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A Review of:

Final Report on the Effects of Developing Angel Oak Village on the Angel Oak

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Introduction

The purpose of this report is to review and comment on the report by Dr. Jean Everett entitled "Final Report on the Effects of Developing Angel Oak Village on the Angel Oak" dated March 4, 2009 (Everett Report). One of two main elements of the Everett Report is a discussion of the soils and the hydrologic character of the Angel Oak Village site and Everett's conclusions about potential hydrologic impacts of the development. My review focuses specifically on the soils and hydrologic issues raised by Everett.

Over a period of more than 18 months, I have worked with the developer of the proposed Angel Oak Village, Mr. Robert DeMoura of CC&T Real Estate Services, Inc., in conducting an assessment of the soils and hydrologic character of the site and providing assistance in planning the Village, particularly the proposed Stormwater Infiltration and Management System. The stated and highly achievable goal of the Stormwater Infiltration and Management System is to retain a very high proportion of all rainfall received each year on the site and facilitate infiltration to the groundwater system. As will be discussed in more detail below, the Stormwater Infiltration and Management System will ameliorate the potential hydrologic changes that could occur with development of Angel Oak Village and maintain the hydrologic regime to which the Angel Oak is adapted. The inescapable conclusion is that the integrity of the hydrologic environment of the Angel Oak will be protected and no adverse impacts on the health of the tree will ensue.

"Current Hydrology"

Everett's discussion of the current hydrology of the Angel Oak Village site has a number of important inaccuracies and omissions that lead to very erroneous conclusions regarding the hydrologic character of the site.

The theme of this section of the Everett Report is the described "natural drainage patterns on the site", referring, I presume, to surface runoff through streams. Though Everett did not provide any data or estimates of water balance components on the site, the conclusion that one draws from her discussion is that surface runoff is an important component of the hydrologic fluxes on the site. That conclusion is wrong. The "intermittent stream" that Everett refers to that "drains west into Church Creek on the northern part of the property" is not a stream on or in the immediate vicinity of the Village site. The feature to which Everett refers is a very shallow swale grown over by woody vegetation that likely originated as a shallow drainage ditch during the era of extensive agriculture across the southern Piedmont and Coastal Plain during the 1700's and 1800's. That swale does not have an active channel, does not carry base flow, and likely drains water from the depressional wetland on the northern portion of the Angel Oak Village site only during very infrequent, high volume rainfall events. The main purpose of the culvert under Maybank Highway referred to by Everett is to transport stormwater drainage from the highway.

The term "stranded wetland" used by Everett in referring to the depressional wetland on the northern side of the Village site is of unknown origin and definition. The term is not a common one in the field of wetland science. In addition, Everett's statement that "However, the soils maps and the vegetation patterns clearly indicate a stranded wetland that drains from the

Haut Gap School property, under Bohicket Road, across the Angel Oak Village site, under Maybank Highway and west into Church Creek" is incorrect and ill-informed. The presence of wetlands cannot be determined from any map; they must be delineated on the ground by an experienced wetland delineator. The soil mapping unit of Stono fine sandy loam as depicted on the Natural Resources Conservation Service soils map (Everett's Figures 4-6) is much larger than the actual extent of the depressional wetland. In addition, relatively large elements of the Stono fine sandy loam mapping unit are depicted on the soils map as lying in areas of relatively high density development north of Bohicket Road and west of Maybank Highway where there are no wetlands.

Everett's incorrect contention that the depressional wetland on the Angel Oak Village site is connected via an intermittent stream to the unnamed tributary of Church Creek/Bohicket Creek to the west of the Village site also raises the issue of jurisdictional status of the depressional wetland. That wetland is isolated and is not a water of the United States. The wetland does not meet any of the criteria in the current jurisdictional guidance that was issued by the U.S. Environmental Protection Agency (USEPA) and the U.S. Army Corps of Engineers (USACE) in response to the Rapanos-Carabell Supreme Court Decision (USEPA and USACE 2008). The Charleston District, USACE confirmed the non-jurisdictional status of the wetland in the jurisdictional determination for the Angel Oak Village site issued on August 7, 2008.[1] In addition, the determination of consistency of the Village development plan with the South Carolina Coastal Zone Management Program was issued on January 10, 2007 by the Office of Ocean and Coastal Resource Management of the South Carolina Department of Health and Environmental Control. [2]

