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ENGINEERING REPORT

Cumberland University
Drainage Improvements

PREPARED FOR:

City of Lebanon Engineering Department

PREPARED BY:

Neel-Schaffer, Inc.

March 31, 2011

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Introduction

It has been reported that several streets, intersections, and private properties surrounding the campus of Cumberland University have routinely experienced flooding during short, intense rainfall events. This causes unsafe conditions for motorists, and also causes nuisance flooding for property owners in the area.

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 west side of the field review began at the corner of Leeville Pike and Pennsylvania Avenue. Water is collected from street runoff flowing east on Leeville Pike into an 18-inch reinforced concrete pipe (RCP) inlet of a catch basin. The catch basin empties into another 18-inch RCP and the water flows east through the street ditch until emptying in a small stream flowing north. On its west bank, the stream collects water from street runoff flowing west near 300 Leeville Pike. Further north upstream, the stream collects runoff from West Sunset Drive through 12-inch driveway drains. The stream collects water from street runoff from Martin, Cleveland, and McClain Avenues as well. Further north, a 12-inch corrugated metal pipe (CMP) cross drain and beneath South Tarver Avenue directs runoff along West Spring Street and into the main stream. The stream crosses West Spring Street through a 10-foot by 44-inch box culvert. At this point roadside drainage is also emptied into the stream from West Spring Street on both the east and west banks. The stream continues to flow north and collects water from a 16-inch plastic ditch connected to a series of catch basins located on Pennsylvania Ave. The stream flows through another box culvert at the intersection of South Tarver Avenue and West Main Street. Water is also collected here from storm drains along West Main Street on both the east and west banks.

The east side of the field review began at the corner of South Maple Street and Leeville Pike. Drainage is collected from storm drains flowing east along Leeville Pike and collected into a 24-inch RCP located at the south corner of South Maple Street. Water is collected into storm drains along South Maple Street and flows north. The water continues to drain north and also collects runoff from Cumberland Drive as well as from McClain Avenue. The ditch then flows into a series of catch basins and pipes and empties east into street drainage on Newby Street that drains into Sinking Creek, which flows north, parallel to U.S. Highway 231. Newby Street also collects runoff from the curb and gutter drainage on University Avenue just north of it. Further north, at the corner of West Spring Street and South Maple Street, water is collected from street runoff along West Spring Street flowing east into a series of storm drains and catch basins before emptying into Sinking Creek.

Watershed Description

The study area consists of seven separate drainage areas that cover a combined area of approximately 134 acres (0.21 square miles). Seven primary areas of interest were identified, with each point having a defined drainage area. Figure 1 presents the drainage area locations and calculated hydrologic parameters for the following Points of Interest:

- **Point of Interest A – Watershed outfall at West Spring Street bridge over Sinking Creek**: This receives runoff from approximately 38 acres, which includes the northeastern drainage area of Cumberland University and the drainage area between South Greenwood and this outfall. The portion of West Spring Street between South Greenwood Street and Sinking Creek has been known to flood during frequent, intense storms, which causes unsafe conditions for motorists.
- **Point of Interest B – South Greenwood Street at West Spring Street**:
  This includes the northeastern portion of Cumberland University. A potential detention pond site was evaluated at the southwest corner of this intersection. The drainage area at this point is approximately 14 acres, and runoff from this area drains eastward to Point of Interest A. This intersection has been known to flood during frequent, intense storms, which causes unsafe conditions for motorists.
- **Point of Interest C – The intersection at McClain Avenue/Cumberland Drive and South Greenwood Street**:
  This intersection receives runoff from approximately 29 acres. This area drains eastward along Cumberland Drive. This intersection has been known to flood during frequent, intense storms, which causes unsafe conditions for motorists.
- **Point of Interest D – Martin Avenue at South Tarver Avenue**:
  The drainage area at this intersection is approximately 12 acres, and runoff from this area drains westward along Martin Avenue and into Tarver Branch. This intersection has been known to flood during frequent, intense storms, which causes unsafe conditions for motorists.
- **Point of Interest E – West Spring Street at South Tarver Avenue**:
  This intersection receives runoff from approximately 8 acres of the northwest portion of Cumberland University, and runoff from this area drains westward along West Spring Street and into Tarver Branch. This intersection has been known to flood during frequent, intense storms, which causes unsafe conditions for motorists.
- **Point of Interest F –Intersection of West Spring Street at Pennsylvania Avenue**:
  This intersection receives runoff from approximately 24 acres, and runoff from this area drains eastward along West Spring Street and into Tarver Branch.
- **Point of Interest G – Residences near the intersection of Martin Avenue and Cleveland Avenue**:
  This area receives runoff from approximately 24 acres, and runoff from this area drains across Cleveland Avenue and into Tarver Branch. Several residences near this intersection experience frequent flooding. According to the property owner at 1107 Cleveland Avenue, minor flooding of yards and streets in this area occurs approximately 4 times per year.

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 is 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 study area was determined from aerial photography and includes residential, commercial and educational developments. Hydrologic Soil Group data was obtained from the Natural Resource Conservation Service (NRCS). Runoff Curve Numbers within the watershed range from 83 to 88, which reflects the dense urbanization of the drainage areas. A summary of the hydrologic parameters is presented on Figure 1.

Analysis and Recommendations

Analysis of Point of Interest A – Drainage along West Spring Street

It was noted during the field review that the storm sewer system along West Spring Street to the east of South Greenwood Street is very shallow and clogged with sediment. Furthermore, it is believed that the inlets near the intersection are not low enough to capture runoff efficiently, and the existing storm sewer is undersized. These issues all contribute to the frequent flooding of the intersection.

Therefore, it is recommended to remove the existing storm sewer and replace it with 1,375 linear feet of curb and gutter system. The main trunk of the curb and gutter system will be on the south side of West Spring Street, and will consist of 38” by 60” Elliptical Reinforced Concrete Pipe (ERCP). Typical curb and gutter inlets should be connected to this storm sewer. The curb and gutter system will cross beneath the railroad and will outfall into Sinking Creek at the same location as the existing storm sewer.

For this preliminary analysis, only the approximate size of storm sewer was determined (based on 10-year storm). It may be determined during the survey/design phase that the presence of numerous utilities, the crossing beneath the railroad, and other potential conflicts/constraints may preclude the recommended improvements. Details of recommended drainage improvements are shown on Figure 2.

