UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

BEFORE THE ATOMIC SAFETY AND LICENSING BOARD

In the Matter of	)	
	)	
PHILADELPHIA ELECTRIC COMPANY	)	Docket Nos. 50-352
	)	50-353
(Limerick Generating Station	)	
Units 1 and 2	)	

TESTIMONY OF REX G. WESCOTT CONCERNING THE IMPACT OF BRADSHAW RESERVOIR ON GROUNDWATER RESOURCES

Q1. Please state your name and position with the NRC?

A1. My name is Rex G. Wescott and I am employed by the U.S. NRC as a hydrologist in the Division of Engineering, Office of Nuclear Reactor Regulation. A copy of my professional qualifications is attached hereto.

Q2. What is the purpose of your testimony?

A2. The purpose of my testimony is to respond to contention V-16b which states:

> "Seepage of water and toxics from Bradshaw Reservoir will cause a risk of contamination and hydraulic saturation"

Q3. What is your understanding of the basis for admission of this contention?

A3. It is my understanding that this contention was admitted by the Board for consideration in the expedited proceeding because the Bradshaw Reservoir has been significantly increased in size (doubled) over what was reviewed at the CP Stage. It is my understanding that because of this increase in size the Board determined that there could be an increased risk of contaminates

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reaching the groundwater, therefore invalidating the assessment of impacts performed for the original design of the reservoir.

Q4. What is the seepage rate originally calculated for the original design of the reservoir?

A4. I have not as yet found any reference to an analysis of seepage from the originally proposed reservoir design in any of the documents that I have reviewed to date. It is my understanding that the original proposed design never got beyond the conceptual design stage and, therefore, it is possible that a detailed seepage calculation was never performed.

Q5. Has the applicant made an estimate of seepage from the reservoir as presently designed?

A5. Yes. In response to my Environmental Review Question E 240.24 b (Exhibit 1) the applicant provided an estimate of the maximum seepage rate from the reservoir. The applicant estimated the seepage rate to be .67 cfs.

Q6. Have you reviewed the applicant's calculations and do you agree with them?

A6. Yes, I have made an independent calculation using the reservoir dimensions and volume as shown in the applicant's reports and drawings and have calculated approximately the same seepage rate.

Q7. Do you consider your calculations to be conservative?

A7. Yes, I took no credit for the relatively impermeable material underneath the reservoir which would lower the assumed gradient and significantly reduce the calculated seepage.

Q8. Did the applicant make a similar assumption in his calculation?

A8. Yes.

Q9. Did you assume the same liner permeability in your calculation as was used by the applicant?

A9. Yes.

Q10. Why?

A10. In the response to my Environmental Review Question E 240.24 b, the applicant stated that the maximum permeability of the liner material will be 5×10^{-6} cm/sec (0.014 ft/day). In a letter to me dated September 9, 1982 (Exhibit 2), Mr. Robert Bourquard of E. H. Bourquard Associates Inc., the applicant's engineer, stated that the maximum permeability of the liner would be assured through specifications on the soil to be selected, soil tests to be employed and the addition of bentonite, if necessary.

Q11. What effects of seepage did the applicant estimate?

A11. In response to my question E 240.24 the applicant provided a map showing the expected rise in the present groundwater level due to seepage from the reservoir and the resulting groundwater gradients. The map of existing and expected post construction water table contours (Figure E 240.24-5 of Exhibit 1) shows a groundwater mound approximately 3 ft above the present ground water level adjacent to the reservoir tapering off to the present level approximately 400 ft from the reservoir. The direction of flow as shown by the groundwater level contours is toward the Northeast.

Q12. Have you had an opportunity to review the applicant's estimates of altered groundwater levels as represented by this map?

A12. No, I have not.

Q13. Assuming that the applicant's analysis is correct, is it likely that the seepage from the reservoir will affect any nearby wells?

A13. No.

Q14. Why not?

A14. According to the applicant's groundwater level map, all nearby wells are upgradient of the reservoir, i.e., in the opposite direction to the direction of groundwater movement.

Q15. Could pumpage from the nearby wells reverse the gradient and draw in the seepage from the reservoir?

A15. At the present time I have no information regarding depth or pumping rates of the wells shown by the applicant. From a description of the subsurface investigations presented in "Supplemental Data and Information Accompanying Permit Application for Bradshaw Reservoir - Philadelphia Electric Company" dated November, 1981 by E. H. Bourquard Associates, Inc. (Exhibit 3), I assume that the wells are not withdrawing from the surface groundwater table but from a deeper aquifer, probably in a fractured zone in the rock. Therefore, based on these assumptions, I would not expect these wells to influence the near surface groundwater gradient.

Q16. Please describe the design changes in the reservoir that would tend to influence seepage rate.

A16. The most detailed description of the original reservoir design that I have located is found on Plate 6 (Exhibit 4) of the Final Environmental Impact Statement - Point Pleasant Diversion Plan prepared by Delaware River Basin Commission dated February 1973.

Plate 6 shows the reservoir as being rectangular in shape, approximately 900 ft long and 500 ft wide (from top of dike to top of dike). The plate also shows 3 feet of impervious existing soil in the reservoir area and a maximum water depth of 15 ft. Drawings recently obtained from the applicant show the presently designed reservoir to be approximately 900 ft by 900 ft (top of dike to top of dike), an impervious liner of 2 ft and a maximum depth of 19 ft (Exhibit 1). The most apparent features influencing seepage rate would be size, water depth, and liner thickness.

Q17. If the proposed reservoir were to be built as originally presented in the DRBC Environmental Impact Statement would the seepage rate be significantly less than that for the reservoir design as is now proposed?

A17. No.

Q18. Why not?

A18. The original design showed the bottom of the reservoir as consisting of 3 ft of existing impervious soil with a layer of gravel underneath. The permeability of the existing soil as determined from laboratory permeability tests presented in the Supplemental Data and Information report by Bourquard (Exhibit 3) is approximately 5×10^{-5} cm/sec. This is ten times the permeability which will be guaranteed for the liner to be constructed in the presently proposed design. This factor of 10 more than offsets the increase in size of the reservoir and the reduced thickness of impermeable material.

