20.86	0.60
KINCAID DITCH	208	1/100 Annual Chance	259.11	181.24	185.1		185.48	0.0070	4.93	52.56	25.20	0.60
KINCAID DITCH	0	1/10 Annual Chance	107.37	181.00	183.38	182.17	183.44	0.0015	1.99	54.05	32.76	0.27
KINCAID DITCH	0	1/25 Annual Chance	160.34	181.00	183.90	182.46	183.98	0.0015	2.22	72.13	36.88	0.28
KINCAID DITCH	0	1/100 Annual Chance	259.11	181.00	184.66	182.9	184.76	0.0015	2.53	102.24	59.00	0.29

KINCAID ST DITCH Plan: SCENARIO #2 9/4/2019

MAXTON TRIBUTARY KINCAID DITCH

Legend

- EG 1/100 Annual Cha
- WS 1/100 Annual Cha
- EG 1/25 Annual Chan
- WS 1/25 Annual Chan
- EG 1/10 Annual Chan
- WS 1/10 Annual Chan
- Crit 1/100 Annual Cha
- Crit 1/25 Annual Chan
- Crit 1/10 Annual Chan
- Ground

Elevation (ft)

188
187
186
185
184
183
182
181

0
200
400
600
800
1000

Main Channel Distance (ft)

Kincaid Street Ditch - HEC RAS Analysis Results

Reach	River Sta	Profile	Q Total (cfs)	Min Ch El (ft)	W.S. Elev (ft)	Crit W.S. (ft)	E.G. Elev (ft)	E.G. Slope (ft/ft)	Vel Chnl (ft/s)	Flow Area (sq ft)	Top Width (ft)	Froude # Chl
KINCAID DITCH	920	1/10 Annual Chance	107.37	182	185.74		185.81	0.0016	2.12	50.75	28.77	0.28
KINCAID DITCH	920	1/25 Annual Chance	160.34	182	186.44		186.51	0.0014	2.20	73.02	34.69	0.27
KINCAID DITCH	920	1/100 Annual Chance	259.11	182	187.16		187.26	0.0015	2.59	100.22	40.76	0.29
KINCAID DITCH	700	1/10 Annual Chance	107.37	181.99	185.54		185.58	0.0010	1.61	68.23	51.37	0.22
KINCAID DITCH	700	1/25 Annual Chance	160.34	181.99	186.32		186.36	0.0006	1.52	117.2	74.12	0.18
KINCAID DITCH	700	1/100 Annual Chance	259.11	181.99	187.06		187.1	0.0005	1.71	179.65	95.57	0.18
KINCAID DITCH	264	1/10 Annual Chance	107.37	181.55	184.66	183.69	184.77	0.0030	2.58	41.61	28.60	0.38
KINCAID DITCH	264	1/25 Annual Chance	160.34	181.55	185.96	184.04	186.01	0.0009	1.81	93.65	56.23	0.21
KINCAID DITCH	264	1/100 Annual Chance	259.11	181.55	186.75	184.54	186.8	0.0007	1.96	183.05	186.46	0.2
KINCAID DITCH	236		Culvert									
KINCAID DITCH	208	1/10 Annual Chance	107.37	181.24	183.88		184.14	0.0077	4.08	26.31	17.88	0.59
KINCAID DITCH	208	1/25 Annual Chance	160.34	181.24	184.38		184.69	0.0075	4.46	35.92	20.86	0.60
KINCAID DITCH	208	1/100 Annual Chance	259.11	181.24	185.1		185.48	0.0070	4.93	52.56	25.20	0.60
KINCAID DITCH	0	1/10 Annual Chance	107.37	181.00	183.38	182.17	183.44	0.0015	1.99	54.05	32.76	0.27
KINCAID DITCH	0	1/25 Annual Chance	160.34	181.00	183.90	182.46	183.98	0.0015	2.22	72.13	36.88	0.28
KINCAID DITCH	0	1/100 Annual Chance	259.11	181.00	184.66	182.9	184.76	0.0015	2.53	102.24	59.00	0.29