Analysis of Point of Interest B – Potential detention site at West Spring Street and South Greenwood Street

During the initial phases of the project, a location for a potential detention area was identified at an open tract of land to the southwest of the intersection of South Greenwood Street and West Spring Street. Runoff from the northeastern portion of Cumberland University (14 acres) drains to this point naturally. Therefore, a proposed 0.85 acre detention pond was analyzed in the hydrologic model. As stated above, the storm sewer along West Spring Street is very shallow.

Therefore, the depth of the proposed pond is limited since the outflow would need to enter the existing storm sewer system. A conceptual development plan of the Cumberland University campus was used to determine the conceptual dimensions of the pond. It was determined that the maximum dimensions that are feasible for the proposed detention pond consist of a length of 225 feet, a width of 165 feet, and a depth of two feet.

Hydrologic analysis of the proposed detention pond shows a minimal reduction in storm water outflows from the detention area into the storm sewer system. East of South Greenwood Street, immediately downstream of the pond, the 2-year discharge would only be reduced by approximately 11%, while the 25-year discharge would only be reduced by less than 1%. At the outfall, near the railroad, the 2-year discharge would be reduced by approximately 8%, while the 25-year discharge would remain unchanged. Therefore, the detention basin would not have sufficient capacity to mitigate the existing flooding issues along West Spring Street. However, if the recommended improvements for Point of Interest A (proposed storm sewer along West Spring Street) are implemented, there will be no need for a detention pond at this location. Therefore, it is not recommended to construct a detention pond at the parcel to the southwest of the intersection of West Spring Street and South Greenwood Street.

Analysis of Point of Interest C – Drainage at intersection of McClain Avenue/Cumberland Drive and South Greenwood Street

It was noted during the field review that there are several pipes beneath the intersection of South Greenwood/McClain/Cumberland Avenue. It appears that several of the pipes were retrofitted to add capacity to the system; but the manner in which the pipes are routed provides for a very inefficient drainage system and contributes to the frequent flooding of the intersection and streets. Furthermore, the outfall of the pipe system at this intersection drains into a roadside ditch on the south side of Cumberland Drive, but the ditch disappears, forcing water onto the road before it enters a street inlet approximately 500 feet east of the intersection. This inlet is connected to a large elliptical corrugated metal pipe (32” by 53”), which outfalls behind the residence at 215 Cumberland Drive and drains into a small ditch with no positive drainage. Therefore, water fills up low spots along the properties between Cumberland Drive and University Avenue, leading to marshy conditions during most of the wet season due to lack of positive drainage.

Therefore, it is recommended to remove the existing pipes at the intersection of South Greenwood/McClain/Cumberland and replace them with 730 linear feet of single 36” Reinforced Concrete Pipe beneath South Greenwood Street, running to the east along the north side of Cumberland Drive. The new storm sewer will also connect to a catch basin near 215 Cumberland Drive and turn north in the same location as the existing storm sewer. However, it is recommended to construct a 0.4-acre detention pond on a vacant lot behind 215 Cumberland Drive in order to store and slowly release concentrated storm water that will drain to this point faster than the current system allows. This pond/control structure configuration will mitigate any increase in discharge to this outfall point to prevent downstream damages, and will also help to solve local flooding issues along South Maple Street that occur when the aforementioned low areas fill up during large storm events and overflow toward South Maple Street.

In addition, it is recommended to reroute the drainage from the south side of McClain Avenue to the south along the west side of South Greenwood and install a new 42" RCP beneath the road that outfalls to a former detention area behind the Cumberland University dormitory. It was discovered during the field review that a large portion of the soccer field formerly served as a detention pond, but has been filled in with earth. A concrete riser outlet structure was found buried along the east side of the field. It is unclear how large the pond was or why it was filled in, but it should be restored to its original design specifications immediately since it could be causing downstream flooding issues to the east. This should be the responsibility of the University. Currently, water flows across the former pond site (currently a soccer field) and fills up low spots along the properties on the south side of Cumberland Drive, leading to marshy conditions during most of the wet season due to lack of positive drainage.

The proposed storm pipe will have a length of 310 feet and will discharge to a ditch that will carry outflow into the restored University detention pond. In addition, it is recommended to construct a new 0.3-acre detention pond on a vacant lot immediately east of the restored detention pond in order to control the concentrated storm water that will drain to this point faster than the current system allows. The new pond should be combined with the restored University pond, and a new outlet structure or pipe should be placed at the new pond outlet to mitigate any increase in discharge to this outfall point to prevent downstream damages. The new pond system will also help to solve local flooding issues along South Maple Street that currently occur when the aforementioned low areas fill up during large storm events and overflow toward South Maple Street.

For this preliminary analysis, only the approximate sizes of storm sewers and detention ponds were determined (based on 10-year storm). Pond control structures were not sized and therefore actual decreases in storm water discharge cannot be determined. It may be determined during the survey/design phase that numerous utilities and other potential conflicts/constraints, and the permanent drainage easements required for the ponds may preclude the recommended improvements.

Details of recommended drainage improvements are shown on Figure 2.

<u>Analysis of Point of Interest D – Drainage at intersection of Martin Avenue and South Tarver Avenue</u>

It was noted during the field review that there are several pipes beneath the intersection of Martin Avenue and South Tarver Avenue, including a long 12" RCP that discharges to a roadside ditch. The pipes are undersized, and the roadside ditches in this area are in need of maintenance. The inlets near the intersection are not low enough to capture runoff efficiently. Plus, the manner in which the pipes are routed provides for a very inefficient drainage system and contributes to the flooding of the intersection and streets.

Therefore, the logical solution is to convert the section of Martin Avenue between South Tarver Avenue and the creek to a curb and gutter system, which will replace the driveway pipe/ditch system and remove runoff from the road more quickly and efficiently than the catch basins and small pipes at the intersection. Plus, the curb and gutter system will prevent the need for future ditch/driveway pipe maintenance. The main trunk of the curb and gutter system will be on the

south side of Martin Avenue, and will consist of 430 linear feet of 30" RCP. Typical curb and gutter inlets should be connected to this storm sewer. The outfalls of the curb and gutter system will drain into Tarver Branch near the existing box culvert beneath Martin Avenue.

