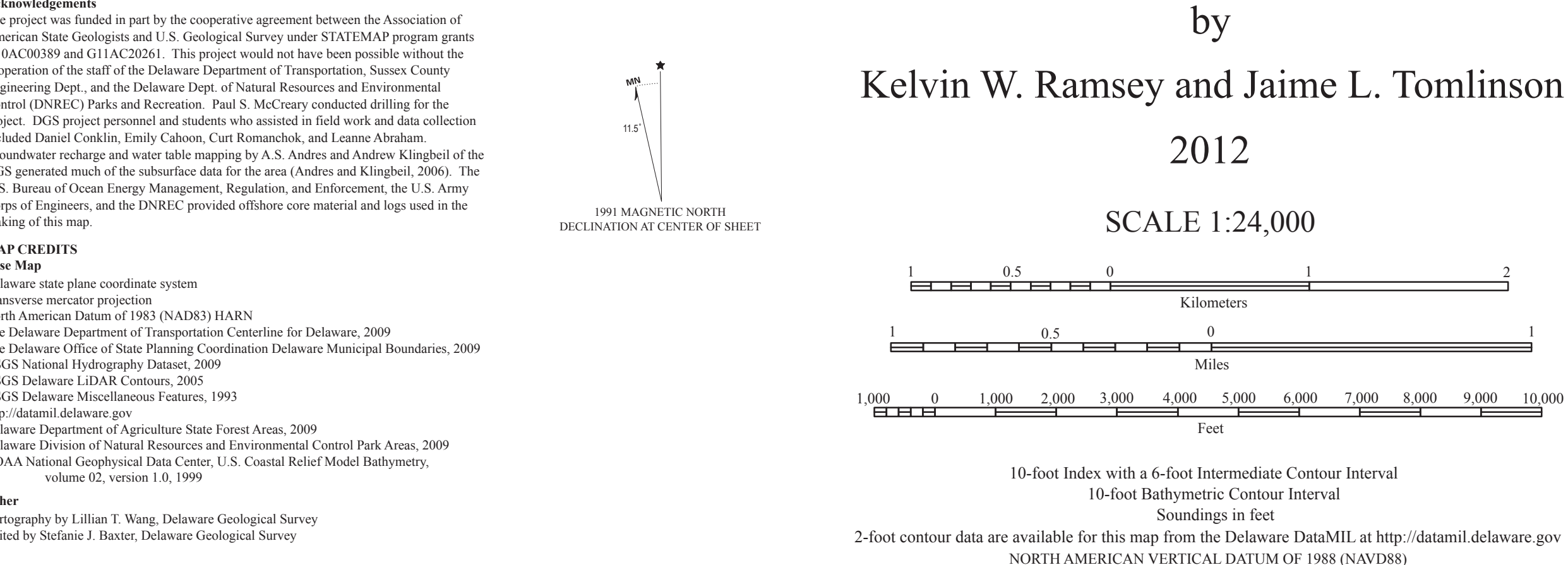


GEOLOGIC MAP OF THE BETHANY BEACH AND ASSAWOMAN BAY QUADRANGLES, DELAWARE

by
Kelvin W. Ramsey and Jaime L. Tomlinson
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EXPLANATION

FILL
Man-made and natural materials (sand, gravel) emplaced in stream valleys or marshes to bring the topography above grade, usually in road beds, dams, or construction near a shoreline. Fill deposits include sediment dredged from the marshes and offshore in Indian River Bay and emplaced on the uplands.

MODIFIED LAND
Areas of land where the surficial deposits have been modified due to human activity to the point that surficial deposits can no longer be reliably determined. The unit is mapped in areas large enough to be shown on the map and does not include local disturbances on the scale of an individual housing lot or shallow disturbances such as large parking lots or retail areas. An example of modified land is a golf course where numerous ponds and embankments have been constructed.

NEARSHORE DEPOSITS offshore
Pale-yellow to light-gray, cross-bedded, very fine, silty sand to fine to coarse sand with laminae to thin beds of very coarse sand, granules, and pebbles. Shells are a common constituent of the sands and range from fragmented, granule-size pieces to whole shells. Nearshore deposits are mapped from the shoreline to the break in slope where water depths increase from less than 10 ft to greater than 20 ft. Texture of nearshore sediments is related to texture of underlying deposits from which they are reworked. Nearshore deposits consist of fine, silty sand and north of Bethany Beach to fine to coarse sand with shells reworked from the underlying Sinepuxent Formation of Bethany Beach. To the south of Bethany Beach, nearshore deposits range from medium to coarse sand. Nearshore deposits are thin, usually less than 2 ft in thickness. Holocene.

