

ENGINEERING REPORT

Richmond Hills Subdivision at Barnes Drive Drainage Improvements



PREPARED FOR:

City of Lebanon Engineering Department

PREPARED BY:

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Introduction

It has been reported that several homes on Barnes Drive suffered flood damages during the May 2010 flood. Storm water rose to a level that caused nuisance flooding in the 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 major/minor structural improvements and routine maintenance items were identified; and preliminary estimated project costs for each are included.

Field Review

The field review began just outside of the Churchill Downs subdivision. A small creek runs along the outskirts of the subdivision to where it intersects with another ditch and continues north. Downstream along the creek, drainage flows from an 18-inch reinforced concrete pipe (RCP) cross drain north of Vicksburg Lane, which drains into a ditch flowing along the property line on Lexington Drive and finally empties into the creek. Further downstream, water is also collected from an 18-inch corrugated metal pipe (CMP) cross drain, which flows into a ditch running along the property lines of Lexington Drive. As the creek crosses Letcher Avenue, it flows through two (2) 8-foot by 3-foot box culverts. Between Letcher and Arlington Drive, water is collected from a 16" CMP cross drain flowing into a ditch along the property line. As the creek crosses Arlington, it again flows through two (2) 8-foot by 3-foot box culverts. A ditch empties into the creek, draining from pipes along Arlington Drive just before the creek flows through the box culverts. Water is also collected from a 36" CMP cross drain at the corner of Arlington Drive and Barnes Drive and flows into a ditch that drains into the main creek. Further downstream, water empties into the creek on either side from a 12" CMP cross drain (west) and a 36" CMP cross drain (east), both of which discharge to small ditches that drain into the main creek. The creek also receives discharge on the east bank from an 18" CMP further downstream. On the west bank, water is collected from a ditch receiving flow from another 18" CMP cross drain. Approximately three (3) lots downstream along Petersburg Court drain to a 24" CMP cross drain beneath Lexington Drive that discharges into a ditch that drains into the main creek. The next road crossing on the main creek is at South Fork Drive through a double 10-foot by 4-foot box culvert, and the last road crossing in the study area is at Palmer Road through a 10-foot by 7-foot box culvert with two elliptical CMP overflow pipes.

Watershed Description

The watershed covers an area of approximately 604 acres (0.94 square miles), and extends from Palmer Road to the southeast approximately two miles. The upper portions of the watershed

extend beyond the City of Lebanon corporate limits. Three primary areas of interest were identified for this study:

- A potential location for regional detention between the end of Lexington Drive and Churchill Downs;
- The main creek channel behind the residential properties along Barnes Drive; and
- The main creek channel extending from the end of Barnes Drive to South Fork Drive.

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 watershed was determined from aerial photography and is primarily residential, with large areas of undeveloped open spaces in the upper reaches of the watershed. Hydrologic Soil Group data was obtained from the Natural Resource Conservation Service (NRCS). Runoff Curve Numbers within the watershed range from 74 to 82, which 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 415 acres (0.65 square miles) of residential and undeveloped area is collected in the main creek channel running parallel to Barnes Drive. The channel runs northwest, generally along the property boundaries between residential properties on Barnes Drive (to the west) and Lexington Drive (to the east). The runoff collected by the creek discharges to the previously mentioned double box culvert beneath South Fork Drive, which also collects runoff from an additional 115 acres of residential property.

A partial topographic survey of the area was conducted and is presented on Figure 3. During the technical analysis, it was determined that the main creek channel from Arlington Road to the end of Barnes Drive has insufficient capacity to carry the amount of storm water runoff draining to it. The channel depth varies from 2 feet to 3.5 feet, which is exceeded during the 2-year storm event, causing back yards of properties along Barnes Drive to experience flooding. During larger storm events, it is apparent that these homes experience damage to HVAC units and garages.

The recommendations are presented in two groups. The "Major Drainage Improvement Recommendations" are intended to mitigate flooding issues caused by the main creek during larger storm events. The "Minor Drainage Improvement Recommendations" are intended to



improve the minor, or local, drainage issues caused by the low areas and lack of positive drainage in the back yards. It should be understood that the minor drainage improvements will not necessarily mitigate issues caused by flooding of the main creek during larger storm events.