For this preliminary analysis, only the approximate size of storm sewer was determined (based on 10-year storm). It may be determined during the survey/design phase that the presence of numerous utilities and other potential conflicts/constraints may preclude the recommended improvements.

Details of recommended drainage improvements are shown on Figure 2.

Analysis of Point of Interest E – Drainage at intersection of West Spring Street and South Tarver Avenue

It was noted during the field review that there are several pipes beneath the intersection of West Spring Street and South Tarver Avenue. It appears that the manner in which the pipes are routed provides for a very inefficient drainage system and contributes to the flooding of the intersection and streets. All of the runoff draining to this intersection outfalls to a roadside ditch on the north side of West Spring Street that drains to the west toward Tarver Branch. Furthermore, the invert of the 16" RCP beneath West Spring Street on the east side of South Tarver Avenue sits about 18 inches lower than the 8" pipe that drains back to the west side of South Tarver. This means that water draining from the south of the intersection (on the east side of South Tarver Avenue) has to fill up the roadside ditch almost to the edge of pavement before being able to drain back across South Tarver Avenue into the ditch that carries it to the creek. This issue is definitely contributing to the flooding of this intersection. Plus, the 8" cross drain beneath South Tarver Avenue is severely undersized.

Therefore, the logical solution is to convert this section of West Spring Street between South Tarver Avenue and the creek to a curb and gutter system, which will replace the driveway pipe/ditch system and remove runoff from the road more quickly and efficiently than the catch basins and small pipes at the intersection of West Spring Street and South Tarver Avenue. Plus, the curb and gutter system will prevent the need for future ditch/driveway pipe maintenance. The main trunk of the curb and gutter system will be on the south side of West Spring Street, and will consist of 390 linear feet of 19" by 30" ERCP. Typical curb and gutter inlets should be connected to this storm sewer. The outfalls of the curb and gutter system will drain into Tarver Branch near the existing box culvert beneath West Spring Street.

For this preliminary analysis, only the approximate size of storm sewer was determined (based on 10-year storm). It may be determined during the survey/design phase that the presence of numerous utilities and other potential conflicts/constraints may preclude the recommended improvements.

Details of recommended drainage improvements are shown on Figure 2.

Analysis of Point of Interest F – Drainage at intersection of West Spring Street and Pennsylvania Avenue

It was noted during the field review that there are several pipes beneath the intersection of West Spring Street and Pennsylvania Avenue. It appears that the pipes are undersized and the inlets near the intersection are not low enough to capture runoff efficiently, thereby contributing to the frequent flooding of the intersection and streets. All of the runoff draining to this intersection outfalls to small roadside ditches on both sides of West Spring Street that drain to the east toward Tarver Branch. The roadside ditches in this area have lost capacity due to siltation and are in need of maintenance.

Therefore, the logical solution is to convert this section of West Spring Street between Pennsylvania Avenue and the creek to a curb and gutter system, which will replace the driveway pipe/ditch system and remove runoff from the road more quickly and efficiently than the catch basins and small pipes at the intersection. Plus, the curb and gutter system will prevent the need for future ditch/driveway pipe maintenance. The curb and gutter system will consist of 460 linear feet of 24" by 38" ERCP on each side of West Spring Street. Typical curb and gutter inlets should be connected to this storm sewer. The outfalls of the curb and gutter system will drain into Tarver Branch near the existing box culvert beneath West Spring Street.

For this preliminary analysis, only the approximate size of storm sewer was determined (based on 10-year storm). It may be determined during the survey/design phase that the presence of numerous utilities and other potential conflicts/constraints may preclude the recommended improvements.

Details of recommended drainage improvements are shown on Figure 2.

Analysis of Point of Interest G – Drainage near intersection of Martin Avenue and Cleveland Avenue

It was noted during the field review that roadside ditches along Martin Avenue are not large enough for the volume of water draining to them. Plus, water is forced to make a 90-degree bend to the north at the intersection of Martin and Cleveland Avenues. This drainage travels in a roadside ditch on the west side of Cleveland Avenue before crossing beneath this road through an elliptical CMP. The pipes in this area are undersized, and the roadside ditches in this area are in need of maintenance. Plus, the manner in which the roadside drainage is forced to make a 90-degree bend contributes to the flooding of the intersection, streets, and private properties. Another local property drainage issue is caused when the capacity of the pipe beneath the concrete driveway at 313 Pennsylvania Avenue is exceed and the excess discharge flows north across the driveway and into the back yards of the properties at 314 and 316 Cleveland Avenue. These yards remain marshy during most of the wet season due to lack of positive drainage back to the roadside ditches.

Therefore, to help solve both the local property drainage and the street drainage issues, it is recommended to divert drainage entering the aforementioned driveway pipe at 313 Pennsylvania Avenue into a storm drain that will effectively cut off the 90-degree bend at Cleveland Avenue, while also providing a means for the low areas in the two yards at 314 and 316 Cleveland Avenue to drain toward the Cleveland Avenue cross drain. In addition, the existing

elliptical CMP cross drain beneath Cleveland Avenue is recommended to be upgraded to a double-24" by 38" elliptical RCP. Downstream ditch improvements are also needed between this pipe's outlet and the outfall into Tarver Branch.

For this preliminary analysis, only the approximate sizes of storm drains were determined (based on 10-year storm). It may be determined during the survey/design phase that the presence of numerous utilities and other potential conflicts/constraints, including acquisition of property easements, may preclude the recommended improvements.

Details of recommended drainage improvements are shown on Figure 2.

