

TOWN OF CHAPEL HILL, NORTH CAROLINA

Ecological Analysis and Comparison of Two Proposed Obey Creek Development Concepts

Environmental Assessment Report/September 17, 2014



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Executive Summary

This report offers a comparative ecological assessment of two development concepts that have been proposed for the development of Obey Creek. Forest cover on the site was divided into eight forest stands based on disturbance history, habitat quality and stand age. Based on field work, historic aerial photos, and a spatial habitat evaluation and analysis, the relative impacts of the single use versus mixed use concepts are compared. Overall, the mixed use development concept will allow more of the existing valuable forest habitat to remain undisturbed. With the mixed use concept, interior forest habitat was reduced by 21% vs. 63% with the single family residential concept. And with the mixed use concept, the wildlife habitat evaluation score was reduced by 24%, vs. 52% with the single family residential concept.

I. Site Description

A. Introduction and Purpose of Analysis

The Obey Creek Development site is a 120-acre, sparsely developed, heavily wooded tract located on the east side of US 15-501 across from the Southern Village development (See Figure 1). It is approximately one mile south of the 15-501/NC 54 By-pass. Old Lystra Road runs in a north-south direction to the east of the site, separated by a wooded buffer. Property frontage along US 15-501 is approximately 3,600 feet, extending south from the Market Street intersection at Southern Village approximately 2,700 feet.

Since the majority of the property is undeveloped, it supports substantial natural resources. Naturally occurring stands of diverse hardwoods and mixed pine/hardwoods occupy most of the site. Wilson Creek, a stream that has documented high water quality (Lenat 2012) roughly bisects the site north-to-south. There are many ephemeral and intermittent stream tributaries that form confluences with Wilson Creek on the property. A significant unnamed tributary flows east across the property to Wilson Creek near the center of the site. The floodplain along Wilson Creek is well-developed through most of the site, and hydric soils and hydrophytic plant species are present, indicating the potential presence of jurisdictional wetlands in some areas.

Portions of the site have steep slopes. These areas (slopes greater than 15%) occur mainly in the eastern portion of the site, in the headwaters of the unnamed tributary. A less extensive area of steep slopes occurs along and near the southern boundary of the site. Smaller areas of steepness occur along Wilson Creek just north of the confluence of the main unnamed tributary, and where Wilson Creek exits the site to the north.

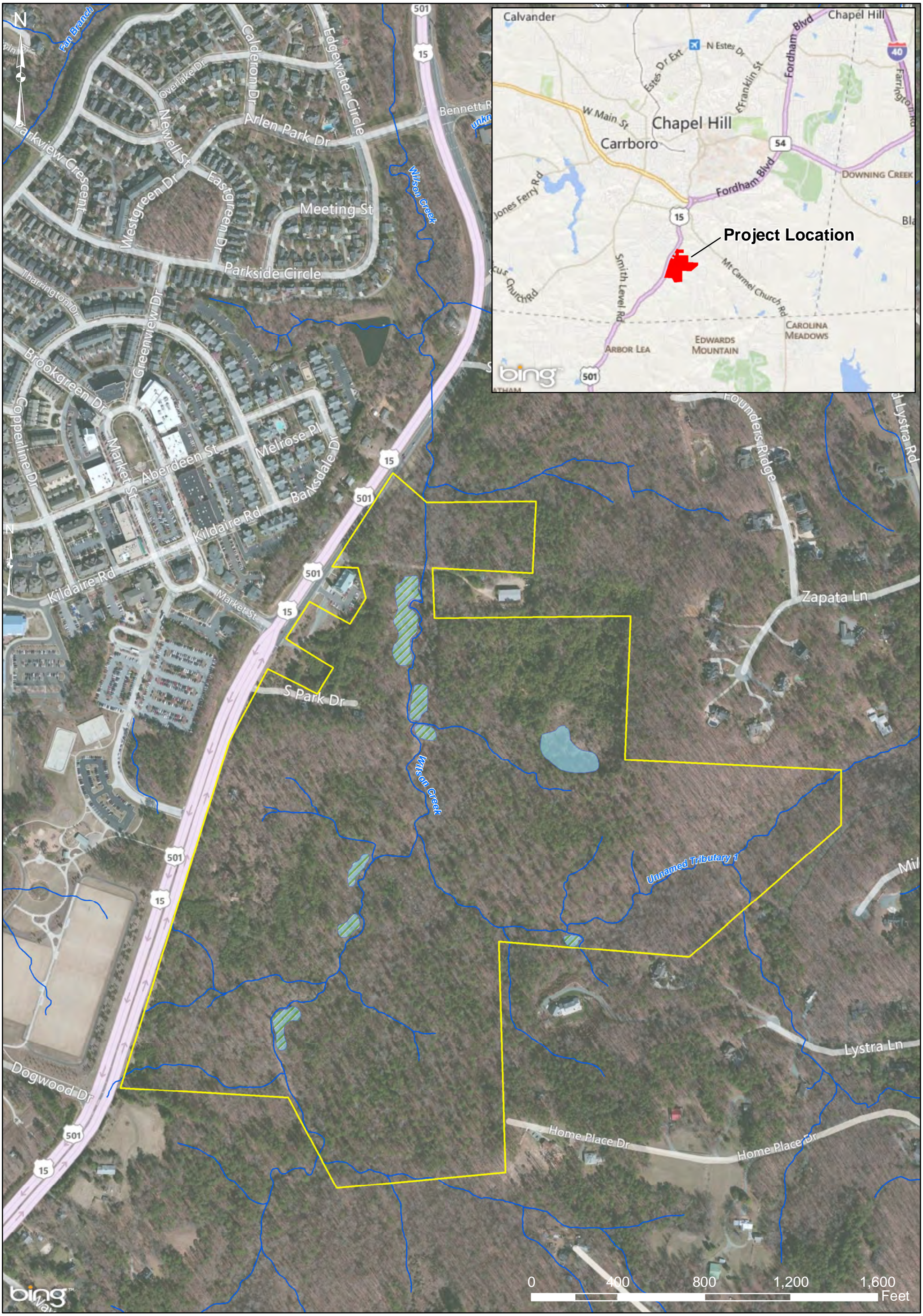
1. Obey Creek Development Proposal

The Obey Creek Development was first proposed in April of 2010 by East West Partners Management Company. A mixed use concept, with a total floor area of approximately 2.4 million square feet, was proposed including:

- 1,200 dwelling units,
- 120,000 square foot hotel,
- 453,000 square feet of office/retail/commercial floor area.

In July of 2012, a revised Concept Plan Application was submitted. The total floor area proposed was approximately 1.5 million square feet, including:

- 600 dwelling units,
- a 100,000 square foot hotel (130 rooms),
- 375,000 square feet of office-commercial and civic space,
- 350,000 square feet of retail space,
- And 21 ac of impervious surface



Obey Creek
 Site Location
 Figure 1



- Stream
- Open Water
- Estimated Wetlands
- Obey Creek Site Boundary

In addition to the revised mixed use concept plan described above, an alternative residential concept plan was proposed, including:

- 79 residential lots
- 69.5 ac of disturbed area
- 25 ac of impervious surface

From the Town of Chapel Hill's Obey Creek Technical Team Evaluation Memorandum dated October 31, 2013, the following items were identified as issues for discussion and/or negotiation during the Development Agreement process:

- The function and value of Obey Creek, wetlands and the surrounding upland habitat should be studied so that a base line pre-development condition can be defined.
- *Information needed: wetlands, biological study, and function and value assessment of jurisdictional wetland areas.*
- The potential impacts (both temporary, construction-related and long-term, operational concerns) should be identified, and addressed. The concepts must adequately define the specific methods that will be used to protect the viability of the environmental resources in a sustainable manner as an integrated part of the development plan.
- Any planned areas to be used for passive or active recreation should be identified and potential impacts should be identified and addressed. Any mitigation, enhancement, or maintenance functions should be identified.
- The presence of any species of concern (State or Federal listings) should be identified. If suitable habitat for any species of concern has been previously identified, or is anticipated, studies should be conducted to determine whether the species is present. These comments apply to both flora and fauna. A search of the North Carolina Natural Heritage Database should be included.