EBB TIDAL SAND DEPOSITS offshore
Pale-yellow to light-gray, cross-bedded coarse to fine sand with laminae of heavy minerals and granules to pebbles. Shells and shell fragments are a rare constituent of the sands. Ebb tidal delta deposits are found offshore of Indian River Inlet. The sediments are partly disturbed by dredging and influenced by the location of the jetties offshore of the inlet. Ebb tidal delta deposits range from 5 to over 25 ft in thickness. Holocene.

FINGER SHOAL DEPOSITS offshore
Gray, silty, coarse to fine, and fine to very fine sand that fines seaward to very fine sandy silt. In medium sands, shell fragments and whole shells are common. Clay and clays, silt-lined burrows are common throughout. The sands are finely laminated with opaque heavy minerals and textural laminae of very fine, silty sand and coarser sand. The deposits interfinger with the quiet-water deposits. Finger shoal deposits extend from the bathymetric break between 20 and 30 ft offshore that marks the limit of the nearshore deposits to water depths of about 35 ft. They have a characteristic bathymetric signature of shore-oblique highs that extend like fingers from the nearshore. Thickness ranges from less than 1 ft off of Bethany Beach to greater than 10 ft to the south. Holocene.

SHEET SAND DEPOSITS offshore
Pale-yellow, well-sorted, fine to medium, to coarse to very coarse sand with abundant granules, pebbles, and shell fragments. Cross-bedding is common, consisting of laminae of sand, granules, and pebbles. Shells most common within sheet sand deposits are *Spisula*, *Ensis* and *Anomia* (few to common in abundance) and lesser amounts of sand dollars, echinoid spines, and solitary corals (*Astragala*) have been observed. Sheet sand deposits range from a few inches to about 10 ft in thickness. Where thin (<2 ft), the deposits tend to be patchy, overlying shoal, finger shoal, or quiet-water deposits. Thicker, the deposits form extensive level areas of sand on the seafloor, most commonly where the Beaverdam Fm. underlies the sheet sand deposits. Holocene.

QUIET-WATER DEPOSITS offshore
Light-gray to very dark-gray, very fine, silty sand to silt. Burrows are common to abundant. Whole and fragments of *Ensis* shell are common to abundant. Thin laminae of silt and very fine silty sand are common. These deposits are commonly found at water depths greater than 45 ft, which is below storm wave base. Deposits range from 1 to 10 ft in thickness. Holocene.

FLOOD TIDAL DELTA DEPOSITS Indian River Bay
Light-gray to gray, clean to silty, very fine to coarse sand. Sedimentary structures range from well-developed cross-bedding to structureless where the deposit is completely bioturbated. Flood tidal delta deposits are found adjacent to Indian River Inlet in Indian River Bay and have been greatly modified by dredging. The deposits are up to 25 to 30 ft thick adjacent to the barrier and thin to the west in Indian River Bay (Chrzastowski, 1986). Flood tidal delta deposits grade laterally into barrier washover deposits along the coast and into lagoon deposits in Indian River Bay. Holocene.

LAGOON DEPOSITS Indian River and Little Assawoman Bays
Medium-gray to dark-gray clayey silt. Sedimentary structures are rare, consisting of relict burrows or thin laminae of marsh grass fragments or very fine sand. Shells and shell fragments are rare to common. Lagoon deposits grade laterally into marsh deposits and barrier washover deposits. They underlie a portion of the water body of Indian River Bay and Little Assawoman Bay and the tidal portions of their tributaries, and extend offshore. Lagoon deposits are up to 30 ft thick near the center of Indian River Bay (Chrzastowski, 1986). Holocene.

SHORELINE DEPOSITS
White to light-gray, well-sorted, very coarse to fine sand with scattered pebbles. Along the shoreline of Indian River Bay, they are thin, ephemeral bodies of sand less than 3 ft thick. Along the Atlantic shoreline, the sands on the beach are up to 10 ft thick and grade laterally into dune deposits and washover deposits. Holocene.