A description of the proposed structural improvements and preliminary estimated project costs are shown below. The following costs include engineering/design fees and provision for 20% contingency:

Structural Improvements (See Figure 2)	**Preliminary Estimated Project Cost**
Point of Interest A – Storm sewer/curb & gutter along West Spring Street between South Greenwood Street and Sinking Creek	$ 457,500.00
Point of Interest B – Potential detention site at West Spring Street and South Greenwood Street	$ N/A
Point of Interest C – Storm sewer/curb & gutter along Cumberland Drive, rerouted storm drain beneath South Greenwood near dormitory, two detention ponds (0.3 acre and 0.4 acre) with inlet/outlet ditches	$ 267,000.00
Point of Interest D – Storm sewer/curb & gutter along Martin Avenue between South Tarver Avenue and creek (Tarver Branch)	$ 139,400.00
Point of Interest E – Storm sewer/curb & gutter along West Spring Street between South Tarver Avenue and creek (Tarver Branch)	$ 131,800.00
Point of Interest F – Storm sewer/curb & gutter along West Spring Street between Pennsylvania Avenue and creek (Tarver Branch)	$ 158,200.00
Point of Interest G – Storm sewer and drainage improvements between Martin Avenue/Cleveland Avenue and creek (Tarver Branch)	$ 29,100.00
Total Cost of Recommended Structural Improvements	**$ 1,183,000.00**

Routine Maintenance

In addition to the structural recommendations described above, 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 regrading ditches to have positive drainage. While correcting these deficiencies will not solve any flooding issues, 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. A map showing locations identified as requiring immediate 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:

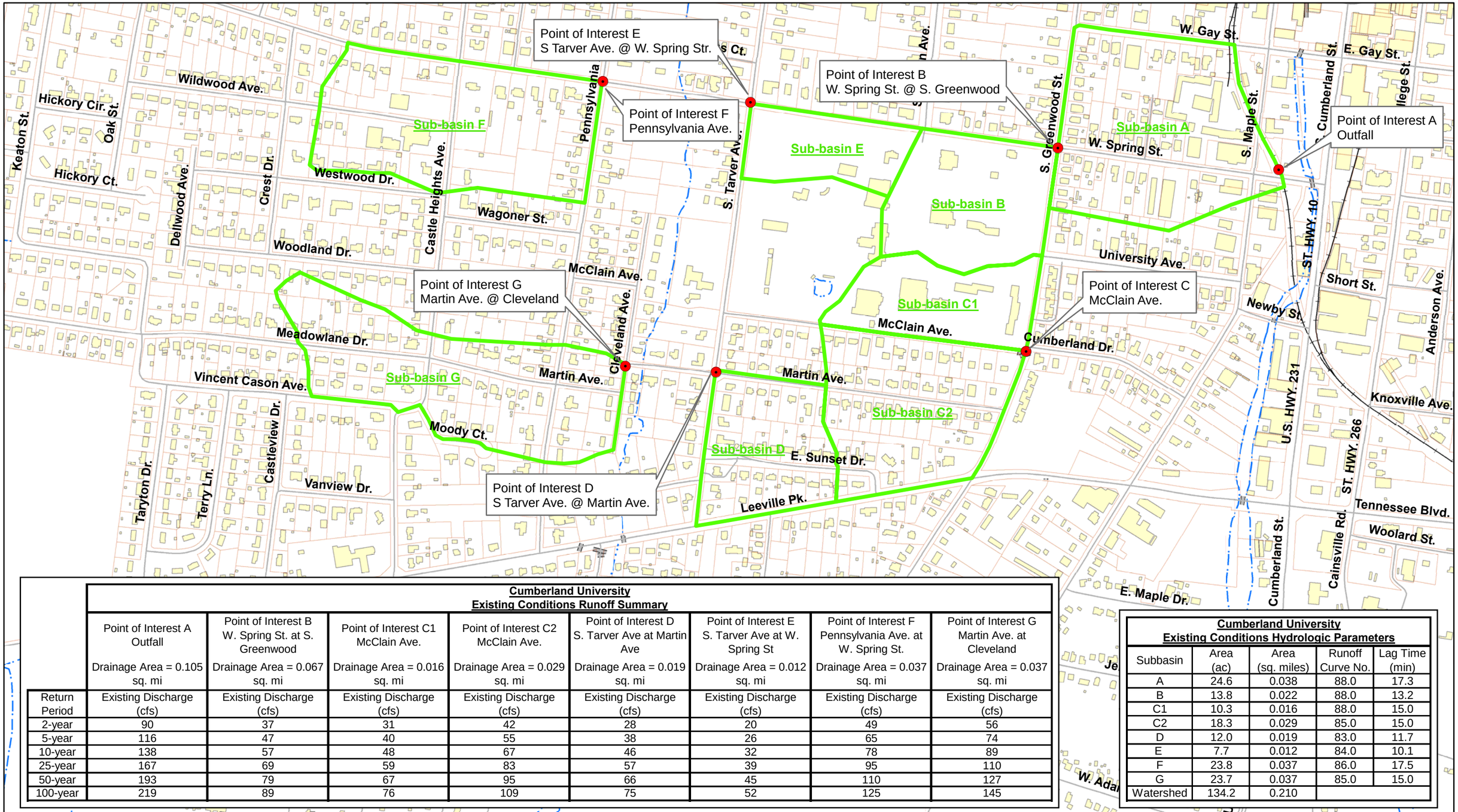
Infrastructure Maintenance Items (See Figure 3)	**Preliminary Estimated Project Cost**
1. Debris/sediment removal from culvert ends at 36 locations	$ 14,400.00
2. Culvert end repair at fourteen locations	$ 9,800.00
3. Debris/sediment removal from channel at three locations – 3,875 L.F.	$ 15,500.00
4. Debris/sediment removal from roadside ditch at five locations – 4,010 L.F.	$ 16,000.00
5. Remove sediment/debris from catch basins at five locations	$ 2,500.00
6. Repair catch basins at two locations	$ 2,000.00
Total Maintenance Cost	**$ 60,200.00**

Property Acquisition and Future Design Considerations

The above costs do not include property acquisition, which will be necessary for Points of Interest C and G. The proposed detention ponds associated with Point of Interest C are situated on two mostly undeveloped tracts of land. The tract required for the northern pond is owned by Front Porch Realty, LLC; and the tract required for the southern pond is owned by BSR Investment, Inc.

Point of Interest G will require small drainage easements from the owners at 313 Pennsylvania Avenue and 314 and 316 Cleveland Avenue.

It should be understood that no field survey data was available for this study. Elevations were estimated based on the 5-foot interval topographic mapping provided by the City, and from information obtained during the field reconnaissance. Therefore the evaluation of the proposed infrastructure upgrades included as a part of this study should be regarded as conceptual. Therefore, it will be necessary to conduct full topographic and property boundary surveys during the design phase to determine the extent of drainage easements required, and to determine the extent of utility conflicts and other constraints.



