6.0 THE ARCHAEOLOGICAL PREDICTIVE MODEL

The predictive model developed for the current project attempts to define areas of high, moderate, and low potential for prehistoric and historic archaeological resources. Characterization of the relative archaeological sensitivity of the study area has been accomplished using data available in a GIS format, and GIS has been used to compare the relative significance of the relevant criteria used to determine these probabilities.

6.1 Prehistoric Archaeological Potential

Cultural ecology, as defined by Steward (1968b), remains an important unifying theory in prehistoric studies in the Middle Atlantic region. Culture as an adaptation to the environment is a prominent theme in the current scholarship, as can be seen in the summary prehistoric context presented above. In the literature, environmental criteria presumed important to hunter/gatherers in their selection of locations for base camps or procurement sites are usually identified. The prehistoric component of the model developed for the current project also uses this approach. The method is predominantly deductive, in that the significant criteria considered by the model were chosen on the basis of their perceived relative importance in subsistence strategies practiced by the area's inhabitants during the prehistoric period, based on the context presented above.

Because vicinity to water is such an important component of this model, and because it is cited as an important criterion throughout the prehistory of the area, no attempt has been made to distinguish archaeological potential by prehistoric period. While significant climatic and hydrological changes did occur during the period, most notably during the Early Holocene when the area warmed and sea levels rose, the model assumes that the currently evident active and remnant stream channel patterning approximates that existent within the study area throughout prehistory.

The study area has been divided into two parts, the larger of the two composed of the bulk of the area, which falls within the Midpeninsular Drainage Divide Zone, and the smaller of the two composed of the part that falls within the Mid-drainage Zone. The model distinguishes between

the Midpeninsular Drainage Divide Zone and the Mid-drainage Zone in the valuation of the weights of the variables it considers. The environmental criteria considered by the model were assigned relative values reflective of their assumed significance. Clustering within the range of scores generated by this approach was discerned using the Jenks Optimization Method for identifying natural breaks within a dataset distribution, and the patterning defined by this analysis was then used to define the three classes of probability, high, moderate, and low. Kvamme's Gain statistic, a measure of how the model improved the selection of site locations over chance (with a perfect model having a gain statistic near one), was applied to the model to determine its efficiency in defining the locations of previously reported sites within the study area. The values assigned to the significant criteria were then modified to improve its efficiency in capturing the locations of the previously reported sites. Finally, historic and modern ground disturbances were modeled to qualify the areas of archaeological potential relative to their likely integrity.

The prehistoric probability calculation generates a range of values, not initially pointing to low, moderate, and high classes. The model uses the Jenks Optimization method, also known as the Goodness of Variance Fit (GVF), to define natural breaks in the dataset. This classification method groups classes of similar value by minimizing the squared deviations of class means. This is an iterative calculation which starts at an arbitrary class break, compares variance within classes, and continues to compare successive class breaks until the minimum variance is found. This is a standard classification method found in all high-end GIS software products.

Once the initial classes are identified, Kvamme's Gain Statistic (1 − % total area / % known sites) is calculated to determine the effectiveness of the classes and the model. Several combinations and numbers of classes may be tested until the optimal efficiency is achieved.

Initially a set of six significant variables was defined to evaluate the prehistoric archaeological potential of the study area, based on the current understanding of prehistoric land use and settlement systems and on the criteria determined significant during studies associated with the U.S 13 Relief Route project. These six included: (1) cost distance to streams; (2) cost distance to springs; (3) cost distance to confluences; (4) cost distance to wetlands; (5) percent slope; and (6)

soil permeability. The modern soils data was referenced to define likely seasonal wetland areas along drainageways and around headwaters and upland swamps, using the less well-drained soils of the Othello, Fallsington, and Johnston series as indicators.

The estimation of cost distance was intended to take into account the relative effort required to cross geographic space. Geographic cost can be defined as the expenditure of energy or time when moving across terrain. In this model, ground slope is used as a cost factor in determining cost distance. Cost is modeled parabolically (i.e. as a second-order function). As slope increases slightly, the additional cost incurred is minimal, but as the slope increases sharply, cost increases dramatically as well. The curve used for the cost layer in this model is represented by the equation: $\text{cost} = 1 + (\text{slope}^2/100)$.

The cost-distance parameters used for the vicinity to water sources (Tables 3 and 4 below) are based on previous models. Kellogg (1993:66) used distances defined by grid squares (with these squares measuring 500 feet on a side) to distinguish classes, with grid squares containing water sources or poorly drained soils (i.e., within 500 feet [152.4 meters] of water) representing high probability, those one square removed from such a resource (i.e., 500 to 1000 feet [154.2 to 304.9 meters] from water) representing moderate probability, and those more than one square removed (i.e., more than 1000 feet [304.9 meters] from water) representing low probability. Lothrop et al. (1987:29) uses a distance of 200 meters or less to define high probability areas and greater than 200 meters to define low probability areas. (The technique used by Custer et al. [1984] did not generate distance parameters, and as a consequence, it was not used to develop these cost-distance figures.) Different cost-distance criteria were used for the Midpeninsular Drainage Divide Zone and the Mid-drainage Zone, as the character of the water sources in each is different; those in the Mid-drainage Zone (higher order streams, bay/basin features, estuarine settings) seemed likely to represent richer subsistence resources, and cost-distance parameters for the high and moderate potential areas within this zone were increased over those of the Midpeninsular Drainage Divide Zone.

Soil permeability was used to define areas that likely would have been too wet during prehistory to accommodate camping or other longer term activities. Areas mapped as having slow or very

slow drainage were considered unlikely to contain prehistoric deposits. While it has to be assumed that the modern soils data deviates to some extent from the soil characteristics seen in prehistoric times, it is the best approximation available at the scale of the study area.

Ground slope is considered in this model as a relatively minor variable. As Lothrop et al. (1987) noted, the Midpeninsular Drainage Divide Zone in particular shows little ground slope variation, and with the exception of some of the more deeply incised stream banks, the same could be said for the Mid-drainage Zone as well. Using the criterion suggested by Stewart and Kratzer (1989), ground slopes greater than 8% were rated somewhat lower than those less than 8%. In general, the study area is notable for the relative uniformity of its topography.

In early iterations of the probability model, there were a number of previously reported sites that were falling within areas defined as low probability by the model. These sites were located on uplands between 250 and 500 meters from any mapped water source. Faye Stocum (personal communication, 2005), who had identified one of these outliers during a survey in 1983, suggested that there was some prehistoric site potential associated with the smaller drainage divides located between low-order streams (referred to here as microdrainage divides) and that this potential was less sensitive to the cost-distances involved. In an effort to identify such settings within the landscape, a two-part calculation was used. First, all areas between 250 and 500 meters from streams were identified. Second, a neighborhood calculation was performed which summed for each grid cell the number of other grid cells in a 500m radius that included streams. (This second calculation is essentially a map of stream density.) The two calculations were combined, and a stream density threshold was drawn by looking at two sites that displayed this particular site location pattern. By factoring this microdrainage divide layer into the prehistoric site probability calculation, these two areas and many others like them fell within either the moderate or high probability zones.

Tables 2 and 3 below present the six criteria and the score each was ultimately assigned.

Table 2. Predictive Model Landscape Criteria, Value Ranges, and Weights for the Midpeninsular Drainage Divide Zone

Landscape Feature	Weight	Value Range
Cost distance to streams	10	0-150 meters
	5	150-250 meters
	3	250-500 meters
Cost distance to springs	10	0-100 meters
	4	100-200 meters
	1	200-500 meters
Cost distance to confluences	10	0-100 meters
	4	100-200 meters
	1	200-500 meters
Cost distance to wetlands	10	0-100 meters
	4	100-200 meters
	1	200-500 meters
Percent slope	10	0 to 3
	10	3 to 8
	5	> 8
Soil permeability	10	Moderate, mod. rapid, rapid
	5	Moderately slow
	0	Slow
	0	Very slow
Microdrainage divide	20	See criteria above

Table 3. Predictive Model Landscape Criteria, Value Ranges, and Weights for the Mid-drainage Zone

Landscape Feature	Weight	Value Range
Cost distance to streams	10	0-200 meters
	5	200-350 meters
	3	350-500 meters
Cost distance to springs	10	0-100 meters
	5	100-200 meters
	2	200-500 meters
Cost distance to confluences	10	0-100 meters
	5	100-200 meters
	2	200-500 meters
Cost distance to wetlands	10	0-200 meters
	5	200-350 meters
	3	350-500 meters
Percent slope	10	0 to 3
	10	3 to 8
	5	> 8
Soil permeability	10	Moderate, mod. rapid, rapid
	5	Moderately slow
	0	Slow
	0	Very slow
Microdrainage divide	NA	

The Kvamme's Gain Statistic value computed for the model (Table 4) for the high probability areas was 0.67, which falls short of the standard of 0.75 used to indicate that a model is efficient in identifying archaeology probability relative to the set of known sites. Previous iterations of the model that did not use the microdrainage divide criterion proved to be more efficient and satisfied the 0.75 standard, but they included more sites that fell within low probability areas.

The decreased efficiency is apparently attributable to the fact that a larger percentage of the study area falls within the high probability areas with the inclusion of the microdrainage divide criterion, and that increase is disproportionately high relative to the number of additional sites that now fall into the high probability areas. On the other hand, the relatively high negative gain computed for the low probability areas suggests that the model is much more useful than the previous iterations for identifying areas with low prehistoric archaeological potential.

Table 4. Kvamme's Gain Statistic

Zone Profiles- Three Classes		
Zone	Area (in number of 10mx10m cells)	Percent of Total Area
Low	785336	37.82%
Moderate	886871	42.71%
High	404275	19.47%
Site Distribution by Zones		
Zone	Count	Percent of Total Number of Sites
Low	2	3%
Moderate	28	39%
High	41	58%
Gain Computation		
Gain (Low)	-11.67	
Gain (Moderate)	0.36	
Gain (High)	0.67	

As currently formulated, only two previously reported prehistoric sites fall within a low probability area. Both lie to the other side of Route 896 from the nearest drainage head, and their falling within the low probability area may be attributable to the disruption of the drainage caused by the construction of the road. If modern disruption of the natural drainage pattern is in fact responsible for the two outliers falling in low probability areas, then the model is even more efficient at identifying areas of low probability.