KINCAID ST DITCH Plan: SCENARIO #3 9/4/2019

MAXTON TRIBUTARY KINCAID DITCH

Elevation (ft)

188
187
186
185
184
183
182
181

0
200
400
600
800
1000

Main Channel Distance (ft)

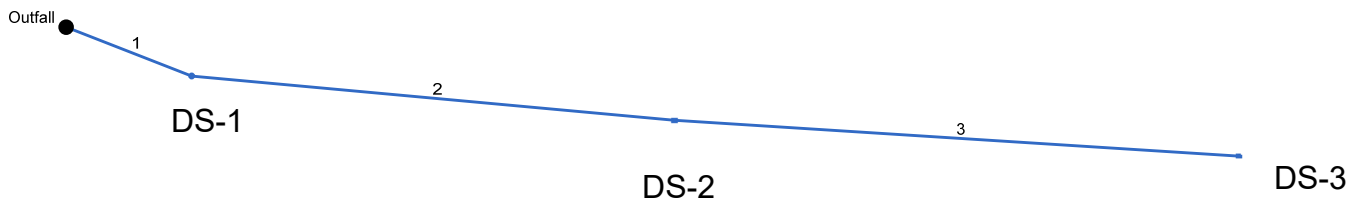
Legend

- EG 1/100 Annual Cha
- WS 1/100 Annual Cha
- EG 1/25 Annual Chan
- WS 1/25 Annual Chan
- EG 1/10 Annual Chan
- WS 1/10 Annual Chan
- Crit 1/100 Annual Cha
- Crit 1/25 Annual Chan
- Crit 1/10 Annual Chan
- Ground

ATTACHMENT D

STORM SEWER DESIGN

Hydraflow Storm Sewers Extension for Autodesk® AutoCAD® Civil 3D® Plan



Project File: Existing Network Design.stm	Number of lines: 3	Date: 8/26/2019

Storm Sewer Inventory Report

Line No.	Alignment				Flow Data				Physical Data								Line ID
	Dnstr Line No.	Line Length (ft)	Defl angle (deg)	Junc Type	Known Q (cfs)	Drng Area (ac)	Runoff Coeff (C)	Inlet Time (min)	Invert El Dn (ft)	Line Slope (%)	Invert El Up (ft)	Line Size (in)	Line Shape	N Value (n)	J-Loss Coeff (K)	Inlet/ Rim El (ft)	
1	End	136.656	21.354	MH	0.00	0.00	0.00	0.0	183.00	1.00	184.36	24	Cir	0.013	0.33	192.27	Pipe - (56)
2	1	491.325	-16.101	Grate	0.00	2.01	0.35	15.0	184.36	0.50	186.82	24	Cir	0.013	0.50	195.09	Pipe - (55)
3	2	573.429	-1.596	Grate	0.00	5.19	0.35	15.0	186.82	0.50	189.69	24	Cir	0.013	1.00	194.55	Pipe - (54)

Project File: Existing Network Design.stm

Number of lines: 3

Date: 8/26/2019

Storm Sewer Summary Report

Line No.	Line ID	Flow rate (cfs)	Line Size (in)	Line shape	Line length (ft)	Invert EL Dn (ft)	Invert EL Up (ft)	Line Slope (%)	HGL Down (ft)	HGL Up (ft)	Minor loss (ft)	HGL Junct (ft)	Dns Line No.	Junction Type
1	Pipe - (56)	11.04	24	Cir	136.656	183.00	184.36	0.995	184.16	185.55	n/a	185.55	End	Manhole
2	Pipe - (55)	11.64	24	Cir	491.325	184.36	186.82	0.501	185.63	188.08	0.24	188.32	1	Grate
3	Pipe - (54)	9.14	24	Cir	573.429	186.82	189.69	0.500	188.32	190.77	0.44	190.77	2	Grate