Cumberland University
Existing Conditions Runoff Summary

Return Period	Point of Interest A Outfall Drainage Area = 0.105 sq. mi Existing Discharge (cfs)	Point of Interest B W. Spring St. at S. Greenwood Drainage Area = 0.067 sq. mi Existing Discharge (cfs)	Point of Interest C1 McClain Ave. Drainage Area = 0.016 sq. mi Existing Discharge (cfs)	Point of Interest C2 McClain Ave. Drainage Area = 0.029 sq. mi Existing Discharge (cfs)	Point of Interest D S. Tarver Ave at Martin Ave Drainage Area = 0.019 sq. mi Existing Discharge (cfs)	Point of Interest E S. Tarver Ave at W. Spring St Drainage Area = 0.012 sq. mi Existing Discharge (cfs)	Point of Interest F Pennsylvania Ave. at W. Spring St. Drainage Area = 0.037 sq. mi Existing Discharge (cfs)	Point of Interest G Martin Ave. at Cleveland Drainage Area = 0.037 sq. mi Existing Discharge (cfs)
2-year	90	37	31	42	28	20	49	56
5-year	116	47	40	55	38	26	65	74
10-year	138	57	48	67	46	32	78	89
25-year	167	69	59	83	57	39	95	110
50-year	193	79	67	95	66	45	110	127
100-year	219	89	76	109	75	52	125	145

Cumberland University
Existing Conditions Hydrologic Parameters

Subbasin	Area (ac)	Area (sq. miles)	Runoff Curve No.	Lag Time (min)
A	24.6	0.038	88.0	17.3
B	13.8	0.022	88.0	13.2
C1	10.3	0.016	88.0	15.0
C2	18.3	0.029	85.0	15.0
D	12.0	0.019	83.0	11.7
E	7.7	0.012	84.0	10.1
F	23.8	0.037	86.0	17.5
G	23.7	0.037	85.0	15.0
Watershed	134.2	0.210		

Legend
Streams
Sub-Basins
Parcels_clip
Buildings
Culverts
Railroad

City of Lebanon Drainage Analysis
Cumberland University
Drainage Improvements

N W E S
1 inch equals 500 feet

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Solutions you can build upon

Hydrology Results

Figure 1

- Remove all existing pipes at intersection
- Remove all driveway pipes and ditches
- IInstall Typ. Curb & Gutter
- Connect curb inlets to 24" x 38" Elliptical RCP (One run each side of W. Spring. St.) 460 LF @ 1.0% per run.
- Install 4 catch basins at intersection.

- Remove all existing pipes at intersection
- Remove all driveway pipes and ditches
- Install Storm Sewer/Curb & Gutter Inlets (Spacing to be determined)
- Connect curb inlets to 18" RCP (North side of W. Spring. St.) 390 LF @ 1.5% per run
- Install 2 catch basins north of intersection.

- Remove all existing pipes at intersection
- Remove all driveway pipes and ditches
- Install Storm Sewer/Curb & Gutter Inlets (Spacing to be determined)
- Connect curb inlets to 19'' x 30'' Elliptical RCP (South side of W. Spring St.) 390 LF @ 1.5%
- Install 2 catch basins south of intersection.

Replace existing storm sewer
-38" x 60" Elliptical RCP
-775 LF @ 0.9%
-Install Typ. Curb & Gutter Inlets
(Spacing to be determined)

775 LF

600 LF

Replace existing storm sewer
-38" x 60" Elliptical RCP
-600 LF @ 0.5%
-Install Typ. Curb & Gutter Inlets
(Spacing to be determined)

Install storm sewer
-36" RCP
-730 LF @ 0.5%
-Install Typ. Curb & Gutter Inlets
(Spacing to be determined)
-Install 2 catch basins

Proposed (Potential) Detention Pond -
Surface area of pond = 0.4 ac.

Grade ditch to provide adequate drainage.

- Remove existing cross drain
- Replace with 2 - 24" x 38" Elliptical RCP 35 LF @ 0.5%

Grade ditch to provide adequate drainage.

- Remove all existing pipes at intersection
- Remove all driveway pipes and ditches
-Install Typ. Curb & Gutter Inlets (Spacing to be determined)
- Connect curb inlets to 18" RCP (North side of Martin Ave.) 430 LF @ 1.0%
- Install 2 catch basins north of intersection.

Plug or remove all ex. pipes

Grade ditch to drain to new storm sewer.

Install storm sewer
-42" RCP
-310 LF @ 0.5%
-Install 4 catch basins

- Remove end of existing driveway pipe
- Install 24" x 38" Elliptical RCP 314 LF @ 0.5%
- Install 2 catch basins.

Construct Trapezoidal
Grass-Lined Channel
-2' bottom width, 3' depth,
2.5:1 side slopes, 130 L.F. @ 0.7% grade

- Remove all existing pipes at intersection
- Remove all driveway pipes and ditches
-Install Typ. Curb & Gutter Inlets (Spacing to be determined)
- Connect curb inlets to 30" RCP (South side of Martin Ave.) 430 LF @ 1.0%
- Install 2 catch basins south of intersection.

Existing Detention Pond -
(University to remove fill material, restore to original design specifications, and grade to drain)

Proposed (Potential) Detention Pond -
Connect pond to University's pond on soccer field to form regional pond.
Surface area of new pond = 0.3 ac.

Construct Trapezoidal
Grass-Lined Channel
-2' bottom width, 2' depth,
2.5:1 side slopes, 180 L.F. @ 0.7% grade

Construct Trapezoidal
Grass-Lined Channel
-2' bottom width, 2' depth,
2.5:1 side slopes, 190 L.F. @ 0.7% grade

Castle Heights Ave.
Moss Ct.
Pennsylvania Ave.
S. Hatton Ave.
W. Gay St.
E. Main St.
Stone St.
S. College St.
E. Gay St.
Cherry St.
Thomas Terrace
Baird St.
S. Cumberland St.
W. Spring St.
S. Greenwood St.
E. Spring St.
Wagoner St.
University Ave.
ST. HWY: 10
Anderson Ave.
Short St.
Starnes Alley
Joe Branham Dr.
McClain Ave.
Newby St.
Comer Ln.
Cumberland Dr.
S. Maple St.
Martin Ave.
Cleveland Ave.
Knoxville Ave.
Harding Dr.
Moody Ct.
U.S. HWY: 70
ST. HWY: 266
S. Tarver Ave.
E. Sunset Dr.
W. Sunset Dr.
Leeville Pk.
Tennessee Blvd.
Blue Devil Dr.
Campbell St.
Cainsville Rd.
Tott St.
Woolard St.
Hobbs Ave.
W. Adams Ave.
S. Cumberland St.
E. Maple Dr.
W. Adams St.
Cleveland St.
Elkins Dr.
Jennings Ave.
Gulf St.
Pencil Mill Alley
Park Dr.