Q19. What is your understanding of the term "hydraulic saturation" used in the contention?

A19. The term "saturation" when applied to the study of fluid flow in a porous medium is generally used as an indicator of the degree of filling of the interconnected pore space with a fluid. For example, "degree of saturation" is the ratio of the volume of fluid to the volume of voids in the medium. When a porous medium is "saturated" the interconnected pore spaces are completely filled with a fluid. Saturation when used to describe groundwater movement refers to the filling of the open void spaces in the soil with water. I would understand "hydraulic saturation" to refer to the same thing.

Q20. Has Del-Aware attempted to clarify the meaning of this term?

A20. Yes, in response to the Applicant's Interrogatories Del-Aware explains that "hydraulic saturation refers to ground water table level" (Exhibit 5). In response to NRC Staff Interrogatories Del-Aware explains that "hydraulic saturation means below the groundwater table" (Exhibit 6).

Q21. Have the responses clarified their contention for you?

A21. No, the responses are somewhat contradictory and don't appear to make sense in the context of the contention.

Q22. Then how do you interpret Del-Aware's responses as to the meaning of "hydraulic saturation"?

A22. I interpret Del-Aware's responses to mean that "hydraulic saturation" refers to a change in local groundwter level induced by the reservoir.

Q23. Could you explain how groundwater level might be changed by the reservoir?

A23. My answer to this question was stated in answer 11 where I addressed seepage.

LIST OF EXHIBITS

Exhibit No.	Title
1	Applicant's response to Environmental Review Question E.240.24.
2	Mr. Robert Bourquard's letter of September 9, 1982 to Rex Wescott.
3	Pages 1-8 of subsurface investigation report contained in "Supplemental Data and Information Accompanying Permit Application for Bradshaw Reservoir - Philadelphia Electric Company", dated November, 1981 by E. H. Bourquard Associates, Inc.
4	Plate 6 of the "Final Environmental Impact Statement - Point Pleasant Diversion Plan", dated February 1973 by Delaware River Basin Commission.
5	Page 3 of Del-Aware's Answers to Applicant's Interrogatories and Request for Production of Documents.

6 Page 13 of Del-Aware's Answers to NRC Staff's Discovery Request.

Rex G. Wescott, Hydrologist
Hydrologic Engineering Section
Hydrologic and Geotechnical Engineering Branch
Division of Engineering
Office of Nuclear Reactor Regulation

Professional Qualifications

I am a hydrologist in the Hydrologic Engineering Section, Hydrologic and Geotechnical Engineering Branch, Division of Engineering.

My formal education consists of a B.S. in Physics received from Clarkson College of Technology in Potsdam, New York in 1970, an M.S. in Engineering Science received from Clarkson College in 1974, and approximately 27 graduate credit hours in hydraulics, advanced fluid mechanics and coastal engineering from Polytechnic Institute of New York and Rutgers University. My graduate study at Clarkson College consisted primarily of courses in surface and subsurface hydrology, water resources engineering, and systems analysis.

My present employment with NRC dates from 1978 when I was employed as a hydraulic engineer with the Office of Nuclear Reactor Regulation as a hydrologist in the Hydrologic and Geotechnical Engineering Branch. My responsibilities in the licensing review of nuclear facilities is in the area of flood vulnerability, adequate water supply and surface and groundwater acceptability of effluents.

From 1975 to 1978 I was employed as a Civil Engineer with Ebasco Services Inc. in New York, New York. I was responsible for conceptual designs of dams. reservoirs and spillways; preparation of SAR's and ER's for nuclear power plant projects; and for studies and reports in other various water related projects.

From 1973 to 1975 I was employed as a staff engineer with Woodward-Clyde consultants Inc. in Clifton, New Jersey. At Woodward-Clyde my responsibilities were very similiar to those which I had at Ebasco Services.

I am a registered Engineer-In-Training in the State of New Jersey and an associate member of the American Society of Civil Engineers.

Exhibit 1
Wescott (Bradshaw)

QUESTION E240.24

Please provide the following information regarding the bradshaw Reservoir of the Point Pleasant Diversion Plan:

a) A drawing(s) of the reservoir showing deimensions, water level, impervious liner, drains and filters.

b) The thickness and permeability of the imperviuos liner on the bottom of the reservoir.

c) Calculations of seepage through the reservoir and the path of the seepage (downstream or into ground).

d) A drawing of the stratigraphy underneath the reservoir showing ambient water table elevation, potable aquifers, confining layers, and any other data pertinent to determining the potential for groundwater contamination from the reservoir.

e) A map showing the location of groundwater users near Bradshaw Reservoir that could be affected by seepage from the reservoir.

RESPONSE

a) Figure E240.24-1 shows a plan view of Bradshaw Reservoir. Figure E240.24-2 shows elevations of the dikes, the high and low water levels, and the location of the impervious liner. Details of the drains and filters are shown in Figure E240.24-3.

b) The thickness of the impervious liner as shown in Figure E240.24-2 is to be a minimum of 2 feet. The maximum permab 'ity of the liner material will be 5 x 10-6 cm/sec (0.014 fpd).

c) Calculations of seepage through the reservoir bottom are shown in Exhibit E240.24-1, the calculated seepage rate is .67 cfs. The seepage will flow to the northeast of the reservoir and into the tributary of Geddes Run as shouwn in Figure E240.24-5.

d) Figure E240.24-4 shows the stratigraphy below the reservoir. It should be noted that there are no confining beds or separate aquifiers present. Figure E240.24-5 shows water table elevations.

e) Figure E240.24-5 shows the location of groundwater users near Bradshaw Reservoir; however, since they are located south of the reservoir and the seepage will flow to the north, they will not be affected. It has been concluded that there will be no reversal of the direction of groundwater flow, and there will be no new recharge to existing wells in the area.