Major Drainage Improvement Recommendations

Several drainage improvement alternatives were considered for the mitigation of major flooding issues at Barnes Drive. Details of the items discussed below are shown on Figure 2.

Potential (Future) Regional Detention

During the initial phases of the project, a location for a potential detention area was identified between the end of Lexington Drive and Churchhill Downs (See Figure 1). A 4.2-acre detention basin, with a depth of 17 feet, was modeled to intercept flow from the upper reaches of the watershed. Such a detention basin would provide a reduction of almost 27% in the existing discharges at Barnes Drive. However, the detention basin alone would not be sufficient enough to solve all flooding issues at Barnes Drive.

A second potential detention area was identified on the south side of Arlington Road at Barnes Drive. A detention basin at this location would intercept storm water runoff from approximately 26 acres. Hydrologic analysis revealed that, due to the topography of the site, there would not be enough detention capacity to provide any significant reduction in the existing discharges along Barnes Drive.

Potential (Future) Channel Improvement

The approximate dimensions of the channel adjacent to Barnes Drive were obtained from the partial topographic survey provided by Couch Enterprises. Surveyed channel geometry was used to evaluate the potential for flood mitigation gained by channel improvement. The channel dimensions were input into a hydraulic model that uses a solution of the Manning's equation to estimate the normal depth of the channel section. Due to the long distance downstream to a culvert constriction at South Fork Drive, and due to the fairly steep slope of the channel beyond the cul-de-sac at Barnes Drive, it was determined that backwater effects are not the cause of flooding along Barnes Drive. Therefore, a normal depth solution was calculated for each channel section independently with no backwater effects from downstream areas considered.

The analysis shows that the existing 2-year flood elevation exceeds the elevation of the southern stream bank, and therefore flooding occurs along the properties on the south side of the creek (between 405 and 415 Barnes Drive) in less than a 2-year storm. To evaluate the benefits of channel improvements, it was assumed that the improved channel would have a 10-foot bottom width, sides slopes of 2:1 (two feet horizontal for every one foot vertical), and a minimum depth of 3.5 feet. It was determined that the existing 2-year discharges would be contained within the improved channel (i.e. no flooding) by constructing this trapezoidal section for a length of 1,150 feet along the creek. However, due to the low level of benefit versus the high cost of channel improvements, it is **not recommended** to perform the channel improvements unless the



detention pond is constructed upstream. With the future detention pond in place, the improved channel would contain the 5-year discharges without flooding properties along Barnes Drive. This potential detention basin is located on portions of two large, undeveloped tracts of land, and is partially outside of the current Lebanon City Limits. However, it is possible that when the landowner develops the tract in the future, the City may annex this area and negotiate with the owner to build a regional detention basin. Therefore, the detention basin and channel improvements are shown as “potential future improvements” on Figures 1 and 2.

Better reduction in flood levels are achieved with construction of the proposed detention basin, but this alternative causes significant additional expense. A description of the proposed structural alternatives and preliminary estimated project costs are shown below. The following costs include engineering/design fees and provision for 20% contingency:

Major (Future) Drainage Improvement Alternatives (See Figures 1 and 2)	Preliminary Estimated Project Cost
Grade 1,150 L.F. of main drainage channel to dimensions shown on Figure 2.	\$ 28,000.00
Construct 4.2-acre detention pond as shown on Figure 1.	\$ 200,000.00

Minor (Local) Drainage Improvement Recommendations

Channel Clean-out

During the field reconnaissance, it was noted that the channel from approximately the cul-de-sac of Barnes Drive northwestward to South Fork Drive was in need of maintenance. As shown on Figure 2, the channel contains numerous debris piles, sediment and rock deposits, and large diameter trees that are obstructing both normal and flood flows. As stated previously, backwater effects are not the sole cause of flooding along Barnes Drive. However, removing obstructions and cleaning sediment and debris from this reach of channel may yield a small improvement to the flooding depths upstream. In addition, many reaches of the channel banks are severely eroded between the end of Barnes Drive and South Fork Drive (see photographs on Figure 2). This is due in part to the large volumes of storm water runoff, but is also due to these obstructions causing turbulent conditions, which leads to stream bank erosion and scour.

