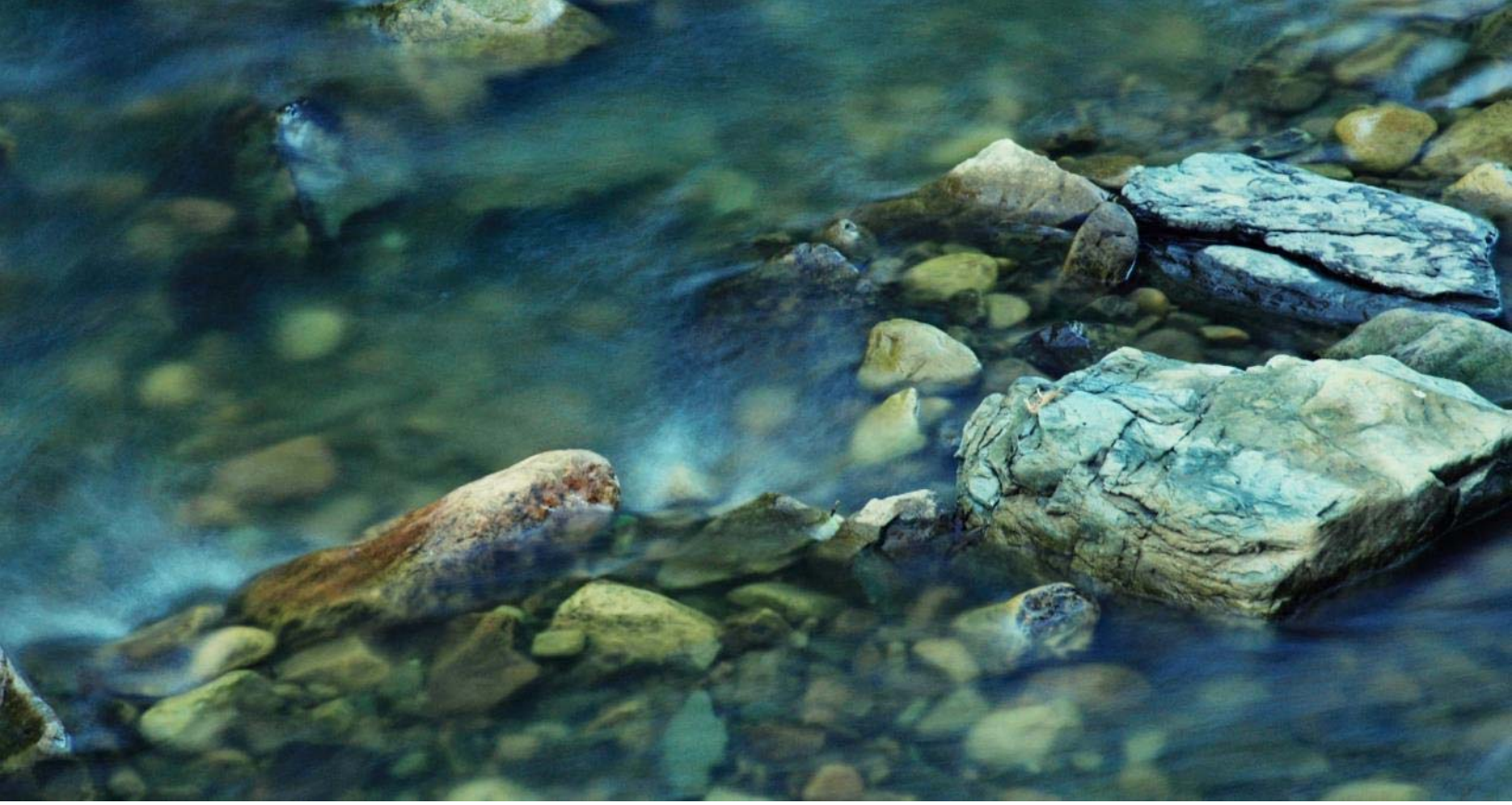

April 2018

ANCHOR QEA

Vanderbilt Road Drainage Study

Prepared for the Town of Biltmore Forest

April 2018

Vanderbilt Road Drainage Study

Prepared for
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Town of Biltmore Forest
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1 Background

Anchor QEA of North Carolina, PLLC, understands that residents of the Town of Biltmore Forest with homes west of Vanderbilt Road have experienced increased storm runoff and erosion conditions in recent years. Anchor QEA personnel met with Mr. Jonathan Kanipe and Mr. Terry Crouch of the Town of Biltmore Forest to review drainage conditions along a portion of the Vanderbilt Road (the Site). During our Site visit, we observed measures that had been installed in an attempt to control runoff, including asphalt curbs.