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REASON

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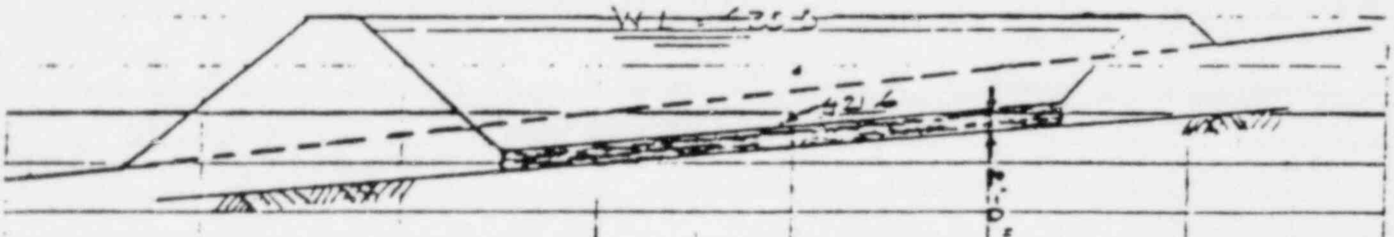


Normal High Water Level	435.0
Aver. Elev. Bot of Reservoir	421.6
Aver. Head on Bottom	13.4 ft.

Bottom Area = 825 × 575 + 725 × 200
= 474,375 + 145,000
= 619,375 Say 620,000 sq. ft.

Permeability Coefficient
Natural Residual Soil — 5×10^{-5} cm/sec
Rolled & Consolidated — 5×10^{-6} cm/sec
— 0.014 fpd

Q = K i A i = 13.4 ÷ 2
= 6.7 ft/ft

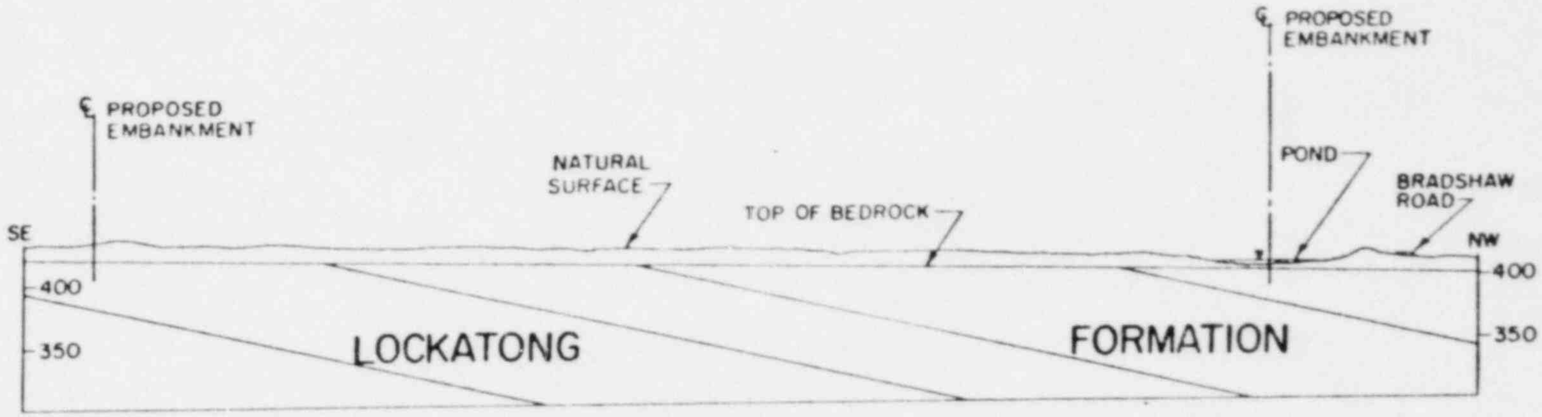
= 0.014 × 6.7 × 620,000

= 58,156 cu. ft. / day

= 436,170 gpd = 0.67 cfs.

Note — This will be a conservative estimate as it assumes free flow under lining, with no back pressure. Pond on site with relatively constant level indicates very limited flow thru overburden or thru underlying weathered rock