Planning Department staff point out in this document that existing natural conditions at this site pose a challenge to development, including regulated stream buffers and floodplains, regulated steep slopes and erodible soils.

The Development Agreement process implemented for this proposed project employs a Compass Committee, composed of various stakeholders. The Obey Creek Compass Committee (OCCC) Report, dated December 16, 2013, states that:

“Transitioning from a natural wooded tract to developed area poses a number of challenges, including protection of water quality, conservation of natural area and tree canopy, and mitigation of noise, light and air pollution impacts.”

Issues that were most important to OCCC and community members included: water quality and flow on-site and downstream; conservation and management of land east of the creek; protection of the tree canopy and wildlife corridor; impervious surface and greenspace in developed area; and air, noise and light pollution impacts.

2. Purpose of Analysis

This analysis was authorized by the Town of Chapel Hill because the Development Agreement process identified the need for an ecological assessment of the wildlife habitat resources on the site and a comparison of the impacts of the two development concepts proposed. The assessment relies on existing information and information gathered during a brief, strategic field analysis. The purpose of this analysis is to help quantify, compare and illustrate the apparent ecological impacts of two proposed development concepts, and how the impacts relate to wildlife habitat and forest natural resource assets, and in a less direct way, stream and wetland integrity. It should be noted that this analysis is not intended to represent an in-depth, comprehensive analysis of the broad array of ecological components of the site. It was beyond the scope of this analysis to delineate and functionally assess wetlands and streams or to identify specific areas of rare species habitat, as were recommended in the documents previously mentioned. While information on wetland and stream attributes was gathered across the site, the methods used were visual and rapid, and no direct samples or measurements were taken. Therefore, this analysis is intended to make a relatively uncomplicated and direct comparison of how the proposed development concepts may impact the landscape ecology, wildlife habitat, existing forest structure and stream and aquatic resources on the site, based on existing information and a relatively brief, strategic field-sampling effort. The analysis was largely based on spatial data using metrics such as acres of wildlife habitat lost or forested acres impacted.

B. Information Gathered For the Analysis

A large amount of information on the natural resources present on the site has already been gathered and developed including:

- Topography
- Steep slopes analysis
- Soil survey mapping
- Developability of soils present
- Stream 100 year floodplain boundary and
- State and local jurisdictional stream buffer boundaries

Additional electronic information gathered included historical aerial photography images from 1938, 1955, and 1975, Geographic Information Systems files on land use/land cover, streams, and current aerial photography.

Eight individual sampling plots were placed throughout/across the site. Data gathered at each plot included vegetation community information such as dominant tree species, percent cover, apparent relative diversity, midstory tree species and percent cover, shrub and herb layer percent cover, and invasive species presence and percent cover. Tree cores to estimate the age of the average dominant-sized canopy tree were taken at each plot. The stream channel morphology, such as evidence of channelization, degree of incision, and bank stability, was also documented in three locations along Wilson Creek and two locations on the main unnamed

tributary. Locations where jurisdictional wetlands were likely to be present, based on vegetative community types and surface hydrology, were also noted.

C. Wilson Creek, its Tributaries, and Potential Wetland Areas

This section describes the hydrological features of the site. An evaluation of their importance to habitat and wildlife follows in Part II, the Analysis of the Site and Alternatives. Overall, the aquatic and riparian zone habitat, based on a rapid visual inspection in the field, is relatively high in quality, uncommonly so for an area so close to dense development.



Photo 1. Snapping turtle in Wilson Creek

Wilson Creek is the primary watercourse on the property. The main channel flows south to north for approximately 4,000 feet, roughly bisecting the site. There are six smaller tributaries to Wilson Creek, with predominantly intermittent flows. There is one larger unnamed tributary that originates east of the site near Old Lystra Road, and it flows west across a prominent arm of the property to Wilson Creek, near the center of the site. This stream has intermittent flows near the eastern property boundary and perennial flow deeper into the site.

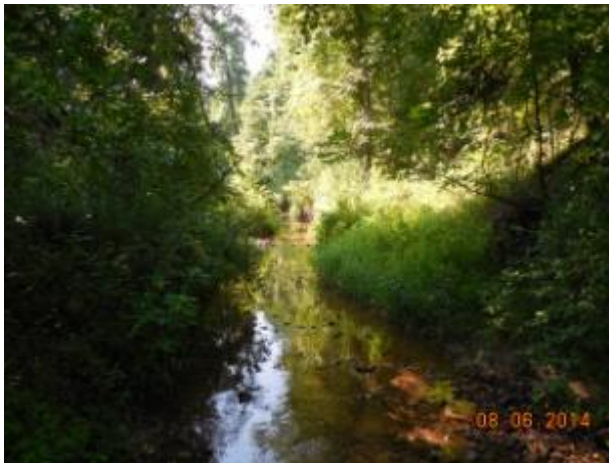


Photo 2. Wilson Creek near the site's southern boundary

As previously mentioned, the floodplain of Wilson Creek is well-developed and ranges in width from approximately 30 to 50 yards wide in many places. Soils mapping by the Natural Resource Conservation Service identifies Chewacla soils in many of these areas. Chewacla soils indicate the potential presence of jurisdictional wetlands. Using field observations of typical hydrophytic or wetland vegetation presence, along with observations of surface hydrology indicators, soils mapping and topography, areas of potential jurisdictional wetlands were estimated in the field. These

estimates are not intended to take the place of a formal wetland delineation, which was

beyond the scope of this project, but were done to support the broader ecological analyses of this report.

Abundant minnows and amphibians were noted in Wilson Creek and the adjacent riparian areas. A black racer snake (*Coluber constrictor constrictor*) was observed in the riparian zone and a 12-14 inch snapping turtle (*Chelydra serpentina*) was observed in the creek channel itself.

D. Description of Forested Areas

1. Background Information

Forest and natural areas cover approximately 95% of the site, reflecting the land use history of the past 100 years. Historic aerial photography from 1938, 1955 and 1975 reveals that there were large areas of the site in agricultural use over the years. Without any documentation of land use before 1938, and based on what is known about land use and practices in the 19th century, it is logical to assume that the entire site has been used for agricultural row crops, pastureland and for timber and firewood harvesting at some point in the past (the N.C. Forest Service was queried, but no timber harvest records exist for the site).

The habitat value of the site is enhanced by the forests' uneven-aged stands, which suggest a specific land use history. Areas that were cleared or disturbed were then left fallow, and natural regeneration of the forest occurred, with seedlings germinating from seeds dispersed by nearby, mature trees. The forests that result from natural regeneration support dominant trees that were germinated immediately after the disturbance occurred. As time passes, and the dominant (and oldest) overstory trees in the forest get taller, and mid-story and understory vegetation becomes more well developed. Forests that exhibit older dominant trees with a midstory and understory of younger trees are termed uneven-aged forest stands (as opposed to tree plantations, which are generally referred to as even-aged stands, because they are generally harvested before midstory and understory vegetation have a chance to develop to any notable degree). All forested areas on the site are uneven aged stands, reflecting the abandonment of disturbance on a particular area, and a natural regeneration of forest from surrounding vegetation that follows. This type of forest regeneration is common, and uneven aged stands generally support a higher diversity of tree and shrub species than a more highly managed tree plantation stand. Diverse uneven aged stands provide excellent wildlife habitat. They provide nursery/rearing, shelter and food supply areas for a broad array of species. Depending on the species, wildlife often display preferences for uneven aged stands of different ages. Some species prefer forests within a certain range in age, while others can use forests with a broader range of ages. Some use forests of different ages for certain parts of their life cycle.

2. Forest Stand Delineation Process

Stands 1-8 were classified by the age of the trees (coded with letters A-D). Using historical aerial photography, site reconnaissance and tree core data, forest stands were delineated on the site (See Figure 2). Based on the information available, four stand categories were derived:

<u>Stand Category</u>	<u>Description</u>
A	Less than 35 years old
B	Less than 65 years old
C	Greater than 65 years old
D	Greater than 65 years old, with disturbed areas

Boundaries for the Categories were estimated using the aerial photography and field reconnaissance. Table 1 summarizes the basic characteristics of each stand.

