DELAWARE GEOLOGICAL SURVEY
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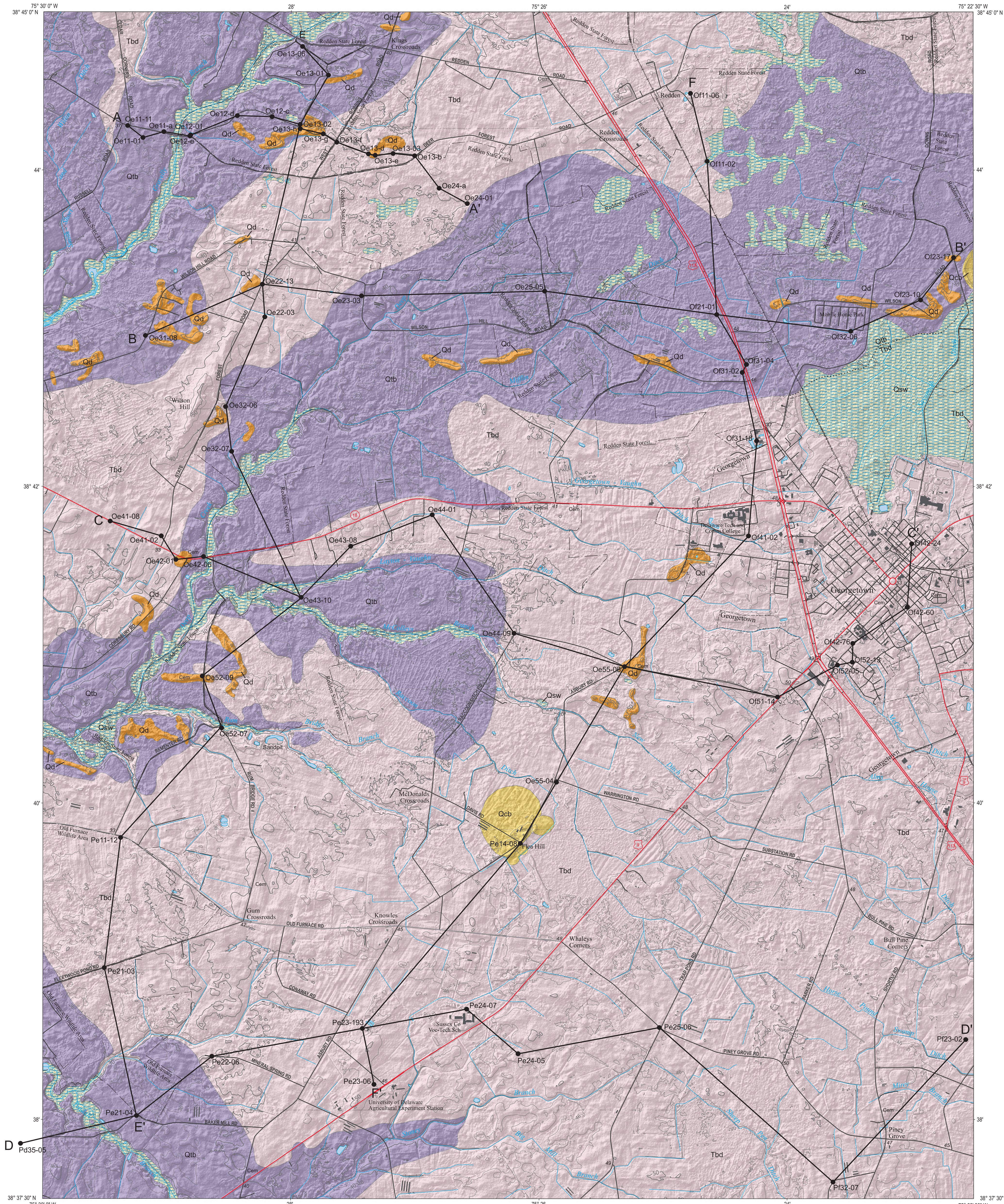

