

Glen Echo Heights

from MacArthur Boulevard to Sangamore Road,
Walhonding Road to Westpath Way

Roadway and Drainage Study

MONTGOMERY COUNTY, MARYLAND



**Montgomery County
Department of Public Works and Transportation**



August 2007

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I. INTRODUCTION

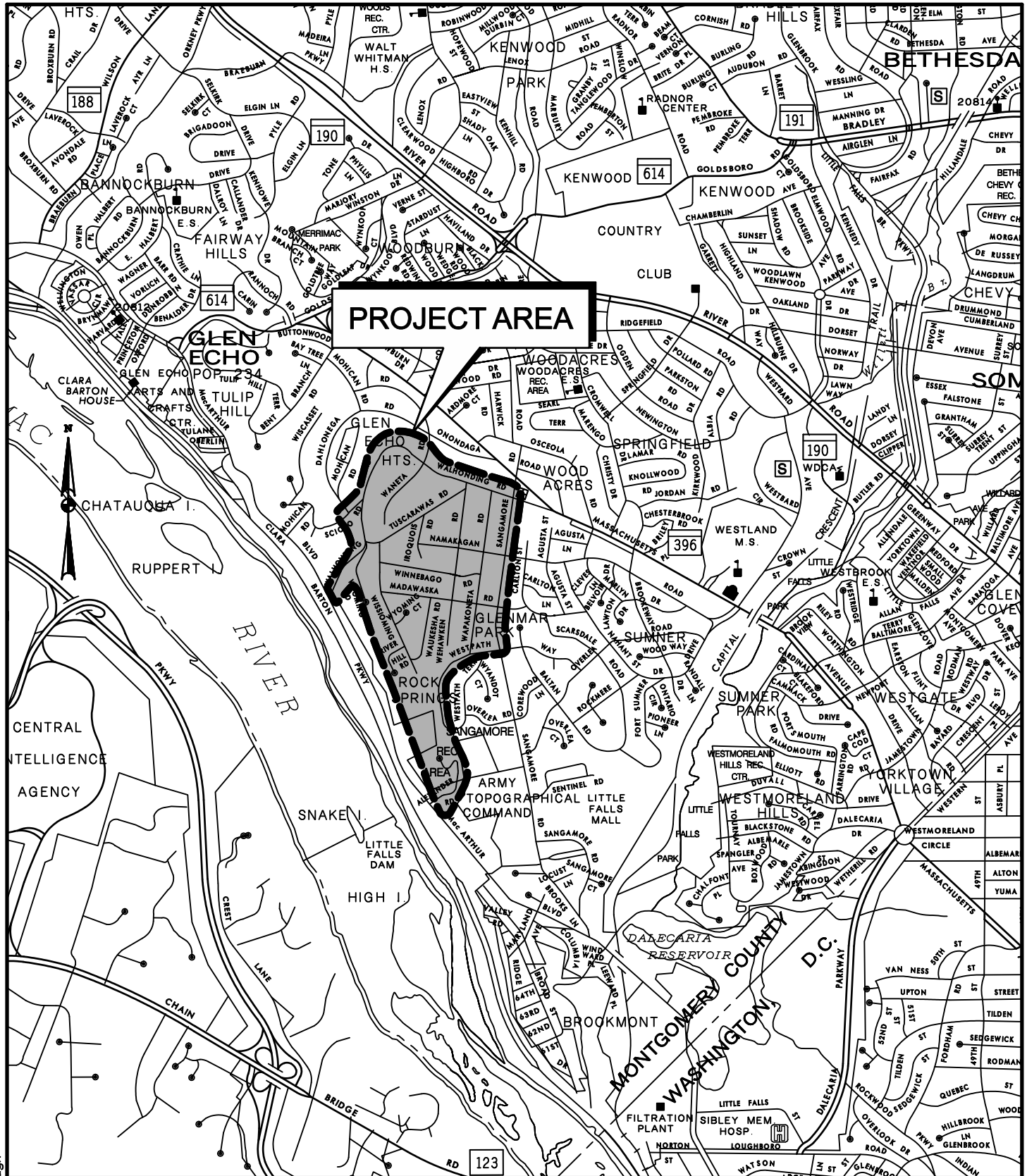
As requested by the Montgomery County Department of Public Works and Transportation (DPWT), we have evaluated the existing drainage facilities and various concerns of the Glen Echo Heights (G.E.H.) community. The community is located in southern Montgomery County, close to the northwest border with the District of Columbia (**see Figure 1**). This report presents the findings of our analysis of the G.E.H. area to determine the needs of the community in terms of upgrades to the existing storm drain system at various locations as well as general recommendations to the overall drainage and roadway system.

PURPOSE OF STUDY

The primary purpose of this study is to analyze the current drainage facilities in the Glen Echo Heights area of Montgomery County, MD. The study area (**see Figure 2**) includes the following roads:

- Alexander Road (Addresses on Macarthur Boulevard)
- Iroquois Road
- Madawaska Road
- Namakagan Road
- River Hill Road
- Tuscarawas Road
- Walhonding Road
- Waneta Road
- Wapakoneta Road
- Waukesha Road
- Wehawken Road
- Winnebago Road
- Wiscasset Road
- Wissioming Road
- Wyoming Court
- Wyoming Road

The size of the drainage area as defined by the referenced roads covers approximately 174 acres with three main outfall points. Multiple residents in this area have reported problems with excessive standing water and flooding of private property at various locations following storm events. This report represents the findings of the drainage study.



MONTGOMERY COUNTY
 DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION

GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY

LOCATION MAP

DATE	2000'	0	2000'	FIGURE NO.
AUGUST 2007				1
SCALE IN FEET				



MONTGOMERY COUNTY			
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION			
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY			
STUDY AREA			
DATE	500'	0	500'
AUGUST 2007	SCALE IN FEET		FIGURE NO.
			2

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

SCOPE

The study included the following:

1. Determination of the watershed areas using electronic topographic mapping.
2. Field investigation to verify limits of the watershed and subdrainage areas within the watershed; determine flow path characteristics; locate existing closed drainage systems and verify flow routes; and determine present land use. This effort was performed between December 4, 2006 through January 17, 2007 and also included discussions with residents of the community while performing our field investigation.
3. A review of the soil types within the watershed from the “Soil Survey of Montgomery County, MD.”
4. Preparation of input data for hydrologic analysis using the Rational Method for 1, 2, 5, 10, and 25 year storm events at critical areas.
5. Determination of required open or closed storm drain system capacity to alleviate problems either identified during the field investigation or commented by residents of the community.
6. Analysis of the potential Low Impact Development (LID) techniques that can be implemented to reduce storm runoff and improve water quality.

DESCRIPTION OF COMMUNITY

The Glen Echo Heights community is an established neighborhood located in southern Montgomery County, near the border with the District of Columbia. The predominant lot size is approximately ¼ acre, with 20-foot roadway widths. Many of the roadways are narrower, or used for on-street parking. The terrain within the community is rolling hills, sometimes steep, with very few flat areas. As a developed community, there are a lot of large trees providing cover, and established runoff drainage patterns. There are very few curbed streets, and no sidewalk within the community.

Many of the lots in the community have been, or will be in the future, redeveloped to contain much larger houses. This has contributed to a loss of some forest cover as trees have been removed for redevelopment. The result has been a steady increase in the volume of runoff from the same area. There is very little stormwater management treatment within this community, due to the age of the development. Additionally, runoff across private property has frequently been captured into closed or hardened drainage systems to convey the discharge across the property, leading to more concentrated peak runoff amounts. The majority of the development has been exempt from stormwater management regulations, therefore treatment of the increased runoff has not been provided.

II. COMMUNITY-WIDE ISSUES

The community of Glen Echo Heights is located adjacent to the Potomac River, Northwest of Washington D.C. The subdivision is located in an area of rolling hills with some steep hillsides. The terrain of the study area generally gets steeper (slopes greater than 10%) as one proceeds to the west across the study area (**see Figure 3**). We have identified three locations as the main drainage outfalls for Glen Echo Heights (**see Figure 4-1**). These outfall areas are located at or near the following addresses:

1. 6405 Walhonding Road – services a residential drainage area of approximately 145 acres
2. 5202 Wyoming Road – services a residential drainage area of approximately 9 acres
3. 5104 River Hill Road – services a residential drainage area of approximately 17 acres

Prior to this project, a community workshop was held by Montgomery County Department of Public Works and Transportation. Included was a survey used to determine resident opinion on the condition of the community in various aspects relating to roadways and drainage. Of 110 respondents:

- 72 mentioned pavement condition as a problem
- 59 mentioned drainage problems
- 28 were interested in adding curb and gutter to some or all streets in the community
- 24 were interested in adding some additional storm drain capacity
- 9 mentioned needs for more on-street parking
- 41 indicated a desire for more sidewalk installations.
- 24 indicated they would not like to see sidewalk constructed.
- 19 showed a desire to keep the character of the community as it is.

The roads mentioned most often for sidewalk treatments were Walhonding and Sangamore (Sangamore has since had sidewalk construction for a portion of its length). The drainage problems mentioned most often were instances of roadway drainage flowing onto private property in an uncontrolled manner.

During our field analysis of the study area, we found several community wide issues challenging Glen Echo Heights, of which, the main issues are as follows:

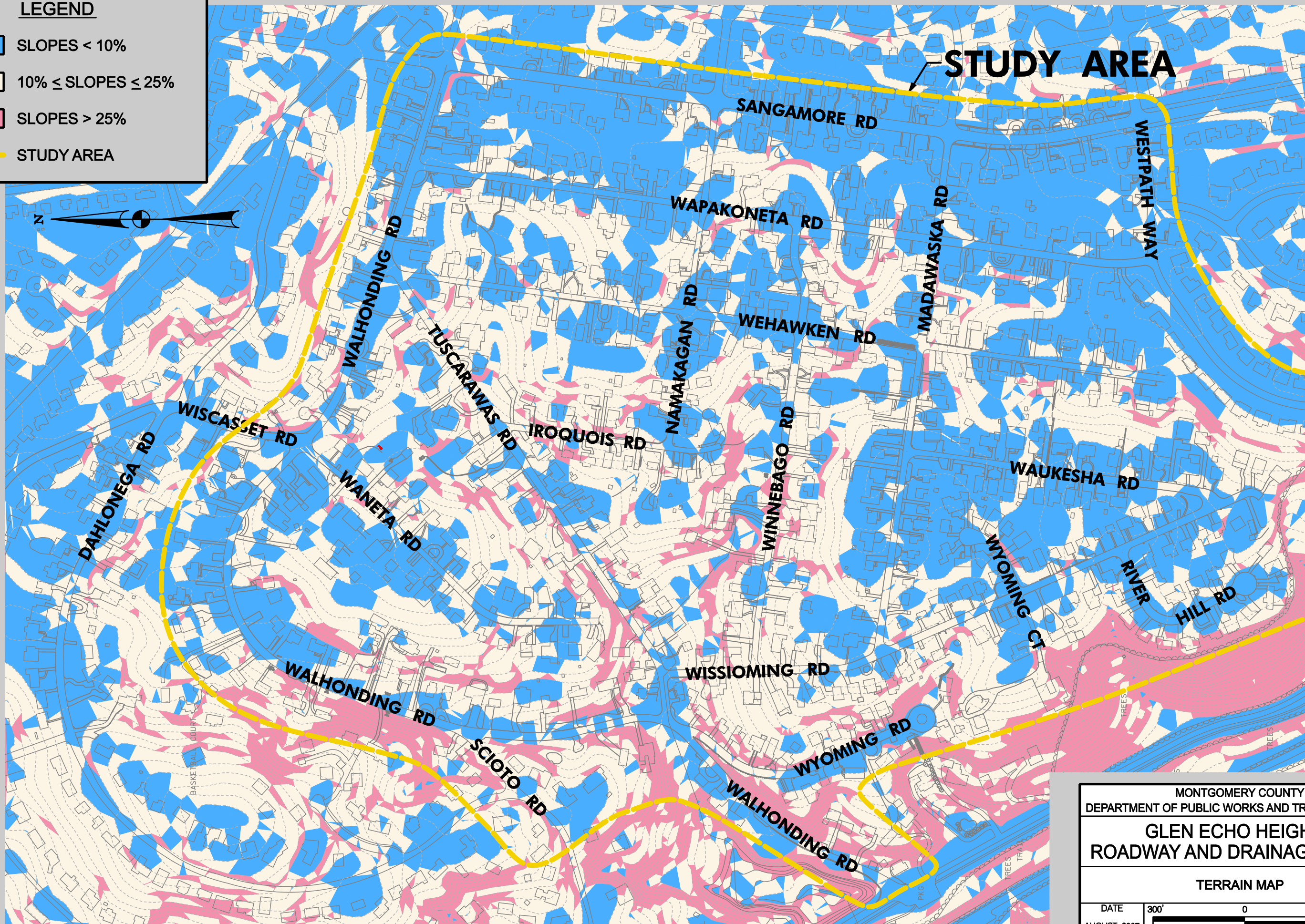
- Roadway and safety issues
- Lack of proper storm water conveyance
- Re-development of private properties

LEGEND

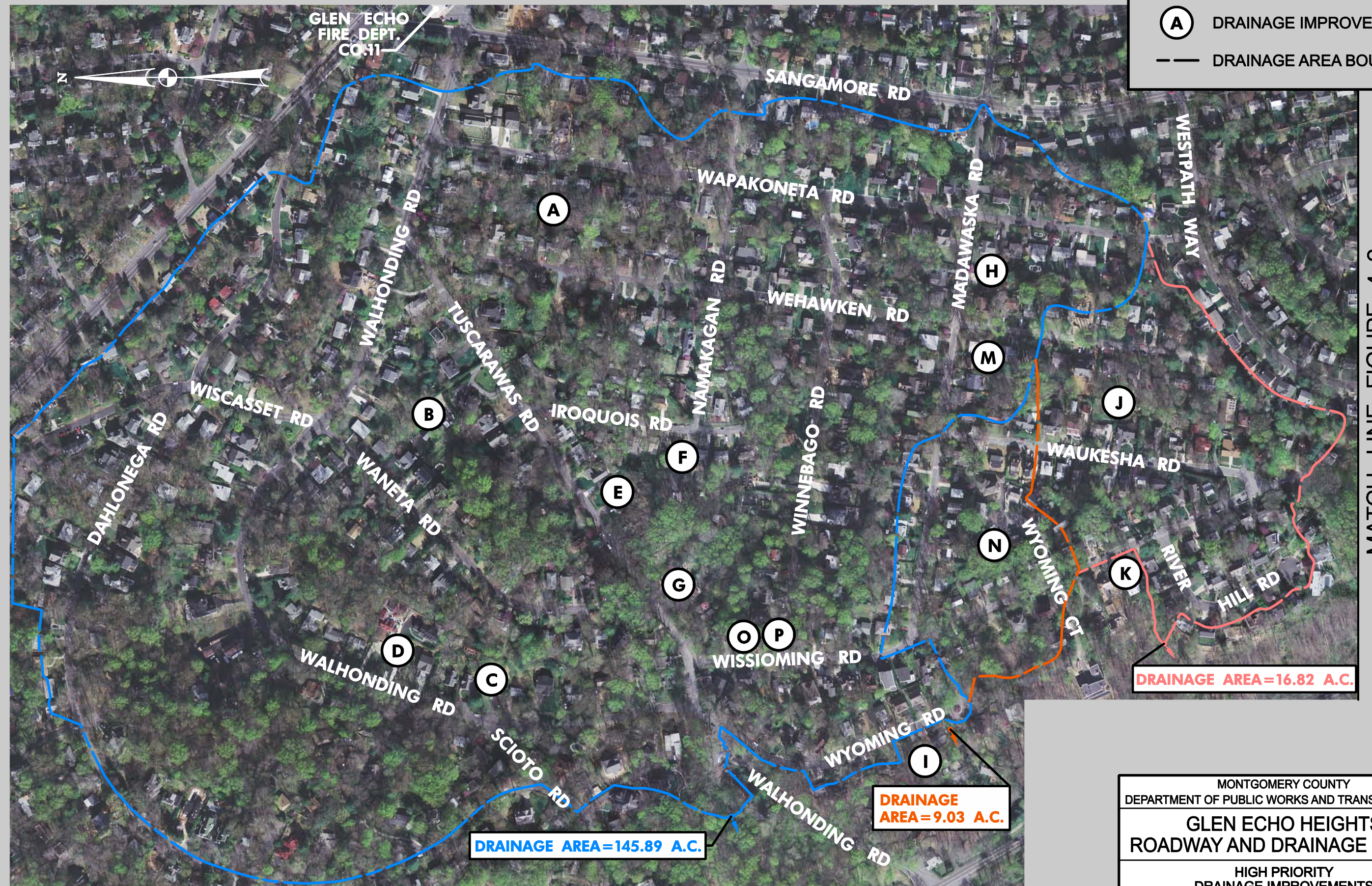
-  SLOPES < 10%
-  $10\% \leq \text{SLOPES} \leq 25\%$
-  SLOPES > 25%
-  STUDY AREA



STUDY AREA



MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION			
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY			
TERRAIN MAP			
DATE AUGUST 2007	300' 0 300' SCALE IN FEET	FIGURE NO. 3	



LEGEND

A DRAINAGE IMPROVEMENT
— DRAINAGE AREA BOUNDARY

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
HIGH PRIORITY DRAINAGE IMPROVEMENTS		
DATE AUGUST 2007	300' 0 300'  SCALE IN FEET	FIGURE NO. 4-1

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MATCH LINE FIGURE 4-1



LEGEND



DRAINAGE IMPROVEMENT

MONTGOMERY COUNTY			
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION			
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY			
HIGH PRIORITY DRAINAGE IMPROVEMENTS			
DATE	300'	0	300'
AUGUST 2007	SCALE IN FEET		FIGURE NO. 4-2

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

Our observations coincide closely with those reported by the community residents. The study area was primarily developed prior to any Stormwater Management (SWM) requirements for development, and therefore there are no SWM facilities for either quality or quantity control within the study area. The combination of the terrain of the study area and the current level of development would prove problematic in the implementation of traditional SWM practices moving into the future. Implementation of SWM measures would be difficult due to the steep slopes present within the community, and the developed areas would require the clearing of some remaining forested areas for SWM facilities. Additionally, the large total area and the higher than average amount of impervious development would require larger facility sizes and more numerous facilities to meet SWM goals. These facilities would also surely create utility impacts as well.

In order for any proposed SWM facilities to mitigate many of the community concerns with stormwater runoff, they must be placed in the upland areas of the community. Since this area is already fully developed, facilities will require acquisition of private property by the County, and the clearing of some properties, including the potential for residential displacements. Additionally, outfalls from these facilities will require construction of receiving systems to provide safe conveyance to downstream drainage facilities, which will require additional acquisition of private property for right-of-way and drainage easement.

ROADWAY AND SAFETY ISSUES

The existing road network within the Glen Echo Heights study area has over 5.15 miles of roadway that serves approximately 586 residences. The conditions of the roadways vary significantly within the study area from those that have been reconstructed to a closed roadway section with sidewalks (e.g. Sangamore Road, Westpath Way, and River Hill Road), to those which are as narrow as 14 FT with no pedestrian accommodations (portions of Wehawken and Wissioming Roads), and show signs of potential subgrade deterioration.

As part of this study, DPWT extracted 33 pavement cores from within the project area to determine the bound pavement thickness as well as to determine the presence of aggregate base subgrade. The following data was collected:

- Average bound pavement thickness – 5.5” (includes the thickness of concrete base where present)
- Minimum bound pavement thickness – 1.5” HMA on Madawaska Road
- Maximum bound pavement thickness – 9.9” (2.9” HMA with 7.0” PCC) near 5214 Wapakoneta Road
- Presence of aggregate base subgrade – 12 out of 33 cores

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

Montgomery County's minimum pavement thickness for primary, secondary and tertiary residential roads are as follows:

- Primary Residential Road
 - 3" HMA Surface Course
 - 5" HMA Base Course
 - Approved Subgrade
- Secondary and Tertiary Residential Roads
 - 3" HMA Surface Course
 - 3" HMA Base Course
 - Approved Subgrade

Based upon the existing pavement core samples, Montgomery County's recommended pavement thickness for primary, secondary and tertiary residential roadways, and our field observations, we recommend providing a nominal 2" HMA wedge/level course to correct existing roadway crown and surface irregularities and overlay with a 1.5" surface course along all roadways within the project limits with the exceptions noted below. These improvements would provide a minimum combined depth of 8" of HMA and PCC along primary roadways such as Walhonding Road and 6" along secondary and tertiary roadways as recommended in the County's latest Design Standards. No improvements are required along Sangamore Road, Westpath Way, and River Hill Road as well as portions of Waukesha, Wapakoneta, Wyoming, and Winnebago Roads other than minor roadway patching at select areas. Refer to Appendix P for more detailed information concerning pavement core data.

In addition to roadway overlays, we recommend providing curbs and gutter along both sides of Wapakoneta Road from 250' north of Westpath Way to Madawaska Road to complete the section of roadway that currently is without curb and gutters. Several residents also requested the addition of sidewalks within the community. In Glen Echo Height, there are a significant number of parking areas on the shoulders of the roadways that serve as additional residential parking areas. If sidewalks were constructed adjacent to these roadways, a significant area of available on-street parking would be displaced. Also, curbing would need to be installed along the edge of the roadway through the areas where the sidewalk would be provided, which would necessitate the need for additional drainage improvements. As a result of observed pedestrian traffic during the field study, we recommend that the addition of a mountable curb with a five foot sidewalk be considered along the North side of Walhonding Road. The new pedestrian facility would begin at the intersection of Walhonding and MacArthur Roads and extend the length of Walhonding Road until the intersection with Sangamore Road. Along this section of roadway, the existing drainage generally runs along the edge of the open section of the roadway, and there would be fewer residential impacts. The addition of the proposed sidewalk adjacent to Walhonding Road would connect the sidewalk along Sangamore Road with the existing Glen Echo Park trail located on the West side of MacArthur Boulevard. In addition, by providing a pedestrian facility along Walhonding Road, vehicular and pedestrian interaction would be reduced along one of the highest volume

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

roadways in the community which connects Massachusetts Avenue with MacArthur Boulevard (**see Figure 5**). Other thoroughfares within the community showed very little pedestrian traffic based on observed pedestrians during field studies. Therefore, in combination with the factors mentioned above, we feel that larger scale sidewalk installations are not warranted, and would change the character of the community significantly.

Another concern voiced by community residents is the inconsistent nature of street parking. Due to the variable nature of the roadways, primarily the width and adjacent grading, there are areas with adequate on-street parking available, and others where any vehicles parked along the road severely narrow the available throughway. Due to the desire of many residents to maintain the current ‘character’ of the community and the need for permanent right-of-way and additional stormwater treatment for any widening of the roadways or installation of curbing, providing additional on-street parking is not recommended.