Legend

- Proposed Storm Sewer Inlets
- Proposed Storm Sewer
- Proposed Ditch
- Potential Detention Ponds
- Existing Culverts
- Streams
- Railroad
- Parcels
- Buildings

MARCH 2011

City of Lebanon Drainage Analysis
Cumberland University
Drainage Improvements

N W E S

Not to Scale

NEEL-SCHAFFER

Conceptual Drainage Improvement Recommendations

Figure 2

INTENDED FOR PLANNING PURPOSES ONLY.

Item 53
Clear debris, brush & sediment from approx. 3,410 LF of channel from W. Main St. to W. Sunset Dr. Provide bank stabilization & erosion control measures where necessary.

Item 19
Clean debris & sediment from culvert inlet.

Item 23
24" CMP
Flush pipe & remove sediment & debris from ditch.

Items 21 & 22
20" x 14" ellip. CMP and 15" CMP
Clean debris from inlets & outlets.

Item 53
Clear debris, brush & sediment from approx. 3,410 LF of channel from W. Main St. to W. Sunset Dr. Provide bank stabilization & erosion control measures where necessary.

Item 41
Clear debris, sediment & brush from approx 200 LF of channel.

Item 42
Clear debris from 15" x 10" ellip. CMP.

Item 39
Clear debris & sediment from approx. 400 LF of roadside ditch and driveway culverts.

Item 40
Clear debris & sediment and repair end sectionof 14" x 9" ellip. CMP.

Items 37 & 38
Repair end of 26" x 20" ellip. CMP.
Clear debris from ends of 10" CMP.

Item 43
Clear debris & sediment from 23" x 12" CMP.

Item 44
Clear debris & sediment from roadside ditches & all driveway culverts.
Approx. 340 LF each side of road.

Item 48
Clear debris & sediment from ditch & culverts on the west side of Pennsylvania Ave. Approx. 900 LF.

Item 47
Improve ditch section at end of 18" CMP

Item 45
Clean debris & sediment from roadside ditches & all driveway culverts.
Approx. 860 LF each side of road.

Item 20
Improve channel section immediately upstream of 10' x 4' RCB

Items 17 & 18
Clean debris from culvert inlets.

Item 28
Clear debris & repair end section of 12" CMP.

Item 29
Flush sediment & debris from 12" clay pipe

Item 30
Clear debris & sediment from both ends of 18" RCP cross drain,

Item 31
Clear debris from 12" CMP

Item 32
Clear debris & sediment from both ends of 12" CMP.

Item 33
Clear sediment & debris and repair end section of 20" x 10" ellip. CMP cross drain.

Item 34
Provide positive drainage in ditch and under driveways for approx. 310 LF.

Item 36
Clear debris from 15" RCP.

Item 35
Repair end of 22" x 12" CMP.

Item 49 & 50
Clear debris & sediment, repair damaged end sections of 2 cross drains. Each cross drain consists of 2 - 14" x 10" ellip. CMP's

Item 51
Repair end sections of all driveway culverts from E. Susset Dr. to Leeville Pkwy.

Item 46
Clear debris & sediment from 57" x 36" ellip. CMP.

Item 52
Clear sediment from 15" RCP.

Items15 & 16
Clean debris from catch basin grates.

Item 3
Remove debris from 12" CMP

Item 2
Clear sediment & debris from 18" CMP

Item 4
Clean catch basin grate

Item 1
Clear sediment from 16" x 10" ellip. CMP

Items 5 & 6
Clear sediment & debris from 12" CMP's

Item 7
Clear sediment & debris from RCP

Items 9
2 - 14" x 10" ellip. CMP's
Repair damaged inlets.
Clean sediment & debris from inlets & outlets.

Item 8
Repair pipe end section, clear sediment & debris from CMP

Item 10
Repair damaged end section of 12" CMP.

Item 11
20" x 10" elliptical CMP.
Repair damaged end sections.
Clear sediment & debris from inlet & outlet.

Item 54
Restore filled in detention pond to original design specifications.
Grade outlet ditch to drain.

Item 24
Clear debris & brush from approx. 265 LF of channel.
Grade to drain toward pipe at Hwy. 231.

Item 14
Clean sediment & debris from opening of 4' x 2' box culvert.

Item 25
Clear brush & debris from pipe opening.

Item 26
Clear debris from catch basin grates

Item 27
Install grate on catch basin.

Item 13
Clean debris& sediment from under catch basin grate

Item 12
Repair catch basin cover.
Clean out catch basin grate
Clear sediment & debris from HDPE inlet

Private
N. Hatton Ave.
Lewis Ct.
S. Hatton Ave.
N. Greenwood St.
S. Greenwood St.
Carruthers Ave.
Bair
W. Market St.
E. Market St.
N. Maple St.
S. Cumberland St.
N. College St.
S. College St.
W. Main St.
E. Main St.
W. Gay St.
E. Gay St.
W. Spring St.
E. Spring St.
Thomas Terrace
Pennsylvania Annex.
Pennsylvania Ave.
S. Tarver Ave.
Wildwood Ave.
Castle Heights Ave.
Westwood Dr.
Woodland Dr.
McClain Ave.
Meadowlane Dr.
Martin Ave.
Vincent Cason Ave.
Cleveland Ave.
Vanview Dr.
W. Sunset Dr.
E. Sunset Dr.
Cumberland Dr.
University Ave.
Short St.
Starnes Alley
Comer Ln.
Knoxville Ave.
Anderson Ave.
ST. HWY. 10
ST. HWY. 266
U.S. HWY
Leeville Pk.
Tennessee Blvd.
Woolard St.
Gulf St.
Tott St.
Cainsville Rd.

Legend

- Existing Culverts
- Streams
- Railroad
- Parcels
- Buildings
- Area of Field Reconnaissance
- Infrastructure Maintenance Location
- Drainage Ditch Maintenance
- Detention Pond Restoration
- Roadside Ditch Maintenance
- F Directional Photo Log

City of Lebanon Drainage Analysis
Cumberland University
Drainage Improvements

Not to Scale

NEEL-SCHAFFER

Infrastructure Maintenance Locations

Figure 3

MARCH 2011

INTENDED FOR PLANNING PURPOSES ONLY.

