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FINAL REPORT

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TECHNICAL EVALUATION OF ZONE OF CONTAMINATION 1 (GENTLE CLEANERS, GRANITE KNITTING MILLS, PARKSIDE APARTMENTS SITE) SOUDERTON, PENNSYLVANIA

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AUGUST 1, 1988

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1.0 EXECUTIVE SUMMARY

Versar Inc. has completed a review of available documents submitted for Zone of Contamination 1 located in Souderton, Pennsylvania. Three potentially responsible parties (PRPs) have been identified within this zone: Granite Knitting Mills, Inc., Gentle Cleaners, Inc., and Parkside Apartments. This report evaluates the completeness and adequacy of information gathered with respect to the criteria in EPA remedial investigation/feasibility study (RI/FS) guidance documents, the National Contingency Plan (NCP), and quality assurance/quality control standards (e.g., National Data Validation Standards and the Contract Laboratory Program). The scope of this work assignment did not stipulate that Versar identify or investigate other facilities in the zone which have not been identified as PRPs, but may have contributed to the contamination. Identification of additional PRPs in the future could prompt generation of new information requiring Versar's evaluation within the scope of this work assignment. The results of this study were developed from evaluating only data and information made available to Versar from the sources listed below.

Contamination was first discovered within Zone of Contamination 1 by the North Penn Water Authority (NPWA) in 1979. Volatile organic compounds were discovered in 2 local water supply wells and in two private wells. The contaminants included perchloroethylene, 1,1,1-trichloroethane, trichloroethylene, 1,1-dichloroethane, 1,1-dichloroethylene, and cis/trans-1, 2-dichloroethylene (Reference 10).

To date, no RI/FS has been performed for Zone of Contamination 1 or for any of the individual PRPs within the zone. The information available for the three PRPs was obtained from the North Penn Water Authority (NPWA), EPA Region III, NUS Corporation, and from the site visit performed by Versar on May 8, 1987, and includes site discovery and hazard ranking reports, as well as data submitted by the PRPs and background reference material. Findings from the review of this information are presented in Sections 4.0 and 5.0 of this report.

Recommendations for further studies and a characterization of the PRPs' relationships to the contamination are found in Section 6.0.

Overall, the review team found the information available about the zone to be sketchy and incomplete when compared with the RI/FS guidelines, particularly since no RI/FS was ever performed for Zone of Contamination 1. The data available is inadequate to support any remedial investigation or remedial action, beyond temporary remedial measures. The majority of the information reviewed was for Granite Knitting Mills. Virtually no information is available about the chemicals and wastes handled and the current or past methods of disposal at the Parkside Apartments property. Only a small amount of information is available for Gentle Cleaners, Inc. The existing information about the site is specifically lacking in the following areas:

- Local subsurface conditions, including both aquifer parameters and quality of ground water, have not been clearly defined. Additional data on ground-water quality needs to be made available for review.
- Necessary background information on site operations and physical conditions within and around the zone, including demographics, land use, and meteorological information, is incomplete.
- Information about the types, forms, and means of handling wastes must be obtained before a feasibility study is performed. In particular, information about waste handling processes at the Gentle Cleaners facility should be made available for review.
- Basic information on flow characteristics and quality of air and surface water is not available.
- The potential for contaminants to travel by pathways other than ground water, such as by surface water routes, has not been determined.

At this point, it is difficult to associate any single PRP as a source of the contamination plume defined by NUS. Some information leads to Gentle Cleaners as a source, but a lack of detail prohibits any definite conclusions from being made. It is possible that all three PRPs

may be contributors to the plume, but the extent and time frame of their contributions may vary widely. Further study of the area is essential to locate other potential PRPs as well as to define the means and paths of contamination.

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2.0 INTRODUCTION

The North Penn area of Pennsylvania, located primarily in central Montgomery County, includes a 220-square mile region where volatile organic compounds have contaminated ground water and drinking water supply wells. The contamination was first discovered by the North Penn Water Authority (NPWA) in 1979. To date, 12 zones of contamination have been defined in the North Penn area. Six of these zones have been proposed for inclusion on the National Priorities List (NPL). This report concerns the northernmost of these six zones, Zone of Contamination 1, in Souderton, Pennsylvania. The potentially responsible parties (PRPs) identified for Zone 1 include Gentle Cleaners, Inc., Granite Knitting Mills, Inc., and Parkside Apartments.

In mid-March 1987, the CDM Federal Programs Corporation/Versar team received work assignment number 332 from U.S. EPA under the TES III contract to perform a review and evaluation of existing data from Zone of Contamination 1. These data were evaluated against recommended guidelines and needs developed from EPA guidance documents (Reference 13, 14) and the National Contingency Plan (NCP). Copies of the existing data and other references are included in the reference section of this report. Not all references are cited in this document, but are included for completeness of information. A visual site inspection of the facilities in this zone was performed on May 8, 1987, to obtain additional background information. This report details the findings of Versar's evaluation, and is included in Appendix B.

In addition to the RI/FS data overview, EPA asked Versar to summarize existing data and information, and independently acquire additional information through follow-up of sources when possible, regarding hydrogeologic characterization of the North Penn area and each of the six zones proposed on the NPL. The hydrogeologic study of the North Penn area is presented as Appendix A of this report. Any hydrogeologic information specific for Zone of Contamination 1 is presented and discussed in Section 2.4 of this report.

2.1 History of Zone of Contamination 1

In 1979, NPWA detected tetrachloroethylene (PCE) in one of their production wells, well S-9, in Souderton, Pennsylvania. Service of this well was discontinued at that time. Subsequent ground-water sampling has resulted in the detection of various volatile compounds including PCE, 1,1,1-trichloroethane (1,1,1-TCEA), trichloroethylene (TCE), 1,1-dichloroethane (1,1-DCA), 1,1-dichloroethylene (1,1-DCE) and cis/trans-1,2-dichloroethylene (c/t-1,2-DCE) in two private wells and an additional NPWA well (well S-10). The most significant degree of contamination was detected in a private well located on the Granite Knitting Mills property (see Figure 1). Levels of 1,1,1-TCEA at 249.5 ppb (Reference 10) and PCE at 61 ppb (Reference 9) have been detected. Levels of 1,1,1-TCEA exceed the EPA proposed maximum contaminant level of 200 ppb, and levels of PCE exceed EPA recommended standards of 10 ppb (Reference 9). See Table 1 for a listing of sampling results. Well locations are shown in Figure 5. On January 22, 1987, Zone of Contamination 1 was listed by EPA as a proposed addition to the NPL. According to NPWA, PRPs for this contamination include Gentle Cleaners, Inc., Granite Knitting Mills, Inc., and Parkside Apartments (Reference 9). Gentle Cleaners and Granite Knitting Mills have a history of using PCE and/or other chlorinated hydrocarbons as solvents or cleaners. Parkside Apartments has no history of use of these compounds, however, the site previously housed a dry cleaning establishment that may have contributed to the contamination of ground water in the area (Reference 9).

All three PRPs are located in the town of Souderton, Montgomery County, Pennsylvania. Approximate locations of the PRPs and the NPWA wells are shown in Figure 3. The area of concern has a large urban population, and also has a large number of industrial businesses that may have used or may currently be using chlorinated solvents in their processes. Water in this area is supplied by both the NPWA and private wells.

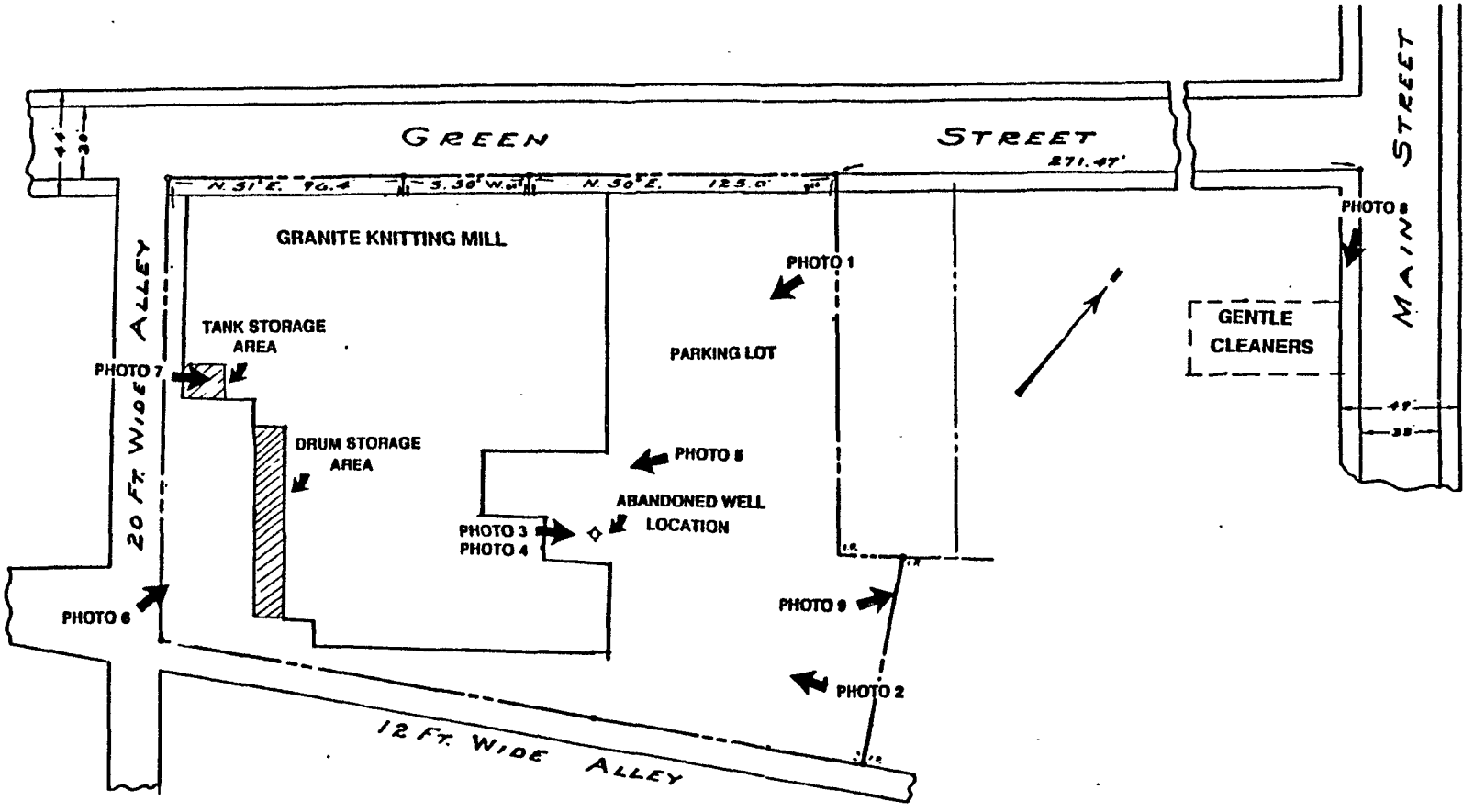

FIGURE 1
APPROXIMATE BUILDING AND PROPERTY BOUNDARIES,
WELL AND PAST STORAGE LOCATIONS, AND PHOTOGRAPH LOCATIONS
GRANITE KNITTING MILL AND GENTLE CLEANERS
SOUDERTON, PENNSYLVANIA
(Parkside Apartments off diagram, to the southwest)
Photographs included in Appendix C

NOT TO SCALE

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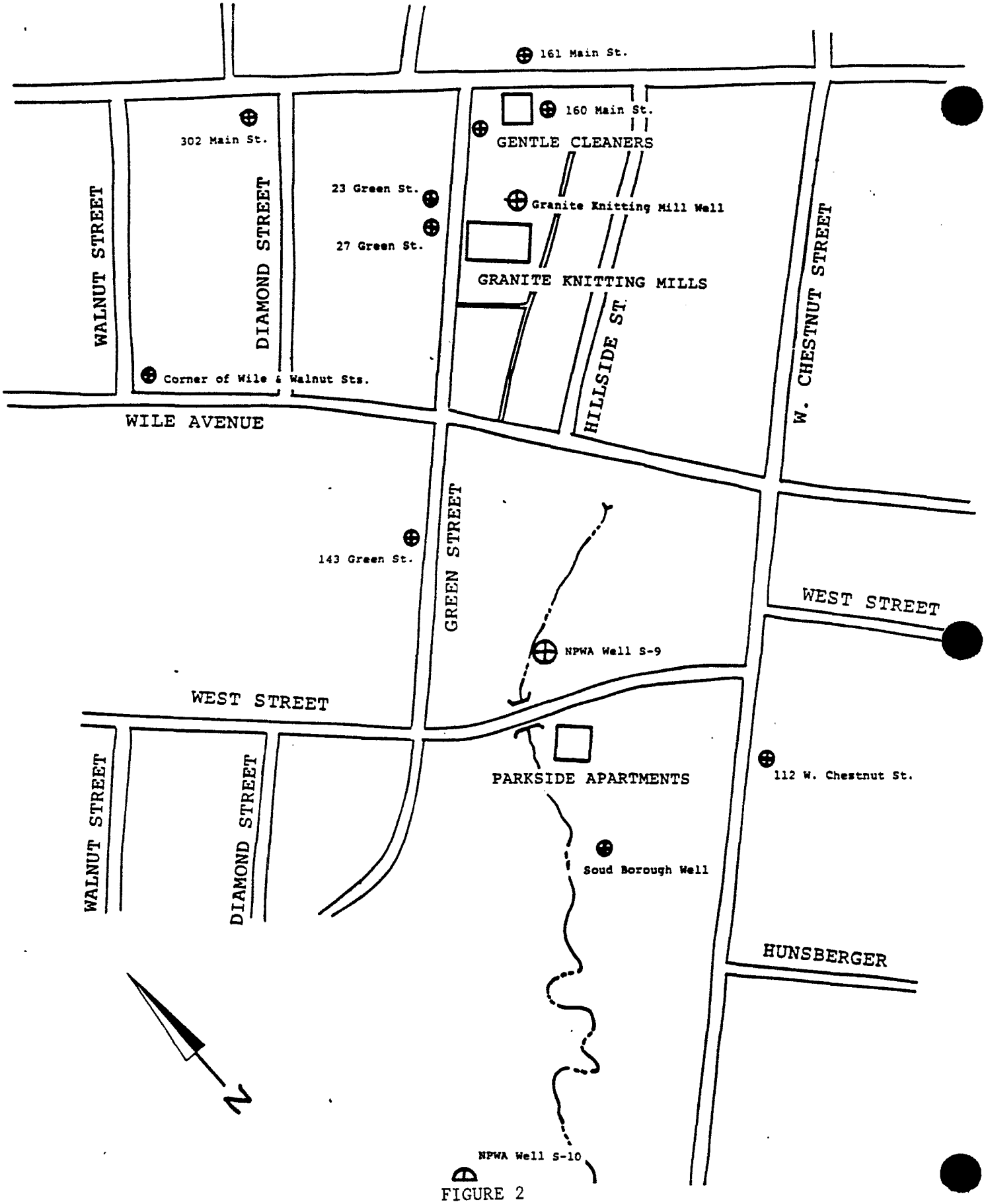

FIGURE 2
APPROXIMATE SAMPLING LOCATIONS FOR THE NUS AUGUST 28, 1986, SAMPLING EVENT, SOUDERTON, PENNSYLVANIA
(ADAPTED FROM NPWA SOUDERTON BOROUGH DISTRIBUTION MAP, REVISED DECEMBER 22, 1983)
(Reference 10)

SCALE 1" = 300'

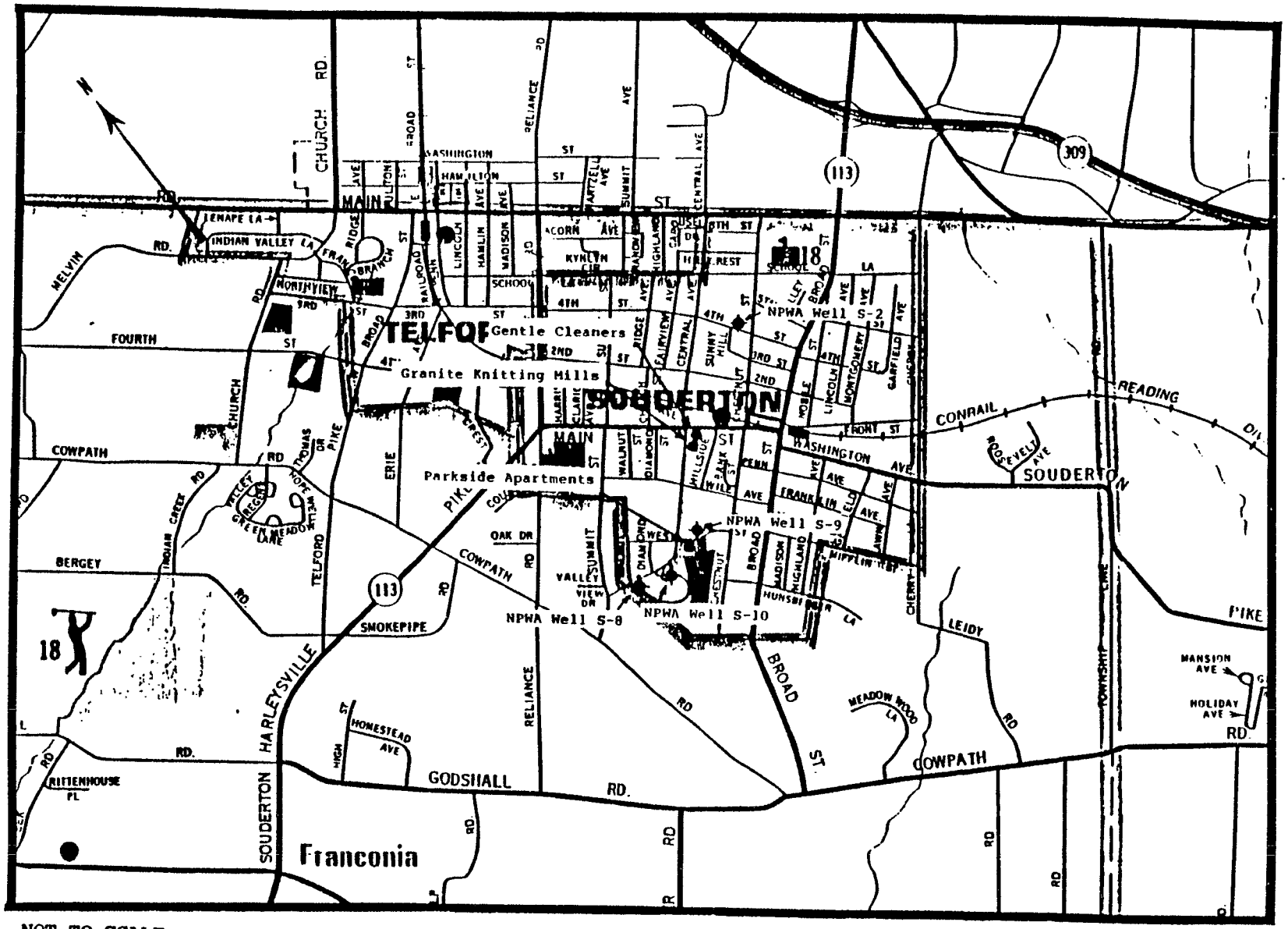

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FIGURE 3
APPROXIMATE LOCATION MAP OF THE PRP FACILITIES AND
THE NPWA WELLS IN ZONE OF CONTAMINATION 1, SOUDERTON, PENNSYLVANIA
(MONTGOMERY COUNTY COMMISSIONERS, 1985)

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Gentle Cleaners, Inc. is located at 162 North Main Street in Souderton at a topographic high within Zone 1. The facility is situated just south of the intersection of Main and Green Streets, approximately 1,400 feet north of NPWA well S-9. The company used approximately 75-100 gallons of PCE per month in its dry cleaning operations from 1953 to 1983. In 1983, a new dry cleaning machine was purchased and PCE use was reduced to approximately 50 gallons per month (Reference 10).