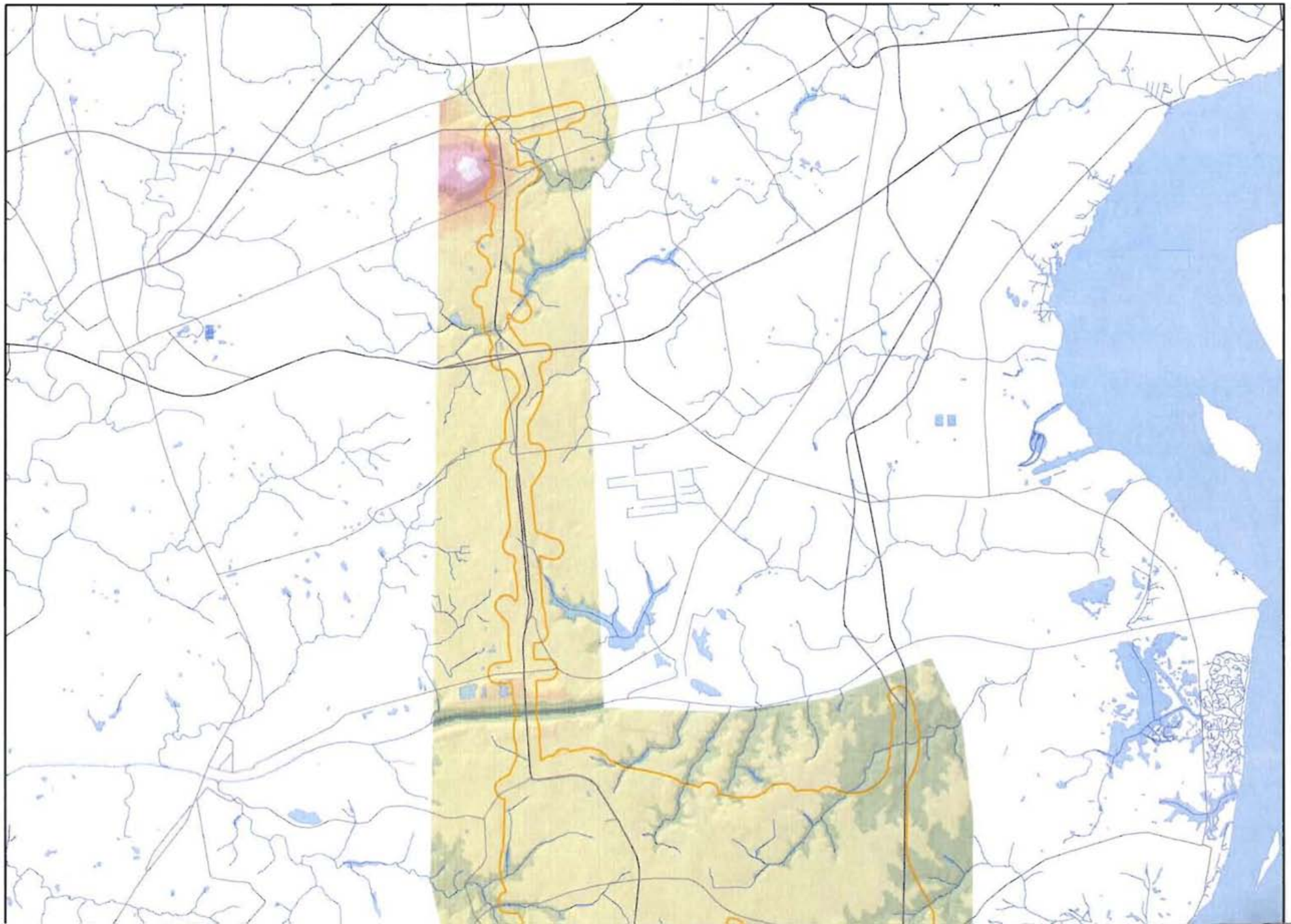
Figures 2 through 5 portray graphically the GIS data used to develop the model. All but Figure 3, which shows the mapping of the hydrologic features in the area, show the data without interpretation. Figure 3, on the other hand, includes some extrapolations based on the finer drainage resolution seen in county soil maps of the area but not portrayed in the digitized watercourse data, and an assumption that the extensive areas of poorly drained soils along the drainage divide indicates their likely association with headwaters and upland swamps. Figure 6 shows the areas defined for the purposes of this model as microdrainage divides, the derivation of which was discussed above.

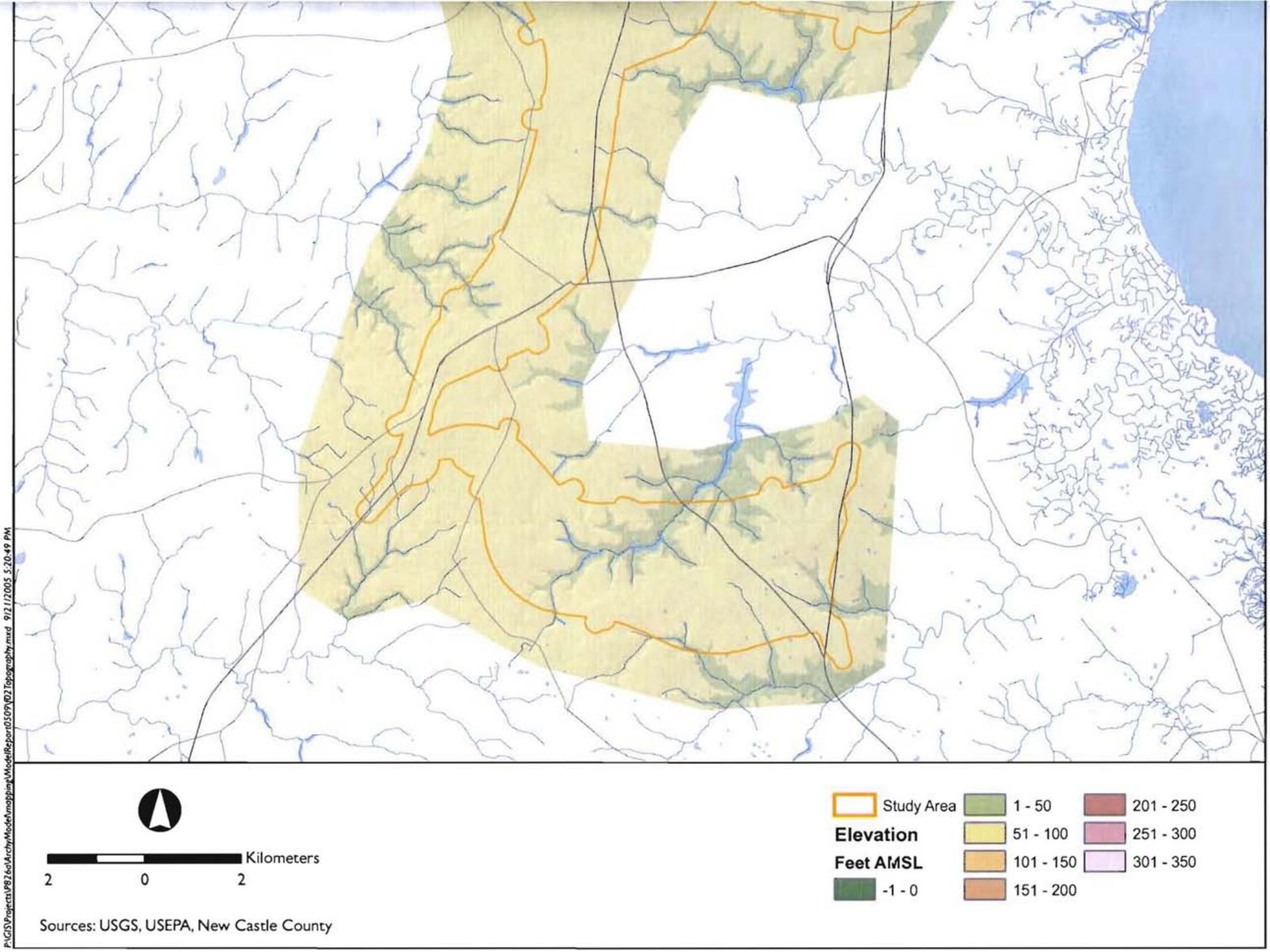
Figure 7 represents an assessment of the prehistoric archaeological potential of the study area without factoring in post-Contact ground disturbance. As can be seen from Figure 8, which used recent (2002) aerial photographs of the study area as a reference, this disturbance has been substantial. In Figure 8, an effort has been made to distinguish among three classes of disturbance. The least disruptive is that associated with plowing and other agricultural practices. While these activities disturb the surficial strata over large areas, they displace artifacts the least from their original context and may preserve at least the deepest parts of subsurface features. Next most disruptive is historic roadside development, both commercial and residential, the effects of which extend much deeper into the soil column but which tend to be localized within the vicinity of the structures themselves. The most disruptive is modern land development, which tends both to affect extensive tracts of land and to disturb much of the part of the soil column that might contain intact archaeological deposits.

Figure 9 shows the influence post-Contact ground disturbance likely has had on prehistoric archaeological potential within the study area. As is evident in the contrast between Figures 7 and 9, this effect has been profound. Large areas that lie within the boundaries of modern housing tracts and/or strip malls are essentially devoid of prehistoric archaeological potential. Because of the extensiveness of the practice of field farming within the study area during the historic period, much of the rest of the study area has had its potential reduced as well. Of course, this effect is much less severe that that caused by modern development and would not on its own necessarily preclude an area's retaining archaeological deposits that could contribute significant information regarding the region's prehistory. It is notable that sizable areas along

many of the drainages within the study area and in the vicinity of as-yet undrained swamps and marshes still retain relatively high prehistoric archaeological potential.

Figure 2
Elevation and Landforms
US 301 Project Development
New Castle County, Delaware