Project File: Existing Network Design.stm

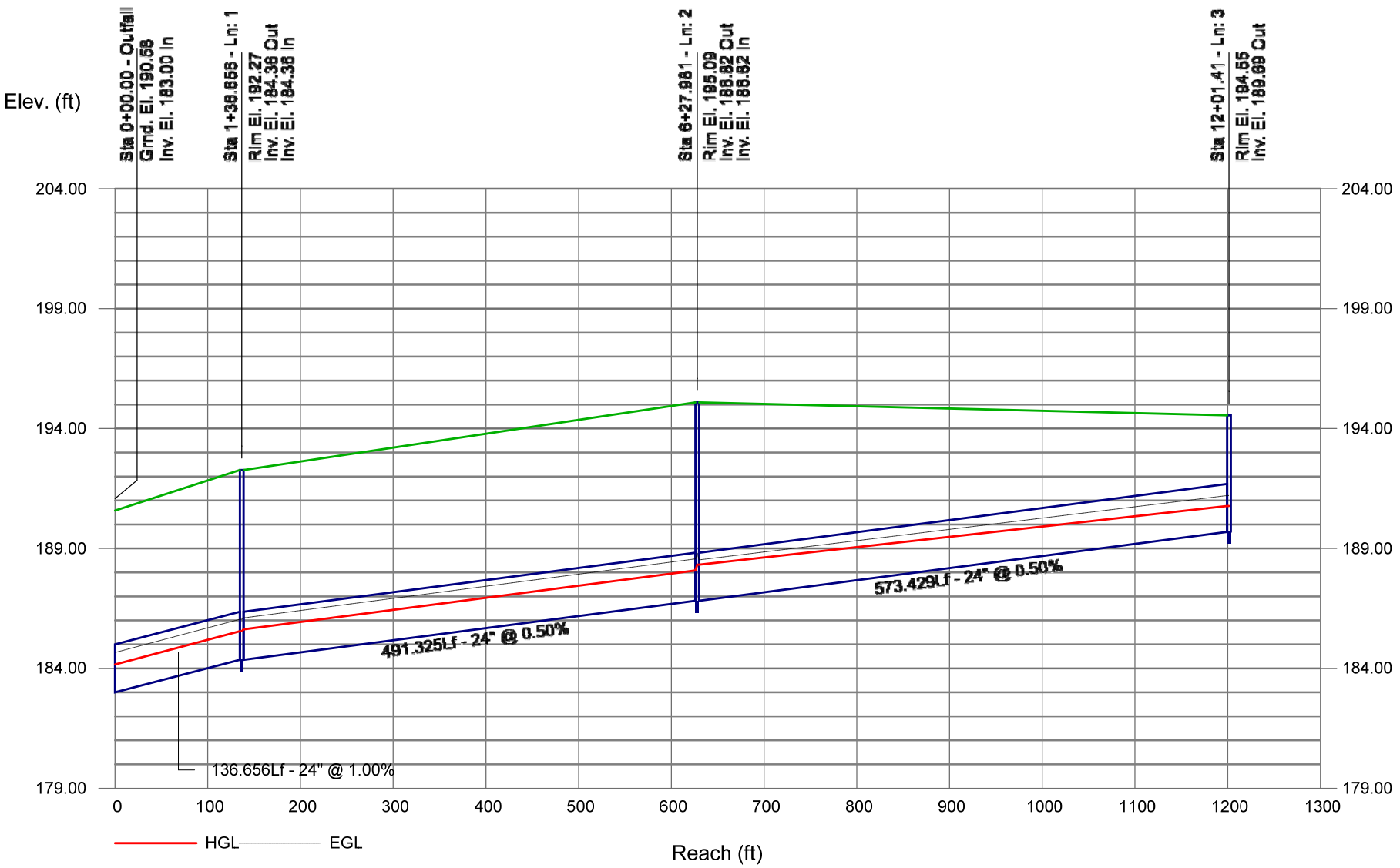
Number of lines: 3

Run Date: 8/26/2019

NOTES: Return period = 10 Yrs.

