

STATE OF DELAWARE
UNIVERSITY OF DELAWARE
DELAWARE GEOLOGICAL SURVEY

OPEN FILE REPORT No. 9

GEOLOGIC FIELD TRIPS IN DELAWARE

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FOREWORD

The information contained in this Guidebook was compiled on the occasion of the Annual Meeting of the Association of American State Geologists held in Delaware in June 1977. The Delaware Geological Survey is pleased to have been selected to host this national meeting. The field trip logs were designed to familiarize geologists from across the United States with basic features of Delaware's geology and resources. We have also sought to identify some points of historical and cultural interest that may help the visitor become familiar with our State.

Experience has shown that field guides retain their usefulness beyond the event that they initially served. They may assist classes, other groups, and individuals seeking additional information about their physical environment. Therefore, this Guidebook has been published as an Open File Report for public distribution. All users of this information are urged to exercise caution, especially at rock faces and along waterways, and to obtain specific permission for visits from landowners where necessary.

It is hoped that Delawareans may find these trips educational and that visitors will feel welcome and come to share our pride in the First State.

Robert R. Jordan
State Geologist

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ROAD LOG

GEOLOGY AND WATER RESOURCES OF THE WESTERN PORTION OF THE DELAWARE PIEDMONT

Allan M. Thompson and William F. Hahn

Leave from main entrance of Clayton Hall, North Campus, University of Delaware, Newark. Distances are given to nearest tenths of miles as measured by automobile odometer.

<u>Distance</u>	<u>Cumulative Distance</u>	<u>Notes</u>
0.0	0.0	Leave Clayton Hall bearing south (right) on main drive from North Campus.
0.1	0.1	Jct. Del. Rt. 896, New London Road. Turn south (left) following Del. Rt. 896.
0.2	0.3	Jct. Del. Rt. 896 and Cleveland Ave. Turn east (left) following Cleveland Ave.
1.2	1.5	Jct. Cleveland Ave. and Del. Rt. 2. Turn east (left) following Del. Rt. 2.
0.7	2.2	Jct. Del. Rt. 2 and S. Dilwyn Drive, just before bridge. <u>Veer right</u> on access road just after light, descending below bridge.
0.1	2.3	<u>STOP 1.</u> Windy Hills Bridge Park in cul-de-sac adjacent to bridge.

The rocks exposed in the bed of White Clay Creek belong to the Wissahickon Formation, a thick, eugeosynclinal accumulation of probably Cambrian metasediments that characterizes much of the central Appalachian Piedmont. The exposure contains two distinct facies. The thin-bedded gneisses and amphibolites near the creek toward the western end typify the granular psammitic facies, and probably represent metasedimentary (and possibly metavolcanic) rocks of the Wissahickon, probably transitional into metavolcanogenic lithologies of the James Run Formation which lies adjacent to the Wissahickon. Several quartz-feldspar gneisses contain small porphyroblasts of magnetite, and also retrogressive epidote and chlorite.

The southern part of the exposure contains thin-layered biotite schists and granule metaconglomerates more typical of the psammitic facies of the Wissahickon. These less competent rocks are tightly folded along southwest-plunging axes; several small folds are visible. A northeast-trending tear fault with right-lateral drag and later pegmatite is visible near the east end of the outcrop.

Based on correlations with rocks in eastern Maryland, the rocks are probably of Cambrian age. The deformation and metamorphism are of Middle Ordovician age, part of the Taconic orogenic event. The Wissahickon-James Run rocks have been inferred to represent Cambrian volcanic arc and back-arc deposition above an active subduction zone.

- | | | |
|-----|-----|--|
| | 2.3 | Leave Stop 1, returning to Del. Rt. 2. |
| 0.1 | 2.4 | Jct. Del. Rt. 2. Turn east (right) following Del. Rt. 2. |
| 1.6 | 4.0 | Jct. Del. Rt. 2 and Harmony Road (Rd. 355). Turn south (right) following Harmony Road. |
| 0.3 | 4.3 | <u>STOP 2.</u> Harmony Road Bridge |
- Park on shoulder at north end of bridge over White Clay Creek. Walk down culvert to open space beneath bridge on north side.

The rocks exposed here are typical amphibolites of the Wilmington Complex, a mass of granulite-facies metamorphic and igneous rocks which lies southeast of the Wissahickon Formation and underlies Wilmington and its suburbs. Major minerals in the amphibolite include hornblende, quartz, and diopside; the mafic minerals have been partially retrograded to epidote, which can be seen as 2-3 mm clusters surrounding amphibole. This amphibolite is perhaps 30 m thick, and is interlayered with magnetite-pyroxene-quartz-plagioclase leucogneisses; these gneisses may be viewed along the trail at water level 100 m upstream.

The amphibolite is deformed into tight to isoclinal, similar folds whose axes

plunge steeply at N60E. This direction is distinctly different from those in the Wissahickon to be seen at Stop 3, and may indicate faulting along the contact.

- | | | |
|-----|-----|---|
| | 4.3 | Leave Stop 2, following Harmony Road (Rd. 355) south. |
| 0.2 | 4.5 | Jct. Harmony Road and left turn road. Make a U-turn returning north on Harmony Road. |
| 0.5 | 5.0 | Jct. Harmony Road (Rd. 355) and Del. Rt. 2. Turn east (right) following Del. Rt. 2, and proceed immediately to left lane. |
| 0.2 | 5.2 | Jct. Del. Rt. 2 and Pike Creek Road (Rd. 322). Turn north (left) following Pike Creek Rd. |
| 0.8 | 6.0 | Jct. Pike Creek Road and Old Coach Road (Rd. 316). Turn west (left) over wooden bridge, then north (right) following Pike Creek Road (Rd. 322) north. |
| 0.6 | 6.6 | <u>STOP 3.</u> Jct. Pike Creek Road (Rd. 322) and Linden Hill Road (Rd. 321). Turn west (left) onto Linden Hill Road, and park not more than 50 m west of intersection. |

The rocks exposed at the base of the hill are tightly folded biotite-almandine-sillimanite-plagioclase schists typical of the pelitic facies of the Wissahickon. Noses of small folds plunge gently N35E; this typifies the style and orientation of deformation in the Wissahickon and related rocks of northwestern Delaware. Many of the plagioclase stringers are refolded isoclinal, and record two episodes of deformation. Sillimanite may be seen growing across some fold noses at angles to foliation trends.

- | | | |
|-----|-----|--|
| | 6.6 | Leave Stop 3. |
| 0.1 | 6.7 | Return to Pike Creek Road (Rd. 322) and proceed north (left). |
| 0.1 | 6.8 | Note gullying (here and for the next 0.8 miles) in soils developed on pelitic schists of the Wissahickon. |
| 1.2 | 8.0 | Note eastern side of Pike Creek Valley across stream (right). Stability problems have been encountered in developing |

slopes of this type underlain by pelitic, quartz-mica schists of the Wissahickon Formation. The humid climate and mica-ceous soils contribute to high moisture retention thus accelerating creep on hillsides.

0.3

8.3 STOP 4. (OPTIONAL) Piedmont Test Well Cbl3-10.

Test Well Cbl3-10 was drilled in 1976 as part of a cooperative ground-water exploration program of the City of Newark and the Delaware Geological Survey. Water transmission from here to town is not economically feasible at this time. However, water rights have been secured for the well pending future needs.

The site was selected on the basis of lineations identified on aerial photography. The well is located at the intersection of two lineations trending N18E and N20W.

Log for Well Cbl3-10:

<u>Depth</u>	<u>Lithology</u>
0 - 87	Soil and weathered schist, amphibolite, and pegmatite.
87 - 96	Pegmatite, with schist and amphibolite.
96 -117	Schist, quartz-biotite.
117-163	Amphibolite and schist, moderately to well fractured.
163-308	Schist, garnet-quartz-biotite, with minor amphibolite and pegmatite.
308-311	Pegmatite, intensely fractured.
311-327	Amphibolite and schist, intensely fractured.
327-353	Gneiss, quartz-biotite, and schist.
353-378	Schist, garnet-quartz-biotite, and amphibolite.
378-604	Schist, biotite-quartz-garnet, minor pegmatite.

88.5 feet of 6-inch casing installed.

Major water-bearing fracture zones:

Depth	Amount (in gallons per minute)	Total (in gallons per minute)
74-87'	30	cased off
96-136'	6	6
163-178'	14	20
308-327'	130	150

Recorders such as the one housed at this well are installed on selected wells to provide information on ground-water levels. Seasonal fluctuations, earth tidal fluctuations, and response to nearby wells, provide basic data required for ongoing water resource studies.

- 0.1 8.3 Leave Stop 4, following Pike Creek Road (Rd. 295) north.
- 0.1 8.4 Pass Lime Kilns on east (right) side of road.

The lime kilns, located adjacent to quarries in Cockeysville Marble (next stop) are the remnants of a principally 19th century industry. The kilns were used to convert marble to lime for agricultural use.

- 0.1 8.5 STOP 5. Cockeysvills Marble-Eastburn Quarries.

The Cockeysville Marble underlies the Wissahickon. It consists of layered, thin-bedded, sucrosic, quartzose calcite and dolomite marble which contains phlogopite and rare diopside as minor phases. This marble underlies two valleys in northern Delaware and is an aquifer of considerable importance. Porosity is mainly fracture-generated, with solution-widening of existing fractures. Pervasive vuggy porosity is not evident.