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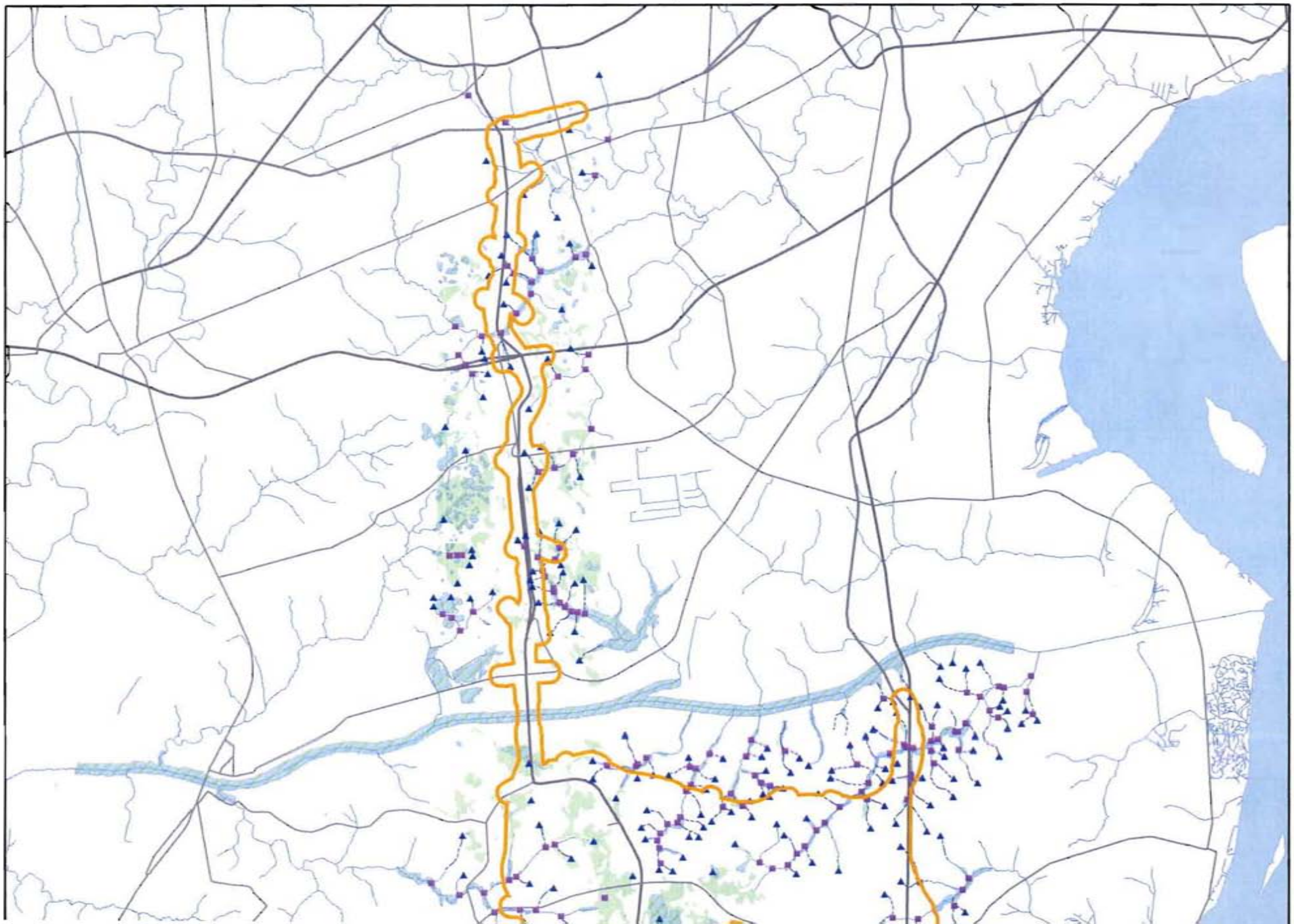
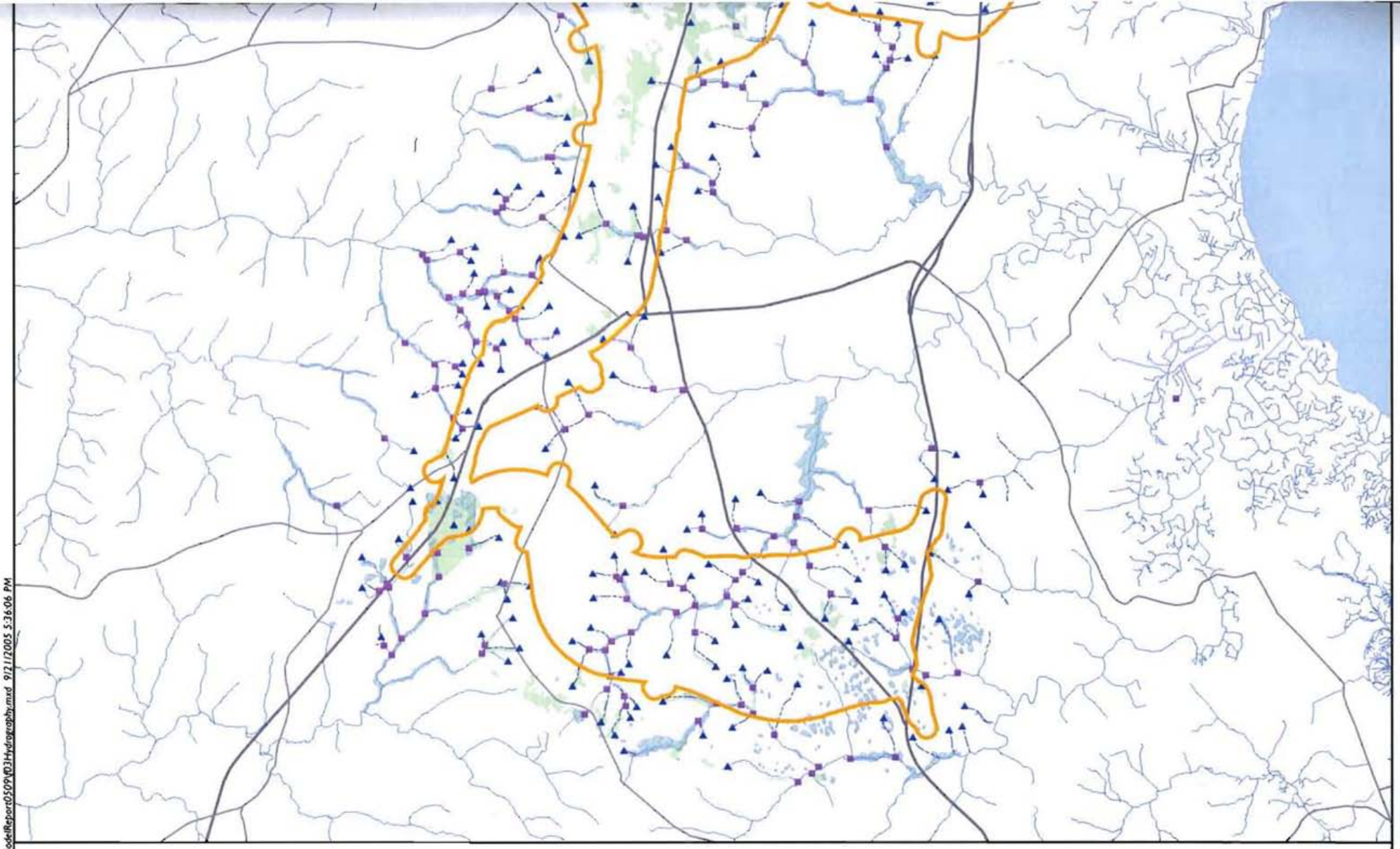
US 301 Project Development
Archaeological Predictive Model

Figure 3
Hydrologic Features
US 301 Project Development
New Castle County, Delaware





Kilometers

2 0 2

Study Area

Remnant Drainages

Modern Natural Wetlands

Estimated Headwaters

Stream Confluences

Fallsington Loam and Othello Silt Loam

Streams

Sources: USGS, USEPA, New Castle County

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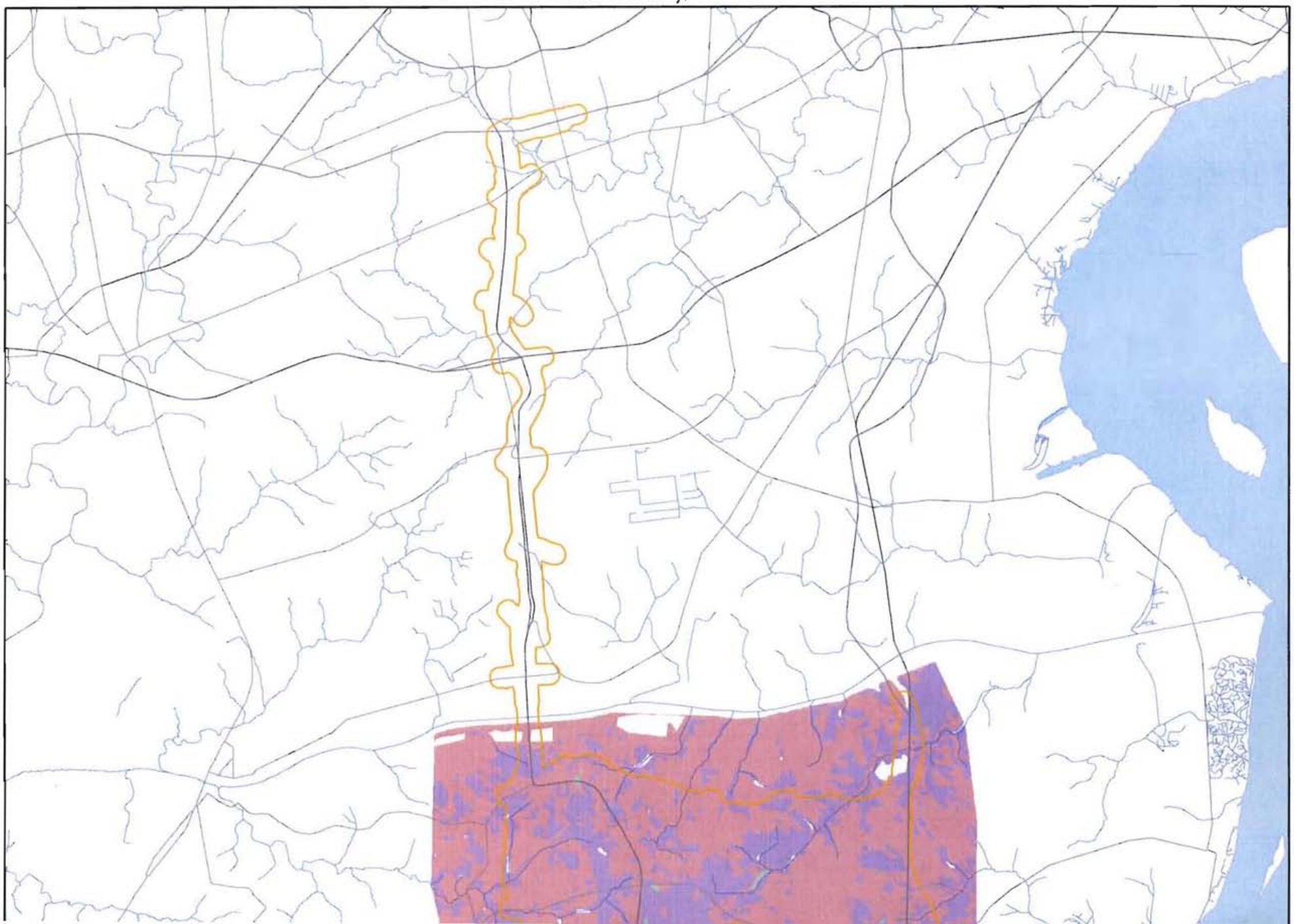
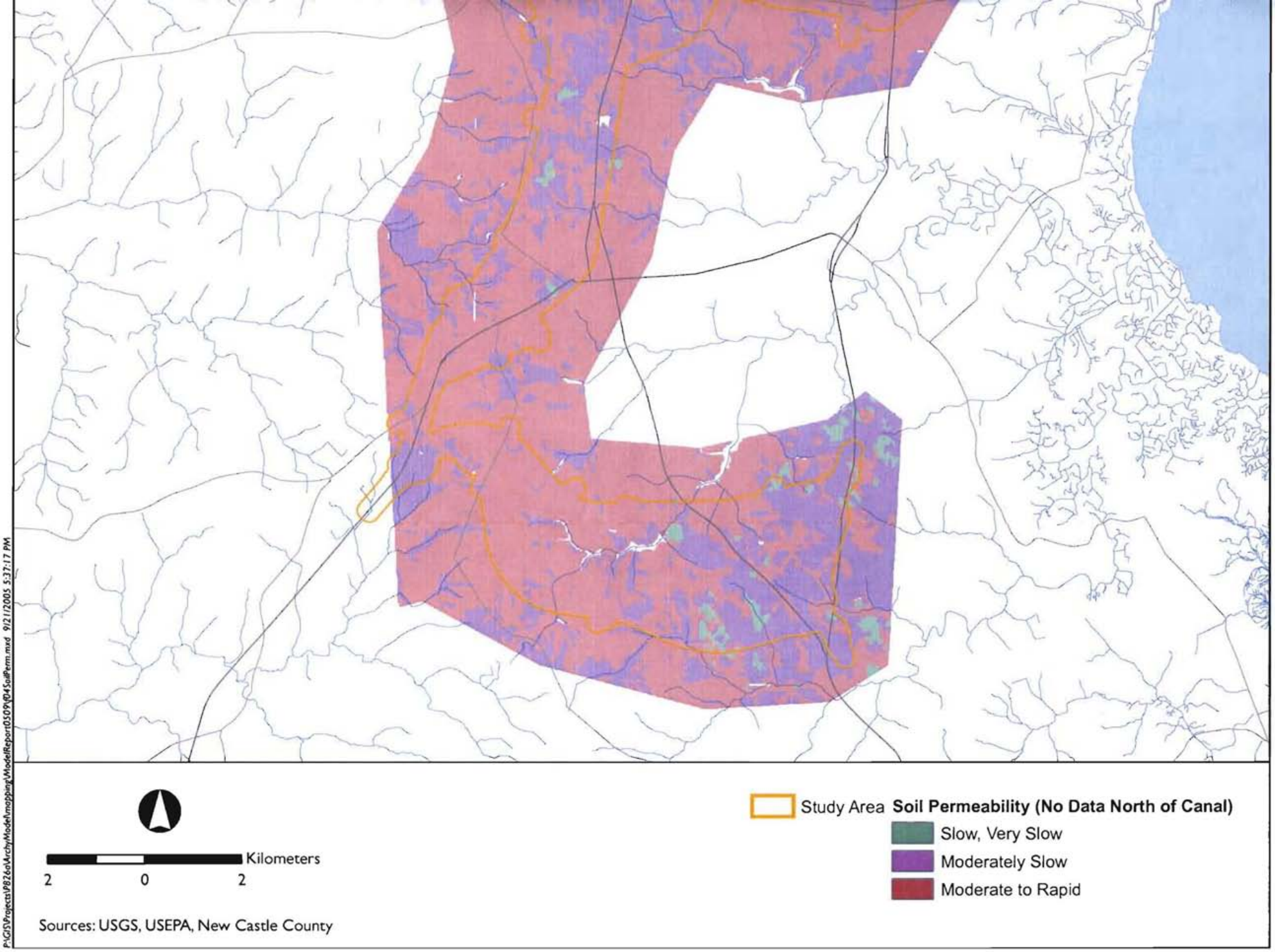
US 301 Project Development
Archaeological Predictive Model