There are no streams on the Angel Oak Village site nor in the immediate vicinity of the site and surface runoff is an insignificant flux component in the water balance of the Village site. The dark blue lines drawn by Everett on the U.S. Geological Survey 1:24,000 scale topographic map of her Figure 3 that she calls "Major Drainages" are very misleading. Those features are not "drainages" as that term is used by hydrologists and they are most certainly not streams as the dark blue color implies. Most of those features are shallow swales that carry stormflow only during very infrequent, high volume storm events. There is a network of stormwater ditches in the developed area to the north and east of Fenwick Crossroads but the purpose of those ditches is to transport stormwater draining from impervious surfaces. Those stormwater ditches produce a pattern of surface runoff that is dramatically different than the supposed pattern of "surface drainage" described by Everett.

The discussion of soils on the Angel Oak Village site in the Everett Report is incomplete. The focus on the very poorly drained soils of the wetland without any mention of the dominant soils on the site is quite misleading because the dominant soils on the site are well suited to development. A major portion of the depressional wetland will be preserved and will be utilized as stormwater storage and infiltration facilities, thus optimizing the hydrologic functions of the wetland. The dominant soil mapping units on the Angel Oak Village site in terms of area are

[1] Jurisdictional Determination letter signed by Charles R. Crosby, Charleston District, USACE, Charleston, SC, dated August 7, 2008.

[2] Coastal Zone Management Program Consistency Determination letter signed by John Hensel, South Carolina Office of Ocean and Coastal Resource Management, dated January 10, 2007.

Seabrook loamy fine sand which is moderately well drained and Wando loamy fine sand which is well drained.

The hydrologic characteristics of the soils across the Angel Oak Village site outside the depressional wetland have been determined by onsite measurements. Deep coring to determine soil texture, infiltrometer tests to measure rain water infiltration capacity, and examination of soil cores to determine the depth of seasonal high water table indicators have been conducted by WPC Engineering, Environmental, and Construction Services. Subsurface stratigraphy is dominated by sands to depths of 18-27 feet, i.e. approximately sea level. Surface infiltration capacity averaged 10 inches per hour, several times higher than the highest sustained rainfall intensities ever recorded in the southeastern U.S. Seasonal high water table indicators generally ranged from approximately 42-66 inches below the surface across the site. Conclusions from these data are that the soils across the Village site where development will occur are:

- Very deep sandy soils with very high surface infiltration capacity and subsurface lateral and vertical percolation rates that can infiltrate all the water from the highest intensity rainfall events expected in coastal South Carolina.

- There is relatively high soil water storage capacity in the late winter/early spring period of highest water table elevations and very high soil water storage capacity during the late summer/early fall period of lowest elevation water tables (i.e. deepest below the surface) when the largest storm events commonly occur in coastal South Carolina.

The hydrologic characteristics of the site that are described above are typical of low elevation, gently rolling landscapes along the southeastern coastal zone that are derived from ancient beach zones. My studies of the hydrology of the Buxton Woods area of Hatteras Island on the Outer Banks of North Carolina documented a hydrologic regime that is quite similar to that of the Angel Oak Village site (Gregory 1995, Gregory and Morgan 1996). The Village site is near the crest of a hydrologic peninsula bounded by streams on three sides (Figure 1). The highest elevations along the spine of the peninsula are along Maybank Highway. The subsurface water divide likely coincides closely with the zone of highest surface elevations.

There are two predominant liquid water fluxes in the water balance of the Village site, (1) infiltration of all rainfall to the near surface groundwater and (2) subsurface drainage toward the off site streams in response to hydraulic gradients that are similar in direction to the surface elevation gradients. Evapotranspiration loss to the atmosphere, of course, is the third principal flux in the water balance of the Village site. Subsurface drainage in the groundwater of the Village site flows toward the west and southwest to the unnamed tributary of Church Creek/Bohicket Creek that parallels Maybank Highway and toward the south and southeast to Church Creek/Bohicket Creek. The proposed Stormwater Infiltration and Management System coupled with the vegetated open space in Angel Oak Village will maintain rainfall infiltration to the groundwater across the Village site, will minimize discharge of stormwater offsite, and will maintain the hydrologic regime to which the Angel Oak is adapted.