Storm Sewer Profile

Proj. file: Existing Network Design.stm

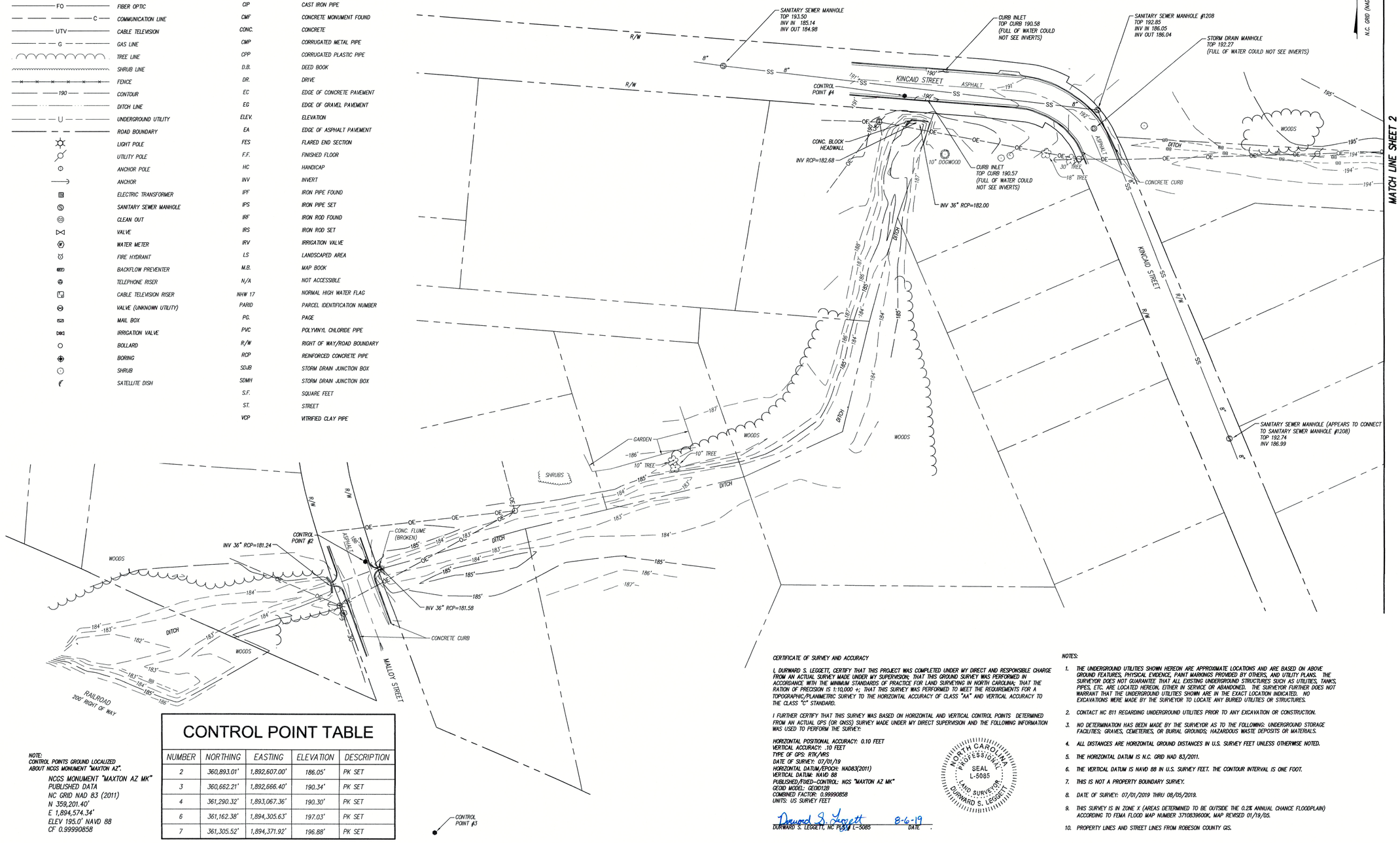


ATTACHMENT E

EXISTING CONDITIONS SURVEY

LEGEND

PROPERTY LINE (SURVEYED)		HA	HEAT AND AIR UNIT
ADJOINING PROPERTY LINE (FROM COUNTY GIS)		DI	DROP INLET
SUBDIVISION LINE (FROM RECORD)		MH	STORM DRAINAGE MANHOLE
STORM SEWER	SD	O	MISCELLANEOUS POST
SANITARY SEWER	SS	-o-	SIGN
FORCE MAIN	FM	H	ELECTRIC HAND BOX
WATER LINE	W	BLDG.	BUILDING
OVERHEAD ELECTRIC	OE	CHLF	CHAIN LINK FENCE
UNDERGROUND ELECTRIC	UE	C20	COASTAL WETLAND FLAG
FIBER OPTIC	FO	CIP	CAST IRON PIPE
COMMUNICATION LINE	C	CMF	CONCRETE MONUMENT FOUND
CABLE TELEVISION	UTV	CONC.	CONCRETE
GAS LINE	G	CMP	CORRUGATED METAL PIPE
TREE LINE		CPP	CORRUGATED PLASTIC PIPE
SHRUB LINE		D.B.	DEED BOOK
FENCE		DR.	DRIVE
CONTOUR	190	EC	EDGE OF CONCRETE PAVEMENT
DITCH LINE		EG	EDGE OF GRAVEL PAVEMENT
UNDERGROUND UTILITY	U	ELEV.	ELEVATION
ROAD BOUNDARY		EA	EDGE OF ASPHALT PAVEMENT
LIGHT POLE		FES	FLARED END SECTION
UTILITY POLE		F.F.	FINISHED FLOOR
ANCHOR POLE		HC	HANDICAP
ANCHOR		INV	INVERT
ELECTRIC TRANSFORMER		IPF	IRON PIPE FOUND
SANITARY SEWER MANHOLE		IPS	IRON PIPE SET
CLEAN OUT		IRF	IRON ROD FOUND
VALVE		IRS	IRON ROD SET
WATER METER		IRV	IRRIGATION VALVE
FIRE HYDRANT		LS	LANDSCAPED AREA
BACKFLOW PREVENTER		M.B.	MAP BOOK
TELEPHONE RISER		N/A	NOT ACCESSIBLE
CABLE TELEVISION RISER		NHW 17	NORMAL HIGH WATER FLAG