Figure 4
Soil Permeability

US 301 Project Development
New Castle County, Delaware

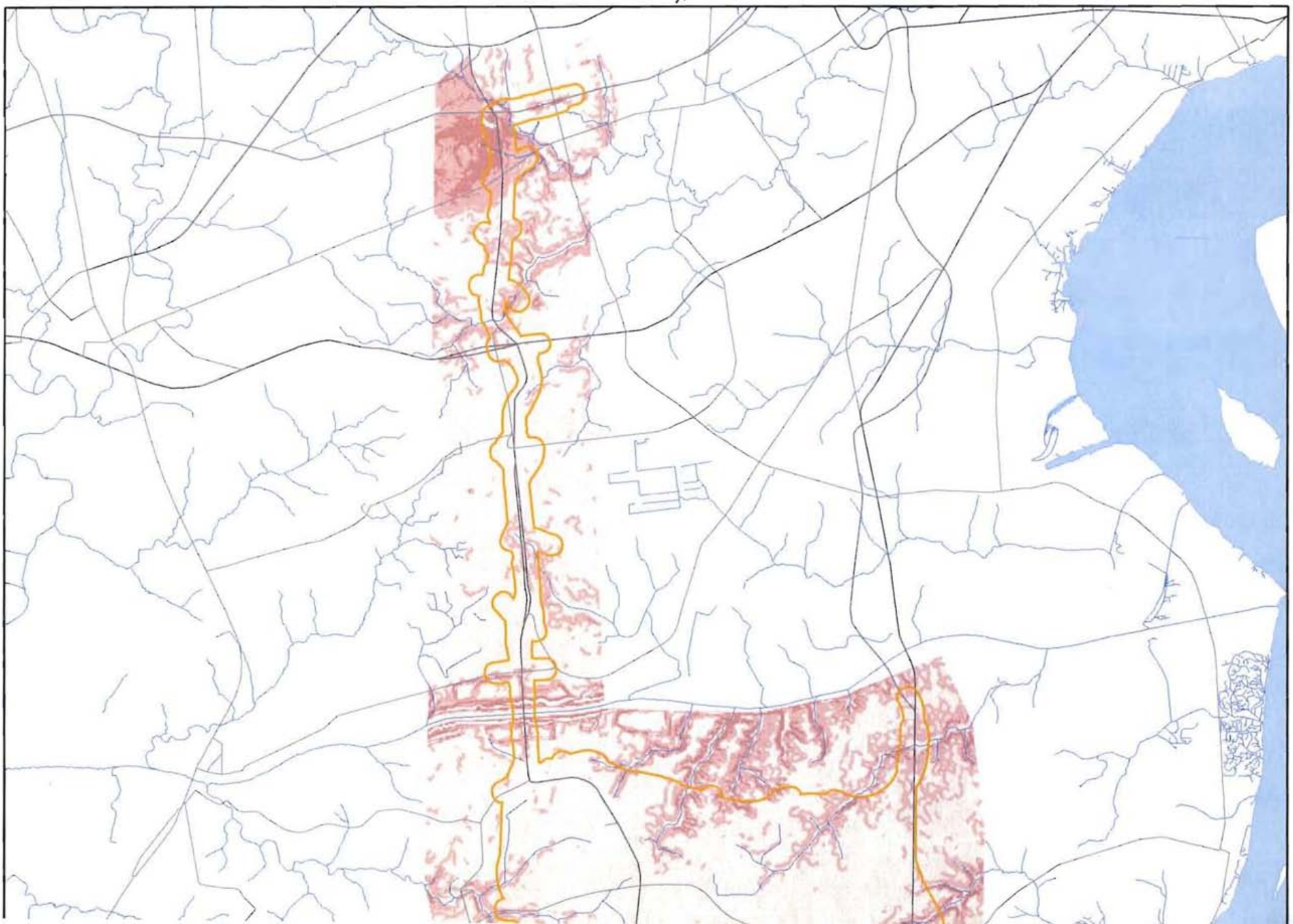


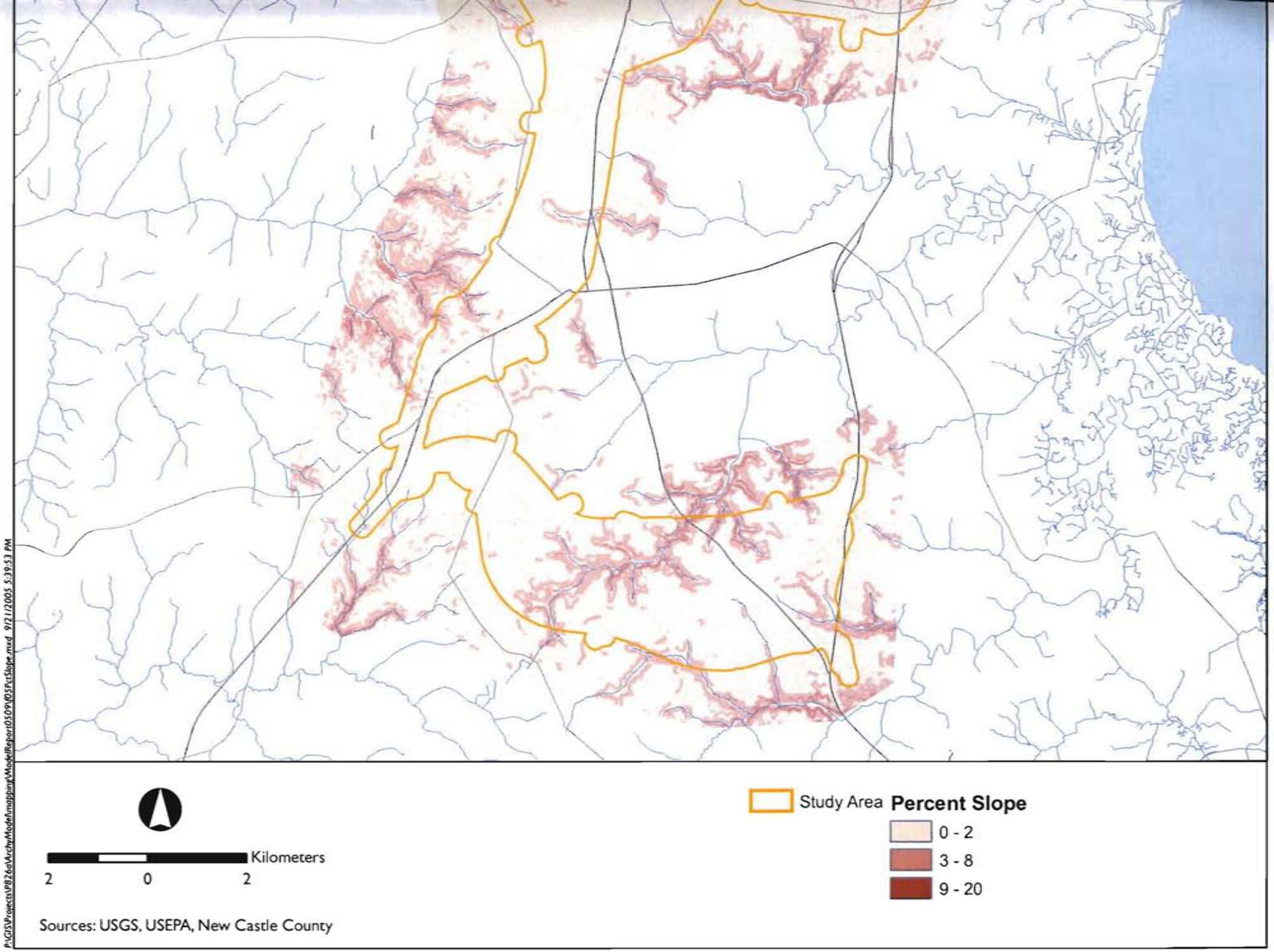


US 301 Project Development
Archaeological Predictive Model

Figure 5
Percent Slope

US 301 Project Development
New Castle County, Delaware

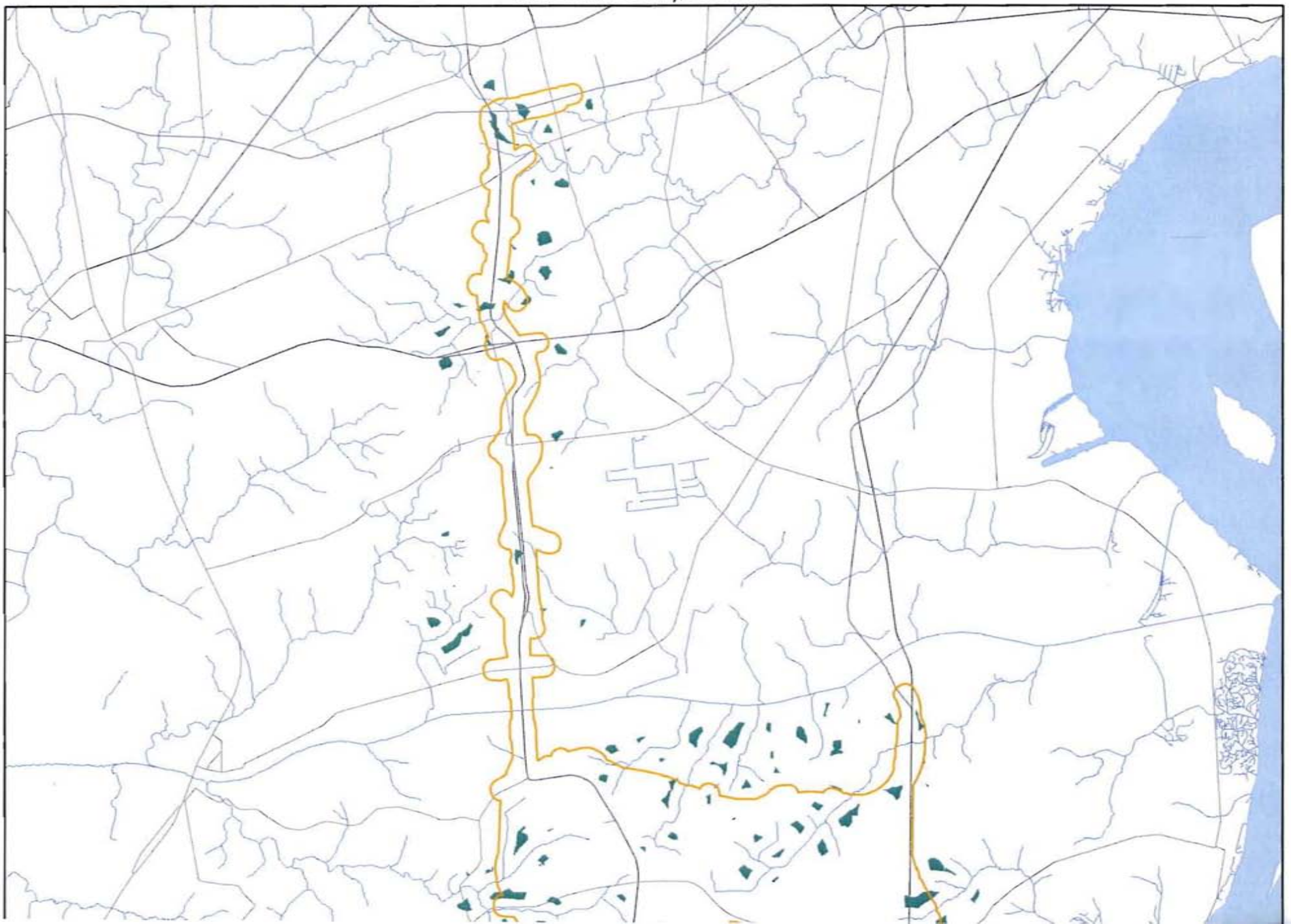


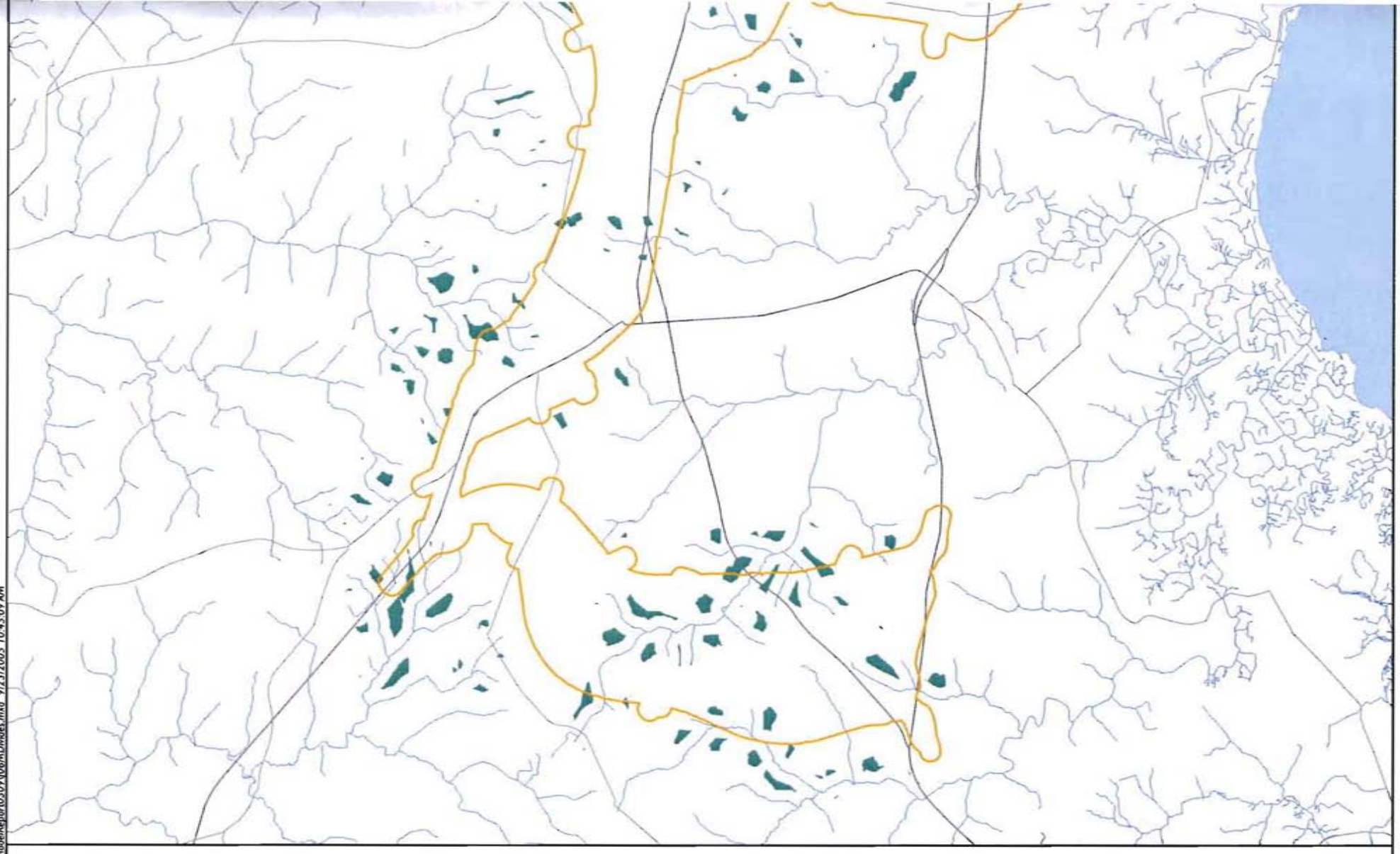


US 301 Project Development