The quarry exposes a tight fold typical of deformation in northwest Delaware. Its axis plunges gently southwest; along with plunges seen at Stop 3, this suggests a later gentle warping of the northeast-trending folds.

	8.5	Leave Stop 5, following Pike Creek Road north.
0.3	8.8	Jct. Pike Creek Road (Rd. 295) and Del. Rt. 72. Turn west (left) following Del. Rt. 72.
0.6	9.4	Jct. Del. Rt. 72 and Pleasant Hill Road (Rd. 324). Turn north (right) following Pleasant Hill Road.
0.1	9.5	Jct. Pleasant Hill Road (Rd. 324) and Thompson Station Road (Rd. 301). Turn west (left) following Thompson Station Road. Ponds visible to the southeast (left) for the next 1/4 to 1/2 mile occupy the sites of 19th and early 20th Century kaolin pits. Several localized deposits, the result of decomposition of granitic pegmatites, reportedly were of such quality as to be used in the manufacture of ceramics and fine porcelain china.
1.9	11.4	Jct. Thompson Station Road (Rd. 301) and Thompson Road (Rd. 53). Continue, following Thompson Station Road (Rd. 302).
0.6	12.0	Cross White Clay Creek.
0.1	12.1	Jct. Thompson Station Road (Rd. 302) and Creek Rd. (Rd. 311). Turn south (left) following Creek Rd. (Rd. 311) (unpaved for the next 0.8 mi.).
0.5	12.6	Pass E. I. duPont de Nemours and Co. water supply and treatment facilities, on east (left). Water primarily for sanitary services, fire protection and miscellaneous uses. All other industrial and commercial water users in the area rely on wells or on public supply where available.
0.3	12.9	Jct. Creek Rd. (Rd. 311) and Appleton Road (Rd. 312), following Creek Road south. USGS/DGS gaging station on east (left) side of road, and site of proposed White Clay Creek Dam.

Design details (Whitman, Requardt and Associates, 1967):

Earth dam with core of compacted earth from nearby alluvial terraces. Designed for two stages of construction. First stage spillway crest elevation 155' above mean sea level, spillway length of 160'. The standard project flood of 100,000 cubic feet per second routed through

reservoir produces a maximum stage elevation of 176.8' while discharging 58,300 cfs. At a second stage pool elevation of 165' above mean sea level, reservoir would extend about 4 miles up White Clay Creek into Pennsylvania. Total water surface area of 1,160 acres, of which 560 would be in Delaware and 600 in Pennsylvania. Flow augmentation: The reservoir is designed to increase the flow of White Clay, Red Clay, and Christina creeks from the historical low flow average of 9 mgd to an average of 80 mgd during drought conditions by using 90% available storage for stream-flow augmentation at the confluence.

- | | | |
|-----|------|--|
| 0.4 | 13.3 | Pass exposure of Wissahickon schist (pelitic facies) on west (right) side of road. |
| 0.8 | 14.1 | Jct. Creek Road and access road. Turn east (left) and continue to Stop 6. |
| 0.1 | 14.2 | <u>STOP 6.</u> Newark Well Ca45-21 |

Well Ca45-21 was drilled as part of an intensive ground-water study by the Delaware Geological Survey on University of Delaware-owned lands in cooperation with the City of Newark in 1971. The site was selected on the basis of lineations identified on aerial photography and magnetic lows possibly indicative of extensive fracturing.

The well was drilled to a depth of 400', encountering fractured, water-bearing zones in the interval 126-237 feet.

A pumping test in 1971 at a rate of 100 gallons per minute for a period of 24 hours yielded a drawdown of 15.67' and a specific capacity of 6.38 gpm/ft.

The 8 inch diameter well was completed at an elevation of 82 feet amsl (10 feet above land surface) to minimize the potential for contamination by surface water during periods of flooding.

The well was put into service by the City of Newark in 1973 and is producing an average of 130 gpm continuously. The discharge of the well is regulated to maintain a pumping level of approximately 90'.

	14.2	Leave Stop 6, returning to Creek Road.
0.1	14.3	Jct. Creek Road (now North College Ave). Turn south (left) following North College Ave.
0.3	14.6	Pass Newark Well Ca45-20 on west (right) side of road.

Well Ca45-20 was drilled as part of the same ground-water exploration program in 1971. The 6-inch diameter well was drilled to 447', encountering only minor water-bearing fractured zones. A pumping test in 1971 at a rate of 42 gpm for a period of 12 hours yielded a draw-down of 132.4', and a specific capacity of .32 gpm/ft. As a result of testing it was determined that this well and Ca45-21 (previous stop) communicate hydraulically.

The well was put into service in 1973 by the City and is producing an average of 14 gpm on a continuous basis. The discharge of the well is regulated to maintain a pumping level of approximately 180'.

0.6	15.2	Jct. North College Avenue and Cleveland Avenue. Turn west (right) following Cleveland Avenue.
0.2	15.4	Jct. Cleveland Ave. and Del. Rt. 896. Turn north (right) following Del. Rt. 896.
0.3	15.7	Jct. Del. Rt. 896 and Pencader Dr., University of Delaware North Campus. Turn east (right) following Pencader Drive to Clayton Hall.

END OF FIELD TRIP.

ROAD LOG

ENVIRONMENTAL GEOLOGY, NORTHERN DELAWARE

K.D. Woodruff

Leave from main entrance of Clayton Hall, North Campus, University of Delaware, Newark. Distances are given to nearest tenths of miles as measured by automobile odometer.

<u>Distance</u>	<u>Cumulative Distance</u>	<u>Notes</u>
	0.0	Leave Clayton Hall bearing south (right) on main drive from North Campus.
0.1	0.1	Jct. Del. Rt. 896, New London Road. Turn south (left) on Del. Rt. 896. Altitude 160 feet.
0.3	0.4	Jct. New London Road and Cleveland Ave. Turn west (right) following Del. Rt. 896.
0.1	0.5	Jct. Cleveland Ave. and West Main Street. Turn east (left) following Del. Rts. 896 and 273.
		Descend Fall Zone from Piedmont Province to Atlantic Coastal Plain.
0.1	0.6	Cross ConRail R.R. Bear south (right) following Del. Rts. 896 and 273.
0.1	0.7	Jct. Elkton Rd. and Delaware Ave. Turn east (left) following Del. Rts. 896 and 273.
0.2	0.9	Jct. Delaware Ave. and South College Ave. Continue east (straight) following Del. Rt. 2 (Delaware Ave.)
0.1	1.0	Pass through main quadrangle, University of Delaware Campus.
		To the north (left) are men's dormitories. To the south (right) are major academic buildings housing the Departments of Physics, Chemistry and Biology. The University's theater and administration building are also in this group. At the end of the quadrangle is Memorial Hall which is dedicated to Delawareans who have died in military Service.
0.2	1.2	Jct. Delaware Ave. (Del. Rt. 2) and Academy St. Turn south (right) on Academy St.
0.3	1.5	Pass Penny Hall (to the east: left) which houses the Delaware Geological Survey and the Department of Geology.

0.2	1.7	Jct. Academy St. and Courtney St. Turn east (left) on Courtney St.
0.2	1.9	Jct. Courtney St. and Ashley Rd. Bear east (left) on Ashley Rd.
0.2	2.1	Jct. Ashley Rd. and Del. Rt. 72 (Chapel St.). Turn south (right) on Del. Rt. 72.
0.3	2.4	Cross ConRail R.R., formerly Penn Central R.R., the route of the Metroliner high-speed trains. Continue south through the University of Delaware Farms.

Solid waste disposal is a major environmental problem in many areas. In Delaware it is complicated by the high permeability of the Columbia sands which combined with relatively high rainfall permits leachate to migrate rapidly into ground water. Three generations of solid waste disposal facilities are present in this area:

1. The old town dump which occupied an abandoned borrow pit has been covered and is now part of the pasture to the east (left) of the road.
2. A completed, capped, and reclaimed landfill lies under the mound to the west (right) about 0.3 miles from the road. It was discontinued when its leachate was found to be threatening a nearby city well-field.
3. Also to the west (right) lies the present solid waste transfer facility of the City of Newark and the University of Delaware. Solid waste is transferred to large trucks and taken across the county to the location of a large landfill where a pioneering reclamation plant will soon be built. The waste is intended to become "urban ore."

1.0	3.4	Jct. Del. Rt. 72 and Del. Rt. 4. Continue south (straight) on Del. Rt. 72.
0.2	3.6	Pass City of Newark's South Basin Well-field. This channel of thick Columbia sand and gravel was discovered during the 1950's. The community's sprawl has resulted in much pavement which intercepts recharge and has decreased the efficiency of the wellfield.

