4.0 RESULTS OF ARCHEOLOGICAL SURVEY – INDIAN RIVER INLET

4.1 PREVIOUSLY IDENTIFIED ARCHEOLOGICAL SITES

There are four (4) known archeological sites within the two-mile-radius study area of the project (Figure 19). Two (2) of the archeological sites are prehistoric, one (1) is a multi-component and one (1) is historic. The prehistoric sites within the study area are Quillens Point (7S-G-11), Burton Island (7S-G-83), and 7S-K-13. Artifacts were first collected from the Quillens Point site (7S-G-11; CRS S-651) by Henry Hutchinson, H. T. Purnell (both active in the SSAH), and the Section for Archaeology (CRS Archeological Site Form). Hutchinson's surface collection, held by the Delaware State Museums (Accession No. 71/104), is comprised of five ceramic sherds and two stone items. Quillens Point site (7S-G-11) has a Woodland I period association based on the recovery of Coulbourn ceramics.

Supplemental Phase I investigations conducted in this area by JMA for a different project concluded that the Quillens Point site (7S-G-11) may be relatively extensive, but the density of cultural material in the areas investigated to date is sparse and there are gaps in the distribution (Kellogg and Catts 2001). It is suggested by Kellogg and Catts (2001) that the site encompasses a cluster of smaller sites focusing along the shore and may have included areas of shell disposal into middens. JMA identified one (1) chert projectile point base, eighteen (18) pieces of lithic debitage, and twenty-one (21) ceramic sherds (including four (4), Woodland II period of Delaware, Townsend ceramic fragments) from Quillens Point (Kellogg and Catts 2001). The Kellogg and Catts (2001) collection is held by the Delaware State Museum (Accession No. 2000/16).

The Burton Island site (7S-G-83; CRS S-6858) is located on Burton Island and was characterized as having an Archaic and Woodland I cultural association (CRS Archeological Site Form). Artifacts recovered from Burton Island during the surface collection of a beach located on the southern shore of the island included two (2) distal fragments of projectile points and a full grooved axe. Site 7S-K-13 locus A (CRS-687) is located on a point of land on the southeastern shore of Beach Cove. The site is quite large and is composed of multiple loci. Locus A artifacts were collected from the 7S-K-13 (CRS S-687) by Glen Mellin for the University of Delaware Center for Archaeological Research (UDCAR), under a grant from the SHPO. Mellin's surface collection is held by the Delaware State Museum (Accession No. 72/4) and includes a Fox Creek projectile point and Coulbourne and Mockley ceramics as well as historic artifacts from a series of loci (CRS Archeological Site Form). The aforementioned artifacts from Locus A place the temporal period for 7S-K-13 within the Woodland I period of Delaware.

The historic period archeological site within the survey area is 7S-G-156 (CRS S-9804) is associated with a standing structure. The site was identified by Cherie Clark (DNREC) through shovel testing and an interview with Rick Lynch (CRS Archeological Site Form). The site is described as a sand and gravel ridge of "old spoil material" located east of the Boat Basin that is east of Burton Island. Artifacts collected from 7S-G-156 include various mid-twentieth century building debris associated with former seasonal cabins and an isolated, unidentified, ceramic sherd in disturbed fill.

4.2 REVIEW OF EXISTING GEOARCHEOLOGICAL DATA

Susan Halsey (1978) conducted a geological study of the bay barrier system within the study area. This study revealed several landscape features that have potential for human occupation. The first of these features are Pleistocene age recurved spit ridges that are currently being submerged by the present sea level rise (Figure 19). These recurved spit ridges are related with Omar Formation deposits (Groot and Jordan 1999, Ramsey 1999, and Groot et al. 1990). During prehistoric periods, additional segments of these landscape features presently buried would have been exposed above seal level and available for human occupation when sea level was lower in the past. Thus, the interface between the Holocene deposits and the Omar Formation and where the Omar Formation deposits are exposed at the surface are potential locations for prehistoric occupation. However, these deposits have also been periodically and locally modified by later Holocene age events such as slope wash, fluvial activity, wave action, tidal effects, and tidal inlet opening, scouring, and closing (Halsey 1978).

Additional geologic study was conducted by Michael Chrzastowski (1986) in Indian River Bay and Rehoboth Bay. This study resulted in a pre-Holocene bathymetric map showing the paleo-valleys associated with these bays (Figure 20). Figure 21 depicts a detailed reconstruction of the paleogeography of the bays at approximately 4,000 BP (Chrzastowski 1986, Hoyt et al. 1990). The hatched symbol depicts Pleistocene age landforms that were above sea level at that time and that could have supported occupation. This figure does not depict the Holocene Age bay barrier deposits within the area that could have supported human occupation (Chrzastowski 1986, Hoyt et al. 1990).

A geologic cross section of the Atlantic Coast of Delaware produced by Kelvin Ramsey (1999) depicts the present Indian River Inlet in relation to Quaternary and Pliocene-Pleistocene deposits (Figure 22). This cross section identifies a Pleistocene age terrace approximately 1219 meters (m) (4000ft) to the south and approximately 6 m (20ft) below mean sea level (MSL). This inlet extends a further 1097m (3600ft) south, thus identifying a potential landscape that could have supported human occupation. Also, the Holocene age bay barrier deposits within the study area, which could have supported human occupation, are younger than 3,736 BP (Ramsey and Baxter 1990, Ramsey 1999). This date is based on a calibrated radiocarbon date from a shell sample beginning approximately 9m (28.7ft) below mean sea level (MSL) in core number Pj42-11 (DGSID) just north of the present inlet (Ramsey and Baxter 1990, Ramsey 1999). The sample was located within the upper portion of Holocene age deposits interpreted as lagoon deposits. The base of these lagoon deposits are dated at 12,561BP (calibrated date) based on a radiocarbon date of basal peat beginning approximately 24m (77.64ft) below MSL in core number Pj42-11 (DGSID) (Ramsey and Baxter 1990, Ramsey 1999).

4.2.1 PEDESTRIAN SURVEY

The archeological pedestrian survey was conducted on June 23 and 24, 2003, and February 9 and 10, 2004. The 2003 survey was conducted in a standard pattern within the potential limits of disturbance as illustrated on project design plans available at that time for the new Indian River Inlet Bridge. Subsequent areas were added to the study area and were surveyed in 2004 in a systematic pattern (Figure 23). The areas surveyed included disturbed areas, open areas, and vegetated areas. The areas systematically walked consisted of sand dunes, interdune swales, and wind blown sand planes. The pedestrian survey was not systematically undertaken in clearly

CROSS SECTION OF PLIOCENE AND QUATERNARY DEPOSITS ALONG THE ATLANTIC COAST OF DELAWARE

By
Kelvin W. Ramsey
1999

EXPLANATION

N25-02 (1) Delaware Geological Survey borehole identifier. Number in parenthesis refers to location of borehole on map above cross section.