GEOLOGIC MAP OF THE GEORGETOWN QUADRANGLE, DELAWARE

by

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EXPLANATION

SWAMP DEPOSITS — Qsw

Found in two depositional settings, along streams and in undrained areas on uplands. Along streams, swamp deposits consist of black to brown, organic-rich, very fine to coarse sand to silt. Very coarse sand to gravel commonly is found at the base of the unit. Where the streams are ditched, the organics are completely oxidized and the sands are white to pale yellow. On uplands, the swamps consist of brown to dark-brown, organic-rich, fine to very fine sand to an organic muck. In the swamp area north of Georgetown, the organic sands and silts commonly overlie a 1 to 2-ft thick bed of gray to greenish-gray, very fine sandy silt. Stream swamp deposits range from a few inches thick along the stream margins to as much as 10 ft thick near the streams. Upland swamp deposits range from a few inches thick to as much as 7 ft thick. The unit is interpreted to be swamp deposits along streams and to be bogs on uplands. Holocene.

DUNE DEPOSITS — Qd

Composed of pale-yellow to white, loose, well-sorted, fine to medium sand. They are located in linear features that rise from 3 to 10 ft above an otherwise flat landscape. Dune deposits range up to 15 ft in thickness. Interpreted to be wind-blown deposits laid down during the late Pleistocene to early Holocene when there was little forest cover during periglacial conditions. Late Pleistocene to Holocene.

CAROLINA BAY DEPOSITS — Qcb

Circular features of well-sorted, fine to very fine sand along the outer rim and poorly sorted, fine to coarse sand in the center. The original character of the sediments within the features has been obliterated by plowing, although the sandy rims remain recognizable. The deposits range up to 10 ft in thickness along the rims and are 1 to 3 ft in thickness in the center. Interpreted to be eolian features related to late Pleistocene to Holocene cold climate. Late Pleistocene to Holocene.

TURTLE BRANCH FORMATION — Qtb

New formation (Ramsey, 2010). Fining-upward sequence of a thin (less than 1 ft thick), gravelly sand, to an interlaminated, medium to coarse sand with heavy mineral laminae, to a well-sorted fine to medium, fluffy sand that makes up the bulk of the unit. Near the present stream valleys, 1 to 5-ft thick beds of light-grayish-brown to brown, organic-rich, clayey silt are common. Along the margins of the unit where it is adjacent to the Beaverdam Formation, the unit commonly consists of pale-yellow to yellowish-brown, fine to very fine silty sand. The unit is less than 5 ft thick over much of its mapped area but can range up to 20 ft thick near the present stream valleys. The well-sorted sands of the Turtle Branch Formation are differentiated from those of the dune deposits by their slightly coarser texture, better developed soil profile, and common presence of heavy mineral laminae. Interpreted to be a sand-dominated fluvial to tidal and shoreline deposit associated with a high stand of sea level during the middle Pleistocene. Middle Pleistocene.

BEAVERDAM FORMATION — Tbd

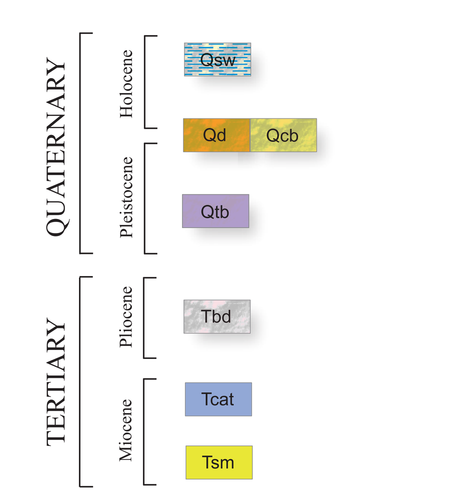
Heterogeneous unit ranging from very coarse sand with pebbles to silty clay. Predominant lithologies at land surface are white to mottled light-gray and reddish-brown, silty to clayey, fine to coarse sand. Laminae and beds of very coarse sand with pebbles to gravel are common. Laminae and beds of bluish-gray to light-gray silty clay are also common. In a few places near 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 commonly have a white silt matrix that gives drill cuttings a milky appearance (Ramsey, 2001, 2007). This white silt matrix is the most distinguishing characteristic of the unit and readily differentiates the Beaverdam Formation from the adjacent clean sands of the Turtle Branch Formation. Interpreted to be a fluvial to estuarine deposit of late Pliocene age on the basis of pollen assemblages and regional stratigraphic relationships (Andres and Ramsey, 1995, 1996; Groot and Jordan, 1999; Groot et al., 1990). Ranges from 50 to 120 ft thick in the Georgetown Quadrangle. Late Pliocene?