APPENDIX A

Routine Maintenance Location Photographs

Item 1 W. Spring St. and S. Greenwood St. Clear sediment from 16” x 10” ellip. CMP. Picture 2167.

Item 2 - W. Spring St. and S. Greenwood St. Clear sediment and debris from 18” CMP. Picture 2169.

Item 3 – W. Spring St. and S. Greenwood St. Remove debris from 12" CMP. Picture 2171.

Item 4 – S Greenwood St. at W. Spring St. Clean catch basin grate. Picture 2173.

Item 5 – West side of S. Greenwood St. just north of University Ave. Clear sediment and debris from 12" CMP under parking lot access drive.
Picture 2176.

Item 6 – West side of S. Greenwood St. just south of University Ave. Clear sediment and debris from 12" CMP. Picture 2177.

Item 7 – West side of S. Greenwood St. south of University Ave. Clear sediment and debris from RCP. Picture 2178.

Item 8 – West side of S. Greenwood St. north of McClain Ave. Repair pipe end section, clear sediment and debris from CMP. Picture 2182.

Item 9 –S. Greenwood St. and McClain Ave. 2 – 14” x 10” elliptical CMP’s under S. Greenwood St. Repair damaged inlets. Clean out sediment and debris from inlets and outlets.

Inlets of 2 – 14” x 10” ellip. CMP’s. Picture 2184.

Outlets of 2 – 14” x 10” ellip. CMP’s. Picture 2189.

Item 10 – S. Greenwood St. and McClain Ave. Repair damaged end section of 12” CMP. Picture 2191.

Item 11 – S. Greenwood St. and Martin Ave.. 20” x 10” elliptical CMP. Repair damaged end sections. Clear sediment and debris from inlet and outlet.

Outlet. Picture 2192.

Inlet. Picture 2193.

Item 12 – 334 S. Maple St. Repair catch basin cover, clean out catch basin grate, and clear sediment and debris from HDPE inlet.

Catch basin cover and grate. Picture 2256.

HDPE Inlet. Picture 2255.

Item 13 – 217 Cumberland Dr. Clean debris and sediment from under catch basin grate. Picture 2197.

Item 14 – W. Main St. and railroad. Clean sediment and debris from opening of 4’ x 2’ box culvert. Picture 2213.

Item 15 – W. Main St. and S. Hatton Ave. Clean debris from catch basin grate. Picture 2215.

Item 16 – W. Main St. and S. Hatton Ave. Clean debris from catch basin grate. Picture 2217.

Item 17 – W. Spring St. and S. Tarver Ave. Clean debris from culvert inlet. Picture 2223.

Item 18 – W. Spring St. and S. Tarver Ave. Clean debris from culvert inlet. Picture 2224.

Item 19 – 514 W. Spring St. Clean debris and sediment from culvert inlet. Picture 2225.

Item 20 – 514 W. Spring St. Improve channel section immediately upstream of 10' x 4' RCB. Picture 2230.

Item 21 – W. Sprint St. and Pennsylvania Ave. Clean debris from 20” x 14” ellip. CMP. Picture 2234.

Item 22 – W. Spring St. and Pennsylvania Ave. Clear debris from west end of 15” CMP. Picture 2239.

Item 23 – 520 W. Spring St. 24" CMP clogged with debris and sediment. Flush pipe and remove debris from ditch. Picture 2235

Item 24 – 338 S. Maple St. to 220 Cumberland Dr. Clear debris and brush from approx. 265 LF of channel.

Picture 2251.

Picture 2257.

Item 25 – 316 S. Maple St. Clear brush and debris from pipe opening. Picture 2268.

Item 26 – 319 S. Maple St. Clear debris from catch basin grates. Picture 2271.

Item 27 – 319 S. Maple St. Install grate on catch basin. Picture 2272.

Item 28 – East side of S. Tarver Ave. Clear debris and repair end section of 12" CMP. Picture 2299.

Item 29 – 224 S. Tarver Ave. Flush sediment and debris from 12” clay pipe. Picture 2304.

Item 30 – 224 S. Tarver Ave. Clear debris and sediment from both ends of 18” RCP cross drain. Picture 2305.

Item 31 – East side of S. Tarver Ave. north of St. Frances Cabrini Catholic Church. Clear debris from 12" CMP. Picture 2311.

Item 32 – S. Tarver Ave. north of St. Frances Cabrini Catholic Church. Clear debris and sediment from both ends of 12" CMP. Picture 2312.

Item 33 – S. Tarver Ave. and McClain Ave. Clear sediment and debris from both ends 20" x 10" ellip. CMP cross drain. Repair end section. Picture 2315.

Item 34 – S. Tarver Ave. from Martin Ave. to McClain Ave. View is looking north towards McClain Ave. No culverts under sidewalks and driveways on east side of S. Tarver Ave. Provide positive drainage in ditch. Approx. 310 LF. Picture 2324.

Item 35 – S. Tarver Ave. and McClain Ave. Repair end of 22” x 12” CMP. Picture 2326.

Item 36 – 431 Martin Ave. Clear debris from 15” RCP. Picture 2331.

Item 37 – Martin Ave. and Cleveland Ave. Repair end of 26” x 20” ellip. CMP. Picture 2340.

Item 38 - Martin Ave. and Cleveland Ave. Clear debris from ends of 10” CMP. Picture 2342.

Item 39 – Cleveland Ave north of McClain Ave, looking north. Clear debris and sediment from driveway culverts and ditch. Approx. 400 LF Picture 2344.

Item 40 – Cleveland Ave. and McClain Ave. Clear debris and sediment from 14" x 9" ellip. CMP cross drain and repair damaged end section. Note crack in pavement. Picture 2346.

Item 41 – Drainage channel running east from Pennsylvania Ave at 227 Pennsylvania Ave. Clear debris, sediment and brush from approx 200 LF of manmade channel.

Looking east from Pennsylvania Ave. Picture 2347.

Looking west from behind 227 Pennsylvania Ave. Picture 2348.

Item 42 – Wagoner St. and Pennsylvania Ave. Clear debris from 15” x 10” ellip. CMP. Picture 2352.

Item 43 – Martin Ave. and Pennsylvania Ave. Clear debris and sediment from 23” x 12” CMP. Picture 2356.