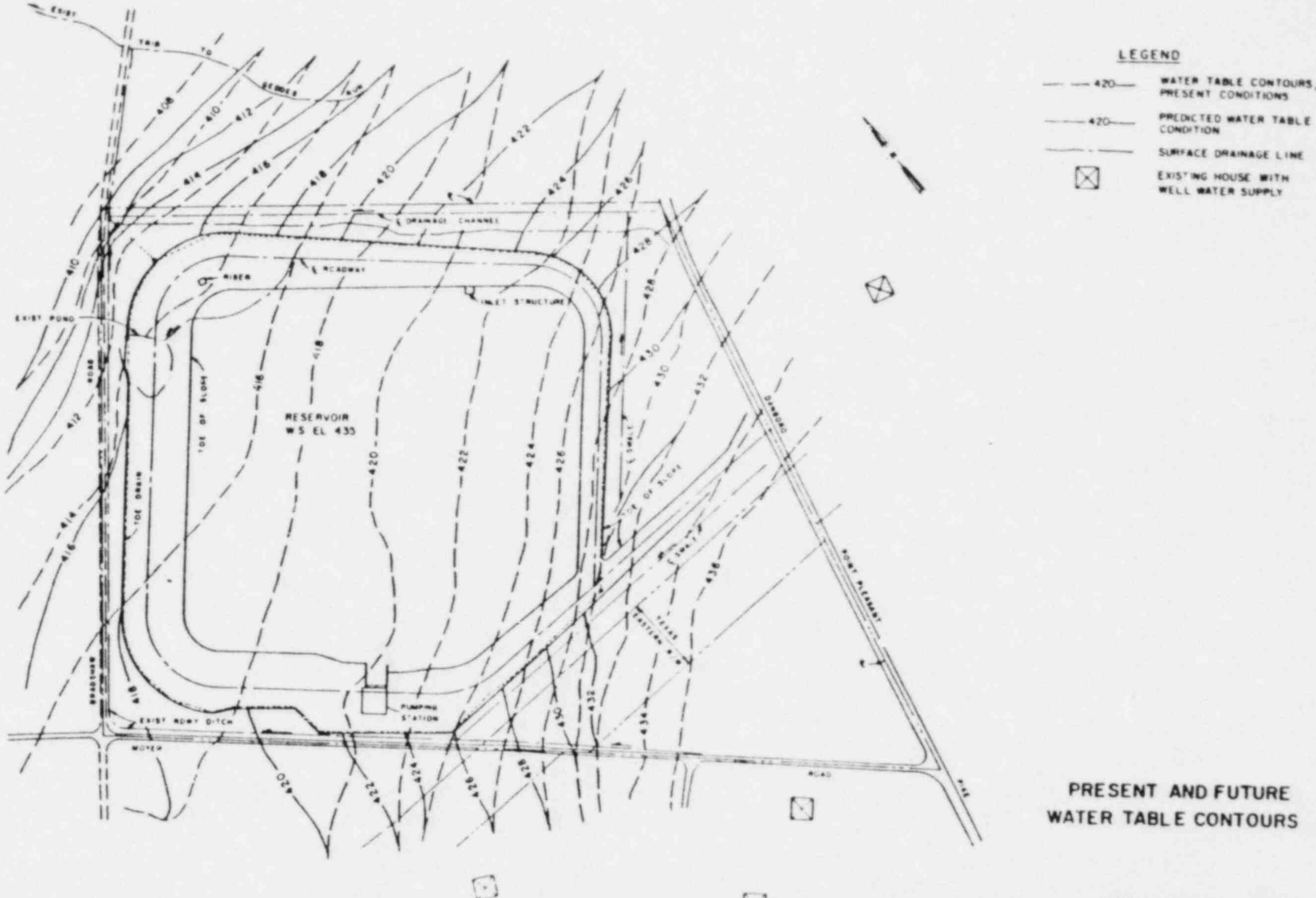
EXHIBIT E 240.24-1



SCALE 1 INCH = 100 FEET
VERTICAL AND HORIZONTAL

GEOLOGIC
CROSS SECTION AT
BRADSHAW RESERVOIR

FIGURE E 240.24-4



PRESENT AND FUTURE
WATER TABLE CONTOURS

FIGURE E 240.24-5

Exhibit 2

Wescott (Bradshaw)

E. H. BOURQUARD ASSOCIATES, INC.
WATER RESOURCES ENGINEERING
1400 RANDOLPH STREET
(EXIT NO. 24, INTERSTATE 83)
HARRISBURG, PA.
17104-3497

TELEPHONE (717) 238-9505

WATER SUPPLY
WASTEWATER DISPOSAL
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FLOOD CONTROL PROJECTS
DAMS & RESERVOIRS
DRAINAGE-STORMWATER
HYDROLOGIC STUDIES
ENVIRONMENTAL STUDIES

September 9, 1982

Mr. Rex Wescott,
U. S. Nuclear Regulatory Commission,
7920 Norfolk Ave.,
Bethesda, MD 20014.

Re: Bradshaw Reservoir and Pumping Station

Dear Mr. Westcott:

In accordance with our phone conversation today, enclosed are the following:

1. Bradshaw Reservoir Specification Section 02220, Earth Fill.

2. Soil Testing for Engineers, Lambe, Chapter VI, Permeability Test.

Item 1 specifies the requirements the Contractor must follow in construction of the earthen dam and impervious liner. As we discussed, there will be no specific permeability requirement for the Contractor to meet. However, the material as specified should provide a maximum in place permeability of 0.000005 cm/sec. In the unlikely event the material would exceed this permeability, bentonite would be incorporated into the liner material as necessary to reduce the permeability. Since the need for bentonite is unlikely, it has not been included in the Specification. If needed, the additional work would be carried out under a Contract change order.

Item 2 describes the permeability test procedure. Tests will be conducted at the Contractor's proposed off-site borrow area on the natural undisturbed material and also on the liner after compaction. Undisturbed samples will be taken at both locations. The variable head method will be used.

Sincerely yours,

Robert Bourquard

Robert H. Bourquard

RHB/bs
Encl. As Noted
c.c. Dave Morad, PECO w/encl.

Exhibit 3
Wescott
(Bradshaw)

SUPPLEMENTAL DATA AND INFORMATION

ACCOMPANYING

PERMIT APPLICATION

FOR

BRADSHAW RESERVOIR

PHILADELPHIA ELECTRIC COMPANY

November, 1981

E. H. BOURQUARD ASSOCIATES, INC.
Consulting Engineers

REPORT ON
THE SUBSURFACE INVESTIGATION
ALONG THE SITES
OF THE PROPOSED
POINT PLEASANT PUMPING FACILITIES
UNDER
CONTRACT 24
OF THE
BUCKS COUNTY
NESHAMINY WATER RESOURCES AUTHORITY

Field work on Contract 24 began on October 17, 1972 and was stopped (with Hole F-1 held in abeyance under a Stop Order) on December 21st. There were 46 working days in this period. F-1 was later completed on January 11, 1973, the Delaware River having fallen meanwhile to a level permitting work. This brought the total number of work days to 48.

Tinney Drilling Company of Bridgeville, Pennsylvania was granted the contract. They sent in three drill rigs as follows:

1. A Central Mining Equipment, Model 45.
2. A Joy, Model 12.
3. A Tinney-built rig.

A fourth rig was present between November 6th and 16th as follows:

4. An Acker, Model AD II.

The final hole (F-1) was drilled by,

5. A Caterpillar mounted Joy, Model 12.

Harold Scott was in charge of the operation for Tinney Drilling Company and he was present in the field during the most difficult part of the investigation. John Bell, drilling foreman, was present for most of the time. Drillers on the three rigs were Ron Doyle, Joseph Eger, and E. W. Gardner. L. Spiker was the driller on the fourth rig and William Crane drilled hole F-1.

On October 25th and 26th eight test pits were dug, logged, sampled, and back-filled according to specifications. Michael Baker, Jr., Inc. of Beaver, Pennsylvania was charged with the work done in this connection. Their representative in the field was Mr. Carr.

The investigation dealt with an area in Point Pleasant, where a pumping station has been proposed along the western shore of the Delaware River, thence along a surveyed line for a proposed transmission main to Bradshaw and Moyer Roads, where a storage reservoir has been proposed, and finally along a proposed transmission main from the reservoir area to a point near the intersection of Bradshaw Road with Highway #413 and at the headwaters of North Branch of Neshaminy Creek.