CAT HILL FORMATION (subsurface only) — Tcat

Yellowish-brown to light-gray, medium to fine sand with thin beds and laminae of medium to coarse sand and scattered pebbles (B) that grades downward into bioturbated, gray, very fine sand to silt (A). Rare beds of light-gray to red silty clay are found near the contact with the overlying Beaverdam Formation. Laminae of opaque heavy minerals are present in the upper sands. Laminae of very fine organic particles are found in the lower sand as well as laminae to thin beds of coarse sand to gravel. The burrows in the lower sand are clay lined, and in some intervals, the sediment is completely bioturbated to the extent that no sedimentary structures are preserved. Sand is primarily quartz with less than 5% feldspar and a trace to less than 1% mica (in the very fine sand to silt). Glauconite is present only in trace amounts. Fragments of lignite are common to rare in the organic laminae. Interpreted to be a late Miocene, very shallow marine to marginal marine (shoreface) deposit (McLaughlin et al., 2008). About 100 to 120 ft thick in the Georgetown Quadrangle. Late Miocene.

ST. MARYS FORMATION (subsurface only) — Tsm

Bioturbated, dark-greenish-gray silty clay, banded light-gray, white, and red silty clay, and glauconitic, shelly, very fine sandy silt. In the Georgetown Quadrangle, the St. Marys Formation is capped by about 5 to 15 ft of bioturbated, dark-greenish-gray silty clay. A distinct burrowed horizon separates the clay from the underlying banded clay that consists of a 10- to 15-ft thick, compact, color-banded silty clay with scattered white clayey concretions. The banded clay has a sharp contact at its base with underlying glauconitic, very fine, sandy silt. The sandy silt contains shells of the gastropod *Turritella*. The entire thickness of the St. Marys Formation is less than 100 ft in the Georgetown Quadrangle, thinning from its thickest in the southeast corner to about 50 ft thick in the northwest corner of the map area. Interpreted to be a marine deposit of late Miocene age (McLaughlin et al., 2008). Late Miocene.

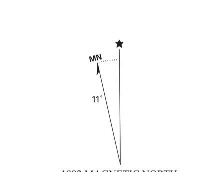


SYMBOLS

- ● Oe11-11 Well or borehole
- ● Oe11-a Outcrop or soil auger boring
- State Forest and Wildlife Areas
- Municipal Boundary
- Concealed contact
- Inferred contact *(on cross sections)*
- Inferred internal contact *(on cross sections)*
- Formation contact *(on cross sections)*

GEOPHYSICAL LOGS

- gamma log
- spontaneous potential log
- resistivity log



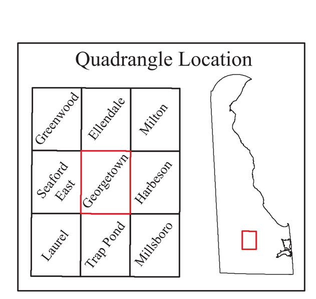
SCALE 1:24,000

Kilometers

Miles

Feet

10-foot Index with a 6-foot Intermediate Contour Interval
2-foot contour data are available for this map from the Delaware DataMIL at http://datamil.delaware.gov
NORTH AMERICAN DATUM OF 1988 (NAVD88)



MAP CREDITS

Base Map
Delaware state plane coordinate system
Transverse mercator projection
North American Datum of 1983 (NAD 83) HARN
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Delaware Division of Natural Resources and Environmental Control Wildlife Areas, 2009

Other
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Discussion

The geologic history of the surficial geologic units of the Georgetown Quadrangle is primarily that of deposition of the Beaverdam Formation and its subsequent modification by erosion and deposition of younger stratigraphic units. The age of the Beaverdam Formation is uncertain due to the lack of age-definitive fossils within the unit. Stratigraphic relationships in Delaware indicate that it is no older than late Miocene and no younger than early Pleistocene. Regional correlations based on similarities of depositional style, stratigraphic position, and sediment textures suggest that it is likely late Pliocene in age; correlative with the Bacons Castle Formation of Virginia (Ramsey, 1992, 2010).