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Item 44 – Martin Ave. from Pennsylvania Ave. to Cleveland Ave. Clear debris and sediment from roadside ditches and all driveway culverts. Approx. 340 LF each side of road.

Ditch & driveway culverts on the south side of Martin Ave. Looking east. Picture 2363.

Ditch & driveway culverts on the north side of Martin Ave. Looking east. Picture 2364.

Item 45 – W. Sunset Dr. from Pennsylvania Ave. to S. Tarver Ave.. Clean debris and sediment from roadside ditches and all driveway culverts. Approx. 860 LF each side of road.

Looking east towards S. Tarver Ave. Picture 2381.

Looking west towards Pennsylvania Ave. Picture 2383.

Item 46 - 511 W. Sunset Dr. Clear debris and sediment from 57” x 36” ellip. CMP. Picture 2380.

Item 47 – Pennsylvania and W. Sunset Dr. Improve ditch section at end of 18” CMP. Picture 2389.

Item 48 – Pennsylvania Ave from Leeville Pk. to Martin Ave. View is looking north from 410 Pennsylvania Ave. Clear debris and sediment from road side ditch and culverts on the west side of Pennsylvania Ave. Approx. 900 LF. Picture 2390.

Item 49 – E. Sunset Dr. at S. Tarver Lane, east bound lane. Clear debris and sediment, repair damaged end sections of 2 – 14" x 10" ellip. CMP's. Picture 2413.

Item 50 - E. Sunset Dr. at S. Tarver Lane, west bound lane. Clear debris and sediment, repair damaged end sections of 2 – 14" x 10" ellip. CMP's. Picture 2414.

Item 51 – S. Tarver Ave from E. Sunset Dr. to Leeville Pk. View is looking south from E. Sunset Dr. Repair end sections of all driveway culverts. Picture 2411.

Item 52 – Leeville Pk. and Cleveland St. Clear sediment from 15" RCP. Picture 2430.

Item 53 – W. Main St. to W. Sunset Dr. Clear debris, brush and sediment from approx. 3,410 LF of channel. Provide bank stabilization and erosion control measures where necessary.

Looking south. Picture 2274

Looking northeast towards W. Main St. Picture 2275.

Item 53 – Continued.

Looking northeast towards W. Main St. Picture 2276.

Looking southwest. Picture 2277.

Item 53 – Continued.

Looking north the rear of 502 W. Main St. Picture 2278. Bridge inlet is under building. Note bridge abutment footing on right side of photo.

Looking north from W. Spring St. Picture 2229.

Item 53 – Continued.

Looking south from W. Spring St. Picture 2231.

Looking north from 214 S. Tarver Ave. Picture 2281.

Item 53 – Continued.

Looking south from 214 S. Tarver Ave. Picture 2282.

Looking south from 224 S. Tarver Ave. Picture 2283.

Item 53 – Continued.

Looking south from 300 S. Tarver Ave. Picture 2289.

Looking south from 300 S. Tarver Ave. Picture 2294.

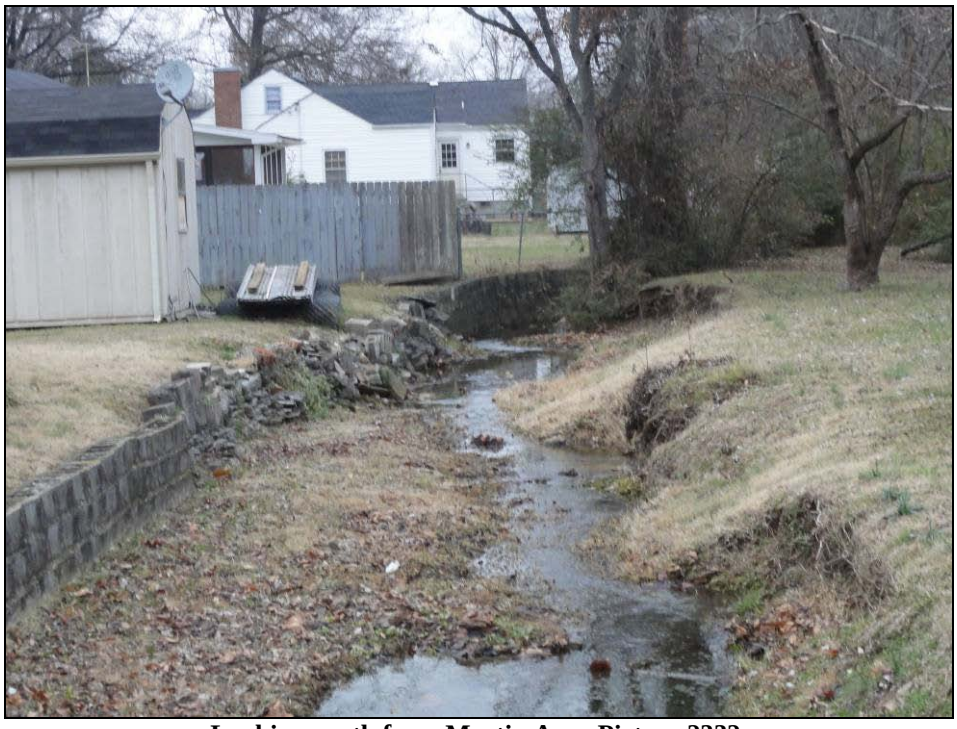
Item 53 – Continued.

Looking south from 302 S. Tarver Ave. Picture 2296.

Looking south from 431 Martin Ave. Picture 2297.

Item 53 – Continued.

Looking south from 431 Martin Ave. Picture 2298.



Looking north from Martin Ave. Picture 2332.

Item 53 – Continued.

Looking south from Martin Ave. Picture 2335.

South of Martin Ave. looking north. Picture 2372.

Item 53 – Continued.

View looking southeast. Picture 2374.

View looking south. Picture 2375.

Item 53 – Continued.

View looking northeast. Picture 2376.

View looking northeast. Picture 2377.

Item 53 – Continued.

Looking south towards W. Sunset Dr.. Picture 2379.

Looking north. Picture 2382.

Item 54 – Restore filled in detention pond at soccer fields to original design specifications. Remove fill material from concrete riser structure and grade to drain into ditch along property lines.

Looking south toward former detention pond. Picture 2252.

Looking east toward former detention pond and concrete riser structure that is filled in with dirt. Picture 2251.