VALVE (UNKNOWN UTILITY)		PARID	PARCEL IDENTIFICATION NUMBER
MAIL BOX		PG.	PAGE
IRRIGATION VALVE		PVC	POLYVINYL CHLORIDE PIPE
BOLLARD		R/W	RIGHT OF WAY/ROAD BOUNDARY
BORING		RCP	REINFORCED CONCRETE PIPE
SHRUB		SDJB	STORM DRAIN JUNCTION BOX
SATELLITE DISH		SDMH	STORM DRAIN JUNCTION BOX
		S.F.	SQUARE FEET
		ST.	STREET
		VCP	VITRIFIED CLAY PIPE



NOTE:
CONTROL POINTS GROUND LOCALIZED ABOUT NCGS MONUMENT "MAXTON AZ".

NCGS MONUMENT "MAXTON AZ MK"
PUBLISHED DATA
NC GRID NAD 83 (2011)
N 359,201.40'
E 1,894,574.34'
ELEV 195.0' NAVD 88
CF 0.99990858

CONTROL POINT TABLE

NUMBER	NORTHING	EASTING	ELEVATION	DESCRIPTION
2	360,893.01'	1,892,607.00'	186.05'	PK SET
3	360,662.21'	1,892,666.40'	190.34'	PK SET
4	361,290.32'	1,893,067.36'	190.30'	PK SET
6	361,162.38'	1,894,305.63'	197.03'	PK SET
7	361,305.52'	1,894,371.92'	196.88'	PK SET

CERTIFICATE OF SURVEY AND ACCURACY

I, DURWARD S. LEGGETT, CERTIFY THAT THIS PROJECT WAS COMPLETED UNDER MY DIRECT AND RESPONSIBLE CHARGE FROM AN ACTUAL SURVEY MADE UNDER MY SUPERVISION; THAT THIS GROUND SURVEY WAS PERFORMED IN ACCORDANCE WITH THE MINIMUM STANDARDS OF PRACTICE FOR LAND SURVEYING IN NORTH CAROLINA; THAT THE RATION OF PRECISION IS 1:10,000 +; THAT THIS SURVEY WAS PERFORMED TO MEET THE REQUIREMENTS FOR A TOPOGRAPHIC/PLANIMETRIC SURVEY TO THE HORIZONTAL ACCURACY OF CLASS "AA" AND VERTICAL ACCURACY TO THE CLASS "C" STANDARD.