STORM WATER CONVEYANCE

One of the main issues encountered during the analysis of the study area was the lack of drainage systems, either open or closed, for the Eastern half of Glen Echo Heights. Specifically, the following areas were found to be without a comprehensive drainage system:

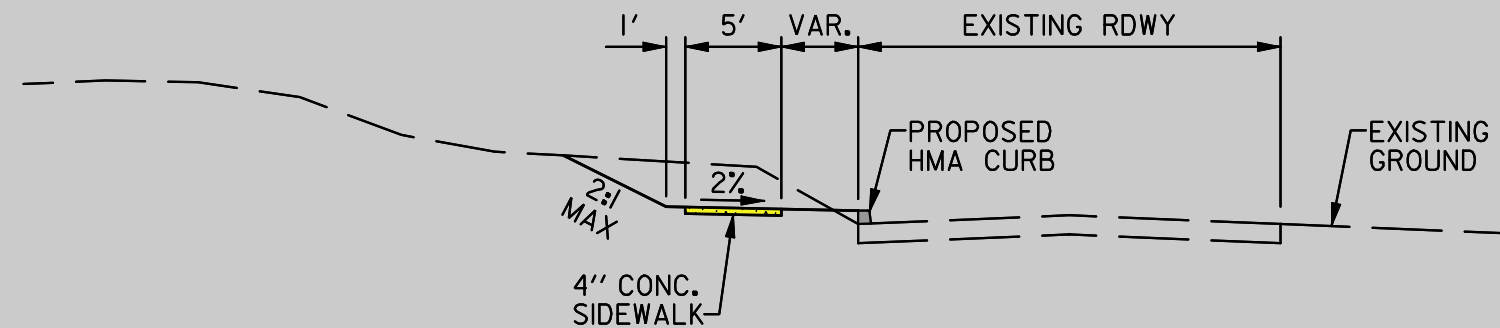
- Alexander Road
- Iroquois Road
- Madawaska Road
- Namakagan Road
- Wapakoneta Road
- Wehawken Road
- Wyoming Court
- Sections of Onondaga Road
- Sections of Walhonding Road
- Sections of Waneta Road
- Sections of Waukesha Road
- Sections of Winnebago Road
- Sections of Wiscasset Road
- Sections of Wissioming Road

Out of a total of 18 roads that comprise the study area, only 4 of the roads were found to have a comprehensive drainage system (open or closed).

Based on field investigations, it was discovered that several segments of a storm drain improvement project (Job number 69-054, 1969) were never built or were altered due to opposition from local residents (**see Figure 6**). The proposed drainage improvements as shown on the above referenced plans contained the following:

LEGEND

- PROPOSED CONC. SIDEWALK
- EXISTING SIDEWALK
- PROPOSED CROSSWALK



WALHONDING ROAD
PROPOSED SIDEWALK IMPROVEMENTS
TYPICAL SECTION

SCALE: 1" = 10'

MONTGOMERY COUNTY
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION

GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY

PROPOSED SIDEWALK IMPROVEMENTS
ALONG WALHONDING ROAD

DATE	200'	0	200'	FIGURE NO.
AUGUST 2007	SCALE IN FEET			5

LEGEND

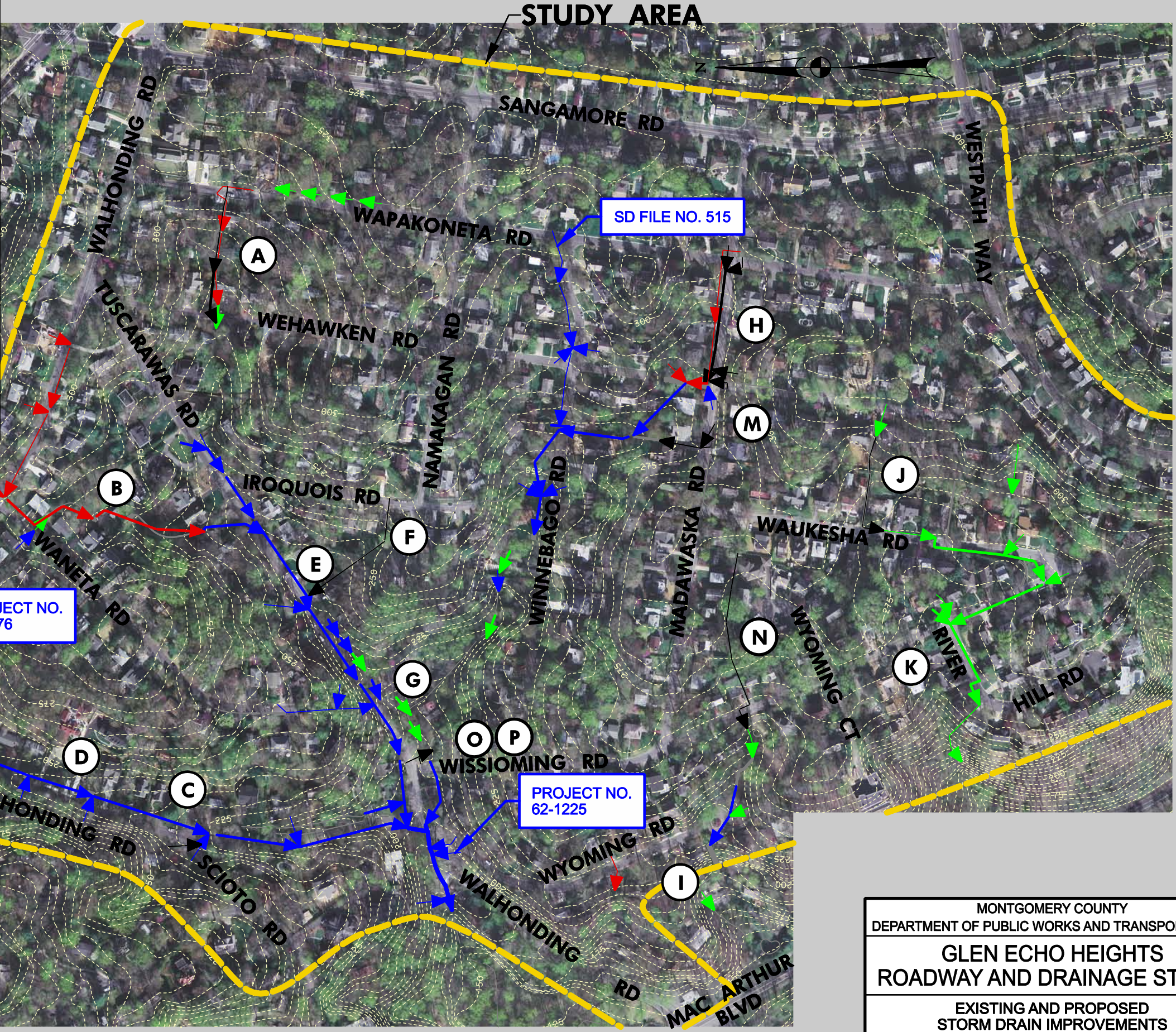
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DRAINAGE IMPROVEMENT
- EXISTING STORM DRAIN SYSTEM
NOT PART OF DESIGNATED
CONTRACTS
- EXISTING STORM DRAIN SYSTEM
CONSTRUCTED AS PART OF
DESIGNATED CONTRACTS
- PROPOSED STORM DRAIN SYSTEM
OMITTED FROM DESIGNATED
CONSTRUCTION CONTRACTS
- RECOMMENDED STORM DRAIN
SYSTEM IMPROVEMENTS
- STUDY AREA
- STORM DRAIN SIZES

DIAMETER < 24"

24" ≤ DIAMETER ≤ 48"

DIAMETER > 48"



NOTE:
EXISTING DRAINAGE IMPROVEMENTS
SHOWN AS  WERE
CONSTRUCTED UNDER CONTRACT
NO. 69-054 UNLESS OTHERWISE NOTED.

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
EXISTING AND PROPOSED STORM DRAIN IMPROVEMENTS		
DATE	300' 0 300'	FIGURE NO.
AUGUST 2007	SCALE IN FEET	6

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ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

- Madawaska Road – five inlets, two manholes and 520 FT of piping
- Onondaga Road – one inlet
- Wiscasset Road – three inlets, one manhole and 391 FT of piping
- Walhonding Road – five inlets and 541 FT of piping
- Waneta-Tuscarawas Road – six inlets, three manholes, and 798 FT of piping
- Wapakoneta-Wehawken Road – five inlets, two manholes, 453 FT of piping and one headwall

The following is a summary of the drainage improvements implemented from the drainage project 69-054:

- Madawaska Road – one inlet, 25 FT piping
 - Refer to Drainage Improvement H for additional proposed drainage improvements
- Waneta-Tuscarawas Road – with four inlets, 233 FT of piping, and 376 FT of ditches
 - Refer to Drainage Improvement B for additional proposed drainage improvements
- Wapakoneta-Wehawken Road – two asphalt flumes, 234 FT of swales, 257 FT of ditches, 20 FT of pipe and one headwall
 - Refer to Drainage Improvement A for additional proposed drainage improvements

DEVELOPMENT OF PRIVATE PROPERTY

During the hydrologic analysis of Glen Echo Heights, the contribution of storm runoff from rooftops, driveways and on-street parking pads was analyzed to determine the effect of redevelopment in the study area. Older homes are being replaced with larger houses with larger driveways on the same quarter acre lots. With the increase in the size of the houses, the increase in rooftop areas also increased. For example, on Walhonding Road, the main road connecting MacArthur Boulevard to Massachusetts Avenue, the total impervious area from the rooftops was calculated to be 3.83 acres. Further analysis of Walhonding Road showed that as a percentage of total impervious area, the County roadway only contributed approximately 29%, as compared to the rooftop area that contributed 42%(see **Chart 1**). For more information regarding the statistics used to create Chart 1, refer to Appendix A – Appendix E.

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

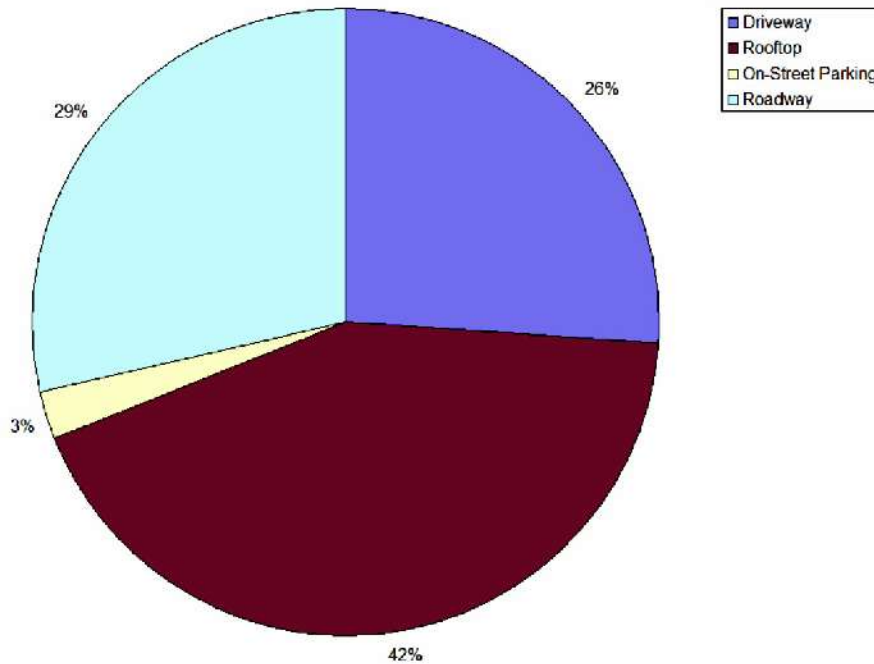


Chart 1 – Analysis of Impervious Area along Walhonding Road

As a check to insure that the analysis of the impervious area of Walhonding Road is representative of Glen Echo Heights, Tuscarawas Road was also analyzed. The analysis of Tuscarawas Road also showed that the roadway itself contributed only 30% to the total impervious area present on Tuscarawas Road (**see Chart 2**). For more information regarding the statistics used to create Chart 2, refer to Appendix F – Appendix J.

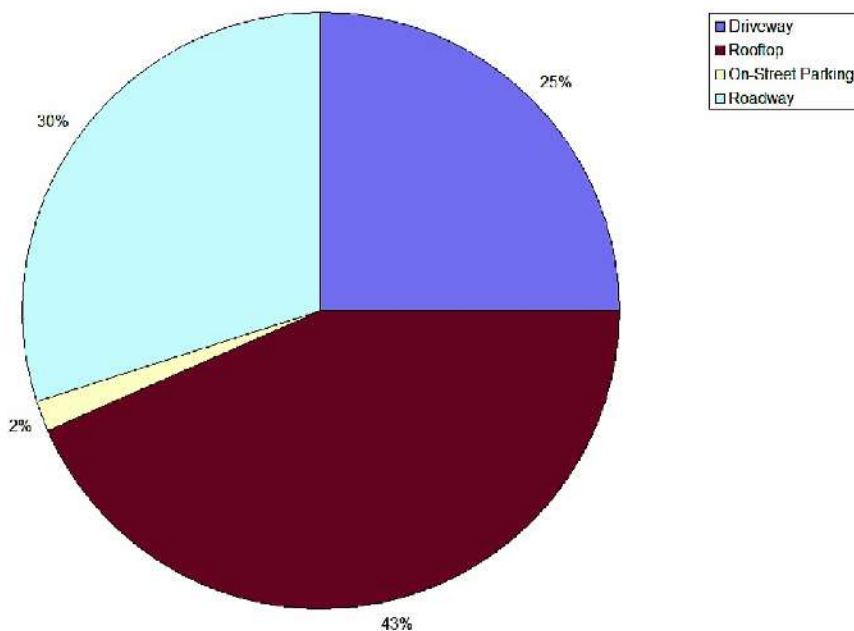


Chart 2 – Analysis of Impervious Area along Tuscarawas Road

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

The analysis of both Tuscarawas and Walhonding Roads showed that the largest amount of impervious area comes from rooftops. The combined rooftop area for both Walhonding and Tuscarawas is 229,141 SF or 5.26 acres. Also, an analysis of the total area of driveways on the private properties along both Walhonding and Tuscarawas Roads revealed that they represented almost as much impervious area as the roadways. It was calculated that the total area of the driveways that connect to both roads was 3.13 acres (Walhonding Road was 2.36 acres, Tuscarawas Road was 0.83 acres. In comparison, the total surface area of both roads is 3.56 acres (2.57 acres for Walhonding Road and 0.99 acres for Tuscarawas Road). More information can be found in Appendix A – Appendix J.

In another analysis, the total impervious area was computed, relative to the total area, for two of the most developed blocks within the community. The results of this study showed that the most developed blocks had an impervious coverage of 42% of total area. This is an increase from the standard value of 38% for ¼ acre lots and will represent a commensurate increase in the Runoff Curve Number (RCN) for the drainage area. It should be noted that if higher density redevelopment continues to occur in the Glen Echo Heights area, peak discharges from all storms will continue to increase, due to the higher impervious percentages.

III. LOCALIZED EXISTING DRAINAGE ISSUES

In response to Montgomery County's request for comments concerning the current condition of the roads and existing storm drainage system, the residents identified several areas that needed attention. In addition to these areas, several other drainage issues were identified during the field investigation that needs corrective measures. When the field investigation was completed, a list of the identified drainage issues was generated and divided into two categories; high priority and low priority drainage issues. The methodology used to distinguish between a low and high priority issue was whether the drainage problem was affecting more than one property, the potential impacts caused by the drainage issue, and the complexity of the problem.

In general, the overall drainage issues impacting the Glen Echo Heights community are not inadequate capacity of the existing storm drainage system, where it exists, but instead is the lack of proper storm water conveyance across private properties. The issues listed in this section deal primarily with those problem areas, and will not reduce the overall volume of runoff from the Glen Echo Heights area. These improvements will, instead, reduce the impact of surface runoff, or reduce the surface portion of the runoff itself, at critical locations noted by various community members or observed by the field study team. Since the types of improvements recommended will have very little effect on the time of concentration, there will be little to no increase in downstream runoff volumes due to these improvements. The outfalls of any proposed storm drain system would be stabilized to maintain the pre-construction runoff velocities to the greatest extent possible.

HIGH PRIORITY DRAINAGE IMPROVEMENTS

The locations of the proposed high priority improvements that were identified as part of this study are as follows (see **Figures 4-1 and 4-2**):

- A. 5409 Wehawken Road – 5332 Wapakoneta Road
- B. 5421 Waneta Road – 5332 Tuscarawas Road
- C. Intersection of Walhonding Road & Scioto Road
- D. 6305, 6241 & 6233 Walhonding Road
- E. 5317 Tuscarawas Road
- F. 5319 Tuscarawas Road
- G. 5311 & 5309 Tuscarawas Road
- H. Intersection of Wehawken Road & Madawaska Road
- I. 5202 Wyoming Road

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

- J. 5110 Wehawken Road
- K. 5104 River Hill Road
- L. 6691 Alexander Road
- M. 6115 Madawaska Road
- N. #4 & #5 Wyoming Court
- O. Intersection of Tuscarawas and Wissioming Road
- P. Intersection of Walhonding and Tuscarawas Road

We have placed each of the proposed high priority drainage improvements into the following table, and have identified whether it is a Capital Improvement Program (C.I.P.) project, or an Operations / Maintenance issue and whether the improvement will require additional right-of-way or easement to perform the proposed work.

Drainage Improvement	C.I.P. Project	Operations / Maintenance	Additional Right-of-Way Required?
A	X – New closed system	X – Culvert cleanout	Yes
B	X		Yes
C	X		No
D		X	No
E	X		No
F	X		Yes
G		X	Yes
H	X		No
I	X		Yes
J	X		Yes
K		X	No
L		X	Yes
M	X		Yes
N	X		Yes
O – P	X		Yes

DRAINAGE IMPROVEMENT A: 5409 WEHAWKEN ROAD – 5332
WAPAKONETA ROAD

Description of Problem



**Photo 1 – Drainage Ditch at 5409
Wehawken Road**

This drainage improvement consists of two problem areas. The first area is located at 5328 Wapakoneta Road. The issue at this location is the ponding of storm runoff in front of the asphalt flume located in the front yard of this property. In large rain events, the ponding water could create a driving hazard. Also, storm runoff from the opposite side of Wapakoneta Road is crossing the surface of the roadway, creating a safety concern for drivers. The second problem area is at 5409 Wehawken Road. The issue at this location is the surface runoff of water from Wapakoneta Road through the property at 5328 Wapakoneta. This water is carried in an asphalt swale to the backyard of 5332 Wapakoneta. The swale then ends in a dirt channel onto 5409 Wehawken Road and continues down very close to the house at 5409 Wehawken. Further downstream, the undersized and blocked 18" pipe under Wehawken Road

contributes to an undesirable ponding situation in the front yard of 5409 Wehawken Road. Additionally, the surface watercourse adjacent to 5409 Wehawken Road is within a few feet of the building, and has caused flooding and water damage to the structure (see **Plan A**).

Contributing Factors

While conducting the field investigation during a nominal rain event (approximately 1 – 2 inches of rain within a 24 hour period), ponding was observed in front of the property at 5328 Wapakoneta Road. Subsequent analysis of the area revealed two factors contributing to the drainage issue at this location. The first contributing factor is the lack of storm drainage structures on this segment of Wapakoneta Road. This segment of Wapakoneta Road begins at the intersection with Walhonding Road and ends at the intersection with Namakagan Road; approximately 950 ft of roadway without one storm drain structure. The second factor causing this drainage issue is the natural topography of the area in which the property at 5328 Wapakoneta is located at the natural low point for this segment of the road.

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

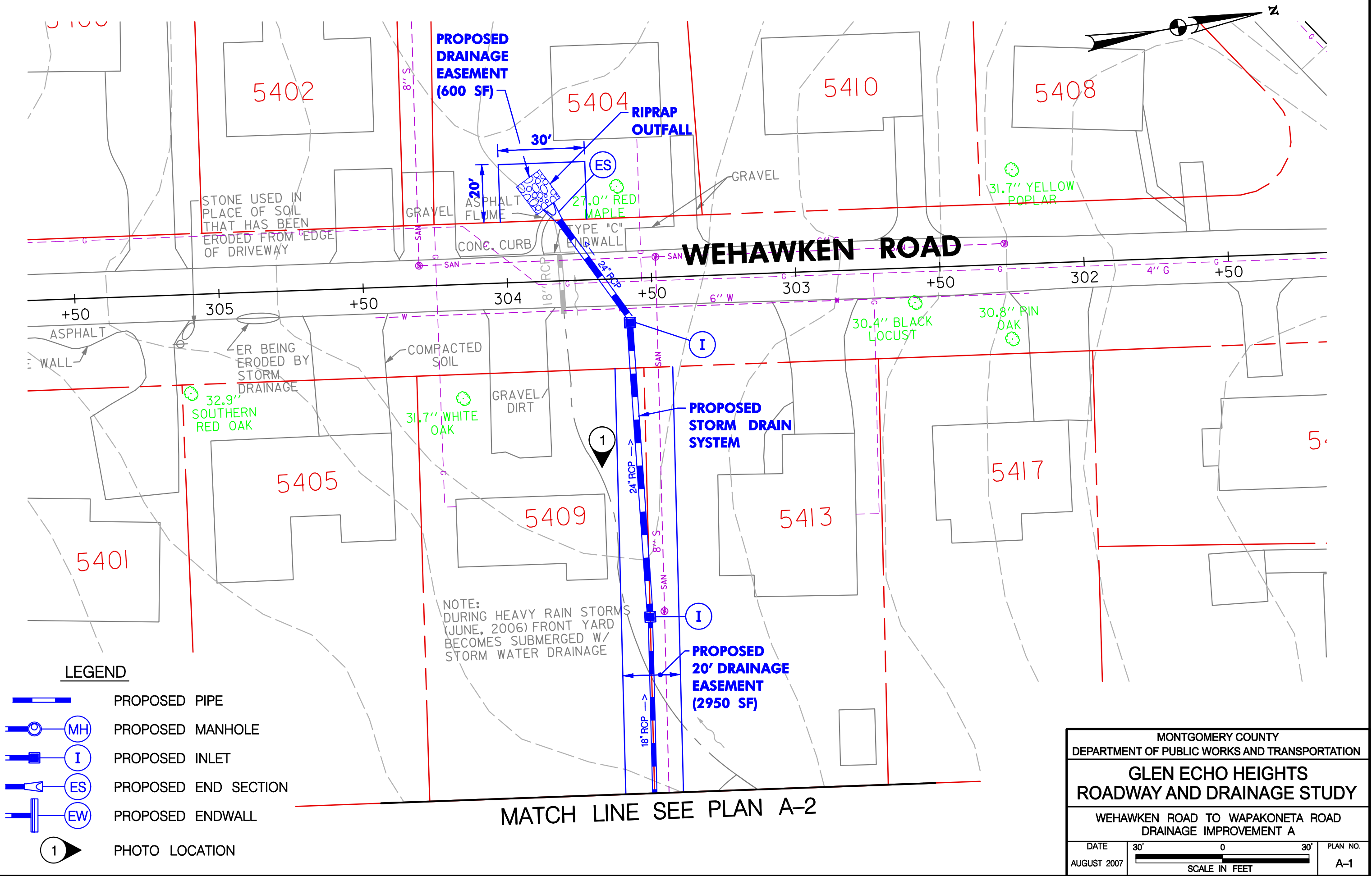
Two main factors were identified at the drainage problem at 5409 Wehawken Road. One of the factors is the clogging of the 18-inch reinforced concrete pipe (RCP) that allows the storm runoff to eventually drain into the existing SD system on Tuscarawas Road. An asphalt flume was installed near the outfall of the 18-inch cross culvert on Wehawken Road. Over time, storm runoff from Wehawken Road carried sediment, down the asphalt flume and deposited the sediment in front of the downstream end of the cross culvert, preventing it from draining the storm runoff from Wapakoneta Road. Due to the clogged cross culvert, the entire front yard of 5409 Wehawken Road becomes submerged during rain events. Another factor is the proximity of the drainage ditch in relation to the house at 5409 Wehawken Road. The drainage ditch that runs along the north side of the property is located only two to three feet away from the house. As shown in Photo 1, the property owner has attempted to reduce the impacts to their property by placing sand bags adjacent to the doorway and broken concrete slabs within the swale. The existing swale does not have adequate capacity given the size of the contributing drainage area.