Archaeological Predictive Model

Figure 6
Micro-divides

US 301 Project Development
New Castle County, Delaware





Kilometers

2 0 2

Study Area

Micro-divide areas

Sources: USGS, USEPA, New Castle County

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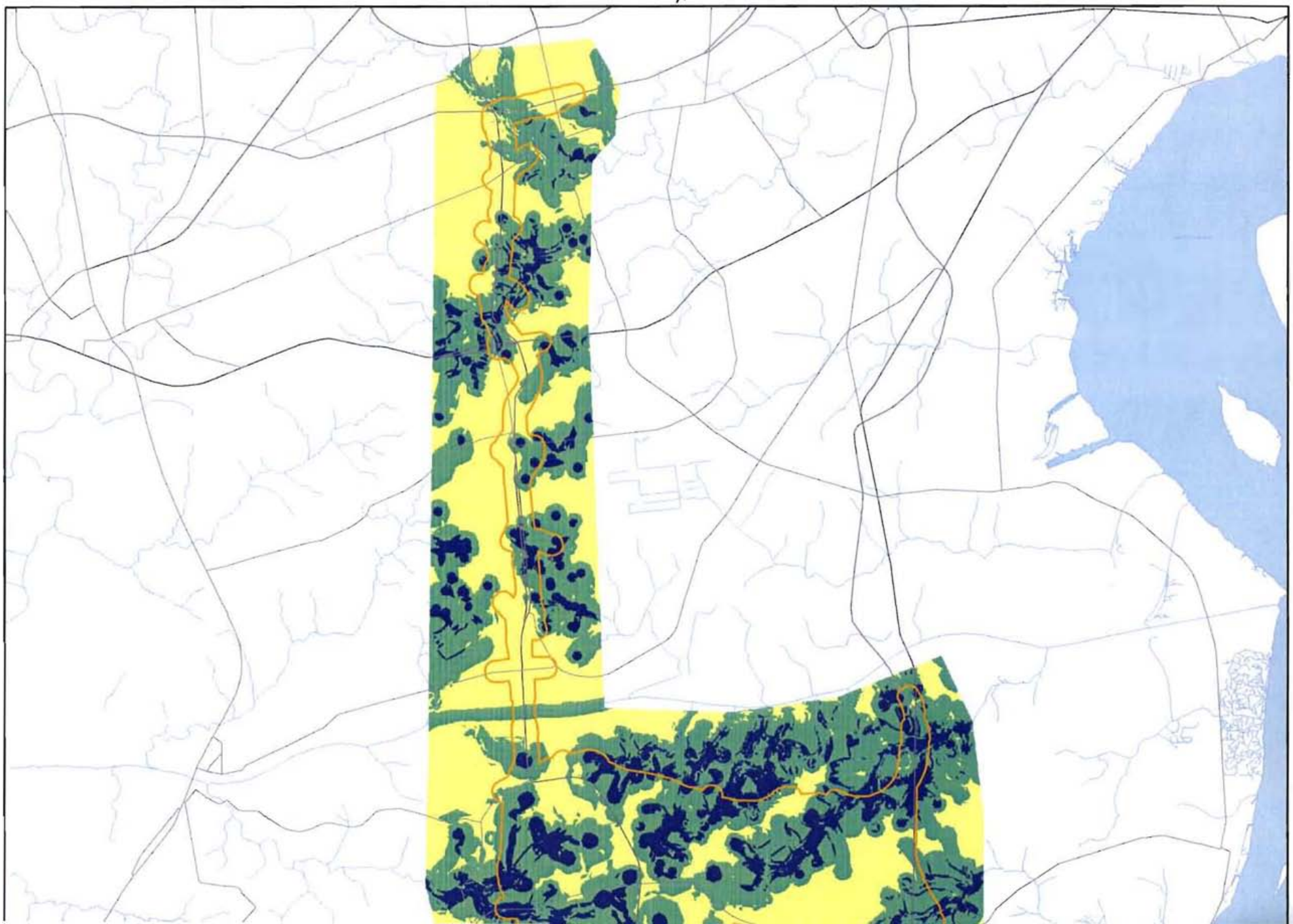
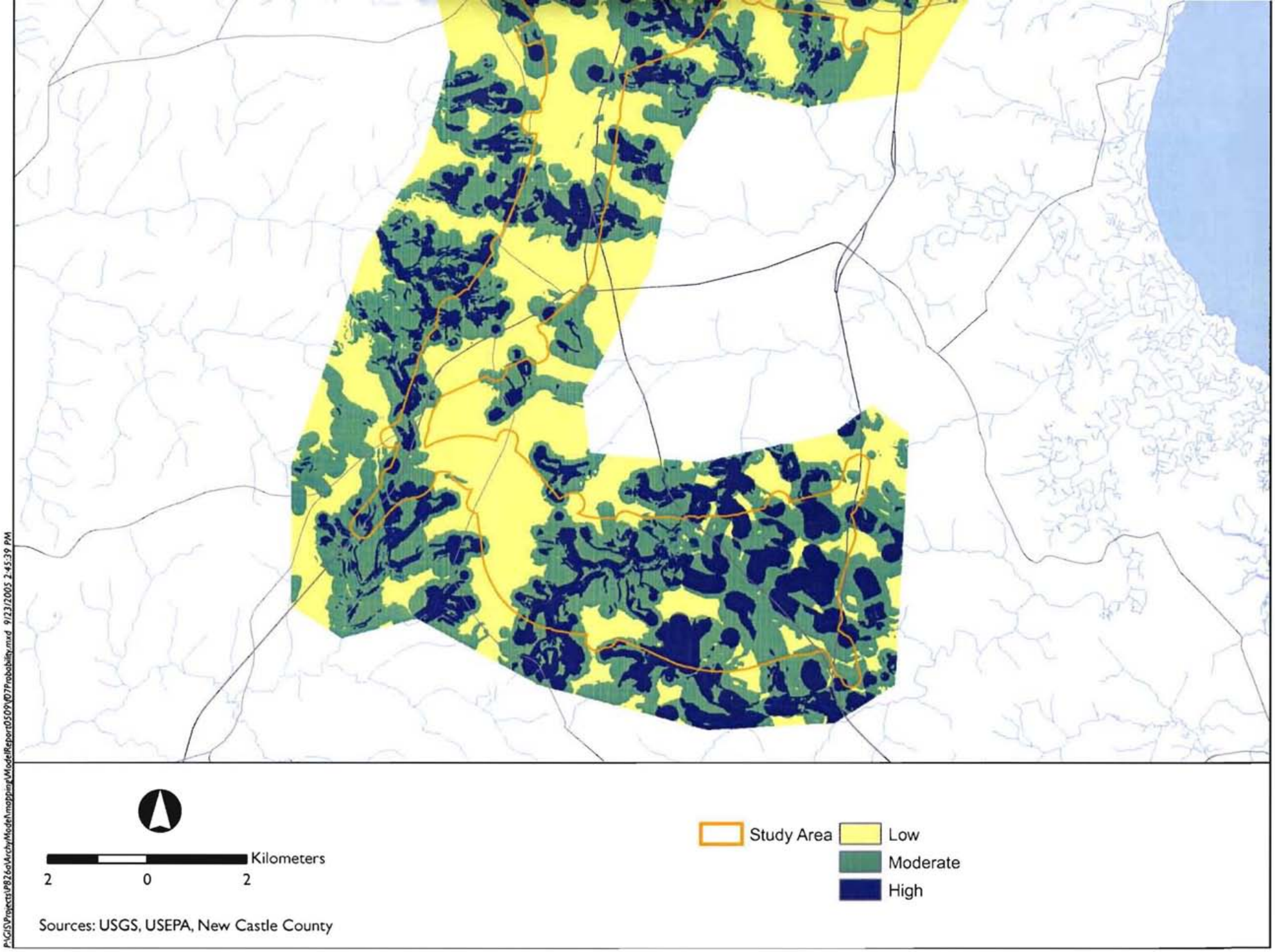
US 301 Project Development
Archaeological Predictive Model