Interpretation of the depositional environment(s) of the Beaverdam Formation relies upon analysis of split-spoon and wire-line cores and corresponding geophysical (primarily gamma) logs. These data indicate that the Beaverdam Formation consists of stacked 1- to 5-ft thick beds of very coarse sand and gravel that commonly fine upwards to fine to medium sand and rarely to very fine silty sand to silty clay. These types of deposits are typical of either fluvial or estuarine environments. Due to the lack of muddy beds, a typical river channel to overbank setting is not likely. A braided fluvial system can produce stacked sand beds (Cant, 1982) such as those found in the Beaverdam Formation (Ramsey, 2010). Similar deposits are also found in sandy estuarine settings where flow velocities are high enough to preclude fine-grained deposition (Clifton, 1982). It is likely that the Beaverdam Formation was deposited in a transition zone between braided fluvial and estuarine environments. Rare burrows have been observed in the Beaverdam Formation elsewhere in Delaware that indicate at least a marginal estuarine setting (DGS unpublished data; Owens and Denny, 1979). The Beaverdam Formation at the land surface in the Georgetown Quadrangle is coarser to the west and north than to the south and east, in many places consisting of a granule to pebble sand to gravel. To the south and east, the unit is more commonly a very fine to medium, silty to clayey sand. These observations suggest that the Beaverdam Formation becomes finer to the south and southeast perhaps indicating a transition from a more fluvial to a more estuarine setting. The Beaverdam Formation fines upwards which also suggests a transition from fluvial to estuarine deposition (Owens and Denny, 1979).

The land surface expression of the Beaverdam Formation in the Georgetown Quadrangle ranges from about 40 ft in elevation near the stream valleys to about 50 ft in elevation away from the streams. Local variations in elevation of ±4 ft give the land surface a slightly hummocky appearance. The primary exception is a feature in the northwest section of the quadrangle called Wilson Hill, which rises about 14 ft above the surrounding landscape. Isolated high spots (hills) of Beaverdam Formation also have been observed east of Georgetown and west of Selbyville (Selbyville Quadrangle). No clear explanation of their origin is apparent. Beaverdam Formation was eroded by at least 10 ft over much of its extent after deposition.

The Turtle Branch Formation (Ramsey, 2010) is found along the major stream valleys that cross the Georgetown Quadrangle (cross section A-A'). Its contact with the Beaverdam Formation at the land surface is marked by a subtle scarp with the surface of the Turtle Branch Formation being less than 40 ft and the surface of the Beaverdam Formation greater than 40 ft. There are many places, however, where there is no break in topography between the two units. The two units are readily differentiated by the recognition of the well-sorted, clean sands of the Turtle Branch Formation contrasted with the poorly sorted, silty to clayey sands of the Beaverdam Formation. At the contact between the two formations, the sands of the Turtle Branch Formation are siltier than elsewhere in the unit. The Turtle Branch Formation thickens toward modern streams (all cross sections), and on the northwest sides of the streams consists of a brown, very fine, silty, organic-rich sand. The land surface of the Turtle Branch Formation is relatively flat, ranging from 34 ft near the edge of stream valleys to about 40 ft near its contact with the Beaverdam Formation. In the area of Redden State Forest east of Route 113, the otherwise flat surface of the Turtle Branch Formation ranges up to 45 ft in elevation and is interspersed with low areas that contain upland swamps.