• 5 Location of borehole

* Radiocarbon date (Ramsey and Baxter, 1996).

DGSID	Lab ID	Calib R.C. Date	Sample Elev.	Sample Type
		(Years BP)	(ft)	
Nj35-03	R-4103	7880	-80	peat
Nj51-02	R-4104	174	-0.187	peat
Nj51-02	R-4104	1915	-20	shell
Nj51-02	R-4104	3168	-23	shell
Nj51-02	R-4104	28400	-48.5	plant
Oj51-01	R-4101	272	-0.7	peat
Oj51-01	R-4101	2781	-19.3	shell
Oj51-01	R-4101	6282	-36.8	wood
Oj51-01	R-4101	7016	-42.3	peat
Pj22-01	R-4111	3083	-19.4	peat
Pj22-01	R-4111	3116	-19.4	peat
Pj42-11	R-4115	3736	-36.3	shell
Pj42-11	R-4115	12561	-84.3	basal peat
Qj22-06	TEM-204	45000	-24.6	shell hash
Qj22-06	I-6207	39900	-25	wood
Qj42-09	Beta 18-32	31750	-37.7	organic silt

AA Amino
others,

Shell

Uncon

vf-f sd Very fi
amoun

f-m sd Fine to

m-c sd Mediu
and gr

c-vc sd Coarse
and gr

org slt Organi
dissem
a peat)

cly slt Clayey
clay or

cly sd Clayey
may be

Sand s

Litholo

Holoce

Omar F

Beaver

DISCUSSION

Introduction

Exploration for sand resources for beach nourishment has led to an increase in the amount of geologic data available from areas offshore Delaware's Atlantic Coast. These data are in the form of cores, core logs, and seismic reflection profiles. In order to provide a geologic context for these offshore data, this cross section has been constructed from well and borehole data along Delaware's Atlantic coastline from Cape Henlopen to Fenwick Island. Placing the offshore data in geologic context is important for developing stratigraphic and geographic models for predicting the location of stratigraphic units found offshore that may yield sand suitable for beach nourishment. The units recognized onshore likely extend offshore to where they are truncated by younger units or by the present seafloor.

This cross section emphasizes lithology. The distribution of lithologies onshore indicates their potential distribution offshore where they crop out at the seafloor or are overlain by thin marine deposits of Holocene age. Because of the scale represented on the cross section, lithology is necessarily generalized, and all the details of lithology from a particular borehole are not shown. The continuity of lithology between boreholes allows for the recognition of lithologic trends within stratigraphic units.

Previous Work

Cross sections of the Holocene portion of the Atlantic Coast include those of John (1977) and Kraft et al. (1987). They show detail only in the Holocene-age sediments; everything beneath is shown only as pre-Holocene without any detail of stratigraphic unit or lithology. Miller (1971) included a cross section from Cape Henlopen to Fenwick Island that showed the geology in terms of stratigraphic units, aquifers, and aquicludes. No detailed lithology was shown. More recent stratigraphic studies in southern Delaware (Andres, 1986; Ramsey and Schenck, 1990; Ramsey, 1993; Andres and Ramsey, 1995) have identified the major stratigraphic units underlying coastal Delaware and have provided information regarding their ages and stratigraphic relationships.

Stratigraphy

Beaverdam Formation

The oldest unit shown on the cross section is the Beaverdam Formation of latest Miocene to Late Pliocene in age on the bases of palynomorphs examined from fine-grained sediments within the unit (Groot et al.,1990). The formation is composed primarily of fine to coarse sand with interbeds of fine silty sand to sandy and clayey silt (Benson, 1990) deposited in fluvial to estuarine environments. Gravel and pebbly sand beds are common. In the coastal areas of Delaware, the Beaverdam has a characteristic fining-upward signature on gamma logs (Andres, 1986; Benson, 1990).

Omar Formation

The Omar Formation is the principal unit of Pleistocene age in coastal Delaware (Jordan, 1974). On the bases of studies of palynomorphs and aminostratigraphy of shell material from the Omar, the unit is considered to range in age from late Pliocene to late Pleistocene (Groot et al., 1990) and to have been deposited during several distinct transgressive events associated with rising sea level and high sea stands. For this cross section, the Omar is mapped as one lithologic unit rather than separate depositional units associated with different sea level events. The dominant lithology within the Omar in coastal Delaware is a gray clayey sand to sandy silt that contains scattered shell and organic-rich beds containing plant fragments. Scattered beds of fine sand and silty fine sand are common. Less common are thin beds of medium to coarse sand (Benson, 1990). The Omar was deposited in lagoonal, tidal delta, marsh, and spit environments, much like that of the present coastal system.

Holocene deposits

The Holocene deposits consist of fine to coarse sand, sandy to clayey silt, silty clay, and organic rich
fragments. These sediments were de
during the rise of sea level in a transg
1977; Kraft and John, 1979; Chrzasto
Radiocarbon dates from organic rema
Ramsey and Baxter (1996).

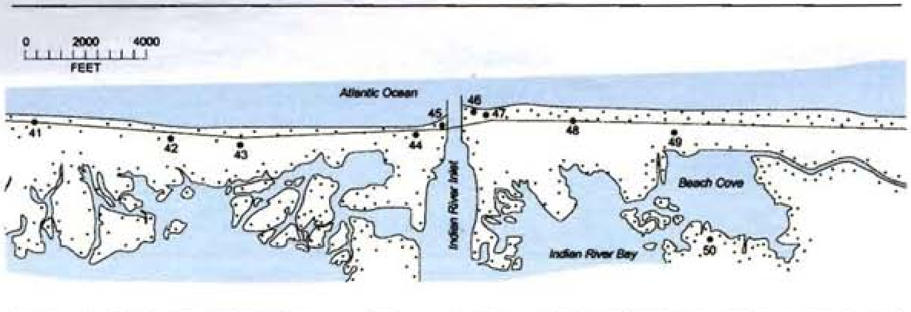
Unconformities

The stratigraphic boundaries bet
generated by subaerial exposure duri
Pliocene and Pleistocene and by ravi
transgressive systems during sea lev
recognized on the bases of contrastin
weathering horizons, and differences

Sand Resources

Analysis of distribution of litholog
coastal Delaware indicates that they
sand for beach nourishment material.
fine-grained sediments deposited in n
The largest body of sand is the Cape
movement of sand along the shorelin
Delaware Bay during the Holocene (K
abundant sand is adjacent to the Indi
composed of sand deposited in the fl
with the past lagoonal inlets of Rehob
reflection profiles and cores offshore
do underlie the seafloor in this area.