I FURTHER CERTIFY THAT THIS SURVEY WAS BASED ON HORIZONTAL AND VERTICAL CONTROL POINTS DETERMINED FROM AN ACTUAL GPS (OR GNSS) SURVEY MADE UNDER MY DIRECT SUPERVISION AND THE FOLLOWING INFORMATION WAS USED TO PERFORM THE SURVEY:

HORIZONTAL POSITIONAL ACCURACY: 0.10 FEET
VERTICAL ACCURACY: .10 FEET
TYPE OF GPS: RTK/VRS
DATE OF SURVEY: 07/01/19
HORIZONTAL DATUM/EPOCH: NAD83(2011)
VERTICAL DATUM: NAVD 88
PUBLISHED/FIXED-CONTROL: NCS "MAXTON AZ MK"
GEOID MODEL: GEOID12B
COMBINED FACTOR: 0.99990858
UNITS: US SURVEY FEET

Durward S. Leggett 8-6-19
DURWARD S. LEGGETT, NC PLS# L-5085 DATE

NORTH CAROLINA PROFESSIONAL SEAL L-5085 LAND SURVEYOR DURWARD S. LEGGETT

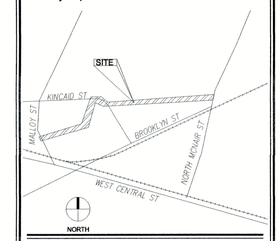
NOTES:

1. THE UNDERGROUND UTILITIES SHOWN HEREON ARE APPROXIMATE LOCATIONS AND ARE BASED ON ABOVE GROUND FEATURES, PHYSICAL EVIDENCE, PAINT MARKINGS PROVIDED BY OTHERS, AND UTILITY PLANS. THE SURVEYOR DOES NOT GUARANTEE THAT ALL EXISTING UNDERGROUND STRUCTURES SUCH AS UTILITIES, TANKS, PIPES, ETC. ARE LOCATED HEREON, EITHER IN SERVICE OR ABANDONED. THE SURVEYOR FURTHER DOES NOT WARRANT THAT THE UNDERGROUND UTILITIES SHOWN ARE IN THE EXACT LOCATION INDICATED. NO EXCAVATIONS WERE MADE BY THE SURVEYOR TO LOCATE ANY BURIED UTILITIES OR STRUCTURES.
2. CONTACT NC 811 REGARDING UNDERGROUND UTILITIES PRIOR TO ANY EXCAVATION OR CONSTRUCTION.
3. NO DETERMINATION HAS BEEN MADE BY THE SURVEYOR AS TO THE FOLLOWING: UNDERGROUND STORAGE FACILITIES; GRAVES, CEMETERIES, OR BURIAL GROUNDS; HAZARDOUS WASTE DEPOSITS OR MATERIALS.
4. ALL DISTANCES ARE HORIZONTAL GROUND DISTANCES IN U.S. SURVEY FEET UNLESS OTHERWISE NOTED.
5. THE HORIZONTAL DATUM IS N.C. GRID NAD 83/2011.
6. THE VERTICAL DATUM IS NAVD 88 IN U.S. SURVEY FEET. THE CONTOUR INTERVAL IS ONE FOOT.
7. THIS IS NOT A PROPERTY BOUNDARY SURVEY.
8. DATE OF SURVEY: 07/01/2019 THRU 08/05/2019.
9. THIS SURVEY IS IN ZONE X (AREAS DETERMINED TO BE OUTSIDE THE 0.2% ANNUAL CHANCE FLOODPLAIN) ACCORDING TO FEMA FLOOD MAP NUMBER 3710839600K, MAP REVISED 01/19/05.
10. PROPERTY LINES AND STREET LINES FROM ROBESON COUNTY GIS.