Following this visit, we developed maps using Buncombe County Geographic Information System (GIS) to determine the acreage, gradient, land uses, stormwater conveyance channels, and drainage areas that drain to the subject area (See Figures 1 and 2). The soil type was determined from the U.S. Department of Agriculture (USDA) Natural Resources Conservation Service (NRCS) web soil survey and is included as Appendix A.

After compiling this preliminary data, Anchor QEA conducted a subsequent site visit to review existing conditions (e.g., evaluate drainage patterns, measure approximate channel cross sections, and similar) and gather additional data. That data is summarized in the report below. All culvert capacity evaluations use a slope extrapolated from Buncombe County GIS contour grade along the channel, an approximate length gathered from the shape file of pipes we received from the Town of Biltmore Forest, and a 12% impervious drainage area, which is based on residential districts with an average of 2-acre lot size. It is important to note that, due to the expense, stormwater management systems are rarely designed to handle all storm events. Regulatory agencies (e.g., County, State Department of Transportation, and similar) typically require increasingly stringent design parameters as the potential for impact to transportation facilities; property; and health, safety, and welfare of the public increases. The North Carolina Department of Transportation (DOT) requirement for the design of cross-culverts under minor arterials, collectors, and local roads is that they must be designed to carry the 25-year, 24-hour storm.

2 Summary of Observations

This report includes our evaluation of the drainage features and conditions along Vanderbilt Road from ~2100 feet north of Cedarcliff Road south to Busbee Road in the Town of Biltmore Forest, North Carolina. For organizational purposes, we have divided the subject area into three sections: 1) ~2100 feet north of Cedarcliff Road to Cedarcliff Road 2) from Cedarcliff Road south approximately 1400 feet to the high point of the road (between the driveways for 328 and 330 Vanderbilt Road), and 3) from the high point south to Busbee Road.

2.1 Study Section 1

This study begins on Vanderbilt Road approximately 2100 feet north of Cedarcliff Road. This is near a high point in Vanderbilt Road close to house number 292. At this point there is a stable roadside swale along both sides of Vanderbilt Road. Traveling south along Vanderbilt Road toward the next low point, there is a culvert east of Vanderbilt Road that traverses below two private driveways (294 and 296). This is an approximately 15-inch-diameter corrugated metal pipe (CMP) that coveys flow to the south. From inspection of the visible ends of the culvert, it appeared to be open and functioning properly. Just south of the driveway for house number 296, the culvert discharges into a junction box with the top above the surrounding grade. This junction box has a 24-inch terracotta outlet that conveys flow to the west under Vanderbilt Road toward stormwater channel (SC) 2A. Stormwater conveyance channels are shown on Figure 1. Based on visual inspection of the ends, this terracotta culvert appeared to be clear of debris and functioning properly. Our preliminary analysis determined that this culvert can pass the 25-year storm, but larger storm events will result in a condition where the inlet restricts the inflow into the culvert and results in accumulation/ponding of storm runoff east of Vanderbilt Road.