The Omar Formation appears to
sand. Much of the unit is composed o
sand in the Omar is common, it is in
level. Sand is less common at depths



AA Amino acid racemization analysis (Groot and others, 1990).

Shell

Unconformity

f-f sd Very fine to fine sand (may contain varying amounts of silt and some organic material).

f-m sd Fine to medium sand.

m-c sd Medium to coarse sand (may contain pebbles and gravel beds).

c-vc sd Coarse to very coarse sand (may contain pebbles and gravel beds).

org slt Organic-rich silt (contains plant fragments and disseminated organic material; may in places be a peat).

cly slt Clayey silt (commonly identified in well logs as clay or mud).

cly sd Clayey sand (contains varying amounts of silt; may be identified in well logs as mud).

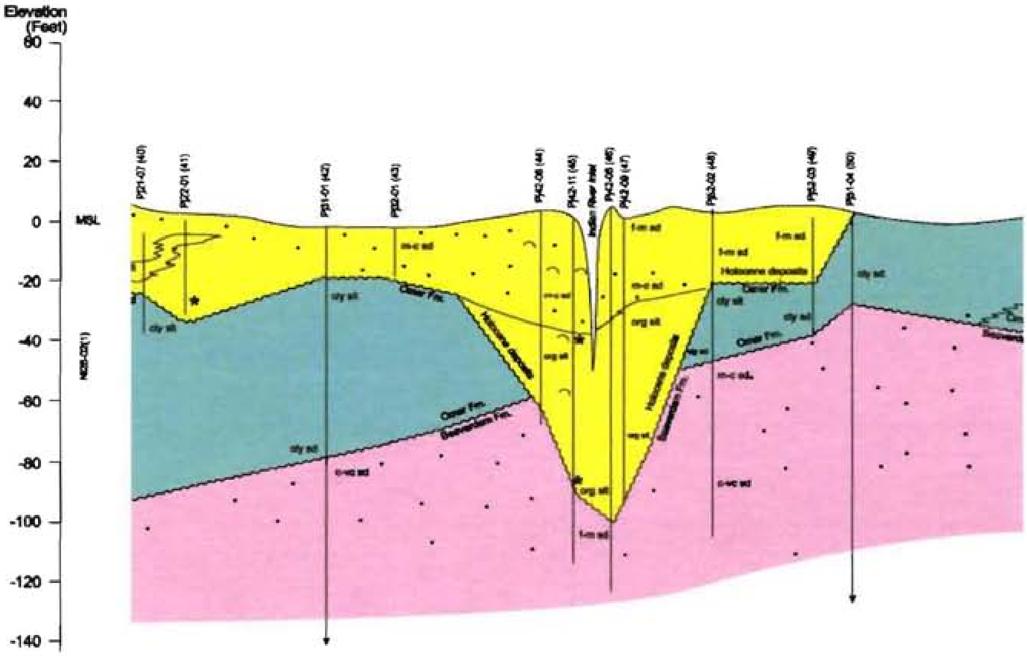
Sand suitable for beach nourishment.

Lithologic contact

Holocene Deposits

Omar Formation

Beaverdam Formation



nd organic rich clayey silt beds with abundant plant
iments were deposited over the last 10,000 years
evel in a transgressive barrier-lagoon system (John,
1979; Chrzastowski, 1986; Kraft et al., 1987).
m organic remains from these deposits are listed in
998).

boundaries between the units are unconformities
l exposure during low stands of sea level during the
ne and by ravinement surfaces associated with
during sea level rise. The unconformities are
as of contrasting lithogies, age relationships,
nd differences in compaction and fossil content.

ution of lithologies within the Quaternary units of
ates that they are not particularly good sources of
ment material. The units are composed primarily of
deposited in marsh and lagoonal environments.
nd is the Cape Henlopen spit, formed by the path of
ng the shoreline and out into the mouth of the
he Holocene (Kraft et al., 1978). Another area of
cent to the Indian River Inlet. This area is
osited in the flood and ebb tidal shoals associated
inlets of Rehoboth and Indian River bays. Seismic
cores offshore of the inlet indicate that sandy units
r in this area.

tion appears to be less promising as a source of
is composed of relatively fine sand and silt. Where
mmon, it is in most places close to present sea
mon at depths greater than 20 ft below sea level.

These sandy deposits have been removed by shoreface and nearshore erosion within a few hundred feet offshore of the present shoreline where water depths are greater than 20 ft.

The Beaverdam Formation is the unit most likely to be a source of sand offshore. The unit is dominated by sand, especially in the interval between 40 and 100 ft below sea level. The formation extended offshore crops out on the sea floor over a distance of several miles offshore. Colors and textures of these sands are similar to those sands dredged in 1988 from about 2.5 miles off Fenwick Island for beach nourishment.

Acknowledgments

Funds for this project were provided by the Minerals Management Service through a cooperative agreement with the Association of American State Geologists and the University of Texas at Austin. I thank Stefanie J. Baxter who assisted in the data compilation and preliminary drafting. Randall Kerhin, Thomas McKenna, and William Schenck provided helpful reviews of this publication.

References cited

Andres, A. S., 1986, Stratigraphy and depositional history of the post-Choptank Chesapeake Group: Delaware Geological Survey Report of Investigations No. 42, 39 p.

Andres, A. S., and Ramsey, K. W., 1995, Geologic Map of the Seaford Area, Delaware: Delaware Geological Survey Geologic Map No. 9, scale 1:24,000.

Benson, R. N., 1990, ed., Geologic and hydrologic studies of the Oligocene-Pleistocene section near Lewes, Delaware: Delaware Geological Survey Report of Investigations No. 48, 34 p.

Chrzastowski, M. J., 1986, Stratigraphy and geologic history of a Holocene lagoon: Rehoboth Bay and Indian River Bay, Delaware: unpublished Ph.D. Dissertation, University of Delaware, Newark, 337 p.

Groot, J. J., Ramsey, K. W., and Wehmiller, J. F., 1990, Ages of the Bethany, Beaverdam, and Omar formations of southern Delaware: Delaware Geological Survey Report of Investigations No. 47, 19 p.

John, C. J., 1977, Internal sedimentary structures, vertical stratigraphic sequences, and grain size parameter variations in a transgressive coastal barrier complex: The Atlantic Coast of Delaware: University of Delaware Sea Grant Publication, no. DEL-SG-10-77, 287 p.

Jordan, R. R., 1974, Pleistocene deposits of Delaware, in Oaks, R. Q., and DuBar, J. R., eds., Post-Miocene stratigraphy central and southern Atlantic Coastal Plain: Logan, Utah, Utah State University Press, p. 30-52.