GRAPHIC SCALE
0 10 20 40 80 120
SCALE: 1"=40'

STEWART
2018 EASTWOOD RD, STE 207 / 208
WILMINGTON, NC 28403
T 910-796-0145
FIRM LICENSE #: C-1051
www.stewartinc.com

Vicinity Map:



Title:

TOPOGRAPHIC SURVEY
PREPARED FOR:
WK DICKSON & CO.
OF
KINCAID STREET
HYDRAULIC STUDY

NEAR THE TOWN OF MAXTON,
ROBESON COUNTY, NORTH CAROLINA
SCALE:1" = 40'
CONTOUR INTERVAL = 1 FOOT

Revisions:

No.	Date	Description
–	–	–

Seal:

Project number: G19104 Sheet:
Date: 08/06/19
Drawn by: KEA
Checked by: DSL

1 OF 2

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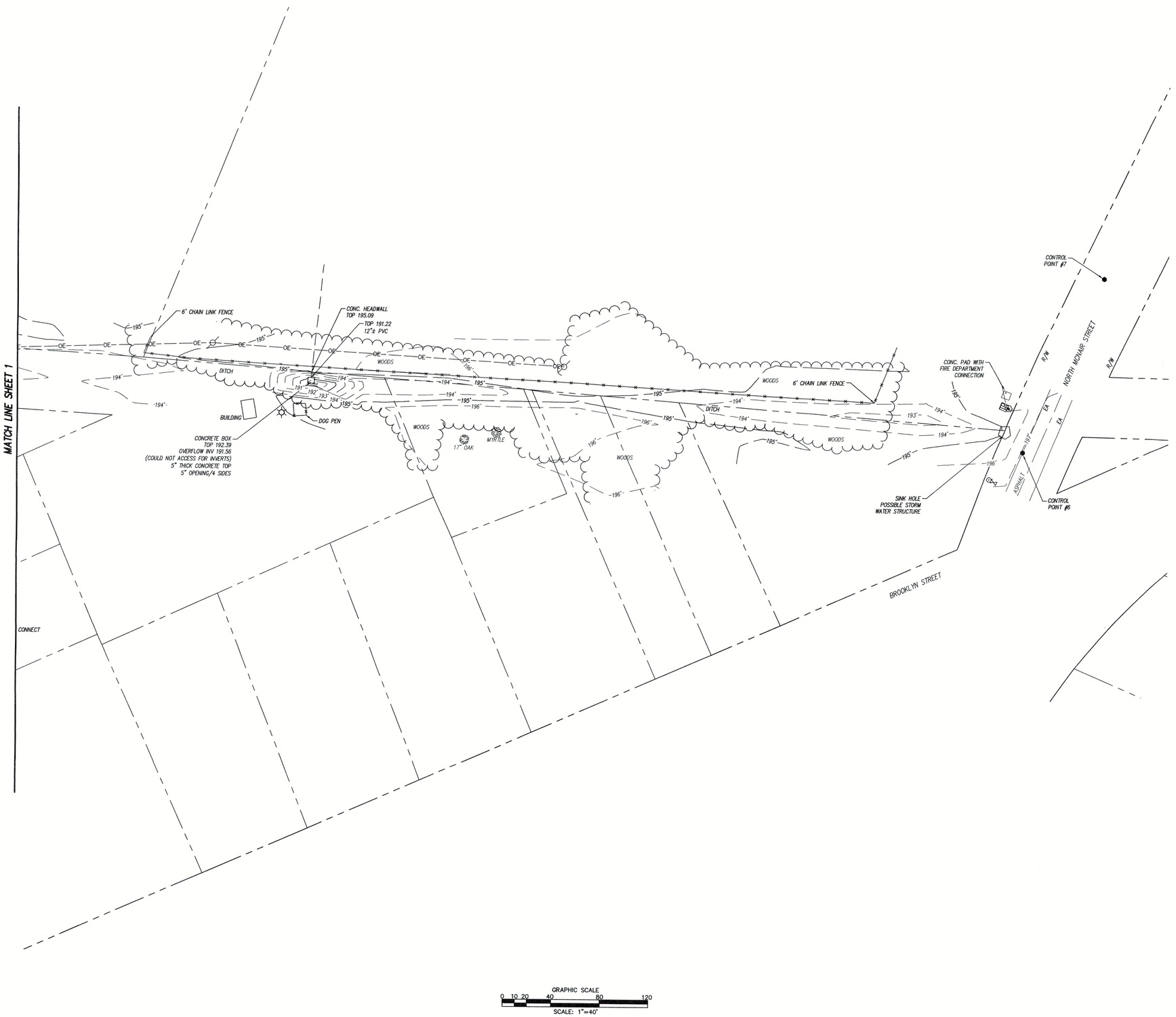