Table 1. Summary Characteristics of the Forest Stands

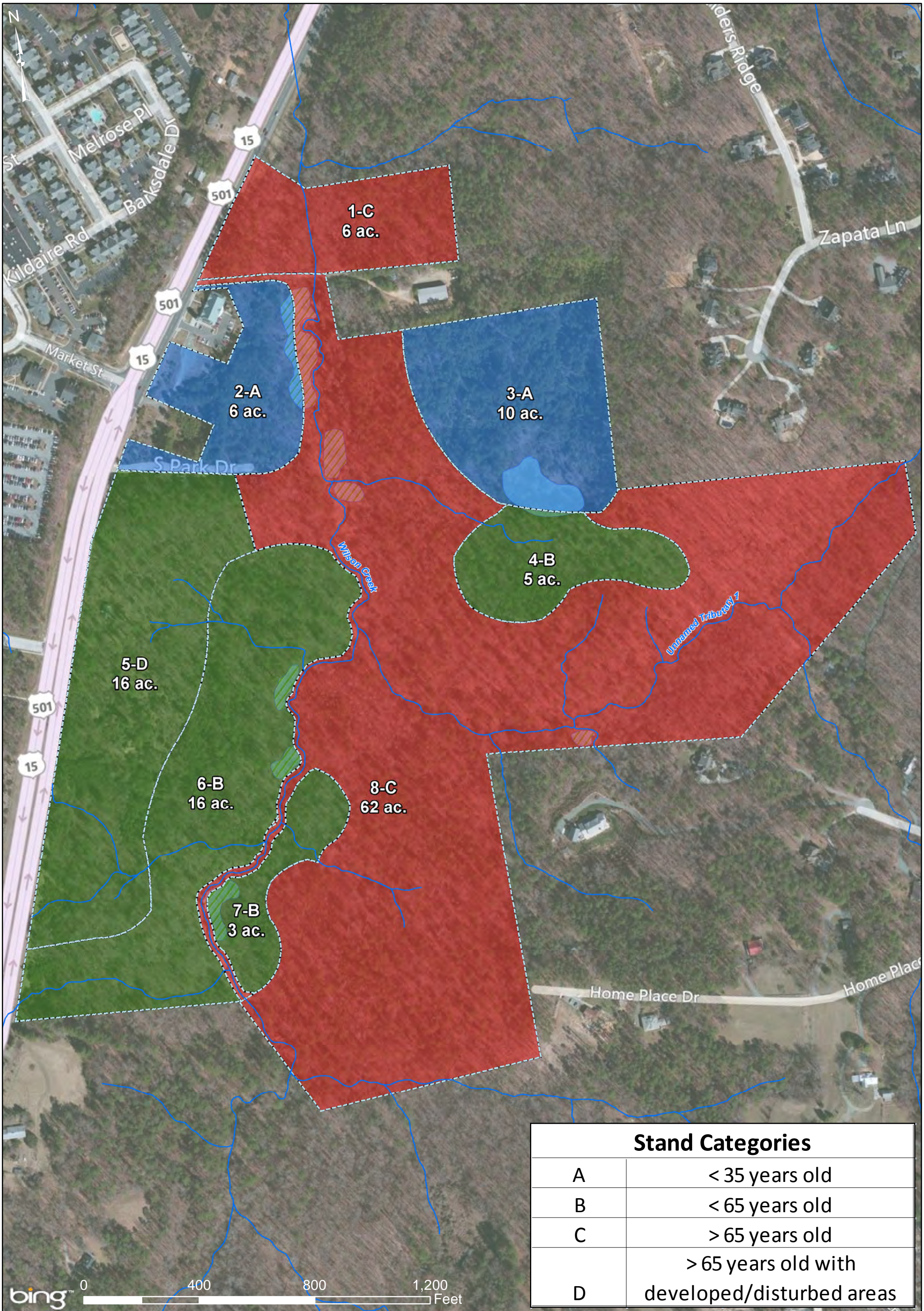
Forest Stands	Area (ac)	Estimated age	Comments
1-C	6.1	> 65 yrs	Northernmost stand on property, 500 ft. frontage, scattered mature trees, invasives along creek
2-A	5.5	< 35 yrs	300 ft. frontage, across from Market St, disturbed site, invasives on slope towards creek
3-A	9.6	< 35 yrs	Old quarry site, Includes small pond
4-B	4.8	< 65 yrs	Higher tree species diversity, dense understory
5-D	15.8	< 65 yrs	1,900 ft. frontage, many old abandoned structures, past disturbance and invasives throughout
6-B	15.9	< 65 yrs	Old agricultural field, some invasives
7-B	3.1	< 65 yrs	Old agricultural field, invasives in creek floodplain
8-C	61.5	> 65 yrs	Largest stand, many old specimen trees, high tree diversity, unnamed tributary flows through, invasives

Stand 1-C is approximately 6.1 acres, situated on the northern tip of the property. A tree core taken in this stand indicated the age of a dominant canopy tree at about 65 years. There are scattered individual hardwoods present that may be 80-100 years old, so the overall stand was classified as being greater than 65 years old. Species noted at the plot in this stand included loblolly pine (*Pinus taeda*), yellow poplar (*Liriodendron tulipifera*), sweetgum (*Liquidambar styraciflua*), southern red oak (*Quercus falcata*), black oak (*Quercus velutina*), sourwood (*Oxydendrum arboretum*), beech (*Fagus grandifolia*), hophornbeam (*Ostrya virginiana*) and black cherry (*Prunus serotina*).



Photo 3. Hardwoods of the riparian zone of Stand 1-C.

Tree diversity is high in the canopy and midcanopy, and this stand supports good wildlife habitat. There are approximately 500 feet of frontage on US 15-501 on its western border, which create a habitat boundary and pose a migration barrier and threat to wildlife. There is also a large area of Japanese stiltgrass (*Microstigeum vimenium*) a problematic invasive plant species, in the riparian areas beside Wilson Creek.



Stand Categories	
A	< 35 years old
B	< 65 years old
C	> 65 years old
D	> 65 years old with developed/disturbed areas

Obey Creek
Forest Stands
Figure 2



Evaluation Score	Stream
30	Forest Stands
60	Estimated Wetlands
70	Open Water

Stand 2-A- is approximately 5.55 acres, located across from the Market Street intersection on US 15-501, on the northwest side of the property. A tree core taken in this stand indicated the age of a dominant canopy tree at about 25 years. There are scattered individual trees present that may have been somewhat older, and aerial photography from 1975 shows this stand to be completely cleared, so the overall stand was classified as being less than 35 years old. By far the dominant species noted at the plot in this stand was loblolly pine. Scattered individual stems of yellow poplar, sweetgum, and red maple (*Acer rubrum*) were also noted.



Photo 4. Pine-hardwoods in Stand 2-A.

Tree diversity is relatively low in the canopy. The midcanopy layer is not well defined. The shrub layer is scattered, mostly consisting of younger individuals of the species that comprise the dominant canopy listed above. There were substantial briars and other weedy herbaceous species present closer to the highway right of way. This stand supports only moderate wildlife habitat. There is approximately 300 feet of frontage on US 15-501 on the western border of this stand, along with two outparcels that complete the western border of the stand. These features create a habitat boundary and pose a migration barrier and threat to wildlife. There is also a large area of Japanese stiltgrass on the hillside sloping towards Wilson Creek.



Photo 5. Pond in old quarry in Stand 3-A

Stand 3-A- is approximately 9.58 acres, located in the northeastern area of the property. This stand area corresponds to the site of a quarry/construction fill area where use was discontinued at some point between 1975 and 1992, from the information available. This area was identified in the Phase 1 report for the site, if more information on the past operation is desired. A tree core taken in this stand indicated the age of a dominant canopy tree at about 32 years. Aerial photography from 1975 shows this stand to be almost completely cleared, so the

overall stand was classified as being less than 35 years old. The dominant species noted in this stand was loblolly pine. Scattered individual stems of yellow poplar, sweetgum, and red maple were also noted.

Like stand 2-A, tree diversity is relatively low in the canopy. The midcanopy layer is not well defined. The shrub layer is scattered, mostly consisting of younger individuals of the species that comprise the dominant canopy listed above. There is a small area of open water, less than an acre, which likely filled in after the excavation operation closed down. A very abundant frog population was observed here. The forested area in this stand is not as diverse as other areas on the site, but the pond feature adds diversity to the wildlife habitat.