Kraft, J. C., Allen, E. A., and Maurmeyer, E. M., 1978, The geological and paleogeomorphological evolution of a spit system and its associated coastal environments: Cape Henlopen spit, Delaware: Journal of Sedimentary Petrology, v. 48, p. 211-226.

Kraft, J. C., Chrzastowski, M. J., Belknap, D. F., Toscano, M. A., and Fletcher, C. H., III, 1987, The transgressive barrier-lagoon coast of Delaware: Morphostratigraphy, sedimentary sequences and responses to relative rise in sea level, *in* Nummedal, D., Pilkey, O.H., and Howard, J.D., eds.: The Society of Economic Paleontologists and Mineralogists Special Publication No. 41, p. 129-143.

Kraft, J. C., and John, C. J., 1979, Lateral and vertical facies relations of transgressive barrier: American Association of Petroleum Geologists Bulletin, v. 63, p. 2145-2163.

Miller, J. C., 1971, Ground-water geology of the Delaware Atlantic Seashore: Delaware Geological Survey Report of Investigations No. 17, 33 p.

Ramsey, K. W., 1993, Geologic Map of the Milford and Mispillion River Quadrangles: Delaware Geological Survey Geologic Map 8, scale 1:24,000.

Ramsey, K. W., and Baxter, S. J., 1996, Radiocarbon dates from Delaware: A compilation: Delaware Geological Survey Report of Investigations No. 54, 18 p.

Ramsey, K. W., and Schenck, W. S., 1990, Geologic Map of Southern Delaware: Delaware Geological Survey Open File Report No. 32, scale 1:100,000.

Figure 22. Selected portion of geologic cross-section of Delaware Atlantic Coast (Ramsey 1999).

disturbed areas and wetland areas. The wetland and disturbed areas were documented as such. Wetland areas were not walked due to their setting and road medians and areas covered with macadam were not included in the pedestrian survey due to their disturbed nature. Due to the dynamic nature of coastal environments, cultural materials (historic and prehistoric) become buried and exhumed periodically based on the movement of wind blown dune sand and coastal erosion and deposition. Thus, historic and prehistoric cultural material could (1) be exposed within those areas subjected to the pedestrian survey; (2) be deeply buried beneath the bay barrier; or (3) have undergone a combination of these processes. A combination of burial and exposure would lead to deposits out of their original contexts. Through historic map and aerial photography, it is known that the ancestral Indian River Inlet has been located in areas north and south of the present inlet and that the morphology of the bay barrier has changed through time (see Section 2.4 above). The portions of bay barrier within the extent of these ancestral inlets (documented since the early nineteenth century) have been scoured and thus preclude the existence of intact prehistoric archeological deposits to depths within 3 meters of the surface. In the areas of ancestral inlets, the potential for historic archeological sites is high due to its availability for use and occupation during portions of the historic period. Because of this dynamic coastal system, the pattern of blowouts, dunes, and swales have resulted in ground visibility, on average, of over 40% of the landscape that was undisturbed, nor wetlands, during the pedestrian survey.

Approximately 27 acres were systematically walked in an attempt to visually determine the presence and/or absence of materials related to the prehistoric and historic occupation or use of the landscape within those areas not previously disturbed (Figure 23). All areas within the study area having potential for prehistoric occupation, north and south of the current inlet, were either walked, contained areas of previous disturbance, or were wetlands.

The archeological walkover on the ocean (Plate 4) and bay side (Plate 5) of the two-mile-radius study area produced some archeological remains. The ocean side of the study area was clear and open for examination, but the bay side was a marsh with heavy vegetation observable only from the highway's edge. A part of a ship's keel was observed approximately a quarter mile north of the inlet eroding from the base of a dune's ocean side. A piece of ship's planking was observed on the upper ocean face of a dune about one and a half miles north of the inlet.

The section of ship's keel was 1-ft. square and 34 ft. in length (Plate 6). There were iron drift pins in the keel section with deteriorated lead washers, and the section was scarfed on both ends indicating there were at least two additional sections. The scarfs were 5 ft. long with 2-in. thick abutments. The vessel based on the additional sections would have been at least 100 ft. in length, and the iron drift pins suggest a late nineteenth century date.

The plank, measuring 30+ feet in length, one foot in width, and four inches in thickness, had the remains of iron drift pins that had attached it to a ship (Plate 7). The size of the plank and the attached drift pins indicate it came from a nineteenth century ship. This plank had the appearance and location that suggest it had floated ashore rather than eroding from the dune. Subsequent field inspection in the winter of 2004 failed to relocate the plank.

The two observable ship pieces were the only identifiable archaeological remains discovered during the walkover. There were other observable debris areas to the west of the dunes but it could not be

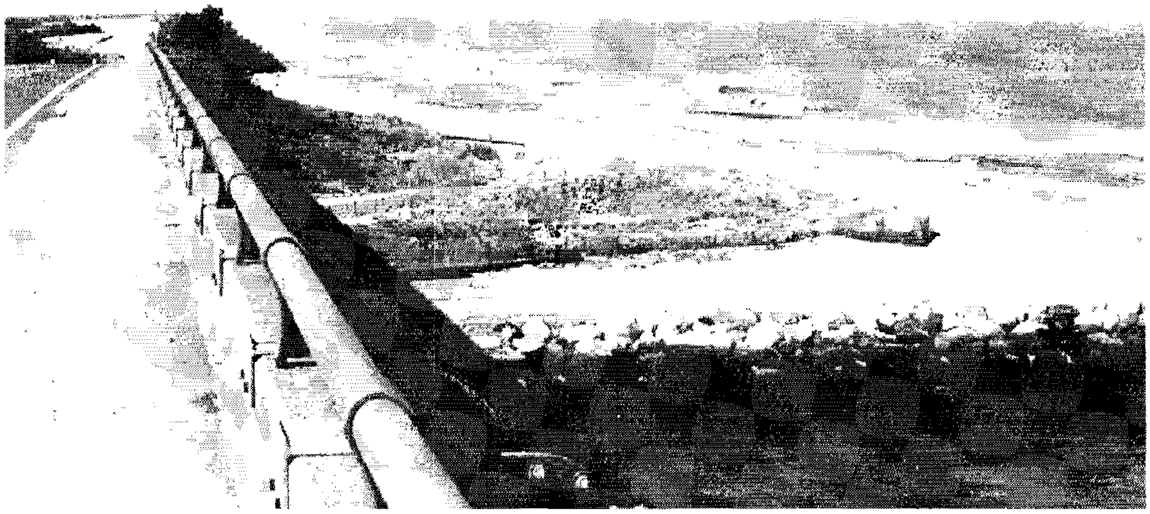


Plate 4. View of the ocean shore north of the Indian River Inlet Bridge.