Continuing south on Vanderbilt Road, there is a swale along the east side of the road and the conditions on the west side of the road vary from initially having a roadside swale to sloping off an embankment near the driveway to house number 307. Stormwater from the swale on the west side of Vanderbilt Road flows southwest across the ground surface on the north side of house number 307. Flow is also conveyed aboveground on the south side of house 307 between houses 307 and 309. Two concrete drop inlets were observed in the landscape area between the driveways of houses 307 and 309. Evaluation of these inlets and pipes was not within this scope of work; however, they appeared too small to convey the runoff in this area. Moving farther south along Vanderbilt Road, a 24-inch terracotta culvert conveys flow from east to west below the Road. We were unable to locate the upstream end of this culvert. The downstream end was approximately half-full of sediment and discharged into the southeast corner of the lot containing house number 309. Our preliminary analysis indicates that, if this pipe were free of debris and sediment, it would pass the 25-year event, but larger events would result in a condition where the inlet would restrict the inflow into the culvert

and result in accumulation/ponding of storm runoff east of Vanderbilt Road. It is unlikely that it would pass the 25-year event in its current condition.

Just downstream from the discharge point of the culvert, there is a stone headwall with a drop inlet installed to receive the discharge from the 24-inch terracotta culvert. The drop inlet has an 8-inch corrugated plastic pipe (CPP) outlet that coveys flow northwest through the south yard of house 309. It passes very close to the southwestern corner of the house, before discharging west of the house in an open channel. Flows from the drainage north of house 307 and south of 307 (between 307 and 309) join to form SC 2B. There are four additional small, plastic yard inlets along this 8-inch CPP. We understand that this area has been the source of reoccurring stormwater problems and have video footage showing flooding that has exceeded the capacity of the inlet and pipe system. Preliminary analysis indicates that this 8-inch CPP system is unable to carry the 2-year storm event. This condition is exacerbated by the fact that the topography along the southern side of house 309 does not have a well-defined swale, and surface flow that is not conveyed through the 8-inch CPP system flows close to (or in contact with) the house. Recommendations for upgrading this system will be discussed below.

Continuing south on Vanderbilt Road, we observed that the 6-inch iron culvert under the driveway to house number 311 was fully obstructed. The 6-inch terracotta culvert under the driveway to house 313 was also fully obstructed. South of the driveway to house 313, areas of instability along the edges of the road were observed that have likely occurred when drivers allowed the vehicle they were driving to leave the pavement.

Just south of the driveway to house number 313, a culvert crosses under Vanderbilt Road to carry runoff west into SC 3. The upstream and downstream ends of this culvert are both completely obstructed. We were unable to determine the size and material of this culvert because it was completely buried by sediment. Just to the south of this point is the intersection of Vanderbilt Road and Cedarcliff Road.

2.2 Study Section 2

2.2.1 Cedarcliff Road

The following section describes the infrastructure along Cedarcliff Road, starting at the northeast end at the intersection with US Hwy 25 and traveling southwest toward Ram Branch.

At the northeastern end of Cedarcliff Road, near the intersection with US Hwy 25, there is a small brick headwall at the opening of a 15-inch CMP. The Town of Biltmore Forest provided Anchor QEA a shapefile of the Town's stormwater infrastructure that shows this pipe traveling southwest along the south side of Cedarcliff Road to Ram Branch. We were unable to verify this full alignment from our visual inspection. There is evidence of preferential flow under the inlet of the pipe at the brick

headwall. Traveling southwest along Cedarcliff Road and downstream along the assumed alignment of this CMP, there is a partially collapsed drop inlet located approximately 230 feet southwest of the intersection of Hwy 25 and Cedarcliff Road. The upstream portion of SC 3 is visible south of Cedarcliff Road approximately 380 feet southwest of Hendersonville Road. It enters a 15-inch CMP where it is assumed to connect to the roadside CMP along Cedarcliff Road. We were unable to verify this in the field. Based on our preliminary evaluation, this 15-inch CMP is undersized and unable to carry runoff from the 10-year event.

Just east of the intersection of Cedarcliff and Vanderbilt Roads, there is a drop inlet that connects to the CMP along the south side of Cedarcliff. A storm pipe along the east side of Vanderbilt Road conveying flow northward connects to the system in Cedarcliff Road but we were not able to locate the junction. This pipe may connect to the system in Cedarcliff Road by a tee or a junction box with no aboveground access.

After crossing Vanderbilt Road to the southwest there is another drop inlet on the stormwater system along the south side of Cedarcliff. An asphalt curb has been installed along the north side of Cedarcliff Road. The curb continues from the intersection at Vanderbilt Road southwest to the gated driveway at house number 7 on Cedarcliff Road. There appears to be a culvert below the driveway to House number 7 but it could not be located. It may be overgrown by vegetation or buried below rubble that was observed on the property.