PCE has been stored onsite in either a storage tank or drums. At one time, an underground storage tank may have been used (Appendix C). The presence of this storage tank could not be confirmed by NPWA (Reference 1) or by Versar. The exact storage practices currently employed at the site are unknown. Waste PCE is contained within the dry cleaning machine in filters, which are removed periodically by Safety Kleen Corporation, Elgin, Illinois (Reference 10). The cleaners also use spotting mixtures which contain varying amounts of solvents, brighteners, and detergents. The solvents include 1,1,1-TCEA, various petroleum distillates, and other chlorinated solvents of unknown composition. The spotting chemicals are used in quantities of less than 1 gallon (Reference 18).

It is not known how many years before 1953 that Gentle Cleaners operated at this site. They have held their current lease since July 1985. No other information is available on the history or current practices of the Gentle Cleaners facility.

Granite Knitting Mills, Inc. owns property downgradient and approximately 200 feet southwest of Gentle Cleaners, along Green Street (see Figure 3). The facility operated as a knitting mill beginning in at least the early 1960s. In 1969, control of the mill was taken over by a local bank. In early 1976, the bank relinquished control of the facility and Mr. Lake Clemmer became the major stock holder and president of Granite Knitting Mills, Inc. With the exception of the years in which the bank had control of this property, the Clemmer family has been involved in the company throughout most of its history (Appendix C).

In 1967, a dry cleaning machine was installed at the facility for use in the cleaning of yarns processed by the mill. PCE was used in this process. In 1979, the machine was removed. Use of this machine ceased some time prior to removal (Appendix C). The PCE was recycled in the dry cleaning machine, while waste residues and oils were drummed and stored on the southwest side of the building. The waste drums were collected by Towamencin Township road crews for spraying on local roadways, or by an unknown waste disposal firm (Reference 10). These wastes were estimated to contain approximately 2 percent PCE (Appendix C). Approximate locations of the tank storage area and the drum storage area are given in Figure 1.

Currently, Granite Knitting Mills leases its warehouse to Standard Terry Mills, Inc., a company owned by Mr. Clemmer since 1953. Standard Terry Mills operates a weaving business at this facility. PCE is no longer used at the site (Appendix C). Small quantities of Zep Safety Solvent, which contains 1,1,1-TCEA, methylchloroform, and chloroethene, are currently being used to clean and degrease the looms. The product is wiped on and allowed to evaporate leaving no waste material. Only one 55-gallon drum of this solvent is used at the facility every two or three years. This drum is stored within the warehouse (Appendix C).

Parkside Apartments are located approximately 100 feet south of NPWA well S-9 on West Street, south of both Gentle Cleaners and Granite Knitting Mills (see Figure 3). The apartments are currently owned by Mr. Paul Derstein (Reference 9). It has been reported by NUS that a dry cleaning establishment may have been located at this site at some time in the past. Mr. Clemmer recalls a dry cleaning operation at this site approximately 15-20 years ago (Appendix C). The dry cleaners may have had an underground storage tank on the property for storing PCE; however, the presence of this tank has not been confirmed (Reference 9). No additional information is available about this site.

2.2 Previous Environmental Investigations

Ground-water sampling has occurred in Zone of Contamination 1 since the discovery of PCE in NPWA well S-9 in 1979 (Reference 10). Very little sampling data for the area during this time period were available. NPWA well S-10 was sampled every two weeks during 1985 by NPWA. Although no details of this sampling are available, the results are presented in Figure 4, which indicates levels of PCE in this well of 1.2-2.6 ug/l (Reference 9).

In January 1986, NPWA conducted a pump test at well S-9. During a 45-hour period, the well was continuously pumped and ground-water samples were taken at various time intervals. The results of this pump test are given in Figure 5. PCE concentrations fell from 24.7 ug/l to 10.6 ug/l after 24 hours of pumping. Levels increased slightly to 13.6 ug/l over the final 21 hours of the test (Reference 9). Specific details of the pump test, sample collection, and sample analysis were not given.

In 1986, NUS Corporation was contracted by U.S. EPA to perform a site discovery in the North Penn area. They completed this study in July 1986. As part of this study, they examined each of the six zones of contamination which had been proposed for the NPL, including Zone of Contamination 1. Background information on each of the zones was given, as well as selected information about the area including demographics, environmental setting, and hydrogeologic information (Reference 9).

On August 28, 1986, an NUS Field Investigation Team (FIT III) conducted sampling of area wells in Zone 1. Neither a sampling plan nor field data was given for this event. Samples were analyzed by NPWA laboratories and results are given in Table 1. Three wells, including Soud Borough well, a well at 12 Green Street, and the Granite Knitting Mill Well exhibited contamination. The highest concentrations of contaminants were found in the Granite Knitting Mills well. All six compounds analyzed were detected in this well. (Reference 10). Specific sampling locations are shown in Figure 2.

S-10 RESULTS FOR 1985 ug/L

DATE	DAY #	SAMPLE #	TCE	PCE	1,1,1-TCA
07-Jan-85	7	63	0.7	1.5	<0.5
21-Jan-85	21	148	<0.5	2.1	<0.5
11-Feb-85	42	354	<0.5	1.9	<0.5
25-Feb-85	56	443	<0.5	2.3	<0.5
11-Mar-85	70	532	<0.5	2.4	<0.5
25-Mar-85	84	682	<0.5	1.7	<0.5
22-Apr-85	112	834	<0.5	1.5	<0.5
06-May-85	126	971	<0.5	1.8	<0.5
20-May-85	140	1063	<0.5	2.1	<0.5
03-Jun-85	154	1160	<0.5	2.2	<0.5
17-Jun-85	168	1247	<0.5	1.9	<0.5
24-Jun-85	175	1286	<0.5	2.6	<0.5
08-Jul-85	189	1351	<0.5	1.2	<0.5
22-Jul-85	203	1466	<0.5	1.8	<0.5
05-Aug-85	217	1534	<0.5	2.3	0.6
19-Aug-85	231	1645	<0.5	1.8	0.6
03-Sep-85	246	1759	<0.5	2.0	<0.5
16-Sep-85	259	1853	<0.5	2.2	0.5
07-Oct-85	280	1954	<0.5	1.3	<0.5
21-Oct-85	294	2123	<0.5	1.8	<0.5
04-Nov-85	308	2202	<0.5	1.3	<0.5
09-Dec-85	343	2539	<0.5	1.7	<0.5
30-Dec-85	364	2670	<0.5	2.4	<0.5

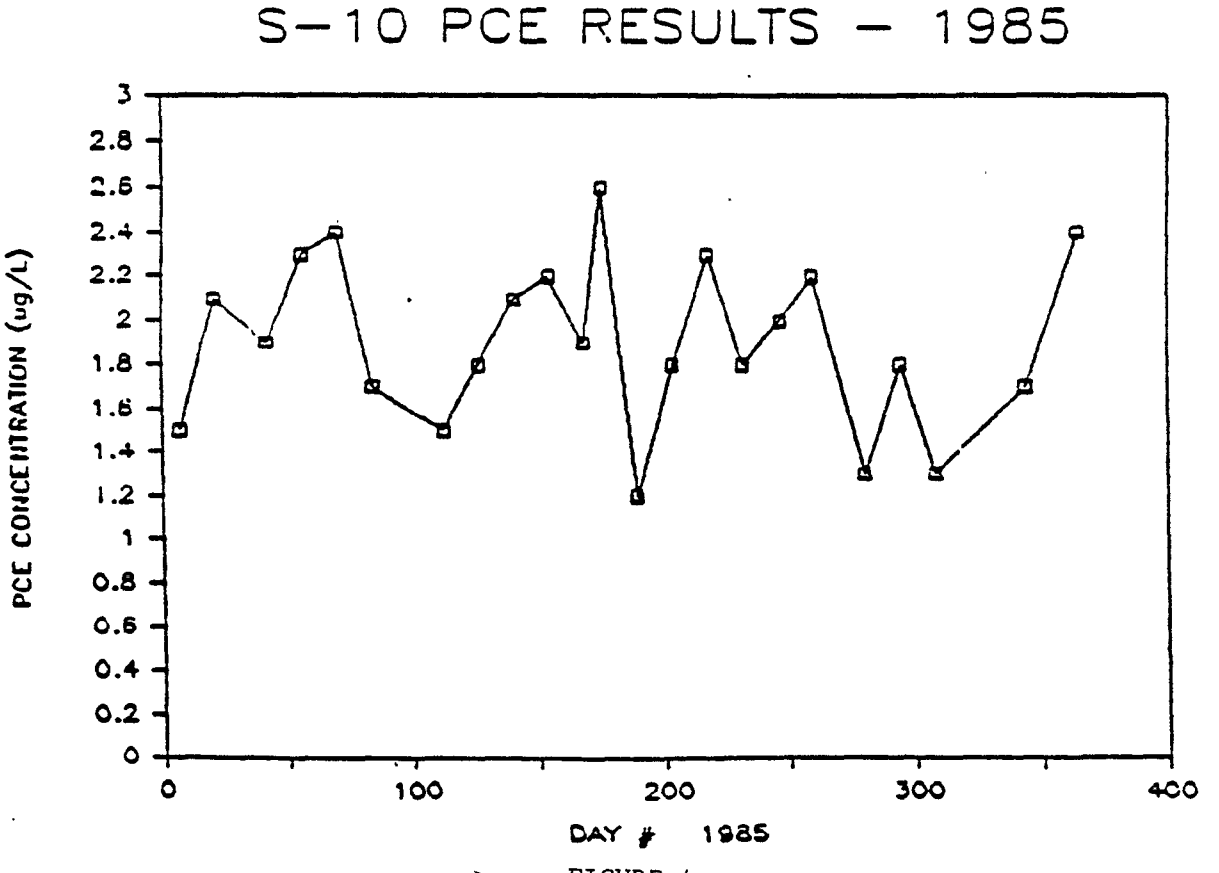

FIGURE 4
PCE CONCENTRATIONS IN NPWA WELL S-10 FOR 1985
(Reference 9)

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TABLE 1
ANALYTICAL RESULTS FOR THE NUS AUGUST 28, 1986,
SAMPLING EVENT, SOUDERTON, PENNSYLVANIA

RESULTS OF SOUDERTON AREA SAMPLING PERFORMED BY NUS

Samples Collected: 8-28-86
Date Analyzed: 9-2-86
Analyzed by: J.A. Coyle, North Penn Water Authority Laboratory

Method Used: EPA Method 502.1

All results expressed as ug/L.

NPWA SAMPLE #	NUS SAMPLE #	LOCATION	1,1-DCE	1,1-DCA	c/t-1,2-DCE	1,1,1-TCA	TCE	PCE
1825-86	S-1	NPWA Well S-10	<0.5	<0.5	<0.5	<0.5	<0.5	1.7
1827-86	S-2	NPWA Well S-9	<0.5	<0.5	<0.5	<0.5	<0.5	13.4
1829-86	S-3	Soud Borough well after 2 hours	<0.5	<0.5	0.5	<0.5	5.0	4.5
1831-86	S-4	Soud Borough well before purge	<0.5	<0.5	<0.5	<0.5	4.8	3.5
1833-86	S-5	112 W. Chestnut St	<0.5	<0.5	0.5	0.5	<0.5	<0.5
1835-86	S-6	143 Green St	0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1837-86	S-7	27 Green St	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1839-86	S-8	23 Green St	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1841-86	S-9	12 Green St	<0.5	<0.5	<0.5	<0.5	<0.5	4.1
1843-86	S-10	Granite Knitting Mill	9.9	4.4	23.0	249.5	12.2	33.5
1845-86	S-11	160 Main St	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1847-86	S-12	161 Main St	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1849-86	S-13	Duplicate of S-11 160 Main St	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1851-86	S-14	Corner of Mile & Walnut Sts	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1853-86	S-15	302 Main St	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5
1855-86	S-16	Blank	<0.5	<0.5	<0.5	<0.5	<0.5	<0.5

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S-9 PUMPING TEST, 1986

LOCATION	DATE	MIN FR START	SAMP #	ug/L PCE	C-1,2-DCE	TCE	1,1,1-TCA
S-9 TEST, 1 MIN	27-Jan-86	0.017	261	24.7	0.7	0.7	<0.5
S-9 TEST, 10 MIN	27-Jan-86	0.17	262	18.6	0.6	0.6	<0.5
S-9 TEST, 1 HOUR	27-Jan-86	1	263	13.7	0.5	0.5	<0.5
S-9 TEST, 7 HRS	28-Jan-86	7	272	10.6	0.5	<0.5	0.5
S-9 TEST, 24 HRS	28-Jan-86	24	275	10.6	<0.5	<0.5	0.6
S-9 TEST END	29-Jan-86	45	282	13.6	<0.5	<0.5	0.6

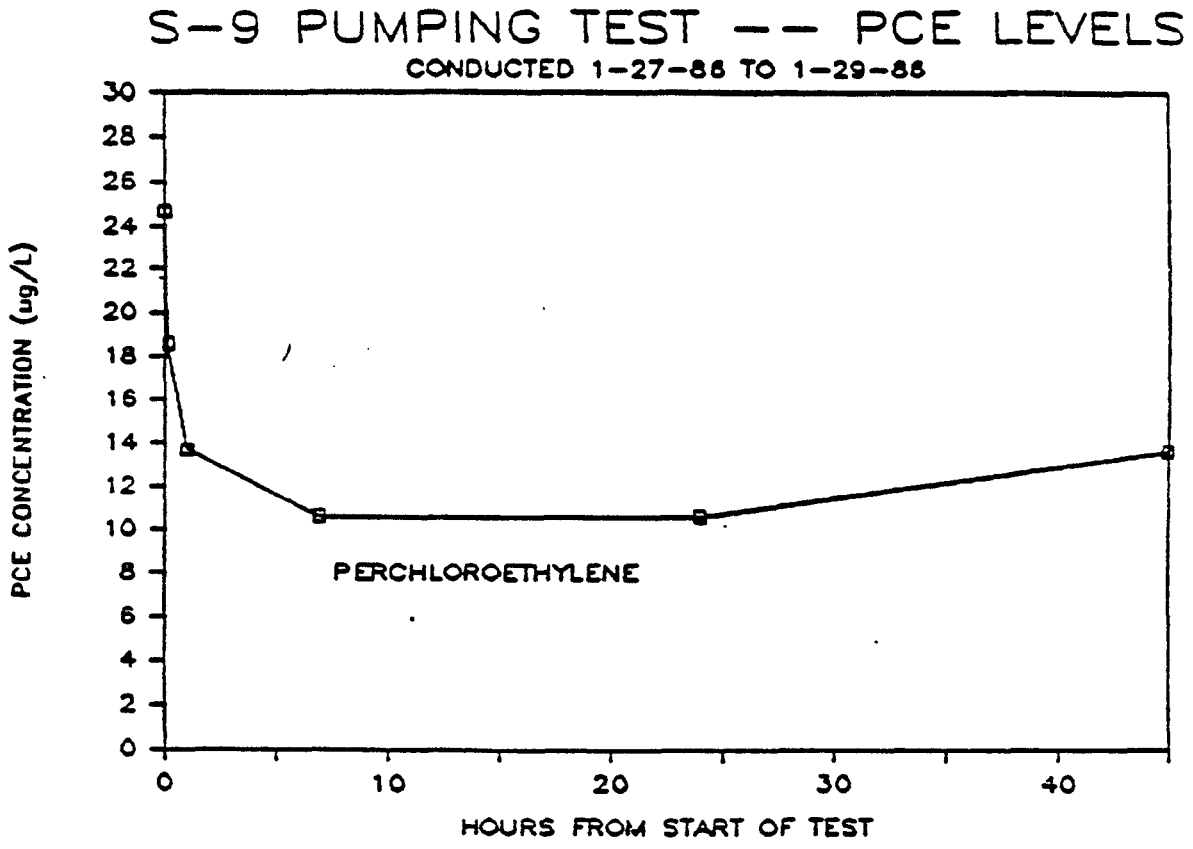

FIGURE 5
ANALYTICAL RESULTS FOR SAMPLES TAKEN FROM NPWA
WELL S-9 DURING A 1986 PUMP TEST
(Reference 9)

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In October 1986, NUS submitted to EPA a Hazard Ranking System report for Gentle Cleaners and Granite Knitting Mills. (Reference 10). This report included additional references regarding the site and regional geology. This completed the studies performed by NUS.

No additional studies are known to be documented for Zone of Contamination 1. It is known that Granite Knitting Mills has initiated an internal investigation which may have included some soil sampling on their premises (Appendix C). However, this effort has not been documented and cannot be evaluated.

2.3 Site Visit Information

On May 8, 1987, Versar visited Zone of Contamination 1 in Souderton, Pennsylvania. The visit consisted of a tour of the Granite Knitting Mills facility, a drive around the zone to observe locations of other PRPs and the NPWA wells, and an informal discussion of site history with representatives of Granite Knitting Mills. A report detailing this inspection is included in Appendix B. Photographs taken during the visit, and a copy of Versar's site inspection field notes, are include in Appendix C.

The following information was obtained during the visit to Zone of Contamination 1:

- The Granite Knitting Mills facility occupies a lot approximately 160 feet by 220 feet (see Photographs 1 and 2). The mill site consists of a large warehouse covering most of the property from the westernmost edge along Green Street to the fence that borders an alley along the easternmost edge of the property. The property on the northern and southern sides of the facility is mostly asphalt parking lots, with a small grassy area on the northern side of the building in the area of the Granite Knitting Mills well. The westernmost portion of the warehouse is a large unmarked tan cinderblock building with no windows. This portion of the building now houses weaving operations. The easternmost end of the warehouse is a brick building which has been used as a woodworking shop (Appendix C). This portion of the building now appears to be vacant.

- Private residences are located on all sides of the Granite Knitting Mills facility (see Photograph 9). A small clinic was located across the parking lot on the north end of the property.

- Specific areas of Granite Knitting Mills which were inspected during the visit included the Granite Knitting Mills well, the room which housed the dry cleaning machine and the PCE storage tank, the area where PCE was transferred from trucks to the PCE storage tank, and the areas where drums of waste PCE were stored prior to pickup (see Photographs 3, 4, 5, 6, and 7). No evidence of release of hazardous materials was found.

- The Granite Knitting Mill well is located on the northern side of the facility under a concrete pad. The well has not been used in 20 years, except for the occasional collection of samples (Appendix C). The area around the well is grass with several concrete pads which at some time supported some type of tower. Upslope to the north is an asphalt parking lot which slopes gently towards the well. (See Photograph 3)

- The room which housed the dry cleaning machine and the PCE storage tank is located on the southern side of the building near the loading dock. Both the tank and the machine have been removed and there was no visible evidence of release in this area (see Photograph 7). The PCE tank was filled from the outside through a hole in the wall (Appendix C); however, the hole has been covered over. PCE was transferred from trucks which could pull along the south side of the building on an asphalted alleyway. There was no evidence of spills in this area.

- Just outside of the loading dock area, along the edge of the building, 55-gallon drums of waste material were stored before they were removed for disposal. This area is also covered over with asphalt; however, the asphalt in this area is worn and broken in some areas (see Photograph 6). It was in this area that Granite Knitting Mills claims to have collected soil samples (Appendix C). Information on the analyses or compositions of these samples was not available at the time of this report.