In addition, an unauthorized wooden pedestrian bridge was found that causes a minor constriction during high flood flows (see photograph on Figure 2). This bridge should be removed at the expense of the property owner who installed it. While it is not a major contributor to flooding upstream, removing this manmade obstruction along with the other natural obstructions mentioned above may have small positive impacts to the upstream flooding situation along Barnes Drive.



Grading (Filling) of Low Areas between 405 and 415 Barnes Drive

Several of the properties along Barnes Drive have yards that are lower than the bank elevations of the main creek. This causes local runoff received from Barnes Drive to the west to pond around the houses and in the yards. The low areas and the lack of positive drainage also cause damage to HVAC units and garages during larger storm events.

Runoff from Barnes Drive discharges to a 12" corrugated metal pipe, which discharges into a shallow swale that runs between 413 and 415 Barnes Drive. The berm on the southern creek bank, which is approximately 2 feet higher than the back yard, forces the runoff to flow to the northeast after passing between the two houses. The topographic survey of the property shows that the patio and area around the southeast corner of the house at 413 Barnes Drive are low points, and the HVAC pad is only 3 inches higher. In other words, during minor rainfall events the patio is flooded and the HVAC pad is flooded if the water is more than 3 inches deep. As shown on Figure 3, the placement of fill material at least one foot deep in the back yards of 411 and 413 Barnes Drive, and deepening/widening of the current grass swale between 413 and 415 Barnes Drive will help mitigate the minor flooding issues.

Another grass swale is located between 407 and 409 Barnes Drive, where runoff from Barnes Drive discharges to an 18" corrugated metal pipe, which outlets between these two houses. This swale is recommended to be deepened/widened, and fill material about one foot deep should be placed in the back yards of these two houses.

Plastic area drains connected to plastic pipes (8" diameter HDPE) should be installed in several locations as shown on Figure 3 to drain areas that cannot be filled. It should be noted that full topographic survey of the area will be needed before finalize the grading plan. The complete topographic survey may expose other areas between/adjacent to certain homes that may not be able to be filled. Area drains and/or trench drains may need to be used in other areas not shown on Figure 3.

Channel cleanout limits are shown on Figure 2. A preliminary grading plan for the areas between 405 and 415 Barnes Drive is shown on Figure 3. An approximate cost estimate is provided below for Minor Drainage Improvements. The following costs include engineering/design fees and provision for 20% contingency:

Minor Drainage Improvement Alternatives (See Figures 2 and 3)	Preliminary Estimated Project Cost
Clear debris, sediment, trees and brush from approximately 1,900 L.F. of main drainage channel as shown on Figure 2.	\$ 12,700.00
Grade (fill) yards between 405 and 415 Barnes Drive as shown on Figure 3.	\$ 36,000.00



Routine Maintenance

In addition to drainage improvements 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 drain into the main creek behind Barnes Drive. 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 4. 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 4)	Preliminary Estimated Project Cost
1. Ditch grading at four locations (Items 4, 5, 8, and 9) – 750 L.F.	\$ 3,750.00
2. Debris/sediment removal from culvert ends at five locations (Items 1, 2, 3, 6, and 7)	\$ 2,500.00
Total Maintenance Cost	\$ 6,250.00

It should be noted that only a partial topographic field survey was completed for this study. Therefore, evaluation of the proposed improvements included in this study should be regarded as conceptual, and should be verified and finalized once a full topographic survey is completed, which will include property lines, utilities, etc.