BARRIER WASHOVER DEPOSITS
White to gray, cross-bedded beds of very coarse to fine sand with scattered laminae of pebbles and heavy minerals. Laminae of organic fragments and thin peat layers are also common. These deposits are the result of storm events transporting shoreline and dune deposits into the margin of Indian River Bay. Peat and organic debris layers represent establishment of marshes that were buried by subsequent washover events. Washover deposits are up to 25 ft thick (Chrzastowski, 1986). Holocene.

SWAMP DEPOSITS
Gray to brown silty and clayey gravely sand overlain by organic-rich fine to coarse sand. In some of the larger stream valleys, the unit has a vertical face of organic silt at its top. Swamp deposits are up to 15 ft thick in the larger stream valleys and less than 5 ft thick in the smaller tributaries. Deposits are found in the upper reaches of modern stream valleys and interfinger with and grade into marsh deposits. Holocene.

MARSH DEPOSITS
Light-gray to brown, organic-rich, clayey silt. Peat beds consisting of finely comminuted organic fragments (primarily of marsh grass) are common near the base of the unit and scattered throughout. Marsh deposits are generally less than 10 ft thick along the northern shore of Indian River Bay and up to 25 ft along buried stream channels in Indian River Bay (Chrzastowski, 1986). Holocene.

CAROLINA BAY DEPOSITS
Circular features located primarily in the Assawoman Wildlife Area. They consist of raised rim dunes of well-sorted, medium to fine sand with silty sand in the interior of the circular features. A few of the features contain either seasonal or year-round bodies of water where the water table is high. The deposits are less than 5 ft thick in their interiors and up to 10 ft thick where rim crests are best developed. Circular features that are actively being filled and covered by marsh deposits are inferred to be Carolina Bays and are shown with a dashed line. Features are likely related to cold-climate processes during the Pleistocene (Ramsey, 1997). Late Pleistocene to Holocene.

DUNE DEPOSITS
White to pale-yellow, well-sorted, medium to fine sand. In dune deposits found along the shoreline, some coarse to very coarse sand laminae with scattered pebbles are found, and are relicts of storm-related washover deposits. The sands in shoreline dunes are typically cross-bedded. The unit includes man-made dunes along the Atlantic shoreline, which are similar in morphology and texture to natural dunes. Dune deposits along the Atlantic Coast are up to 10 ft thick and grade laterally with barrier washover and shoreline deposits. They are Holocene in age. Inland, dune deposits have a similar lithology. Laminae of coarse sand and silt, brown soil lamellae are commonly found at depths of 1 to 3 ft within the inland dunes. Inland dune deposits, which are up to 6 ft thick, are eolian features related to cold-climate processes when arboreal vegetation was scarce and wind-blown sand dunes across the landscape. Some of the inland dunes that have well-developed and deep (>3 ft) soil profiles may be older than latest Pleistocene and are middle to late Pleistocene in age. Middle Pleistocene to Holocene.

SCOTTS CORNERS FORMATION (YOUNGER)
Pale-yellow to light-gray, gravely sand grading up to medium to coarse sand, to fine sand, commonly capped by 1 to 3 ft of very fine, silty, clayey silt. Scattered beds of 1- to 3-ft-thick gray silty clay with organic-rich laminae are also common. These deposits are found beneath low terrace flats less than 5 ft in elevation along the margins of Indian River Bay and are up to 8 ft in thickness. They are considered to be lagoon-margin deposits, the result of a sea-level highstand along the margins of an ancestral Indian River Bay at approximately 80,000 yrs B.P. (Ramsey, 2010a). Late Pleistocene.

SINEPUXENT FORMATION
Gray, laminated, silty very fine to fine micaceous sand to sandy silt. The base of the unit is typically a 3- to 5-ft-thick zone of blue-gray to dark-gray clayey silt to silty clay that is interbedded with and grades upward into the sandy silt. In places, the silty clay and the lower portion of the sandy silt are interbedded with a fine to medium sand. In the vicinity of Bethany Beach, the lower sand contains abundant *Malina* clam shells. The upper portion of the Sinepuxent Formation, especially near its contact with the Ironshore Formation, consists of 2 to 10 ft of clean, fine to medium sand with some coarse sand to pebbles that coarsens to the northward Cedar Neck. Total thickness of the unit ranges from less than 5 ft at its western margin to over 50 ft thick just west of the town of Fenwick Island. The Sinepuxent Formation is interpreted to have been deposited in a lagoonal environment during the late Pleistocene (approximately 80,000 yrs B.P.) (Ramsey, 2010a). The coarser sediments near the land surface represent nearshore deposits laid down after the lagoon was filled when the Atlantic Ocean shoreline was west of its present position (Ramsey, 2010a). Late Pleistocene.