Recommendations

Since the initial field investigation, the downstream end of the cross-culvert at 5409 Wehawken Road has been cleaned out, remedying the problem in the front yard of 5409 Wehawken. MCDPWT maintenance should continue to inspect this culvert and clean out as necessary.

The upstream drainage problem could be remedied through the construction of a closed drainage system beginning in front of 5319 Wapakoneta Road and outfalling near 5404 Wehawken Road. Two grate inlets would be installed on the low point of Wapakoneta Road and connected by an 18" RCP to two grate inlets placed between 5409 and 5413 Wehawken Road. A 24" RCP would connect the two grate inlets to a new cross culvert on Wehawken Road. In addition, the existing ditch at 5409 Wehawken Road should be regraded to provide more depth and increased offset from the existing home located on this property. This work would require right-of-way or easement for the entire length of the proposed pipe and may impact existing water and gas facilities along both Wehawken and Wapakoneta Roads as well as have potential Waters of U.S. impacts. For plan view, refer to Plans A-1 and A-2.

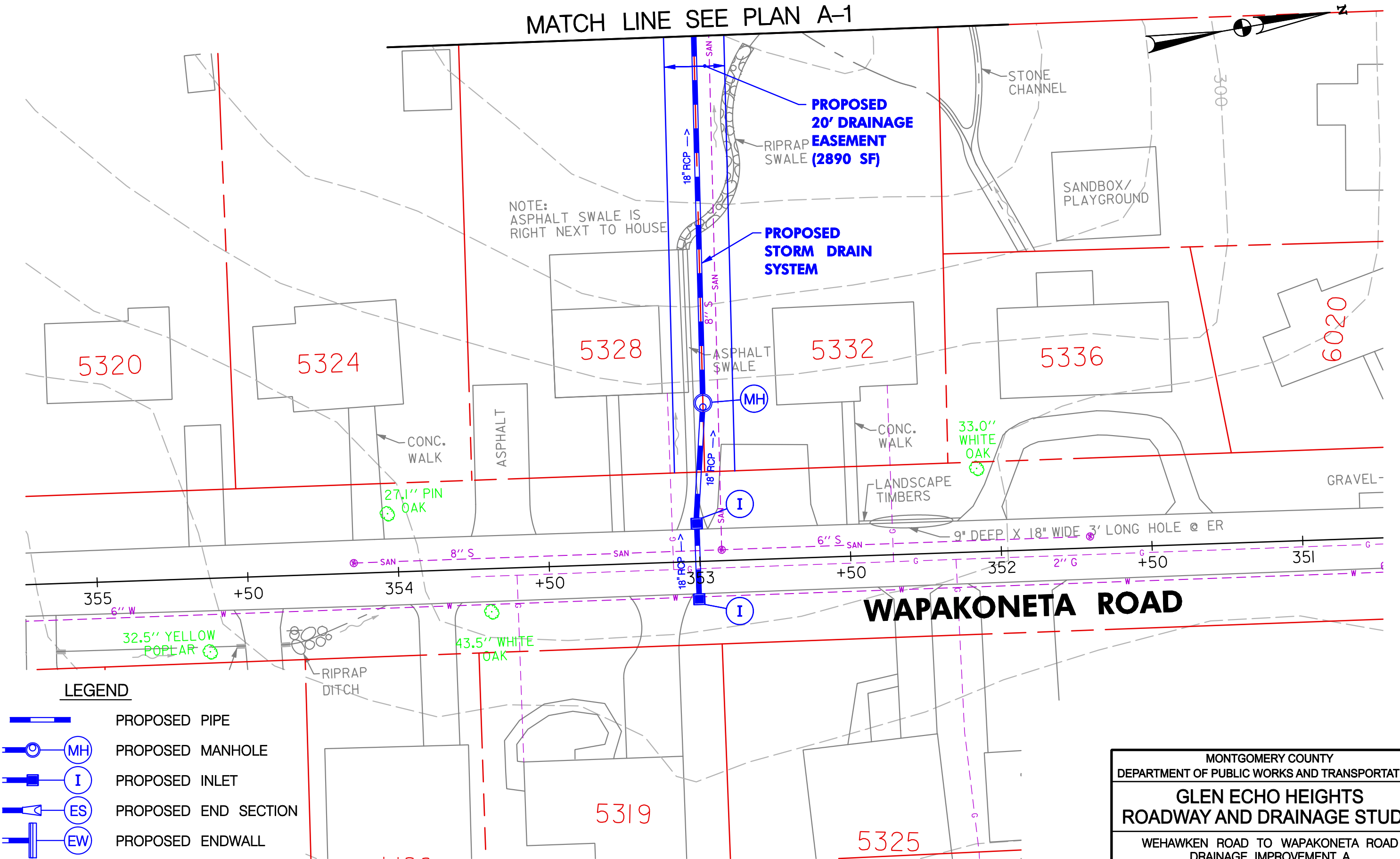
BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:51 AM
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MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WEHAWKEN ROAD TO WAPAKONETA ROAD DRAINAGE IMPROVEMENT A		
DATE AUGUST 2007	SCALE IN FEET 30' 0 30'	PLAN NO. A-1

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:52 AM
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MATCH LINE SEE PLAN A-1



LEGEND

-  PROPOSED PIPE
-  PROPOSED MANHOLE
-  PROPOSED INLET
-  PROPOSED END SECTION
-  PROPOSED ENDWALL
-  PHOTO LOCATION

MONTGOMERY COUNTY		
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WEHAWKEN ROAD TO WAPAKONETA ROAD DRAINAGE IMPROVEMENT A		
DATE	30' 0 30'	PLAN NO.
AUGUST 2007	SCALE IN FEET	A-2

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

DRAINAGE IMPROVEMENT B: 5421 WANETA ROAD – 5400 TUSCARAWAS ROAD

Description of Problem



**Photo 2 – Concrete and Stone Ditch at
5400 Tuscarawas Road**

A closed drainage system that was planned by MCDPWT but never implemented would have connected Waneta and Tuscarawas Roads. Due to homeowner opposition at the time, the improvements were limited to a cross culvert at Waneta Road. Runoff discharges into the backyard of 6114 Walhonding Road and drains to the low point of the backyard of 5417 Waneta Road. The storm runoff flows into a small yard inlet and is carried by 6" plastic pipe to the back property line of 5417 Waneta Road where it is discharged into a surface ditch. This concrete and stone ditch carries the runoff to an inlet adjacent to 5400 Tuscarawas Road. The outfall behind 5421 Waneta Road is silted in and the ditch at the rear of 5400 and 5402 Tuscarawas Roads shows signs of erosion. In addition, the yard inlet and outlet pipe are not adequately sized for the volume of water that reaches the area.

Contributing Factors

Several factors were identified that contribute to this drainage problem. In 1970, Montgomery County DPWT proposed building a closed drainage system on Waneta, Walhonding, Wiscasset, Onondaga, and Tuscarawas Roads. This system would have captured runoff at the low point at 5421 Waneta Road and conveyed it to Tuscarawas Road within the closed system. Due to homeowner opposition, the scale of this project was significantly reduced. The resulting system discharges water in the side yard of 5421 Waneta Road to drain through the back yards of 6114 Walhonding, 5417 and 5407 Waneta, and 5402 and 5400 Tuscarawas Roads.

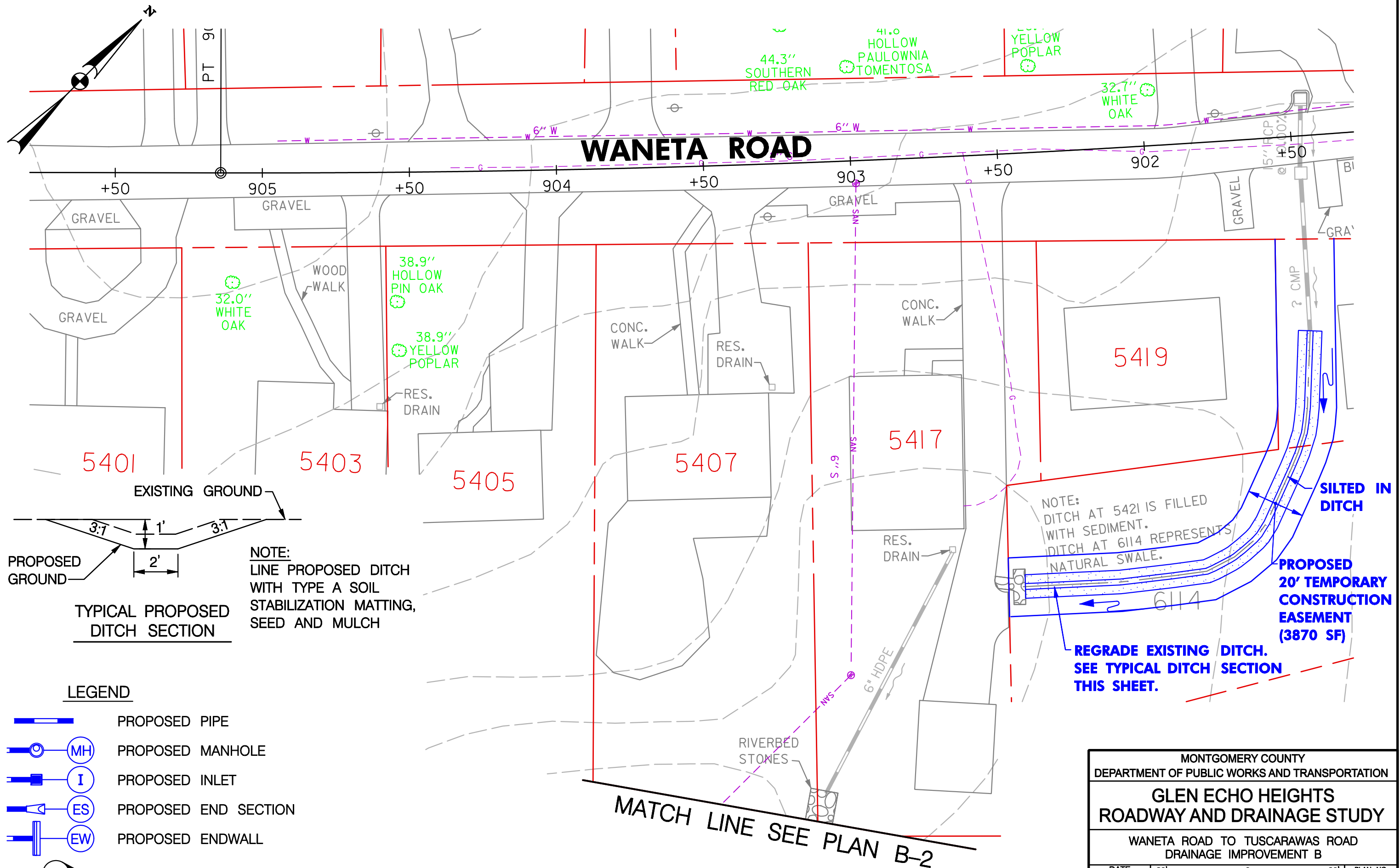
Calculations showed that a 25 year storm would generate a flow rate of approximately 19 cfs that the current drainage system would have to manage. As shown in Photo 2, the storm runoff is beginning to erode the ground surrounding the existing ditch.

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

Recommendations

The recommendations for this area may be dependent upon the coordination with the multiple residents affected by this drainage improvement. The minimum remediation would include the reconstruction of the two open channels. Additional work could include extending the closed system from Tuscarawas Road to Waneta Road. All work on this drainage improvement would require Right-of-Way or easement from the affected properties. For plan view, refer Plans B-1 and B-2.

BY: daw
PLOTTED: Wednesday, August 08, 2007 AT 09:59 AM
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MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WANETA ROAD TO TUSCARAWAS ROAD DRAINAGE IMPROVEMENT B		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. B-1

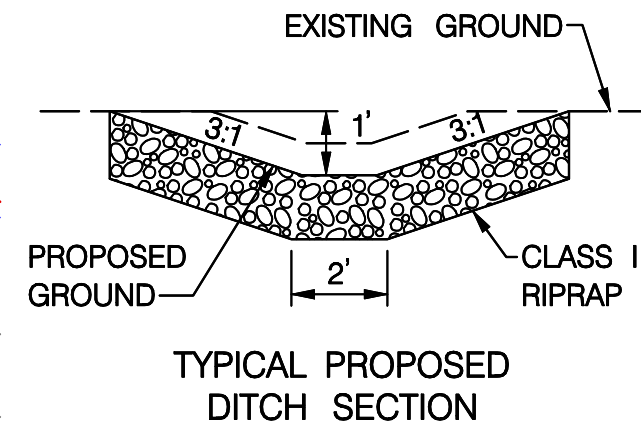
BY: daw
PLOTTED: Wednesday, August 08, 2007 AT 10:07 AM
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MATCH LINE SEE PLAN E

LEGEND

- PROPOSED PIPE
- PROPOSED MANHOLE (MH)
- PROPOSED INLET (I)
- PROPOSED END SECTION (ES)
- PROPOSED ENDWALL (EW)
- PHOTO LOCATION

MATCH LINE SEE PLAN B-1



REMOVE EXISTING CONCRETE /
STONE DITCH AND REGRADE
EXISTING DITCH. SEE TYPICAL
DITCH SECTION THIS SHEET.

PROPOSED
20' DRAINAGE
EASEMENT
(4965 SF)

PROPOSED
20' TEMPORARY
CONSTRUCTION
EASEMENT
(1440 SF)

TUSCARAWAS ROAD

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WANETA ROAD TO TUSCARAWAS ROAD DRAINAGE IMPROVEMENT B		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. B-2

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

DRAINAGE IMPROVEMENT C: INTERSECTION OF WALHONDING AND SCIOTO ROADS

Description of Problem



Photo 3 – Intersection of Walhonding and Scioto Roads

The drainage issue at the intersection of Walhonding Road and Scioto Road is ponding at the intersection. Scioto Road approaches Walhonding Road on a steep downgrade, while Walhonding is relatively flat through the intersection area. Runoff flows from north to south across the intersection, to an inlet on the southwest corner. The areas of ponding water at the intersection freeze in the winter, making it difficult to travel on Scioto Road. The northwest corner of the intersection also serves as a school

bus stop.

Contributing Factors

There are two main factors contributing the drainage issue at this intersection. The first contributing factor is a sump area in the northwest corner of the intersection where the runoff from Scioto and Walhonding Roads ponds until it crosses the intersection. Another factor contributing to the ponding of water at Walhonding and Scioto Roads is that the three grate inlets located upstream of the intersection with Scioto Road are covered by topsoil (See Drainage Improvement D). The storm water runoff bypasses these inlets and continues to flow along the west edge of Walhonding Road draining to the intersection with Scioto Road instead of draining into the SD system. The distance between the intersection to the nearest functioning upstream inlet on Walhonding Road is approximately 850 feet.

Recommendations

We recommend the following measures to improve drainage at this intersection:

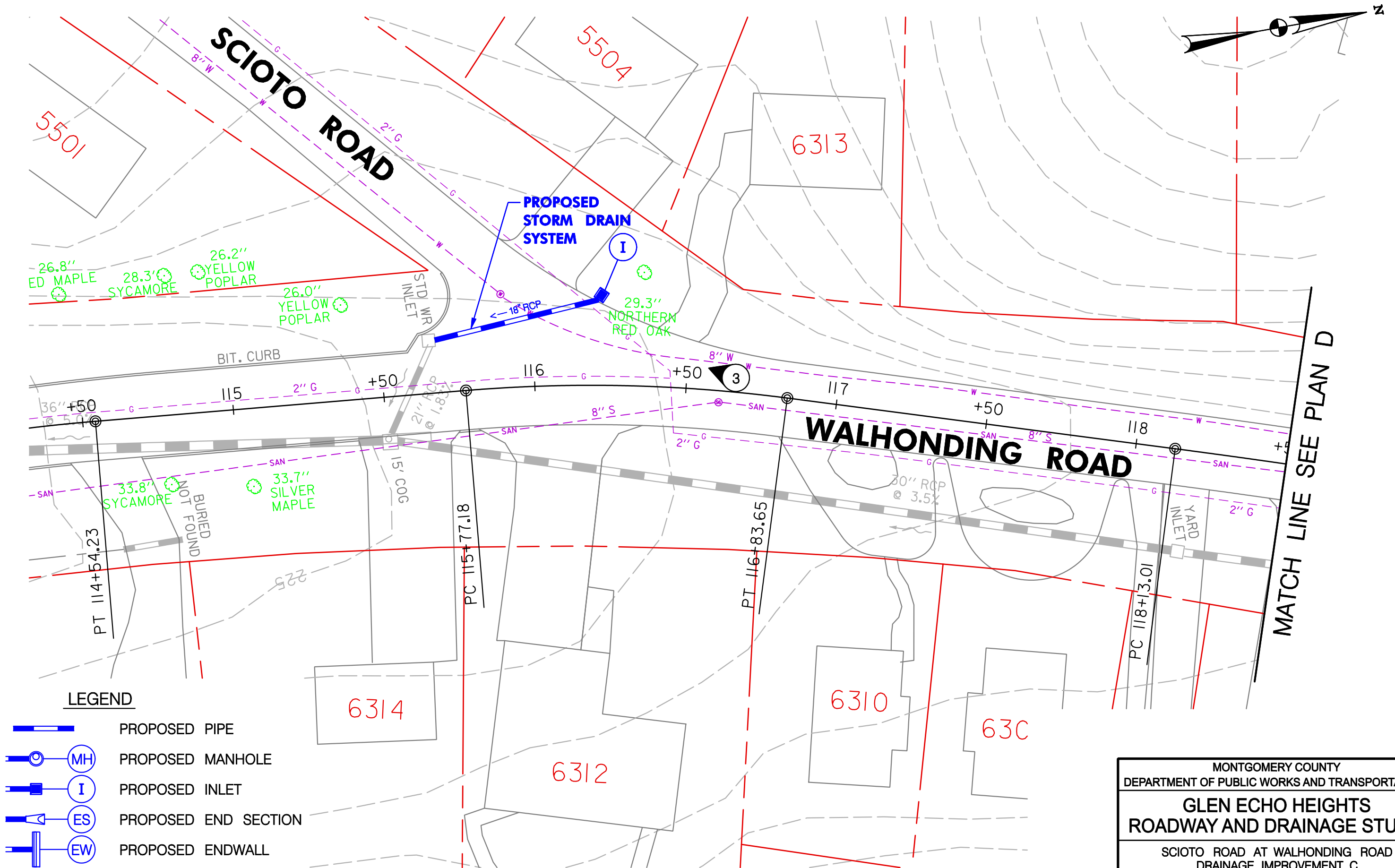
1. Clean out the existing inlet at the southwest corner of the intersection.
2. Construct a new pipe and inlet to the northwest corner of the intersection to intercept runoff before it flows across the surface to the southwest corner.

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

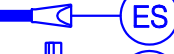
3. Resurface Scioto and the intersection area of Scioto and Walhonding Roads to provide a more defined crown to the road that would better confine the runoff to the roadsides where it can be collected in the inlets more efficiently.
4. Perform work recommended in Drainage Improvement D

This work can all be done within existing right-of-way, but may impact existing water and gas facilities on Scioto Road. For plan view, refer to Plan C.

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:53 AM
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LEGEND

-  PROPOSED PIPE
-  PROPOSED MANHOLE
-  PROPOSED INLET
-  PROPOSED END SECTION
-  PROPOSED ENDWALL
-  PHOTO LOCATION

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
SCIOTO ROAD AT WALHONDING ROAD DRAINAGE IMPROVEMENT C		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. C

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

DRAINAGE IMPROVEMENT D: 6305, 6241 and 6233 WALHONDING ROAD.

Description of Problem

The grate inlets near each of these properties was found to be buried underneath several inches of topsoil, with the exception of the inlet at 6241 Walhonding Road, which the survey crew could not locate.

Contributing Factors



Photo 4- Covered Inlet along Walhonding Road

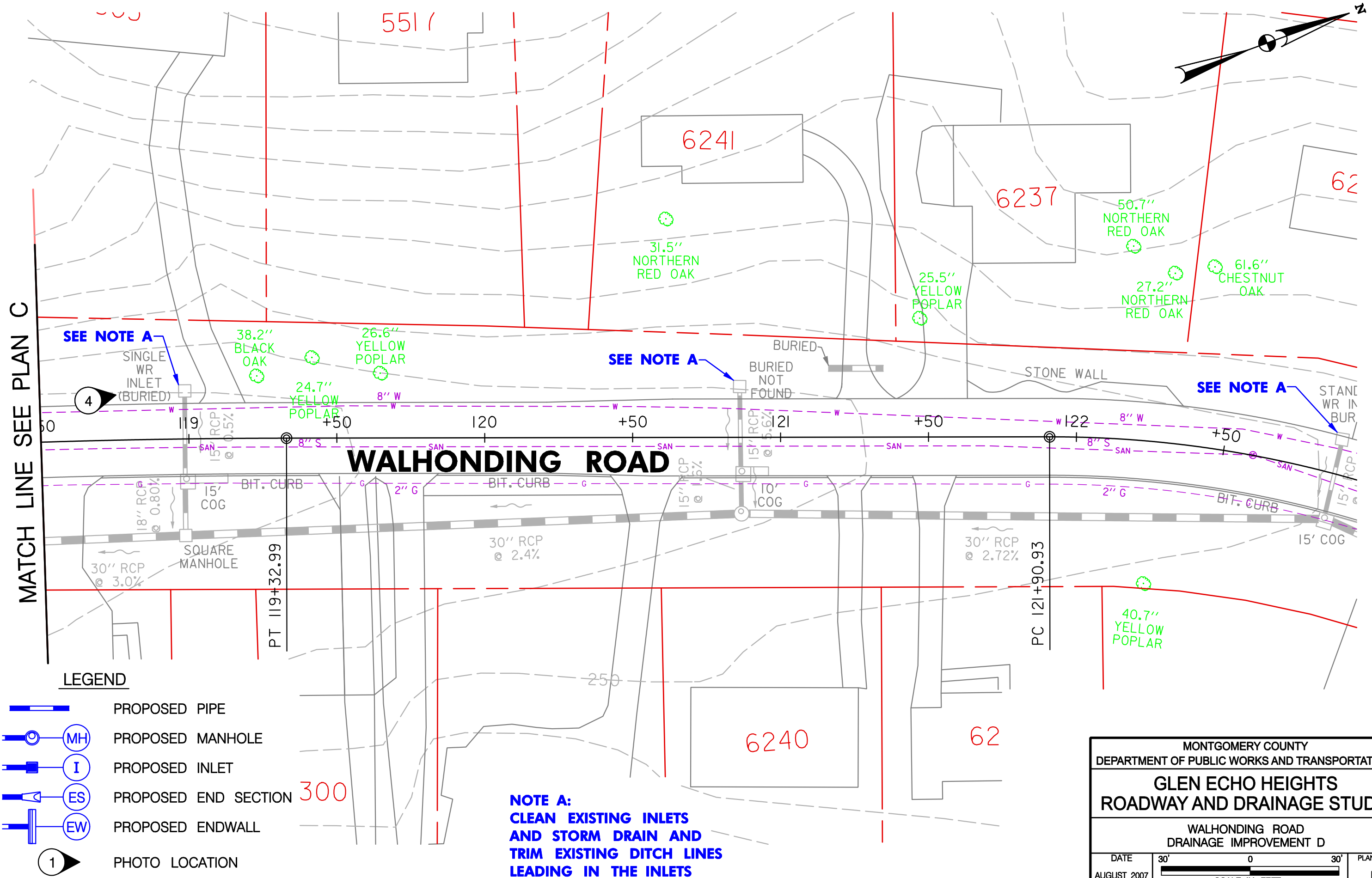
During the field investigation, several grate inlets were discovered buried under several inches of topsoil. As mentioned previously in the report, Glen Echo Heights is located in an area of rolling topography with many elevation changes. Specifically, the area where these three inlets are located, the western side of Walhonding Road, has a very steep hillside. Due to the steep hillside, soil has eroded from the slopes and collected on the grate inlets.

