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ENGINEERING REPORT

U.S. Highway 231 (North Cumberland Street)
Drainage Improvements

PREPARED FOR:

City of Lebanon Engineering Department

PREPARED BY:

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Introduction

It has been reported that several homes between Oakdale Drive and Elmwood Drive suffered flood damages during the May 2010 flood. Storm water rose to a level of three to four feet deep in this area, but it is not believed that water inundated first floor living spaces. Damages were primarily incurred in garages, crawl spaces, and HVAC units.

The City of Lebanon commissioned Neel-Schaffer, Inc. to perform a comprehensive drainage analysis of this area in order to identify conceptual drainage improvements that will help reduce flooding. The following report describes methodology utilized and results obtained in the drainage analysis. In addition, both structural improvements and routine maintenance items were identified, and preliminary estimated project costs are included.

Field Review

The field review began at Westlynn Drive. Initially, water is collected from lots along Vosswood Drive and Eastland Avenue (south crown) through 12-inch driveway culverts into a 36-inch corrugated metal pipe (CMP) and drains into a small creek. At the north crown of Eastland Avenue, water flows through 12-inch and 16-inch driveway culverts and is collected by a long 20-inch iron storm drain that runs along U.S. Highway 231 (North Cumberland Street) and outfalls on the south side of Lealand Lane. A 30-inch CMP cross drain is located just north of this outfall, which carries water across U.S. Highway 231 and into another 30" CMP that outfalls into a ditch. This ditch is drained by three 32-inch CMP culverts across Creekside Drive. Water then flows into another ditch flowing through a 12-foot by 3-foot box culvert, and after combining with outflow from a detention pond along Hunters Creek Boulevard, empties into a small creek near Kelsie Drive.

Watershed Description

The watershed covers an area of approximately 117 acres (0.18 square miles), and extends from Hunters Creek Boulevard south to Eastland Avenue. Three primary areas of interest were identified:

- The inlet of the storm sewer system at 1003 U.S. Highway 231;
- The U.S. Highway 231 cross drain (just south of Lealand Lane); and
- The watershed outfall at Hunters Creek Boulevard.

Sub-basins for the watershed were delineated to provide an estimation of the storm water runoff at each of the areas of interest. The sub-basin boundaries were estimated based on the 5-foot interval topographic mapping provided by the City, and from information obtained during the field review.

The hydrologic model used in this analysis in HEC-HMS, developed by the U.S. Army Corps of Engineers. The Soil Conservation Service (SCS) method was used to compute storm water runoff

for various frequency recurrence intervals. The SCS procedure is based on land use, soil data, and other topographic features which together are used to estimate the runoff potential (known as the runoff curve number) at each area of interest.

Land use within the watershed was determined from aerial photography and information gathered during the field review. Land use along U.S. Highway 231 is primarily commercial. A triangular shaped area generally bounded by U.S. Highway 231 on the east and Westlynn Drive on the north includes several large undeveloped commercial parcels. The remainder of the watershed contains single family and multi-family residential developments. Hydrologic Soil Group data was obtained from the NRCS. Runoff curve numbers within the watershed range from 82 to 91. This reflects the varying degree of urbanization within the watershed. A summary of the hydrologic parameters is presented on Figure 1.

Analysis and Recommendations

Storm water runoff from approximately 28 acres of residential area is collected at the inlet of a 20-inch iron storm sewer pipe near 1003 U.S. Highway 231. The iron pipe runs north, adjacent to U.S. Highway 231, for approximately 850 linear feet. At some point near the north end, the pipe transitions from iron to reinforced concrete pipe (RCP). Additional runoff is collected in the storm sewer system at two catch basins located north of Oakdale Drive.

The storm water leaves the storm sewer system and flows northward to the 30-inch RCP cross drain under U.S. Highway 231. The cross drain conveys storm water to the west side of North Cumberland, and into a 30-inch corrugated metal pipe (CMP) that runs under Creekside Drive. The storm water runoff ultimately is discharged into the channel immediately upstream of the Creekside Drive cross drain, which consists of three 30-inch CMPs.