Stand 4-B- is approximately 4.79 acres, located in the northeastern area of the property, just south of the old quarry area. A tree core taken in this stand indicated the age of a dominant canopy tree at about 60 years. Aerial photography from 1955 shows much of the area of this stand as being cleared for what appears to be agriculture, so the stand was classified as being less than 65 years old. The dominant species noted in this stand was loblolly pine. Scattered individual stems of yellow poplar, sweetgum, red maple, sourwood and pignut hickory (*Carya glabra*) were also noted.



Photo 6. Cored tree and mixed pine/hardwood forest in Stand 4-B

Similar to Stand 1-C, tree diversity is relatively high in the canopy. There is a prominent, often dense midcanopy and understory layer that is approximately 15-20 years old. This dense layer is likely the result of new growth that occupied overstory gaps after windthrown trees fell during Hurricane Fran in 1996 and during more recent ice storms. This layer consists of younger individuals of the species that comprise the dominant canopy listed above. This area, with a more dense understory, adds to the habitat diversity of the site, supplying areas that are used by species that prefer forest with a relatively dense understory.

Stand 5-D- is approximately 15.79 acres, located across from Southern Village, south of the Market Street intersection on US 15-501, on the west side of the property. A tree core taken in this stand indicated the age of a dominant canopy tree at about 65 years. There are scattered individual hardwoods present that may be 80-100 years old, so the overall stand was classified as being greater than 65 years old. This stand supports a mix of hardwood, pine/hardwood, and hardwood/pine areas (pine/hardwood designation indicating pines are more numerous and

hardwood/pine indicating hardwoods are more numerous). Common species include loblolly pine, yellow poplar, sweetgum, red maple, white oak, southern red oak, pignut and mockernut hickories (*Carya ovata*).

A review of the aerial photography from 1938 indicates a large portion of this site was in agriculture. In 1955, the same areas were in agriculture, but there are more dwellings/buildings visible. In 1975, all the former agricultural areas support well-defined forest, and more dwellings/buildings are visible. Six old home sites or dwellings and several out buildings were encountered in this site during field work. There is approximately 2,000 feet of frontage on US 15-501 on the western border of this stand, and development and disturbance have influenced this stand substantially over the years. For the purposes of this analysis, the stand is classified as being greater than 65 years old, but it also is classified as containing disturbed areas, which somewhat lessen the habitat value.

While tree diversity is relatively high in the canopy, past disturbance and existing abandoned buildings result in scattered areas of degraded habitat. There are heavy invasive species infestations associated with past disturbance and openings created in the forest, most notably bamboo around an old barn site, wisteria (*Wisteria sinensis*) in several scattered locations, privet (*Ligustrum sinense*), and Japanese stilt grass in many locations near the old buildings. Its proximity to US 15-501 is a habitat boundary that creates an obstacle and threat to wildlife movement.

There is an area near the middle of the stand that supports a dense understory, and it is difficult to determine if this understory, with its many invasives, was formed as a result of tree windthrow openings formed during past storm events, or by human disturbance. The presence of invasives degrades this area relative to other locations on the site where there is a dense understory formed by native vegetation.



Photo 7. Abandoned house in Stand 5-D



Photo 8. Privet among hardwood trees in Stand 5-D

Stand 6-B- is approximately 15.86 acres, and is south and east of Stand 5-B, between it and Wilson Creek. A tree core taken in this stand indicated the age of a dominant canopy tree at about 60 years. There are a few scattered individual hardwoods present that may be 80-100 years old, but aerial photography from 1955 shows most of this area as being in agriculture use. The older trees encountered were likely old fencerow or yard trees, and their locations are dispersed, so the overall stand was classified as being less than 65 years old. Like



Photo 9. Ravine and ephemeral channel on the north side of Stand 6-B

Stand 5-D, this stand supports a mix of hardwood, pine/hardwood, and hardwood/pine areas. Common species include loblolly pine, yellow poplar, sweetgum, red maple, and sourwood.

Tree diversity is moderately high in the canopy, and the midcanopy layer is well developed in many areas. Japanese stilt grass is common on the slopes leading down to Wilson Creek. Stand 6-B supports higher quality wildlife habitat than Stand 5-D because there are no extensive areas of invasive species related to past disturbance throughout the stand, as is common in Stand 5-D.

Stand 7-B- is approximately 3.09 acres, bordering the east side of Wilson Creek near the southern boundary of the property. A tree core taken in this stand indicated the age of a dominant canopy tree at about 60 years. Aerial photography from 1955 and 1975 shows all of this stand being in agricultural use. It apparently went fallow just after 1975, and forest began reestablishing from native species around the perimeter of the field, so the overall stand was classified as being less than 65 years old. Stand 7-B supports a mix of hardwood and pine/hardwood areas. Common species include loblolly pine, yellow poplar, sweetgum, red maple, with sycamore (*Platanus occidentalis*) being common along the creek.



Photo 10. Wilson Creek as it flows beside Stand 7-B

Tree diversity is relatively high in the canopy, and the midcanopy layer is well developed in many areas. Japanese stilt grass is common in the floodplain of Wilson Creek. This area is relatively good habitat and would be even better with some invasive control.

Stand 8-C- is approximately 61.54 acres, and lies predominantly east of Wilson Creek, occupying much of the land there, notably on the southern and eastern arms of the property. Several tree cores taken in this stand indicate the age of a dominant canopy trees at about 65 years. There are numerous scattered individual hardwoods present that may be 80-100+ years old, so the overall stand was classified as being greater than 65 years old. Important species noted within this stand include loblolly pine, yellow poplar, sweetgum, white oak, southern red oak, black oak, sourwood, beech, hophornbeam, pignut hickory, mockernut hickory and black cherry. Umbrella magnolia (*Magnolia tripetala*) occurs in many areas along the stream in the understory and midcanopy. Examples of several large trees that were noted along the main unnamed tributary include three white oaks ranging in diameter breast height from 26-30 inches, a 27 inch beech and a 32 inch yellow poplar.



Photo 11. 27 inch beech on unnamed tributary



Photo 12. 32 inch poplar on unnamed tributary

Tree diversity is high in the canopy and midcanopy, and this stand supports good wildlife habitat. It also has a large area of relatively dense understory, likely the result of canopy gaps created from past storms, as noted elsewhere in the site. The combination of riparian habitat, potential wetlands, mature forest, older growth areas of forest and dense understory areas provides a variety of good to excellent wildlife habitat for an area so close to an urbanized, more densely developed area. The age of the trees in some areas makes this stand a unique component of the property, one that has a high opportunity cost for replacement if it is disturbed and developed. Japanese stiltgrass (*Microstigeum vimenium*) is common in the stream riparian zones and wisteria and privet occur in scattered locations throughout.

II. Ecological Analysis of Site and Alternatives

Once the forest stands were defined and described, two analytic methods were used to compare the habitat impacts of the single family residential concept to those of the mixed use concept. The first analysis compares the loss of habitat and habitat connectivity for each concept, and the second analysis compares wildlife habitat and forest stand loss for each concept.

A. Landscape Ecology Analysis

1. Principles and Background

Landscape ecology principles were used in this analysis to characterize habitat structure and patterns on the site. These accepted principles are a tool that integrates existing data and data gathered in the field, with the goal of producing an evaluation of the natural resources that the site supports. A brief description of the principles applied, based on peer-reviewed research, follows.

Species native to an area need habitat that existed prior to development in order to persist under developed conditions. In landscape ecology, these areas of habitat which are interspersed with areas of development or disturbance, are called habitat patches or hubs. Patches come in an infinite number of sizes and shapes and can have varying degrees of connectivity with each other. The connections between patches are called habitat corridors or linkages.