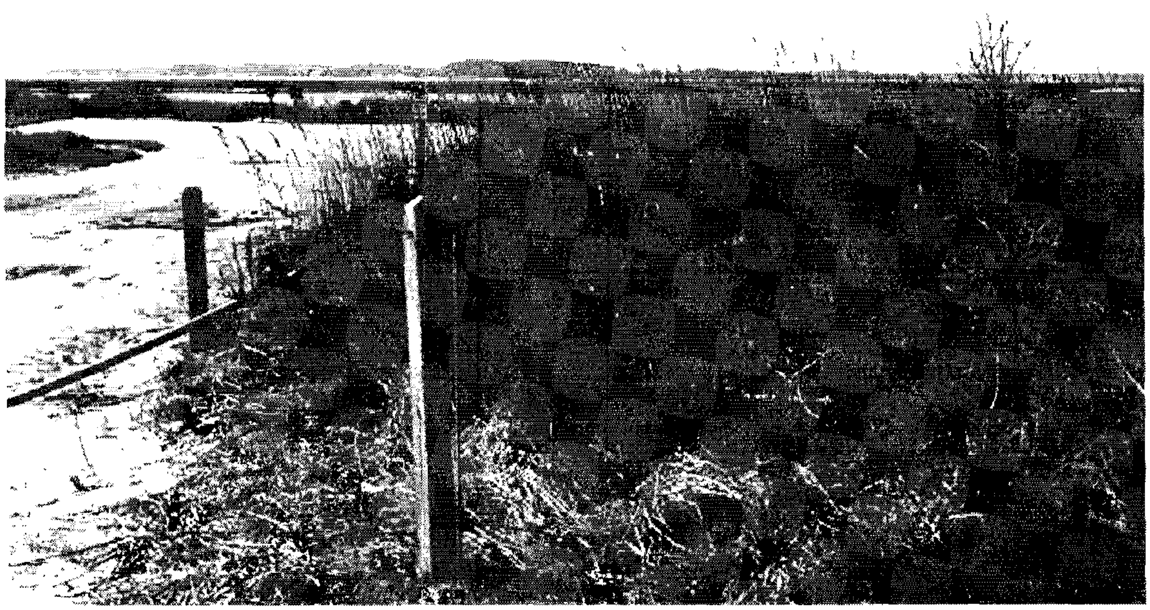


Plate 5. View of bay area north of the Indian River Inlet Bridge.

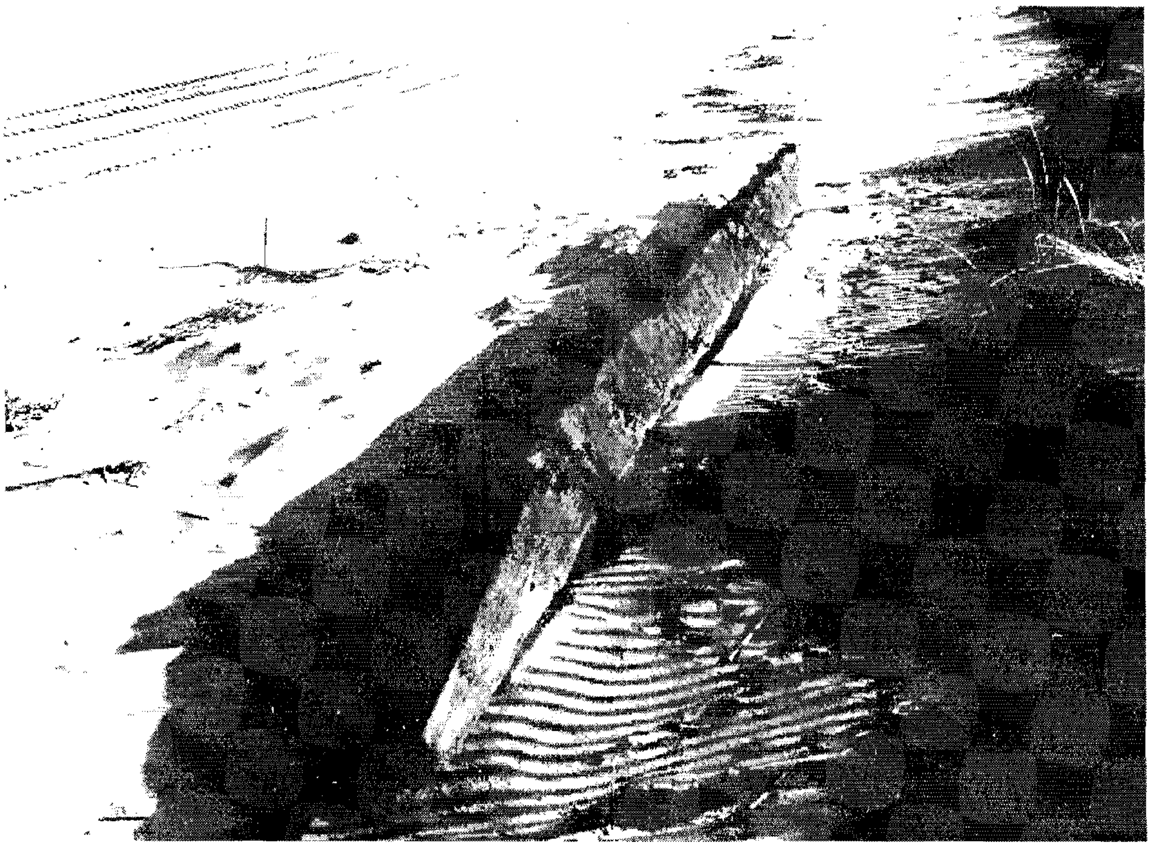


Plate 6. View of ship's keel section toward south.

Plate 7. View of ship's plank section toward west.

determined if they were ship remains. No identifiable archaeological remains were observed on the bay side of the study area primarily due to the marsh environment and vegetation.

No evidence of prehistoric use of the landscape within the survey area was observed at the surface during the pedestrian survey. Documentation for the study area indicates that prior to acquisition by the State of the barrier dune, squatters' dwellings and habitations were present (Eckman et al. 1938). Located within the coastal dunes, these squatters habitations ranged in quality from "old houseboats hauled out on the edge of the bay to cottages of much greater value"(Eckman et al.1938:411). However, no historic archeological resources related to these potential resources or any other historic resources were identified during the pedestrian survey. No artifacts were identified or collected related to historic and prehistoric periods during the survey. Modern debris (such as candy wrappers, plastic cups, plastic tarp fragments, etc.) younger than 50 yrs old was observed, but not collected during the pedestrian survey. Based on the lack of surface evidence for prehistoric and historic occupation within the study area, the highly dynamic conditions of the coastal environment, the relatively low percentage of ground visibility (>40%) during the pedestrian survey, and the oral directions related to the pedestrian survey provided by the SHPO, no additional archeological investigations related to prehistoric and historic occupation of the areas covered by the pedestrian survey is recommended.