During the technical analysis, it was determined that the U.S. Highway 231 cross drain and the long storm sewer pipe that runs along this road are both undersized. U.S. Highway 231 should experience very slight overtopping (less than one inch) in the vicinity of the cross drain during the 2-year rainfall event. As the amount of storm water runoff exceeds the capacity of the cross drain, the water backs up and begins to submerge the outlet of the long storm sewer pipe that runs parallel to U.S. Highway 231. Therefore, the storm sewer system cannot convey the 2-year storm water runoff without inducing backwater onto the adjacent property at 1003 U.S. Highway 231. However, it should be noted that the storm sewer is so undersized that it would not be able to convey the 2-year discharge even without the backwater from the cross drain.

Structural Drainage Improvements

Four alternatives were evaluated to upgrade the pipe system adjacent to U.S. Highway 231. Two alternatives include an upgraded cross drain beneath U.S. Highway 231 along with an upgraded storm sewer system, while the other two alternatives use the existing cross drain with an upgraded storm sewer. The proposed alternatives and hydraulic model results are shown on Figure 2.

Better reduction in flood levels are achieved with replacement of both the long storm sewer U.S. Highway 231 and cross drain, but replacing the cross drain adds expense and difficulty to the

project due to partial road closure. A description of the proposed alternatives and preliminary estimated project costs are shown below. The following costs include engineering/design fees and provision for 20% contingency:

Structural Alternatives (See Figure 2)	**Preliminary Estimated Project Cost**
Alternative 1: Replace Existing Hwy. 231 Cross Drain with 2-48" RCPs and Replace Existing 20" Storm Sewer with 2-30" RCPs	$ 353,500.00
Alternative 2: Replace Existing 20" Storm Sewer with 2-30" RCPs (No Cross Drain Replacement)	$ 316,800.00
Alternative 3: Replace Existing Hwy. 231 Cross Drain with 2-48" RCPs and Replace Existing 20" Storm Sewer with 1-6'x3' Concrete Box Culvert	$ 509,000.00
Alternative 4: Replace Existing 20" Storm Sewer with 1-6'x3' Concrete Box Culvert (No Cross Drain Replacement)	$ 472,400.00

Routine Maintenance

In addition to the recommended structural improvements, numerous routine maintenance issues were found throughout the study area during the field reconnaissance. Examples of required maintenance items include removing sediment buildup from culvert inlets, removing excess vegetation and debris from culvert inlets, and installing erosion control measures. While correcting these deficiencies will not solve flooding problems, it is critical to correct them sooner, rather than later, so that the drainage system can function as designed and conditions do not worsen, leading to possible flooding problems in the future. In addition, it is important to note that areas identified as requiring remediation should be regularly scheduled for maintenance by City crews to prevent future buildup of debris and sediment. A map showing locations identified as requiring maintenance is included as Figure 3. In addition, a document containing captioned photographs of each maintenance location is included as Appendix A, with locations and orientations of each photograph indicated with red arrows on Figure 3. A preliminary cost estimate for the proposed maintenance items are shown below:

Infrastructure Maintenance Items (See Figure 3)	Preliminary Estimated Project Cost
1. Culvert end repair at eight locations (Items 1, 3, 4, 8, 9, 11, 12, 13)	$ 8,000.00
2. Debris/sediment removal from culvert ends – at least seven locations (Items 2, 5, 7, 10, 14-multiple)	$ 3,500.00
3. Debris/sediment removal from channel at one locations (Item 6) – 150 L.F.	$ 750.00
4. Install erosion control measures at three locations (Items 4, 5, 6)	$ 4,000.00
Total Maintenance Cost	**$ 16,250.00**

It should be noted that no field survey data was available for this study. Elevations of the pipe systems were estimated based on the 5-foot interval topographic mapping provided by the City, and from information obtained during the field reconnaissance. Therefore, evaluation of the proposed improvements included in this study should be regarded as conceptual.