- Along with a tour of the facility, Granite Knitting Mills' representatives (L. Clemmer, K. Gingrich, and J. Maza) provided a driving tour of Souderton, which included a look at the other PRPs (i.e., Gentle Cleaners, Parkside Apartments) and the NPWA well S-9 (see photograph 8). EPA did not arrange for Versar to inspect the Gentle Cleaners facility or Parkside Apartments complex. During the tour, Granite Knitting Mills' representatives mentioned several miscellaneous facilities in the area which they believe might have used organic solvents at one time, and might have contributed to the current contamination problem. (e.g., welding shops, mechanical repair shops, garages).

2.4 Geological Setting

2.4.1 Location

Zone of Contamination 1 is located in southeastern Pennsylvania, in the town of Souderton, Montgomery County. The zone is located in the Piedmont Physiographic Province. The PRPs for this zone are all located within 1/2 mile of one another. Gentle Cleaners and Granite Knitting Mills are located within 200 feet of one another. Gentle Cleaners is located at the topographic high and the northernmost end of the zone, at an approximate elevation of 400 feet. Parkside Apartments is located southwest of Gentle Cleaners and Granite Knitting Mills, and topographically lower than the other two facilities at an approximate elevation of 360 feet. The land slopes gently towards the southeast (Reference 15).

One of the main tributaries to Skippack Creek has its headwaters approximately 800 feet southeast of Gentle Cleaners and Granite Knitting Mills. Parkside Apartments are located on the easternmost side of the tributary, approximately 600 feet below its headwaters. At one time this creek was known to extend further northward, following a straight course up towards Main Street (Reference 5). There is now a concrete storm sewer where the tributary used to flow. The tributary flows in a southerly direction until it meets with Skippack Creek approximately 1 mile south of its beginning. Skippack Creek flows to the southwest where it eventually joins with Perkiomen Creek to feed into the Schuylkill River (Reference 7).

2.4.2 Geology

No known site-specific geologic studies have been performed for any of the facilities in Zone of Contamination 1, however, geological surveys of Montgomery County and surrounding areas characterize in general the subsurface in this area. The study area is underlain by Triassic rocks of the Brunswick formation in a region of folding with the older Triassic Lockatong formation. The Brunswick formation is comprised mostly of red

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shales, and the Lockatong is made up of dense shales. More specific descriptions of the lithologies of these units can be found in Appendix A. Joints and fractures throughout these formations are the major structural feature, and provide secondary porosity which makes these formations water-bearing units (Reference 4).

The soils in the area are clay and silt-rich, being weathered from underlying bedrock. Permeability in the soil is low, on the order of 0.1 feet per day, due to the fine grain size (Reference 12). Most of the area around the Granite Knitting Mills facility and the Gentle Cleaners facility is paved or asphalted as discussed earlier in Section 2.3 (A. Fleitas, personal observation, May 8, 1987, also Appendix C, photographs 1, 2, and 6).

2.4.3 Ground Water

Both the Brunswick formation and the Lockatong formation are considered aquifers in this region. The abundant joints and fractures in these formations, particularly the Brunswick, provide channels for ground-water flow. At depths ranging from 200-500 feet, these joints and fractures provide most of the permeability. At shallower depths, the openings are generally plugged with fine-grained clays and other weathered material. At greater depths, the fractures are generally closed due to pressure effects (Reference 4). In the shallower weathered zone, the permeability is generally low resulting in slow recharge by percolation to the underlying aquifer. These conditions resemble semiartesian conditions. Unlike true artesian conditions, deep aquifers are not protected by any confining beds, so contamination can slowly percolate downward with recharge (Reference 11).

The ground-water flow specific to the three sites (Gentle Cleaners, Granite Knitting Mills, and Parkside Apartments) in Zone of Contamination 1 has not been investigated. No water level data for area wells was available during this review. The ground-water flow in the North Penn area is generally north-northeast to south-southwest; however,

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the abundance of joints and fractures in the rocks may cause flow direction to vary in the localized area (Reference 7). Pump test data or fracture trace analyses are not available to determine specific flow pathways within the zone.

Several NPWA wells and many private wells exist in this zone. The lack of boring data and well construction details make it difficult to use these wells to correlate the geology of the area or determine ground-water flow. Four NPWA wells are located in Zone of Contamination 1. These include wells S-2, S-8, S-9, and S-10. The locations of these wells are shown in Figure 3. These wells have total depths and pump rates as follows (Reference 8):

WELL NUMBER	TOTAL DEPTH	PUMP RATE
S-2	216 feet	95,342 gpd
S-8	300 feet	49,885 gpd
S-9	300 feet	Not pumping
S-10	300 feet	58,153 gpd

Currently, NPWA wells S-9 and S-10 are known to be contaminated. These wells are located on opposite sides of the tributary to Skippack Creek. PCE concentrations in S-9 are up to 24.7 ug/l. During 1985, NPWA well S-10, located south and downgradient of S-9, was found to contain PCE at levels ranging from 1.2-2.6 ug/l. These levels are below EPA proposed standards of 10 ug/l for PCE (Reference 9). Well S-8, located south of the contamination plume, is not contaminated (Reference 9). Recently, previously uncontaminated well S-2, located approximately 1,900 feet north of the Granite Knitting Mills well and north of the contamination plume, has begun to show indications of contamination (Reference 1). It is not clear whether this contamination can be linked to the same PRPs. In addition to NPWA well S-10, low levels of TCE and/or PCE, at or below EPA recommended or proposed levels, were detected in a Souderton Borough private well, located south of Parkside Apartments, and a private well on Green Street, between the Gentle Cleaners and Granite Knitting Mills facilities (Reference 10; see

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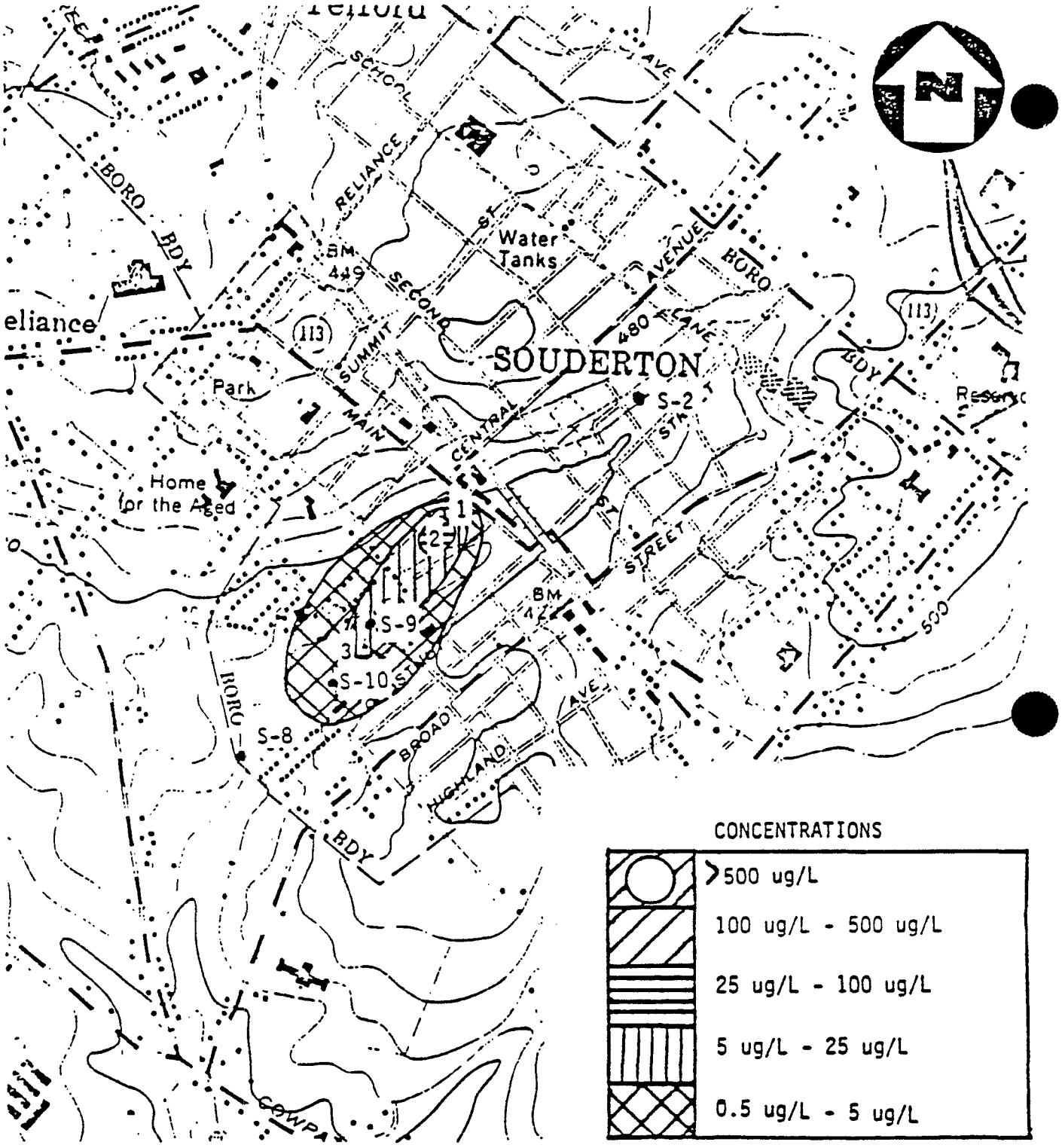
also Figure 5 and Table 1). The highest concentration of contaminants appears at the northernmost end of the zone, where levels of PCE at 249.5 ppb (Reference 10) and 1,1,1- TCEA at 61 ppb (Reference 9) were detected in the well on the Granite Knitting Mills property.

The approximate location of the contaminant plume for Zone of Contamination 1 is shown in Figure 6. The plume is very loosely defined based on the analytical data obtained in the NUS FIT III August 28, 1986 sampling event (Reference 9).



AREA 1
(no scale)

1 GENTLE CLEANERS INC.

2 GRANITE KNITTING MILLS, INC.

3 PARKSIDE APARTMENTS

FIGURE 6
APPROXIMATE LOCATION OF THE CONTAMINANT PLUME
FOR ZONE OF CONTAMINATION 1, SOUDERTON, PENNSYLVANIA
(REFERENCE 9)

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3.0 TECHNICAL APPROACH TO THE EVALUATION

In conducting this evaluation, Versar has reviewed existing data from EPA, NPWA, and PADER files, and compared its adequacy to the EPA technical requirements set forth in the "Guidance on Remedial Investigations Under CERCLA" (RIGD) (Reference 14). Since a full remedial investigation (RI) has not been conducted at any of the facilities in Zone of Contamination 1, and since some of the facilities have limited available data, full compliance with the NCP was not anticipated. An evaluation of the existing data is given in Section 4.0, and recommendations for further studies are given in Section 6.0 of this report.

Remedial activities have not been initiated by any of the PRPs at this time, so no feasibility studies (FS) were available for review. Recommendations for future studies of this type, based on the "Guidance on Feasibility Studies Under CERCLA" (FSGD) (Reference 13), are presented in Section 6.0 of this report.

In addition to these evaluations and recommendations, Versar has attempted to establish links between the PRPs and the ground-water contamination in Zone 1. Due to the lack of detailed information about this zone, establishing links at this time is difficult. Recommendations for further studies which might better establish links are given in Section 6.0 of this report.

The primary documents which were available for review during this investigation include the following:

- NUS Corporation, Site Discovery of Groundwater Contamination in the North Penn Area, July 7, 1986 (NUS Site Discovery report; Reference 9)

- NUS Corporation, A Hazard Ranking System for Gentle Cleaners, Inc./Granite Knitting Mills, Inc., October 10, 1986, with references (NUS Hazard Ranking report; Reference 10).

Miscellaneous documents and correspondence from Gentle Cleaners, Granite Knitting Mills, and Parkside Apartments were also reviewed. In

addition to the documents review, a site inspection of the Granite Knitting Mills facility and the surrounding area was conducted on May 8, 1987, as described previously in Section 2.3.

Existing data on the characterization of the zone of contamination and PRPs was used to outline the magnitude of the problem at the site along with outlining data gaps and insufficiencies which would require further investigation. Many of these data gaps were filled during the visual site inspection. Other information needs are discussed in this report in the sections described above.

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4.0 EVALUATION OF SITE CHARACTERIZATION INFORMATION

This section assesses the adequacy of the existing data and information according to the technical subject areas discussed on the RIGD (Reference 13). To maintain consistency with the EPA guidance document, these areas are evaluated in the same order as the suggested order found in Chapter 9 of the RIGD as follows (Reference 13):

- Background Information (Introduction)
- Site Features
- Hazardous Substances
- Hydrogeology
- Surface Water
- Air
- Biota
- Bench and Pilot Studies
- Public Health and Environmental Concerns

Each topic or subtopic in this section begins with a summary of EPA's technical recommendations for conducting an RI under CERCLA, and the importance of that information for meeting the objectives of the RI program. For each technical category, an evaluation of the adequacy of the available data for each individual PRP facility in Zone of Contamination 1, as compared to these technical recommendations, is given wherever sufficient data were available for this evaluation.

Since RI/FS studies have not been performed for the Zone of Contamination 1, a review and evaluation of background information for PRP facilities in this zone have constituted the major focus of this study. Background information was made available primarily through the two NUS reports (References 9 and 10) and by interviews conducted by Versar during its visit to the zone on May 8, 1987. The largest quantity of information was obtained for Granite Knitting Mills, Inc. Almost no information was available for Gentle Cleaners and for Parkside Apartments.

The data were generally not specific to either zone of contamination or to any one PRP. For example, the geological data was applicable to the whole North Penn region and was identical to that supplied for other

zones of contamination. For this reason, the topics below are discussed in terms of the entire Zone of Contamination 1 when information about individual PRPs is absent. The data do not completely supply the necessary detail for either a remedial investigation or an in-depth remedial action in the zone or at any PRP facility.

4.1 Background Information

For each facility within Zone of Contamination 1, information on basic site-specific characteristics and their relationship to environmental conditions at each facility is needed to establish a basis for recommending further data collection and analysis activities.

Needs

Facility location, size, existing structures, activities and operations, types and conditions of wastes, and timeframe of waste-related activities are needed to establish background data prior to any subsequent data collection and analysis (Reference 13).

Evaluation

Background information for the three PRPs identified for Zone of Contamination 1 was supplied by both the NUS site discovery report and the NUS hazard ranking report (References 9 and 10). These reports do not supply adequate information regarding the conditions, both historical and present-day, of any of these facilities. Information on Parkside Apartments is particularly lacking. Information on Gentle Cleaners is presented, but is inadequate to thoroughly establish background data for this facility. The available data for Gentle Cleaners and Parkside Apartments did not include a complete listing of hazardous materials used and wastes generated, information regarding waste handling practices, and specific dates during which these facilities were in operation. Although the information supplied for Granite Knitting Mills in the NUS reports (References 9 and 10) is also inadequate, sufficient background information was gathered by Versar during the May 8, 1987, zone of

contamination inspection (Appendices B and C) to supply a good basis for subsequent data collection and analysis.

Adequate background information needs to be gathered prior to the initiation of additional studies in this zone. Background information will aid in defining specific objectives, developing a technical approach, and insuring adequate coverage for future investigations.

4.2 Facility Features

The site feature data should include sufficiently detailed information on past activities at each facility so that technical, public health, and environmental analyses can be conducted during a feasibility study. The data should also be sufficient in scope and quantity to enable technically sound evaluation of alternative remedial measures (Reference 13).

The data and information to be developed or considered during the facility feature investigation include demographics, land use, natural resources, meteorology and climate (Reference 13).

4.2.1 Demographics and Land Use

Demographic and land use data and other information are needed to address the past, present, and future changes in the characteristics of the population and land use in the area; changes in the hydrogeology; the population potentially at risk to exposure from the facility (including municipal water supplies); the potential socioeconomic impacts of contaminant release; and observed effects on the local ecosystem (Reference 13).

Needs

The following demographic information is pertinent to an assessment (Reference 13):

- Community characteristics - Socioeconomic setting relative to public, cultural, and scientific resources; the local economic structure; and the population density.

- Familiar characteristics - Household stability, housing tenure, ethnic composition, age distribution, local geographic distribution of the population, and economic status of families.

The following land use information is also pertinent to an assessment (Reference 13):

- Past, present, and projected changes to land adjacent to uses of the site and environs including: urban, industrial, commercial, agricultural, recreational, forest, barrier, and wetlands.
- Location of the 100-year flood plain.
- Fraction of the land covered by impermeable surfaces

Evaluation

Demographics

A small amount of demographic information is contained in the NUS hazard ranking report (Reference 10) and in the NUS site discovery report (Reference 9) for Zone of Contamination 1. Information on the population of the area and distribution of the population around the zone is briefly discussed. The Site Discovery Report (Reference 9) contains general information on population density in the zone; however, other demographic information for the zone is not available.

Currently available data for the use of municipal well supplies in and around the zone are incomplete and unclear. Basic demographic information should be obtained to assist in planning of remedial actions, which are expected to affect water supply to the community. A more complex demographic study, such as might be performed to determine exposure to airborne contaminants, is not expected to be needed since the contamination is found only in the subsurface.

Land Use

Zone 1 is identified in both NUS reports as urban and may be classed as partly industrial and partly urban residential. Areas surrounding the town of Souderton are either farmland or suburban residential. No

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further information on land use in the zone is available. Knowledge of prior land use could reveal details about previous property owners and potentially responsible parties. This is of particular interest in the case of Parkside Apartments, where a previous owner may have been a major cause of contamination in the zone. It is also of interest in terms of locating other PRPs that have not yet been found either in or around the zone.

4.2.2 Natural Resources

Needs

The natural resources of the zone must be sufficiently characterized to determine what influence, if any, contamination of the resources may have on the health, lifestyle, and economic stability of the local inhabitants. Therefore, a baseline of natural resource information should be established for the local ecosystems. This information must be sufficiently detailed to determine, analyze, and describe the extent of effects on human and nonhuman receptors as a result of the contaminants discharged from the site. Specific concerns should focus on regional natural resources and their relationships to commercial, residential, and recreational needs, and aesthetic considerations. In addition, another purpose of obtaining natural resource data and information is to aid in determining and evaluating impacts of effective remedial alternatives for the zone of contamination during the feasibility study (Reference 13).

Evaluation

No specific information on natural resources is currently available for this zone of contamination. Ground water may be classified as a natural resource in this zone; however, the available information on ground water is discussed in Section 4.4.2 of this report.

4.2.3 Meteorology and Climate

Needs

Meteorological and climatological data are necessary to determine the potential pathways and dispersion characteristics of known

contaminants released from the facility to the atmosphere, ground water, or surface water. Local meteorological and climatological information should address precipitation, temperature, evaporation (including evapotranspiration), wind speed and direction, seasonal climate variations and weather extremes. This information should make it possible to define eolian (wind induced) and fluvial (water induced) erosion, evaporation potential, particulate deposition, and ground-water recharge. Those data should then be used to assess the potential effects of weather patterns on selection, timing, and implementation of remedial actions. Information on wind speed and direction, including a wind rose, should be included when a potential assessment or remedial activity might produce discharges to the air (Reference 13).

Evaluation

Some general information on local climate, average temperatures and temperature ranges, average precipitation and precipitation ranges is given in the NUS Site Discovery report (Reference 9). Other information regarding meteorology and climate in the zone of contamination is not available. Currently available information should be augmented if it is to be used to supplement remedial work. In particular, data on storm events and evapotranspiration would prove useful in further hydrogeological studies.

4.2.4 Topography

Needs

A topographic map of the area should be prepared to a horizontal scale of 1 inch equals 200 feet, showing elevations with respect to a mean sea level in 2-foot contour intervals. The map should show surface features such as buildings, fences, power lines, roads, railroads, surface impoundments, lakes, and rivers. For ease of use in correlating stratigraphic and water-level elevations, locations of wells, piezometers, and boreholes should also be shown (Reference 13).