Continuing along the south side of Cedarcliff Road there are three more inlets that connect to the stormwater system on the south side of Cedarcliff Road. Based on information provided by The Town of Biltmore Forest, we understand this system continues almost to the Cedarcliff bridge across Ram Branch before crossing to the north side of Cedarcliff Road and discharging into Ram Branch. We observed a 12-inch terracotta pipe in this area, but we were unable to determine if this was the discharge of the above-described system. If this is the discharge of the system that collects the runoff from Cedarcliff Road, this system is significantly undersized and unable to carry runoff from the 25-year event. Based on the lack of information we have about the pipe that runs along the south side of Cedarcliff Road we cannot confidently evaluate its capacity. However, we believe it is likely undersized and further investigation should be performed to determine its condition.

On the north side of Cedarcliff Road, just downhill of the driveway to house number 7, is the first stone-covered drop inlet in a stormwater system that runs parallel to Cedarcliff Road along its north side. The second inlet is just uphill (northwest) of the driveway to house number 9. The third inlet in this system is just downhill from the driveway to house number 11. All three of these inlets are stone topped and clear of debris; however, we were unable to observe the pipe size and material. The fourth and final inlet in the system on the north side of Cedarcliff is a yard inlet just northeast of the bridge over Ram Branch. This is a small yard inlet that was not clogged but not in a well-defined

ditch line. From there, this system discharged into Ram Branch. We observed a 12-inch terracotta pipe in this area but could not confirm if it was the discharge from this system.

2.2.2 Vanderbilt Road South of Cedarcliff Road

Standing at the intersection of Cedarcliff and Vanderbilt Roads looking south down Vanderbilt Road, there is a stormwater system, mentioned above, present along the eastern edge of Vanderbilt Road. The system joins to the above-discussed CMP along the south side of Cedarcliff Road. The system consists of an approximately 6-inch diameter terracotta pipe with 4 drop inlets. Two of these drop inlets are fully obstructed. Based on our preliminary evaluation, this system is undersized and unable to carry runoff from the 10-year event.

An unvegetated ditch is located along the west side of Vanderbilt Road just south of the intersection with Cedarcliff and Vanderbilt Roads. This ditch flows to the north and should be stabilized to prevent erosion.

Approximately 650-feet farther south along Vanderbilt Road a 24-inch terracotta culvert crosses under the road just south of the driveway to house number 322. This culvert carries runoff in SC 4. The upstream end is unobstructed; however, the downstream end is approximately 60% obstructed and should be cleaned out. The ditch downstream from the outlet is also obstructed by sediment and debris and should be excavated and stabilized. Based on our preliminary evaluation, even if this system were cleaned, it would remain undersized and unable to carry runoff from the 25-year event.

Just to the south of this culvert along the east side of Vanderbilt Road is a stormwater system consisting of a 12-inch terracotta pipe and three inlets. The outlet is half-filled with sediment and it discharges just south of the 24-inch terracotta culvert under Vanderbilt Road.

2.3 Study Section 3

Just south of the driveway to house number 329 on Vanderbilt Road is a small high point in the ditch line on the east side of Vanderbilt Road. Approximately 150-feet south of this point is a 24-inch terracotta culvert that conveys SC 5 under Vanderbilt Road. The upstream end of the culvert has been extended with a CMP that has rusted through the bottom. The downstream end has eroded the receiving channel and needs velocity dissipation. Based on our preliminary evaluation, this system is undersized and unable to carry runoff from the 25-year event.

A 12-inch terracotta pipe collection system along the east side of Vanderbilt road contributes drainage to SC 5. This 12-inch terracotta system collects drainage from three drop inlets.

There is an asphalt curb along the west side of Vanderbilt Road that extends from the driveway to house number 331 to just past the driveway to house number 335. This asphalt curb is preventing flow from entering SC 6 between house 333 and 335.