Although many steps will have to be taken prior to implementing structural drainage improvements in the study area, including survey and design; the infrastructure maintenance items discussed above and shown in Figure 3 can be performed by City crews immediately.

Hwy 231 N (North Cumberland Street)
Hydrologic Parameters

Subbasin	Area (ac)	Area (sq. miles)	Runoff Curve No.	Lag Time (min)
A	18.9	0.030	86	15.4
B	13.3	0.021	83	17.9
C	13.2	0.021	90	20.6
D	9.4	0.015	91	27.4
E	11.8	0.018	83	27.9
F	15.1	0.024	85	32.2
G	7.4	0.012	85	22.9
H	8.4	0.013	84	22.1
I	19.0	0.030	82	35.7
Watershed	116.5	0.18		

Hwy 231 N (North Cumberland Street)
Existing Conditions Runoff Summary

Return Period	Point of Interest A Outfall Area (sq. miles)	Point of Interest A Outfall Discharge (cfs)	Point of Interest B N. Cumberland Str. Area (sq. miles)	Point of Interest B N. Cumberland Str. Discharge (cfs)	Point of Interest C 1003 N. Cumberland Str - Culvert Inlet Area (sq. miles)	Point of Interest C 1003 N. Cumberland Str - Culvert Inlet Discharge (cfs)
2-year	0.18	160	0.079	63	0.043	30
5-year		212		85		41
10-year		256		103		50
25-year		316		129		63
50-year		366		149		73
100-year		417		171		84

Point of Interest A
Outfall

Point of Interest B
N. Cumberland Str.

Point of Interest C
1003 N. Cumberland Str.
Culvert Inlet

1001 N. Cumberland Str.

Sub-basin A
Sub-basin B
Sub-basin C
Sub-basin D
Sub-basin E
Sub-basin F
Sub-basin G
Sub-basin H
Sub-basin I

Tucker Trice Blvd.
Kelsie Dr.
U.S. HWY. 231
Hartwell Ct.
Christine Dr.
Atwood Ct.
Piercy Ct.
Hunters Creek Blvd
Hunters Ln
Tenear Dr.
Maize Ln.
Princeton Dr.
Stroud Dr.
Lucas Ct.
Tyler Ct.
Lealand Ln.
Westlynn Dr.
N. Cumberland St.
Belaire Dr.
Private
Mayfair Dr.
Sam Houston Dr.
Heydel Cir.
Bent Tree Ct.
N. Castle Heights Ave.
Elmwood Dr.
Edgehill Dr.
Stoneway Dr.
Oakdale Dr.
Vosswood Dr.
Eastland Ave.
Nixon Dr.
Webster Ln.
ST. HWY. 10
Western Ave.

Legend
- Sub-basin Boundaries
- Parcels
- Existing Culverts
- Buildings
- Flooded Parcels

City of Lebanon Drainage Analysis
U.S. Highway 231
(North Cumberland Street)
Drainage Improvements

N
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1 inch equals 400 feet

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Hydrology Results

Figure 1

Alternative	Cross Drain	Storm Sewer Pipe	Return Period (yrs)	Inflow (cfs)	Water Elev. (ft)	Water Elevation Clearance from House Elev. (1) (ft)
Existing Conditions	30" RCP	20" Iron	2	30	561.26	0.54
		850 L.F.	5	41	561.35	0.45
			10	50	561.42	0.38
			25	63	561.52	0.28
			50	73	561.59	0.21
			100	84	561.66	0.14

Alternative	Cross Drain	Storm Sewer Pipe	Return Period (yrs)	Inflow (cfs)	Water Elev. (ft)	Δ Water Elev. from Existing Conditions (ft)	Water Elevation Clearance from House Elev. (1) (ft)
1	Proposed 2 - 48" RCP	Proposed 2 - 30" RCP 850 L.F.	2	30	559.52	-1.74	2.28
			5	41	560.93	-0.42	0.87
			10	50	561.11	-0.31	0.69
			25	63	561.28	-0.24	0.52
			50	73	561.38	-0.21	0.42
			100	84	561.49	-0.17	0.31