Evaluation

Some topographic maps included in both NUS studies (References 9 and 10) are of low quality. This appears to be due to poor reproduction of original documents rather than to omission of data. The appropriate topographic map for the region is referenced but is not included in the available documents. Since no cut and fill or other operations have significantly altered the zone since the publication of the U.S. Geological Survey map, this map should be sufficient to characterize the topography of the region. Ideally, a copy should be included with the zone data. Beyond this, a good map specific to the zone of contamination is not included. A map showing all property boundaries, building locations, well locations, and any other pertinent information and surface features should be produced to supplement further study of the zone. Preferably, this map should have a horizontal scale of 1 inch to 200 feet, showing elevations with respect to mean sea level in 2-foot contour intervals.

4.3 Hazardous Substances

Information on hazardous substances present at each source in the environmental matrix at each facility is needed to identify the potential contaminants, to estimate the quantities of contaminants, to predict the chemical behavior and potential for migration of specific contaminants and to set reasonable limits and goals for subsequent sampling and analysis during a remedial investigation.

4.3.1 Waste Types

Needs

Information on the types and physical states (e.g., solid, liquid, or gas) of wastes disposed of or released at each facility over time should be collected. Those data should help determine what contaminants may be present, the amounts and origin (source) of contaminants present or released, the current storage practices for the hazardous

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constituents, and the potential for contaminants to migrate. This information is the technical basis for exposure assessments and evaluations of interim remedial measures and remedial alternatives proposed in feasibility studies (References 13 and 14).

Evaluation

Wastes generated by Gentle Cleaners, Inc., include used filters containing waste PCE which are generated from the dry cleaning process. The composition of the filters themselves is unknown. The company also uses other chemicals as spotting solvents in its processes, including 1,1,1-TCEA, various petroleum distillates, and organic solvents and solvent mixtures. The specific compositions of these chemicals and mixtures are not known (Reference 9).

In the past, Granite Knitting Mills has generated wastes while recycling PCE from their dry cleaning processes. The wastes were oily residues that remained after the distillation of PCE from their dry cleaning machine. The oils were removed from the machine and temporarily stored in drums on the side of the building adjacent to the loading dock until they were removed. These wastes are estimated to have contained approximately 2 percent PCE (Reference 3). It is not known exactly how long the mills generated this particular type of waste. No other wastes are known to have been generated. Currently no wastes are known to be produced at the Granite Knitting Mills facility (Appendix C).

Parkside Apartments apparently does not produce any kinds of hazardous wastes (Reference 9). However, previous property tenants may have produced wastes of concern, possibly including solvent residues from dry cleaning operations. No further information is currently available regarding wastes produced at that property.

A complete history of operations at each facility is needed to better determine the amounts and types of wastes produced by each PRP.

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No documented onsite sampling of soils or water has been conducted to better qualify potential wastes and pinpoint areas of high concentration or possible source areas. In addition, no records were available listing amounts and types of wastes removed from the properties, or listing chemicals purchased by the PRPs. The lack of information in these areas prevents proper identification of the sources of contamination and therefore hampers development of appropriate remedial actions for alleviating site problems.

4.3.2 Characteristics and Behavior of Waste Components

Needs

At each facility within the zone of contamination, information on the individual hazardous chemical components of the waste and their physical, chemical, behavioral, and toxicological characteristics is needed to identify the specific contaminants present and to determine their respective potential for migration. This information helps to establish the technical basis of exposure assessments and evaluations of remedial alternatives in a feasibility study after a comprehensive RI has been completed (References 13 and 14).

Evaluation

Information about cleaning compounds and chemical mixtures used at the Gentle Cleaners site is included in the NUS Site Discovery report and the NUS Hazard Ranking Report (References 9 and 10). However, no information about specific waste behavior, nor physical and chemical characteristics of the wastes, is included, beyond the mention of the presence of PCE in the waste filters. Likewise, the same information is lacking for both Granite Knitting Mills and Parkside Apartments. Further information on the behavior of the wastes produced, in particular, their environmental transport properties and fate, is essential to the selection of appropriate remedial technologies. For example, the volatility of chlorinated hydrocarbon compounds varies widely, and must be quantified before air stripping could be implemented as a remedial alternative.

4.4 Hydrogeology

The collection of hydrogeologic information is a necessary part of a remedial investigation because of the interrelations between geology, ground-water occurrence and flow, waste sources and characteristics, and the migration of contaminants. The amount of hydrogeologic information collected should be sufficient to identify and characterize all potentially impacted subsurface water-bearing zones or aquifers, surface water bodies, and barriers to or conduits of ground-water flow. This information is necessary to properly place ground-water monitoring wells in both horizontal and vertical space or assess the placement of present wells. The ground-water quality components of the recommended hydrogeological data set must be sufficiently detailed to evaluate the occurrence and the three-dimensional distribution of contaminants in the water-bearing zones or surface waters potentially at risk from facility contamination. This is particularly important when an aquifer or surface water body provides a local or regional source of potable water. The investigation should outline the dimensions of any contaminant plume as well as its flow direction and estimated speed of migration (Reference 13).

4.4.1 Geology and Soils

Needs

Information on the lithologic and structural characteristics of the local and regional subsurface should be obtained to adequately describe the geology at each facility and in particular the zone of contamination. Regional geologic information obtained from literature should not be the sole sources of information available and utilized for a remedial investigation, as defined under CERCLA. However, this supplemental information may be used to enhance or verify new information collected by direct means, such as onsite borings, soil tests, and geophysical studies.

An adequate interpretation of geologic data includes (1) a review of available drilling logs to identify major rock and soil types and water-bearing zones, (2) the construction of representative geologic cross

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sections from drilling log data, (3) the identification of any zones of suspected high permeability or structures (e.g., fractures and faults) likely to influence contaminant migration through the saturated zones, (4) the definition of the local stratigraphic structure and its lateral and vertical heterogeneities, (5) the acquisition of mineralogical and geochemical information on the subsurface materials, and (6) the determination of facility-specific soil properties including soil composition and geochemistry, and hydraulic and engineering properties. Any available geophysical survey information (e.g., seismic refraction and inductive electromagnetic conductivity) should also be evaluated at each facility to assist in the characterization of the subsurface environment (Reference 13).

Evaluation

Geologic information about the Gentle Cleaners site is limited to publications about regional and county-wide geology (Reference 10) and a brief generalized synopsis of the local geology in the NUS Site Discovery report (Reference 9). The publications are very thorough and provide valuable information about the geology of the region, but they lack site-specific information. There is no onsite field information, such as boring logs, included in the documentation for the zone of contamination. As a result, the available information may be used to enhance or verify future investigations, but is not sufficient to completely characterize the zone.

It is critical that the subsurface of the zone of contamination be adequately defined, both to determine the source(s) of contamination, and to delineate the extent and direction of plume movement. In particular, identification of suspected low- and high-permeability zones or structures, and the definition of stratigraphic structure and variation could aid in determination of the source of contamination, and in the selection of appropriate remedial actions.

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4.4.2 Ground-Water Hydrology and Quality

Needs

An adequate characterization of ground-water hydrology involves locating laterally and vertically the water-bearing zones, confining layers, and fractures; providing and correlating well and boring log data to determine the interrelationships of aquifers; determining the distribution of ground-water elevations and developing flow nets (horizontally and vertically, and preferably on a seasonal basis) to determine flow directions; determining hydraulic conductivity (or transmissivities), porosity, aquifer thickness and boundaries, and storage coefficients to determine specific discharge and flow velocities; and determining ground-water discharge and recharge rates, including localized sources and sinks of ground water (Reference 13).

Regional and local ground-water extraction for municipal, domestic, agricultural, or industrial use should also be assessed in this section. The characterization of ground-water quality involves identifying and quantifying the contaminants present in each aquifer, mapping their lateral and vertical distribution, and determining the flux of the contaminants from the study area to the regional ground or surface waters. While characterizing water quality, the investigator should give detailed attention to the drilling, installation, and development of monitoring wells; sample collection, preservation, and processing procedures; and methods of chemical analysis (Reference 13).

Evaluation

Information regarding ground-water hydrology in Zone 1 is limited to the literature on regional hydrogeology mentioned previously (Reference 10) and the synopsis provided in the NUS Site Discovery report (Reference 9). The regional ground-water flow regime appears to be fairly well defined, with information available on locations of water-bearing zones, well and boring log data, hydraulic properties of aquifers, and local sources and sinks of ground water. However, no

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site-specific information on ground-water flow has been reported for the zone. This includes distributions of ground-water elevations or other quantitative properties such as porosity, hydraulic conductivity, flow direction, or aquifer thickness.

The amount of information currently available is inadequate to characterize the local hydrology within the zone of contamination. This is due in part to the wide amount of variation in the aquifers of the region. Fracturing and faulting in the bedrock and interfingering of strata allow a large variability in flow characteristics across the region and within each smaller zone of contamination. Pumping of local NPWA wells in and around the zone also could vary flow direction and velocity. The regional information should only be used on a limited basis as supplemental or reference data to support future investigations.

The ground-water quality data for Zone of Contamination 1 is limited in extent. Information on contaminant concentrations for one sampling of 15 Souderton wells on August 28, 1986, is included in the NUS Site Discovery Report (Reference 9) along with concentrations of PCE determined from samples taken during a pump test conducted on NPWA well S-9 in January 1986. Data on concentrations of PCE, 1,1,1-TCEA, and TCE for 1985 from well S-10 is also available in Reference 9. Based on this data, NUS has constructed a generalized map indicating the extent of the contaminant plume (see Figure 6). The plume, however, is loosely defined and does not necessarily indicate current subsurface conditions. No explanation of how the extent of this plume was determined at was given in the zone documentation. Also, no information on pump test procedures was provided. No other water quality data has been reported for this zone. It is not clear if any data from before 1985 might be available for this zone, or if sampling has been conducted since 1985. Presumably this zone was sampled concurrently with the other zones of contamination in the region. If so, a great deal of water quality data may be missing or may not have been reported.

Extensive quality assurance/quality control (QA/QC) information from the NPWA testing laboratory has been included in the NUS Hazard Ranking report for the analysis of samples collected by NUS from the 15 Souderton wells (Reference 10). Information on laboratory analysis and sample collection procedures is included. Generally, this information appears to be adequate for the purpose of assessing the quality of test data, except that the QA/QC information is not always clearly presented.

Some information on well depths, diameter, average daily withdrawal, safe well yields, and limiting factors in water withdrawal are included in the NUS Site Discovery report (Reference 9). However, no information on length of screen or open hole length, location of pump, well construction materials, or well integrity is available for the particular wells of interest (S-9, S-10, S-8, and other Souderton wells). There are some diagrams of well construction specifications for the NPWA wells No. NP-21, NP-33, and NP-39, and boring logs for wells No. NP-5 and NP-15 included in the report (Reference 9). Data for these wells may apply to the general construction of all NPWA wells; however, this is not specifically stated and these details may not necessarily apply to the Souderton wells. Well construction information is not reported for the residential wells that were sampled, although such information could possibly be found from local or public sources.

Generally, the water quality information for Zone of Contamination 1 is of greater quantity and depth than other information available, but is still not enough to completely characterize groundwater quality in and around the zone of contamination. These data are needed to assess plume location and concentration, to determine potential hazards, and to develop appropriate remedial alternatives. This is particularly important since the affected aquifer is used as a water supply for the area, and the presence of contamination has placed restrictions upon its full use (Reference 1).

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4.5 Surface Water

Needs

The characterization of local and regional surface water is extremely important for a facility remedial investigation. Surface runoff may carry contaminants in dissolved or suspended form; therefore runoff is a major potential pathway for the migration of contaminants from a facility to nearby drainage channels where biota may be adversely impacted as a result of water quality degradation. The hydrologic characteristics of the drainage basin in which site runoff occurs will influence the timing and magnitude of runoff events that can scour potentially contaminated stream bed sediments. The amount of potentially contaminated ground water that discharges to a surface water body may be affected by the interaction between the surface water and ground water (particularly during storm events), bed material transport, and flood potential. These issues should be discussed in each facility's characterization (Reference 13).

Evaluation

There is a brief discussion in the NUS Site Discovery report of surface water characteristics in the study region (Reference 9). However, there is no information regarding surface water specific to Zone of Contamination 1, other than what can be interpreted from topographic and geologic maps included in the data. No information is available on surface water quality for the zone or the area around the zone.

Surface water flow and quality of the local tributary to Skippack Creek should be determined, since it can be a significant pathway for contaminant migration. Hydrologic factors, such as contaminant loading rates, dilution factors, and quantity and depth of flow should be defined. Runoff may contain contaminated soil materials in suspension, while base flow in streams may give an indication of ground-water quality upgradient. Also, the potential effects of storms and flooding, including magnitude, extent of contamination, direction, receiving

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bodies, and controls should be evaluated, since they could present significant pathways for contaminant transport.

4.6 Air

Needs

A major potential pathway for the discharge of volatile and dustborne contaminants from any facility is via the release of vapors or particulates to air. Information on the specific contaminants present, their concentrations and volatility, potential for release by fire, explosion, evaporation, or industrial process, and the meteorological and climatological conditions at the time of sampling is recommended at each facility. This data is needed to assess the impact of hazardous constituent releases on local air quality and the potential health and environmental effects on receptors (Reference 13).

Evaluation

There is no information available in file documents for either air quality or physical characteristics (e.g., air flow rates or directions) in the zone of contamination. At least a minimal study of air characteristics should be performed to define ambient air quality and to aid in the selection of remedial actions. In particular, if air stripping is chosen as a remedial method as it has been in other zones, an air investigation might be necessary to determine if further hazard exists from the resulting air emissions.

4.7 Biota

Needs

The collection of biological and ecological information is essential to properly conduct the endangerment and environmental assessments performed either at the end of a remedial investigation or during a feasibility study. These assessments should include information on the local fauna and flora (especially endangered species and those consumed by humans or found in the human food chain). The analysis of floral and

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faunal information should concentrate primarily upon the dominant species and their sensitivity/resistance to environmental change, the presence of rare or endangered species, and any important interrelationships (References 13 and 14).

Evaluation

The NUS Site Discovery report (Reference 9) included some brief information about critical environments and endangered species within and around the study area. No critical environments or critical habitats are located within the contaminated area. Two endangered species of birds and one endangered plant may exist in and around the zone (Reference 9).

No other information regarding biota in this area is available. Since the routes of potential exposure are so poorly defined for the zone, a more specific investigation of biota might not be appropriate until exposure routes are further investigated. If the contamination is found to be solely in the subsurface, an in depth biota investigation will not be necessary. However, if surface contamination is found, the effects of exposure on both endangered biota and the remainder of the ecosystem should be examined.

4.8 Bench and Pilot Studies

Needs

The specific need for bench and pilot studies is defined from an assessment of what is known and what is required to establish the feasibility of applying a technology. Considerations may include the following (Reference 13):

- What is the level of development of the technology? Has the process, technique, or material been studied or used previously? If so, what are the results?
- Characteristics of the wastes/contaminants of concern
- Cost savings anticipated from minimizing the risk of failure at full scale

Bench and pilot studies may be performed in the RI. Here, tests may range from limited treatability studies, to screening of general technology types in the FS to full evaluations of particular FS remedial alternatives. In the FS phase, full-scale pilot studies may be needed to determine design and operating standards for the selected remedial alternatives (References 13 and 14).

Evaluation

No information about bench or pilot tests are available in file documents for the zone of contamination.

4.9 Public Health and Environmental Concerns

Needs

The remedial investigations should discuss the potential public health and environmental impacts resulting from facility contamination. The discussion on public health should summarize public health concerns resulting from known hazardous constituents and contaminated areas or resources at each facility in the zone of contamination. The discussion on environmental effects should include a review of the actual or potential environmental damage from releases of contaminants from the site. Each discussion should address the relevant potential receptors that may be adversely affected by site contamination, such as human, fauna, and flora (including endangered species); and the types of exposure risks associated with each.

The public health and environmental assessments are further evaluated in the feasibility study (References 13 and 14).

Evaluation

Public health and environmental effects resulting from contamination in and around Zone 1 are not discussed thoroughly in either of the NUS reports, although the implications of groundwater contamination in the area are clear (References 9 and 10). Most of the region relies upon ground water for its drinking water supply. If this supply is

contaminated by hazardous constituents, public health could be at risk. The extent of this risk and the extent and severity of environmental effects has not yet been fully assessed, however.

The types and amounts of wastes handled or released within the zone, as well as the hazards associated with these wastes, are not fully characterized. Current and historic sources of contamination have not yet been fully identified. Pathways of potential exposure to both humans and wildlife, and the fate of contaminants in the environment, are not defined. For example, the types of risks associated with consumption of the ground water are never discussed. In addition, the types of populations that could be at risk are not recognized.

Although immediate remedial actions might not require a full study of the potential effect to the area, at least some evaluation of public health and environmental effects should be performed to determine the most likely ways in which the contamination, or possibly the effects of remediation, will affect the local population; biota; and the environment. At a minimum, a full characterization of all hazardous chemicals that could be or have been released within and around the zone should be performed, and the likely means of exposure to relevant human and wildlife receptors should be identified.

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5.0 EVALUATION OF REMEDIAL PROGRAMS

Remedial activities can take place at any time during a facilities operation. EPA has established guidance by which companies may proceed in these actions in a manner consistent with the objectives of CERCLA and the NCP. While the RI emphasizes data collection and site characterization, as seen in Section 4.0, EPA recommends that companies concurrently initiate an FS to develop specific remedial alternatives to address site contamination problems. The FSGD is used as a basis for evaluating a facility's remedial action program (Reference 14).

Needs

The FS should be performed in three phases: (1) development of alternatives, (2) initial screening of alternatives, and (3) detailed analysis of alternatives. The FSGD recommends that the development of alternatives and the initial screening during each feasibility study should, at a minimum, include each of six elements and that the feasibility study should concisely summarize the results of each step. The six elements are as follows (Reference 14):

- Identification of general response actions to address site problems and pathways
- Identification of possible technologies in each general response action
- Screening possible technologies based on site conditions
- Assembling technologies into remedial alternatives that address all site problems and attain cleanup goals
- Eliminating remedial alternatives based on protection of the environment, public health and welfare, and adverse impacts
- Eliminating remedial alternatives based on order of magnitude costs

The National Contingency Plan (NCP) requires a detailed evaluation of the limited number of alternatives remaining after the initial screening. The NCP specifies that the detailed analysis of each alternative shall include the following (40 CFR 300.68(h)):

- refinement and specification of alternatives in detail;
- detailed cost estimation;
- engineering evaluation in terms of implementation, reliability, and constructability;
- evaluation of effectiveness to protect public health, public welfare, and environment; and
- evaluation of any adverse environmental impacts.

The FS Guidance Document addresses this requirement with the evaluation of the following five considerations (Reference 14): (1) technical feasibility, (2) institutional concerns, (3) public health, (4) environmental concerns, and (5) cost.

Based on available information in file documents and from the zone visit, apparently no PRP in Zone of Contamination 1 has undertaken any type of remedial action to date. Thus, no feasibility study was available for evaluation by Versar. Although Granite Knitting Mills did remove their dry cleaning machine and the PCE storage tank, this was done as a business transaction and not with the intent of remediation. No further information is available about any possible remedial activities at any of the sites.

6.0 CONCLUSIONS AND RECOMMENDATIONS

This section summarizes the findings of this technical evaluation, and provides specific recommendations to enhance any further assessment or remedial studies which may be performed for Zone of Contamination 1. Since no remedial investigation (RI) or feasibility (FS) study has been performed within the zone, it was not expected that all EPA criteria for an RI/FS be met. However, certain minimal steps should be taken to ensure that any selected remedial actions will be appropriate and effective, provided that a comprehensive RI has been performed to clearly define site problems and requisite cleanup standards.