Recommendations

To address the drainage issue at these locations, the existing inlets and storm drains should be cleaned and the ditches adjacent to the roadway trimmed to allow the runoff to flow freely into the inlets. This work would be entirely within the roadway right-of-way. Additionally, future inspection and maintenance should be performed regularly to prevent re-

covering of these inlets. For plan view, refer to Plan D.

BY: daw
PLOTTED: Wednesday, August 08, 2007 AT 10:10 AM
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DRAINAGE IMPROVEMENT E: 5317 TUSCARAWAS ROAD

Description of Problem



Photo 5 – Converted Inlet at 5317 Tuscarawas

In the front yard of 5317 Tuscarawas Road, the existing manhole, previously converted from a curb on grade (COG) type inlet, has experienced a wall failure and is contributing to a sinkhole adjacent to the roadway (see **Photo 5**). Due to the sinkhole, ponding occurs during storm events which appears to have increased the size of the sinkhole.

Contributing Factors



Photo 6 – Inside Converted Inlet

There are two main factors contributing to the drainage problem at 5317 Tuscarawas Road. The first factor is that the inlet was not properly converted into a manhole. Upon an inspection of inside the manhole, it was discovered that the original structure was a COG type inlet because the trough section of the inlet was left intact when it was converted into a manhole (see **Photo 6**). In addition to the trough portion being left intact, the inlet also seems configured to direct the storm runoff into the trough section instead of the 42" RCP that connects this drainage

structure to the rest of the SD system on Tuscarawas Road. The second factor is that the pipe or under-drain structure located at the end of the trough is allowing the storm runoff to pond in the trough section of the inlet. It is likely that there is a leak in the trough of the inlet causing the sinkhole that is located at the end of the trough section of the inlet. This sinkhole has been repaired multiple times, and the same issue has returned.

Recommendations

We recommend the following measures to improve this drainage issue:

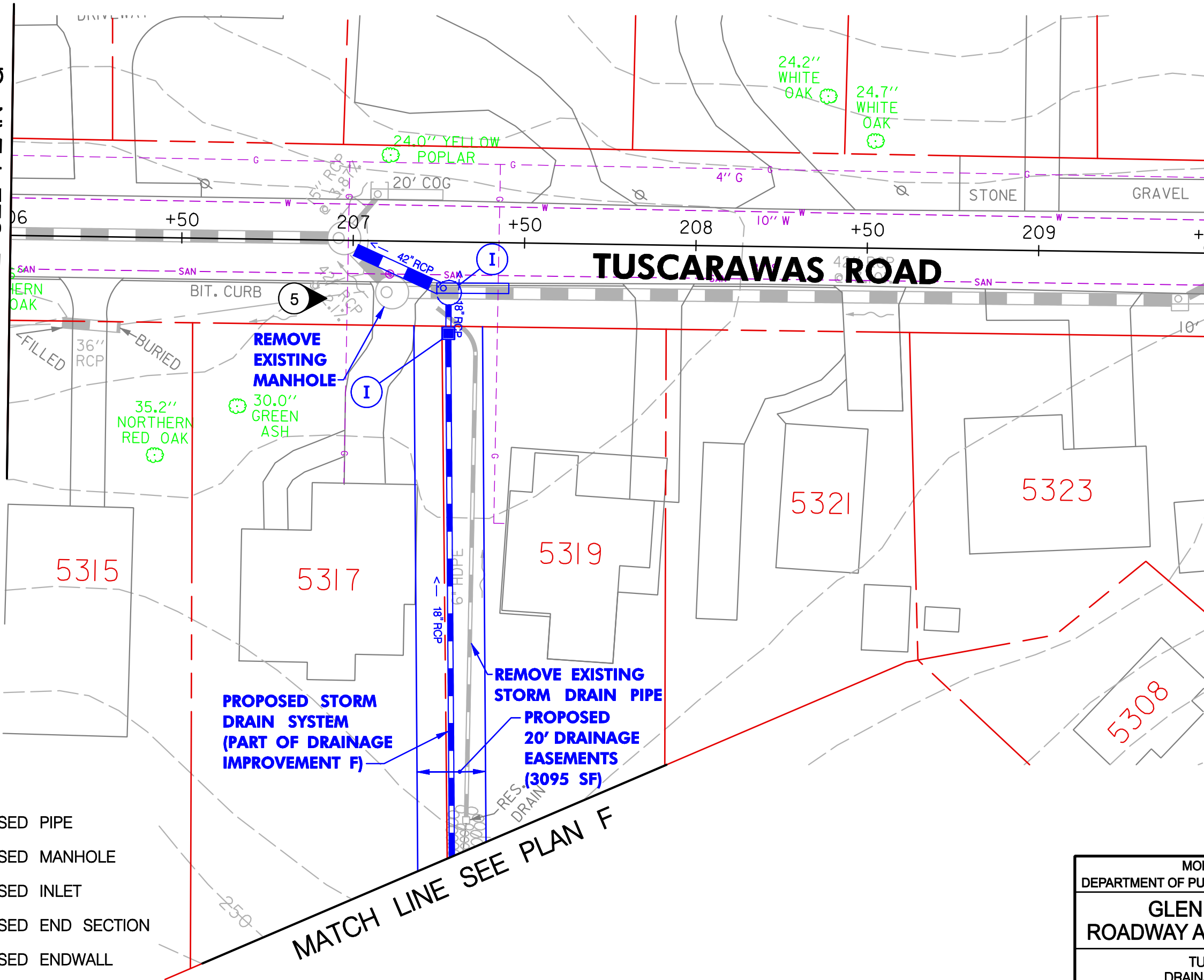
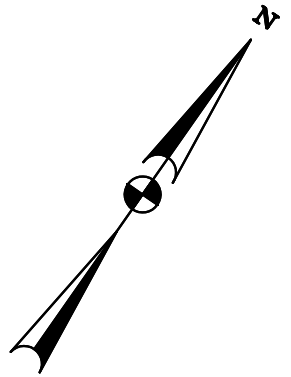
1. Remove the existing manhole and replace it with a COG inlet located approximately 17 feet east of the existing manhole along the existing curb. In addition to improving the drainage at this location, the amount of water flowing along the edge of Tuscarawas Road would be reduced significantly, which was contributing to drainage issues at 5311 Tuscarawas Road (**see Plan G**)
2. Construct a grate inlet between 5317 and 5319 Tuscarawas Road to capture surface runoff.

The reconstruction of the inlet on Tuscarawas Road could be done within existing right-of-way. The additional inlet (Item #2 above) should be constructed in-line with a pipe from Drainage Improvement F, which will require easement or right-of-way. For plan view, refer to Plans E, F, and G.

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:54 AM
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MATCH LINE SEE PLAN G

MATCH LINE SEE PLAN B-2



LEGEND

-  PROPOSED PIPE
-  PROPOSED MANHOLE
-  PROPOSED INLET
-  PROPOSED END SECTION
-  PROPOSED ENDWALL
-  PHOTO LOCATION

MATCH LINE SEE PLAN F

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
TUSCARAWAS ROAD DRAINAGE IMPROVEMENT E		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. E

DRAINAGE IMPROVEMENT F: 5319 TUSCARAWAS ROAD

Description of Problem

The backyard of 5319 Tuscarawas Road is being flooded from storm runoff that originates from Iroquois and Namakagan Roads.

Contributing Factor

- Backyard of 5319 Tuscarawas Serves as an Outfall Area
- Storm Drain System at 5319 Tuscarawas Road is Inadequate



Photo 7 – Type J Inlet at 5301 Iroquois Rd

The main contributing factor for this drainage issue is the storm water runoff collected from Iroquois and Namakagan Roads outfalls into the backyard of 5319 Tuscarawas Road. The runoff enters a grate inlet located near the intersection of Iroquois and Namakagan Roads, which captures the runoff from Namakagan Road. It is then carried across the road and drains into a ditch located in the backyard of 5302 Iroquois Road. The ditch flows across the backyard of 5302 Iroquois Road and outfalls onto the southwest corner of 5304 Iroquois Road where it

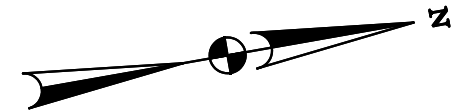
then flows into the backyard of 5319 Tuscarawas. The second factor is the storm drainage installed by the resident to convey the overland flow entering their property from 5304 Iroquois Road was not adequately sized for the volume of runoff. During the field investigation, the survey team found a 12x18 inch residential yard inlet connected to a six-inch High Density Polyethylene (HDPE) pipe which drains the storm runoff (approximately 4.2 acres) from the backyard of 5319 Tuscarawas Road onto Tuscarawas Road. The survey team also found the backyard of 5319 Tuscarawas Road to be saturated from the excess water.

Recommendations

We recommend the installation of a closed drainage system from the upstream side of Iroquois Road to connect to the existing closed drainage system on Tuscarawas Road. This work also includes constructing inlets between 5300 and 5302 Iroquois Road to reduce surface runoff entering the backyard of 5319 Tuscarawas Road. This work will require Right-of-Way or easement and may impact existing water and gas facilities on Iroquois Road. For more detailed information, refer to Plan F. This drainage improvement would require the construction of Drainage Improvement E.

LEGEND

- PROPOSED PIPE
- PROPOSED MANHOLE (MH)
- PROPOSED INLET (I)
- PROPOSED END SECTION (ES)
- PROPOSED ENDWALL (EW)
- PHOTO LOCATION



MATCH LINE SEE PLAN E

PROPOSED
20' DRAINAGE
EASEMENT
(3735 SF)

PROPOSED
STORM DRAIN
SYSTEM

REMOVE EXISTING
STORM DRAIN PIPE

ASPHALT
STRIP

8" HDPE
RIPRAP
CHANNEL

18" RCP

15" RCP

LANDSCAPE
STONES

5210

5300

5302

5304

5306

5308

5323

IROQUOIS ROAD

GRAVEL

SAN

8" S

8" W

+50

253

+50

252

GRAV

256

+50

255

W

254

G

253

W

+50

NAMAKAGAN
ROAD

POT 500+00.00

CONC.
WALK

CAR-PORT

CONC.
PATIO

BIT. CURB

TYPE J
INLET

27.4"
YELLOW
POPLAR

25.1"
WHITE
OAK

30.5"
WHITE
OAK

25.9"
WHITE
OAK

30.7
YELL
POPL

5301

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
IROQUOIS ROAD TO TUSCARAWAS ROAD DRAINAGE IMPROVEMENT F		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. F

DRAINAGE IMPROVEMENT G: 5311 – 5309 TUSCARAWAS ROAD

Description of Problem

The storm runoff from Tuscarawas Road has eroded a ditch along the southern edge of the roadway between 5311 and 5309 Tuscarawas Road. The eroded ditch drains into an ephemeral stream across the front of the properties of 5315 through 5303 Tuscarawas Road. The location of the outfall where the eroded ditch is draining is next to two large



Photo 8 – Eroded Ditch on Tuscarawas Road

trees whose roots are being undermined by the storm runoff. Also, based on conversation with property owners, the driveways at 5311 and 5309 Tuscarawas Road have experienced excessive runoff from the roadway.

Contributing Factors

There are three main factors contributing to the drainage issue along this section of roadway. One of the factors is that the inlet at 5317 Tuscarawas was converted into a manhole. When the inlet was

converted into a manhole, more storm runoff was allowed to stay on the surface of the road. Drainage Improvement E proposes to replace this existing manhole with a new inlet to capture a large amount of this runoff (See Drainage Improvement E). It should also be noted that the distance from the last inlet structure on the same side of Tuscarawas Road as this drainage issue is over 500 feet. The second factor is the lack of curbs on Tuscarawas Road. Since there are no curbs keeping the storm drainage along the edge of the road, the runoff has eroded the edge of the road. Another contributing factor is that crown of Tuscarawas Road has been flattened at places due to recent roadwork.

Recommendations

To reduce the drainage issue at both of these properties, the following improvements should be performed:

1. Tuscarawas Road should be resurfaced in order to redefine the roadway crown, which has been reduced due to roadway patching.
2. The deteriorated and undercut outfall at 5307 Tuscarawas Road should be repaired by removing the remaining portions of the concrete apron and placing riprap to stabilize the outfall. This work should be performed as a first order of work to minimize any additional deterioration of the existing stone retaining wall

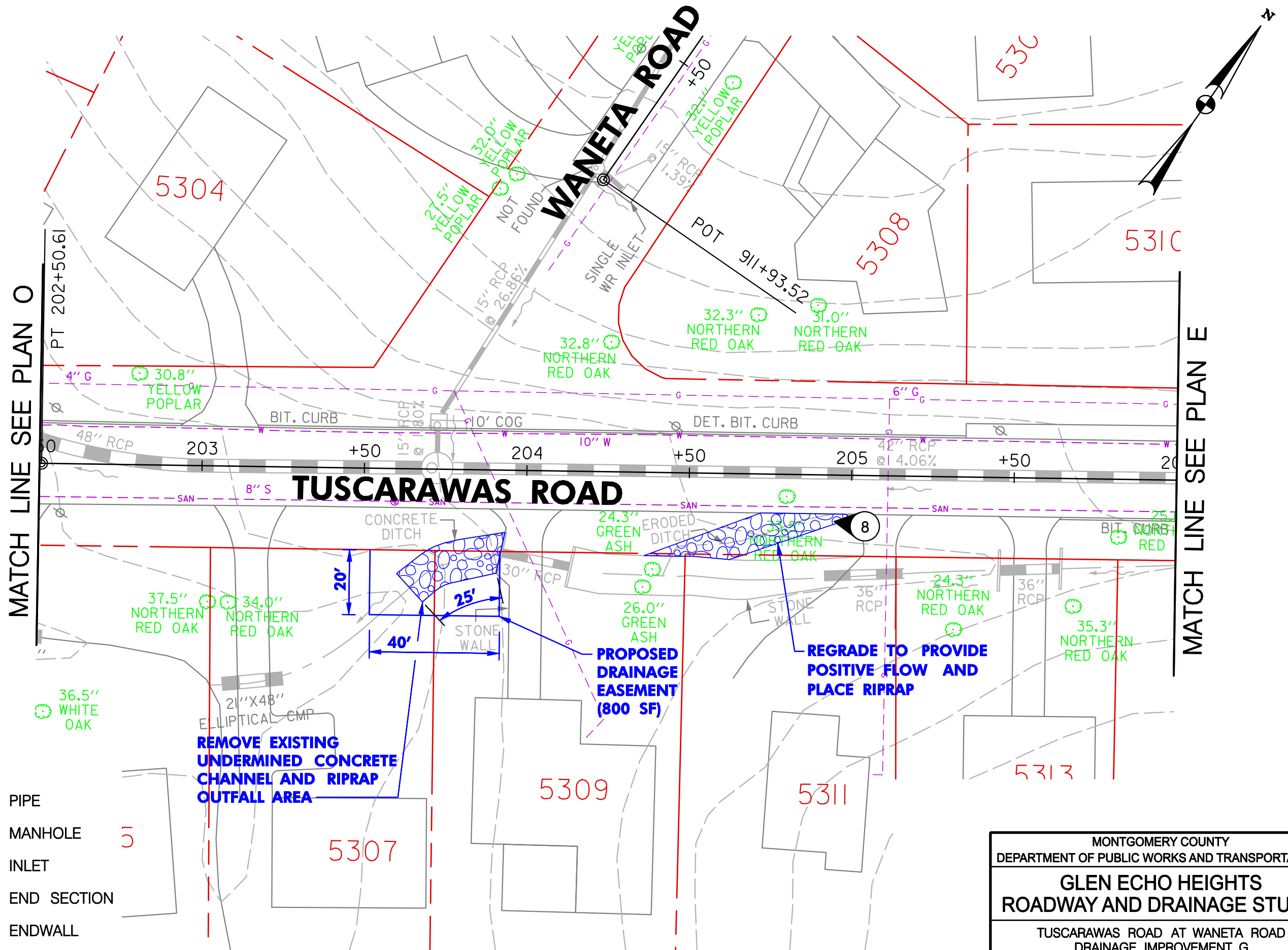
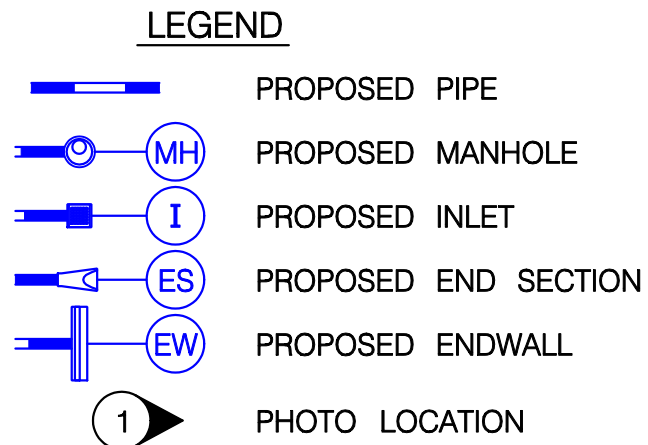
ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

located at the outfall, which shows signs of potential settlement (eg. Cracks in wall, etc.)

3. Regrade the existing incised swale that enters the main channel at 5311 Tuscarawas Road and lined it with riprap

Items 1 and 3 should be considered maintenance issues, and can be performed within the existing right of way. Item 2 will require easement or additional Right-of-Way and may have potential Waters of the U.S. impacts. For plan view, refer to Plan G.

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:55 AM
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MONTGOMERY COUNTY		
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
TUSCARAWAS ROAD AT WANETA ROAD DRAINAGE IMPROVEMENT G		
DATE	30' 0 30'	PLAN NO.
AUGUST 2007	SCALE IN FEET	G

DRAINAGE IMPROVEMENTS H & M: 6115 AND 6111 MADAWASKA ROAD

Description of Problem



Photo 9 – Behind 6108 Winnebago Road

The area between 6108 Winnebago Road and 6111 Madawaska Road has multiple drainage issues. The primary issues are in the area behind 6108 Winnebago Road and 6115 Madawaska Road, where there is an outfall of an existing storm drain system. Roadway runoff drains down the driveway of 6115 Madawaska Road, which is located in a sump area, contributing to the drainage problem. The drainage area to the upstream of the 24" pipe at 6108 Winnebago Road is approximately 15.4 acres, of which 3.8 acres drains down the driveway at 6115 Madawaska Road. The total estimated runoff at the existing headwall behind 6108 Winnebago Road is approximately 35 cfs during the 25 year storm event.

A related drainage issue is located at the intersection of Madawaska and Wapakoneta Roads. A field investigation during a storm event revealed that storm runoff was crossing the roadway diagonally from the southeast corner to the northwest corner of the intersection, and draining to the riprap lined ditch along the east side of 6111 Madawaska Road.

Contributing Factors

The main factor contributing to the drainage issues in this area is the lack of storm drainage systems on both Madawaska and Wehawken Roads. Wehawken Road is approximately 2490 feet in length, yet there are only three 5' COG inlets, three cross culverts and a large drainage ditch. On Madawaska Road, approximately 1700 feet in length, there are no drainage structures. There was a proposed project which included building a SD system on Madawaska Road, starting from the intersection with Wapakoneta Road and tying into the SD system on Winnebago Road. The proposed SD system would have improved the current drainage issues at the intersection of Madawaska and Wehawken Road, but the project was never built.

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

Recommendations

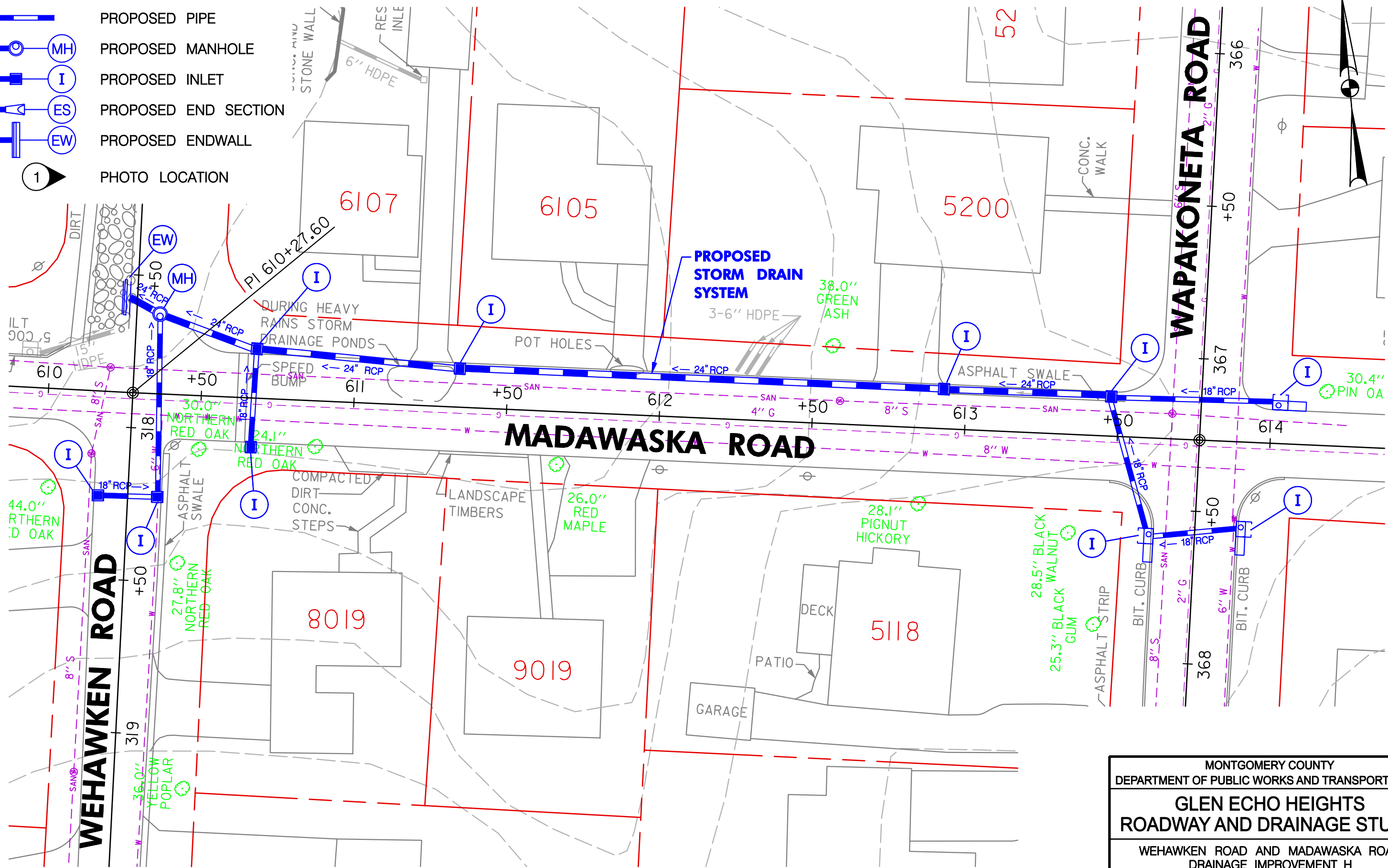
We recommend the following measures to improve these drainage issues:

1. Construct a closed storm drain system along Madawaska Road that includes improvements at the intersections with Wehawken and Wapakoneta Roads. In addition, the existing inlet in front of 6111 Madawaska Road should be cleaned.
2. Construct inlets at the sump of the roadway at 6115 Madawaska Road and outfall into the existing riprap channel at the rear of the residence.
3. Although the current homeowner has not noted any problems with flooding, consideration should be made to increase the size of the storm drain system that connects the area draining to the backyard of 6108 Winnebago Road to the existing storm drain system along Winnebago Road. Based on preliminary drainage analysis, the storm drain would need to be increased from a 24" CMP to a 27" RCP to handle the flow from a 25 year storm.