Alternative	Cross Drain	Storm Sewer Pipe	Return Period (yrs)	Inflow (cfs)	Water Elev. (ft)	Δ Water Elev. from Existing Conditions (ft)	Water Elevation Clearance from House Elev. (1) (ft)
2	Existing 30" RCP	Proposed 2 - 30" RCP 850 L.F.	2	30	561.09	-0.17	0.71
			5	41	561.21	-0.14	0.59
			10	50	561.3	-0.12	0.5
			25	63	561.4	-0.12	0.4
			50	73	561.48	-0.11	0.32
			100	84	561.55	-0.11	0.25

Alternative	Cross Drain	Storm Sewer Pipe	Return Period (yrs)	Inflow (cfs)	Water Elev. (ft)	Δ Water Elev. from Existing Conditions (ft)	Water Elevation Clearance from House Elev. (1) (ft)
3	Proposed 2 - 48" RCP	Proposed 6' x 3' RCB 850 L.F.	2	30	558.37	-2.89	3.43
			5	41	559.04	-2.31	2.76
			10	50	559.63	-1.79	2.17
			25	63	560.53	-0.99	1.27
			50	73	561.04	-0.55	0.76
			100	84	561.23	-0.43	0.57

Alternative	Cross Drain	Storm Sewer Pipe	Return Period (yrs)	Inflow (cfs)	Water Elev. (ft)	Δ Water Elev. from Existing Conditions (ft)	Water Elevation Clearance from House Elev. (1) (ft)
4	Existing 30" RCP	Proposed 6' x 3' RCB 850 L.F.	2	30	560.72	-0.54	1.08
			5	41	561	-0.35	0.8
			10	50	561.11	-0.31	0.69
			25	63	561.24	-0.28	0.56
			50	73	561.32	-0.27	0.48
			100	84	561.4	-0.26	0.4

(1) Low adjacent ground @ 1003 N. Cumberland St.	**561.8**
Road Elev @ Cross Drain	560.4
Road Elev @ 1003 N. Cumberland St.	561.2

Note:

Utility location required during design phase.

Install erosion control aprons at the outlet of all proposed pipes.

Existing 30" RCP Cross Drain. Possibly replace with 50 LF 2 - 48" RCP

Improve ditch between storm sewer and cross drain. 90 LF, 8 ft. bottom width, 2:1 side slopes, 3 ft. deep minimum.

Install erosion control aprons at the outlet of all proposed pipes.

Possible Sanitary Sewer Conflict. Locate sanitary sewer and obtain invert elevations during design phase.

Install 5 catch basins (Typ.)

Existing 20" Iron Storm Sewer Pipe

Replace with either:
850 LF 2 - 30" RCP, or
850 LF 6' x 3' Concrete Box Culvert

1003 North Cumberland St.

1001 North Cumberland St.

Hunters Creek Blvd
Creekside Dr
N. Cumberland St.
U.S. HWY. 231
Stroud Dr.
Maize Ln.
Lucas Ct.
Private
Oakdale Dr.
Edgehill Dr.
Elmwood Dr.
Stoneway Dr.

Legend

- Parcels
- Existing Culverts
- Buildings
- Flooded Parcels
- Recommended Pipe Improvements

City of Lebanon Drainage Analysis
U.S. Highway 231
(North Cumberland Street)
Drainage Improvements