Section 6.1 summarizes the deficiencies found in the information and data currently available about the three PRPs within Zone of Contamination 1. Section 6.2 summarizes information that could more closely associate any of the PRPs as a source of the contamination in the zone, while Section 6.3 provides recommendations for further studies that could improve characterization and remedial studies in the zone.

6.1 Summary of Program Data Deficiencies

6.1.1 Contamination Assessment and Site Characterization

- The available data lacks relevant demographic and land use information.
- The available data lacks any characterization of local natural resources.
- The NUS reports (References 9 and 10) fail to adequately address the available data on meteorological and climatological site characteristics.
- The effects of seasonal fluctuations in precipitation and evapotranspiration on ground-water flow are not explained.
- Information on flood frequency, wind patterns, detailed temperature statistics, and frequency of thermal inversions is not discussed.
- Site topographic maps lack clear representation of plume boundaries and significant features such as wells and buildings.

- Map scale should be enlarged to 1"=200' and appropriate two-foot contour intervals included.

- The hazardous substances disposed or released within the zone of contamination have not been fully identified.

- More complete information is needed about the types and forms of wastes, methods of waste disposal or treatment, and frequencies and duration of waste disposal or release. In particular, more of this information is needed from Gentle Cleaners and Parkside Apartments, and if possible, from previous tenants of the Parkside Apartments property.

- The physical and chemical characteristics and the expected environmental transport and fate of any potential chemical wastes were not available in the current information.

- Site-specific information on soils and the underlying bedrock does not exist.

- Lithology, structure, and stratigraphy within the zone is only generally represented by regional documents.

- No visual representations of onsite geology, such as geologic cr ss sections or maps, are currently available.

- Site-specific information on aquifer properties, particularly quantitative information such as porosity, hydraulic conductivity, and aquifer thickness, is not available.

- Information on nearby sources and sinks of ground water, particularly local NPWA pumping well information, is not sufficient.

- Information on well construction specifications and well integrity is missing.

- The relationship between the aquifer and local surface water is not addressed.

- Procedures and results for the pump test on NPWA well S-9 in 1986 are not presented.

- Large amounts of ground-water quality data are missing from the available information.

- QA/QC information is not clearly presented.

- The plume of contamination is poorly defined and no explanation of the criteria used to locate it is given.

- Surface water characteristics specific to Zone of Contamination 1 are not described. Volume of flow, depths, flow rates, contaminant loading rates and other physical aspects of surface water flow are not available.

- Surface water quality has not been assessed.

- No information regarding air quality or physical characteristics is available in the current information.

- Air quality is not of primary concern in this zone due to the nature of the contamination. However, should a proposed remedial action pose a potential release of volatiles to the atmosphere (e.g., air stripping), then an air quality assessment should be performed.

- Complete information on biota within the zone of contamination is not available.

- Routes of potential exposure to the ecosystem have not been investigated.

- No bench or pilot studies have been performed for this zone.

- All contaminants expected to be found within the zone have not been identified.

- The hazards associated with contaminants have not been identified.

- Exposure points and exposure routes for humans and wildlife have not been fully defined.

- All contaminant sources, either current or past, have not been identified.

- No information on the transport or fate of the contaminants is included in the current data.

6.1.2 Remedial Programs

Since remedial programs or studies have reportedly not been performed by any of the PRPs located within the Zone of Contamination 1, Versar could not evaluate the adequacy of remedial programs relative to EPA criteria and guidelines.

6.2 Summary of PRP Relationships to Sources of Contamination

Since there is little available information regarding most aspects of Zone of Contamination 1, it is difficult to develop or confirm relationships between the individual PRPs and possible sources of contamination. Some generalizations may be made based on preliminary evaluation of technical factors alone, with the reservation that not enough detail is available about the zone to definitively evaluate whether a current PRP is a possible contributor to the contamination. These generalizations are listed below.

- Although flow has not been specifically defined for this zone, flow in this part of the region is generally north northeast to south south-west (Reference 10).

- PCE contamination was originally detected in NPWA well S-9 (Reference 9).

- Gentle Cleaners is located at the topographic high of the zone and is presumably upgradient of Granite Knitting Mills, Parkside Apartments, and NPWA well S-9. Granite Knitting Mills is located approximately 200 feet southwest of Gentle Cleaners, approximately 1,200 feet northeast of NPWA well S-9. The mill is also presumably upgradient of well S-9, while Parkside Apartments is located 100 feet south and downgradient of NPWA well S-9 (Reference 9).

- The highest concentration of contaminants in the ground water was detected in the well on Granite Knitting Mills property. In 1985, concentrations of PCE at 35.5 ug/l and 1,1,1-TCEA at 249.5 ug/l were detected by NUS (Reference 10). NPWA has reported concentrations of 61 ppb of PCE in this well (Reference 10). The Granite Knitting Mills well is located on the north, upgradient, and on the opposite side of the building from where the company had its dry cleaning machine and PCE storage tank. However, the well is located apparently downgradient of Gentle Cleaners property.

- The concentrations of contaminants appear to decrease south (downgradient) of the Granite Knitting Mills well (Reference 9 and 10).

- Low levels of PCE (1.7 ug/l) were detected in NPWA well S-10, located approximately 1,200 feet downgradient of Parkside Apartments and on the opposite side of the tributary to Skippack Creek (Reference 9).

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- There is documentation associating Gentle Cleaners with the use of PCE and 1,1,1-TCEA, two compounds which were detected in NPWA wells in the zone (Reference 10). There may be documentation of deliberate release of PCE to the environment by Gentle Cleaners (Reference 1).

- There is documentation associating Granite Knitting Mills with the use of PCE, which also was detected in NPWA wells in the zone (Reference 10).

- There is no documentation that PCE or other types of chemicals detected in NPWA wells in this zone were once used on the site which now houses Parkside Apartments (Reference 10).

- Currently, no information is available to confirm the existence of an underground storage tank at either the Gentle Cleaners or Parkside Apartments property.

- NPWA well S-2, located upgradient and approximately 1,900 feet north of the Granite Knitting Mills well, may have begun to show indications of contamination. It is not clear whether this contamination is related to that found in Zone of Contamination 1 (Reference 1).

- No evidence of release was observed during the May 8, 1987, site visit.

6.3 Recommended Additional Studies

6.3.1 Site Characterization Information

Due to the lack of technical information regarding contamination assessment and characterization of Zone of Contamination 1, a remedial investigation is recommended to accurately describe the zone, define site problems, develop general response actions which could attain clean-up standards, and possibly provide preliminary identification of probable pollution sources in the zone. Versar recommends that the following be used as guidance for further characterization studies, or when a complete RI is initiated, according to U.S. EPA criteria and guidelines for a RI.

- A demographic analysis of the area surrounding Zone of Contamination 1 should be conducted. This analysis should extend for a radius of approximately one mile from the zone, addressing

the age and geographic distribution of population, the socioeconomic setting of the area, and the potential socioeconomic impacts resulting from a contaminant release. Most of this information should be available from the U.S. and state Census Bureaus (Reference 13).

- Conduct a land use analysis of the area surround the zone for a radius of approximately one mile. This analysis should include a prediction of land use changes over the next several years (Reference 13).

- Conduct a natural resources inventory of the area for a radius of approximately one mile from the zone. This inventory should address the resources that may be affected by exposure to the contaminants (Reference 13).

- Describe the natural resources with respect to residential, commercial, recreational, and aesthetic importance (Reference 13).

- Evaluate the effects a potential contaminant release would have on the locate natural resources, emphasizing those resources affecting lifestyles and economic stability (Reference 13).

- Describe the characteristics of the local and regional meteorology and climate. This description should include precipitation; temperature; wind speed and direction; potential for thermal inversions; and frequency of weather extremes, including storms, floods and high winds (Reference 13).

- Describe the topographic characteristics of the local and regional area surrounding the zone for approximately one mile. Included in this description should be a topographic map prepared to horizontal scale of 1 inch equals 200 feet showing elevations with respect to mean sea level in 2-foot contour intervals. This map should show all surface features such as buildings, roads, railroads, lakes, and rivers. All monitoring and supply wells should also be shown as well as a clear representation of the contaminant plume boundaries (Reference 13).

- Profile data for each of the contaminants found in Zone 1 should be consulted to determine the physical, chemical, and biological characteristics of these compounds (Reference 13).

- The environmental transport and fate of the identified contaminants should be evaluated for their movement through soil, ground water, surface water, and air. Dispersal should consider effects of volatilization and dilution, while fate mechanisms should consider biodegradation, photo-chemical oxidation, sorption processes, and bioaccumulation (Reference 13).

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- Use waste manifests or logs to provide information on the specific types, volumes, and forms of wastes that were disposed or released at the site. (This information should complement the types of analyses to be performed during environmental sampling) (Reference 13).

- Methods of disposal and/or release mechanisms need to be identified. Sources of contamination should be identified based on historical waste handling activities and interview with persons knowledgeable about past site activities (Reference 13).

- The soil characteristics, structure, and variation in the zone should be defined (Reference 13).

- Zone specific information on the lithology, structure, and stratigraphy of this area should be defined (Reference 13).

- Information on aquifer properties such as porosity, hydraulic conductivity, and aquifer thickness should be defined.

- Information on nearby sources and sinks of ground water, particularly local NPWA well information, should be expanded. Well construction specifications should be included for both NPWA wells and any local private wells.

- Aquifer characteristics and relationships, including hydraulic connections with surface water bodies and discharge and recharge rates, should be defined (Reference 13).

- Details on the pump test on NPWA Well S-9 should be provided, and additional tests should be conducted as needed to aide in defining aquifer characteristics.

- Historical ground-water quality data should be presented and supplemented by data collected during additional studies.

- QA/QC information should be more clearly presented.

- The horizontal extent of the contaminants should be comprehensively defined in the aquifer (Reference 13).

- The vertical extent of all contaminants detected in the ground water should be defined (Reference 13).

- Discuss the possibility of contaminant migration through surface water runoff, sediment transport, and base flow.

- Investigate the physical aspects of surface water flow for the tributary to Skippack Creek such as volume of flow, depth, flow rates, and contaminant loading rates.

- Assess the quality of the surface water.

- In the event that treatment of the contaminated groundwater results in the potentially significant emission of contaminated vapors (e.g., as may occur during air stripping), an air quality investigation should be conducted. Wind speed and direction; as well as the number, geographical distribution, and location of potential receptors should be considered in this investigation. Upwind and downwind air quality should also be evaluated.

- Conduct a plant survey (including aquatic species) and consult available public records of the area to identify (1) major vegetative patterns and plant communities, (2) types and diversity of vegetation, and (3) their relative abundance, and (4) unique, rare, and endangered plant species (Reference 13).

- Assess the past and present human influence or dependence on the local vegetation including aesthetic and nutritional dependence (Reference 13).

- Conduct an animal survey including aquatic species of the area and consult available public records to identify (1) resident and seasonal species and population sizes, (2) unique, rare, and endangered species, and (3) important habitats present in the area (Reference 13).

- Assess the past and present human influence or dependence on local wildlife including aesthetic and nutritional dependence (Reference 13).

- Provide test plans and data summaries for any bench and pilot scale studies performed for screening or evaluating remedial technologies.

- Data relevant to characterizing possible effects of VOC-contaminated ground water on human, biological, and ecological receptors in and around the plant site should be gathered and evaluated. Also, other media (e.g., soil) should be assessed for contamination and evaluated for possible effects as well (Reference 13).

6.3.2 Remedial Programs

Versar recommends that a feasibility study should be performed in Zone of Contamination 1, to allow determination of the most cost-effective

remedial action, only after a comprehensive RI has been completed for the zone or for individual PRP facilities. Then, remedial alternatives addressing the site problems and capable of attaining requisite clean-up standards can be developed, screened, and evaluated in detail.

EPA's criteria and guidelines for a feasibility study are described in the FSGD (Reference 14), and were summarized earlier in this report in Section 5.0. Before any remedial activities are initiated in Zone of Contamination 1, Versar recommends that the following items be considered:

- One of the primary concerns in the North Penn area is the growing scarcity of water supplies. For this reason, one of the major goals of any remedial action taken should be to protect the water resources currently available. One possible activity might be to continuously pump the contaminated wells to create a cone of depression which would prevent or decrease the migration of contaminants towards other wells.

- Treatment technologies for the removal of chlorinated organics from the ground water should be reviewed. Treatment of the water in a manner which would result in a potable water source would be beneficial. One method of treatment that has been employed in other zones in the North Penn area is air stripping. Air stripping in combination with other processes, such as carbon adsorption, may eliminate contaminants and produce potable water.

- Treatment of the ground water is a primary concern in Zone of Contamination 1. However, if soil contamination is detected during the RI, then remedial alternatives for the treatment and/or disposal of contaminated soils should be developed.

- Currently, problems with air emissions do not appear to be a concern in this zone. However, should remedial measures be employed which might compromise the air quality (e.g., air stripping) then technologies for the control of air emissions should be reviewed.

- A continuous ground water monitoring plan should be developed to accurately detect the extent of the contamination plume, and indicate the effectiveness of any remedial measures implemented.

6.3.3 Characterization of PRP Relationships to the Contamination

Use of hydraulic gradient as the sole means of associating a PRP facility with the ground water contamination is not reliable due to the

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localized flow directions and complex geology in Zone of Contamination 1. The following recommendations are offered in aid in further characterizing possible relationships of PRP facilities to the contamination in this zone:

- Investigate the chemicals used and wastes generated by former occupants of the facilities currently listed as PRPs for this zone. Specifically, more detailed information is required for the dry cleaning establishment which previously operated on the Parkside Apartments property.

- Determine if additional PRPs exist in the Souderton area which may have contributed to the contamination.

- Review the PRP search currently being conducted to determine if the above points have been investigated.

- Obtain additional information on the chemical storage and handling practices at the Gentle Cleaners facility, and at any additional facilities which may be responsible for the ground-water contamination.

- Determine the possibility of a past release and the probability of future releases of hazardous materials from any PRP facility associated with the contamination.

- Sample and analyze the soil at various depths around the storage or handling areas of these PRP facilities.

Additional technical information may be needed to develop, confirm, or reinforce a PRP's relationship to the contamination. This information may include the following:

- Locations of contaminated wells (public, commercial, and private) in relation to the PRP facilities.

- Well depths and pumping rates.

- Zone-specific geological and hydrogeological information obtained from well logs and boring logs.

- Site specific soil information and soil contamination assessment.

- Contaminant plume concentrations and extent.

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APPENDIX A

HYDROGEOLOGY OF MONTGOMERY COUNTY, PENNSYLVANIA

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EXECUTIVE SUMMARY

To properly understand and evaluate the nature and extent of ground-water contamination in Montgomery County, Pennsylvania, a review of the local geology and hydrogeology is necessary. Stratigraphy, aquifer characteristics, and the structural and geomorphic qualities of the subsurface environment are important in interpreting ground-water flow.

The following report provides an overview of regional hydrogeologic parameters of concern with respect to known contamination of the North Penn Water Supply. Rock strata are characterized by lithologic properties, and by water-bearing characteristics. Structural features are also outlined, and surface water and soil properties are discussed in a section on regional geomorphology. Aside from a regional hydrogeological picture, the importance of any localized subsurface characteristics which may affect regional ground-water flow patterns is emphasized.

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1.0 INTRODUCTION

1.1 Location

Montgomery County is located in southeastern Pennsylvania and occupies an area of 491 square miles. The county is situated northwest of the city of Philadelphia and is surrounded by Berks, Bucks, Philadelphia, Chester, and Delaware Counties. The Schuylkill River, the county's major drainage basin, forms its southwestern border (see Figure 1).

1.2 Physiography

Montgomery County lies within the Piedmont Physiographic Province, a region of low hills and ridges with a topography that gently slopes to the southeast. The county is further separated into two physiographic sections of the Piedmont: the Piedmont Upland in the southern third of the county, and the Triassic Lowland in the northern two-thirds. Surface elevations within the county range from 200 feet to about 600 feet above mean sea level. The topography is a result of both stream erosion and differential resistance to weathering of the underlying bedrock (Rima, 1955). Resistant lithologies form the ridges, which trend northeast-southwest. Lowlands, comprising the majority of the county, are underlain by less resistant bedrock.

The area is drained by the Schuylkill River and several smaller tributaries. Streams generally follow the northeast-southwest trend of the ridges. However, where a water gap exists in a ridge, stream flow is to the southeast (Rima, 1955).

1.3 Climate and Vegetation

The climate of Montgomery County has been termed humid-continental, with warm, humid summers and moderately cold winters. Average annual temperature is 57°F, with an average monthly range from 32°F in January to 77°F in July. Average annual precipitation ranges from 42 inches

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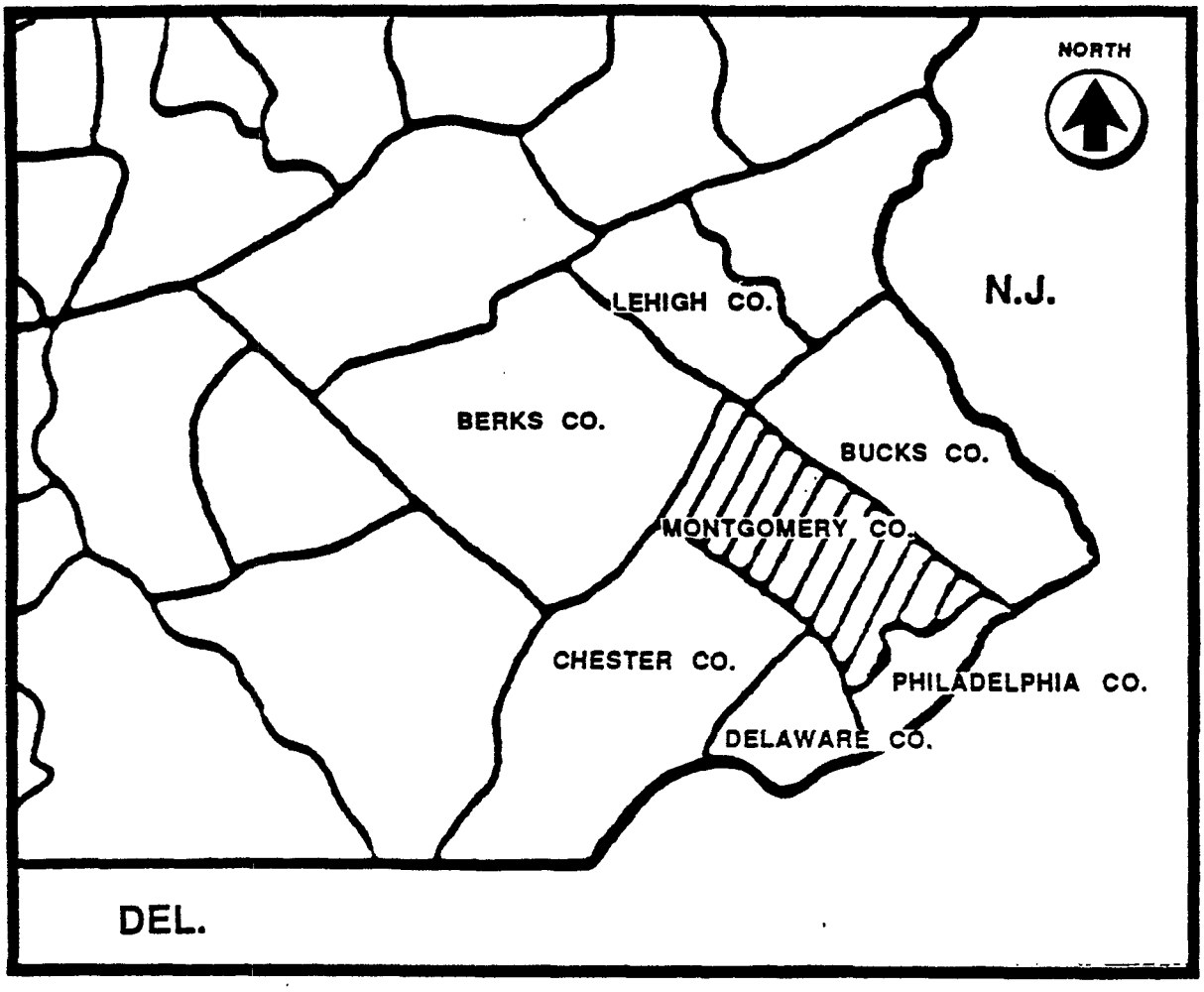

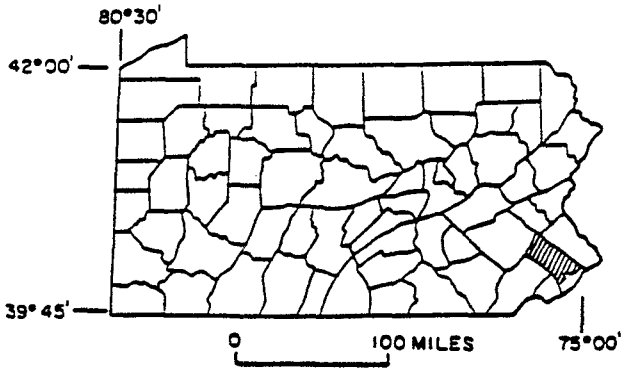

Figure 1. Location of Montgomery and Surrounding Counties in Southeastern Pennsylvania. (From Newport, 1973)

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in the southern portion of the county to 47 inches in the north, and is generally evenly distributed throughout the year (Biesecker, 1968). At times, however, heavy thunderstorms will occur. Because soils in the area have low infiltration capacities, much of the storm water runs off and local flooding and considerable erosion can occur (USDA, 1967).