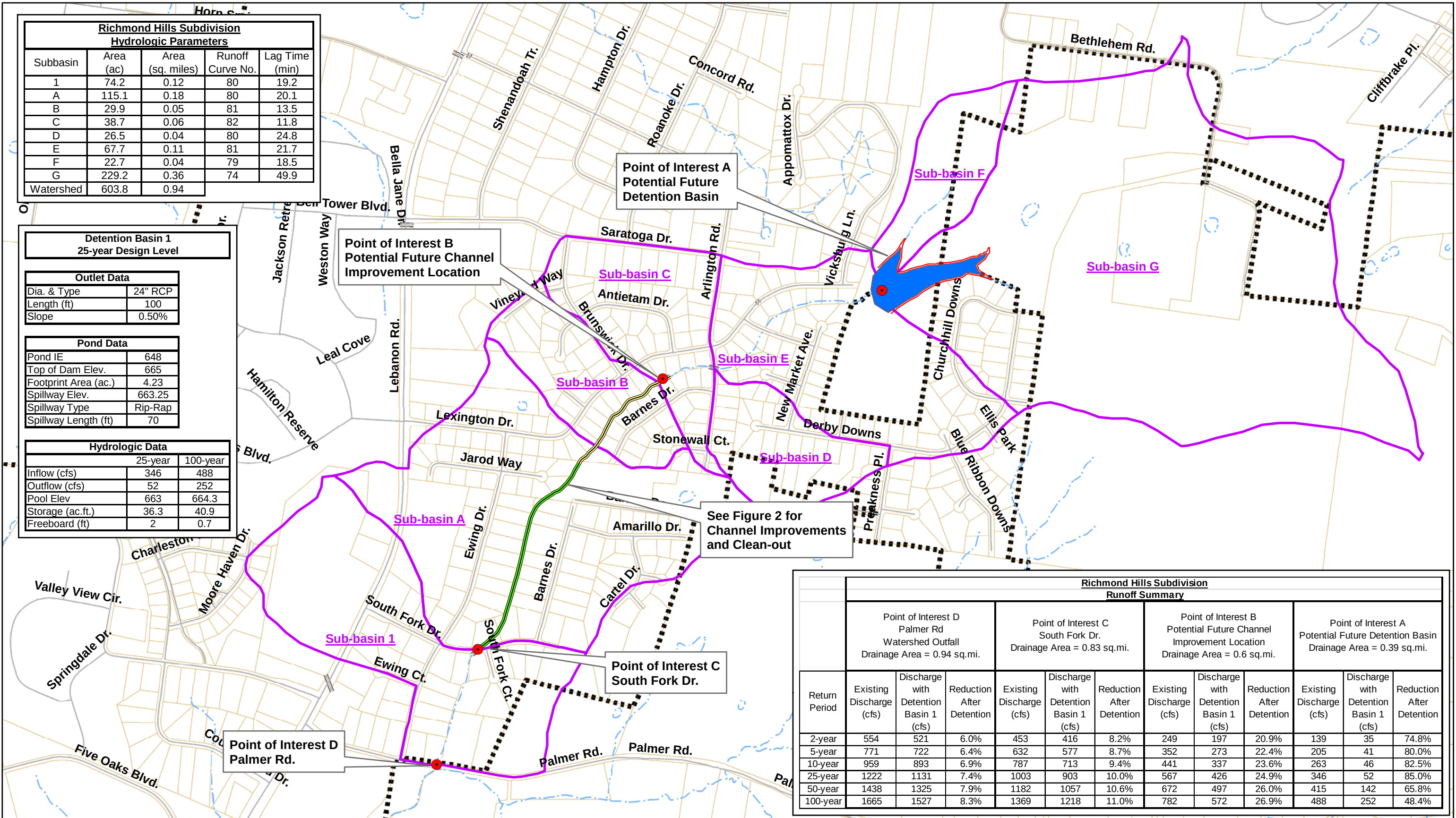
The above costs do not include property acquisition, which will be necessary for the future detention pond. It is estimated that the detention pond would require a drainage easement of approximately 5.0 acres. The proposed pond is situated on two large undeveloped tracts of land, owned by Bethlehem Road Farm Partners and Lynna Rhodes Jackman (see Figure 1). As stated previously, the detention basin location is partially outside of the current Lebanon City Limits. However, it is possible that when the landowner develops the tracts in the future, the City may annex this area and negotiate with the owner to build a regional detention basin.

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 4 can be performed by City crews immediately.



Richmond Hills Subdivision Hydrologic Parameters				
Subbasin	Area (ac)	Area (sq. miles)	Runoff Curve No.	Lag Time (min)
1	74.2	0.12	80	19.2
A	115.1	0.18	80	20.1
B	29.9	0.05	81	13.5
C	38.7	0.06	82	11.8
D	26.5	0.04	80	24.8
E	67.7	0.11	81	21.7
F	22.7	0.04	79	18.5
G	229.2	0.36	74	49.9
Watershed	603.8	0.94		