- 1.5 5.1 Cross Christina River. The telemetered stream gage operated in cooperation by the Delaware Geological Survey and the U.S. Geological Survey is a major link in the flood alert and evaluation system in New Castle County.
- 2.1 7.2 Jct. Del. Rt. 72 and U.S. Rt. 40. Turn east (left) on U.S. Rt. 40.
- 0.4 7.6 Cross ConRail Delmarva R.R. Line.
- 1.1 8.7 Pass large sand and gravel borrow pits in Columbia Formation south (right) of road.
- 1.2 9.9 Bear. Jct. U.S. Rt. 40 and Del. Rt. 7. Turn south (right) on Del. Rt. 7.
- In the area southwest of this intersection is a major wellfield. Typical log:
- Well Dc31-19; Alt. 70'
- | Depth
(feet) | Description
(Columbia Formation) |
|-----------------|---|
| 0 - 1 | Top soil. |
| 1 -15 | Clay, sandy and gravel. |
| 15 -20 | Sand, brown, coarse, and gravel. |
| 20 -40 | Sand, fine to medium, and gravel. |
| 40 -55 | Sand, fine to medium, and much gravel. |
| 55 -58 | Clay, yellow. |
| 58 -62 | Sand with stringers of clay, yellow. |
| 62 -80 | Gravel and sand, brown and white, fine to coarse. |
- 0.3 10.2 Cross railroad spur line. Continue south on Del. Rt. 7.
- 1.3 11.5 Jct. Del. Rt. 7 and Del. Rt. 71 (U.S. 301). Turn left on Del. Rt. 71 (northeast).
- 0.8 12.3 STOP 1. Tybouts Corner Landfill and Borrow Pits.

This pit served as a landfill from 1968 to 1971. Sand and gravel mining continued until 1975. The landfill is producing leachate that is affecting ground and surface waters. The sorted gravel offers evidence of the provenance of the Columbia Formation.

- 0.6 12.9 Leave landfill, continue northeast on Del. Rt. 71 to intersection with U.S. Rt. 13. Turn left (north) on U.S. Rt. 13.
- 1.1 14.0 Pass Buena Vista (to the west, left, of road). Home built in 1845 by John M. Clayton, U.S. Senator from Delaware and Secretary of State in President Taylor's cabinet. His name is given to the building at the University of Delaware from which this trip departed.
- 1.5 15.5 STOP 2. Army Creek Landfill, Llangollen.
At the back or east end of the Division of Highways maintenance yard on right (east) of road.
- This major landfill used from 1960 to 1968, is producing leachate that has contaminated ground water in the Columbia and Potomac Formations over a wide area. The leachate was first detected early in 1972 by a private well located about 900 feet to the southeast of this stop. Since that time a number of domestic wells have been shut down and Army Creek has been contaminated. A major wellfield, adjacent to the landfill, has been affected and ground-water withdrawals from the wellfield have been sharply reduced. The field once produced about 6 mgd. Recovery wells have been installed in an attempt to contain the leachate and have pumped about 3.5 mgd since early 1974. As of September, 1976 about \$1.35 million has been spent on studies and corrective measures.
- 15.5 Leave Stop 2. Continue north on U.S. Rt. 13.
- 0.2 15.7 Jct. U.S. Rt. 13 and U.S. Rt. 40. Continue north (straight) on U.S. Rt. 13/40.
- 1.4 17.1 Jct. U.S. Rt. 13/40 and Del. Rt. 273. Turn east (right) on Del. Rt. 273.
- 0.3 17.4 Jct. Del. Rt. 273 and Quigley Blvd. Turn south (right) on Quigley Blvd.
- 0.1 17.5 STOP 3. Hares Corner
- Large borrow pits are concentrated in the coarse fluvial facies of the Columbia Formation in this area. This pit has been essentially mined out to the Potomac Formation and is being reclaimed as an industrial park. Sedimentary textures

are indicative of its relatively upstream location. The section as measured in 1963 is:

(feet)	Description
0 - 2	Soil, stripped or disturbed.
2 - 7	Gravel, dark brown, with medium sand and cobbles.
7 -8.5	Sand, dark brown, medium, with gravel and cobbles.
8.5 -9.2	Sand, dark brown, medium with gravel.
9.2-11.2	Gravel, brown, with coarse sand and cobbles.
11.2-15.5	Sand, tan, coarse, with gravel and cobbles.
15.5-17.5	Gravel, tan, with cobbles and coarse sand.
17.5-18.5	Gravel, black (manganese stained), with cobbles and coarse sand.
18.5-20.5	Sand, brown, medium, with gravel.
20.5-26.5	Sand, yellow, medium.
26.5-27.5	Sand, black (manganese stained), coarse, with gravel.
27.5-30.5	Sand, yellow, medium.
30.5-31.5	Bench-covered.
31.5-35.5	Sand, yellow, medium, with limonite ledges.
35.5-36.5	Gravel, brown, partly limonite-cemented.
36.5-42.5	Sand, yellow and gray, medium, silty.
42.5-47.0	Slump; sand, gravelly.

Textural parameters (Inman): $Md\phi = 0.30$; $\sigma\phi = 3.575$; $\alpha\phi = -0.6223$; polymodal.

Mean foreset dip azimuth for area: 214° .

Pebble count for 1" to 2" gravel:

vein quartz	- 50%
sandstone	- 34
chert	- 11
crystalline	
rocks	- 3
shale	- 2

17.5

Leave Stop 3. Continue south and west on Quigley Blvd.

1.0	18.5	Clay of Potomac Formation (Cretaceous) has been exposed on right.
0.1	18.6	Jct. Quigley Blvd. and U.S. Rt. 13/40. Turn right (north) on U.S. Rt. 13/40. Continue north, (follow signs to Wilmington, I-295 and I-95 to Baltimore.) Delaware Memorial Bridges visible to northeast. The large twin suspension bridges over the Delaware River are founded on the Potomac Formation.
2.6	21.2	Enter I-95 South. Large borrow area on right was used in construction of Interstate complex. Approximately 10 million cubic yards of fill material was removed. Continue around turn and enter I-95 South (Baltimore). This is one of the largest interchange complexes in the eastern U.S.
6.3	27.5	Cross over Churchman's Marsh, a tidal marsh formed between two major streams and bisected by I-95. Twenty to 30 feet of Holocene mud overlies Columbia and Potomac formations, thus complicating highway construction.
0.8	28.3	Observe slumping of Potomac Formation on right (north) at western end of marsh. Continue south on I-95.
6.2	34.5	Exit I-95 at Del. Rt. 896 (Newark, University of Del.) exit. Hill just ahead and to the right is a gabbroic outlier of the Piedmont surrounded by Coastal Plain sediments. The highest part, Iron Hill, is capped by a gossan from which limonite iron ore was mined in the 18th and 19th centuries.
0.5	35.0	Turn right (north) on Del. Rt. 896.
2.2	37.2	Parking lot on left (west), opposite University Library, is constructed of porous pavement to allow recharging of precipitation. Several shallow monitor wells have been constructed around the perimeter of the lot.
0.4	37.6	Continue north on Del. Rt. 896 to East Main St. (dead end). Turn left (west) go about one and a half blocks.
0.1	37.7	Turn right on Del. Rt. 896.
0.5	38.2	Continue north on Del. Rt. 896, turn right into entrance to Clayton Hall.

END OF TRIP.

ROAD LOG

FIELD TRIP TO THE CHESAPEAKE AND DELAWARE CANAL

(with Two Options)

Thomas E. Pickett

TIME: About 2 hours for
entire trip.

Low Tides (Approx.)	
June 5 (Sun)	June 6 (Mon)
9:37 a.m.	10:28 a.m.
Trip is best at low tide.	

<u>Distance</u>	<u>Cumulative Distance</u>	<u>Notes</u>
0.0	0.0	Leave Clayton Hall, heading out main drive.
0.1	0.1	Jct. Del. Rt. 896, New London Rd. Turn south (left) onto Del. Rt. 896. Altitude 160 feet.
0.3	0.4	Jct. New London Rd. and Cleveland Ave. Turn west (right), following Del. Rt. 896.
0.1	0.5	Jct. Cleveland Ave and W. Main St. Turn east (left) following Del. Rt. 896 and Rt. 273. Descend Fall Zone from Piedmont to Atlantic Coastal Plain.
0.1	0.6	Cross ConRail RR, bear south (right) following Del. Rts. 896 and 273. Altitude 125 feet.
0.1	0.7	Jct. Elkton Rd. and Delaware Ave. Turn east (left) following Del. Rts. 896 and 273.
0.2	0.9	Jct. Delaware Ave. and S. College Ave. Turn south (right) onto S. College Ave. (Rt. 896).
0.5	1.4	Continue through intersection of West Park Place and College Ave. (Rt. 896).
2.1	3.5	Cross over I-95 and note outcrop of weathered gabbro gneiss on right on-ramp to Expressway. Route 896 is on the eastern flank of Iron Hill, a Piedmont outlier in the Coastal Plain. The gneisses and gabbros are similar to rocks exposed in the Wilmington area.

- 0.7 4.2 Continue on Rt. 896 through intersection with Old Baltimore Pike. This pike was a major route from Philadelphia to Baltimore in colonial times. The only skirmish of the Revolution to occur in Delaware was in this vicinity. Washington and Lafayette rode to the top of Iron Hill to observe the British approaching from Maryland.
- 2.1 6.3 Continue through major intersection of Del. 896 and U.S. 40 in Glasgow.
- 3.3 9.6 OPTION A. Those wishing to dig in outcrops (and probably get dirty) can take OPTION A and turn left at the flashing light onto Del. 71/U.S. 301. If you wish to only observe exposures, you can select OPTION B and continue straight on Rt. 896 south (skip down to OPTION B).
- OPTION A
- 0.8 10.4 After turning left at flashing light, pass road on right to Chesapeake City.
- 0.1 10.5 Turn right on small, unmarked paved road.
- 0.3 10.8 Turn left on dirt access road parallel to the Chesapeake and Delaware Canal.
- 0.4 11.2 Park in grove of trees on left and proceed on foot down the switchback to Canal banks, and go left (east) to end of dirt road (about 1/4 mile total). This can be driven if not too wet.