Figure 7
Prehistoric Site Probability Before Incorporation of Modern Surface Disturbance

US 301 Project Development
New Castle County, Delaware





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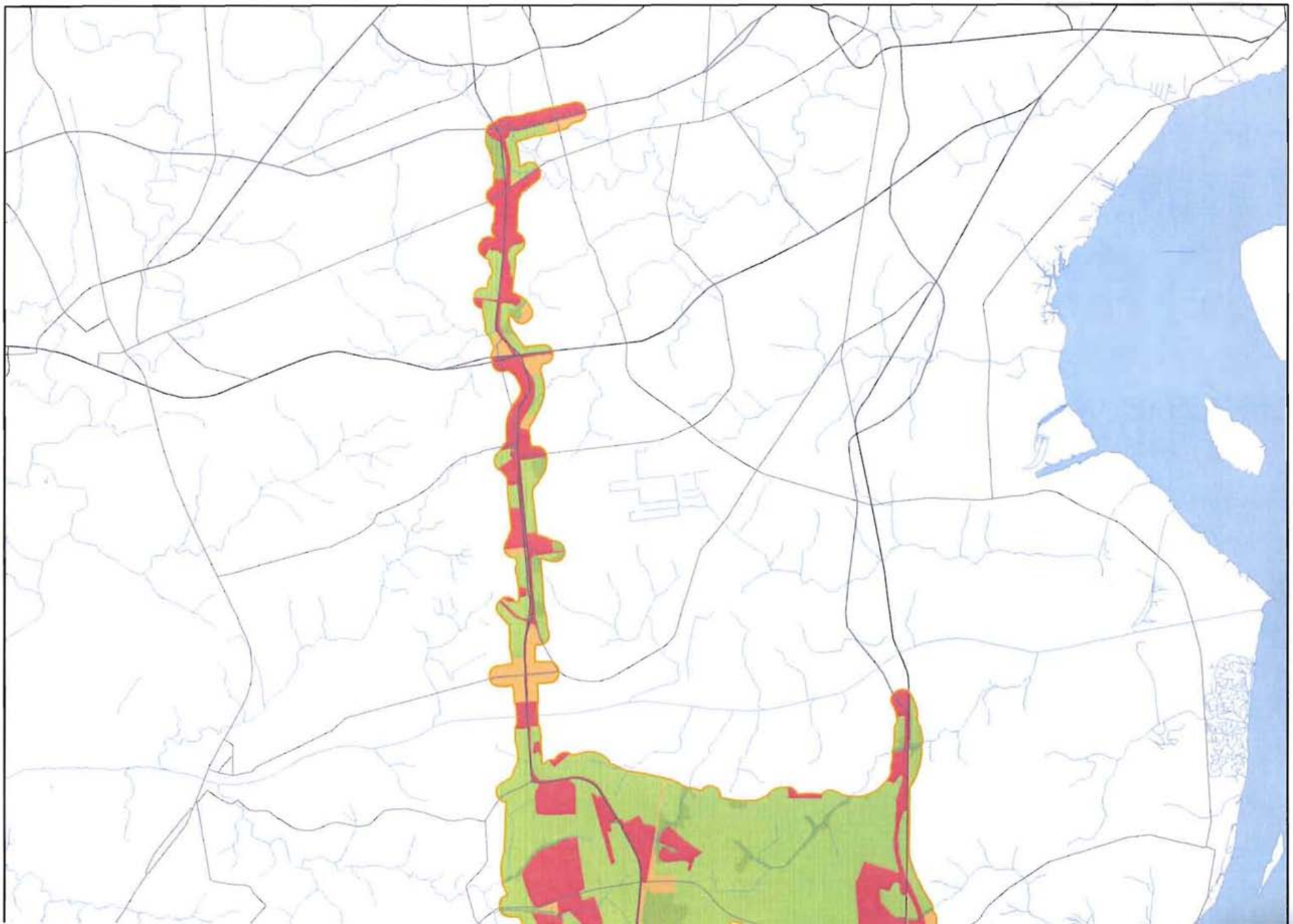
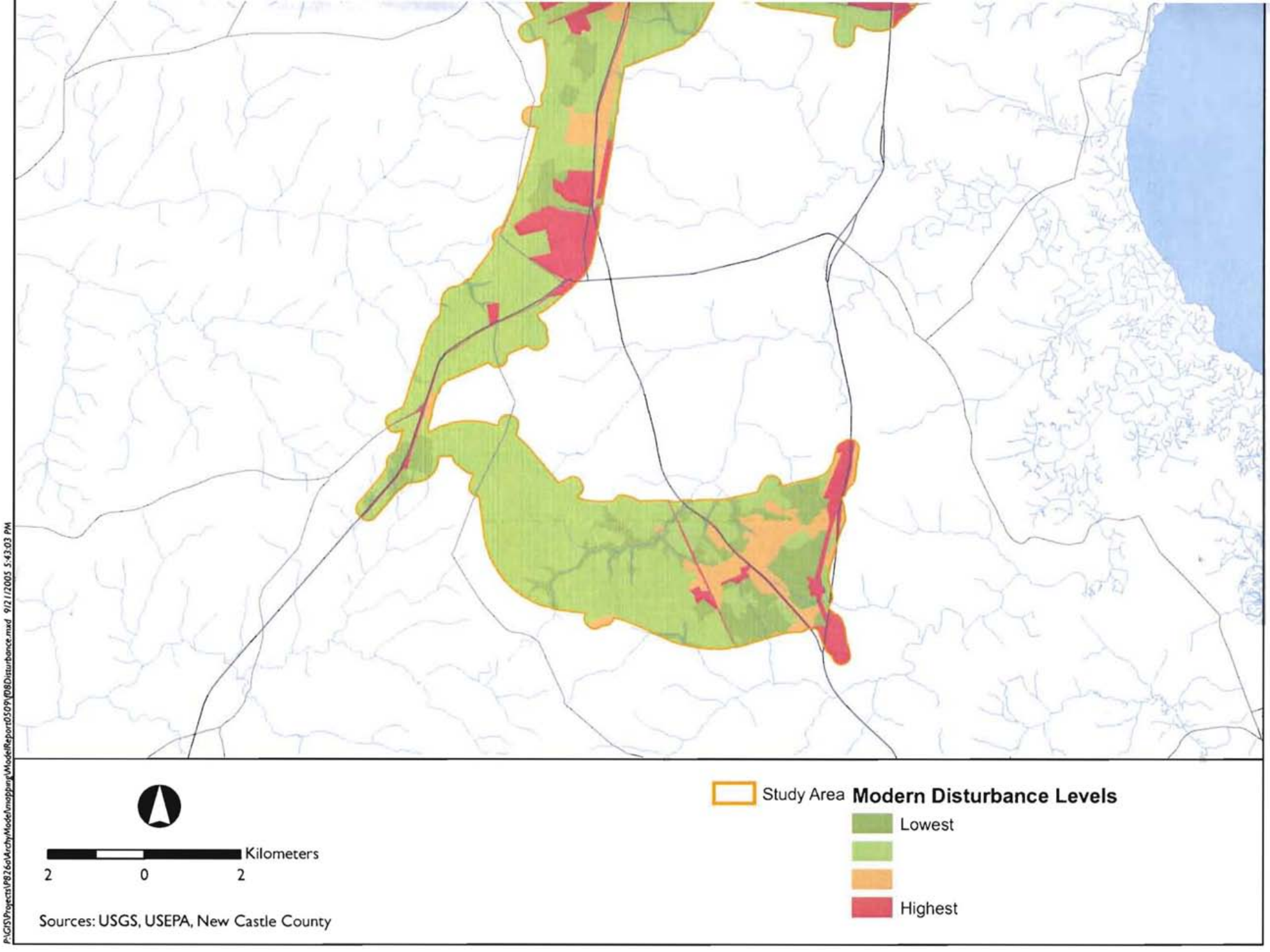
US 301 Project Development
Archaeological Predictive Model

Figure 8
Modern Surface Disturbance
US 301 Project Development
New Castle County, Delaware





US 301 Project Development
Archaeological Predictive Model

6.2 Historic Archaeological Potential

With respect to the historic periods for which reasonably good maps are available, approximately from the middle of the nineteenth century forward, the model for historic archaeological potential is relatively straightforward. High archaeological potential is defined for the area that lies within 140 feet (42.7 meters) of an existing structure that predates 1940, or within 140 feet (42.7 meters) of the former location of such a structure that is no longer standing, as indicated by reference to historic maps, or within 140 feet (42.7 meters) of an intersection on an historic map. The 140 foot criterion is in part a function of the nature of the software program used to map the areas. The initial intention was to delineate a square 200 feet on a side centered on the location of a structure or an intersection. However, the GIS software program could more easily designate and manipulate circles, and a circle with a radius of 140 feet would include within it a 200 foot square. The 200 foot figure itself is commonly used to delineate areas of likely associated deposits in the vicinity of historic structures in the Middle Atlantic area. For example, all of the site plans shown in Bedell (2002) satisfy this criterion, except the farthest extent of the fence ditch associated with the Marsh Grass Site (pg. 63).

The historic archaeological potential for the period predating the nineteenth century is more problematic. As noted above, both De Cunzo and Fithian suggest that the location of these earlier historic sites may be difficult to predict, particular in the interior of the state. Although transportation routes (navigable waterways and roads) have been used traditionally to delineate areas of interest, these are themselves relatively poorly documented. Following Kellogg (1993), areas of moderate historic archaeological potential for this earlier period have been defined within 500 foot corridors centered on the road pattern shown in Faden's 1778 map of New Castle County (as discussed above). It is suggested that once a preferred alternative has been chosen, more intensive research involving New Castle County road papers and Penn's Warrants and Surveys be undertaken to develop a better idea of this potential. Such an effort for the entire project area cannot be accommodated within the constraints of the current study.

The rest of the study area, with one notable exception, is considered to have a low probability to contain historic archaeological sites. That exception is the possible location of unmarked cemeteries, which were sited using criteria distinct from those used to organize the activities of

daily life. Heite and Blume (1992) have suggested a system for defining topographic settings and critical radii for identifying such resources. Their approach has not been incorporated into this initial model because in part it relies on family historical research not undertaken at this stage in the project, and no effort was made to undertake a reconnaissance of the project area to identify such cemeteries to date. However, once a preferred alternative has been chosen, it is recommended that their technique be applied to the area of potential effect associated with that alignment.

Initially, a set of 140 foot diameter circles were mapped within the study area centered on CRS points associated with historic structures. To this mapping was added a 500 foot buffer centered on early historic roads (Figure 10). As can be seen when compared with the source map used to define these corridors (Figure 11), some interpretation of the location of these routes had to be undertaken to accommodate the differences in projection between the two maps and the relative inaccuracies of the eighteenth century cartography. The location of previously standing structures that might have associated with them still intact subsurface deposits were identified using historic maps from 1849, 1868, and 1893 (Figures 12, 13, and 14, respectively). (Interestingly, all of these maps show a route that passes through Middletown from east to west that shares a rough relationship to the route of Herrman's cart road depicted by Heite [1972] [Figure 15].) These data were combined to yield a set of loci that identified areas with high historic archaeological potential (Figure 16).