Detention Basin 1 25-year Design Level		
Outlet Data		
Dia. & Type	24" RCP	
Length (ft)	100	
Slope	0.50%	
Pond Data		
Pond IE	648	
Top of Dam Elev.	665	
Footprint Area (ac.)	4.23	
Spillway Elev.	663.25	
Spillway Type	Rip-Rap	
Spillway Length (ft)	70	
Hydrologic Data		
	25-year	100-year
Inflow (cfs)	346	488
Outflow (cfs)	52	252
Pool Elev	663	664.3
Storage (ac.ft.)	36.3	40.9
Freeboard (ft)	2	0.7



Richmond Hills Subdivision Runoff Summary												
Point of Interest D Palmer Rd Watershed Outfall Drainage Area = 0.94 sq.mi.			Point of Interest C South Fork Dr. Drainage Area = 0.83 sq.mi.			Point of Interest B Potential Future Channel Improvement Location Drainage Area = 0.6 sq.mi.			Point of Interest A Potential Future Detention Basin Drainage Area = 0.39 sq.mi.			
Return Period	Existing Discharge (cfs)	Discharge with Detention Basin 1 (cfs)	Reduction After Detention	Existing Discharge (cfs)	Discharge with Detention Basin 1 (cfs)	Reduction After Detention	Existing Discharge (cfs)	Discharge with Detention Basin 1 (cfs)	Reduction After Detention	Existing Discharge (cfs)	Discharge with Detention Basin 1 (cfs)	Reduction After Detention
2-year	554	521	6.0%	453	416	8.2%	249	197	20.9%	139	35	74.8%
5-year	771	722	6.4%	632	577	8.7%	352	273	22.4%	205	41	80.0%
10-year	959	893	6.9%	787	713	9.4%	441	337	23.6%	263	46	82.5%
25-year	1222	1131	7.4%	1003	903	10.0%	567	426	24.9%	346	52	85.0%
50-year	1438	1325	7.9%	1182	1057	10.6%	672	497	26.0%	415	142	65.8%
100-year	1665	1527	8.3%	1369	1218	11.0%	782	572	26.9%	488	252	48.4%

Legend

Potential Future Detention

Sub-basin Boundaries

Streams

Parcels

City Limits

Existing Culverts

Proposed Channel Improvements

Proposed Channel Clean-out

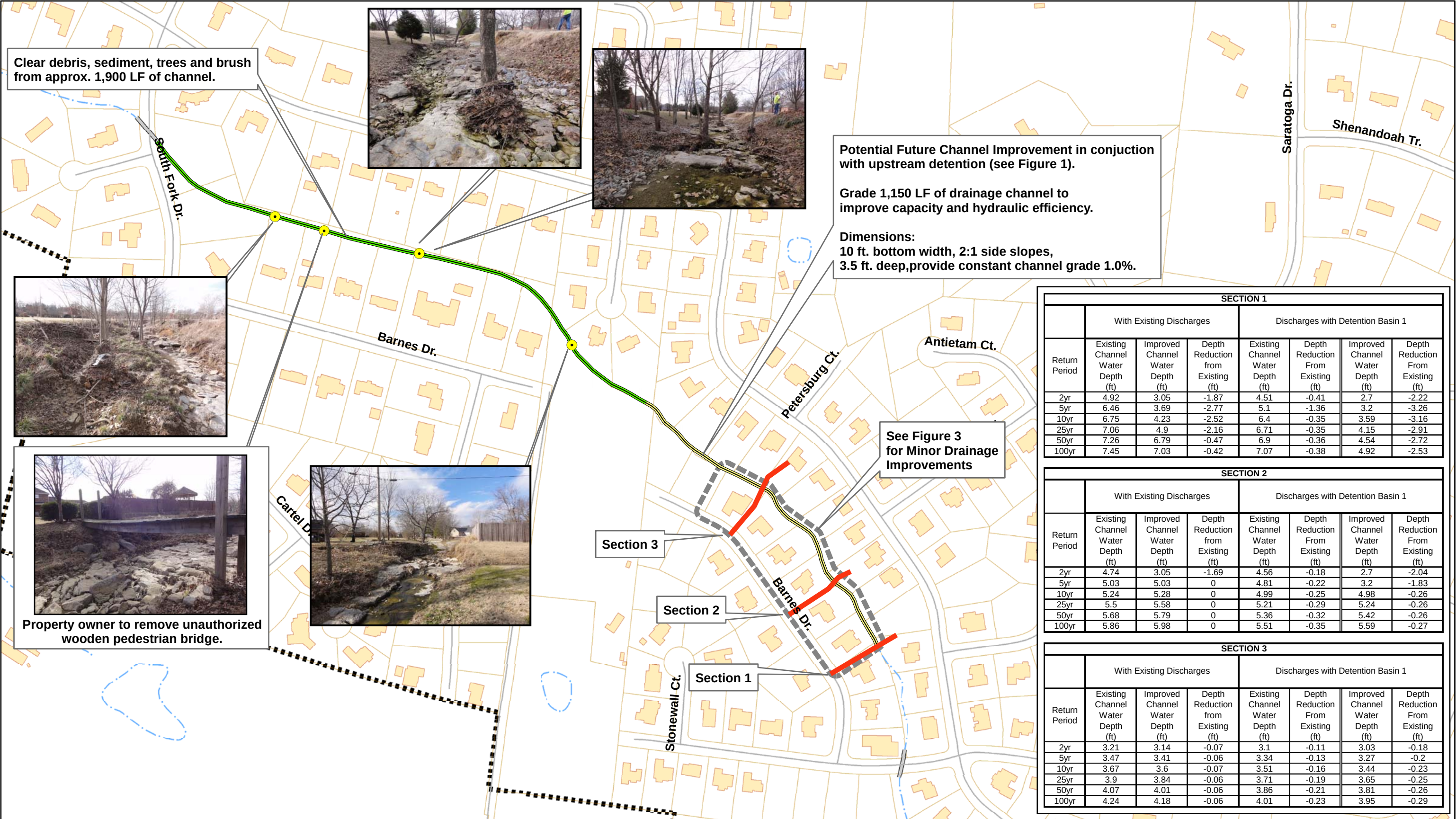
City of Lebanon Drainage Analysis
Richmond Hills Subdivision
Drainage Improvements