Deep Cut of the C and D Canal

Here formations of Upper Cretaceous age are exposed in the "best" Coastal Plain outcrop in Delaware. The bluff is the remainder of a once more continuous outcrop along the Canal, destroyed during widening of the waterway. CAUTION: The outcrop can be extremely muddy and overhanging sections are quite unstable.

The Merchantville Formation forms the beach up to about 8 feet above the water. "Dark gray to dark blue, micaceous, glauconitic sandy silt and silty fine sand: Placenticerias placenta, small siderite nodules" (Pickett, 1970). The English-town Formation is the layered sandy unit in the middle of the bluff: "Light gray and

rust brown, well-sorted, micaceous, sparingly glauconitic, often "fluffy" fine sand with thin interbedded layers of dark gray silty sand. Abundant nodulose burrows of Callianassa and other trace fossils in the upper part." (Pickett, 1970). The Marshalltown Formation, unconformably overlying the Englishtown, is the massive grayish unit near the top of the bluff: "Dark greenish gray, massive, highly glauconitic, very silty fine sand containing the pelecypod Exogyra ponderosa" (Pickett, 1970). A very thin layer of weathered Mount Laurel Formation overlies the Marshalltown. Here it is a "reddish brown, weathered, glauconitic, fine to medium quartz sand with some silt." (Pickett, 1970).

1.6	12.8	Return to car and retrace route to intersection of Route 301/71 and Del. 896. Turn left (south).
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OPTION B

1.2	14.0	Top of Summit Bridge over Chesapeake and Delaware Canal, a major shipping route between Philadelphia and Baltimore.
0.9	14.9	Turn left (east) near foot of bridge toward Village of Summit. Road 433.
0.8	15.7	Turn left at stop sign in the old Village of Summit.
0.2	15.9	Head, bearing left, down dirt access road to the lowest level.
0.3	16.2	Turn right (east) parallel to the Canal. Ammonites (<u>Placenticerus placenta</u>) up to 2 feet in diameter have been found in the Merchantville Formation which is exposed only at lowest tide.

WARNING: watch out for very muddy, sometimes impassable, stretches of this road.

0.3	16.8	You are opposite the Deep Cut which you have just visited if you exercised <u>OPTION A</u> (refer to description).
0.8	17.6	Cross under ConRail Bridge.
2.1	19.7	Public Fishing Pier. (No license required, Tidal Waters).
0.4	20.1	Another fishing Pier.
0.6	20.7	Pass under Route 13 (St. Georges Bridge).

1.2	21.9	Pass through white gate. From this point for the next 0.2 miles, fossils may be collected at low tide. Mount Laurel Formation, Upper Cretaceous.
0.2	22.1	Steel piling around badly eroded remains of "Biggs Farm" outcrop. Park at end of dirt road. See information sheet at rear of this guide.
1.2	23.3	Retrace route. Turn left on dirt road up and out of Canal area at South St. Georges.
0.1	23.4	Turn left (south) on paved road 34B.
0.5	23.9	Turn right onto U.S. 13 North. Cross over Canal.
2.3	26.2	Turn left (northwest) at light onto Del. 72. The Getty Refinery is to the right. Ground water from the Cretaceous Potomac Formation provides 2 mgd to this site.
1.6	27.8	Continue through intersection of Rts. 72 and 71.
2.5	30.3	Intersection with U.S. 40. Turn left, (west).
1.6	31.9	Intersection with Del. 896, turn right on 896 North and retrace route back to Newark (6.3 miles to Clayton Hall).

END OF FIELD TRIP.

INFORMATION SHEET

THE BIGGS FARM FOSSIL LOCALITY, DELAWARE

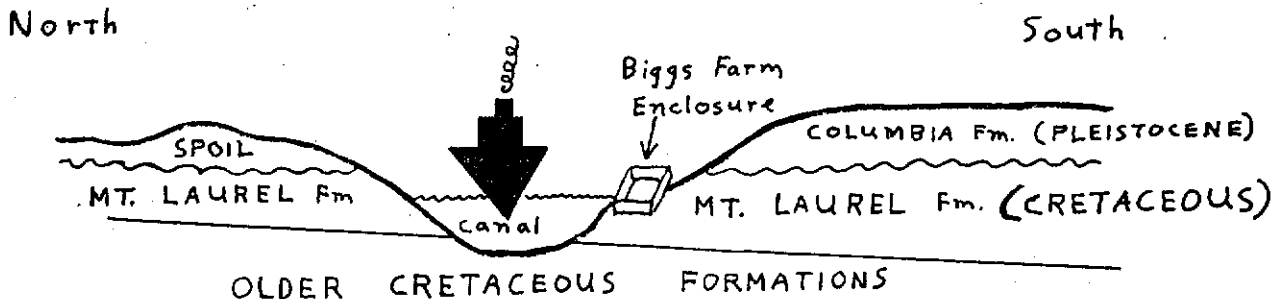
by

Thomas E. Pickett
Delaware Geological Survey, University of Delaware

Description of the Outcrop

The Biggs Farm fossil locality is located just over one mile east of south St. Georges on the bank of the Chesapeake and Delaware Canal. The outcrop has eroded greatly in recent years and was protected by sheet piling in the summer of 1975. This action was taken by the Corps of Engineers because Biggs Farm is one of the most prolific outcrops for Cretaceous fossils in the northern Atlantic Coastal Plain and is valuable for scientific and educational purposes. The outcrop exposes the Mount Laurel Formation, one of 6 Cretaceous formations which dip gently toward the southeast in the Canal area.

Schematic Cross Section



The Mount Laurel is a gray to greenish red-brown, glauconitic, fine to medium quartz sand with some silt. The upper, reddish sand is weathered sediment. It is extensively burrowed.

Fossils

Over 200 species, mostly molluscs, have been found at Biggs Farm. For identification, check references listed below. Fossils include: oysters, clams, snails, corals, sponges, squids, fish and reptilian teeth and vertebrae, burrows, borings, crab and shrimp parts.

Paleoecology

The Mount Laurel Formation at Biggs Farm was deposited under shallow marine conditions, near the shoreline, in perhaps an embayed area approximately 65 million years ago. The date we know by correlation of the fossils and by radiometric dating techniques. The environment is deduced by studying the fossils, sedimentary structures, sediment texture, and the mineralogy.

ROAD LOG

NEWARK TO REHOBOTH BEACH WITH NOTES ON POINTS OF GEOLOGIC INTEREST

R.R. Jordan and R.N. Benson

Road log begins at the main entrance of Clayton Hall, North Campus, University of Delaware, Newark. Distances are given to the nearest tenths of miles as measured by autobomile odometer.

<u>Distance</u>	<u>Cumulative Distance</u>	<u>Notes</u>
0.0	0.0	Clayton Hall. Leave bearing south (left) on main drive from North Campus. Route lies through Newark and south on Delaware Route 72. For details follow beginning of road log of "Environmental Geology: Northern Delaware" on pp. 13-15.
7.2	7.2	Jct. Del. Rt. 72 and U.S. Rt. 40. Continue south (straight) following Del. Rt. 72.
2.2	9.4	Cross Delmarva Line of ConRail R.R.
1.4	10.8	Pass one of several deep wells supplying water to Getty Oil Company's Delaware City Refinery. Wells in Potomac Formation provide about 2 mgd for the refinery. Refinery and associated industries and DP & L Power Plant visible at 11 o'clock.
0.8	11.6	Wrangle Hill. Jct. Del. Rt. 72 and U.S. Rt. 13. Continue southeast (straight) following Del. Rt. 72.
1.0	12.6	Pass Getty's Delaware City Refinery. 140,000 bbl/d throughput capacity. Jct. Del. Rt. 72 and Del. Rt. 9 (Del. Rt. 72 ends). Continue south (straight) on Del. Rt. 9.
2.1	14.7	Enter Delaware City. Laid out in 1826 at original eastern terminus of Chesapeake and Delaware Canal.
0.6	15.3	Cross old Chesapeake and Delaware Canal. Built 1825-29, abandoned for new sea-level canal 1927.
1.0	16.3	<u>STOP 1.</u> Reedy Point Bridge, Chesapeake and Delaware Canal. (NOTE: Stopping on bridge is not permitted.)

To the east (left) may be seen: the eastern end of the Chesapeake and Delaware Canal at the Delaware River (9 o'clock); Governor Bacon Health Center and Fort duPont (8 o'clock); Pea Patch Island and Fort Delaware (7 o'clock).

To the south (ahead) may be seen: Salem (N.J.) Nuclear Power Plant (11 o'clock); Delaware Bay, Reedy Island, coastal marshes (11 to 1 o'clock); Topography of the Atlantic Coastal Plain (1 to 3 o'clock).

To the west (right) may be seen; Chesapeake and Delaware Canal leading toward Chesapeake Bay about 35 miles to the west (3 o'clock); exposures in Canal banks are principally marine Upper Cretaceous units, at this point the Mt. Laurel Formation.

To the north (behind) may be seen: Iron and Chestnut Hills and the towers of Clayton Hall near Newark (5 o'clock); Fall Zone (5-7 o'clock); Delaware Memorial (Twin) Bridges, Delaware River, Wilmington (7 o'clock).