Item 1 will not require additional Right-of-Way, but Items 2 and 3 would require easements or Right-of-Way from multiple property owners. All 3 Items would possibly impact existing water and gas facilities on Madawaska, Wehawken, and Wapakoneta Roads. For plan views of the recommended items, refer to Plans H and M.

LEGEND

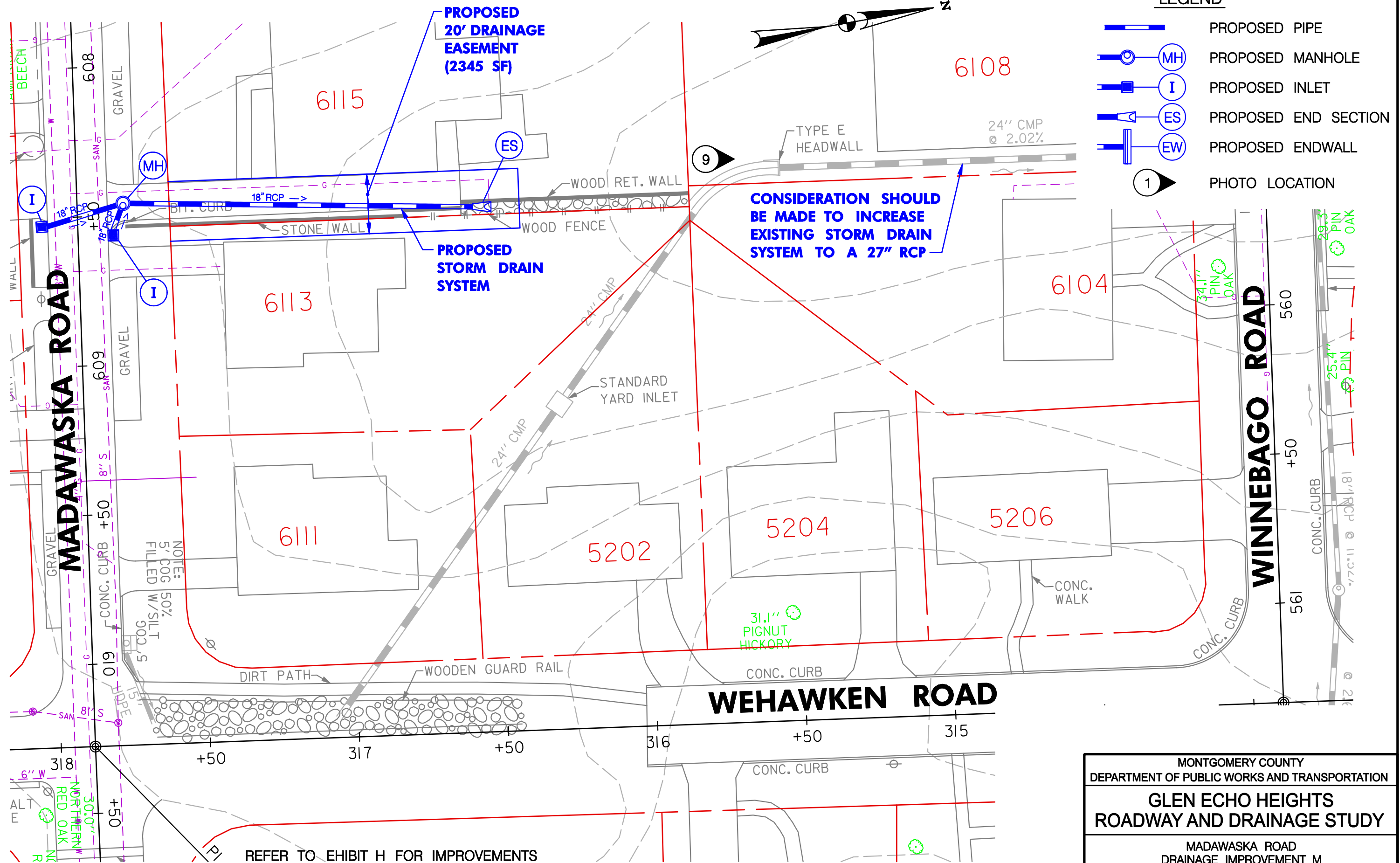
- PROPOSED PIPE
- PROPOSED MANHOLE (MH)
- PROPOSED INLET (I)
- PROPOSED END SECTION (ES)
- PROPOSED ENDWALL (EW)
- PHOTO LOCATION



N

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WEHAWKEN ROAD AND MADAWASKA ROAD DRAINAGE IMPROVEMENT H		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. H

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:59 AM
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REFER TO EXHIBIT H FOR IMPROVEMENTS
AT INTERSECTION OF MADAWASKA ROAD
AND WEHAWKEN ROAD

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
MADAWASKA ROAD DRAINAGE IMPROVEMENT M		
DATE	30' 0 30'	PLAN NO.
AUGUST 2007	SCALE IN FEET	M

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

DRAINAGE IMPROVEMENT I: 5202 WYOMING ROAD

Description of Problem



The drainage issue is located at the outfall pipe (24" RCP) along the side of 5202 Wyoming Road, that has a drainage area of 8.74 acre. The flow is undermining the outfall including the subgrade supporting a wooden retaining wall that in turn supports a wooden deck located between 5102 & 5202 Wyoming Road. In addition, the outfall is flooding the driveway of 7011 MacArthur Boulevard, located downstream of the outfall.

Photo 10 – Outfall Area at 5202 Wyoming Road

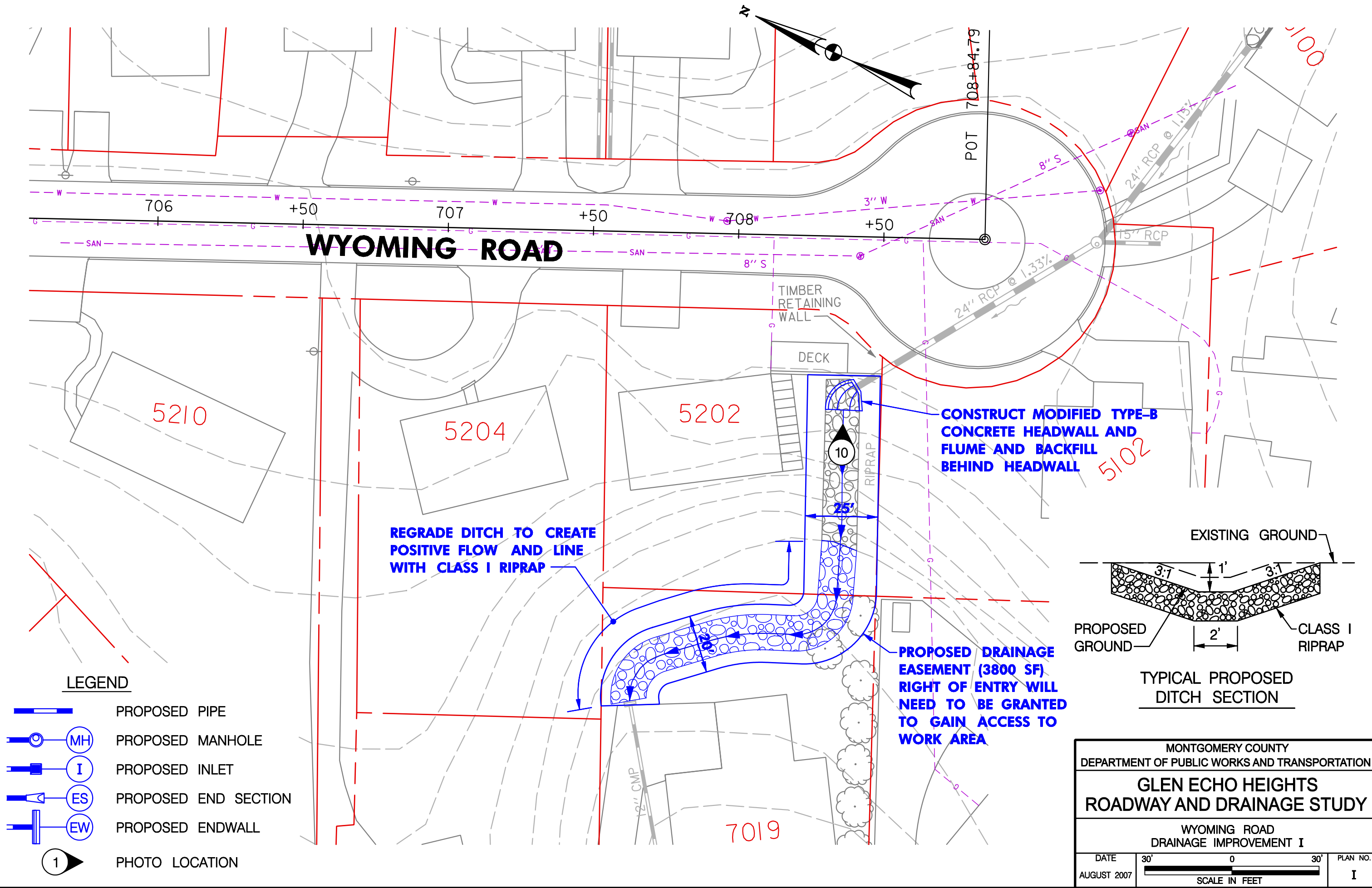
Contributing Factors:

The main contributing factor related to this drainage issue is the lack of outfall protection, such as an endwall, that is needed to protect the surrounding soil from the discharge from the 24" pipe. With a drainage area of approximately 8.74 acres and a 25-year storm event, the outfall from the pipe was calculated to be 28 cfs.

Recommendations

We are recommending two measures to mitigate this problem. First, we propose that a modified Type "B" Headwall and concrete flume be cast in place at the end of the existing 24" pipe to protect the surrounding subgrade and channel the storm runoff downhill into the existing riprap lined outfall. The area underneath the existing retaining wall will also need to be backfilled. The second recommendation is that the existing drainage ditch at the bottom of the riprap outfall be regraded to create positive flow to the existing brick headwall. The ditch should also be lined with riprap and the overall cross sectional area of the ditch be increased to accommodate the current rate of flow without flooding the driveway at 7011 MacArthur Boulevard. Consideration should also be given to increase the size of the existing storm drain that connects to the brick headwall. This work will require Right-of-Way or easement. For plan view, refer to Plan I.

BY: daw
PLOTTED: Wednesday, August 08, 2007 AT 10:14 AM
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ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

DRAINAGE IMPROVEMENT J: 5110 WEHAWKEN ROAD – 5123 WAUKESHA ROAD

Description of Problem



Photo 11 – Concrete Swale at 5123 Waukesha

The drainage issue at 5110 Wehawken Road and 5123 Waukesha Road consists primarily of excessive overland flow running through these two properties. The runoff from the storm drain system is first collected by a 5' COG in front of 5109 Wehawken Road, then outfalls across the roadway onto the side of 5108 Wehawken Road; where it drains into the backyard of 5110 Wehawken Road. The runoff drains into a concrete swale that flows along the southern property line of 5123 Waukesha Road. The runoff is

causing the following types of damage:

- At 5110 Wehawken Road, the storm runoff is causing erosion at the end of a riprap swale.
- At 5123 Waukesha Road, the storm runoff from Wehawken Road is undermining a garage and then flowing into a concrete swale that runs along the northern side of 5119 Waukesha Road.

Another related drainage issue is that the flow at the end of the concrete swale is not intercepted by the 20' COG located approximately 4' downstream from the end of the swale. The flow then crosses the road and drains through the front yards of 5114 & 5112 Waukesha Road. Currently a resident has placed a large stone at the end of the concrete swale that redirects the flow toward the 20' COG instead of across Waukesha Road.

Contributing Factors

The three main factors contributing to the drainage issue at this location are as follows:

- Storm runoff is flowing overland on private property; specifically 5110 Wehawken Road. A 5' COG inlet located across the street from 5110 Wehawken collects storm runoff from 1.33 acres. From the inlet, flow is conveyed through a 12" RCP pipe, into a riprap swale on the lawn of 5110 Wehawken. The flow rate of the storm runoff exiting the 12" pipe has been calculated to be 5.0 cfs for the

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

25 year storm. As the storm runoff flows across the property at 5110 Wehawken, it drains into a concrete swale that lies near 5123 Waukesha Road

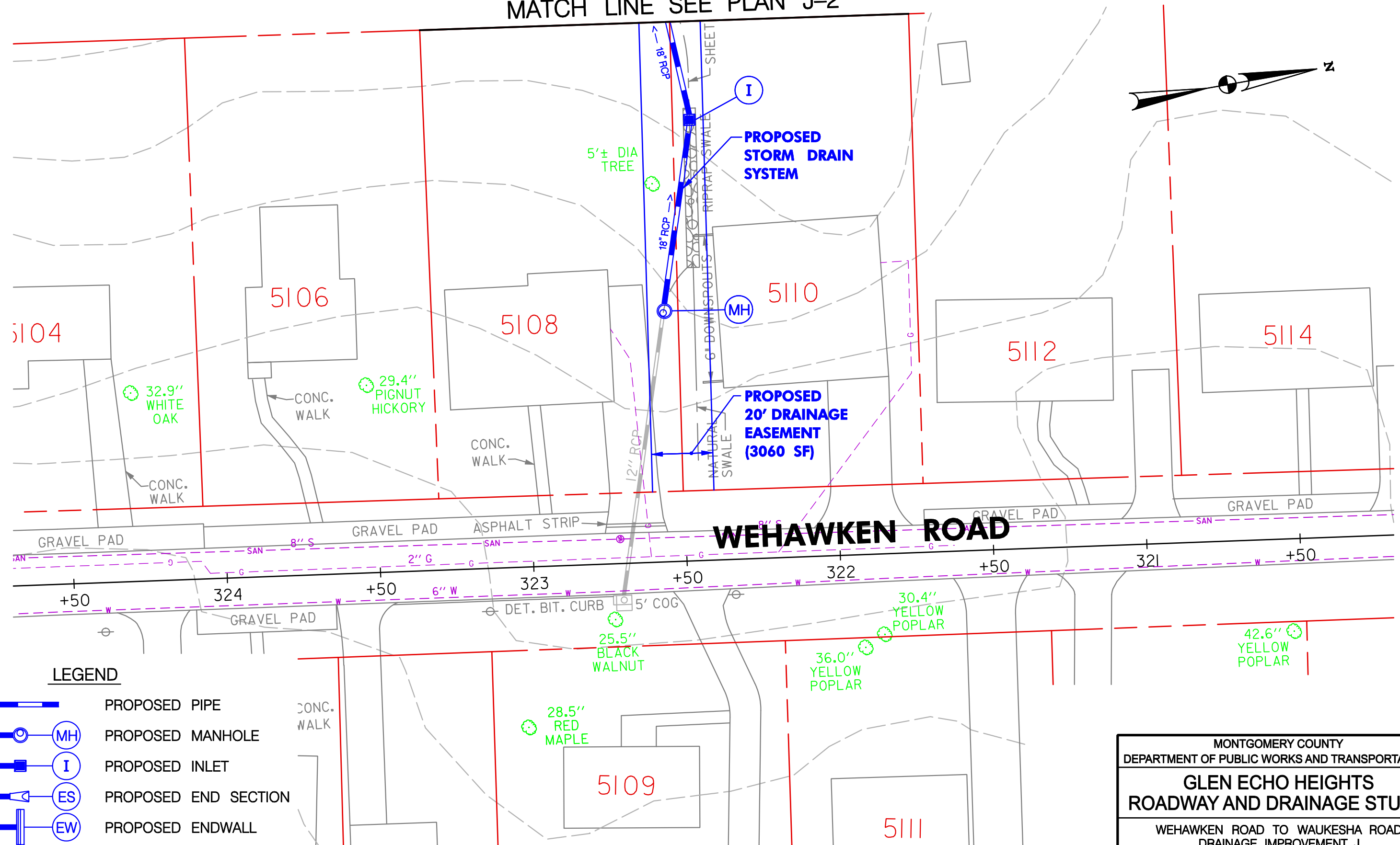
- The concrete swale that runs along the length of the property right next to 5123 Waukesha Road is improperly sized to handle the current volume of runoff. During the field investigation, the survey team found evidence of erosion along the driveway of 5123 Waukesha Road due to storm runoff overflowing from the concrete swale. The flow rate of the storm runoff as it exits the concrete swale was calculated to be 5.0 cfs for the 25-year storm event.
- There is no structure directing the runoff from the concrete swale into the existing SD system on Waukesha Road. Since the storm runoff does not drain directly into the 20' COG inlet that lies 4 ft downstream from the outfall of the concrete swale, local residents reported to the survey team that the runoff flows across the road and damages the front lawns of 5114 and 5112 Waukesha Road.

Recommendations

We recommend constructing a closed drainage system between Wehawken and Waukesha Roads. The closed drainage system would connect the outfall of the existing 12" RCP with the existing 20' COG inlet located in the front of 5119 Waukesha Road. Grate inlets are proposed at three locations to capture surface runoff. This work will require easement or Right-of-Way for all work and may impact a mature tree in the rear of 5108 Wehawken Road. For plan view of the proposed work, refer to Plans J-1 and J-2.

BY: erf
PLOTTED: Wednesday, August 29, 2007 AT 11:06 AM
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MATCH LINE SEE PLAN J-2

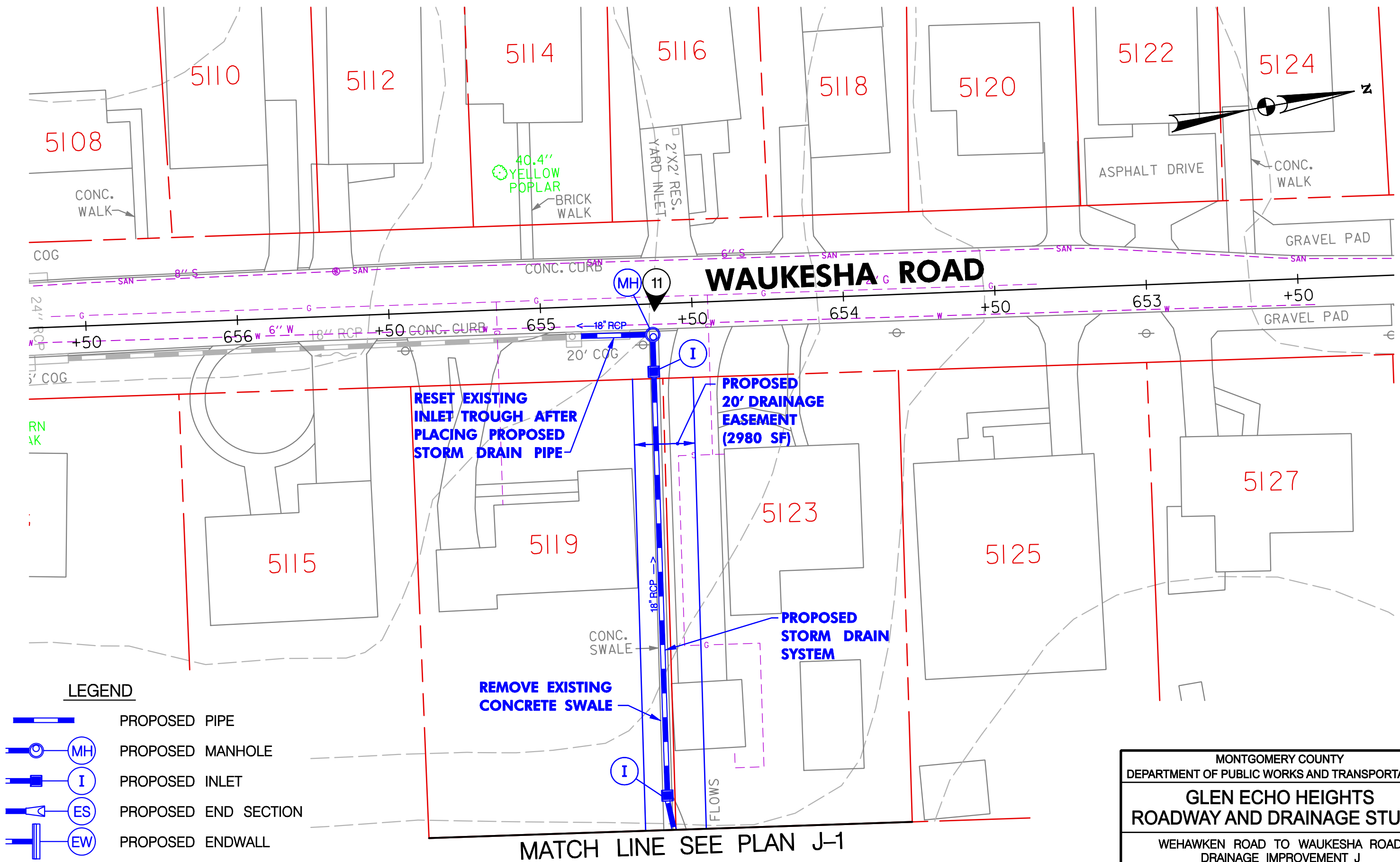


LEGEND

-  PROPOSED PIPE
-  PROPOSED MANHOLE
-  PROPOSED INLET
-  PROPOSED END SECTION
-  PROPOSED ENDWALL
-  PHOTO LOCATION

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WEHAWKEN ROAD TO WAUKESHA ROAD DRAINAGE IMPROVEMENT J		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. J-1

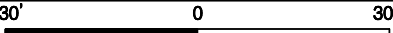
BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:58 AM
FILE: T:\GlenEcho\pDD-P0J2_gh.dgn



LEGEND

-  PROPOSED PIPE
-  PROPOSED MANHOLE
-  PROPOSED INLET
-  PROPOSED END SECTION
-  PROPOSED ENDWALL
-  PHOTO LOCATION

MATCH LINE SEE PLAN J-1

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WEHAWKEN ROAD TO WAUKESHA ROAD DRAINAGE IMPROVEMENT J		
DATE AUGUST 2007	 SCALE IN FEET	PLAN NO. J-2

DRAINAGE IMPROVEMENT K: 5104 RIVER HILL ROAD

Description of Problem



**Photo 12 – Manhole Located Behind
5104 River Hill Road**

opening of the concrete structure. For the last field located manhole of the existing SD system, we recommend further investigation by the appropriate agency to discover where the pipes clogged and/or failed and determine the necessary repairs. In addition, the manhole frame and cover needs to be bolted onto the concrete structure. This structure is located on Maryland-National Capital Park and Planning Commission property. For plan view information, refer to Plan K.