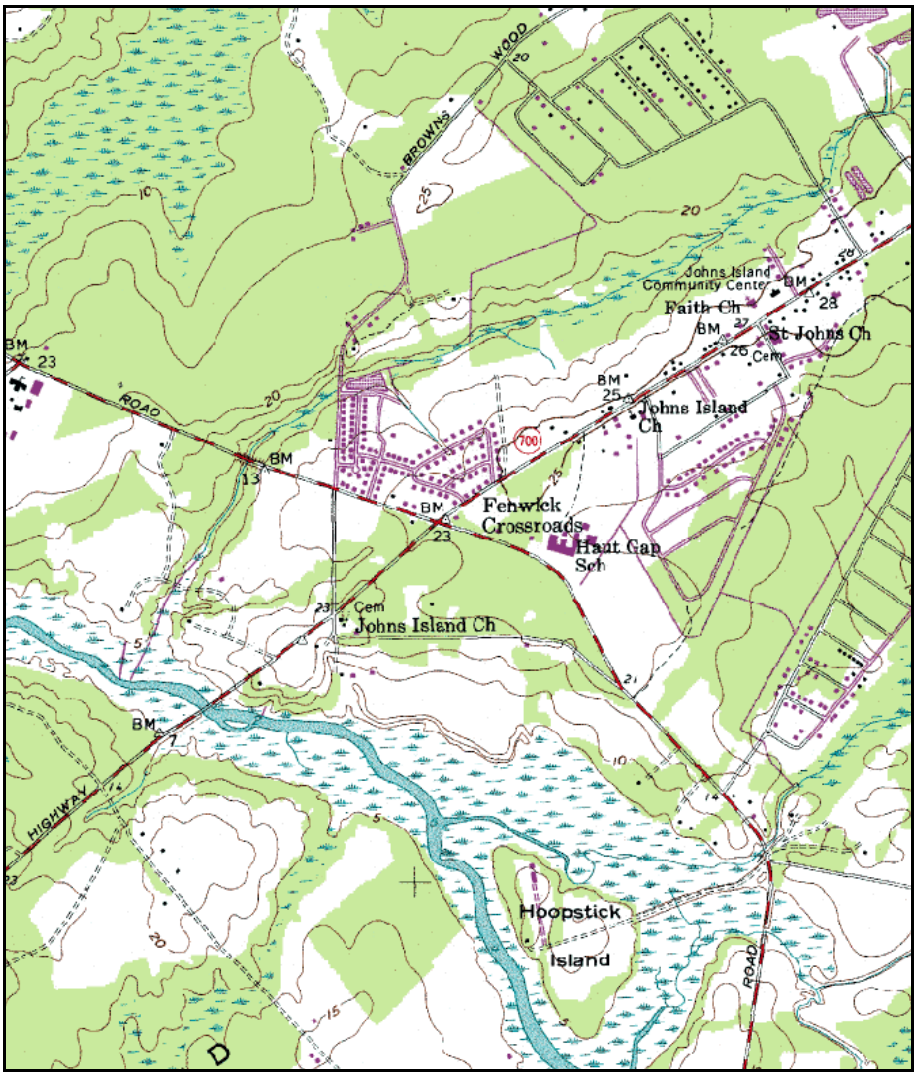

Figure 1. U.S. Geological Survey topographic map of the Angel Oak Village site and surrounding area. The Village site is the triangular area south of Fenwick Crossroads. The large stream to the south of the site is Church Creek/Bohicket Creek. It is named Church Creek to the west of Maybank Highway and Bohicket Creek to the east of the highway.

"Potential Alterations to Hydrology"

In this section of the Everett Report are several inaccurate statements and conclusions. Referring to the proposed Stormwater Infiltration and Management System of Angel Oak Village, Everett asserted that "This will obviously impair the natural drainage pattern and will also reduce the size of the catchment basin that is supplying subsurface water flow to the south". Both elements of that statement are wrong. Everett also stated that, "The proposed project will completely alter this regime", referring to the hydrologic regime to which the Angel Oak is adapted. That statement is wrong. Everett also stated that, " The forest will be essentially clearcut and replaced almost entirely with impervious surfaces". That statement is wrong and one of several examples of erroneous overstatement unsupported by evidence in the Everett Report. The current concept design for Angel Oak Village includes impervious areas separated

by interconnected vegetated areas where many trees on the site will be preserved. A significant percentage of the land on the Village site will be devoted to preserving the forest around the Angel Oak providing a total of more than 10 acres of intact forest surrounding the tree.