In terms of land use, most of the county has seen industrial and residential development, but some farmland is still present. The dominant vegetation is oak, hickory, and yellow poplar, and contributes to considerable evapotranspiration. As much as 26 inches of the water that falls annually is lost through evaporation or transpiration (Newport, 1973).

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2.0 REGIONAL GEOLOGY

2.1 General Features

The bedrock of Montgomery County is exposed over much of the area and represents a large portion of the geologic time scale, as the stratigraphic column in Figure 2 indicates. Most of the county, however, is underlain by Triassic formations of the Newark Group, the largest Triassic basin in the United States, extending from the Hudson River in New York to Northern Virginia. It is these Triassic formations which are most significant from a hydrologic standpoint. Their stratigraphy is detailed in the following subsections. Water-bearing properties, well yields, and water quality are discussed in Section 3.

2.2 Stratigraphy

The Triassic formations described are conformable units of alternating sandstones and shales, with diabase intrusions in the northern portion of the county. All formations bear water and are named from oldest to youngest, the Stockton Formation, the Lockatong Formation, and the Brunswick Formation (Figure 3). In these units, the strata dip to the west or northwest an average gradient of 20°, except near diabase dikes, where dips up to 50° have been recorded (Hall, 1934). Based on dip and outcrop width, the total thickness of the Triassic formations is estimated to be greater than 18,000 feet (Rima, 1955).

2.2.1 Triassic Water Bearing Formations

2.2.1.1 Stockton Formation

The Stockton Formation consists of interbedded layers of sandstone and shale, with an overall thickness of 6,000 feet near the Montgomery County-Bucks County border. The beds dip to the northeast between 5° and 25°, and contain small normal faults and vertical joints scattered throughout the county. Because of the varying lithology among beds, the Stockton Formation has been divided into three members (Rima, 1962; Newport 1973), each with slightly different stratigraphic characteristics.

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Era System and Epoch	Formation	Thickness (feet)	Character
Cenozoic Quaternary Holocene	Alluvium	0-10	Soil, sand, gravel, and clay; deposits in stream valleys.
Pleistocene	Pensauken Formation	0-10	Sand, gravel, clay, yellowish-brown; small areal extent.
Tertiary Pliocene (?)	Bryn Mawr Gravel	0-10	Sand and gravel; small areal extent.
Mesozoic Cretaceous	Patapsco Formation	0-10	Clay and sand, highly colored; small areal extent.
Triassic	Diabase	5-1,800	Medium to coarse grained igneous rock, dark gray, occurs as dikes and sills.
	Brunswick Formation	9,000-16,000	Shale, mudstone, sandstone, and conglomerate beds; reddish-brown.
	Lockatong Formation	0-2,000	Argillite, mudstone, and shale; dark gray to black, thick bedded.
	Stockton Formation	1,000-6,000	Shale and siltstone in upper member; sandstone, fine-to coarse-grained, arkosic, middle member; conglomerate lower member
Paleozoic Ordovician	Conestoga Limestone	500-800	Limestone, impure, thin-bedded upper part; middle dark graphitic phyllite, lower limestone, granular thick-bedded, dark gray.
Cambrian	Elbrook Formation	800	Limestone, fine-grained, light gray to cream-colored, thin-bedded.
	Ledger Dolomite	1,000	Dolomite, granular, gray to bluish gray.
	Harpers Formation	500-800 (?)	Phyllite, fine-grained, greenish-gray, some beds of quartzite and schist.
	Chickies Quartzite	500-1,000	Quartzite, vitreous, light-colored thick-bedded, conglomerate at base.
Precambrian (?)	Wissahickon Formation	—	Schist, albite chlorite, and oligoclase mica, includes hornblende gneiss and phyllite.
Precambrian	Granite gneiss	—	Composed chiefly of quartz, feldspar, biotite, and hornblende.
	Hornblende gneiss	—	Composed of quartz, feldspar, and hornblende.
	Serpentine	—	Soft, fine grained, green.

Figure 2. Geologic Section for Montgomery County, PA (From Newport, 1973)

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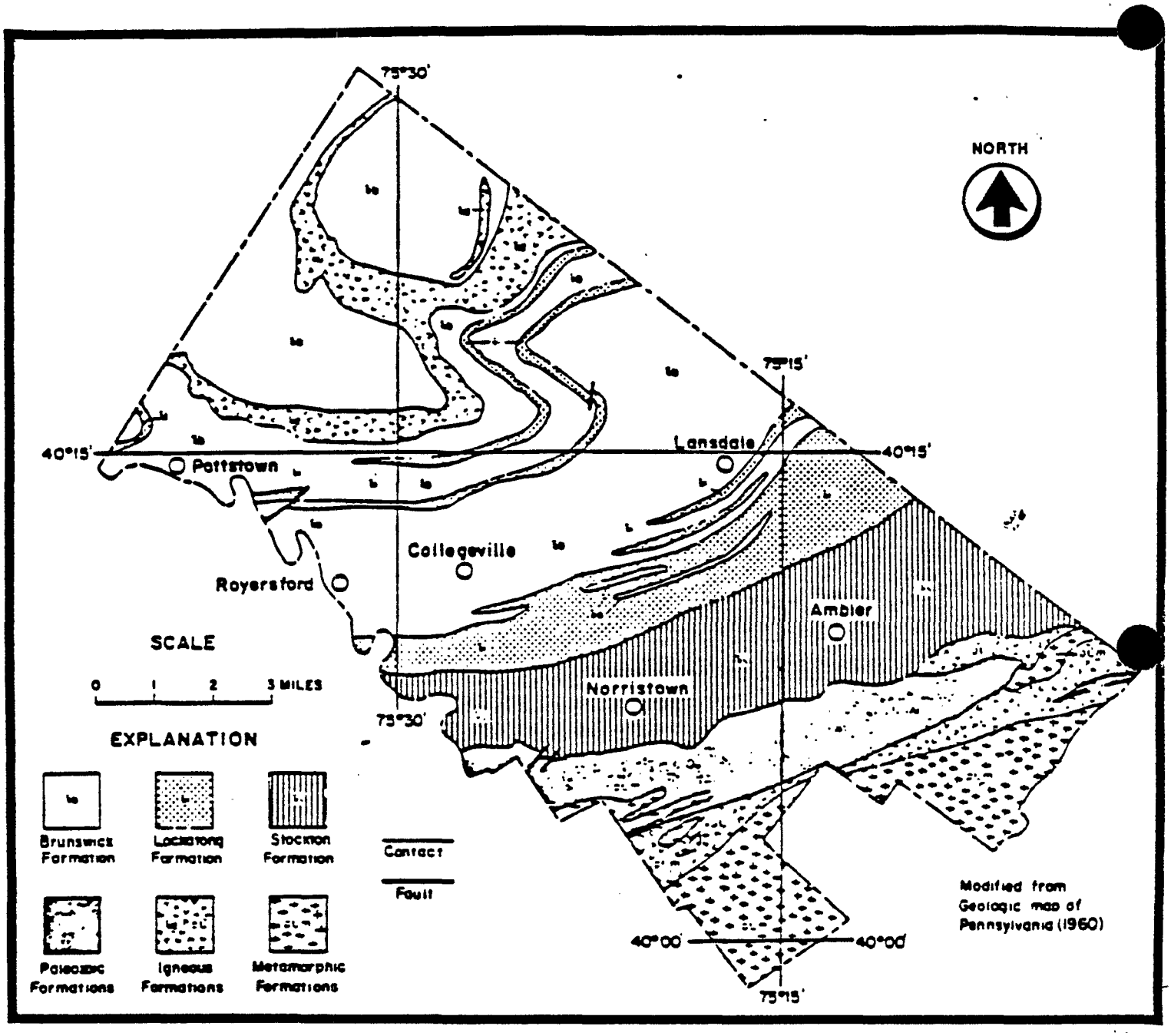

Figure 3. Generalized Geologic Map of Montgomery County, PA (From Newport, 1973).

Lower Member

The lower, and thus oldest, member of the Stockton Formation consists of red to gray, medium-to-coarse-grained arkosic sandstone and conglomerate. Interbedded with this sandstone are numerous lenses of silty, sandy red shale. The member is about 1,500 feet thick at the Montgomery-Bucks County border, and gradually thins eastward.

Middle Member

The middle member of the Stockton Formation is comprised of brown, red, and gray, fine and medium-grained arkosic sandstone, and thick beds of red shale and siltstone. The largest member, this unit reaches a maximum thickness of 4,200 feet near the Montgomery-Bucks County border, and thins towards the west.

Upper Member

Quite different from the lower two members, the upper member contains very fine-grained arkose and siltstone and is capped by an extremely hard and resistant layer of red and gray shale (argillite). Thinning westward, the upper member has a total thickness of approximately 600 feet at the Montgomery-Bucks County border.

2.2.1.2 Lockatong Formation

Interfingering with the upper shale member of the Stockton Formation, the Lockatong Formation contains massive beds of medium to dark gray argillite interbedded with thin beds of gray to black shale, siltstone and marlstone. Large amounts of analcime (up to 40 percent) are present along with dolomite, feldspar, clay, quartz, and scattered pyrite (Longwill and Wood, 1965). Calcite is also quite common in joints, of which there are not many and are narrower and more widely spaced than in the other Triassic formations (Newport, 1973). In Montgomery County, the Lockatong Formation reaches a maximum thickness of 4,000 feet at the Montgomery-Bucks County border, and thins to

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approximately 1,500 feet at the Schuylkill River on the southwestern border of Montgomery County. Beds dip to the northwest an average of 20 degrees.

2.2.1.3 Brunswick Formation

The Brunswick Formation is the most extensive unit in the Triassic basin. Dipping 20° to the north and northwest, it underlies over 300 square miles of Montgomery and Berks Counties. At the Montgomery County-Bucks County border, it is approximately 9,000 feet thick and thickens westward to a maximum of 16,000 feet. The formation consists of thin, discontinuous beds of reddish-brown shale interbedded with siltstone and mudstone. Marble-sized calcareous concretions and thin layers of limestone are present in the Lansdale area (Rima, 1955).

The base of the Brunswick Formation interfingers with the Lockatong and is composed of thick-bedded red argillite. The upper beds grade into limestone breccias beyond Montgomery County's northern border.

As in the Lockatong Formation, fractures and joints in the Brunswick are partially filled with calcite, but are wider and more extensive. There are also several faults and diabase intrusions throughout the formation (Rima, 1955).

2.2.2 Diabase Dikes and Sills

In the northern part of the county, diabase dikes and sills of Upper Triassic age intrude the Brunswick Formation. Dikes, igneous intrusions which cut across bedding planes, are thin, between 5 and 100 feet, but may extend as much as 75 miles laterally across the county. Sills follow the bedding planes into which they were intruded. In Montgomery County, sills have been documented to be greater than 1,000 feet thick in some locations (Rima, 1955). Both dikes and sills are composed of very dense, fine-grained black diabase containing 90 to 95 percent augite and labradorite (Longwill and Wood, 1965).

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2.3 Hydrogeology

2.3.1 General Features

All the formations in the Newark Group of Montgomery County are considered aquifers. Each unit produces some amount of water, although some lithologies are much better aquifers than others. Because these formations are composed of consolidated rock rather than unconsolidated sediments, ground water is present in secondary porosity features such as joints, fractures, and faults. Those aquifers which are the best water producers generally have the greatest amount of secondary porosity.

Confined (artesian) aquifers are the most extensive type of aquifer in Montgomery County. Unconfined (water table) aquifers are also present, but to a lesser extent, and normally occur in valleys. The water table in shallow unconfined aquifers is usually close to the surface in the valleys and rises toward the ridges, although at a lower gradient than the rise in land surface. Hence, water levels are much deeper below land surface in the ridges than in the valley areas (Longwill and Wood, 1965).

As a result of the humid climate, seasonal evapotranspiration is the biggest factor affecting water level fluctuations. Under typical seasonal weather patterns, confined and unconfined water table elevations decline during the growing season (April to October), and are recharged during the remainder of the year. Recharge points may occur locally along ridgetops or over broad areas where bedrock is close to the surface. Deep artesian aquifers in the Triassic formations vary in size and ground-water storage. Confined aquifers are normally perched between leaky silt or clay aquitards, drawing some of their water yield from thin confining beds when pumped (Biesecker, 1968).

Formations in the Newark Group in Montgomery County are all conformable units and interfinger with one another in gradational contacts. As a result, the Stockton, Lockatong, and Brunswick Formations are in good hydraulic connection. Ground water, and possible

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contaminants along with it, can migrate across the entire region because confining beds also transmit water, although at slower rates than the more permeable beds. Diabase dikes and sills are impermeable, except in zones near the surface where weathering and fracturing have produced solution channels. Impermeable zones of diabase intrude only small portions of Triassic aquifers and do not have a large effect on ground-water migration (Rima, 1955).

2.3.2 Stockton Formation

Although secondary porosity dominates water yields of this formation, the degree of sorting and cementation in the three members of the Stockton Formation also affects yields and capacities of water-bearing units.

The middle member is the best water producer due to the presence of well sorted sandstone beds with a high porosity. Wells penetrating the middle Stockton member have an average yield of 131 gallons per minute (gpm) (Newport, 1973).

The lower member is poorly sorted compared to the middle member and, as a consequence of reduced porosity, yields from wells are lower, averaging 106 gpm. The upper shale member of the Stockton Formation is the poorest water producer, with yields from wells only averaging 19 gpm. The low-permeable sediments are too fine and compacted to have greater yields (Newport, 1973).

Water quality for the Stockton Formation is generally good. Waters are hard to very hard, with a medium hardness of 130 mg/l, and are of the calcium-bicarbonate type, reflected by their neutral-to-alkaline pH (ranging from 7.2 to 8.5). Median total dissolved solids (TDS) content is 200 mg/l (Koester and Miller, 1982).

2.3.3 Lockatong Formation

The Lockatong Formation is the poorest source of ground water in the sedimentary rocks in the Triassic Basin of Montgomery County. The shales

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and mudstones of the formation are fine-grained and too densely compacted to have any significant permeability. In addition, the joints and fractures that can hold water (secondary porosity) are narrow and widely spaced (as outlined in Section 2.2.2). As a result, wells tapping the Lockatong shale yield only 4 to 40 gpm of water (Newport, 1973). Furthermore, because the Lockatong Formation is a resistant shale and forms the ridges in the area, unconfined water tables are naturally low, and also cannot receive direct recharge from the low-lying streams. The quality of water from the Lockatong Formation is generally good, however the water is hard (median hardness 220 mg/l) and moderately alkaline as in the Stockton Formation. Total dissolved solids content averages 300 mg/l and values for pH average 7.8 (Koester and Miller, 1982).

2.3.4 Brunswick Formation

The Brunswick Formation also has small grain size and low primary porosity, but secondary porosity from fractures and joints makes the unit a good source of ground water. Joints are wide and extensive and many are vertical, which allows for good recharge percolation (Newport, 1973). Well yields in the Brunswick vary between 100 and 200 gpm due to variable bed thickness (affecting transmissivities) and variable degrees of jointing. Lens-type deposition also causes variability on an areal extent. Generally, production wells penetrating the Brunswick Formation deeper than 200 feet will have yields between 100 and 200 gpm, and as high as 350 gpm. It is believed that above 200 feet, joints are often plugged with clay, thereby reducing permeability (Longwill and Wood, 1965). Water quality of the Brunswick is similar to that of the Lockatong Formation, with median TDS content at 300 mg/l and a median hardness of 220 mg/l. Average pH is 7.3 (Koester and Miller, 1982).

2.4 Structural Features

The structural geology of Montgomery County is not complex. Rock strata dip uniformly to the north and northwest between 10° and 35°, except where diabase dikes have intruded, increasing the dips of

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sedimentary strata up to 50° (Hall, 1934). These zones of igneous intrusion are found principally in the northern part of the county, where several broad synclines and anticlines are also present, creating alternating outcrops of the Brunswick and Lockatong Formations. The axes of the synclines and anticlines trend northwest-southeast.

The rock units contain many scattered, relatively small faults, and three major fault zones (see Figure 4): (1) a fault running east-west along the southern boundary of the Stockton Formation running into Bucks County, (2) a series of faults displacing the basal contact of the Stockton Formation, and (3) the Chalfont Fault, an east-west normal fault with a 3,000 foot displacement, running between Hatfield and Souderton.

Joints and fractures, as mentioned earlier, are the most extensive structural features of the Montgomery County rocks. Vertical jointing is prominent in the Brunswick Formation, where they intersect in vertical planes and are on the average only 6 inches apart. It is this extensive jointing that as generated the high secondary porosity of the Brunswick Formation. Joint systems are similar in the Lockatong shale, but are narrower and more widely spaced. The Stockton Formation has joints and fractures both perpendicular and parallel to bedding planes, and are well distributed in the formation (NUS Corporation, 1986).

2.5 Geomorphology

2.5.1 General Features

The principal geomorphic features of Montgomery County are gently rolling hills and low-lying areas, with an overall gentle slope to the southeast. Resistant lithologies form the ridges throughout the county. In the southern portion of the county, ridges in the Stockton Formation run parallel to strike and are underlain by conglomerates. Depending on the thickness of the underlying resistant beds, the ridges may be broad or narrow (Rima, 1962). In the northern part of Montgomery County, the resistant argillite of the Lockatong Formation and intrusive diabase form the ridgetops in a series of northeast-southwest-trending anticlines.