The purposes of the investigation were to test the soil and bedrock conditions apropos the different uses to which the various areas are to be put. Two kinds of test holes were used in obtaining this information. In an F-series 50 holes were drilled by drive sample boring through the soil and by core drilling into the bedrock underneath. In an AH-series 48 holes were augered to refusal. An additional nine holes were augered in connection with groundwater observations.

The following summarizes the footages resulting from the investigation:

I.	F-series Holes		
	Drive Sample Boring		583.5
	Core Drilling		
	A. Boulders in overburden	157.5	
	B. Bedrock	495.6	653.1
	Footage disallowed in Hole F-13A		24.0
			1,260.6
	Total Footage Drilled		1,260.6
II.	AH-series Holes		
	Soil Testing		277.6
	Groundwater Observation		51.2
	Total Footage Augered		328.8
III.	Standpipes, Total Footage Installed		188.4
IV.	Test Pits, Total Footage		48.2

SURFACE FEATURES

Three geomorphic features were encountered on this project. Each will offer difficulties of access to equipment, to its movement about, and to construction. The Valley Bottom is subject to flooding by the Delaware River. During a heavy rain in November, for example, the site of F-2 was submerged under 2.6 feet for a period of two or three days. Although this is a relatively short time, the ground remained soft and slippery for several more days and an incredible amount of debris, mostly dead trees and branches, was left behind. Also submergence under the rising river can be rapid while emergence from under the receding river can be tantalizingly slow.

On the Plateau the overburden is very impermeable and the ground becomes a virtual bog in wet weather. This is especially true in the vicinity of the proposed reservoir and its borrow areas. Access to these areas together with excavating and filling may not be possible at such times without some method of drainage and protection. Study of the hydrology of these areas through wet and dry seasons should be pursued in order to select a better time for the work and to know if drainage and protection can be avoided. (The area between stations 35+00 and 57+00 also seems poorly drained.)

The Valley Side intervenes between the valley bottom and the plateau, and it will offer the most serious obstacles to access, to movement about, and to construction. For one thing it is strewn with boulders and with blocks of bedrock 12 to 15 feet thick. There is no soil here in the commonly accepted sense. It is virtually the C-zone with B-zone either washed away or dispersed down among the boulders, blocks, and other bedrock fragments.

For another thing the Valley Side is steep; as much as 30% where it starts its rise above the valley floor and for about 800 feet. Then the slope diminishes to about 12% at Ferry Road; it then falls off to 4% at station 21+00 and lessens beyond as the valley side merges with the plateau.

GEOLOGY

The Triassic Period in the earth's history began about 225 million years ago and continued for the next 45 million years. During the early Triassic, widening of the Atlantic Basin caused severe structural movements in what was to become eastern North America. Along with the westerly directed vector of compression had come uplift and the Appalachian Mountains resulted. During the late Triassic these forces ceased and with their cessation came relaxation and the development at various places between Nova Scotia and North Carolina of tensional fractures. Under these conditions blocks of the earth's crust, pulled by gravity, dropped forming basins.

Bucks County lies above one of these - the Newark Basin. With the Appalachian Mountains standing high nearby and with the substrate of the basin subsiding slowly throughout the late Triassic, large amounts of rock detritus were washed into the basin and deposited. A variety of environments developed in the Newark Basin and one of these is of interest because the bedrock encountered in this subsurface investigation was formed from sediment deposited in it.

A very large lake came into existence during the late Triassic. Rock formed by the induration of sediment deposited in it is found today from the Schuylkill River east of Phoenixville, Pennsylvania to the Palisades on the Hudson. That it was a lake is attested to by the fossilized skeletons of freshwater fish plus petrified remains and/or imprints of the freshwater clam, Unio, and of some freshwater crustaceans. Bones of amphibians, phytosaurs and other reptiles, the rare track of a dinosaur, and rare plant remains testify to shoreline conditions. The lake existed for an incredibly long time and cyclic deposition from detrital to chemical, back to detrital, etc., is believed traceable to the "expansion and waning of an extensive lake, controlled by the 21,000 year precession cycle". (1)

The formation that resulted from the hardening of this sediment is called the Lockatong argillite, and the bedrock in all the holes of this project except two (F-19 and F-61) is of this formation. The two exceptions drilled into diabase which formed from magma intruded into the Lockatong during the late Triassic and before its complete induration to argillite. The formation measures about 3,750 feet in thickness and the rock encountered in the test holes near Point Pleasant falls about 1,000 feet above the base of the formation. As one proceeds from this point along the surveyed line toward its western end, the bedrock encountered gets progressively lower stratigraphically until, at F-38, one is about 500 feet above the base of the formation.

The most distinctive characteristics of the Lockatong formation are its color-dark gray when dry and black when wet, its fine texture - argillaceous (clayey), its toughness which has resulted from cementation by carbonates (calcite and dolomite) and analcime, and finally its bedded and fractured nature.

Given the subsiding nature of the crust under the basin, it is not surprising that at times molten material came up along fractures. Some of this material made its way into Triassic formations forming sills and some of it flowed out as lava over the ground of that particular time and was later buried as sedimentation continued with continued subsidence.

The material intruded as sills, being under a thick cover of overlying sediment, retained its heat much longer than did the material which flowed out as a lava. The result was that, in the case of a sill, the underlying and overlying sediment was baked and hardened by the heat and formed a hard rock called hornfels. As indicated above the rock cored in two test holes was from one such sill, the Byram diabase. Other test holes <u>may have</u> encountered the hornfels facies of the Lockatong (F-20, F-18A, F-7, F-6, F-13 & 13A, F-15R).

<u>The Bradshaw Reservoir and its Borrow Areas.</u>

The Lockatong argillite underneath these areas is typical of the rock found elsewhere on the project. Its top surface underneath overburden has its highest elevation in the borrow area which is southeast of the reservoir area and adjacent to Point Pleasant Pike. From here its elevations fall off to the north as well as along the surveyed line to the Delaware River, on the one hand, and to Highway #413, on the other. Quite evidently it is rising and falling with the surface topography, a fact indicating that the overburden has been derived by the weathering of the underlying argillite.