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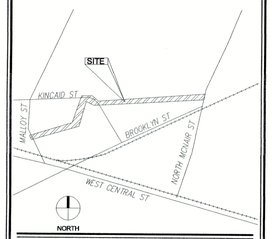
Vicinity Map:



Title:

TOPOGRAPHIC SURVEY

PREPARED FOR :

WK DICKSON & CO.

OF

KINCAID STREET

HYDRAULIC STUDY

NEAR THE TOWN OF MAXTON,
ROBESON COUNTY, NORTH CAROLINA
SCALE:1" = 40'
CONTOUR INTERVAL = 1 FOOT

Revisions:

No.	Date	Description
–	–	–

Seal:

Project number: G19104 Sheet: **2 OF 2**
Date: 08/06/19
Drawn by: KEA
Checked by: DSL

G:\Projects\2019\G19104 - Kincaid Street Hydraulic Study\DWG\G19104-Y-Base.dwg Aug 06, 2019 - 4:10pm

ATTACHMENT F

KINCAID STREET STORM SEWER INSPECTION REPORT

STEWART
STRONGER BY DESIGN

Wilmington Office
T 910.796.0145

2018 Eastwood Road, Suite 207
Wilmington, NC 28403

August 1, 2019

Kristen Morris, PE
WK Dickson & Co.
300 N. 3rd Street
Suite 301
Wilmington NC 28401

Dear Ms. Morris,
On July 30, 2019 Stewart Engineering hired Vision NC to complete CCTV of Storm pipes on Kincaid Street in Maxton NC. This PDF is to serve as a summary of what we discovered and completed on the project site.

When arriving on the site Vision NC crews and myself opened the catch basin on Kincaid Street to examine the storm pipe in question. The catch basin is right on top of a 36" pipe that is exposed out from Kincaid Street on the south side of the project area. In such a low-lying area the 36" pipe was almost completely full of water. This area seems to be a possible creek as fish were swimming in the ditch as we examined it. Vision NC has a crawler type CCTV unit in which the camera head can be raised but only to a reach of 14" which would still leave the camera under water where nothing would be seen. We closed the catch basin up and moved to the manhole up the road.

At the next entry point the manhole on Kincaid Street the manhole was so full of water, pipe sizes could not be obtained, and Vision NC also stated the CCTV unit would be under water once again. The map below shows both the catch basin location and manhole location.

Following the route of the pipe and the sink holes we discovered another storm structure in the woods behind some of the homes. This structure had debris on top of it and was not possible to get access into the structure.

We then moved to N. McNair Street. Upon investigating the site, we saw where a sink hole had collapsed around what seems to be a storm structure. We could not access this structure as well.

Across the street from this sink hole we were able to open another manhole on the storm pipe. At this location heading west into the project area the pipe size was 24" pipe. Once again, the water level was to high to CCTV the storm pipe.

In summary although we were able to determine the location of the storm pipe through the project area as show below, the high-water levels and structures we were not able to access keep Vision NC from doing any CCTV work on the storm pipe.

If you have any questions or concerns, please let me know.

Thank you,
Craig Silvanic
Manager of SUE