The existing manhole located at the rear of 5104 River Hill Road is filled with debris and water. The manhole frame and cover have been removed and a steel grate placed over the hole to allow storm runoff to exit the manhole. Field surveys were unsuccessful in determining the location of the SD outfall, which appears to have either failed or have been covered with debris.

Contributing Factors

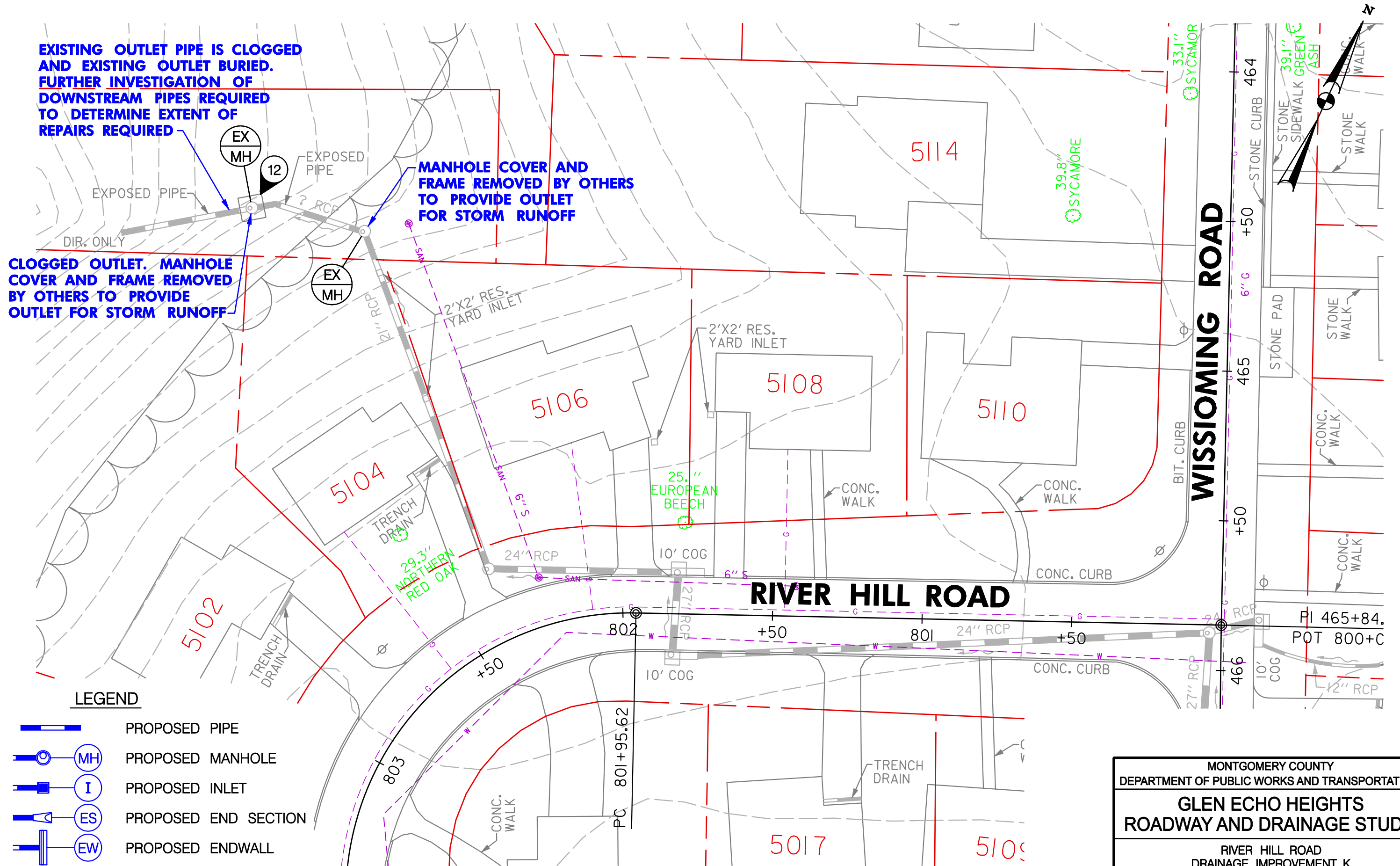
As noted above, the outfall of the existing SD system has either failed or been covered by debris causing the flows to back up the SD system and flow out the existing manhole.

Recommendations

The frame and cover for the upstream manhole should be replaced and bolted over the existing

While performing a field investigation during a rain event, it was observed that a large volume of storm runoff flowing downhill from the study area was collecting in the drainage ditch that runs along the eastern side of MacArthur Boulevard. Further investigation revealed that the nearest cross culvert was filled with sediment, preventing the draining of the ditch. This related drainage issue should be immediately addressed to prevent the flooding of the roadway on MacArthur Boulevard.

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:58 AM
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LEGEND

-  PROPOSED PIPE
-  PROPOSED MANHOLE
-  PROPOSED INLET
-  PROPOSED END SECTION
-  PROPOSED ENDWALL
-  PHOTO LOCATION

MONTGOMERY COUNTY		
DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
RIVER HILL ROAD DRAINAGE IMPROVEMENT K		
DATE	30' 0 30'	PLAN NO.
AUGUST 2007	SCALE IN FEET	K

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

DRAINAGE IMPROVEMENT L: 6691 ALEXANDER ROAD

Description of Problem



Photo 13 – Soil Erosion Along Edge of Alexander Road

Alexander Road is experiencing erosion problems along the edge of the existing roadway at various locations, from the end of the cul-de-sac for a distance approximately 450 ft. The greatest amount of erosion was found at the inside of the two tight turns on Alexander Road.

Contributing Factors:

The contributing factor for this drainage issue is the lack of a comprehensive drainage system, either closed or open, on Alexander Road. Along the length of

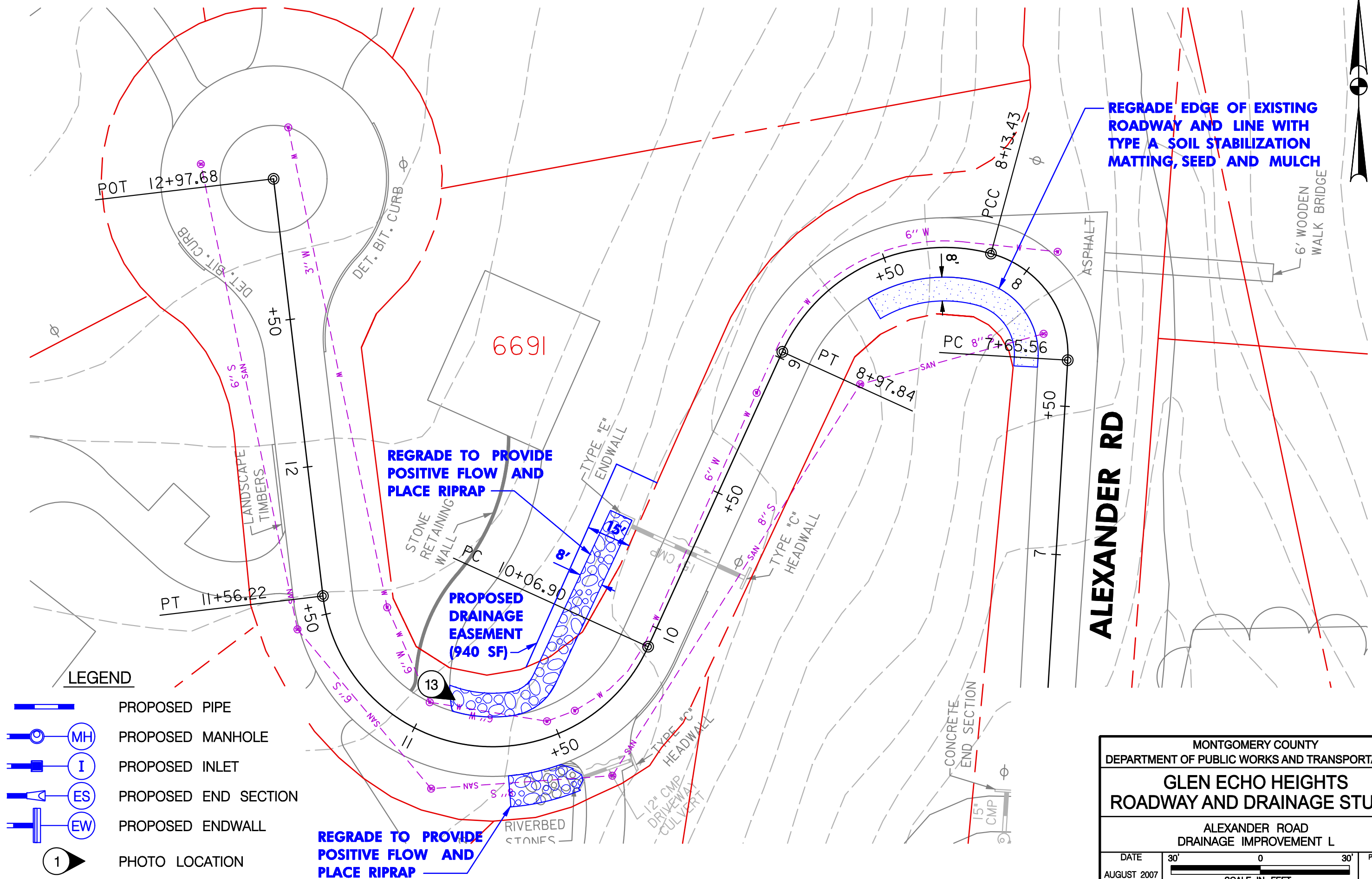
Alexander Road, the only drainage structures were found to be either at or near the end of private driveways. The only exception is an 18-inch cross culvert located approximately 300 ft from the intersection with MacArthur Boulevard.

Recommendations

To mitigate the drainage issues occurring on Alexander Road, the following improvements should be considered:

1. Resurface the roadway to define a crown that would direct storm runoff to both edges of the road.
2. Construct a riprap lined ditch along the edge of roadway from 6691 MacArthur Boulevard to the existing concrete headwall, a length of approximately 100 feet.
3. Stabilize other areas along the edge of Alexander Road that are experiencing erosion by regrading / backfilling and stabilizing with soil stabilization matting.
4. Regrade the drainage ditch leading to the driveway culvert at 6665 MacArthur Boulevard to create positive flow from the edge of Alexander Road to the culvert.

Item 2 will require easement from 6691 MacArthur Boulevard. All other items are located within existing Right-of-Way. For plan view, refer to Plan L.



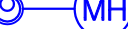
ALEXANDER RD

**REGRADE TO PROVIDE
POSITIVE FLOW AND
PLACE RIPRAP**

**REGRADE TO PROVIDE
POSITIVE FLOW AND
PLACE RIPRAP**

**PROPOSED
DRAINAGE
EASEMENT
(940 SF)**

LEGEND

- | | |
|---|----------------------|
|  | PROPOSED PIPE |
|  | PROPOSED MANHOLE |
|  | PROPOSED INLET |
|  | PROPOSED END SECTION |
|  | PROPOSED ENDWALL |
|  | PHOTO LOCATION |

MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION			
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY			
ALEXANDER ROAD DRAINAGE IMPROVEMENT L			
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. L	

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 09:59 AM
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ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

DRAINAGE IMPROVEMENT N: #4 and #5 WYOMING COURT

Description of Problem



The properties at #4 & #5 Wyoming Court are experiencing flooding in their backyards due to storm runoff draining from the backyards of 5126 Waukesha Road and 6206 Madawaska Road. Both of these properties are located at the sumps of their respective roads and therefore have storm runoff draining off the roads and through their properties.

Contributing Factors

Photo 14 – Overview Wyoming Court

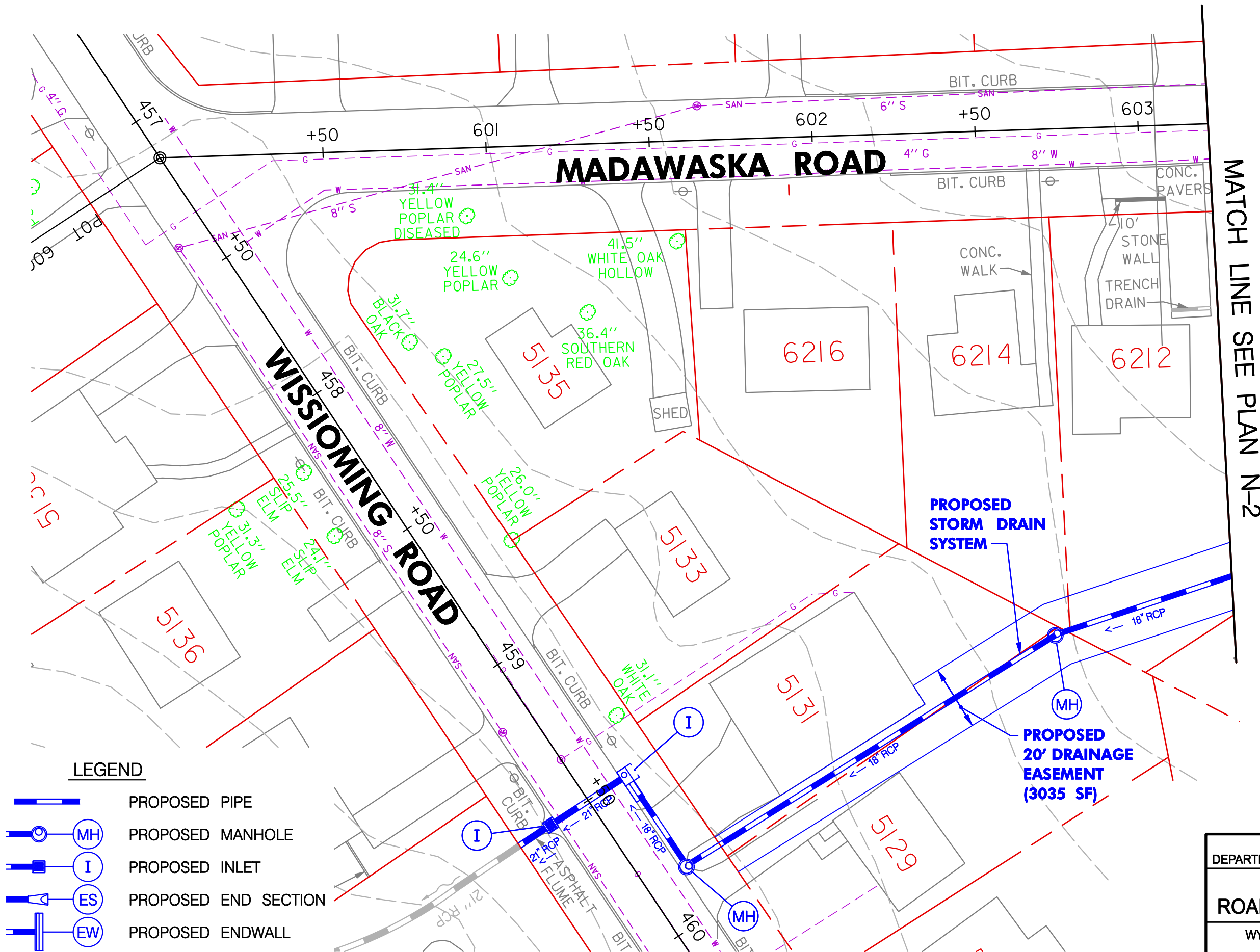
The main contributing factor to the drainage issue at Wyoming Court is the lack of a drainage system on Waukesha and Madawaska Roads. Although a SD system exists for most of Waukesha Road, it does not extend to the intersection with Madawaska Road, which is the location where the storm runoff drains into the backyard of #5 Wyoming Court. A similar situation is occurring in front of 6206 Madawaska Road, where there is no existing SD system. The area draining into the backyards of both properties on Wyoming Court is approximately 2.7 acres. The runoff entering the cul-de-sac on Wyoming Court is approximately 8.1 cfs for the 25 year storm event.

Recommendations

We recommend constructing a closed drainage system from the existing sump area at 5132 Wissioming Road to the back corner of #5 Wyoming Court. In addition to the placement of two inlets at the sump along Wissioming Road, we are recommending two grate inlets in the backyards of #4 and #5 Wyoming Court to capture overland flow through these properties.

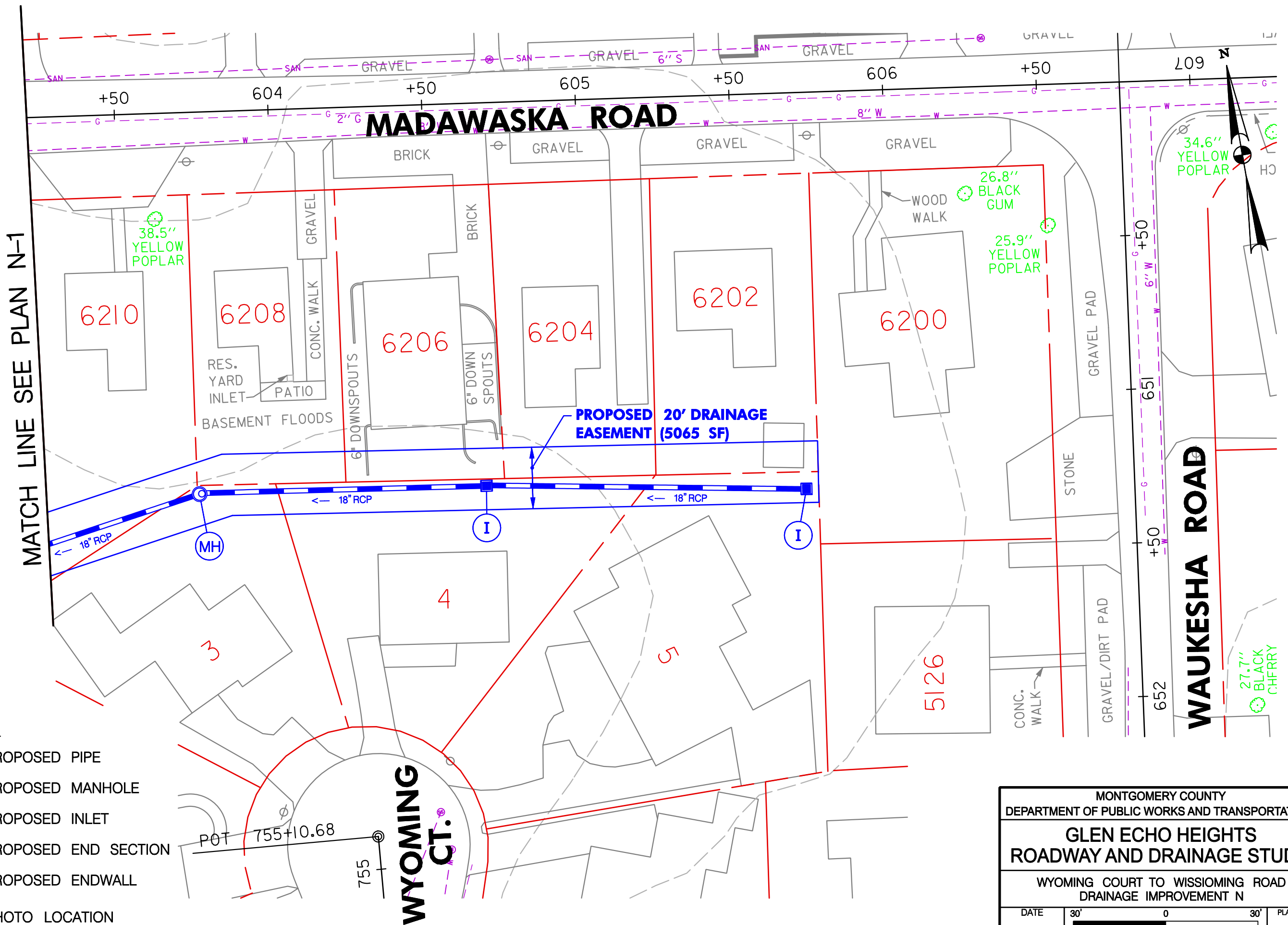
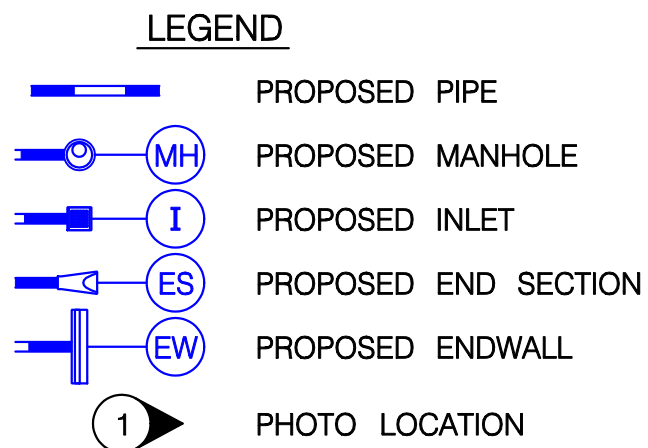
This work will require easement or Right-of-Way from multiple property owners, and may impact existing water and gas facilities on Wissioming Road. For plan view, refer to Plans N-1 and N-2.

BY: daw
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MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WYOMING COURT TO WISSIOMING ROAD DRAINAGE IMPROVEMENT N		
DATE AUGUST 2007	30' 0 30' SCALE IN FEET	PLAN NO. N-1

BY: daw
PLOTTED: Thursday, August 09, 2007 AT 10:00 AM
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MONTGOMERY COUNTY DEPARTMENT OF PUBLIC WORKS AND TRANSPORTATION		
GLEN ECHO HEIGHTS ROADWAY AND DRAINAGE STUDY		
WYOMING COURT TO WISSIOMING ROAD DRAINAGE IMPROVEMENT N		
DATE AUGUST 2007	SCALE IN FEET 30' 0 30'	PLAN NO. N-2

DRAINAGE IMPROVEMENT O: INTERSECTION OF TUSCARAWAS AND
WISSIOMING ROAD

Description of Problem



Photo 15 – Wissioming Road

The main drainage issue at the intersection of Tuscarawas and Wissioming Roads is the ponding of storm runoff at the southeast corner of the intersection. Another related drainage issue is the need to replace/repair the existing 33" CMP cross culvert at Wissioming Road located near the intersection. The bottom of the culvert near the upstream end of the pipe has rusted out, leaving a $\pm 2"$ gap between the top of the culvert and the bottom of the end treatment, which has caused settlement along the edge of Wissioming Road.