The overburden in these areas averages 6.67 feet in thickness. It is uniformly a silty clay and is impermeable.

The Lockatong argillite, even where it has not been baked to hornfels, as it has not in the reservoir and adjacent area, is a tough rock and will have to be blasted if it is to be dug into. The zones of weathered shale frequently found on top of bedrock, the badly broken and the thin-bedded zones - all workable by a backhoe - are deceptive. The weathered zones are not included in bedrock, as they were generally augerable or penetrable by the driven spoon-sampler. The thin-bedded zones belong to the parts of detrital cycles which, although they recur frequently and persist laterally, are only 14 to 20 feet thick and the strike and dip (averaging E-W and 15-deg. N) are such that one cannot count on staying within this interval as one moves about over the area of the reservoir, the borrow areas, or along the projected transmission main. The badly broken parts are associated with fractures. They will, therefore, be linear and narrow and separated by wider areas of tough, massive rock. Although solid argillite is impermeable, where fractured it is permeable. If, therefore, bedrock is to be dug into in making room for the reservoir, the floor will have to be covered with an impermeable material.

The Valley Side (Ferry Road to River Road)

This area (about 1,200 feet wide) presents problems to anyone having to do with it. It was difficult, for example, moving the drill rig across it, and once the rig was set up, getting the hole down presented problems. As has already been indicated these difficulties arose from the steep slope and from the boulder strewn nature of the surface.

Three factors are involved in the situation. One is that the Delaware River has been downcutting faster than any other bodies of flowing water on either side of it. This factor is, however, in no way distinctive for it applies all along the course of the river. A second and important factor is that a rock type not encountered elsewhere on this project, is found on this slope. The geologic map accompanying Bulletin C-9 (2) shows this rock, a diabase, to crop out along Ferry Road near its juncture with Point Pleasant Pike and to extend from there to the valley side. The details of the trend of this rock on the valley side are not clearly exposed. Since diabase was cored in test holes F-19 and F-61 and argillite was cored in F-18A and F-20, the diabase crosses the surveyed lines between 18A and 20. It then probably passed, I believe, where Hickory Run goes under River Road and courses down to the canal. From there it crossed over to New Jersey where there is an excellent outcrop of the rock in a roadcut along highway #29. This diabase, being more resistant to erosion than the argillite, causes the steepness of the valley side between River Road and the site of F-18.

The third factor gives rise to the valley side being strewn with blocks and boulders of bedrock. These blocks and boulders show two interesting things. Firstly, there are abundant growths of moss and especially of fungi on them; and secondly, they show patterns of cracking which I had thought were tension cracks resulting from some heat effect as the diabase intruded nearby. Literature (1), however, indicates them to be syneresis* cracks which develop in the chemical phases of the cyclic deposition mentioned earlier in this report. Because of these cracks, as soon as rock is exposed it begins to fall apart. In addition, exfoliation starts as soon as more than one side becomes exposed and the angular corners and edges become rounded. So whatever the cause of the network of cracks, it is to its presence that the boulder field is ultimately traceable.

The entire valley side, where the surveyed line crosses, is strewn with boulders. Since the chemical cycles, within which the pattern of cracks occur average only 8 to 13 feet thick (1), there has to be some explanation for the size of the boulder field. An obvious possibility is that there are several recurring layers with the syneresis cracks in the rock section of the valley side. It is my opinion, however, that there is but one such layer. It is high up on the valley side and adjacent to the diabase. The argillite erodes faster than

* Syneresis - A spontaneous throwing off of water by a gel during aging. In the hardened or set gel the shrinkage resulting from loss of water causes cracking.

the diabase, so that once the Delaware river had cut below the diabase, it began to undercut and to widen thereby the valley. Meanwhile, the layer with the network of cracks was falling apart to boulders and blocks and these, too heavy to be moved by flowing water, were simply "let down" and eventually came to cover the slope.

Have the boulders and blocks moved down slope under the pull of gravity? There must have been such movement but there is evidence suggesting that this has been very little. Many trees grown on the valley side. Most of them are erect and straight and some of these have large circumferenced trunks at their bases suggesting a considerable age. There are some trees, however, that curve from the ground becoming erect upward, suggesting a slip of their substrate during their lifetime. At still other places on the valley side one comes across a large, dead tree lying flat, suggesting such a movement as to have knocked it over (or at least to have so weakened the root system that a strong wind knocked it over). On the whole, however, a look at the overall forest-picture suggests stability to the ground underneath.

Whether or not the abundant growth of mosses and fungi had any significance in the breakup of the rock is problematic. Their presence is probably due to an abundance of analcime in the cement of the rock. This mineral is a zeolite, a family of minerals whose molecular structure is open resulting in wide channelways in which water may be housed. It may be such water picked up from groundwater that the plants are after. Analcime has a hardness of 5-5 1/2 and gives toughness to a rock containing it.

<u>The Valley Bottom (River Road to the Delaware River)</u>

Seventeen test holes were drilled in this area and they encountered an average of 24.0 feet of overburden above the bedrock. The overburden contains considerable sand and gravel. No permeability tests were possible in these sand-gravel intervals because they were below the water table. November, it was learned during an inquiry made to the Trenton office of the Coast & Geodetic Survey which is charged with conditions along the river, was the wettest since 1897. December, too, proved to be a wet month. The ground, therefore, was thoroughly soaked during the drilling. Although not as abundant as on the valley side, large boulders were encountered in drilling the overburden. Frequently drive-sample boring had to be abandoned because of refusal. Coreing or drilling with a tri-cone roller bit was required to make progress. There were cases, too, where the driven sampler angled past boulders. Large boulders and perhaps even blocks (to 10 feet or more?) may be expected during any excavation in this area.

In general the top of the bedrock surface rises in elevation from 55 feet under F-1 to 90 feet under F-6. The rock itself is typical of the Lockatong argillite. It may prove to be harder than the argillite encountered on the plateau because of the possible baking action of the sill which was intruded stratigraphically above it. A diamond core bit has no difficulty coreing this rock where it is massive. Near fractures, however, difficulty was encountered, but not because the rock could not be cut. Rather pieces of broken rock would twist in the barrel or in the core lifter blocking downward progress. Hole F-13, for example, must have fallen directly above a fracture plane which the core bit encountered and followed down. Fifteen feet of bedrock was cored (27'-42') in an attempt to get broken rock. F-13A relocated (at the driller's request) about 10 feet away encountered good rock immediately under the overburden.