3 Recommendations

3.1 Overall Recommendations

Based on our investigation as described in this report, Anchor QEA recommends the following steps:

- Periodically inspect drop inlets, culverts, and ditch lines to ensure they are free of debris and functioning properly. Driveways culverts that may be outside of the maintenance jurisdiction of the Town should be cleared and properly maintained to facilitate correct operation of the roadway drainage system.
- A subsurface closed-circuit television (CCTV) investigation is advised to clarify the uncertainties related to alignments and to evaluate the condition of the pipes and joints that cannot be inspected from the surface.
- Ensure all ditch lines are stabilized to prevent erosion. The preferred manner of stabilizing channels is through the application of geotextile matting and grass seed.
- Install velocity dissipation at the downstream end of culverts. This typically includes flared end sections and riprap aprons. The latter should be sized in accordance with the *North Carolina Erosion and Sediment Control Planning and Design Manual* (North Carolina Sedimentation Control Commission, et al 2013).
- The Town should budget to repair or replace CMP culverts. These corrugated metal culverts have a limited lifespan, many are showing significant rust, and their failure can create sink-holes, flooding, and road closures. If repair work is scheduled prior to failure, CMP culverts can often be repaired by slip-lining, a process where a smooth wall pipe is inserted into the CMP and then grouted in place. The cost of repair is typically lower and less intrusive than replacement. Culverts should only be replaced with culverts of the same flow capacity. Even where undersized culverts exist now, these should only be replaced with those of the same flow capacity. Replacing undersized culverts with higher flow capacity culverts without providing detention or other mitigation measures may result in increased flooding on the downstream land owner.
- Install a 2-foot wide reinforced shoulder on the edges of Vanderbilt Road and Cedarcliff Road. A reinforced edge along the pavement surface will serve to support and prevent raveling of the asphalt pavement and reduce erosion of runoff flowing parallel to the pavement edge. Examples of a reinforced shoulder include but are not limited to: a simple compacted aggregate base course or a permeable paver block backfilled with a seeded soil and aggregate mix.
- Remove asphalt curb that extends from the driveway to house number 331 to just past the driveway to house number 335. This asphalt curb is preventing flow from entering SC 6 between house 333 and 335. Asphalt water bars installed in the driveways would allow water to flow to SC 6. Allowing the runoff to enter SC-6 would reduce the runoff volume at the end

of the asphalt curb and restore the natural hydrology that previously existed in this area. Grading and/or structural stormwater measures that were not properly constructed when the residence was constructed may be necessary to direct the runoff around the residence at 333 Vanderbilt Road.

3.2 Specific Recommendations for SC 2B and Houses 307 and 309

We understand that the area around houses 307 and 309 on Vanderbilt road has been a source of ongoing stormwater issues. Most of these issues are on private property and likely outside of the responsibility of the Town of Biltmore Forest.

There is a 24-inch terracotta culvert under Vanderbilt Road that discharges between house 309 and 311. We were unable to locate the upstream end and the downstream end was approximately half full of sediment. This should be cleaned out to restore full function; however it should be noted that this maintenance may result in increased discharge not recently experienced from this culvert. The upstream end of this culvert would be a possible location to create temporary stormwater storage (aka detention storage). Based on our review of Buncombe County GIS parcel lines, we believe it would have to be located on private property and would require property owner support and cooperation. Installing detention storage would provide many benefits including reducing the peak rate of runoff, encouraging infiltration, reducing localized flooding, reducing erosion downstream, and would provide water quality benefits. The temporary storage would become inundated during rainfall events and remain inundated for a short period after rainfall; however, assuming proper maintenance, it would not create conditions necessary for wetland plants or mosquito growth. Although beneficial, we do not believe the Town is under any requirement to provide stormwater detention in this area.