4.3 MONITORING OF GEOTECHNICAL BORINGS

The geotechnical borings for the primary pier locations of the proposed bridge north and south of the present inlet began on July 7 and continued until July 18, 2003. Geotechnical Borings BI-6 and BI-7 were monitored (Figure 24). Geotechnical Boring BI-6 is located next to an access road on the southwestern side of the Indian River Inlet Bridge within a parking lot to the east of the camp ground entrance. The test was bored on a small strip of grass, approx. 2m west of the dividing fence, separating the access road from the camp parking lot. Boring BI-6 is roughly 62m south of the waters edge of the Indian River Inlet and 43m west of the western edge of the Indian River Inlet Bridge.

Geotechnical Boring BI-6 extended to a depth of 53.34m (175ft) below ground surface. No evidence of cultural material was observed or recovered from the geotechnical samples that were taken during the drilling of BI-6 (Plate 8). Cuttings (material resulting from the mechanical breaking of rock during drilling activities) that resembled lithic debitage were observed during the drilling operations and were associated with gravel stratum. The knowledge that this material was recovered from cuttings that are directly related to a drill bit with three rotating cutters suggests that the larger pebbles of the stratum were likely pressure-broken into the lithic debitage-like material. It should be emphasized that the geotechnical samples taken in relation to these cuttings did not contain material resembling lithic debitage or other cultural material.

While no cultural materials were recovered from the geotechnical bore, three (3) horizons within BI-6 were notable as having potential to represent stable landscapes that could have supported human occupation and or use. The first evidence of a stable landscape came at 2.35m (7.7ft) below ground surface, based on the recovery of a dense organic layer followed by a B horizon to 2.47m (8.1ft) below ground surface. The second landscape horizon was 43.89m (144ft) below ground surface and was identified by a thin (<2cm) dense organic lens. The third landscape horizon of note

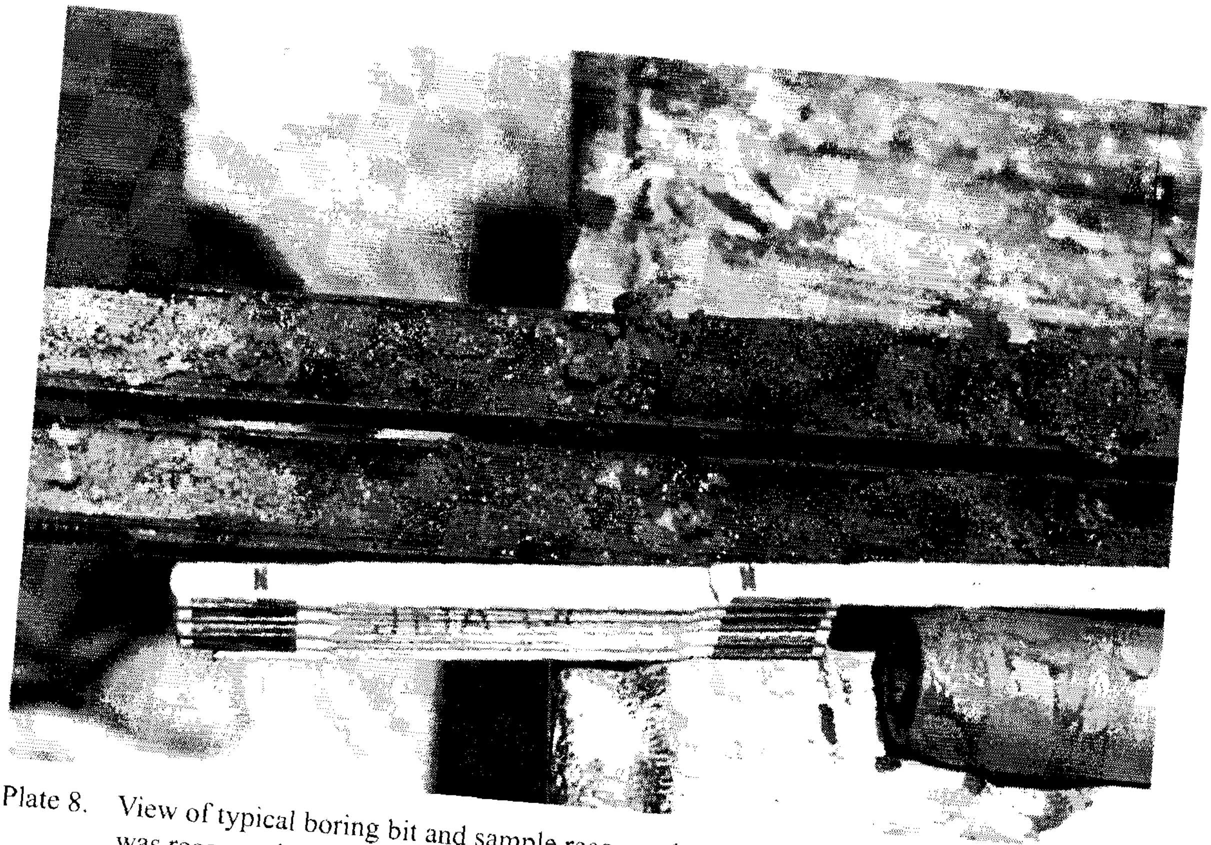


Plate 8. View of typical boring bit and sample recovered during boring activities. This sample was recovered from 98.5ft. to 100ft.below ground surface in boring BI-6.

was again a thin lens of organics at 45.17m (148.2ft) below ground surface. No cultural materials were recovered from any of these soil horizons.

Geotechnical Boring BI-7 was located in the parking lot directly north of the Delaware State Park bathhouse and located approximately 91m north of the waters edge of the Indian River Inlet and 46m west of the existing Indian River Inlet Bridge (Plate 9). Geotechnical Boring BI-7 extended to a depth of 53.34m (175ft) below ground surface. No evidence of cultural material was identified or obtained from the geotechnical samples that were taken during the drilling of the BI-7. Cutting material that resembled lithic debitage was observed during the drilling operations and associated with gravel layers. The reality that this material was recovered from cuttings that are directly linked to a drill bit with three rotating cutters suggest that the larger pebbles of the stratum were likely broken into the lithic debitage-like material. It is emphasized that the geotechnical samples obtained related these cuttings did not have materials resembling lithic debitage.