Modern stream deposits in the map area are poorly sorted and interfinger laterally and vertically with clayey, gravelly, organic-rich sands of swamp deposits. In contrast, the high degree of sorting and the presence of scattered thin, silty clay laminations indicate that the Turtle Branch Formation was deposited in a tidal-channel setting dominated by sand (Weimer et al., 1982). The fine-grained sediments of the Turtle Branch contain disseminated organic material. Oe11-a contained grasses that could possibly be marsh plants. The silty nature of the Turtle Branch Formation near its contact with the Beaverdam Formation is likely both the result of local reworking of the silty sands of the Beaverdam Formation and deposition of fine-grained sediments along the margins of the Turtle Branch tidal channels.

Dune deposits are fine to medium, loose, well-sorted sands that are much like the clean sands of the Turtle Branch Formation. Dune deposits may be more extensive than shown on the map, especially between linear trends of dunes. Dune deposits on the map are delineated by field data and/or well-defined topographic expression. The deposits are mapped on their surficial expression, a weakly developed soil profile compared to the Turtle Branch Formation, and a paucity of opaque heavy mineral laminae that are found in the Turtle Branch Formation. These dunes had as their sand source the loose, clean sand of the Turtle Branch Formation and are latest Pleistocene to early Holocene in age (Andres and Howard, 2000). Some of the dunes overlying the Turtle Branch Formation in the northeast corner of the map lack an underlying soil profile and have a well-developed surficial soil profile. These dunes may be contemporaneous with deposition of the Turtle Branch Formation.

One cluster of Carolina Bays occurs at Flea Hill near the center of the map area. The rim of another large basin is on the northeastern margin of the quadrangle. Flea Hill is the dune rim of a Carolina Bay consisting of medium to fine sand. The deposits in the center of the feature were thin and now are mixed by plowing with the underlying Beaverdam Formation. The Carolina Bays are probably related to a cold-climate setting during the last glaciation and eolian processes on a largely treeless landscape (Ramsey, 1997). The exact process by which these circular features are formed is unknown.

Modern deposition in the map area is represented by swamp deposits along the present streams and on the uplands. Along Deep Creek, the stream swamps are now perched and drying out due to ditching, which has lowered the local water table by more than 10 ft, and much of the organic material has been or is being oxidized leaving behind a white to red silt or sand. Upland swamps consist of organic-rich sand and silty muck formed in areas where the water table is high and ponding has allowed accumulation and preservation of organic material. These upland swamps are best developed in Redden State Forest east of Rt. 113 and north of Georgetown in the vicinity of Savannah Ditch. Upland swamp deposits are mapped on lithology and distribution of swamps as delineated in the U.S. Geological Survey hydrography database. They do not necessarily conform to wetlands mapped on vegetation, soils, or other criteria.

Subsurface units are shown in cross sections down to the St. Marys Formation. The Cat Hill Formation and St. Marys Formation (Andres, 2004; McLaughlin et al., 2008) are found throughout the map area. It is possible that scattered, clayey silt beds found at the contact between the Cat Hill and Beaverdam Formations (cross section F-F') could be the edge of the Bethany Formation; however, sample data are very limited. Andres and Klingbeil (2006) mapped the Bethany Formation in Georgetown and to the east. The western extent of the Bethany Formation probably lies somewhere around the eastern margin of the Georgetown Quadrangle. This study has the benefit of two wire-line core holes (Of11-06 and Pe23-193, cross section F-F') and many more drill holes with geophysical logs not available to Andres and Klingbeil (2006). The core holes provided undisturbed samples which aided in lithologic correlation with another core hole at Bethany Beach (McLaughlin et al., 2008) in the type area of the Bethany Formation and Cat Hill Formation (Andres, 2004). Differentiating the sands of the Beaverdam, Bethany, and Cat Hill Formations is difficult (Andres and Klingbeil, 2006) especially where diagnostic clayey bodies are absent.

Cross sections D-D' and F-F' show that the strata above the lower Cat Hill Formation within the Georgetown Quadrangle are primarily sand with rare, thin (<10 ft thick), scattered mud beds. Where mud beds are present, they cannot be mapped to any distance beyond an individual drill hole. (This indicates that above the lower Cat Hill Formation, confining beds are rare.)

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