N W E S

1 inch equals 200 feet

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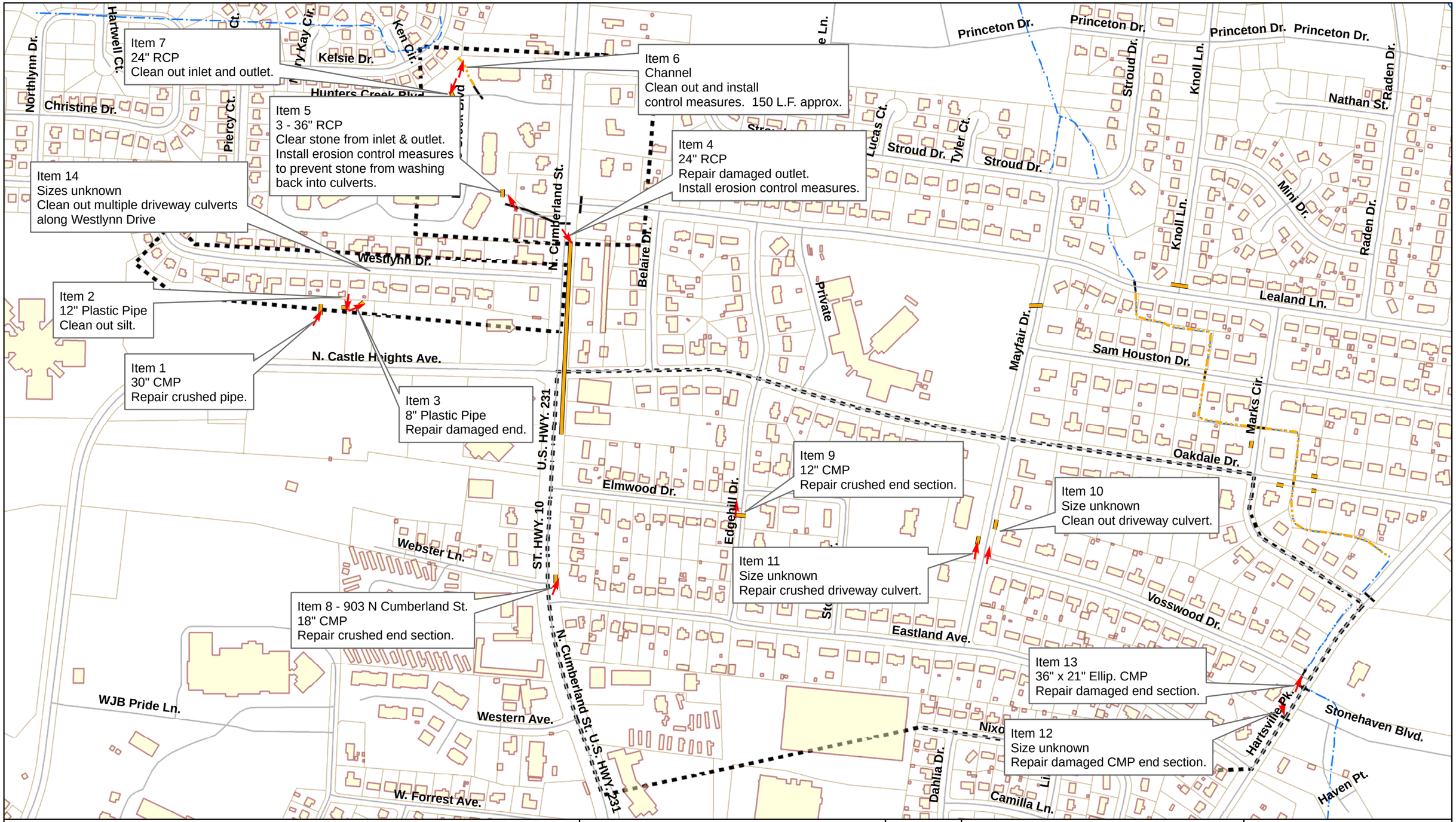
Conceptual Drainage Improvement Recommendations