However, five (5) horizons within geotechnical boring BI-7 were notable as having potential to represent stable landscapes that could have supported human occupation and or use. The first evidence of a stable landscape came at 2m (6.6ft) below ground surface, based on the recovery of a dense organic layer followed by additional soil horizons. This was a solum that extended to 2.16m (7.1ft) below ground surface. The second landscape horizon was 8.82 meters (29ft) below ground surface and was again identified by a dense organic layer followed by a thin B horizon. This second solum extended to 8.9m (29.2ft) below ground surface. The third potential landscape horizon of note was organic, very dark grey, medium sand between 16.71m (54.8ft) and 16.78m (55ft) below ground surface. The fourth horizon was 36.37m (119ft) below ground surface. The final potential landscape horizon of interest was located 53.02 meters (174ft) to the base of the geotechnical boring (175ft). This horizon begins with a dense organic layer followed by mottled sand. Again, as with Geotechnical Boring BI-6, no cultural materials were recovered from within these soil horizons.

The results of the geotechnical boring monitoring indicate that potential landscapes capable of human occupation (and therefore containing archeological potential) are present at a depth of approximately 6.5 to 7 feet below ground surface (approximately 2 to 2.3 meters). No cultural material was recovered in either of the geotechnical borings. The current boring logs of BI-6 and BI-7 (Appendix III) support the previous coring results within the inlet vicinity (Ramsey 1999). Several potential land surfaces capable of supporting human occupation in the past were identified within borings BI-6 and BI-7. It should be reiterated that no cultural materials were recovered during the monitoring of these borings.

The existence of buried potential landscapes greater than one meter depth within the coastal zone of Delaware may offer an opportunity for an examination of the prehistory of Delaware, if there is evidence for occupation. However, those potential landscapes identified within the upper 3 meters of the two geotechnical borings, although having potential for human occupation, did not reveal any evidence of prehistoric occupation. The current sea level rise related to deglaciation over the past 15,000 years has led to the landward and upward migration of the present bay barrier system.

The interpreted paleoenvironmental position of the buried potential landscapes identified in the borings is the back barrier zone during the late Holocene. Thus, the buried landscapes would have been available for occupation during the Woodland I and Woodland II cultural periods. These

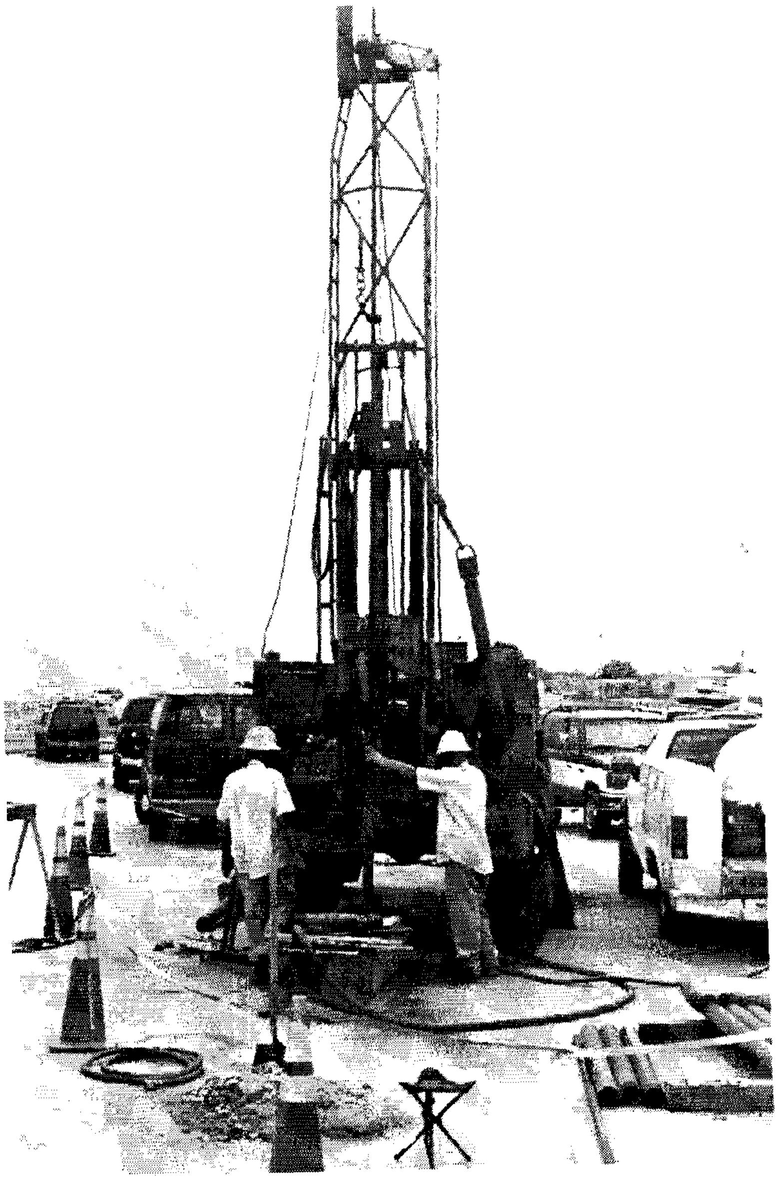


Plate 9. View towards west during drill rig operations at boring BJ-7 located in parking lot north of Indian River Inlet.

cultural associations are based on the radiocarbon date 3736 BP at the base of the bay barrier unit (Ramsey 1999). These basal deposits of the bay barrier would be equivalent to the over wash and tidal inlet deposits currently found within Indian River Bay and Rehoboth Bay. Thus, only until the bay barrier migrated and aggraded above mean sea level would the landscape be inhabitable. The back barrier would have been a location where procurement sites related to shellfish would have been the dominant site type. Thus, there is a low potential for long-term occupation on back barrier landscapes due to the type of site and a frequent inundation resulting from periodic storm events. If a site was located within the study area, it would have likely consisted of a shell midden with ancillary site features such as hearths and pit houses. These characteristic features are prominent associated with the Archaic and Woodland period sites on the relict recurved spits of Cape Henlopen to the north (Griffith 1976; Custer and Mellin 1987; Chadwick 2000; Chadwick and Madsen 2000). As is seen of the shell middens of Cape Henlopen, they are prominent features on the landscape and are typically visible at the surface. With the likely site type within the study area a shellfish procurement site that would result in the aggradation of a shell midden, a site, if present, would have a stratigraphic expression and would likely be visible at the surface; the lack of evidence within the geotechnical borings of deposits of shell in any quantity precludes the finding of a likely site location. Further, as is also evident at Cape Henlopen, shell middens are typically not a single round mound, but are built progressively as the surrounding landscape aggrades above mean sea level, thus resulting in a more oblong features that can exceed 50 meters in length (Griffith 1976; Custer and Mellin 1987; Chadwick 2000; Chadwick and Madsen 2000). With a lack of evidence for prehistoric occupation of the buried landscapes within the geotechnical borings, it is concluded that the likelihood of archeological sites is low associated with the borings at depths less than 3 meters.