Several factors that affect the quality of habitat patches and corridors, including their size, shape, vegetation and access to water. Research has shown that the larger the patches (Robbins et al. 1989, Schiller and Horn, 1997) and wider the corridors (Mason et al. 2006, Schiller and Horn, 1997), the higher quality the overall habitat is. Much of the research in landscape ecology and habitat quality has been done using data collected on neotropical migratory birds, which nest in the continental U.S. in the summer and migrate to Mexico, the Caribbean, or Central or South America in the winter months. Neotropical migrants comprise approximately 50% of the total number of bird species in North America (Franzreb and Phillips 1996). They have been used as habitat indicator species for a broad range of sensitive forest fauna because of their need for forest interior habitat, their use of the entire range of forest habitat types and vertical vegetation levels, and the relative ease with which they can be identified and counted. Freemark and Collins (1992) found few forest interior neotropical migrants in forested tracts less than 25 acres. Robbins et al. (1989) reported the median minimum size of forest habitat to be 25 acres for isolated forests, however, they stated that the results of their study indicated that a smaller area can support many species if there is additional forest area in patches nearby (< 2 km or 1.2 miles away).

Additionally, the shape of the patches affects their potential quality (Matlack 1993, Chen et al. 1990). Habitat patches have edges along their perimeter, and these edges generally have lower habitat quality than areas in the interior of the patch, farther from the edge. The width of the edge, or the amount of habitat negatively affected by its location on the perimeter of a patch, is

determined by individual species' habitat preferences (Matlack 1993). For the purposes of this analysis, a habitat edge width of 100 yards is applied, which is a commonly used width in habitat analyses, based on empirical research (Harper et al. 2006). If the shape of the hub is elongated or narrow, then the amount of interior high quality habitat is diminished as the inner edges of the habitat edge approach and converge on each other, squeezing out interior habitat. The more urbanized the development is along the edge, generally the more detrimental the disturbance. Interior forest patch habitat is an increasingly rare and valuable habitat, as human development and disturbance of natural areas continues to fragment and eradicate large habitat patches.

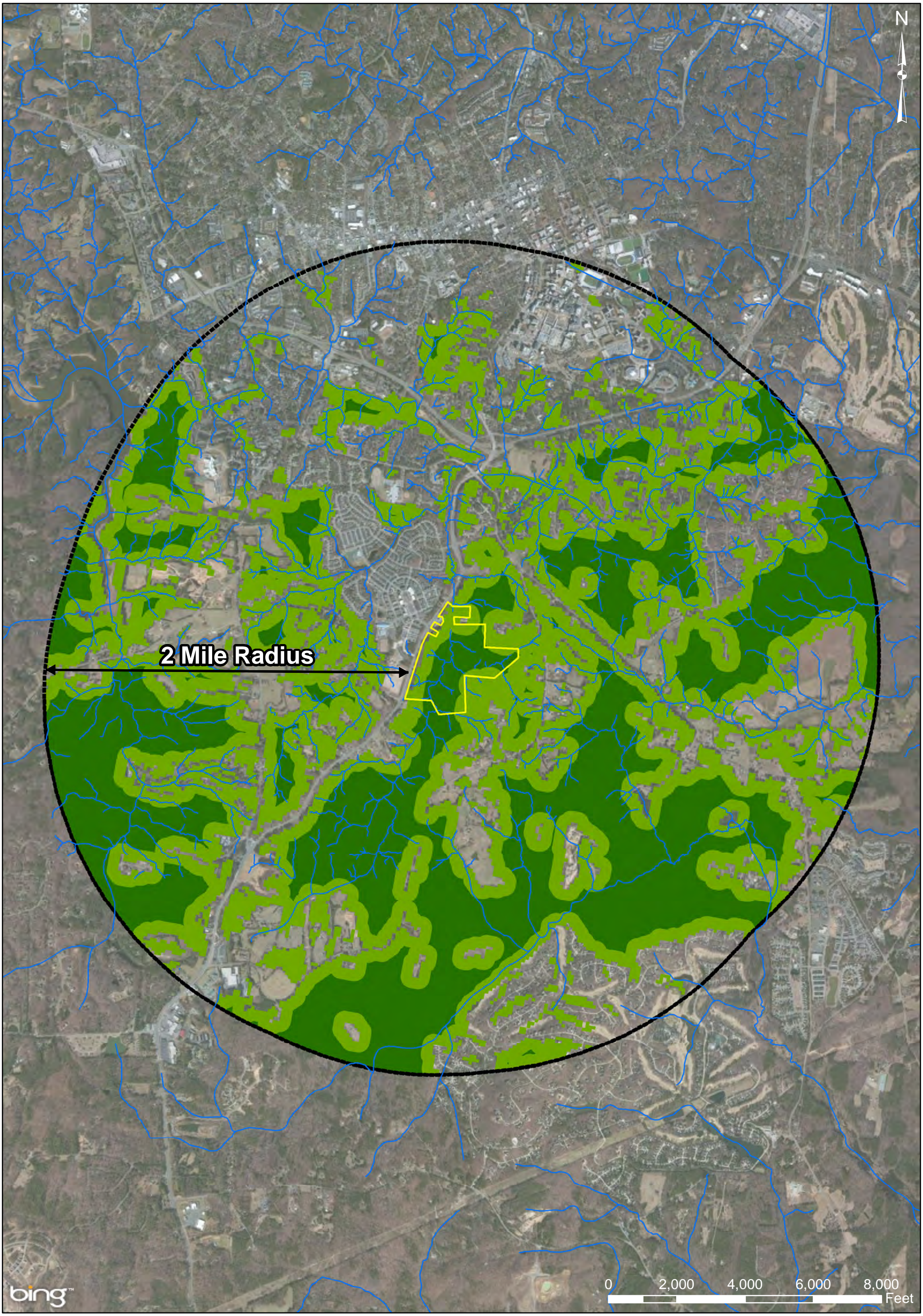
Vegetation composition, age, height and adjacent land use also affect the quality of patches and corridors as habitat or natural resources (Mason et al. 2006, Rodewald and Bakermans 2006). Vegetation with varying degrees of diversity, age and height attract and support different species of wildlife. A relatively young forest stand can attract and support a very diverse array of species. An older forest may not have as much faunal diversity, but it may support species that are more uncommon. Older growth forest stands have become rare due to development and disturbance, and they take longer to replace than younger ones, so their protection often receives a high priority when preserving open space.

The presence of streams and/or wetlands in patches and corridors enhances their ecological value in that these landscape features provide habitat diversity. They also provide important societal services by furnishing potential water supply and retaining and purifying surface and groundwater.

2. Analysis Methods

For this landscape ecology analysis, forest habitat patches on the site were delineated using land use/land cover data in a Geographic Information System (GIS) software platform. Habitat edges were delineated using the habitat patch polygons generated in GIS, applying the 100 yard width to the exterior boundary of all forest polygons. Edge habitat was delineated around disturbed areas, where forest has been cleared for roads and houses, etc., both inside and outside the property boundary. Interior forest habitat is illustrated inside the edge habitat boundaries.

Figure 3 illustrates the property in its regional habitat context, showing the property boundary and the surrounding area within a two-mile radius. There is a relatively large area of interior forest habitat contained in the property, which extends south from the property and connects to interior forest areas to the south and southeast. There is a smaller area of interior forest to the north of the property. The Obey Creek property provides a corridor from this isolated area of interior forest to the larger areas to the south. It should be noted that the boundaries of the edge habitat forest outside of the property have a lower spatial resolution than those within the property boundaries, but they are nevertheless adequate for this analysis.



Obey Creek
 Landscape Ecology
 Figure 3







-  Stream
-  Interior Forest
-  Edge Habitat
-  Obey Creek Site Boundary

Figure 4. is a close-up view of the property and its forested habitat. It can be seen in this Figure that the edge habitat along the western edge of the site does not extend to US 15-501. This is because the only readily available GIS data for land use/land cover is the U.S. Geological Survey 2011 National Landcover Database that has 30 meter accuracy, meaning the pixels or data points are 30m x 30m. So the edges of the data polygons are somewhat jagged and do not have the resolution to correspond precisely to the road.

The area of the forest between the edge boundary and US 15-501 is approximately 5 acres. Given the location and the historically disturbed quality of the forest at this location adjacent to US 15-501, it was chosen to leave the forest edge boundary as it is shown, thus giving a smaller, more conservative estimate of the interior forest area to the east. From the GIS analysis, there are approximately 47 acres of edge habitat, 68 acres of forest interior, and five acres of forest that will be counted as edge based on the resolution of the GIS data. From this analysis, forest interior habitat occupies approximately 57 percent of the site. Forest edge occupies approximately 43 percent of the site.