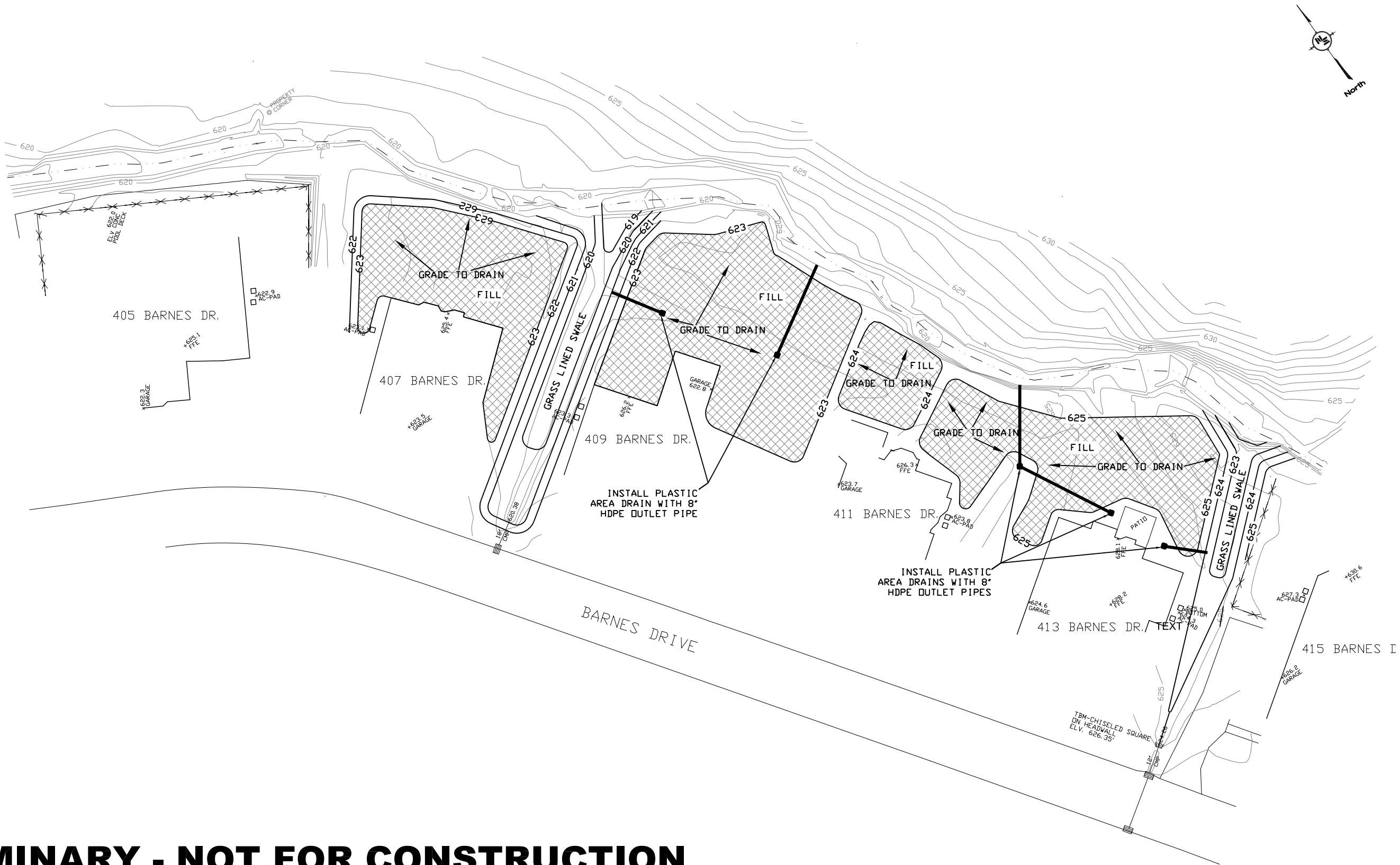
1 inch = 800 feet



Hydrology Results
and Potential Future
Detention Pond Location

Figure 1





PRELIMINARY - NOT FOR CONSTRUCTION

NOTICE TO DRAWING HOLDER				REVISIONS		DRAWING INFORMATION	
NEEL-SCHAFER, INC., HEREINAFTER REFERRED TO AS THE ENGINEER HAS PREPARED AND FURNISHED THIS DRAWING TO THE OWNER FOR USE ON THIS PROJECT ONLY. THIS DRAWING SHOULD NOT BE USED ON EXTENSIONS OF THIS PROJECT OR ON ANY OTHER PROJECT. ANY REUSE OF THIS DRAWING, WITHOUT WRITTEN VERIFICATION OR ADAPTATION BY THE ENGINEER, SHALL BE AT THE REUSER'S SOLE RISK AND THE REUSER SHALL INDEMNIFY AND HOLD HARMLESS THE ENGINEER FROM ALL CLAIMS, DAMAGES, LOSSES AND EXPENSES, INCLUDING ATTORNEY'S FEES ARISING OUT OF OR RESULTING THEREFROM.				NO.	DATE	BY	DESCRIPTION
				N-S PROJECT NO.: NS.08290.009		FILENAME: PRELIM_GRADING.DWG	
				SCALE: 1" = 50'		SURVEYED BY: COUCH ENTERPRISES	
				DSGN: MRP	DATE: 08/29/11		
				DRWN: RDT	DATE: 08/29/11		
				CHKD: MRP	DATE: 08/29/11		
				QA/QC: MRP	DATE: 08/29/11		