Figure 2


Item 7
24" RCP
Clean out inlet and outlet.
Item 6
Channel
Clean out and install
control measures. 150 L.F. approx.
Item 5
3 - 36" RCP
Clear stone from inlet & outlet.
Install erosion control measures
to prevent stone from washing
back into culverts.
Item 4
24" RCP
Repair damaged outlet.
Install erosion control measures.
Item 14
Sizes unknown
Clean out multiple driveway culverts
along Westlynn Drive
Item 2
12" Plastic Pipe
Clean out silt.
Item 1
30" CMP
Repair crushed pipe.
Item 3
8" Plastic Pipe
Repair damaged end.
Item 9
12" CMP
Repair crushed end section.
Item 10
Size unknown
Clean out driveway culvert.
Item 11
Size unknown
Repair crushed driveway culvert.
Item 8 - 903 N Cumberland St.
18" CMP
Repair crushed end section.
Item 13
36" x 21" Ellip. CMP
Repair damaged end section.
Item 12
Size unknown
Repair damaged CMP end section.
Northlynn Dr.
Hartwell Ct.
Christine Dr.
Piercy Ct.
Kelsie Dr.
Ken Cir.
Hunters Creek Blvd
Princeton Dr.
Stroud Dr.
Lucas Ct.
Tyler Ct.
Knoll Ln.
Nathan St.
Raden Dr.
Mini Dr.
Lealand Ln.
Westlynn Dr.
N. Cumberland St.
Belaire Dr.
Private
Mayfair Dr.
Sam Houston Dr.
Marks Cir.
Oakdale Dr.
N. Castle Heights Ave.
U.S. HWY. 231
ST. HWY. 10
Elmwood Dr.
Edgehill Dr.
Webster Ln.
Eastland Ave.
Vosswood Dr.
Hartsville Pk.
Stonehaven Blvd.
Haven Pt.
WJB Pride Ln.
Western Ave.
W. Forrest Ave.
Dahlia Dr.
Camilla Ln.
Legend
Area of Field Reconnaissance
Parcels
Existing Culverts
Buildings
Infrastructure Maintenance Locations
Stream/Ditch Mainenance Locations
Directional Photo Log
City of Lebanon Drainage Analysis
U.S. Highway 231
(North Cumberland Street)
Drainage Improvements
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1 inch equals 400 feet
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Infrastructure
Maintenance Locations
Figure 3

APPENDIX A

Routine Maintenance Location Photographs

Item 1 - Detention area between N. Castle Heights Ave. and Westlynn Dr. Repair crushed inlet of 30" CMP. Picture 1638.

Item 2 – Detention area between N. Castle Heights Ave. and Westlynn Dr. Clean silt from 12" plastic pipe. Picture 1641.

Item 3 – Detention area between N. Castle Heights Ave. and Westlynn Dr. Repair damaged end of 8" plastic pipe. Picture 1642.

Item 4 – 1107 N. Cumberland St. Repair damaged outlet of 24" RCP and install erosion control measures. Picture 1663.

Item 5 – Creekside Dr. 36" RCP's. Clear stone from inlet and outlet and install erosion control measures to prevent stone from washing back into culverts. Picture 1672.

Item 6 – Channel at detention area outlet, north of Hunters Creek Blvd. and south of Kelsie Dr. Approximately 150 l.f. of channel clean out. Provide erosion control measures on unstable banks. Picture 1681.

Item 7 – Hunters Creek Blvd. Clean out inlet and outlet of 24" RCP. Picture 1683.

Item 8 – 903 N. Cumberland St. Repair crushed end section of 18" CMP driveway culvert. Picture 1698.

Item 9 – Elmwood Dr. and Edgehill Dr. Repair crushed end section of 12" CMP. Picture 1704.

Item 10 – Looking north along Mayfair Dr. from Vosswood Dr. Clean out silt blocking driveway culvert. Picture 1730.

Item 11 – 906 Mayfair Dr. Looking north along Mayfair Dr. Repair crushed driveway culvert inlet. Picture 1731.

Item 12 – Adjacent to Hartsville Pike south of Vosswood Dr. Repair damaged CMP Outlet. Picture 1739.

Item 13 – Vosswood Dr. and Hartsville Pike looking north. Repair damaged end section of 36” x 21” elliptical CMP. Picture 1740.

Item 14 – Westlynn Dr. Clean out multiple driveway culverts obstructed with sediment buildup