The amount of interior forest habitat and the relatively mature forest that occupies portions of that interior habitat are valuable natural resources with regional importance, as shown in Figures 3 and 4. The good connection to other interior forest to the south and east and the undisturbed nature of the forest in such close proximity to heavily developed land to the north and west add substantial ecological value to the interior forest on the Obey Creek property. While certainly not unaffected by past disturbance, the site is still relatively intact ecologically and provides a high level of ecological function and value, given its proximity to an urbanized area.

B. Wildlife Habitat Quality Evaluation

A spatial habitat evaluation was used to directly compare the two development scenarios. Although field observations such as species diversity and evidence of disturbance were used along with sources such as soils maps, the age of the stand was the simplest and most direct proxy for habitat quality. Using the stand categories presented in Section IV, forest stands were assigned a value according to the quality of wildlife habitat that they support. The ranking method uses stand age as the primary component of categorization and evaluation. Younger stands rank lower in habitat value than older stands because less time is required to replace younger stands. In other words, the time opportunity cost of replacement is lower for young stands than it is for old stands. The degree of disturbance is also included in category "D" in order to capture the significant disturbances (e.g. abandoned houses) in stand 5D.

The evaluation score for each stand category was determined based on age and level of disturbance on a 1-100 scale as follows (also see Figure 2, stands are color-coded by their Evaluation Score):



Obey Creek

Landscape Ecology
Figure 4



- Stream
- Open Water
- Estimated Wetlands
- Edge Habitat
- Interior Forest
- Obey Creek Site Boundary

<u>Stand Category</u>	<u>Description</u>	<u>Evaluation Score</u>
A	Less than 35 years old	30
B	Less than 65 years old	60
C	Greater than 65 years old	70
D	Greater than 65 years old, disturbed	60

Per the evaluation method, the dominant canopy trees in Stands 2-A and 3-A are less than 35 years old, so they received a habitat evaluation score of 30. The dominant canopy trees in Stands 4-B and 7-B are less than 65 years old, and they received a habitat evaluation score of 60. Stand 5-D is more than 60 years old, but has numerous disturbed areas scattered throughout, and it also received a habitat evaluation score of 60. The dominant canopy trees in Stand 8-C are older than 65 years, so it received an evaluation score of 70 (see color coding on Figure 2). Points were assigned to each acre of the stands according to their respective evaluation scores.

It should be noted that this evaluation method is not intended to quantify the wildlife habitat value of the stands in a comprehensive quantitative way, or for any individual species. It is used only to generally rank or ordinate the respective stands, so that when a development concept is overlaid on the property using GIS, an assessment can be made, using existing information, that is helpful in estimating ecological impacts. The intent of this analysis is to compare the ecological impacts of the two development scenarios, and this methodology was developed because it is based on the accepted ecological concepts of forest age and habitat value, it relatively simple, and uses reliable existing information from the site.

C. Analysis of Development Concepts - Landscape Ecology Impacts

1. Single Family Residential Concept

The single family residential development concept was overlaid with the landscape ecology map layer in GIS, as illustrated in Figure 5. For this analysis, it was assumed that housing or driveways would extend into the middle of each lot, and edge habitat was measured from those points. Outside of the footprints of the residential and commercial lots, there are approximately 49 acres of edge habitat remaining. This represents an approximately 4 percent increase in edge habitat. There are approximately 5 acres of interior forest that would not be disturbed with this development concept, resulting in an overall reduction of about 93 percent of the interior forest.



Obey Creek
 Landscape Ecology
 Single Family Concept
 Figure 5



Stream	Roads
Single Family	Commercial
Estimated Wetlands	Residential
Open Water	Edge Habitat
SW Ponds	Interior Forest
Traffic Islands	Obey Creek Site Boundary



Obey Creek
 Landscape Ecology
 Mixed Use Concept
 Figure 6



- | | |
|-----------------------|--------------------------|
| Stream | Estimated Wetlands |
| Mixed Use Master Plan | Edge Habitat |
| Mixed Use Impact Area | Interior Forest |
| Open Water | Obey Creek Site Boundary |

2. Mixed Use Concept

The mixed use concept was also overlaid on the landscape ecology map layer in GIS, as illustrated in Figure 6. For this analysis, it was assumed that edge habitat extended eastward from the east boundary of the proposed development. Under this development concept, there are 46 acres of edge habitat on the site, a 2 percent reduction. Also, there are approximately 47 acres of interior forest habitat that would not be impacted, an approximately 31 percent reduction.

The development concept overlay impacts to landscape ecology resources are summarized in Table 2.

Table 2. Summary of Development Concept Impacts to Landscape Ecology Resources

Attributes of Site/Development	Development Concept	
	Single Family Lots	Mixed Use
Existing Edge Habitat (ac)	47	47
Existing Interior Forest Habitat (ac)	68	68
Edge Habitat With Development (ac)	49	46
Interior Forest Habitat With Development (ac)	5	47
Change in Edge/Interior Forest (ac)	+2 / -63	-1 / -21
Change in-Edge/Interior Forest (%)	+4 / -93	-2 / -31

D. Wildlife Habitat Quality Impacts of Alternative Concepts

1. Single Family Residential Concept

To assess wildlife habitat quality impacts of the proposed residential development, the single family residential development concept was overlaid in GIS on the wildlife habitat evaluation/forest stand GIS map described in Section VI.

For the first step in this analysis the footprints (or planform views) of lots, roads, stormwater ponds, and traffic islands were superimposed directly on the respective forest stand boundaries, and the impacts were calculated on an acreage basis. Where a development features falls on a forested area, it is assumed that the existing forested area is totally transformed by the impact into developed land, resulting in no habitat evaluation points remaining in those areas in the second step of the analysis, where evaluation points are totaled. That is not to say that there is no habitat value remaining when forest is converted to single family residential use. However, the habitat value of the forest that does persist would be expected to vary substantially depending on the size of the lot, the shape of the lot, the amount of development both within a lot and adjacent to it, and the configuration of the development, etc. Given the variability in such

a scenario and information currently available for this site, it is beyond the scope of this analysis to analyze and model for such impacts. Instead, the simpler method of canceling habitat value for developed areas of any kind is used. It is conceded that the resolution of this simpler method is not as great as a more in-depth analysis would provide. It nevertheless has relevance, value and utility in assessing impacts to habitat and making the needed comparison of development concepts.

A summary of the single family residential impacts to the respective forest stands follows in Table 3.

Table 3. Summary of Impacts of Single Family Concept on Wildlife Habitat Evaluation/Forest Stands

Forest Stands	Single Family Lots (ac)	Commercial Lots (ac)	Roads (ac)	Storm Water Ponds (ac)	Traffic Islands (ac)	Disturbed Area Within Stand (ac)	Total Stand Area (ac)	% of Total Stand Area Disturbed
1-C	0	0	0	0	0	0	6.1	0
2-A	1.18	1.21	0.8	0	0	3.2	5.5	57
3-A	5.26	0	1.6	0	0.51	7.4	9.6	77
4-B	2.84	0	0.9	0	0.47	4.2	4.8	88
5-D	7.38	0.94	2.4	0.41	0.25	11.4	15.8	72
6-B	5.45	0	1.3	0.58	0	7.4	15.9	46
7-B	0.4	0	0.3	0.04	0	0.7	3.1	23
8-C	21.8	0	4.5	0.86	0.2	27.4	61.5	44
TOTALS	44.3	2.1	11.8	1.9	1.4	62	122	51

Approximately 51percent of the property area (62 ac) will be impacted by the single family development concept. Single family lots impact about 22 ac in Stand 8-C, more than twice the amount of impact to any of the other stands. Stand 5-D has approximately 7.4 acres of impact. Stands 3-A and 6-B have over 5 acres of impacts incurred by lots. Roads impact about 4.5 acres in Stand 8-C, and 2.4 acres in stand 5-D. Based on the existing data, the GIS analysis showed no impacts to Stand 1-C.