Contributing Factors

The factors contributing to the drainage issue at the intersection of Tuscarawas and Wissioming are:

- Lack of Drainage Structures
- Road Geometry

The area draining into the intersection is approximately 3.4 acres. Using the rainfall intensity for the 25 year storm, the resulting value of storm runoff draining across the intersection is approximately 10 cfs. There are currently no drainage structures in place to handle the runoff generated by any rain events. In addition, the crown on Wissioming Road was extended into the intersection instead of flattening out as the road approaches the intersection, creating a low spot at the southeast corner of the intersection, where ponding occurs.

Recommendations

We recommend the following to improve the drainage at the intersection of Tuscarawas and Wissioming Roads:

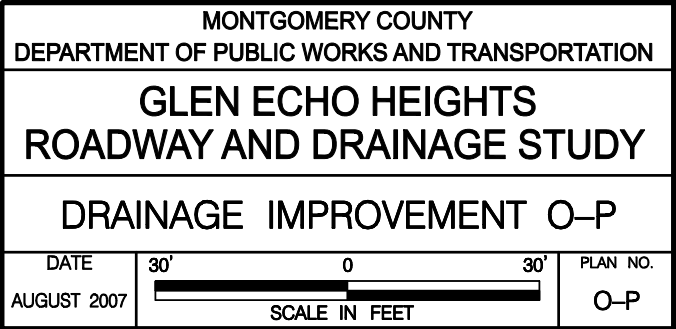
- Construct 10' COG inlets on Wissioming Road immediately upstream from the intersection with Tuscarawas Road and on Tuscarawas Road immediately upstream of the intersection. Both of the inlets will be connected to a

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

manhole located in front of 5303 Tuscarawas Road where the runoff would be directed into the existing ditch that runs parallel to Tuscarawas Road.

- Replace or repair the cross culvert on Wissioming Road. This work could be done by replacing the existing 33" CMP in-kind or relining the existing pipe with a smaller diameter, smooth-bore pipe that would have similar flow characteristics and pressure grouting between the two pipes.
- Because the existing headwall for the 33" CMP is an old stone wall, which may be damaged by the complete removal of the existing pipe and the maintenance of traffic during the replacement of the pipe may be problematic (e.g. require detour, etc), relining the pipe may prove to be a more economical solution.

Easement will be required for discharge from the new inlets, and may be required for replacement / refurbishment of the existing cross-culvert. Additionally, this work may impact existing water facilities on Wissioming Road. For plan view, refer to Plans O – P.



DRAINAGE IMPROVEMENT P: Intersection of Walhonding and Tuscarawas Road

Description of Problem



Photo 16 – Intersection of Walhonding and Tuscarawas

The main drainage issue at the intersection of Walhonding and Tuscarawas Roads is the ponding of storm runoff at the Northeast corner of the intersection. The storm runoff collects at the corner of the intersection before crossing Tuscarawas Road. The storm runoff then continues to flow downstream along the southern edge of Tuscarawas Road and crosses Walhonding Road; entering one of two COG inlets on the western side of the road.

Contributing Factors

The factors contributing to the drainage issue at the intersection of Walhonding and Tuscarawas are:

- Lack of Drainage Structures
- Road Geometry

The area contributing storm runoff into the intersection is approximately 3.3 acres. Using the rainfall intensity for the 25 year storm, the resulting volume of storm runoff draining across the intersection is approximately 10 cfs. There are no existing drainage structures in place to capture the runoff generated by storm events. An important contributing factor to this drainage issue is the road geometry of the intersection. Specifically, there seems to be a low spot on the northeast corner of the intersection that is allowing storm runoff to pond before crossing Tuscarawas Road.

Recommendations

We recommend placing a 10' COS inlet at the northwest corner of the intersection and connecting the inlet to the existing 48" RCP. This work will be entirely within existing Right-of-Way. For plan view, refer to Plans O – P.

LOWER PRIORITY DRAINAGE IMPROVEMENTS

The lower priority drainage issues identified during the course of the drainage study are as follows:

- Intersection of Wehawken Road & Namakagan Road
Problem: Cross culvert has smashed ends
Recommendation: Replace cross culvert
- 6215 Dahlonge Road
Problem: 10' COG damaged when contractor connected residential inlet to COG
Recommendation: Repair brick and mortar of COG structure
- 6216 Dahlonge Road
Problem: Manhole frame sliding off manhole structure
Recommendation: Center manhole frame to completely cover manhole structure and bolt frame to the structure
- 5206 Iroquois Road
Problem: Water is ponding in front yard due to silted ditch on the West side of road
Recommendation: Trim the existing ditch to promote positive drainage to the receiving watercourse
- 6103 and 6101 Namakagan Road
Problem: Storm runoff has eroded the ditch at northern edge of road due to poor drainage caused by road geometry
Recommendation: Regrade the eroded ditch to facilitate drainage along northern edge of road
- 5404 and 5406 Tuscarawas Road
Problem: Driveway culvert is buried
Recommendation: Clean existing driveway culvert
- 6241 Walhonding Road
Problem: Driveway culvert is buried
Recommendation: Clean driveway culvert
- 6306 Walhonding Road
Problem: Runoff bypasses the inlet located north of the driveway
Recommendation: Regrade surrounding area to facilitate drainage to inlet

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

- 6318 Walhonding Road
Problem: Inlet located on Eastern side of road is buried in front yard
Recommendation: Excavate inlet and regrade surrounding area to facilitate drainage to inlet
- 5306 Waneta Road
Problem: Asphalt swale along Western edge of road measures to depth of one foot and left open to public
Recommendation: Place signs alerting drivers and pedestrians of potential hazard
- 5310 Waneta Road
Problem: Storm runoff has eroded ditch in front yard and floods property during large storm events
Recommendation: Regrade the eroded ditch across the front yard of property and line the ditch with soil stabilization matting
- 5312 Waneta Road
Problem: Driveway culvert is buried and out of alignment
Recommendation: Replace existing driveway culvert.
- 5311 Waneta Road
Problem: Homeowner states flooding of private property occurring due to storm runoff from Waneta Road
Recommendation: Regrade on-street parking pad to drain toward the road
- 5419 Waneta Road
Problem: Edge of road has been buried underneath gravel from on-street parking pad and driveway; road width has narrowed due to gravel on road
Recommendation: Reestablish true edge of road by removing gravel from road and resurfacing this section of Waneta Road
- 5421 Waneta Road
Problem: Edge of road has been buried underneath gravel.
Recommendation: Remove gravel from Waneta Road and resurface to provide smooth transition to existing roadway surface. Trim existing ditches leading to existing inlets.
- 5311 Wapakoneta Road
Problem: Driveway culvert is buried
Recommendation: Clean driveway culvert

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

- 5309 Wapakoneta Road
Problem: Driveway culvert is buried
Recommendation: Clean driveway culvert
- 5332 Wapakoneta Road
Problem: Storm runoff eroded hole in front of property at edge of road
Recommendation: Patch existing roadway.
- 5123 Wissioming Road
Problem: Storm runoff eroded hole in front of property at edge of road
Recommendation: Patch existing roadway.

These recommended improvements could be performed by County Operations / Maintenance forces.

IV. POSSIBLE COMMUNITY-WIDE IMPROVEMENTS

LOW IMPACT DEVELOPMENT (LID) TECHNIQUES

Glen Echo Heights is a large community located in steep terrain with many drainage issues as stated in previous sections of this report. Approaching the drainage issues at a system level, the conclusion we have reached is that intermediate portions of a drainage system do not exist in a meaningful way, and thus small drainage courses on private property are being overwhelmed by the amount of storm runoff that is being produced upstream, within the community. An analysis of the impervious area along two of the major roads that services Glen Echo Heights showed that the roadways themselves only contributed 30% to the total impervious area (see pages 7 and 8). Furthermore, the analysis demonstrated that the majority of the impervious area comes from rooftops and driveways. If we assume that the results of the analysis performed on Walhonding and Tuscarawas Road is representative of the community as a whole, then one of the major sources of the increase in quantity of storm runoff being experienced by the residents of Glen Echo Heights is the development taking place within the community, where larger homes with a significantly larger impervious footprint are being constructed. For example, the average surface area of the rooftops along Walhonding Road is 2198 sf and the average surface area of driveways was determined to be 1428 sf. Therefore, on average each home contributes approximately 3626 sf of impervious area on Walhonding Road.

While recommendations to add closed drainage systems along various streets experiencing drainage issues have been made elsewhere in this report, an additional approach may also prove beneficial to the community. Low Impact Development (LID) was first introduced in neighboring Prince George's County, MD in the 1990's as an alternative to the standard closed drainage system. While a typical closed drainage system employs inlets, manholes, and pipes to convey the storm runoff to detention areas before draining the runoff into near by bodies of water, a LID system allows the storm runoff to recharge the ground water table near the original source of the runoff through the use of natural swales, rooftop disconnects, rain gardens and other techniques. An added benefit to employing a LID system is the filtering of the storm runoff that occurs before the runoff eventually drains into a river or other body of water¹.

Potential LID techniques that could be implemented in the Glen Echo Heights community are as follows (see Appendix Q for samples of LID techniques):

1. Disconnect the rooftops of homes through the use of water collection systems such as rain barrels while also asking local residents to remove the pipes allowing the rooftops to drain directly onto the streets and surface water courses, thereby allowing the water to sheet flow across the ground.
2. Convert existing concrete and asphalt swales into natural or bio swales in areas not prone to higher velocity flows where erosion would be an issue.

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

3. Initiate community outreach through the neighborhood associations in Glen Echo Heights asking for volunteers among residents who would be willing to plant rain gardens on their properties or who would be willing to use permeable pavements for their driveways.
4. Convert some two-way roads to one-way roads with select areas of on-street parking. On the newly converted one-way roads, the widths of the roads can be reduced by employing curb extensions with rain gardens planted within them or by adding grass swales along the road edges. This approach would also reduce the number of parking pads located within County right of way.

Without knowing the overall level of commitment of the community members in the implementation of LID techniques, it is impossible to provide a quantitative analysis of the possible benefits of implementation of these treatment methods. As part of a separate study, Montgomery County Department of Environmental Protection is in the process of investigating potential reductions in runoff associated with LID implementation.

Rooftop Disconnection

The use of roof drain disconnection within the Glen Echo Heights community could provide lengthening of the time of concentration for storm water runoff and aid to reduce peak discharges from smaller, more frequent storms. When used in conjunction with rain barrels, this technique has the possibility of capturing significant amounts of rainfall for dispersal over time into use as lawn watering, thereby promoting groundwater recharge. Even the removal of direct connection pipes to the hardened storm drainage system (discharging to inlets, hardened ditches, or curb and gutter) would promote groundwater recharge and attenuation of peak discharges for small storm events. Montgomery County Department of Environmental Protection (DEP) offers a free rain barrel program.

The disconnection of roof runoff would not be without potential impacts. Older homes with cinder block or brick foundations may have the possibility of increased seepage through foundation walls due to increased groundwater. All rain barrel installations must also be installed and maintained properly to prevent becoming mosquito breeding areas. Additionally, this technique will have very little impact on larger storms, including the 9 month to 1 year frequency water quality storm.

Bio-Swales

Another LID technique that could be implemented in Glen Echo Heights is converting concrete and asphalt swales into grass swales also known as bio-swales¹. Although the design constraint of a maximum longitudinal slope of 4% on grass swales² would eliminate many of the locations that contain existing swales, techniques such as check dams, planted rain gardens³ and other methods could be utilized to enable the use of grass swales in Glen Echo Heights. The main benefit of utilizing grass swales is the filtering of

sediments and heavy metals from the stormwater as well as reducing the volume of the runoff through infiltration into the subgrade.

Bio-Retention

Bio-retention, sometimes called rain gardens although there is a slight difference between the two, is an LID technique where plants and other vegetation, native to the area, known for their high water requirements are planted in shallow basins in the flow path of the storm runoff. The purpose of placing the plants in the flow path is to reduce the volume of the stormwater and filter the contaminants before the runoff drains into a natural body of water. While this LID method is usually placed strategically throughout a subdivision on County owned land, this is not possible in Glen Echo Heights because the community has already been developed and there is virtually no County owned land between houses.



Photo 17 – Glen Echo Heights

Therefore, rain gardens would need to be planted on private property downstream of the outfall of the roof downspouts and driveways of the homes. This strategy would best be employed in conjunction with the recommendation to disconnect the rooftops of the homes of the local residents. Additionally, it should be noted that these facilities are likely to have water ponded within them for up to 72 hours following their design storm. The regrading of the surrounding terrain near the rain gardens is especially important in Glen Echo Heights to reduce the

slope of the natural terrain that the community was built upon and should be done to reduce the potential for drainage issues, such as basement seepage, etc. Another reason why planting rain gardens in County owned land between homes may not be feasible, except in a few select locations, is due to the fact that most undeveloped areas are wooded and thus already possess vegetation, trees and shrubs, that would slow storm runoff if the rooftops were disconnected from draining directly into the drainage courses. Bioretention areas would need to be designed and sized for the appropriate drainage area in order to provide the expected benefits. **Any bioretention areas on private property would need to be maintained by the private property owner. At this time, Montgomery County Department of Environmental Protection has a program to assist property owners that wish to implement rain gardens on private property. Property owners are encouraged to take advantage of this program.**

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

Conversion of Impervious Surfaces

If some of the residents of Glen Echo Heights were willing to convert their driveways and other impervious areas to permeable pavements, then the amount of effective impervious area would be reduced within the community. For more information, please see Appendix E, Appendix J, and Appendix O. Permeable paving material includes, but is not limited to, the following materials⁴:

- Permeable Asphalt
- Permeable Concrete
- Grid Block Pavers
- Plastic Grids
- Vegetated Grids
- Belgium Block
- Turf Block
- Gravel
- Cobbles
- Brick
- Natural Stone

It should be noted that except for the first two bulleted items, the other listed materials should not be used as a single, homogenous building material but instead have patches of vegetation between them in a grid pattern.

These materials require maintenance to continue operating in their intended manner. Additionally, some of these materials are especially susceptible to freeze-thaw cycles, siltation, and clogging of infiltration pathways.

ROADWAY CHANGES

While most LID installations would typically require the cooperation of homeowners, and most likely be installed and maintained entirely by homeowners, there are some improvements that MCDPWT could do entirely within the existing roadway right of way to reduce runoff into the storm drainage conveyance in the Glen Echo Heights community. These efforts include the reduction of impervious area through roadway and parking pad reduction and the inclusion of rain gardens or other stormwater management within the right of way. These improvements will not ‘fix’ the drainage problems within the Glen Echo Heights community, but may provide some amount of reduction in runoff and improvement in water quality.

One-Way Streets

The conversion of some of the roads in Glen Echo Heights from two-way roads to one-way streets would be a way to reduce the overall pavement within the drainage area. This would allow DPWT to reduce the road widths of the converted streets. It could also

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

allow the planting of rain gardens in curb extensions or the addition of bio-swales along the edge of the roads. The benefits of this approach are:

1. Reduce the amount of impervious area
2. Increase the quality of the stormwater through infiltration
3. Reduce the quantity of the stormwater through infiltration
4. Solutions are entirely within the existing roadway right-of-way.

Some of the roads that could be converted to one-way roads include the following:

- Winnebago Road
- Wehawken Road
- Waukesha Road
- Wapakoneta Road
- Tuscarawas Road
- Namakagan Road

This recommendation needs to be fully evaluated by County Traffic and Fire and Safety Response Forces to determine any detrimental operation or safety issues. In addition, this approach may meet resistance from members of the community, but the overall environment would benefit from the reduction in the volume of storm runoff entering the drainage system as well as the reduction of untreated stormwater runoff. While conducting the field investigation of this project, we noted that many of the residents engage in walks around Glen Echo Heights with their pets and this alternative strategy would benefit these active members of the community, as one-way streets may prove to be safer for pedestrians.

Parking Pads

Another method for reducing runoff from the roadway right of way would be to either reduce the number of on-street parking pads, or replace them with a more pourous pavement. In general, the construction of parking pads adjacent to the county roadways is a practice that is not condoned by MCDPWT, and is done without a county permit. However, unless they are deemed to be a public safety hazard or are the subject of a written complaint, the County will not remove it from the Right-of-Way. An analysis of the on-street parking pads in Glen Echo Heights revealed that the total surface area equaled 36,046 SF or 0.83 acre (**see Chart 3 for more information**).

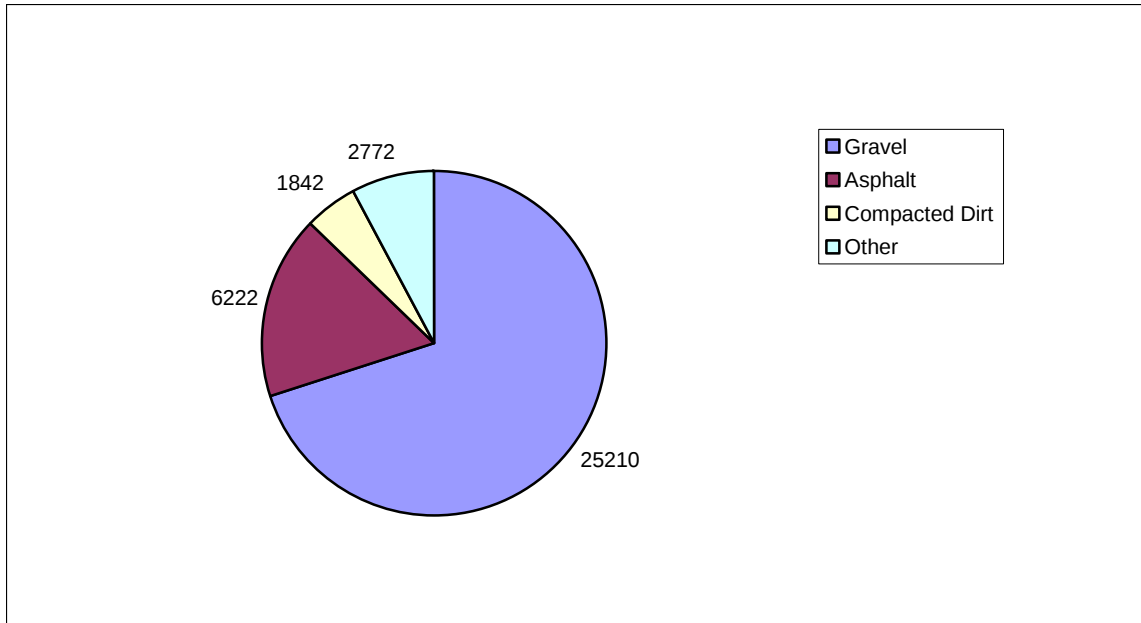


Chart 3 – Total Surface Area (SF) of Existing On-Street Parking Pads

V. CONCLUSION

As outlined in this report, there are numerous roadway and drainage challenges facing the Glen Echo Heights community. The focus of this report is the Drainage Improvements described above, and while the majority of the recommendations for improving these critical drainage issues consist of adding closed drainage systems, the use of LID techniques should be considered where feasible to enhance the drainage within the community. However, it must be noted that no single approach will solve all of the drainage problems within the community, and a multi-faceted approach must be employed to effect long-term improvement of the overall runoff and drainage situation. In addition to County-provided improvements, a successful outcome will require significant involvement and participation from the community. This would include, but not be limited to, construction of bio-retention / rain garden facilities on private property with public and / or private funds, voluntary disconnection of impervious surfaces from drainage courses, and dedication of right-of-way / easement to the county for construction of public drainage improvements.

A main area of concern that was recognized while performing this drainage study is that the incremental redevelopment pattern found in Glen Echo Heights may be representative of development patterns occurring elsewhere in the County. This is characterized by multiple property improvements, each falling below the threshold of stormwater management regulations, but having the cumulative effect of much larger development. If this is the case, Montgomery County should consider revising current permitting practices pertaining to the maximum allowable impervious area for the redevelopment of residential parcels.

APPENDIX A: ANALYSIS OF WALHONDING ROOFTOP AREA

Street Number	Street Name	Rooftop Area (SF)
6409	Walhonding Rd	2277
6405	Walhonding Rd	2441
6401	Walhonding Rd	1066
6327	Walhonding Rd	2713
6325	Walhonding Rd	1427
6321	Walhonding Rd	3460
6313	Walhonding Rd	1320
6305	Walhonding Rd	3599
6241	Walhonding Rd	1169
6237	Walhonding Rd	2230
6233	Walhonding Rd	1375
6229	Walhonding Rd	1664
6225	Walhonding Rd	1755
6221	Walhonding Rd	907
6219	Walhonding Rd	4209
6217	Walhonding Rd	1299
6215	Walhonding Rd	1902
6211	Walhonding Rd	2814
6205	Walhonding Rd	2375
6203	Walhonding Rd	2138
6201	Walhonding Rd	1850
6100	Walhonding Rd	3463
6101	Walhonding Rd	1569
6117	Walhonding Rd	2185
6113	Walhonding Rd	1744
6109	Walhonding Rd	1786
6105	Walhonding Rd	2758
6103	Walhonding Rd	1564
6101	Walhonding Rd	1680
6027	Walhonding Rd	1472
6023	Walhonding Rd	1616
6021	Walhonding Rd	1380
6017	Walhonding Rd	1403

APPENDIX A: Continued

Street Number	Street Name	Rooftop Area (SF)
6015	Walhonding Rd	1802
6011	Walhonding Rd	1743
6009	Walhonding Rd	3125
6005	Walhonding Rd	1730
6001	Walhonding Rd	2852
6004	Walhonding Rd	1539
6008	Walhonding Rd	2647
6012	Walhonding Rd	3541
6020	Walhonding Rd	1169
6022	Walhonding Rd	1270
6024	Walhonding Rd	1051
6100	Walhonding Rd	2563
6104	Walhonding Rd	1607
6108	Walhonding Rd	1576
6110	Walhonding Rd	2332
6112	Walhonding Rd	1258
6114	Walhonding Rd	1154
6200	Walhonding Rd	2457
6204	Walhonding Rd	6204
6208	Walhonding Rd	6208
6212	Walhonding Rd	6212
6216	Walhonding Rd	1630
6220	Walhonding Rd	1914
6224	Walhonding Rd	1550
6228	Walhonding Rd	1456
6232	Walhonding Rd	1455
6236	Walhonding Rd	1960
6240	Walhonding Rd	1905
6242	Walhonding Rd	4923
6300	Walhonding Rd	2052
6302	Walhonding Rd	3059
6304	Walhonding Rd	2035
6308	Walhonding Rd	1343
6306	Walhonding Rd	1136

APPENDIX A: Continued

Street Number	Street Name	Rooftop Area (SF)
6310	Walhonding Rd	1338
6312	Walhonding Rd	2945
6314	Walhonding Rd	1008
6316	Walhonding Rd	2995
6318	Walhonding Rd	2470
6320	Walhonding Rd	1723
6322	Walhonding Rd	1787
6522	Walhonding Rd	1316
6526	Walhonding Rd	1333
6530	Walhonding Rd	1538
6540	Walhonding Rd	1494