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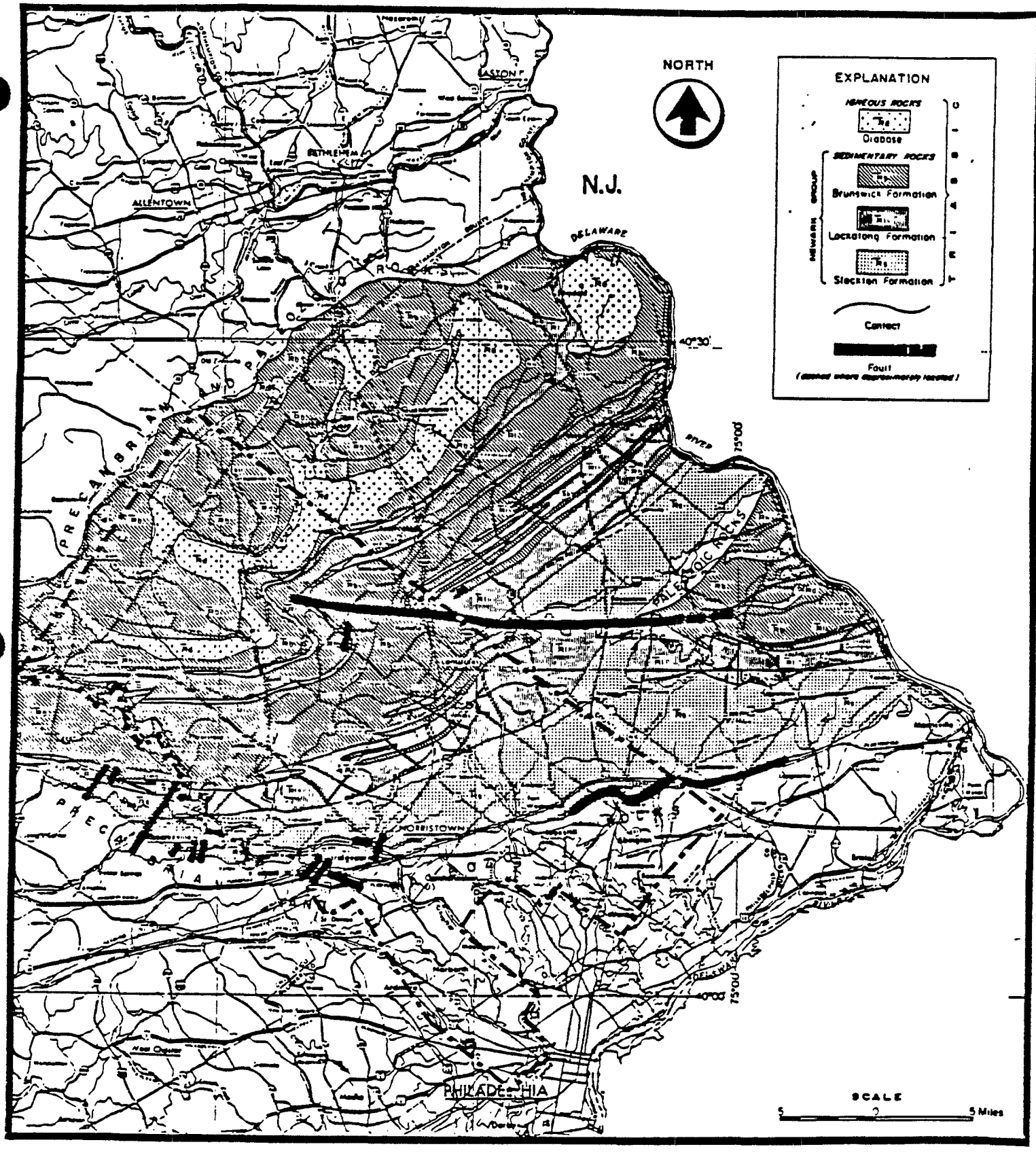

Figure 4. Geologic Map of the Newark Group in Southeastern Pennsylvania (From Rima, 1962)

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Lowlands occupy most of the county and indicate the former presence of less resistant lithologies now eroded by fluvial, alluvial, or aeolian erosion processes.

2.5.2 Drainage

Montgomery County is drained by tributaries of the Delaware River (Figure 6). As much as 15 to 21 inches of annual precipitation (approximately 33 percent) goes to streamflow (Rima, 1955). In the southern two-thirds of the county, Wissahickon and Towamencin Creeks flow to the southwest and empty into the Schuylkill River. The Schuylkill River forms the southeastern border of Montgomery County.

In north-central Montgomery County near the Bucks County border, Neshaminy Creek flows to the northeast and then turns southwest, ultimately emptying into the Delaware River. Most of the northern and central portions of the county are drained by the Perkiomen Creek and Skippack Creek drainage basins which flow southwest, combine, and discharge into the Schuylkill River.

Because of the county's erosional topography, which is directly related to folding of the underlying bedrock, drainage patterns run parallel to the ridges, generally trending northeast-southwest. In some areas within Montgomery County where ridges are breached (water gaps), streams flow to the southeast.

2.5.3 Soils

As the soil map in Figure 5 illustrates, county-wide soil characteristics vary greatly. In the study areas of north-central Montgomery County, however, two soil associations predominate. In Lansdale and Souderton Townships, the Reaville-Penn-Klinesville Association is found. These soils, weathered from red shales, are reddish brown in color. Slopes range from level to steep (up to 25 percent) and depth to bedrock ranges from 10 inches to 3 feet where this soil association dominates. Permeability is low due to clay content, and these soils remain saturated during much of the year (USDA, 1967).

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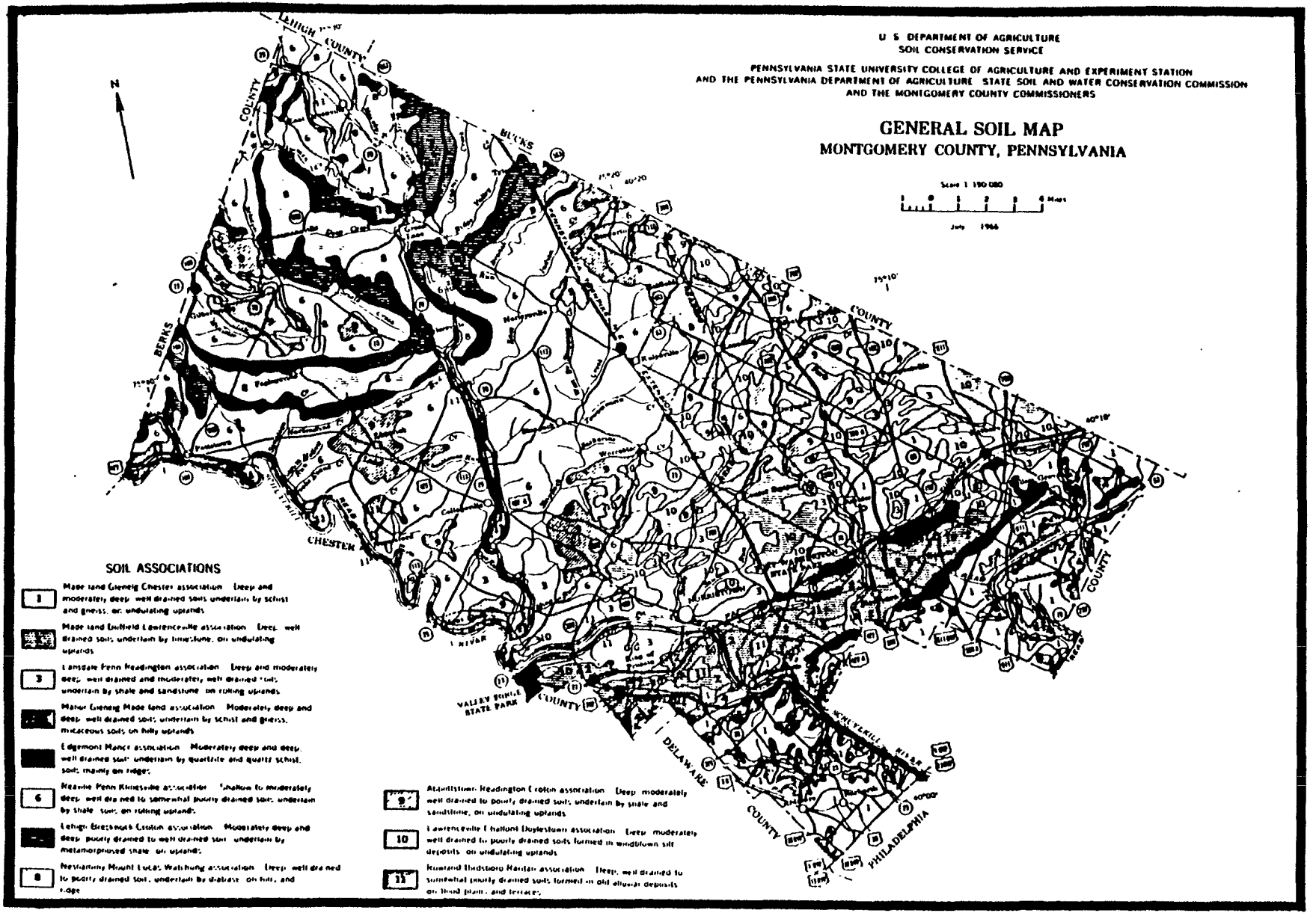

Figure 5. (From USDA, 1967)

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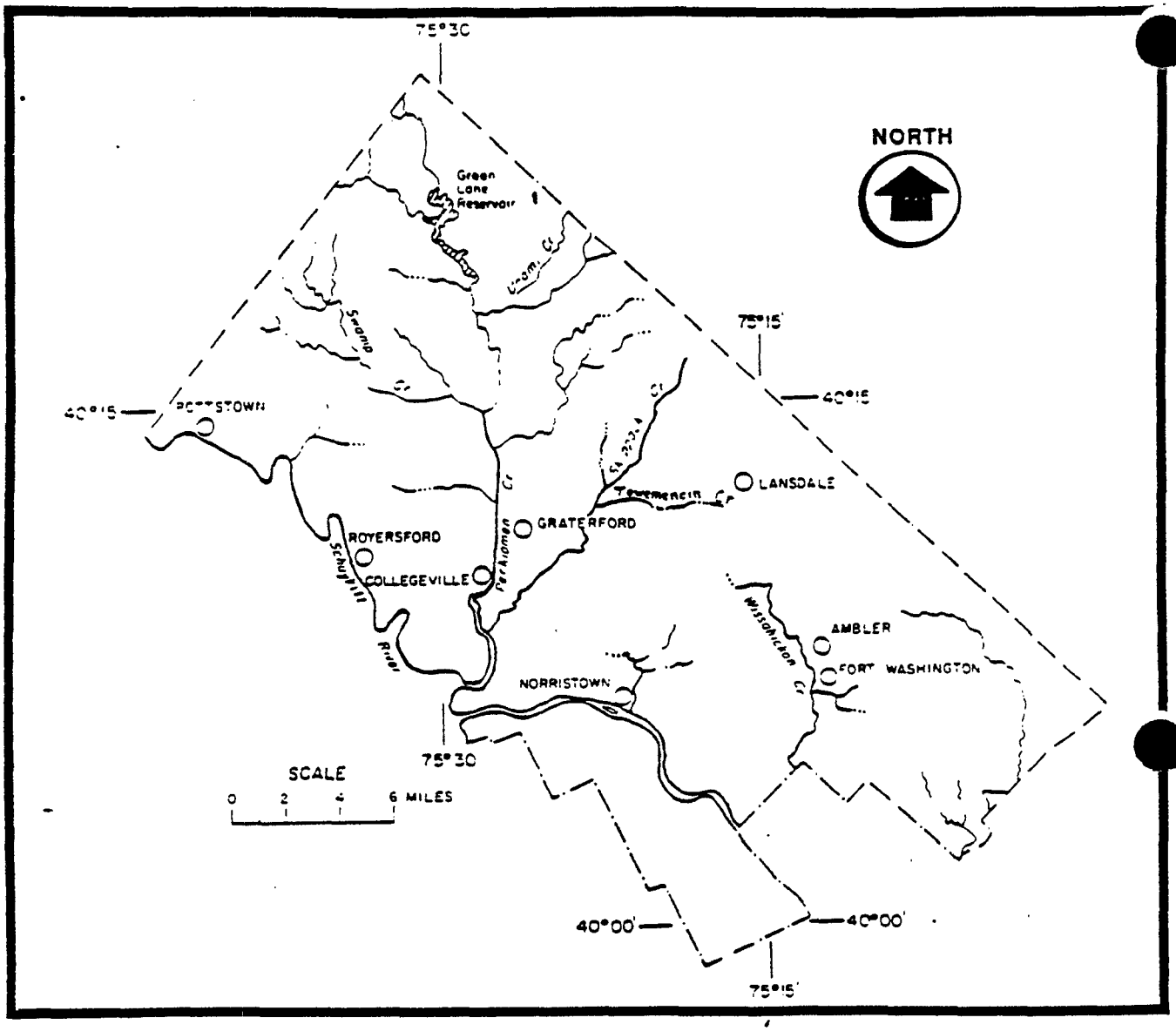

Figure 6. Drainage map for Montgomery County (From Newport, 1973)

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The second predominant soil group in the north-central part of the county, the Abbottstown-Readington-Croton Association, occupies irregularly shaped regions. Soils of this group are also reddish brown, weathered from red, black, and brown argillites of the Lockatong Formation, and contain coarse shale fragments. Slopes are gentle or nearly level, and depth to bedrock varies between 3 to 8 feet. As with the previous soil association, the Abbottstown-Readington-Croton soils have moderate to low permeability and often have a high moisture content. Vadose zone ground-water flow is further hindered by fragipans, densely compacted layers in the soil profile that are virtually impermeable to infiltrating water, and even root growth (Brady, 1974). Fragipans in the soil zone are scattered throughout the study area in north-central Montgomery County and do not seem to have any consistent spacial distribution within the study area. However, where known to be present, they should be considered when determining local hydrogeological conditions. Fragipans result mainly from heavy compaction rather than high clay content or cementation. They occur in lenses and can be several inches to several feet thick. Fragipans block vertical water movement. On slopes, ground water can flow along the surface of a fragipan (Buol, 1980).

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3.0 HYDROGEOLOGY OF NORTH-CENTRAL MONTGOMERY COUNTY

On a regional scale, Montgomery County can be considered a single watershed that discharges into the Delaware River. The drainage pattern empties into one source and, ignoring some spatial variability in well yields, the three Triassic formations (Stockton, Lockatong and Brunswick) can be considered as an interconnected aquifer system with no significant aquicludes or aquitards. However, a more localized hydrogeologic assessment is necessary when studying specific contamination sites in north-central Montgomery County, as ground-water flow is likely to be affected by local heterogeneities. Joints and fractures in the bedrock and fragipans in the soil zone may be widespread throughout the study areas. Due to thin soil zones and the presence of macropores in the bedrock from joints and fractures (secondary porosity), there may be direct hydraulic pathways for contaminants at the surface to infiltrate down to the deeper bedrock aquifers. Similarly, proximity to a fault will likely distort water elevations and ground-water flow directions and ultimately affect contaminant migration pathways.

Contamination problems close to a stream would need to take into account site-specific ground water-surface water hydraulic interactions. Variability of soils over smaller areas could affect the local hydrogeological framework and is a further variable in the characterization of contamination in a specific area. Consequently, although regional geology and hydrology will be fairly similar in the region, the hydrogeology of each zone of contamination should be interpreted and evaluated on a local level with available site data and then related to a regional perspective. Available relevant site-specific geology for each zone of contamination has been outlined in Section 2.4 of the main report.

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4.0 SUMMARY

Montgomery County, Pennsylvania, in the Triassic Lowland and Piedmont Upland Physiographic Sections, is a well-drained region of undulating ridges and valleys. The county is underlain by shales and sandstones of the Newark Group, namely the Stockton Formation sandstones and conglomerates, the Lockatong Formation argillite, and the Brunswick Formation shale, with diabase intrusions in the northern regions of the county.

All three sedimentary formations are aquifer units with water storage predominately in joints and fractures. Water-bearing capacity varies among the formations due to the variability in sediment sorting and compaction and the degree of jointing and fracturing. The Brunswick Formation is the most extensively jointed of the three sedimentary formations. Wells tapping the Brunswick Formation produced water yields in excess of 200 gpm. The Stockton Formation has well-sorted lithostatigraphic beds and fairly extensive jointing. Yields from production wells tapping the Stockton Formation average 130 gpm. The Lockatong Formation is densely compacted and joints are generally narrow and widely spaced; consequently yields from wells are much lower, averaging less than 40 gpm.

The aquifer characteristics of each formation (hydraulic conductivity, porosity, storage) are fairly consistent county-wide, yet local differences related to fracture density and soils require that site-specific hydrogeologic investigations be performed when characterizing a zone of contamination. Local relationships such as proximity to faults, streams or pumping centers and variability of soils may vary from the regional hydrogeologic parameters discussed here.

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APPENDIX B
SITE VISIT TRIP REPORT
GRANITE KNITTING MILLS, INC.
ZONE OF CONTAMINATION NO. 1
SOUDERTON, PENNSYLVANIA

PRELIMINARY DRAFT SUBJECT TO CHANGE AS A RESULT OF CDM QA/QC REVIEW

SITE VISIT TRIP REPORT

WORK ASSIGNMENT NO. 332
EPA CONTRACT NO. 68-01-7331

GRANITE KNITTING MILLS, INC.
ZONE OF CONTAMINATION NO. 1
SOUDERTON, PENNSYLVANIA

SUBMITTED TO:

CAMP DRESSER & MCKEE INC.
7611 LITTLE RIVER TURNPIKE
SUITE 104
ANNANDALE, VIRGINIA 22003

SUBMITTED BY:

VERSAR, INC.
6850 VERSAR CENTER
SPRINGFIELD, VIRGINIA 22151

MAY 21, 1987

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3.0	PROBLEMS AND RESOLUTIONS	2
4.0	RECOMMENDATIONS	2

1.0 INTRODUCTION

On Friday, May 8, 1987, Jeri Bulley, James DiClementi, Alicia Fleitas, and Patricia Watterson of Versar Inc. traveled to Souderton, Montgomery County, Pennsylvania to visit Zone Contamination No. 1. The purpose of the visit was to obtain additional site background information to assist Versar in evaluating existing contamination assessment and site characterization data for this zone. The potentially responsible parties (PRPs) within this zone include Granite Knitting Mills Inc., Gentle Cleaners, and Parkside Apartments. Arrangements were made to visit the Granite Knitting Mills site to gain firsthand knowledge of the facility layout and surroundings. The site visit was coordinated by U.S. EPA Region III with Granite Knitting Mills, Inc. and their legal counsel. In addition to visiting the Granite Knitting Mills site, a quick drive-by inspection of the other two facilities in this zone, Gentle Cleaners and Parkside Apartments, was planned to familiarize Versar with these PRPs.

2.0 SUMMARY OF SITE ACTIVITIES

At approximately 2:50 p.m., Versar and EPA officials were met at the Granite Knitting Mills site by the company officials. Individuals present during the site visit included:

Humane Zia	U.S. EPA Region III, CERCLA Remedial Enforcement
Kate Siftar	U.S. EPA Region III, CERCLA Remedial Enforcement
Lake Clemmer	President, Granite Knitting Mills, Inc.
Kerry Gingrich	Vice President, Granite Knitting Mills, Inc.
James W. Maza	Legal Counsel, Souder, Rosenberger, Lapp and Bricker
Jeri Bulley	Versar Inc.
James DiClementi	Versar Inc.
Alicia Fleitas	Versar Inc.
Patricia Watterson	Versar Inc.

The site visit began with a tour of the Granite Knitting Mills facility grounds, and a walk through the building. Specific areas which were inspected included the Granite Knitting Mills well, the room which housed the dry cleaning machine and the tetrachloroethylene (PCE) storage tank, the area where PCE was transferred from trucks to the PCE storage tank, and the area where drums of waste PCE were stored prior to pickup.