Bedrock conditions are well illustrated in the face of the quarry along Point Pleasant Pike where the latter ascends the valley side. The argillite and the diabase are also well illustrated in road cuts along highway #29 directly across the river near Byram, New Jersey.

(1) Subitzky, Seymour (editor), Geology of Selected Areas in New Jersey and Eastern Pennsylvania, 1969, Rutgers University Press.

(2) Bulletin C-9, Bureau of Topographic & Geologic Surveys, Harrisburg, Pa.

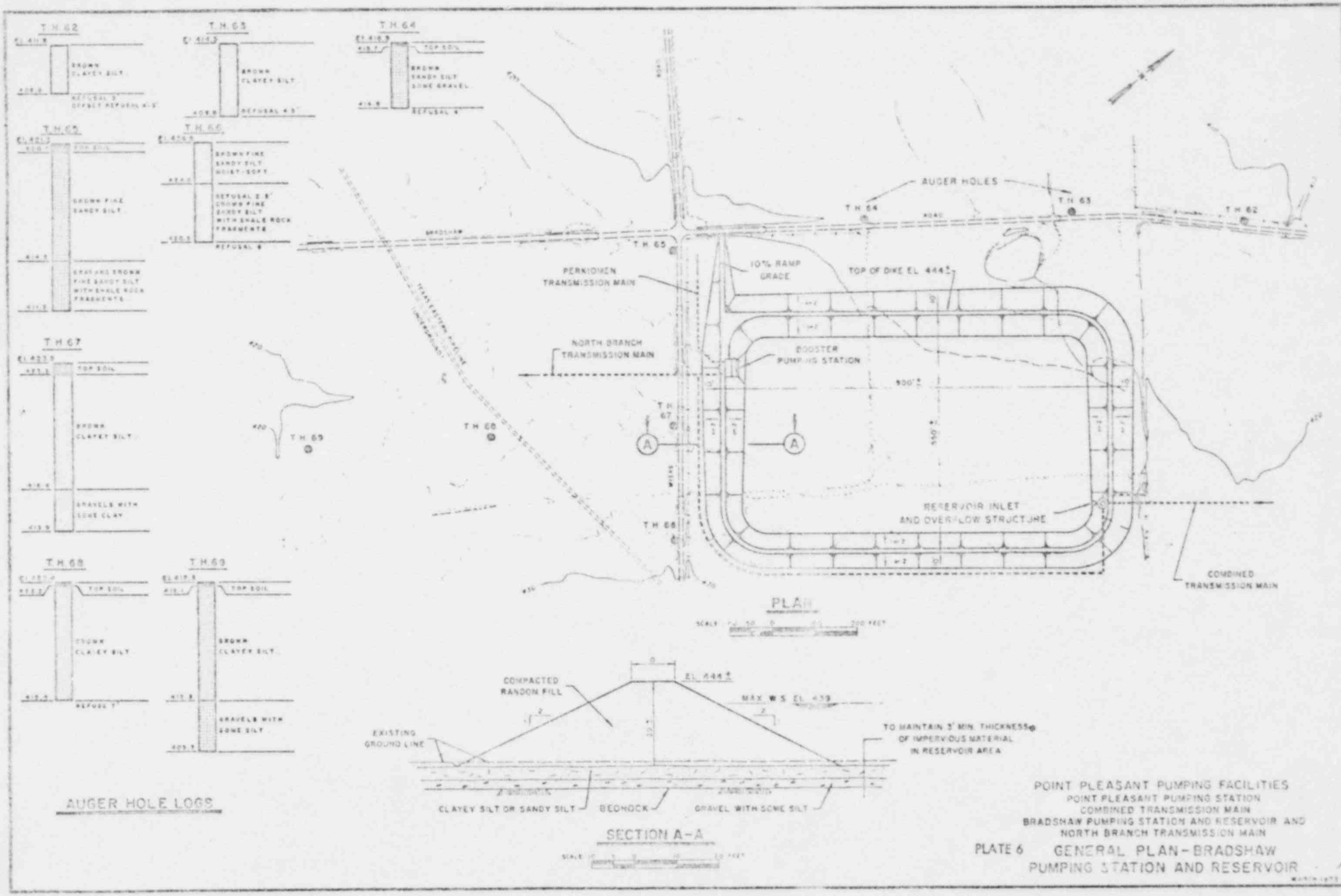
SUMMARY OF SOIL CHARACTERISTICS

Location	Sample Depth	Soil Type	% Gravel	% Sand	% Silt	% Clay	LL/PI	PHI	Tangent	Cohesion psi	Stress Type	Lab Permeability cm/sec.	Samples
TP1	.9-2'	ML	8	5	66	21	26/3	27°-30' 24°-30'	0.5206 0.4557	2.0 2.5	Effective Total	.00005	Undisturbed
TP2	-	ML-CL	1	2	72	25	25/4	-	-	-	-	-	Undisturbed
TP3A	1'-2'	MC-CL	12	8	54	26	28/6	29°-0' 29°-1'	0.5543 0.5547	6.1 5.5	Effective Total	.00004	Undisturbed
TP7A	1.5'-2.5'	ML	0	2	68	30	27/5	-	-	-	-	.00245	Undisturbed
TP8A	-	CL	1	1	64	34	30/9	31°-0' 29°-30'	0.6009 0.5658	8.8 9.0	Effective Total	.000085	Undisturbed
AH17	.5'-5'	CL	19	16	33	32	30/9						Disturbed
AH21	2'-3.5'	CL	4	17	43	36	30/8						Disturbed
AH24	0-3'	CL	10	7	51	32	30/9						Disturbed
AH28	.5'-5'	CL	13	17	33	37	31/8						Disturbed
TP4	0-2'	CL	9	5	59	27	30/9	28°-0'	0.5317	7.0	Total		Disturbed
TP5	0-6.5'	CL	0	1	64	35	32/10	25°-30'	0.4770	14.0	Effective		Disturbed
TP6	4'-7'	ML	8	20	54	18	24/2	28°-30'	0.5430	14.0	Effective		Disturbed
AH38	-	CL	14	11	43	32	28/8	-	-	-	-		