	16.3	Leave Stop 1 continuing south (straight) on Del. Rt. 9.
2.7	19.0	Enter Port Penn. Jct. Del. Rt. 9 and Del. Rd. 2. Turn west (right) on Del. Rd. 2.
1.7	20.7	Jct. Del. Rd. 2 and Del. Rd. 420. Bear west (right) following Del. Rd. 2.
1.1	21.8	Atlantic Coastal Plain "terrace formations" once mapped in area; no longer recognized by DGS. Note Georgian farmhouse.
0.6	22.4	Delaware Bay Range Light (Iron Lighthouse).
0.6	23.0	Jct. Del. Rd. 2 and U.S. Rt. 13. Turn south (left) on U.S. Rt. 13.
0.6	23.6	Pass site of test well to basement drilled in connection with proposed Summit Nuclear Power Plant 2 miles to west. Formation log of well Ec41-10, Alt. 50 feet:

Depth (feet)	Group or Formation	Systems or Series
0-34	Columbia Fm.	Pleistocene
34-52	Marshalltown-	Upper
	Mt. Laurel Fms?	Cretaceous

		<u>Depth (feet)</u>	<u>Group or Formation</u>	<u>Systems or Series</u>
		52-230	Matawan Fm.	Upper Cretaceous
		230-246	Magothy Fm.	Upper Cretaceous
		246-1130	Potomac Fm.	Upper and Lower Cretaceous
		1130-1260	weathered crystalline rock	Early Paleozoic
3.3	26.9	Cross Drawyers Creek (tidal). Exposures in stream cuts are of the Hornerstown Formation (Paleocene) a few tens of feet stratigraphically above the Cretaceous-Tertiary boundary. Thalweg of stream is at about -80 feet. The tidal streams of eastern Delaware are incised toward an ancient master drainage system under the present Delaware Bay.		
0.2	27.1	Pass Drawyers Chapel. Founded 1711; present building 1773 - to west (right) of road.		
0.4	27.5	Enter Odessa (pop. 547). Site of the Indian village Appoquinimi. Named Cantwell's Bridge in 1731. Because of prominence as a grain port it was renamed Odessa in 1855. Odessa contains the Corbit -Sharp House (1774) and other buildings of historic interest.		
0.2	27.7	Jct. U.S. 13 and Mechanic St. (Del. Rd. 429). Turn northwest (right) on Del. Rd. 429.		
0.6	28.3	<u>STOP 2.</u> Drawyers Creek near Odessa.		

The Hornerstown Formation (greensand) of Paleocene age is overlain unconformably by the Columbia Formation (gravels) of Pleistocene age.

The following description of the Hornerstown is taken from the Geologic Map of the Middletown-Odessa Area (Delaware Geological Survey Map Series No. 2): "Green, gray and reddish-brown, fine to medium, silty, highly glauconitic sand and sandy silt." A few highly leached shells may be seen.

Greensand formerly was used as a fertilizer in Delaware. In New Jersey it presently is being sold for ion exchange use in home water systems. The Delaware Geological Survey currently has a grant from the U.S. Bureau of Mines to research the potential use of greensand in large-scale waste-water treatment.

Up to about 90 feet of Holocene marsh sediment fill the thalweg of Drawyers Creek.

	28.3	Leave Stop 2. Continue northwest (straight) on Del. Rd. 429.
1.7	30.0	Pass "Peach Houses" built by peach orchard owners in 19th Century.
0.8	30.8	Jct. Del. Rd. 429 and Del. Rd. 427. Turn south (left) on Del. Rd. 427.
1.5	32.3	Jct. Del. Rd. 427 and Del. Rt. 896. Turn south (left) on Del. Rt. 896.
0.7	33.0	Enter Middletown (pop. 2,800).
1.0	34.0	Cross Deep Creek.
0.1	34.1	Turn east (left) into Division of Highways borrow pit. Continue toward east side of pit.
0.2	34.3	<u>STOP 3.</u> Borrow pit near Middletown.

This location illustrates the fluvial nature of the Columbia Formation which is over 40 feet thick here. The gravel pit is located near the eastern margin of a Pleistocene fluvial valley having a maximum of over 80 feet of sedimentary fill.

Several studies of the sedimentary textures and structures and the hydrology of the Columbia have been conducted in this area. Plant fossils consisting of leaf and wood impressions plus seeds, all with very little organic matter preserved, have been recovered from the gravel pit. The measured section (1963) and quantitative sedimentary properties are:

(feet)

0-1	Disturbed
1-3	Sand, tan, coarse, clayey, soil.
3-9.2	Gravel, tan, with very coarse sand.

(feet)

9.2-16	Sand, yellow (with some black manganese staining), medium, with fine gravel; with fine gravel; cross-bedded.
16-21	Sand, yellow, medium; cross-bedded.
21-23	Slump; floor of pit.

Textural parameters (Inman): $Md \phi = 0.28$;
 $\sigma \phi = 1.860$; $\alpha \phi = -0.333$; bimodal.

Mean foreset dip azimuth for area: 207° .

	34.3	Leave Stop 3 toward pit entrance.
0.2	34.5	Borrow pit entrance at Del. Rt. 896.
		Turn south (left) on Del. Rt. 896.
0.4	34.9	Jct. Del. Rt. 896 and Del. Rd. 38.
		Turn east (left) on Del. Rd. 38.
1.0	35.9	Pass St. Andrews School.
0.6	36.5	Cross Noxontown Pond. Head of tide on Appoquinimink River.
1.9	38.4	Fieldsboro. Jct. Del. Rd. 38 and U.S. Rt. 13. Turn south (right) on U.S. Rt. 13.
3.0	41.4	Cross Blackbird Creek. Enter area of undrained depressions ("bay-basin" or "Carolina bay" topography). For next 2 miles small but well developed depressions may be seen either side of road.
4.2	45.6	Rest Area.
1.0	46.6	Cross Duck Creek (tidal); enter Smyrna and Kent County. Much silicified wood is found in the Columbia Formation in this area. One silicified cypress trunk measured 52 feet in length.
0.9	47.5	Pass main water well of City of Smyrna to west (right) of road. The location of very large capacity, relatively shallow water wells is dependent on the location of channels filled with the Columbia Formation cut into the beveled edges of the older Coastal Plain units. The channels have no surface expression and are very difficult to detect by geophysical means. The Smyrna well is an example of an excellent well located by geologic investigation for a channel.

Log of Well Hc34-22: Alt. 24 feet.

Depth (feet)	Description
0 - 7	Top soil and sandy clay.
7 -58	Sand, brown, medium to coarse.
58-81.5	Sand, brown, coarse.
81.5-88	Clay, gray, silty.
88-97 T.D.	Sand, brown and gray, coarse. Below: silt, gray (Chesapeake Group, Miocene).

Well Construction:

Depth - 97'
Diameter - 20"
gravel packed, 12"
casing.
Screen - 12" Everdur,
slot #110, 55-83' and
88-96'.
Pump - turbine; rated
1,100 gpm.

Performance: Production - 1,000 to
1,200 gpm. Specific
Capacity - Approx.
55 gpm/ft.

0.4	47.9	Jct. U.S. Rt. 13 and Del. Rd. 12.
		Turn southeast (left) on Del. Rd. 12.
4.6	52.5	Jct. Del. Rd. 12 and Del. Rt. 9. Con-
		tinue south (straight) on Del. Rt. 9.
0.2	52.7	For next several miles route is along
		Bombay Hook Wildlife Area (between Rt. 9
		and Delaware Bay), a major waterfowl
		area on the Atlantic Flyway.
1.1	53.8	Cross Leipsic River (tidal); enter
		Leipsic (pop. 183).
4.6	58.4	Pass the Octagonal Schoolhouse (1836).
2.0	60.4	Jct. Del. Rt. 9 and Del. Rt. 8. Con-
		tinue south (straight) on Del. Rt. 9;
		enter Little Creek (pop. 220).
0.8	61.2	Cross Little Creek. Tidal flooding
		troublesome in this area 2 miles from
		Delaware Bay.
0.1	61.3	Jct. Del. Rt. 9 and Del. Rd. 67. Turn
		west (right) on Del. Rd. 67.
2.1	63.4	Pass one of City of Dover's water wells.

Generalized Log (Alt. 22 feet):

		Depth (feet)	Lithology	Unit and Age
		0 - 47	Sand and gravel.	Columbia Fm. Pleistocene.
		47- 148	Clay, some fine sand.	Chesapeake Gp. Miocene.
		148- 216	Sand, some shell.	Cheswold Aquifer Chesapeake Gp. Miocene.
		216- 330	Clay.	Chesapeake Gp., Miocene.
		330- 528	Sand, quartz and glauconite.	Piney Point Fm., Eocene.
		528- 559 T.D.	Clay.	Unit A, Eocene- Paleocene.
0.2	63.6	Enter Dover (pop. 22,480). Settled in 1670; capital of Delaware since 1777.		
1.2	64.8	Jct. Del. Rd. 67 and U.S. Rt. 113. Continue west (straight) on Del. Rd. 67.		
0.1	64.9	Jct. Del. Rd. 67 and U.S. Rt. 13. Continue west (straight), Rd. 67 becomes Court Street.		
0.3	65.2	State Capital, Legislative Hall, 1933. Bear right on Court Street.		
0.1	65.3	Jct. Court St. and Legislative Ave. Turn south (left) on Legislative Ave.		
0.05	65.35			
0.05	65.35	<u>STOP 4.</u> State Capital. Capital Square was laid out in 1933. The original square, The Green, dates from 1717; it lies to the west beyond Old State House which was built in 1722.		
	65.35	Leave Stop 4. Continue south (straight) on Legislative Ave.		
0.05	65.4	Jct. Legislative Ave. and Wm. Penn St. Turn east (left) on Wm. Penn St.		
0.1	65.5	Wm. Penn St. becomes Court St.		
0.3	65.8	Jct. Court St. and U.S. Rt. 13. Con- tinue east (straight) on Court St.		
0.1	65.9	Jct. Court St. and U.S. Rt. 113. Turn south (right) on U.S. Rt. 113.		
1.8	67.7	Pass North Gate of Dover Air Force Base. Largest air freight terminal. Base for C-5's, world's largest airplanes.		
1.3	69.0	Pass Main Gate, Dover Air Force Base.		