Figure 11
Faden 1778
US 301 Project Development
New Castle County, Delaware

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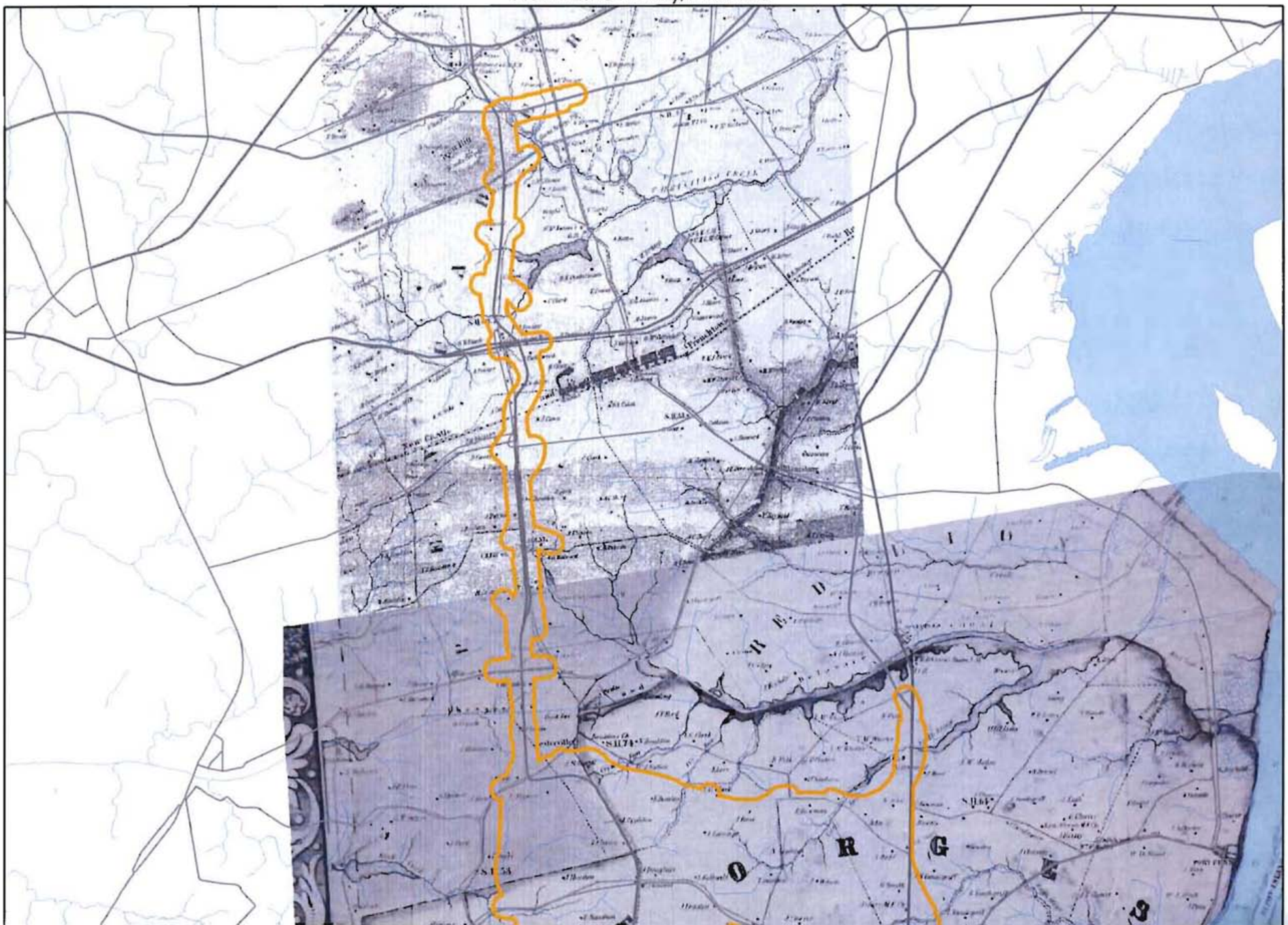
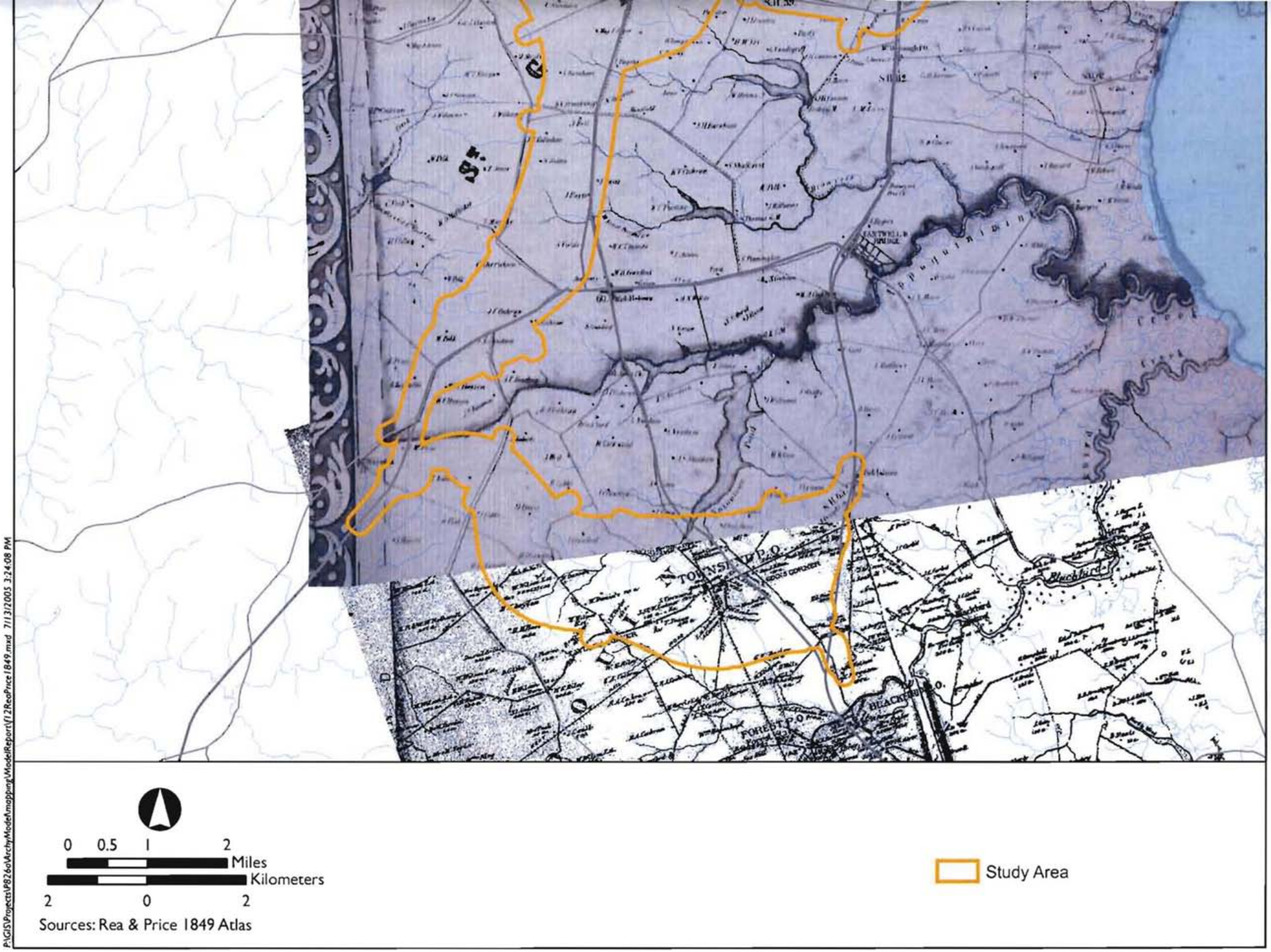
Figure 12
Map of the APE in 1849 (Rea & Price)

US 301 Project Development
New Castle County, Delaware





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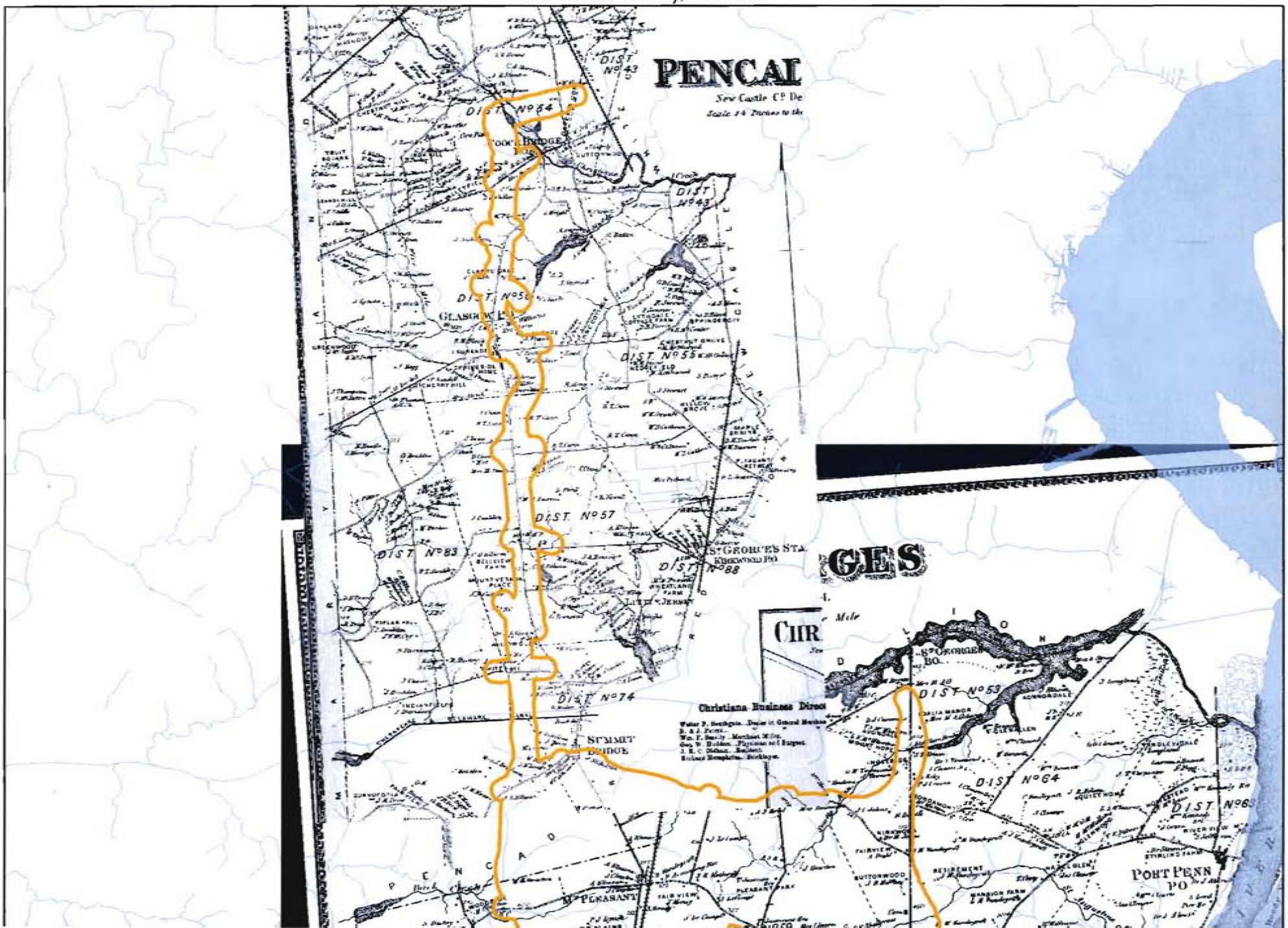
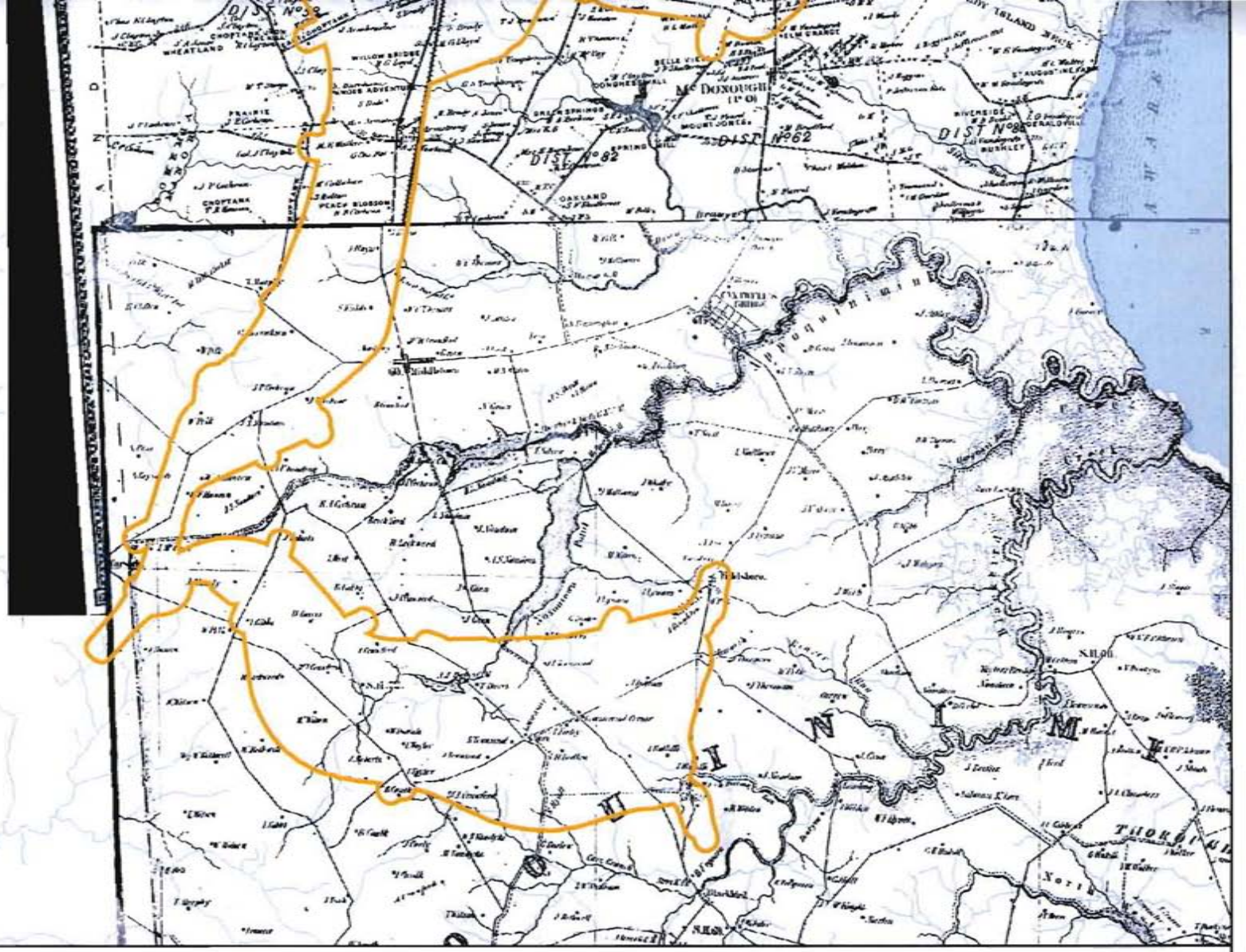
US 301 Project Development
Archaeological Predictive Model