This pipe under Vanderbilt Road discharges into a swale that is directed toward a small yard inlet with a 6-inch CPP outlet. This private system is significantly undersized and appeared to not be properly maintained. One way to fix the flooding issues on the south side of house 309 would be to regrade the south side of that property to provide a well-defined swale that keeps stormwater runoff on the surface of the ground, far from the footprint of house 309. This would require grading the side yard to provide positive drainage away from the house and could require a retaining wall to avoid grading on neighboring property or impacting large trees. It is likely that this would result in impacts to some trees in this area. Another option would be to upsize the private stormwater system to be able to accommodate higher flows. Given the potential for inundation of the structure, we would normally size this system for the 100-year storm event or larger. This option should also be coupled with minor grading to provide positive drainage away from the house. Estimating rainfall is based on probability, and thus designing and constructing the largest possible collection system may not provide protection against all storms.

Another source of stormwater issues in this area is the flow between houses 307 and 309. The driveways to these houses are relatively close together and there are several trees in the landscaped area between the driveways. There is a poorly defined swale between the driveways that may not be receiving the runoff from Vanderbilt Road and the driveways. There is an asphalt water bar in the driveway to house 307 that directs runoff towards the landscape area between the driveways. The drainage in this area would benefit from a more defined swale between the driveways and additional asphalt water bars that direct runoff into the swale. Improving the swale between the driveways would result in substantial impacts to existing large trees. At the bottom of the two driveways is a drop inlet with a CPP outlet. It was difficult to determine how much drainage area this inlet received. The grading of the asphalt and landscape areas at the bottom of the driveways appeared to be relatively flat and may slope toward the house in some places or may result in runoff directed toward the house during high-intensity storms. A detailed topographic survey would be required to confirm the grades. To correct grading in this area, the existing asphalt would have to be removed, the subgrade regraded to provide positive drainage, and new pavement installed. Regrading this area would provide positive drainage to an inlet, and runoff would more effectively be conveyed between the houses to the channel to the west.

North of house number 307 is a drainage that flows very close to the house. It would be beneficial to regrade the channel in this area to provide positive drainage away from the house and keep the swale farther from the building footprint. The separation distance is dependent on the amount of water that may flow through this area under the design storm event. Here again, the 100-year event would be the minimum that we recommend for use when a residential structure is at risk of flooding.

The channel behind houses 307 and 309 that receives stormwater from the systems described above shows signs of incising. This is a condition where a river or a stream cuts downward through its bed. The stormwater detention recommended above would provide a reduction in peak flow and velocity and thus benefit this area as well. Regardless of the possibility of detention and given the level of incision and lack of vegetation/stabilization, it would be beneficial to restore and stabilize the channel to prevent continued erosion and incision.

4 References

North Carolina Sedimentation Control Commission, et al, 2013. *Erosion and Sediment Control Planning and Design Manual*. May 2013.

Figures

TRIBUTAIRY	DRAINAGE AREA	ACRES
SC 1	DA-1	13.75
	Total	**13.75**
SC 2	DA-2	17.6
	DA-2A	6.17
	DA-2B	6.06
	Total	**29.83**
SC 3	DA-3	4.22
	DA-3A	0.74
	Total	**4.96**
Discharge Pt 1	DA-4	
	DA-4A	2.24
	DA-4B	7.9
	DA-4C	2.48
	Total	**12.62**
SC 4	DA-5	2.25
	DA-5A	5.18
	DA-5B	3.26
	Total	**10.69**
SC 5	DA-6	2.14
	DA-6A	3.34
	DA-6B	2
	DA-6C	1.49
	Total	**8.97**
SC 6	DA-7	1.55
	Total	**1.55**
SC 7	DA-8	1.45
	Total	**1.45**

LEGEND

- SC 3B STORMWATER CHANNEL
- PIPE
- DITCHLINE DIRECTION
- DA-2B DRAINAGE AREA
- ASPHALT CURB
- DROP INLET
- 296 HOUSE NUMBERS

0 300
Feet

NOTES:
1. PIPE LOCATIONS ARE FROM A SHAPE FILE PROVIDED BY THE TOWN OF BILTMORE FOREST.
2. STORMWATER CHANNELS AND DRAINAGE AREAS WERE DELINEATED FROM 2-FOOT BUNCOMBE COUNTY GIS TOPOGRAPHIC CONTOURS.
3. DROP INLET LOCATIONS ARE APPROXIMATE AND WERE LOCATED FROM A VISUAL INSPECTION.