Location	Optimum Moisture %	Dry Density pcf	Wet Density pcf
TP4	17	108.6	128

Exhibit 4
Wescott (Bradshaw)

E. H. BOURQUARD ASSOCIATES, INC.



POINT PLEASANT PUMPING FACILITIES
POINT PLEASANT PUMPING STATION
COMBINED TRANSMISSION MAIN
BRADSHAW PUMPING STATION AND RESERVOIR AND
NORTH BRANCH TRANSMISSION MAIN

PLATE 6 GENERAL PLAN – BRADSHAW PUMPING STATION AND RESERVOIR

Exhibit 5

Exhibit 5 Wescott (Bradshaw)

DOCKETED USNRC

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

'82 AUG 23 P4:12

Before the Atomic Safety and Licensing Board

In the Matter of	)	
	)	
Philadelphia Electric Company	)	Docket No. 50-352-OL
	)	50-353-OL
(Limerick Generating Station, Units 1 and 2)	)	

II

Lewis/Hodgdon/Chan/Chandler
Rutberg/PF

DEL-AWARE'S ANSWERS TO APPLICANT'S
INTERROGATORIES AND REQUEST FOR PRODUCTION OF DOCUMENTS

Del-AWARE's Answers are complete based on present information, but will be supplemented as required under 10 C.F.R. Part 740(e), and/or if further contentions are admitted by the Board. All Answers to Interrogatories were prepared by counsel for Del-AWARE Unlimited, Inc.

1. (a) The location of the intake structure as presently proposed, that is, at Station 8+65 will have such an impact. Del-AWARE does not possess sufficient information at this time to determine precisely where the intake could be located to mitigate such impacts, although Del-AWARE believes that such location would be out of the area of influence of the eddy and pool. The basis for this answer is more fully described in Del-AWARE's Answer to NRC Staff's Interrogatories S-1 through S-6, which are incorporated herein by reference.

(b), (c), and (d) See Del-AWARE's answer to NRC Staff Interrogatories S-1 through S-6, incorporated herein by reference.

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(e) Del-AWARE has not at this time developed precise criteria in qualitative terms for judging such effects.

(f) Del-AWARE is not aware of any such study or comparison at this time.

5. Del-AWARE relies on no other bases at this time.

6. (a) See Del-AWARE's answer to NRC Staff's Interrogatories S-11, S-12, and S-15, which are incorporated herein by reference.

(b) Groundwater contamination is defined in Del-AWARE's answer to NRC Staff's Interrogatory S-14, which is incorporated herein by reference. Hydraulic saturation refers to the groundwater table level.

(c) See Del-AWARE's answer to NRC Staff's Interrogatory S-12, which is incorporated herein by reference. Concentrations, to the extent known, are described in the documents referred to in Del-AWARE's answers to NRC Staff's Interrogatories and in the references thereto, all of which are incorporated herein by reference.

(d) The mechanism by which seepage will occur includes constant permeation, soil slope and stability failure of Bradshaw Reservoir.

(e) The seepage is expected or projected to occur in proportion to the concentrations found in the water, the measurements of which, to the extent known, are contained in the documents referred to in answer to Interrogatories (a)

RELATED CORRESPONDENCE Exhibit 6 Wescott (Bradshaw)

DOCKETED USNRC

'82 AUG 23 P4:10

UNITED STATES OF AMERICA
NUCLEAR REGULATORY COMMISSION

Before the Atomic Safety and Licensing Board

In the Matter of)
)
Philadelphia Electric Company) Docket No. 50-352-OL
) 50-353-OL
(Limerick Generating Station,)
Units 1 and 2))

II Lewis/Hodgdon/Chan Chandler/Rutberg/FF

DEL-AWARE'S ANSWERS TO NRC STAFF'S DISCOVERY REQUESTS

Del-AWARE's Answers are complete based on present information, but will be supplemented as required and permitted under 10 C.F.R. 740(e), and/or if additional contentions are admitted by the Board.

Answers to General Interrogatories

G-1 (a) Del-AWARE intends to present the following expert witnesses with respect to Contention V-15:

Mr. Norman Torkelson (Residence: Box 22, Stockton, NJ; Business: Sundrive, Inc., Box 875 RD2, Stockton, NJ 08559), will testify regarding the water quality of the Delaware River in the Point Pleasant area, the nature and extent of aquatic biota in that area, the likelihood of future water quality changes as a result of the project, and the projected impact on aquatic biota. The content of Mr. Torkelson's testimony is summarized, the basis thereof is stated, and his expertise is described, in his deposition taken by Applicant on August 12, 1982.*

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* Del-AWARE presently has no information available regarding the expertise of its witnesses other than as presented in their depositions.

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E.H. Bourquard, and other material identified in answer to Interrogatories G-1 and G-2, and analyses of Edwin Beemer.

S-14 Contamination to groundwater consists of intrusion into groundwater of toxic material in amounts which may be harmful to people, animals and vegetation.

S-15 The soils to be used in creating the Bradshaw Reservoir are not sufficiently adhesive to prevent the substantial likelihood of slumping and destabilization, permitting substantial runoff and seepage into the ground. It appears that the potential for destabilization is by far the more significant potential adverse effect.

S-16 As used by Del-AWARE, the term, "hydraulic saturation" means below the groundwater table. Del-AWARE does not consider hydraulic saturation to present a risk comparable to that posed by groundwater contamination.

S-17 Del-AWARE's contentions regarding Bradshaw Reservoir are based on studies referred to in answer to Interrogatories G-1 and G-2, and in the Phillipe deposition of August 13, 1982, and analyses of Edwin Beemer. Details of how the data and the conclusions of these studies support Del-AWARE's contention, to the extent presently known, are contained in Phillipe's testimony of August 13, 1982, a copy of which is available to the Staff.

Robert J. Sugarman
Attorney for Del-AWARE