Figure 13
Map of the APE in 1868 (Pomeroy and Beers)

US 301 Project Development
New Castle County, Delaware





1 0 1 Miles

2 0 2 Kilometers

Sources: Pomeroy and Beers 1868 Atlas

Study Area

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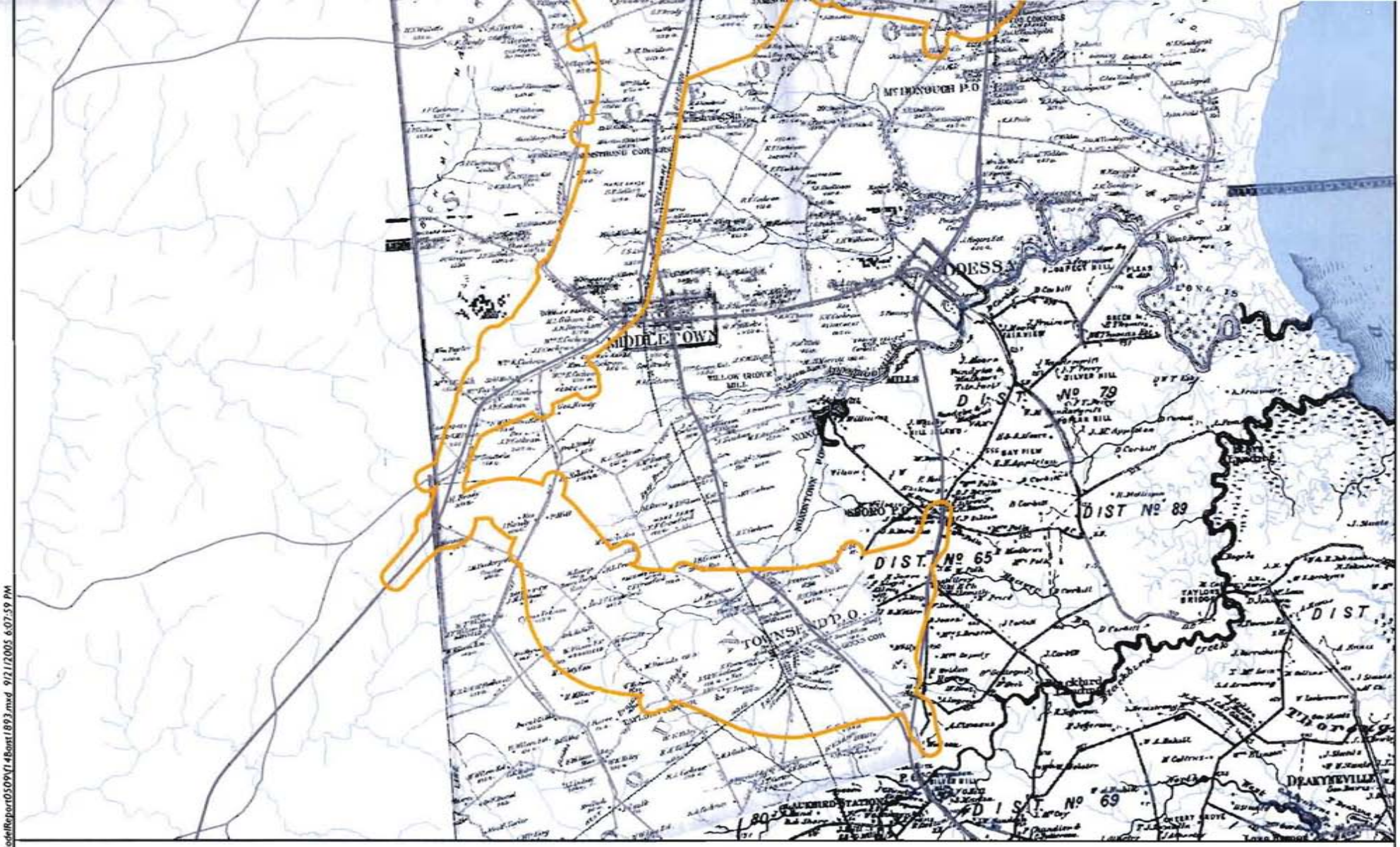
US 301 Project Development
Archaeological Predictive Model

Figure 14
Map of the APE in 1893 (Baist)

US 301 Project Development
New Castle County, Delaware



1 0 1 Miles

2 0 2 Kilometers

Sources: Baist 1893 Atlas

Study Area

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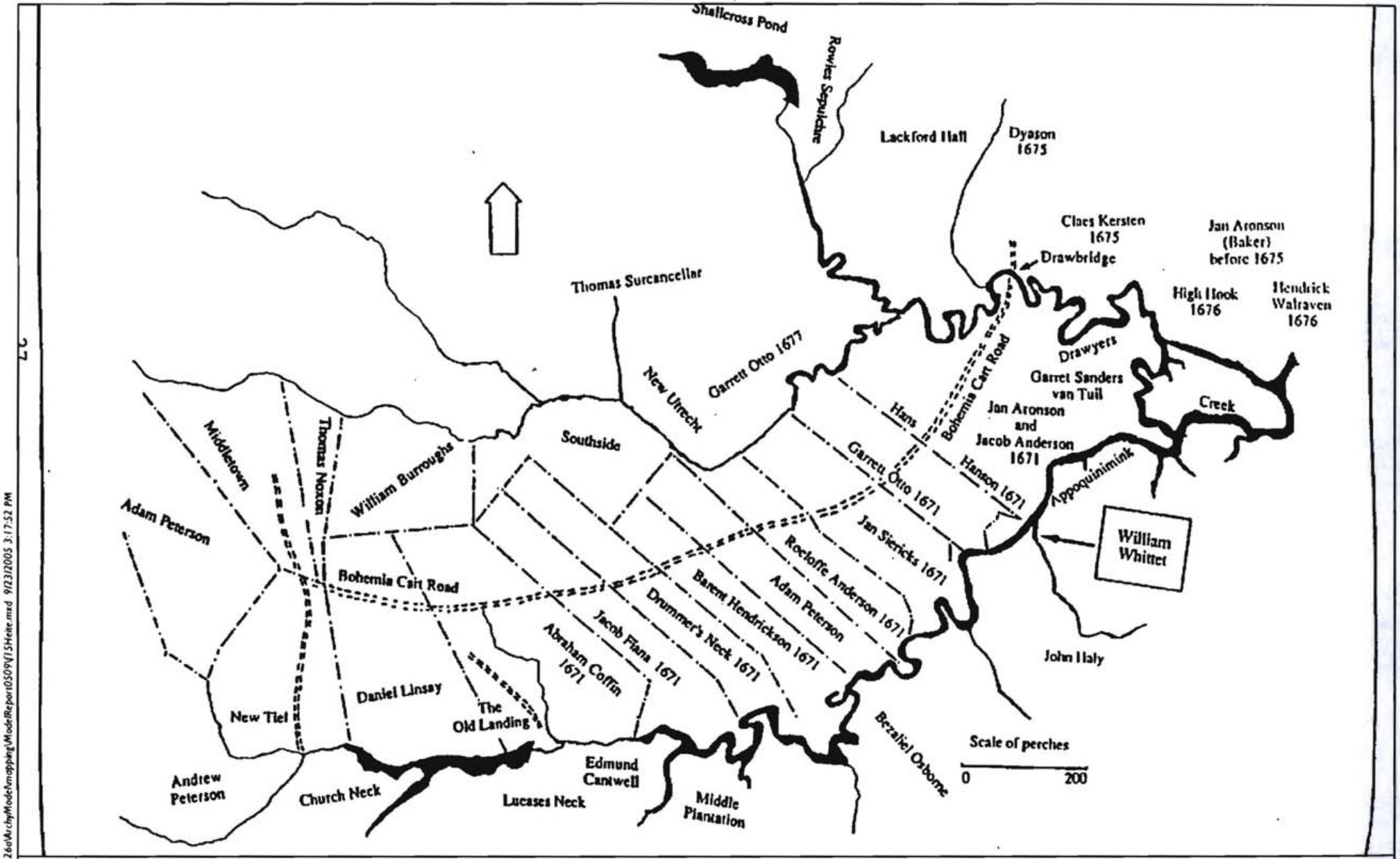
US 301 Project Development
Archaeological Predictive Model

Figure 15
Seventeenth-century Settlement at Appoquinimink
US 301 Project Development
New Castle County, Delaware



Map not drawn to scale

Reproduced from De Cunzo 1993; Source: Heite 1972

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