A major cored testwell was drilled in

this area in 1957 and has been a major element in developing the stratigraphy of the Coastal Plain.

Formation log of Well Je32-4; Alt. 40 feet.

Depth (feet)	Unit	Systems or Series
0-44	Columbia	Pleistocene
44-340	Chesapeake Group	Miocene
340-615	Piney Point Formation	Eocene
615-1090	Unit A	Eocene-Paleocene- Upper Cretaceous
1090-1170	Monmouth Formation	Upper Cretaceous
1170-1275	Matawan Formation	Upper Cretaceous
1275-1369	Magothy Formation	Upper Cretaceous
1369-1422	Potomac T.D. Formation	Upper and Lower Cretaceous
3.0	72.0	Cross St. Jones River. Note tidal marsh development.
2.5	74.5	Enter Little Heaven.
1.7	76.2	Pass Barratt's Chapel (1780). Known as the "Cradle of Methodism in America."
0.9	77.1	Cross Murderkill River (tidal).
1.7	78.8	Jct. U.S. Rt. 113 and Del. Rd. 19. Continue south (straight) on U.S. Rt. 113. This is the turn to Island Field Archaeo- logical Museum, 7.2 miles northeast on the shore of Delaware Bay.

Island Field is a site used as a cemetery by the people of the Webb Phase. During three centuries between 600 and 900 A.D., they practiced elaborate mortuary rites at this location on the Murderkill River. This advanced society, which existed on the Delmarva Peninsula during the period known as Middle Woodland, engaged in hunting, fishing, gathering, and probably horticulture, as well as in a widespread trading system. This area also illustrates the effects of rising sea level along the Delaware shore. The rate of rise for the past

several thousand years has been estimated at 0.5 to 1 foot per century. This has profound effects on the low coast of the Atlantic Coastal Plain and on the shores of its estuaries. Typically, as at Island Field, thin sand beaches migrate landward over marsh deposits.

3.6	82.4	Jct. U.S. Rt. 113 and Del. Rt. 1. Turn southeast on Del. Rt. 1. Bypass Milford (pop. 5,500).
2.2	84.6	Cross Mispillion River (tidal). Enter Sussex County.
12.1	96.7	Cross Broadkill River (tidal). In this vicinity a transition is made from the fluvial facies of the surficial Columbia Fm. to the various shoreline facies of the Columbia.
9.8	106.5	Jct. Del. Rt. 1 and Alt. Del. Rt. 1. Turn east (left) on Alt. Del. Rt. 1.
0.6	107.1	Cross Lewes-Rehoboth Canal.
0.1	107.2	Enter Rehoboth Beach (pop. 1,750).
0.6	107.8	Jct. Alt. Del. Rt. 1 and 1st Street. Turn north (left) on 1st St.
0.3	108.1	Bear east (right) toward beach.
0.1	108.2	Turn right into Henlopen Hotel.

END OF TRIP.

ROAD LOG

FIELD TRIP - DELAWARE COASTAL AREA

J.H. Talley, T.E. Pickett, R.N. Benson

Leave from Henlopen Hotel, Rehoboth Beach, Delaware.
Distances are given to nearest tenths of miles as measured
by automobile odometer.

<u>Distance</u>	<u>Cumulative Distance</u>	<u>Notes</u>
0.0	0.0	Leave Henlopen Hotel on Lake View Street.
		Turn left (west) on Lake Avenue.
0.2	0.2	Bear left (south) on First St.
0.3	0.5	Turn right (west) on Rehoboth Avenue.
		(Del. Route 1 Alternate).
0.7	1.2	Cross Lewes and Rehoboth Canal.
		Fossils dredged from this canal are
		reported by Richards (1936).
0.6	1.8	Jct. Del. Route 14 and Del. Rt. 14A.
		Merge on Del. Route 14 north.
2.1	3.9	Jct. Del. Route 14 and Del. Rt. 24.
		Continue northwest on Del. Route 14.
1.1	5.0	Jct. Del. Route 14 and Del. Rd. 268A.
		Bear right on Del. Rd. 268A.
0.3	5.3	Jct. Del. Rd. 268A and Del. Rd. 268.
		Bear right (northeast) on Del. Rd.
		268 (U.S. Route 9).
1.2	6.5	Turn left (north) on Kings Highway
		(Near Phillips 66 Service Station).
		Enter Lewes (pop. 2,563).
0.7	7.2	Bear left around curve.
0.1	7.3	Jct. Kings Highway and Savannah Rd.
		(Del. Route 18). Zwaanendael Museum on
		left. Turn right (northeast) on
		Savannah Rd.
0.1	7.4	Cross Lewes and Rehoboth Canal.
0.1	7.5	Turn left (northwest) on Anglers Road.
0.1	7.6	Turn left (southwest) into boat yard.
	7.6	<u>STOP 1.</u> Parson's Dock, Lewes and Rehoboth
		Canal, Lewes.

The first part of the field trip
is a voyage down the Lewes and Rehoboth
Canal, through Roosevelt Inlet into
Delaware Bay, and thence out into the
North Atlantic Ocean.

On leaving the dock, notice the old houses on your left (port side). Some of them endured a naval bombardment by the English in the War of 1812. The site of Peter DeVries' fort, built about 1631, was also on the port side near the University of Delaware's College of Marine Studies. Note the Cannon Building and other facilities of the College of Marine Studies (founded in 1970). The new vessel, R/V Cape Henlopen, perhaps may be seen in the harbor.

Pass through Roosevelt Inlet into Delaware Bay. The town of Lewes is to the right (starboard). On approaching Cape Henlopen, note the two breakwaters constructed of stone from the Wilmington area in the 1820's. Immediately after their construction the growth of Cape Henlopen spit accelerated. There now is a real threat of the Cape joining with the nearer breakwater and allowing Lewes Harbor to silt in. Much research on coastal processes has been done in this area by J.C. Kraft and others of the Geology Department of the University of Delaware. Their studies show that the Cape is being extended at a rate of about 20 feet per year. Long-shore drift is bringing sand northward along the ocean beach side and recurving it around the spit into the Bay. Large sand waves may be seen on the inside curve of Cape Henlopen.

Pass Cape Henlopen and enter the North Atlantic Ocean. Oil tankers enroute to or from the large refinery complex in the Philadelphia area constitute a major part of the ship traffic using Delaware Bay. There is much local debate concerning present or future means of transportation of oil, including lightering with high probability of spills, pipelines, supertankers, and superports.

Hen and Chickens Shoal is east of Cape Henlopen. Tradition has it that the DeBraak, an English ship which sank here in the 1790's, lies buried with a cargo which included gold. Complex efforts to

locate the wreck and recover the treasure have been unsuccessful.

After a short trip south along the coast the ship will retrace the route back to Parson's Dock in Lewes.

0.0	7.6	Leave Stop 1. Turn right (southeast), on Anglers Rd.
0.1	7.7	Turn right (southwest) on Savannah Rd. (Del. Route 18).
0.1	7.8	Cross Lewes and Rehoboth Canal and immediately turn right (northwest) on Front St. (Del. Rd. 267).
0.3	8.1	Front Street becomes Pilottown Rd. which parallels the Lewes and Rehoboth Canal (on right).
1.1	9.2	University of Delaware, College of Marine Studies facilities. Harry L. Cannon Marine Studies Laboratory on left, Marine Operations Building on right.
0.1	9.3	Turn left (southwest) into Harry L. Cannon parking lot.

9.3 STOP 2. University of Delaware College of Marine Studies.

LUNCH

0.0	9.3	Leave Stop 2. Turn right (southeast) on Pilottown Rd.
1.4	10.7	Pilottown Rd. becomes Front Street.
0.3	11.0	Turn right on Savannah Rd. (Del. Rt. 18).
0.1	11.1	Turn left (southeast) on Kings Highway.
0.1	11.2	Bear right around curve.
0.7	11.9	Merge on Del. Rd. 268 (U.S. Route 9).
0.8	12.7	City of Lewes well field on right (west).
0.5	13.2	Jct. U.S. Route 9 and Del. Rd. 268. Bear left (southeast) on Del. Rd. 268.
0.4	13.6	Jct. Del. Rd. 268 and Del. Route 14. Turn left (southeast) on Del. Route 14 South.
1.1	14.7	Jct. Del. Route 14 and Del. Route 24. Continue straight (southeast) on Del. Route 14.
2.7	17.4	Cross Lewes and Rehoboth Canal. Inter-coastal Waterway.
1.0	18.4	Enter Dewey Beach.
0.2	18.6	Jct. Del. Route 14 and Del. Route 14 Alternate. Bear right (south) and continue south on Del. Route 14.
1.2	19.8	Enter Delaware Seashore State Park. Atlantic Ocean to the left (east) and Rehoboth Bay to the right (west).