Table 4 summarizes the impacts of the single family concept on forest stands based on their wildlife habitat evaluation points, as described in Section VI. Evaluation points were assigned to each acre in each stand according to their stand age category. Category A stands were assigned 30 points per acre, Category B and D stands were assigned 60 points per acre, and Category C stands were assigned 70 points per acre. The total number of habitat evaluation points were calculated for each existing stand. Then the habitat evaluation points were calculated for areas impacted by development, and the sum of the impact points was subtracted from the existing stand habitat evaluation point total. The percent reduction in points, in the far right column, is used as an indicator of wildlife habitat impacts under this development concept. The percent loss in total area of impact (far right column in Table 3, 51%) is in close agreement

with the loss of total habitat evaluation points due to development (far right column in Table 4, 52%).

Table 4. Summary of Impacts of the Single Family Concept on Wildlife Habitat Evaluation Points

Forest Stands	Total Stand Area (ac)	Total Stand Wildlife Habitat Evaluation Points (ac x points)	Disturbed Area In Stand (ac)	Total Disturbed Area Wildlife Habitat Evaluation Points	Total Minus Disturbed Evaluation Points Col. 3- Col. 5	% Reduction in Points
1-C	6.1	427	0	0	427	0
2-A	5.5	167	3.2	95	71	43
3-A	9.6	287	7.2	222	66	23
4-B	4.8	288	4.2	254	34	12
5-D	15.8	947	11.4	683	264	28
6-B	15.9	952	7.4	442	509	54
7-B	3.1	185	0.7	43	143	77
8-C	61.5	4,308	27.4	1,916	2,392	56
Totals	122.3	7,561	61.6	3,655	3,906	52

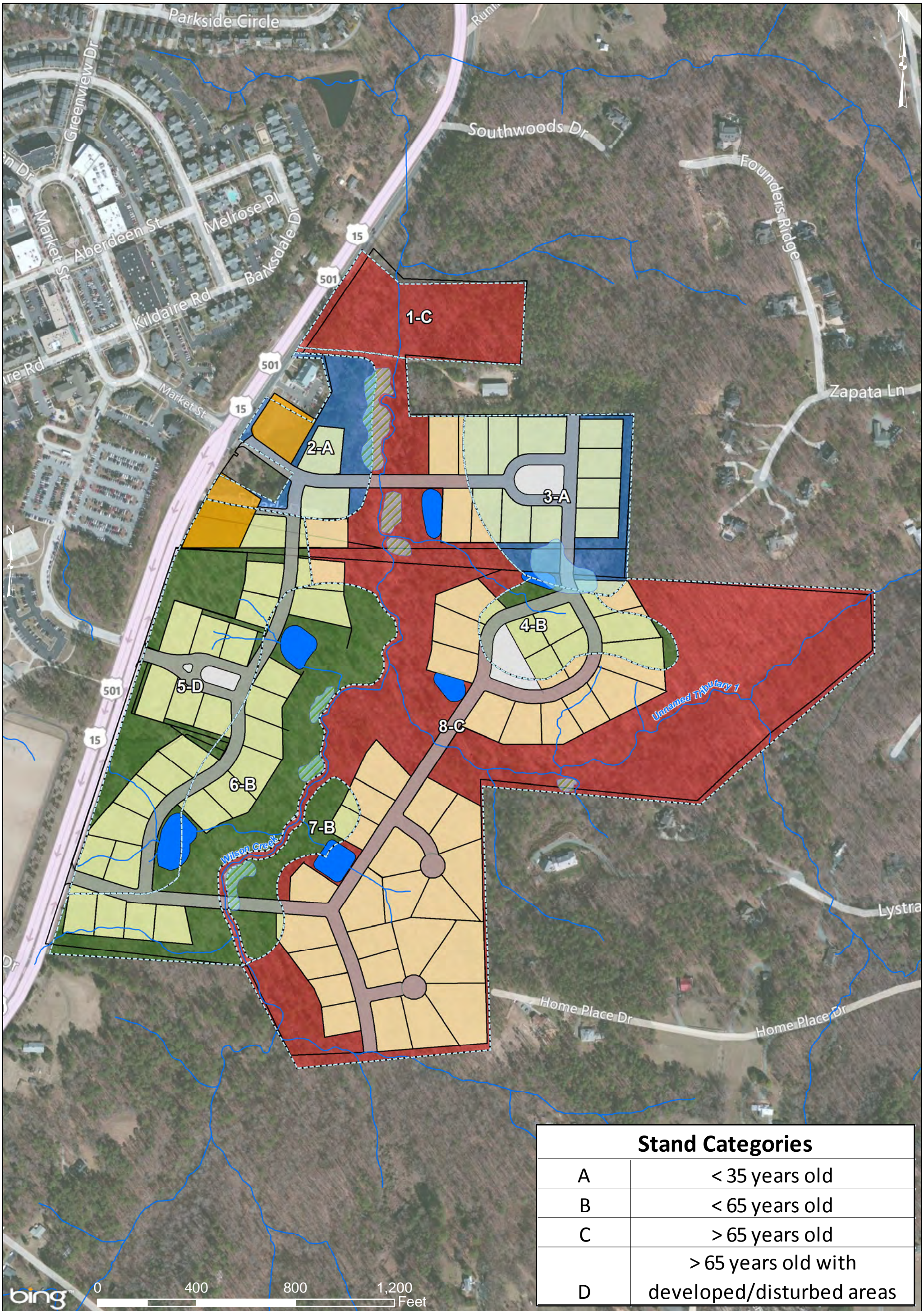
2. Mixed Use Concept

The mixed use concept was also overlaid in GIS on the wildlife habitat evaluation/forest stand GIS map that was described in Section VI. As in the single family residential concept analysis, it is assumed that the existing forested area is totally transformed by the impact into developed land, resulting in no habitat evaluation points remaining in those areas in the second step of the analysis, where evaluation points are totaled. A summary of the mixed use concept impacts on the wildlife habitat/forest stand GIS map is in Table 5.

Table 5. Summary of Impacts of the Mixed Use Concept on Wildlife Habitat Evaluation Points

Forest Stands	Total Stand Area	Total Stand Wildlife Habitat Evaluation Points (ac x points)	Disturbed Area in Stand (ac.)	Total Disturbed Area Wildlife Habitat Evaluation Points	Total Minus Disturbed Evaluation Points Col. 3- Col. 5	% Reduction in Points
1-C	6.1	427	0.6	34	393	8
2-A	5.6	167	3.9	117	49	70
3-A	9.6	287	0.0	0	287	0
4-B	4.8	288	0.0	0	288	0
5-D	15.8	947	15.8	947	0	100
6-B	15.9	952	7.5	451	501	47
7-B	3.1	185	0.0	0	185	0
8-C	61.5	4,308	0.9	62	4,246	1
Totals	122.3	7,561	28.7	1611	5,950	21

The total reduction in habitat evaluation points for the mixed use concept overlay is 21 percent. The footprint of development, and thus the wildlife habitat impacts for this concept, are concentrated on the west side of the property, between US 15-501 and Wilson Creek. Wilson Creek and areas east of it accrue no direct development impacts in this particular analysis. Almost all of the development impacts are sustained in Stands 1-C (8% reduction in points), 2-A (70% reduction in points), 5-D (100% reduction in points), and 6-B (47% reduction in points). Stand 8-C is marginally impacted, with a 1% reduction in points. Table 6. contains a summary comparison of the analysis of the wildlife habitat/forest stand impacts of the two development concepts.