In addition, based on the paleotopographic reconstruction of Indian River and Rehoboth Bays, the locations of the monitored borings are close to the axis of the incised channel of the ancestral Indian River (Chrzastowski 1986). The level of information provided by the borings gave no indication of the slope of the potential landscapes at depths greater than 25 meters. This lack of slope information does not allow a determination of their topographic position related to the ancestral Indian River channel. The topography of these buried potential landscapes is important due to the settlement patterns being focused on quarry locations during the Paleo-Indian period and coastal resources during the Archaic period (Custer 1989). Based on the radiocarbon date for the basal peat (12561 BP in borehole Pj42-11), the interpreted paleolandscape position would be associated with a fresh water to brackish estuarine setting during the Paleo-Indian period and a back bay position during the Archaic period of Delaware (Ramsey 1999). Thus, while it is known that stable terrestrial landscapes are present at depths greater than 25 meters below ground surface (and also below mean sea level) within the proposed bridge construction footprint, the landscape position is unknown. Therefore, the potential for intact prehistoric archeological sites is low based on the unknown paleotopographic position of the identified landscapes.

An additional 38 geotechnical boring logs associated with the present study were reviewed (Figure 25). These logs were produced by MACTEC and Free State Drilling, Inc. (MACTEC 2003). Due to the standards used for these geotechnical borings, the level of detailed information for the additional geotechnical borings does not add to the information related to the potential stable landscapes already discussed from geotechnical borings BI-6 and BI-7. It is also noted that no shell deposits were identified within any of the additional borings, thus precluding the possible existence of buried shell middens. However, the gross stratigraphy from the additional geotechnical borings is consistent to that already known from the bay barrier geologic cross section of Kelvin W. Ramsey (1999).

4.4 OFF-SHORE DISPOSAL AREA

An off-shore disposal area identified as Artificial Reef Creation Site #10 (ARC #10) is proposed as the location for disposal of portions of the existing bridge superstructure and substructure after demolition. ARC #10 is situated approximately five (5) nautical miles east of Indian River Inlet and was identified by NOAA Fisheries as a potential beneficial use site for the disposal of existing bridge materials removed from the project. Along with eleven other potential reef creation sites, ARC #10 was previously surveyed between 1994 and 1999 for submerged cultural resources (Cox 1995; DNREC 1994, 1999). At that time, the site was surveyed using side-scan sonar and magnetometers to detect the presence or absence of artifacts of historic significance. During the survey magnetic anomalies were identified at several locations. No excavation was undertaken at that time nor is any proposed for the present project.

ARC #10 is a pre-approved reef creation site and the disposal of materials from the Indian River Inlet Bridge will not result in any impacts on known cultural resources (DNREC 1994, 1999; USACE 2000). It is understood that those areas containing anomalies will be identified and avoided (USACE 2000). The SHPO recommended that anomalies within ARC #10 be identified prior to the initiation of construction using then Loran C coordinates identified in the geophysical survey (Clifford and Capone 1994) and placed conditions on the permit (Stocum 2000).

4.5 SUMMARY OF ARCHEOLOGICAL SENSITIVITY

Maps depicting areas within the survey area that have potential for preserved landscapes related to cultural resources were developed (Figures 26 and 27). These maps were developed by using available historic maps, aerial photographs, and geologic data. The level of sensitivity for cultural resources must take all spatial aspects of the available data into account. Thus, depth to potential cultural resources must be examined. The more deeply buried the preserved landscape is that could have supported human occupation, the less likely the recovery of cultural resources through traditional archeological methods. The Holocene age deposits and exposed Pleistocene age deposits have the greatest potential for the identification of cultural resources within the survey area and the buried Pleistocene age deposits have the lowest potential for the recovery of cultural resources.

4.5.1 PREHISTORIC SENSITIVITY

Based on the reconstruction of the paleogeography of the survey area 14,000 BP and the identification of late Pleistocene spit ridges within the study area, those portions of the Pleistocene landscape above sea level within the survey area beginning 14,000 BP could have supported prehistoric occupation (Halsey 1978, Chrzastowski 1986, and Hoyt et al. 1990). The question is: where have the probable living surfaces of that landscape been preserved?

Based on the date associated with the base of the Holocene age barrier sands, portions of the present bay barrier may have sustained landscapes that could have supported intermittent occupation associated with marine resources (Figure 28). This conclusion is supported with evidence of occupation related to landscape propagation at Cape Henlopen, Delaware. GPR surveys conducted on several prehistoric sites at Cape Henlopen revealed that the occupation of coastal landscapes maintained pace with their formation. The development, aggradation, and transgression of the coastal landscapes associated with Cape Henlopen were a result from fluctuations in sea level (Chadwick 2000). The archeological sites that were surveyed by Chadwick (Chadwick 2000, Chadwick and Madsen 2000) at Cape Henlopen ranged in age from 1,500BP to 400BP (Woodland I and II). The paleoenvironmental reconstructions of those sites revealed that the occupation of those coastal landscapes began shortly after they aggraded above sea level. These occupational surfaces were active when sea level was over 1 meter below present sea level (Chadwick 2000, Chadwick and Madsen 2000).

Knowing that prehistoric occupation of coastal landscapes can occur shortly after their formation, it is possible that the paleolandscapes associated with the paleogeography of both the Omar Formation and those associated with the Holocene age bay barrier deposits could have supported prehistoric occupation. It would presently be extremely difficult to extract additional archeological and geomorphic information from these deeply buried potential landscapes, due to physical limitations of standard archeological methods, as well as fiscal considerations. Archeological monitoring and/or limited investigations would be recommended in the event that bridge design or construction methods allowed a safe, economical, and efficient way for a team of archeologists to examine the buried potential landscapes. However, the likelihood that such methods (with safeguards) are applicable and will be utilized in the construction of the new bridge is low. Overall, it is concluded from the examination of geotechnical borings conducted within the study area that there is no evidence for buried archeological sites, that the buried potential landscapes have low potential for archeological sites, and that no additional archeological investigation of these potential landscapes is justifiable or recommended.

4.5.2 Historic Sensitivity

The historic use of the bay barrier and headland physiographic landforms within the study area will be greatly influenced by the location of the historically documented tidal inlets and effects from previous coastal storms. The plot of historic tidal inlets provides locations within the study area where overwash events, and subsequent tidal scour, related to historic inlets, would have potentially removed any historic features on the landscape (Figure 9). However, due to the dynamic nature of coastal environments, the preservation of such landscapes within the study area is considered to be extremely low.

4.5.3 Maritime Sensitivity

If the tidal conditions of the present inlet are assumed to be a comparable to the conditions of past inlets, historic inlets have a potential for historic maritime resources. However, as stated above the dynamic nature of the inlet environment and character of the barrier and headland landform makes the potential for maritime sensitivity extremely low.