1.8 21.6 Turn left (east) on Halfway Rd. and
into parking area.

21.6 STOP 3. Delaware Seashore State Park.
Park and walk to top of dune.

At this locality the characteristic and classic development of a baymouth barrier complex may be studied. This barrier complex, which ranges in width from 0.2 to 0.9 miles, stretches from Cape Henlopen to the Delaware-Maryland State line at Fenwick Island, Delaware. All of the expected geomorphic features and environments of the shoreline are present including the barrier island with associated lagoons, back-barrier marshes, tidal deltas, dunes and beaches, and truncated Pleistocene highlands. During storms when erosion is accelerated, the back-barrier surface of the Spartina marsh and an 18th century pine forest are exposed on the beach.

A schematic diagram of a typical holocene transgressive sequence found along the baymouth barrier is shown in Figure 1 (from Kraft, 1971).

The sediments on this shore tend to be rather coarse, a reflection of the high energy of some of the environments and the availability of much coarse-grained material. This material is derived locally from older deposits; it is not being transported by present-day streams supplying the area.

0.0	21.6	Leave Stop 3. Drive west on Halfway Rd.
0.1	21.7	Turn left (south) on Del. Route 14.
1.3	23.0	Pass old Coast Guard Station on left (east). Abandoned in March, 1962 "Five High" storm.
1.8	24.8	Cross Indian River Inlet. Atlantic Ocean to left (east) and Indian River to right (west).
0.3	25.1	Turn right at base of bridge, follow road and proceed under bridge.
0.4	25.5	Turn left into parking area and park in northwest corner of lot.

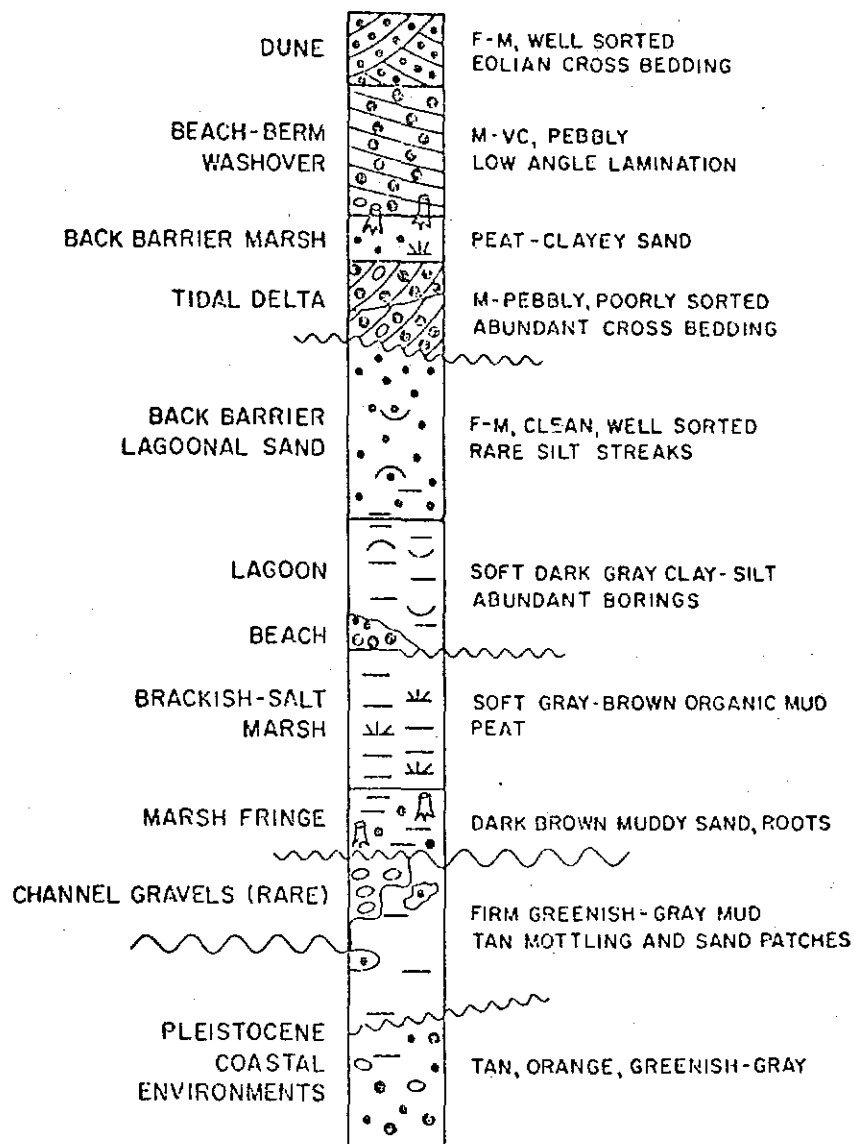


Figure 1. A schematic interpretation of a typical Holocene transgressive environmental sequence which would be expected under the bay-mouth barrier in a transgressive shoreline area. (Kraft 1971)

Walk across road and up staircase at base of bridge.

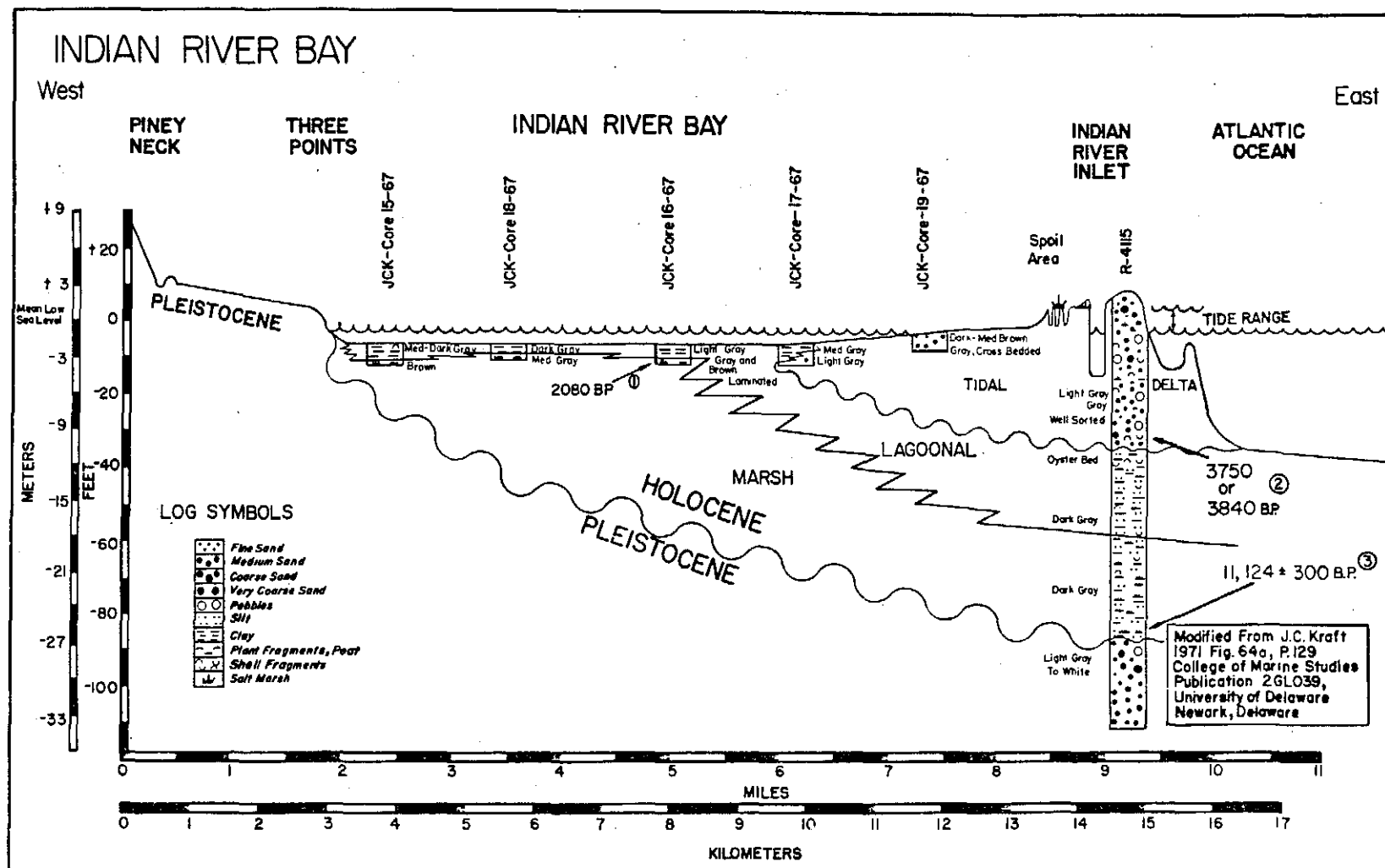
This inlet, the only one along the Delaware Coast at this time, provides access to the Atlantic Ocean from Indian River Bay and Rehoboth Bay.