IRONSHIRE FORMATION
Pale-yellow to light-gray, fine to very coarse sand. Granules to pebbles are a common constituent of the unit, especially near its base. Thin, light-gray, silty clay beds occur but are not present at all localities. The Ironshore Formation is found between the well-developed Sinepuxent Formation to the east and the Omar Formation to the west. It is up to 2 to 8 ft thick. It is distinguished from the Sinepuxent and Omar Formations by the cleaner and coarser textures of the sands. Where the sands are finer, such as the area between Miller and Drickson Creeks, the Ironshore Formation may not be easily differentiated from the sandy, upper portion of the adjacent Omar Formations. In these areas, the contact between the Ironshore and Omar Formations is drawn at the base of a topographic break at approximately 18 ft in elevation. The Ironshore Formation is interpreted to be a shoreline and nearshore deposit related to a sea-level highstand at approximately 120,000 yrs B.P. (Ramsey, 2010a). Late Pleistocene.

OMAR FORMATION
Light-gray to gray, silty clay to silty, very fine sand with scattered shell beds. The Omar Formation consists of up to 5 ft of light to dark-gray, beach, pebbly, coarse to very coarse sand that grades upward into 1 to 3 ft of gray to very dark-gray, fine to coarse silty sand with scattered laminae to thin beds of peat composed of sand to gravel-size plant fragments. The sands are overlain by 3 to 5 ft of very dark-gray to black organic-rich sandy silt to silty clay. Above this organic-rich zone, in the areas where the Omar is thicker, 10 to 40 ft of greenish-gray, compact, silty clay to clayey silt is common. The clayey silt grades upward into a gray to light greenish-gray, silty, gray clay to silty fine sand with scattered laminae to thin beds of *Crossosoma* (oyster) shell. In places, there is a 2- to 10-ft-thick bed of medium to coarse sand separating the compact clayey silt from the overlying silty, silty clay. The overall thickness of the Omar Formation in the map area ranges from 2 ft thick along the surficial contact with the Ironshore Formation to about 7.5 ft thick just south of Ocean View. The Omar Formation fills an east-west oriented paleochannel and is comprised of swamp, marsh, and lagoonal sediments deposited during a sea-level highstand at approximately 400,000 yrs B.P. and possibly reworked during the subsequent highstand at 120,000 yrs B.P. (Ramsey, 2010a). Middle Pleistocene.

BEAVERDAM FORMATION
Heterogeneous unit ranging from very coarse sand with pebbles to silty clay. The predominant lithologies at the land surface are white to mottled light-gray and reddish-brown, silty to clayey, fine to coarse sand. Laminae and beds of very coarse sand with pebbles to gravel are common. Laminae and beds of blue-gray to light-gray silty clay are also common. In a few places near the land surface, but more commonly in the subsurface, beds ranging from 2 to 20 ft thick of finely laminated, very fine sand and silty clay are present. The sands of the Beaverdam Formation have a white silt matrix that gives samples a milky appearance when wet. This white silt matrix is the most distinguishing characteristic of the unit and readily differentiates the Beaverdam Formation from the adjacent cleaner sands of the Sinepuxent, Ironshore and Scotts Corners Formations. The Beaverdam Formation is interpreted to be a late Pleistocene to early Holocene deposit (Ramsey, 2010a, b). It ranges from 50 to 100 ft in the map area. Late Pleistocene.

Discussion
The geologic history of the surficial units of the Bethany Beach and Assawoman Bay Quadrangles is that of deposition of the Beaverdam Formation and its subsequent modification by erosion and deposition related to sea-level fluctuations during the Pleistocene. The geology reflects this complex history underway, in Indian River Bay and Assawoman Bay, and offshore in the Atlantic Ocean. Erosion during the late Pleistocene sea-level lowstand and ongoing deposition offshore and in Indian River Bay during the Holocene in sea level regression resulted in the development of erosion and deposition.

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