Referring to the Stormwater Infiltration and Management System, Everett stated that, "Even if precipitation is retained on site, the distribution of this water will be completely different. Some areas will become much wetter, others much drier." These very erroneous statements demonstrate Everett's lack of understanding of the hydrologic character of the Angel Oak Village site and how the innovative stormwater management system will function to maintain that hydrologic character. Everett's contentions earlier in the report that the "proposed project plans to keep most stormwater on site" were probably unrealistic belies the tremendous efforts made by the development planning team in the conduct of hydrologic assessments, hydrologic analyses, and the iterative and complex process of designing the Stormwater Infiltration and Management System.

Under current site conditions, rain water infiltrates into the surface soils and percolates downward at different rates simply due to natural, random lateral and vertical variation in soil physical properties. Variations in surface elevation create variations in depth to the water table and thus variations in the downward distance that the percolating rain water must traverse to the water table. These spatial variations in rates of rainfall percolation to the water table create temporary variability in water table elevations across the site, i.e. water table highs and lows during and shortly after large rainfall events. Temporary hydraulic gradients may cause groundwater flow in different directions than the sustained regional gradients. However, due to the high lateral and vertical conductivity of the sands, the near surface groundwater flows from the water table highs to the lows and the water table reorients to sustained regional gradients and the sustained regional patterns of water table elevation and depth from the surface within 12-24 hours after a large rainfall event. This fascinating pattern of "undulating water tables" was documented in my studies of the ridge and swale topography of Hatteras Island, NC (Gregory and Morgan 1996).

Under conditions extant after Angel Oak Village is developed, the pattern of impervious surfaces interspersed with open space and the network of stormwater infiltration Best Management Practices (BMPs) will result in a pattern of temporary water table highs and lows after large rainfall events. However, the hydraulic gradients from the groundwater mounds under the infiltration BMPs will rapidly push the water from the mounds into the water table valleys and the regional water table elevation pattern and flux gradients will be rapidly restored. In addition, a key element of the post construction water management system is the large conservation area around the Angel Oak into which rainfall infiltration and percolation to the water table will be unchanged. Several infiltration BMPs will be sited near that conservation area to ensure that the water table regime in the rooting zone of the Angel Oak will not be significantly altered.

The degree of post-construction reduction of transpiration resulting from reduction in the tree canopy that Everett referred to and the impact on increasing available water on the Village site was discussed extensively in the course of designing the Stormwater Infiltration and Management System. Two key elements of the Stormwater Infiltration and Management System

address the issue of preventing high rates of stormwater discharge offsite. Firstly, the system is designed with sufficient storage volume to retain the water delivered by the 100-year return period event, which is 10 inches of rainfall. Secondly, the main detention storage/infiltration BMPs will be interconnected by pipes and will have outlet controls so that the rates of release of excess water from big storm events can be controlled to provide for slow release over several days. The stormwater system is not a typical detention and discharge system but an integrated management system that will provide for flexibility of water management to meet both goals of minimizing adverse hydrologic changes on the Village site and minimizing stormwater discharge off site.

Everett's reference to "result of so much impervious surface will be pulses of pollution that will be entering groundwater" is also an issue that was discussed extensively by the Stormwater Infiltration and Management System design team. Everett is correct that high density development results in discharge of pollutants to stormwater. Typical detention or retention basins often have relatively low capacity to retain and treat many of the pollutants in urban stormwater. However, the BMPs of the Stormwater Infiltration and Management System of Angel Oak Village will consist mainly of two types of detention features that currently provide the greatest retention and amelioration of pollutants, bioswales and depressional wetlands.

Summary

As reiterated a number of times in this report, the Everett Report has many erroneous statements and conclusions regarding the soils and the hydrologic character of the Angel Oak Village site, the hydrologic impact of the proposed development, and the eventual impact of the Village on the hydrologic regime of the Angel Oak. At risk of boring repetition, please let me reiterate that the proposed Stormwater Infiltration and Management System designed by an outstanding stormwater engineering team at HLA Inc. is a highly innovative system that will maintain the hydrologic regime to which the Angel Oak is adapted. The planning and design process in which I have participated has been an excellent professional experience because Robert DeMoura and his team have been fully committed to designing a high quality development while providing maximum protection to the environment of the Angel Oak. The most recent concept plan for Angel Oak Village well illustrates these objectives. Changes that have recently been made to the plan address the few final concerns expressed by the experienced professionals who have reviewed the Village plans. The percent of impervious surface has been significantly reduced, there is a significant increase in vegetated open space that is interconnected across the site, and there is a further expansion of the conservation area around the Angel Oak.

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