Total Area (SF)	167015
Total Area (acre)	3.83
Avg. Roof Area (SF)	2198

APPENDIX B: ANALYSIS OF WALHONDING DRIVEWAY AREA

Street Number	Street Name	Driveway Area (SF)
6409	Walhonding Rd	999
6405	Walhonding Rd	697
6401	Walhonding Rd	1857
6327	Walhonding Rd	801
6325	Walhonding Rd	2156
6321	Walhonding Rd	1234
6313	Walhonding Rd	847
6305	Walhonding Rd	1253
6241	Walhonding Rd	815
6237	Walhonding Rd	2230
6233	Walhonding Rd	541
6229	Walhonding Rd	1085
6225	Walhonding Rd	N/A
6221	Walhonding Rd	4908
6219	Walhonding Rd	2127
6217	Walhonding Rd	1502
6215	Walhonding Rd	2109
6211	Walhonding Rd	662
6205	Walhonding Rd	578
6203	Walhonding Rd	856
6201	Walhonding Rd	1727
6100	Walhonding Rd	N/A
6101	Walhonding Rd	1902
6117	Walhonding Rd	851
6113	Walhonding Rd	2257
6109	Walhonding Rd	N/A
6105	Walhonding Rd	1496
6103	Walhonding Rd	748
6101	Walhonding Rd	831
6027	Walhonding Rd	757
6023	Walhonding Rd	2127
6021	Walhonding Rd	1009
6017	Walhonding Rd	292

APPENDIX B: Continued

Street Number	Street Name	Driveway Area (SF)
6015	Walhonding Rd	913
6011	Walhonding Rd	1224
6009	Walhonding Rd	1612
6005	Walhonding Rd	743
6001	Walhonding Rd	697
6004	Walhonding Rd	735
6008	Walhonding Rd	1885
6012	Walhonding Rd	N/A
6020	Walhonding Rd	648
6022	Walhonding Rd	1439
6024	Walhonding Rd	865
6100	Walhonding Rd	1358
6104	Walhonding Rd	2553
6108	Walhonding Rd	920
6110	Walhonding Rd	848
6112	Walhonding Rd	896
6114	Walhonding Rd	1155
6200	Walhonding Rd	1133
6204	Walhonding Rd	1666
6208	Walhonding Rd	1005
6212	Walhonding Rd	3093
6216	Walhonding Rd	685
6220	Walhonding Rd	994
6224	Walhonding Rd	1455
6228	Walhonding Rd	650
6232	Walhonding Rd	1098
6236	Walhonding Rd	691
6240	Walhonding Rd	594
6242	Walhonding Rd	4885
6300	Walhonding Rd	772
6302	Walhonding Rd	3815
6304	Walhonding Rd	1490
6308	Walhonding Rd	1608
6306	Walhonding Rd	2975

APPENDIX B: Continued

Street Number	Street Name	Driveway Area (SF)
6310	Walhonding Rd	1130
6312	Walhonding Rd	2127
6314	Walhonding Rd	2129
6316	Walhonding Rd	1896
6318	Walhonding Rd	999
6320	Walhonding Rd	1105
6322	Walhonding Rd	2147
6522	Walhonding Rd	N/A
6526	Walhonding Rd	1475
6530	Walhonding Rd	1439
6540	Walhonding Rd	N/A

Total Area (SF)	102801
Total Area (acre)	2.36
Avg. Driveway Area (SF)	1428

APPENDIX C: ANALYSIS OF WALHONDING ON-STREET PARKING

Street Address	Gravel Parking Area (SF)	Asphalt Parking Area (SF)	Compacted Dirt Area (SF)
6540 Walhonding Rd		625	
6526 Walhonding Rd		216	
6522 Walhonding Rd		480	
6409 Walhonding Rd		540	
6409 Walhonding Rd	88		
6405 Walhonding Rd	128		
6401 Walhonding Rd	224		
6242 Walhonding Rd		428	
6237 Walhonding Rd		152	
6215 Walhonding Rd	960		
6211 Walhonding Rd	128		
6208 Walhonding Rd		200	
6112 Walhonding Rd	369		
6110 Walhonding Rd			15
6113 Walhonding Rd		192	
6108 Walhonding Rd		96	
6105 Walhonding Rd	540		
6023 to 6021 Walhonding Rd			788
6017 Walhonding Rd			327
6015 Walhonding Rd	132		
6015 to 6011 Walhonding Rd	669		
6012 Walhonding Rd	360		
6009 Walhonding Rd	320		
6008 to 6004 Walhonding Rd	1248		
6005 to 6001 Walhonding Rd	1485		

Total Area (SF)	10710
Gravel (SF)	6651
Asphalt (SF)	2929
Compacted Dirt (SF)	1130

APPENDIX D: ANALYSIS OF WALHONDING SURFACE AREA

Segment Length (ft)	Segment Width (ft)	Area (SF)
242	26	6292
365	20	7300
609	24	14616
425	26	11050
1116	26	29016
377	25	9425
594	26	15444
358	29	10382
349	24	8376

Total Road Surface Area (SF) 111901

Total Road Surface Area (acre) 2.57

APPENDIX E: ANALYSIS OF WALHONDING IMPERVIOUS AREA

Impervious Material	Area (SF)	Area (acres)
Driveway	102801	2.36
Rooftop	167015	3.83
On-Street Parking	10710	0.25
Roadway	111901	2.57

Total Area (SF) 392427

Total Area (acre) 9.01

APPENDIX F: ANALYSIS OF TUSCARAWAS ROOFTOP AREA

Street Number	Street Name	Rooftop Area (SF)
5300	Tuscarawas Rd	1039
5301	Tuscarawas Rd	1058
5302	Tuscarawas Rd	1614
5303	Tuscarawas Rd	748
5304	Tuscarawas Rd	1651
5305	Tuscarawas Rd	1916
5307	Tuscarawas Rd	1602
5309	Tuscarawas Rd	2677
5311	Tuscarawas Rd	1245
5310	Tuscarawas Rd	1789
5312	Tuscarawas Rd	1274
5313	Tuscarawas Rd	1285
5315	Tuscarawas Rd	2449
5317	Tuscarawas Rd	2372
5314	Tuscarawas Rd	2620
5319	Tuscarawas Rd	1739
5316	Tuscarawas Rd	1398
5321	Tuscarawas Rd	1887
5318	Tuscarawas Rd	1417
5323	Tuscarawas Rd	1826
5325	Tuscarawas Rd	2160
5320	Tuscarawas Rd	2277
5322	Tuscarawas Rd	1213
5400	Tuscarawas Rd	2051
5402	Tuscarawas Rd	3093
5401	Tuscarawas Rd	1420
5404	Tuscarawas Rd	2497
5406	Tuscarawas Rd	2846
5405	Tuscarawas Rd	2180
5408	Tuscarawas Rd	2149
5409	Tuscarawas Rd	4990
5410	Tuscarawas Rd	1644

Total Area (SF)	62126
Total Area (acre)	1.43
Avg. Roof Area (SF)	1941

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

ANALYSIS G: ANALYSIS OF TUSCARAWAS DRIVEWAY AREA

Street Number	Street Name	Driveway Area (SF)
5300	Tuscarawas Rd	579
5301	Tuscarawas Rd	494
5302	Tuscarawas Rd	578
5304	Tuscarawas Rd	575
5305	Tuscarawas Rd	925
5307	Tuscarawas Rd	1303
5309	Tuscarawas Rd	623
5311	Tuscarawas Rd	955
5310	Tuscarawas Rd	1503
5313	Tuscarawas Rd	641
5315	Tuscarawas Rd	701
5317	Tuscarawas Rd	779
5314	Tuscarawas Rd	1812
5319	Tuscarawas Rd	883
5316	Tuscarawas Rd	1146
5321	Tuscarawas Rd	597
5318	Tuscarawas Rd	703
5323	Tuscarawas Rd	837
5320	Tuscarawas Rd	814
5322	Tuscarawas Rd	1509
5400	Tuscarawas Rd	2248
5402	Tuscarawas Rd	783
5404	Tuscarawas Rd	4507
5406	Tuscarawas Rd	3201
5405	Tuscarawas Rd	1367
5408	Tuscarawas Rd	1874
5409	Tuscarawas Rd	1371
5410	Tuscarawas Rd	1925
6100	Walhonding Rd	805

Total Area (SF)	36038
Total Area (acre)	0.83
Avg. Driveway Area (SF)	1243

ANALYSIS H: ANALYSIS OF TUSCARAWAS ON-STREET PARKING

Street Address	Gravel Parking Area (SF)	Asphalt Parking Area (SF)	Compacted Dirt Area (SF)	Stone Area (SF)
5303 Tuscarawas Rd	560			
5310 Tuscarawas Rd		438		
5312 Tuscarawas Rd		100		
5318 Tuscarawas Rd				300
5318 Tuscarawas Rd			300	
5323 Tuscarawas Rd		216		
5320 Tuscarawas Rd	450			
5402 Tuscarawas Rd		320		

Total Area (SF) 2684

Gravel (SF) 1010

Asphalt (SF) 1074

Compacted Dirt (SF) 300

Stone (SF) 300

APPENDIX I: ANALYSIS OF TUSCARAWAS SURFACE AREA

Segment Length (ft)	Segment Width (ft)	Area (SF)
250	26	6500
50	25	1250
500	24	12000
150	22	3300
75	24	1800
125	33	4125
100	25	2500
100	28	2800
350	25	8750

Total Surface Area (SF) 43025

Total Surface Area (acre) 0.99

APPENDIX J: ANALYSIS OF TUSCARAWAS IMPERVIOUS AREA

Impervious Material	Area (SF)	Area (acre)
Driveway	36038	0.83
Rooftop	62126	1.43
On-Street Parking	2684	0.06
Roadway	43025	0.99

Total Area (SF) 143873

Total Area (acre) 3.30

APPENDIX K: ANALYSIS OF ROOFTOP AREA FOR ALEXANDER

Street Number	Street Name	Rooftop Area (SF)
6655	Alexander Rd	1497
6665	Alexander Rd	2631
6671	Alexander Rd	3816
6677	Alexander Rd	3383
6691	Alexander Rd	2029
6699	Alexander Rd	3103
6693	Alexander Rd	3289

Total Area (SF)	19748
Total Area (acre)	0.45
Avg. Roof Area (SF)	2821

APPENDIX L: ANALYSIS OF ROOFTOP AREA FOR IROQUOIS

Street Number	Street Name	Rooftop Area (SF)
5206	Iroquois Rd	1519
5208	Iroquois Rd	1618
5210	Iroquois Rd	1893
5300	Iroquois Rd	811
5302	Iroquois Rd	1038
5304	Iroquois Rd	1435
5306	Iroquois Rd	1702
5308	Iroquois Rd	819
5207	Iroquois Rd	1743
5301	Iroquois Rd	1277
5305	Iroquois Rd	2554
5307	Iroquois Rd	1399
5309	Iroquois Rd	1043
5311	Iroquois Rd	1578
5313	Iroquois Rd	1471

Total Area (SF)	21900
Total Area (acre)	0.50
Avg. Roof Area (SF)	1460

APPENDIX M: ANALYSIS OF ROOFTOP AREA FOR NAMAKAGAN

Street Number	Street Name	Rooftop Area (SF)
6001	Namakagan Rd	2059
6007	Namakagan Rd	1455
6011	Namakagan Rd	2240
6013	Namakagan Rd	1346
6015	Namakagan Rd	1590
6101	Namakagan Rd	1511
6103	Namakagan Rd	2313
6107	Namakagan Rd	1484
6111	Namakagan Rd	1239
6114	Namakagan Rd	1700
6112	Namakagan Rd	1046
6104	Namakagan Rd	1426
6102	Namakagan Rd	2025
6100	Namakagan Rd	1533
6016	Namakagan Rd	2803
6014	Namakagan Rd	2546
6012	Namakagan Rd	2007
6010	Namakagan Rd	2066
6008	Namakagan Rd	1193
6000	Namakagan Rd	2919

Total Area (SF)	36501
Total Area (acre)	0.84
Avg. Roof Area (SF)	1825

APPENDIX N: ANALYSIS OF ROOFTOP AREA FOR WAPAKONETA

Street Number	Street Name	Rooftop Area (SF)
5006	Wapakoneta Rd	2837
5100	Wapakoneta Rd	2722
5104	Wapakoneta Rd	2827
5108	Wapakoneta Rd	2751
5112	Wapakoneta Rd	2267
5116	Wapakoneta Rd	3182
5118	Wapakoneta Rd	2328
5200	Wapakoneta Rd	2573
5204	Wapakoneta Rd	2154
5208	Wapakoneta Rd	1635
5210	Wapakoneta Rd	1345
5212	Wapakoneta Rd	1679
5214	Wapakoneta Rd	1993
5220	Wapakoneta Rd	1698
5304	Wapakoneta Rd	2365
5308	Wapakoneta Rd	1836
5312	Wapakoneta Rd	2910
5316	Wapakoneta Rd	1086
5320	Wapakoneta Rd	1155
5324	Wapakoneta Rd	1528
5328	Wapakoneta Rd	1032
5332	Wapakoneta Rd	1412
5336	Wapakoneta Rd	1697
5325	Wapakoneta Rd	2613
5319	Wapakoneta Rd	1893
5317	Wapakoneta Rd	3405
5315	Wapakoneta Rd	1551
5313	Wapakoneta Rd	1473
5311	Wapakoneta Rd	1475
5309	Wapakoneta Rd	1602
5307	Wapakoneta Rd	1797
5305	Wapakoneta Rd	1829
5219	Wapakoneta Rd	1853

APPENDIX N: Continued

Street Number	Street Name	Rooftop Area (SF)
5217	Wapakoneta Rd	2312
5215	Wapakoneta Rd	1719
5211	Wapakoneta Rd	4325
5209	Wapakoneta Rd	1930
5205	Wapakoneta Rd	2748
5119	Wapakoneta Rd	2066
5117	Wapakoneta Rd	1288
5113	Wapakoneta Rd	1681
5101	Wapakoneta Rd	1960
5007	Wapakoneta Rd	1656
5005	Wapakoneta Rd	2328

Total Area (SF) 90516

Total Area (acre) 2.08

Avg. Roof Area (SF) 2057

APPENDIX O: ANALYSIS OF COMMUNITY ON-STREET PARKING

Street Name	Gravel Area (SF)	Asphalt Area (SF)	Compacted Dirt Area (SF)	Other Material Area (SF)
Iroquois Rd	2114	530		
Madawaska Rd	5425		412	1502
Wapakoneta Rd	890			
Waneta Rd	928			
Wehawken Rd	4485	363		
Namakagan Rd	636			177
Winnebago Rd	636	1326		
Tuscarawas Rd	1010	1074	300	300
Waukesha Rd	2247			
Wissiomining Rd				605
Wyoming Ct	188			188
Walhonding Rd	6651	2929	1130	

Total Area (SF) 36046

Total Area (acre) 0.83

ROADWAY AND DRAINAGE STUDY – GLEN ECHO HEIGHTS

APPENDIX P: PAVEMENT CORE DATA FROM GLEN ECHO HEIGHTS

Core Number	Location	Core Depth	Core Condition	Subgrade
1	6111 Wiscasset Road	<u>6.1" Total</u> 2.1" hma / 4" pcc	Poor (4" pcc contaminated w/soil pockets)	Sandy Soil
2	6200 Walhonding Road	<u>8.75" Total</u> 2" hma / 4.75" pcc	Good	Sandy Soil
3	5419 Waneta Road	<u>2.25" Total</u> hma only	Fair	Aggregate ③
4	5304 Waneta Road	<u>7.75 " Total</u> 2.5" hma / 5.25" pcc	Good	Soil
5	6240 Walhonding Road	<u>7.75" Total</u> hma only	Good	Aggregate
6	6530 Walhonding Road	<u>2.25" Total</u> hma only	Fair	Soil mixed w/ Stone
7	6327 Walhonding Road	<u>4.25" Total</u> hma only	Fair	Aggregate
8	5225 Wyoming Road	<u>6.5" Total</u> hma only	Good	Soil
9	5202 Wyoming Road	<u>8.5" Total</u> 3" hma / 3.25" pcc	Good	Soil
10	5305 Tuscarawas Road	<u>4.5" Total</u> hma only	Fair	Aggregate
11	5217 Wissioming Road	<u>5" Total</u> hma only	Fair/Good	Soil
12	6227 Madawaska Road	<u>1.5" Total</u> hma only	Fair	Aggregate
13	5126 Wyoming Court	<u>5" Total</u> aggregate only	N/A	Soil
14	5121 Wyoming Court	<u>2.25" Total</u> hma only	Fair	Soil mixed w/ Stone
15	Int. Wissioming and Waukesha Road	<u>9" Total</u> hma only	Good	Soil
16	5133 Waukesha Road	<u>3.5" Total</u> hma only	Poor	Soil
17	5125 Wissioming Road	<u>1.6" Total</u> hma only	Fair	Aggregate

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18	6113 Madawaska Road	<u>4.5" Total</u> hma only	Fair	Aggregate
Continued ↓				
19	5113 Wehawken Road	<u>9" Total</u> 3" hma/6" pcc	Good	Soil
20	5116 Wapakoneta Rd	<u>5.25" Total</u> hma only	Good	Soil
21	6016 Madawaska Road	<u>7.9" Total</u> hma only	Good	Soil
22	5206 Wehawken Road	<u>7" Total</u> hma only	Good	Soil
23	5214 Wapakoneta Rd	<u>9.9" Total</u> 2.9"hma/7"pcc	Good	Soil
24	6007 Namakagan Road	<u>5" Total</u> 1"hma / 4" tar&chip	Poor	Unknown ④
25	5305 Wapakoneta Rd	<u>3" Total</u> 1"hma / 2" tar&chip	Poor	Unknown ④
26	5336 Wapakoneta Rd	<u>6" Total</u> 2"hma / 4"tar&chip	Poor	Unknown ④
27	6015 Walhonding Rd	<u>5.5" Total</u> hma only	Fair	Aggregate
28	5413 Wehawken Road	<u>3" Total</u> hma only	Poor	Aggregate
29	6114 Namakagan Road	<u>4.5" Total</u> hma only	Fair	Aggregate
30	5301 Iroquois Road	<u>3.75" Total</u> hma only	Fair	Aggregate
31	5409 Tuscarawas Road	<u>6.5" Total</u> 2.25"hma / 4.25" pcc	Good	Soil
32	6655 Wapakoneta Road	<u>7" Total</u> hma only	Fair/Good	Aggregate
33	6691 Alexander Road	<u>5" Total</u> hma only	Fair	Soil

Note: ① Some core locations were adjusted based on accessibility, safety, and/or field conditions.

② Cored specimens will be available (for observation) at the MCDPWT Lab until 4/30/07, at which time they will be discarded.

③ Aggregate beneath cored specimen undermined leaving the cored hole full of water from coring activities.

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- ④ The large aggregate used for tar & chip layer caused the core drill to lock-up; as a result, determination of subgrade material was not determined.

Clarification: hma (hot mix asphalt), pcc (portland cement concrete), aggregate (aggregate particles that are undefined with various compositions)

APPENDIX Q: REFERENCES

- ¹ Whole Building Design Guide – Low Impact Development Technologies. 2007.
Website: <http://www.wbdg.org/design/lidtech.php>
- ² Maryland Department of the Environment, “2000 Stormwater Management Design Manual”
- ³ U.S. Environmental Protection Agency, Office of Water, Low-Impact Development Center, “Low Impact Development (LID) – A Literature Review”, October 2000
- ⁴ University of Rhode Island Porous Pavement Publications: Website:
<http://www.uri.edu/ce/wq/publications.htm#Pavements>

Examples of Rain Gardens



Prarie Garden – Photo used with permission of The City of Maplewood, Minnesota

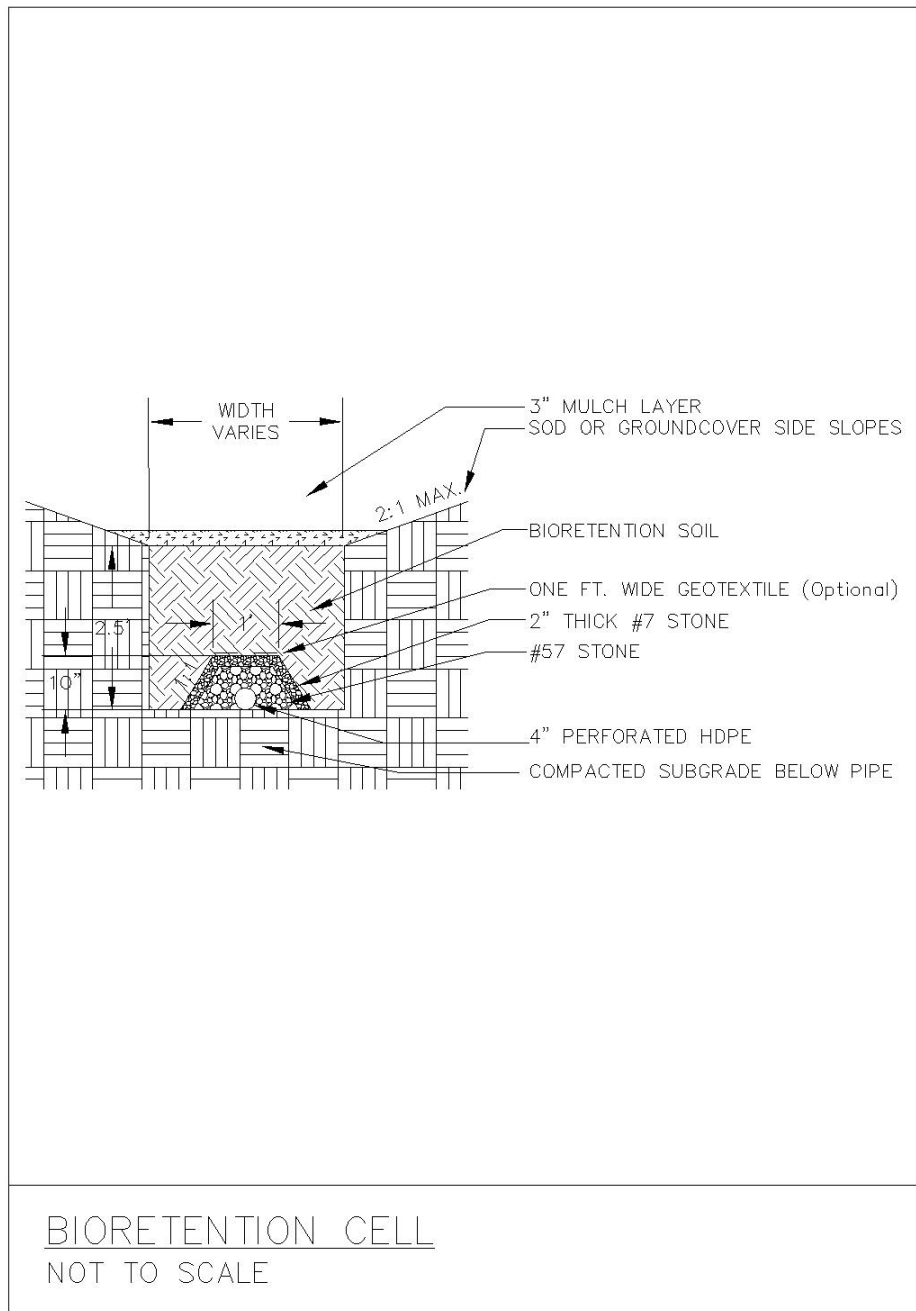
Uses plants that are hardy and native to the area, this type of garden is for use in areas of full sun.



Shrub Garden – Photo used with permission of The City of Maplewood, Minnesota

Placed in partial sunlit areas, this garden is low maintenance

Bioretention Cell



Bioretention cell section. Perforated HDPE pipe must outfall to a ditch or closed drainage system.