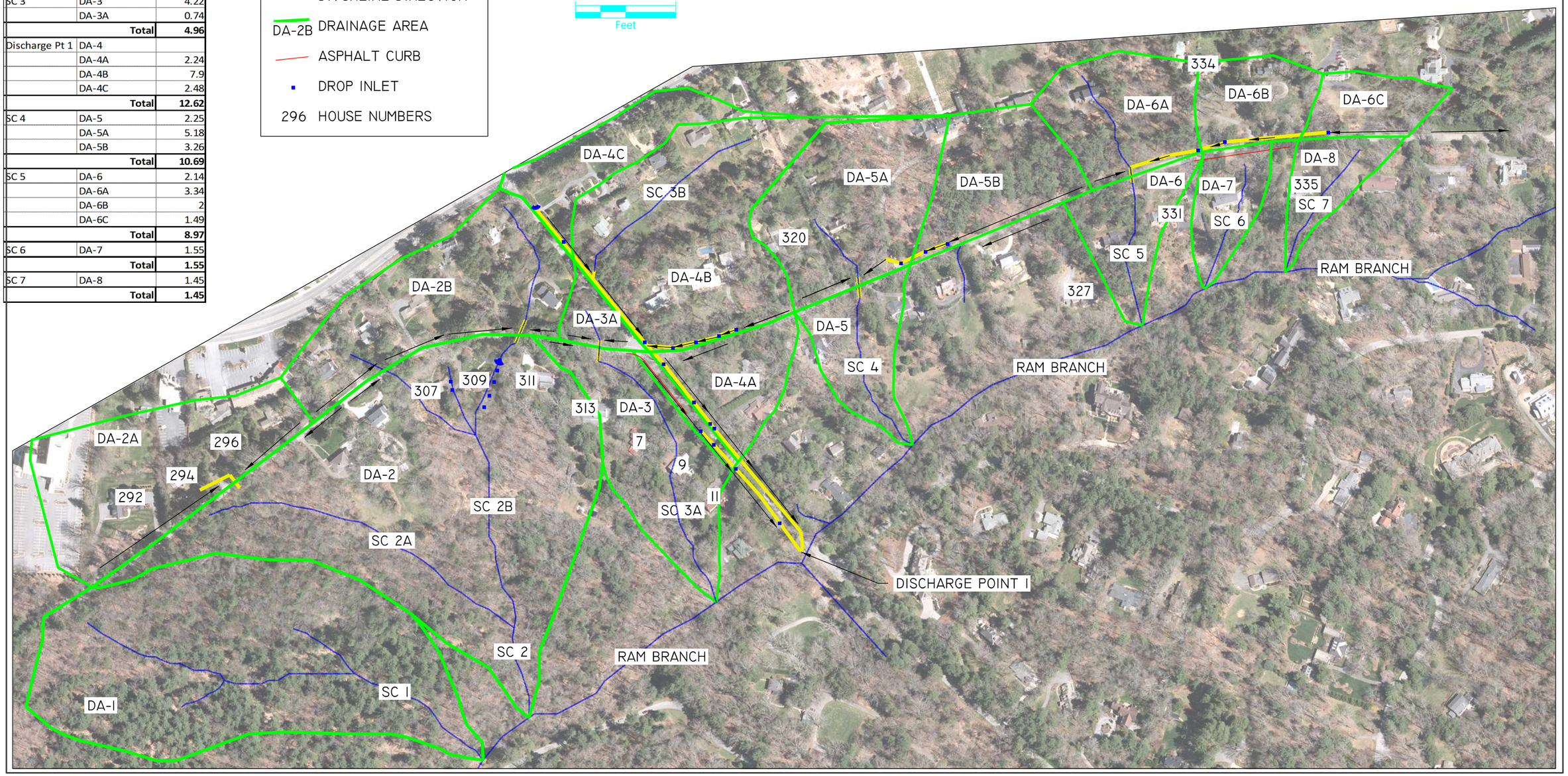

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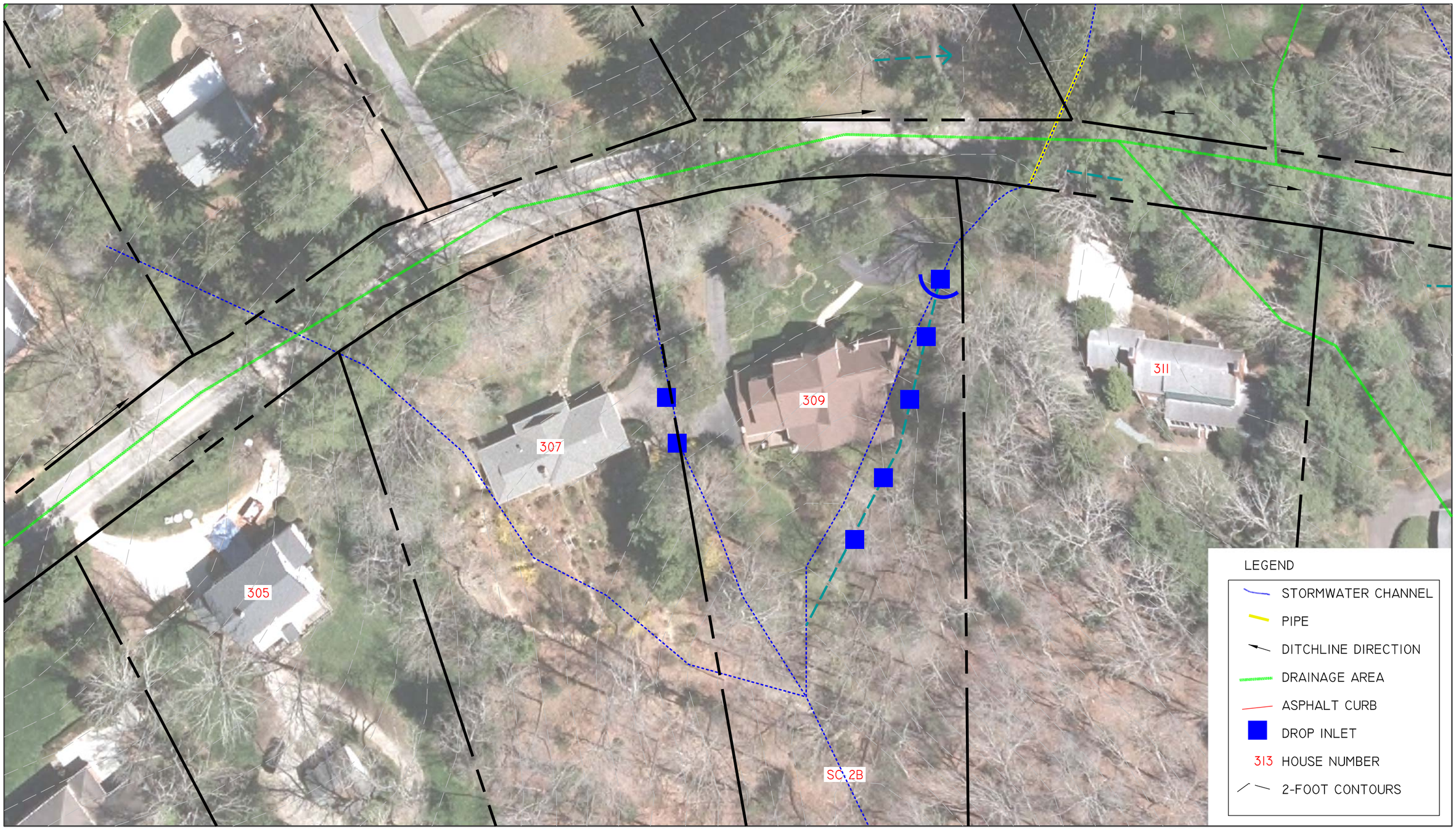
Figure 1
OVERALL DRAINAGE AREAS

VANDERBILT ROAD DRAINAGE STUDY



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0 50
Feet

FIGURE 2
ENLARGEMENT OF DRAINAGE AREA TO SC 2B

VANDERBILT ROAD DRAINAGE STUDY