During historic time the original natural inlet was dynamic in that it migrated up and down the coast (three to four miles). In order to stabilize the inlet and keep it open for navigation, jetties had to be built to prevent closing of the inlet by wave action and littoral drift. The resulting "jetty effect" has caused a build up of sand on the southern side of the inlet facing the ocean and accelerated erosion north of the northern jetty.

In order to maintain the beach area north of the Inlet, the U.S. Army Corps of Engineers in 1973 initiated a beach nourishment program in which they dredged sand from the middle of the inlet and pumped it onto the beach north of the north jetty.

The relative rise of sea level during the Holocene has had a significant effect on coastal erosion. Kraft et al., (1976) report that sea level rose at a rate of about 1 foot per century before 5,000 years ago, about 0.68 feet per century between 5,000 and 2,000 years ago, and about 0.41 feet per century from 2,000 years ago to present. The rate of coastal erosion varies according to location along the shore area and ranges from 300 to 1,200 feet of shoreline retreat per century. (Kraft, 1968).

The geomorphic features associated with a baymouth barrier complex are also present at this stop. A geologic cross section from the Pleistocene highland to Atlantic Ocean (west-east) showing the horizontal and vertical sequence of environments is shown in Figure 2. (from Kraft and John, 1976).



Radiocarbon Dates Are Given In Calendar Time Masca Correction:
 Radiocarbon Years, 5568 \pm 1/2 Life = ① 2060 \pm 110 B.P. ② 3430 \pm 170 B.P. ③ = 5730 \pm 1/2 Life Date; 5568 - 1/2 Life = 10,800 \pm 300 B.P.

Figure 2. Geologic cross section, Indian River. (Kraft and John, 1976).

0.0	25.6	Leave Stop 4. Turn right (north) and proceed under bridge.
0.4	26.0	Turn right (south) on Del. Route 14 and continue south.
4.0	30.0	Enter Bethany Beach (pop. 189).
0.4	30.4	Jct. Del. Route 14 and Del. Route 26. Note municipal water supply facility on southeast corner.
0.7	31.1	Note multistory resort complex on left (east) side of road.
4.0	35.1	On left (east) adjacent to parking lot is the location of a multiple screened (4) observation well (aquifer) monitoring system, completed as part of the DGS-USGS Cooperative Program.

Log of Well Rj22-5 Altitude 5'± 2'

Depth (feet)	Description
0- 20	Sand, white; clay; organic material
20- 34	Sand, gray, medium and coarse, with stringers of gray clay.
34- 78	Sand, gray, fine to coarse, with stringers of tan, brown, and gray clay.
78-148	Sand, tan, fine to coarse; gravel, occasional stringers of clay and organic material.
148-275	Clay, gray, green and brown, with occasional layers of gravel and shell.
275-323	Sand, gray, very fine to medium, some wood.
323-343	Sand, gray, fine to medium, minor coarse sand.
343-373	Sand, gray, fine with some medium, wood and streaks of clay.
373-423	Sand, gray, fine and medium, some wood.
423-443	Sand, gray, fine with some medium; wood.
443-463	Sand, gray, fine to coarse.
463-493	Sand, gray, very fine.

Screened intervals:

110-115	Water-table aquifer
180-185	Pocomoke=Ocean City aquifer?
290-295	Top of Manokin aquifer
450-455	Bottom of Manokin aquifer

0.2	35.3	Enter Fenwick Island (pop. 56).
1.1	36.4	Jct. Del. Route 14 and Del. Route 54.
0.1	36.5	Jct. Del. Route 14 and 146th Street (Ocean City, Maryland). Delaware- Maryland State Boundary. Turn right (west) on 146th Street.
0.1	36.6	<u>STOP 5.</u> Fenwick Island, Delaware Lighthouse, and eighteenth century monument on Transpeninsular Boundary Line.

Near the base of the 18th century lighthouse is one of the original monuments from the survey of 1750 which started from this point and proceeded westward. The purpose of the survey was to delineate the boundary between lands of the Calvert family (coat of arms on south side) and the Penn family (coat of arms on the north side). This initial point of the Transpeninsular Line was located in 1750 "due west (from the ocean) 139 perches and near a mulberry tree." Stones were placed at five-mile intervals between this point and the southwestern corner of Delaware 35 miles west.

In 1971 the Delaware Boundary Commission was established to re-survey and, where necessary, re-align the State's boundary lines. The Transpeninsular Line re-survey was recently completed as a cooperative effort of Delaware, Maryland and the National Geodetic Survey with the field work performed by NGS.

As we leave, note the distant skyline of Ocean City, Maryland, contrast that with Delaware's shoreline and contemplate the difference in shoreline development policy.

0.0	36.6	Leave Stop 5. Proceed east on 146th St.
0.1	36.7	Turn right (south) Md. Route 528 and immediately make a U turn and proceed north on Md. Route 528.
0.1	36.8	Jct. Del. Route 14 and Del. Route 54. Turn left (west) on Del. Route 54.
0.6	37.4	Cross Assawoman Canal. Inland Waterway.
3.3	40.7	Jct. Del. Route 54 and Del. Rd. 381. Turn right (north) on Del. Rd. 381.
0.9	41.6	Cross Dirickson Creek.
0.3	41.9	Bear left (northwest) on Del. Rd. 381.
0.8	42.7	Jct. Del. Rd. 381 and Del. Rd. 384. Turn right (north) on Del. Rd. 384.

0.2 42.9 STOP 6. Agricultural Ditch.

Park on road shoulder and walk across to ditch.

A two-foot thick shell bed of the Omar Formation is exposed near the bottom of Agricultural Ditch where it intersects Road 384 to upstream for a distance of over 1,000 feet. The elevation of the bed is estimated as 4 to 6 feet above mean sea level. The land surface adjacent to the ditch is at an elevation of 10 feet.

An autochthonous fossil assemblage is indicated by the fact that many of the shells are in growth position and are articulated. The predominant species is the oyster Crassostrea virginica (Gmelin). A few additional bivalve species and several gastropod species are present but rare. The macrofossils indicate an estuarine or lagoonal paleoenvironment.

The only microfossils observed were a few species of benthic foraminifers representing the genera Elphidium and Ammonia. Elphidium clavatum Cushman, comprising over ninety percent of all individuals, overwhelmingly dominates the assemblage. This assemblage best corresponds to the deeper Central Bay-Lagoonal assemblage that Kraft and Margules (1971) described for Indian River Bay, Delaware.

The above evidence indicates that at the time of deposition of the Omar Formation at Agricultural Ditch sea level was higher and the shoreline was farther inland than at present. D.F. Belknap (personal comm.) has gathered evidence on the age of the Omar Formation here and at Pepper Creek Ditch, 6.5 miles to the west-northwest. Amino acid racemization techniques of dating applied to shells of Crassostrea virginica from both localities gave results of 100,000 to 150,000 years before present. In addition, Belknap reports that uranium-series dating of Pepper Creek Ditch material gave comparable results of $125,000 \pm 25,000$ years before present.

0.0	42.9	Leave Stop 6. Continue ahead on Del. Rd. 384.
0.3	43.2	Jct. Del. Rd. 384 and Del. Rd. 370. At this point Del. Rd. 384 becomes Del. Rd. 84. Continue on Del. Rd. 84.
0.4	43.6	Jct. Del. Rd. 84 and Del. Rd. 363. Bear right (northeast) on Del. Rd. 363.
0.2	43.8	Jct. Del. Rd. 363 and Del. Rd. 364. Bear left on Del. Rd. 363.
0.9	44.7	Cross Miller Creek.
0.3	45.0	Jct. Del. Rd. 363 and Del. Rd. 362. Bear left on Del. Rd. 362.
1.6	46.6	Jct. Del. Rd. 362 and Del. Rd. 361. Turn left (north) on Del. Rd. 361.
0.3	46.9	Enter Ocean View (pop. 411).
0.5	47.4	Jct. Del. Rd. 361 and Del. Route 26. Turn right (east) on Del. Route 26.
0.5	47.9	Cross Assawoman Canal. Inland Waterway.
1.1	49.0	Jct. Del. Route 26 and Del. Route 14. Turn left (north) on Del. Route 14.
4.7	53.7	Indian River Inlet.
6.2	59.9	Jct. Del. Route 14 and Del. 14 Alternate. From this point the route will be retraced to Lewes. Those wishing to follow the log may reverse the southward log from mile 11.0 to mile 18.6
7.6	67.5	Jct. Savannah Rd. (Del. Rt. 18) and Front Street. Cross Lewes and Rehoboth Canal and proceed northeast on Savannah Rd.
0.4	67.9	Jct. Savannah Rd. and Cape Henlopen Drive. Proceed northeast on Savannah Rd. and into parking area.
0.1	68.0	<u>STOP 7.</u> Lewes Beach.

DINNER

0.0	68.0	Leave Stop 7.
0.1	68.1	Turn left on Cape Henlopen Drive (Del. Route 18).
0.3	68.4	Turn right on U.S. Route 9 (Del. Rd. 23).
0.6	69.0	Cross Lewes and Rehoboth Canal
0.8	69.8	Bear right, then left and continue on U.S. Route 9.
		From this point the route will be retraced to the Henlopen Hotel. Those wishing to follow the log may reverse the southbound log from mile 0.0 to mile 6.5
6.5	76.3	Henlopen Hotel.

END OF FIELD TRIP

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