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LEBANON, TN 37087

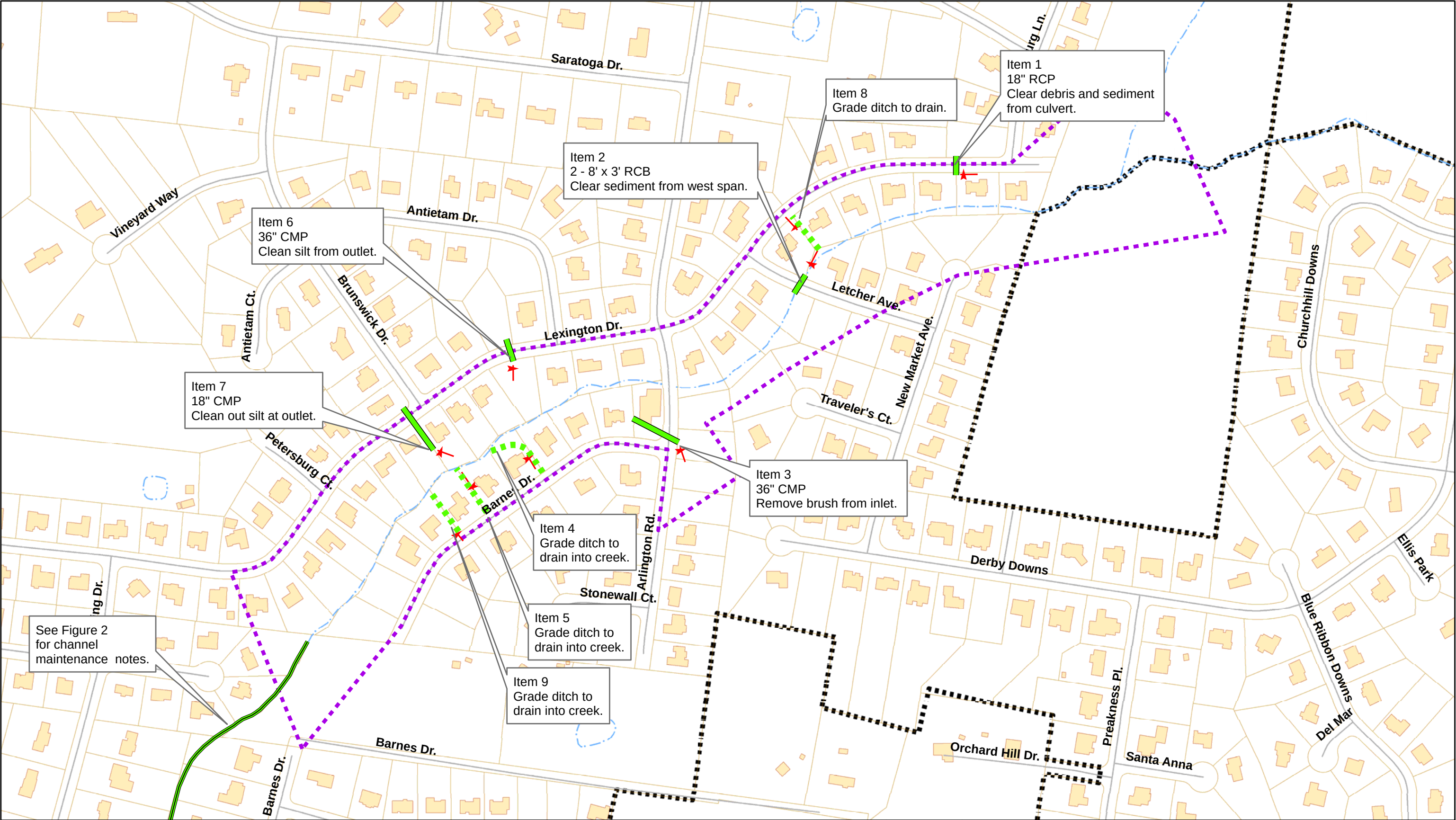


BARNES DRIVE AREA
PRELIMINARY GRADING PLAN

WORKING NUMBER:

DRAWING NUMBER:

FIGURE 3



APPENDIX A

Routine Maintenance Location Photographs



Item 1 - 18" RCP on Lexington Dr. north of Vicksburg Ln. Clear debris and sediment from 18" RCP culvert. Picture 2312.



Item 2 – Looking north at Letcher Ave. Clear sediment from west span of double 8' x 3' RCB. Picture 2318.



Item 3 - Arlington Rd. and Barnes Dr. Remove brush from inlet of 36" CMP. Picture 2333.



Item 4 - 413 Barnes Drive. Grade ditch to drain into creek. Note standing water. Looking downstream (east) from Barnes Dr. Picture 2350.



Item 5 – 409 Barnes Drive. Grade ditch to drain into creek. Looking upstream (west) toward Barnes Drive. Note standing water and debris. Picture 2352.



Item 6 - Lexington Dr. north of Antietam Dr. Clean silt from 36" CMP outlet. Picture 2368.



Item 7 - Lexington Dr. at Brunswick Dr. Clean out silt at outlet of 18" CMP. Picture 2370.



Item 8 – Looking west from Lexington Dr. cross drain (south of Letcher Ave). Grade ditch to drain into creek. Note standing water. Picture 2315.



Item 9 – 407/409 Barnes Dr.. Grade ditch to drain into creek. Picture 2356.