Stand Categories	
A	< 35 years old
B	< 65 years old
C	> 65 years old
D	> 65 years old with developed/disturbed areas

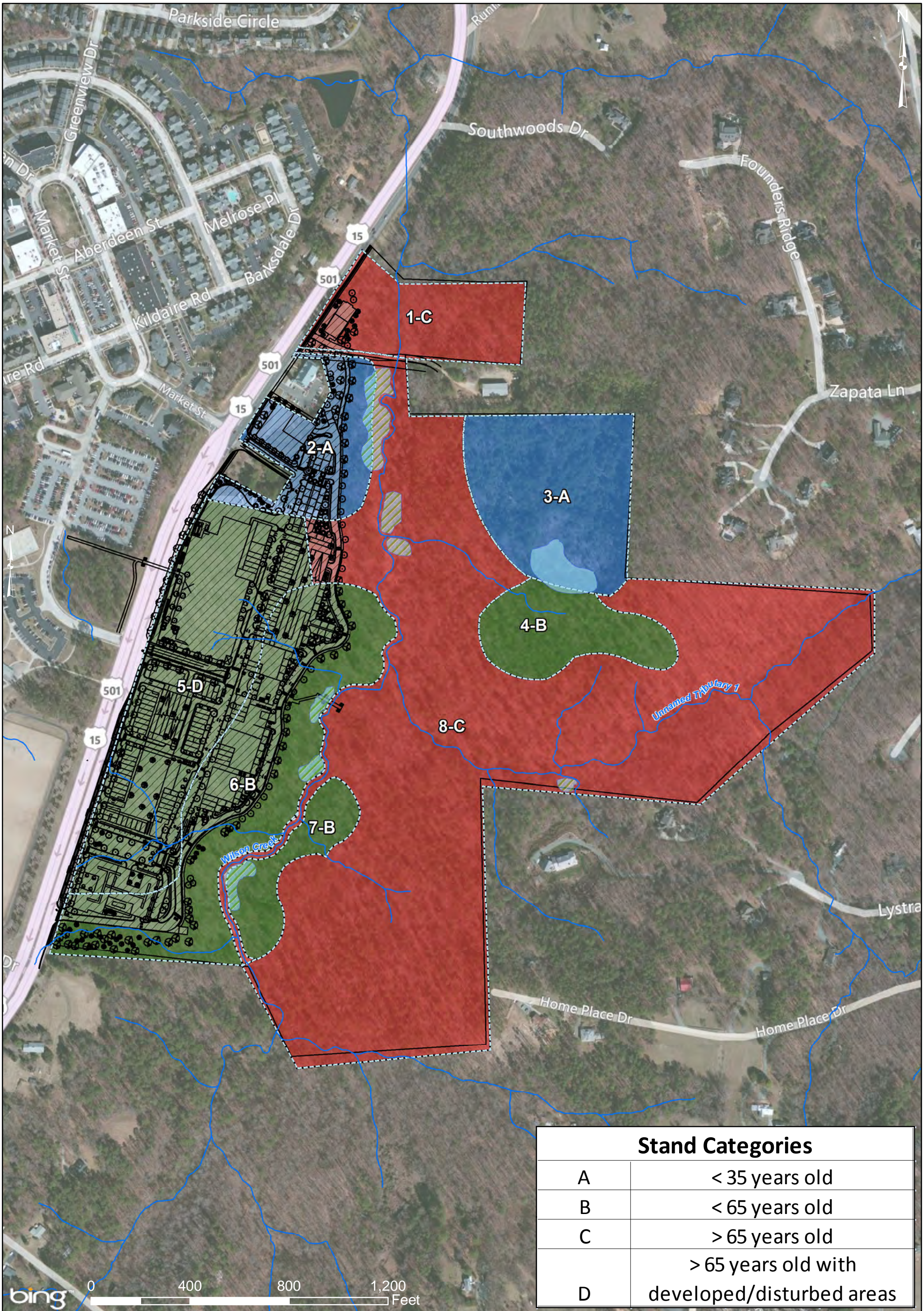
Obey Creek
Forest Stands
Single Family Concept
Figure 7



Evaluation Score

- 30
- 60
- 70

- Stream
- Single Family
- Forest Stands
- SW Ponds
- Traffic Islands
- Commercial
- Residential
- Open Water
- Estimated Wetlands



Stand Categories	
A	< 35 years old
B	< 65 years old
C	> 65 years old
D	> 65 years old with developed/disturbed areas

Obey Creek
 Forest Stands
 Mixed Use Concept
 Figure 8




Evaluation Score

- 30
- 60
- 70

- Stream
- Mixed Use Master Plan
- Open Water
- Estimated Wetlands
- Forest Stands
- Mixed Use Impact Area

Table 6. Summary of Development Concept Impacts to Wildlife Habitat and Forest Stands

Attributes of Site/Development	Development Concept	
	Single Family Lots	Mixed Use
Existing Edge Habitat (ac)	47	47
Existing Interior Forest Habitat (ac)	68	68
Edge Habitat With Development (ac)	49	46
Interior Forest Habitat With Development (ac)	5	47
Change in Edge/Interior Forest (ac)	+2 / -63	-1 / -21
Change in-Edge/Interior Forest (%)	+4 / -93	-2 / -31

As previously stated, this analysis uses an approach to the evaluation of forest habitat based on existing information and somewhat limited data gathered in the field over the course of two days. The data does not contain comprehensive, detailed data associated with any particular species of interest. It does, however, employ accurate field measurements of stand age and reasonably accurate stand boundaries based on current and historical aerial photography. Therefore by applying sound, accepted ecological principles to the data that does exist, meaningful comparisons can still be made, although the degree of accuracy and detail should only honestly be described as general.

The results of this analysis and comparison indicate that the single family residence development concept impacts wildlife habitat 31% more than the mixed use concept, more than double the impact. A large portion of the additional impacts of the single family residential concept occur in Stand 8-C, on the eastern half of the property. 56 % of this large stand is impacted with the single family residential concept, versus 1% with the mixed use concept.

III. Summary Discussion of Results and Conclusions

To facilitate discussion, the results of the landscape ecology and wildlife habitat/forest stand analyses are summarized in Table 7.

Table 7. Summary of Analysis Results

Analysis/Attributes of Site/Development	Development Concept	
	Single Family Lots	Mixed Use
Landscape Ecology Analysis		
Existing Edge Habitat (ac)	47	47
Existing Interior Forest Habitat (ac)	68	68
Change in Edge/Interior Forest (ac)	+2 / -63	-1 / -21
Change in-Edge/Interior Forest (%)	+4 / -93	-2 / -31
Wildlife Habitat/Forest Stand Analysis		
Existing Wildlife Habitat Evaluation Points	7,561	7,561
Wildlife Habitat Evaluation Points Remaining After Development	3,906	5,950
Reduction in Habitat Evaluation Points (%)	52	21

Based on the landscape ecology analysis performed, the mixed used development concept would result in fewer impacts to interior forest habitat, an increasingly rare natural resource, as forests and habitat become more and more fragmented as a result of human development pressures on the landscape. Approximately 70% of the existing interior forest would avoid disturbance with the mixed use concept, but only about 7% would not be disturbed by the single family residential concept, a large, order-of-magnitude difference in impacts. Clearly, the mixed use concept is less detrimental to wildlife and valuable, rare interior forest habitat than the single family residential concept, which disturbs forest east of Wilson Creek, while the mixed use concept does not.

The wildlife habitat/forest stand analysis provides results that are not as dramatic, yet still definitive. While a high percentage of forest is lost west of Wilson Creek in the mixed use concept, the forest east of Wilson Creek is preserved, and approximately 80% of the wildlife habitat evaluation points are retained. The single family residential concept results in a reduction of over 50% of the wildlife habitat evaluation points.

The landscape ecology and wildlife habitat/forest stand analyses both show less ecological impact with the mixed use development concept.

The stormwater impacts of the two development concepts are not addressed directly with these analyses, but since both concepts will alter and potentially disturb aquatic wildlife habitat, a short stormwater discussion is included here. The single family residential concept will generate stormwater from impervious surfaces extensively across the site. It will impact the very high quality waters of the unnamed tributary, where a road is designed to cross. This concept will add two more crossings over Wilson Creek, which will generate more stormwater that will enter the stream.

The mixed use development will not result in any crossings over the unnamed tributary or any additional crossings over Wilson Creek. However, it will generate stormwater runoff over much of its densely developed, approximately 30 acre footprint. Both scenarios pose risk to the fragile water quality of the streams on the site. The concentration of stormwater in the mixed use concept development area spares the unnamed tributary from disturbance and narrows the extent of potential negative impacts, however there are challenges to successfully treating and discharging stormwater from heavily developed areas, so that no negative impacts result downstream.

Lastly, invasive species are widespread across the site. However, their concentration is highest west of Wilson Creek and closer to US 15-501, where more disturbance has historically taken place. In order to prevent further degradation of natural resources on the site, regardless of which development concept goes forward, it is recommended that an invasive species control plan is developed, funded, and implemented for the important natural resources that occupy this site.

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