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All areas were photographed. Throughout the tour Mr. Clemmer, Mr. Gingrich, and Mr. Maza provided historical information on the facility's operations and additional information about the other PRPs in the zone. During these discussions, the facility representatives mentioned information about Gentle Cleaner's practices which had been verbally given to them by Mr. Harry Borcher of the North Penn Water Authority (NPWA). Versar later verified this information with Mr. Borcher.

Along with the tour of the facility, Granite Knitting Mills provided a driving tour of Souderton which included a look at the other PRPs, Gentle Cleaners and Parkside Apartments, and NPWA well S-9. During the tour, Granite Knitting Mills representatives also pointed out and mentioned several facilities which they believe might have used organic solvents and might have contributed to the current contamination problem.

A summary of the information obtained during the site visit will be presented in Section 2.3 of the Evaluation Report.

3.0 PROBLEMS AND RESOLUTIONS

There were no major problems associated with this inspection.

4.0 RECOMMENDATIONS

The site visit was useful in providing firsthand knowledge of the facility layout, features, and surroundings. Developing a clear picture of the site is valuable for completing subsequent tasks under this work assignment. It is recommended, therefore, that site visits continue to be part of the scope of work for technical review of documents. Due to the valuable information which was obtained in speaking directly with the facility representatives, it is also recommended that, in future tasks which require the evaluation of multiple facilities, attempts be made to visit each facility individually.

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APPENDIX C
SITE INSPECTION FIELD NOTES AND PHOTOGRAPHS
GRANITE KNITTING MILLS
ZONE OF CONTAMINATION NO. 1
SOUDERTON, PENNSYLVANIA
MAY 8, 1987

Granite Knitting Mills - May 8, 1987 VSI

Lake Clemmer, President, Granite Knitting Mills
Kerry Gingrich, VP, Granite Knitting Mills
James W. Maza, Souder, Rosenberger, Lapp & Bricker, Law Of
Humane Zia, US EPA Region III, CERCLA Remedial Enforcem
Kate Siftar, US EPA Region III, CERCLA Remedial Enforcem
Jim DiClementi, Versar
Patty Watterson, Versar
Jerri Bulley, Versar
Alicia Fleitas, Versar

Granite

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KERRY E GINGRICH.
V.P.
STANDARD TERRY MILLS (PO Box 285
112 E Chestnut St
Sanderton - 18964

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PO Box 215 Atlanta GA.
30301
404 - 352 - 1680

#16, 17, 18, 79 Behind Granite

Fence is Property Line. - will give

20 - old. Tower fondation

21, 22 old Gr. Kn. M. Well.
operated last 20 yrs ago. Pump in well.
went dry? long ago -

1979 - ~~at~~ 1st Indication.

200092

Zahn
~~Walter~~ Clemmer - bought out
operations, closed down in 1979

Zahn took back control in 1975
from Bank, Bank 1969-1975

He had had partial share
in operation all along.

Std Terry Mills leases ~~to~~
bldg for weaving operations.
Granite only owns real estate
& bldg has no conn.

He (Zahn) owns Std Terry Mills
w/

Dry Cleaning Mach. out in 1979.

Abandoned Heating / boiler oil tank
in ground ~ 20-30 feet from well

200093

Spill History - unknown?

Lwr - Gentle Cleaners may have had spill
& pipe Rung out back
- quote from Harry Borchers, head N

Granite Hired Envir. Soils - (Mr. Ge
to find spills.
Pinned it on gentle Poss.

Had another guy do Soil tests.

Old Perc was kept on far sic
of property.

#23 - Gentle from Granites
prop line (Eastern) Uphill granite

No Dry Cleaning Activity since 1979
1st Installed at 1967 (2a

Parkside - 15-20 years ago - No more
than 20.

Dry Clea Mach adj. to Loading Dock

200094

filled machine thing hole in wall.

Sludge oil - outside Dock.
(where Roof tar buckets now)

wipe on
Zep. - Dry Degreaser. for machines
50 gal - 1 every 3-4 yrs. -
drum

Perc tank inside near.

Keep drum in bldg.
evaporates
wipe on & evaporates.

Drainage bottom - dry
takes all site drainage.

Terry

"Copes Garage"? Gasoline into Sewer System -

N. of the Mill.

200095

granite

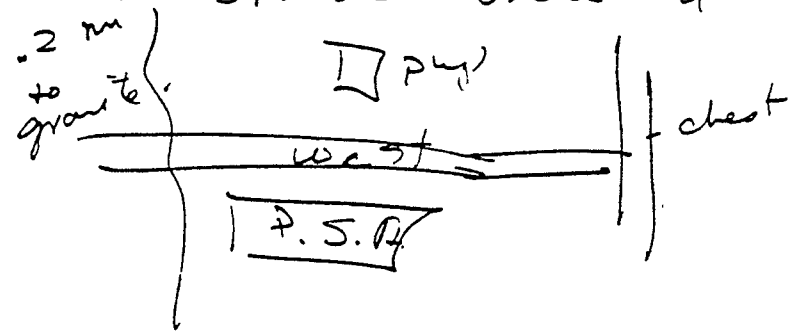
Tour of area.

Down Main to Chestnut.

To S - Tex - Gr. W. divide.
other side of

#2 Parkside. on West St
across from off Chestnut.
N Penn Well & Pump Statio.
down grad.

Stream across Rd.



Lexco Hydraulic Lift.
betw. Chestnut & Broad
(Lumber St)

200096

Prefer to remediate rather than fund RIFS Study. Property only worth 100,000. Does ~ 2-3 million in bus. net. profit ~ 20,000-50,00 per year

Can't afford 500,000 - 800K. Have lost collateral.

Can smell dry cleaners from parking lot!

Action - call Borchers to determine if Gentle Cleaners spill is documented

200097

1953 owned by Lake

1450 Granite Knitting Mill (Standard Terry Mills Inc.)

Zep Safety solvent - Memo posted see Jerri's notes
MSDS - for 1,1,1 TCEA posted ie. Zep Safety Solvent
dated March 16, 1987
Kerry Gingrich - VP
Lake Clemmer - President

last sampling - NUS - this is how it all got started
well hasn't been used in 20 years

1969 bank had taken over operation until end of 1975
early 60's Lake was involved, several prior owners
stock owned
Granite leases to Standard which is operating weaving

2% of perc left in stuff sprayed on roads

pipe running out back of Gentle Cleaners + spill
(relayed to Maza by Borcher (?) NPWA)

Soil tests performed around storage area & nothing
found, downgradient (hired by facility)

rear view for Gentle Cleaners
tanks overflowed because of manufacturing
malfunctions (Maza)
underground tanks on GC propert (kerry)

Drycleaning ~1967 (installed) 1971 (removed, not used up to end)
Other industries existed in area, welders, mechanics etc

gradient slopes towards south

15-20 years ago Parkside Apt was drycleaner & laundry mat (Maza)

PCE tank located inside, filled from outside through hole in the wall

volumes not given, will have to go through purchase orders

1 gp solvent small quantity, stored in drum inside building

~60 employees

200099

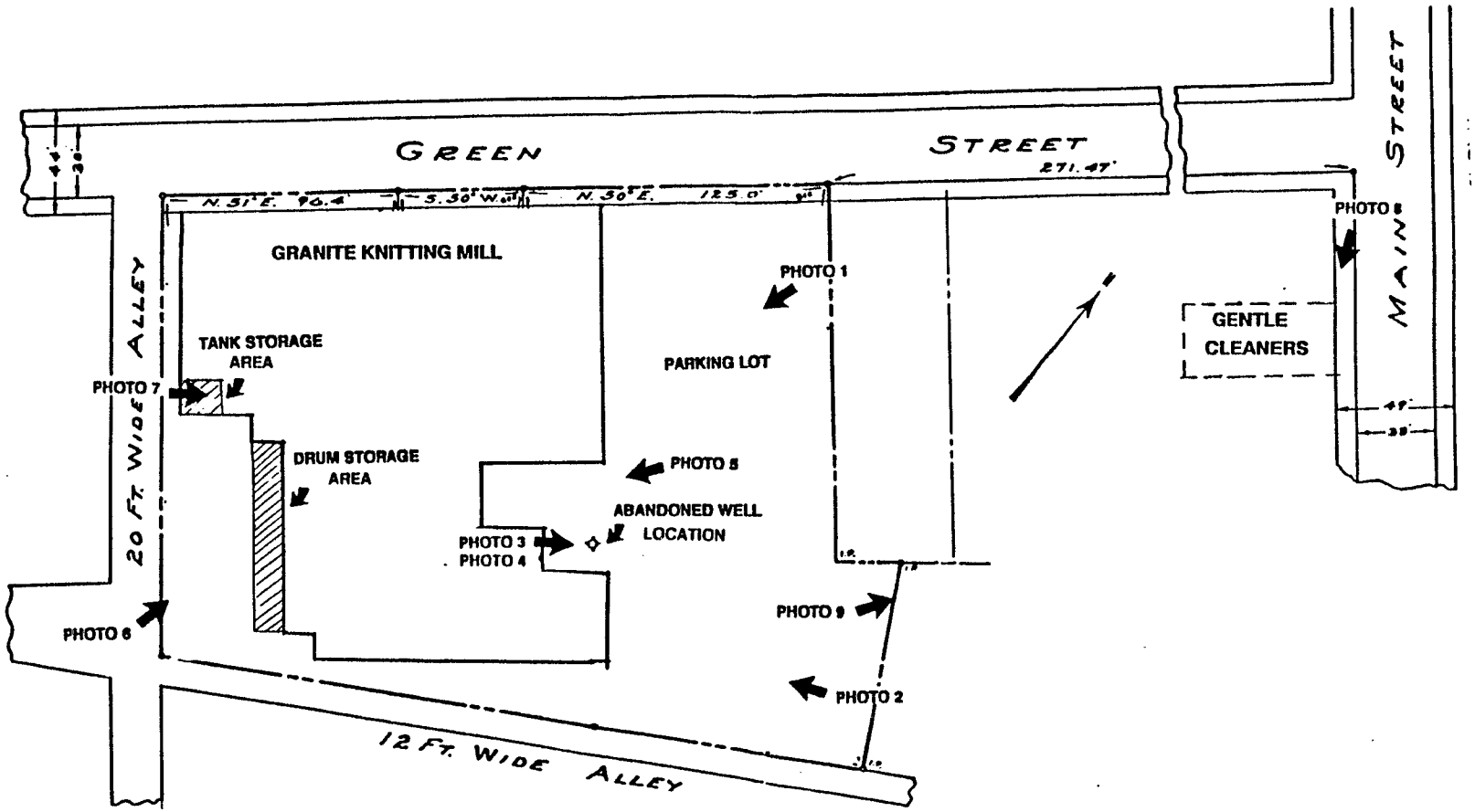


FIGURE C-1
APPROXIMATE BUILDING AND PROPERTY BOUNDARIES
AND PHOTOGRAPH LOCATIONS
GRANITE KNITTING MILLS AND GENTLE CLEANERS
SOUDERTON, PENNSYLVANIA

NOT TO SCALE

200100

Photograph 1: View of main building from parking lot, Granite Knitting Mills. View towards south.

Photograph 2: View of Granite Knitting Mill from east towards location of old well.

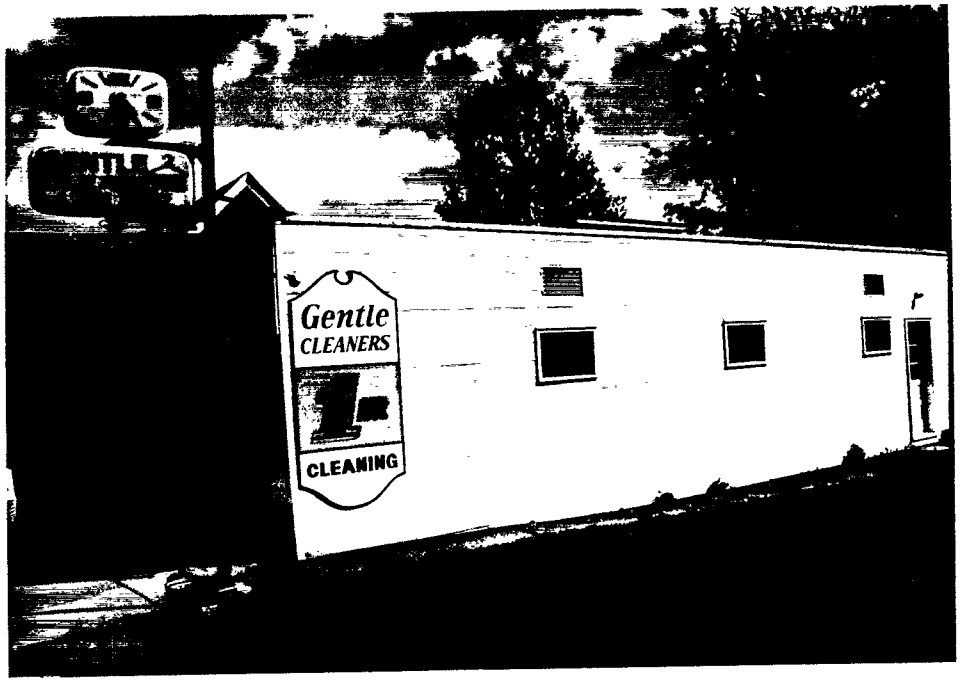
Photograph 3: View of old Granite Knitting Mill production well location

Photograph 4: View beneath concrete slab over old Granite Knitting Mill well.

Photograph 5: View from east of old water tank supports behind Granite Knitting Mill. Old well is to left.

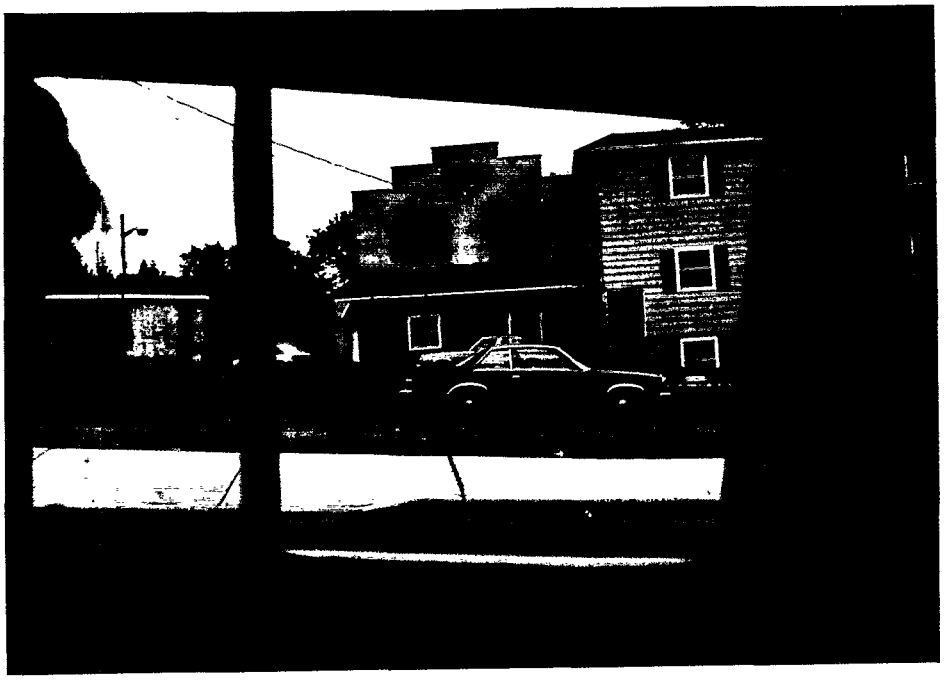
Photograph 6: View from south of historical oil drum site area, Granite Knitting Mill. PCE tank location was to left, inside building behind loading dock door.

Photograph 7: View of room which had contained PCE storage tank. Loading dock to right.



Photograph 8: View from north of Gentle Cleaners site.

Photograph 9: View from southwest of Gentle Cleaners site, from Granite Knitting Mills fence line.



Photograph 10: View from northeast of Parkside Apartments.

REFERENCE 1

REFERENCE 2

SEE APPENDIX C

REFERENCE 3

SEE APPENDIX C

REFERENCE 4

Bur
no. 22

BULLETIN

Ground-Water Resources of the Brunswick Formation in Montgomery and Berks Counties, Pennsylvania

by Stanley M. Longwill and Charles R. Wood
Hydraulic Engineers, U. S. Geological Survey

Prepared by the United States Geological Survey,
Ground Water Branch, in cooperation with the
Pennsylvania Geological Survey

PENNSYLVANIA GEOLOGICAL SURVEY
FOURTH SERIES
HARRISBURG
1965

200117

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2001118

Ground-water Resources of the Brunswick Formation in Montgomery and Berks Counties, Pennsylvania

By

Stanley M. Longwill and Charles R. Wood

ABSTRACT

The Brunswick Formation in Montgomery and Berks Counties, Pa., consists of reddish-brown shale, mudstone, and siltstone, which are interbedded with sandstone and fanglomerate near the northern border of the Triassic basin. In places the Brunswick Formation has been intruded by diabase dikes and sills, and throughout much of its outcrop area it is interbedded with the Lockatong Formation. The Lockatong Formation in Montgomery County consists principally of massively bedded medium- to dark-gray argillite interbedded with thin beds of gray to black shale, siltstone, and marlstone.

Ground water in the Brunswick and Lockatong Formations occurs largely in secondary openings such as joint planes. These secondary openings are more abundant and much more closely spaced in the Brunswick Formation than in the Lockatong Formation. Consequently, wells in the Lockatong Formation generally yield water for domestic purposes only whereas many wells in the Brunswick Formation yield sufficient water for industrial and municipal use.

Data from 199 wells that obtain water from only the Brunswick Formation in Montgomery County indicate that wells should be drilled at least 200 feet deep, if yields of more than 100 gpm (gallons per minute) are desired. Wells drilled to depths between 200 and 550 feet are most likely to obtain maximum yields.

Pumping tests in the Brunswick Formation, using observation wells, were made at six localities. Coefficients of transmissibility computed from drawdown data at the observation wells are much higher than transmissibilities calculated at the pumped wells, demonstrating the poor hydraulic connection between the pumped wells and the observation wells. The excessively high transmissibilities are useful for estimating the effect of pumping upon nearby wells and indicate that interference between wells during brief periods of pumping may be somewhat less in the Brunswick Formation than in an ideal aquifer. Water levels in the observation wells declined to a greater extent than predicted by the transmissibilities computed from data obtained during the early part of a pumping test, however, because impermeable boundaries appear in the test data of almost all observation wells. Transmissibilities computed for the pumped wells at the six test localities range from 100 to 5,000 gpd (gallons per day) per foot, and the median transmissibility is 1,100 gpd per foot.

Transmissibilities determined from additional pumping tests in the Brunswick Formation, which were made without observation wells, range from 140 to 4,000 gpd per foot, and the median is 600 gpd per foot. Transmissibilities determined from pumping tests in the Lockatong Formation, all of which were made without observation wells, range from 60 to 2,600 gpd per foot, and the median is 150 gpd per foot.

Observation wells situated along a line from the pumping well that is perpendicular to the strike of the beds show much less drawdown in response to pumping than do wells situated along a line parallel to the strike, because the former do not penetrate the same strata as the pumped well. The resultant cone of depression surrounding a pumping well is ellipsoidal in shape—being elongated parallel to strike.

Chemical analyses of ground-water are available from 36 wells in the Brunswick Formation and six wells in the Lockatong Formation. Ground water in both formations is largely of the calcium-bicarbonate type. However, water samples from the Brunswick Formation having concentrations of dissolved solids greater than 500 ppm (parts per million) are of the calcium-sulfate type. Median dissolved-solids content is 302 ppm in water from the Brunswick Formation and 268 ppm in water from the Lockatong Formation. Median hardness as $CaCO_3$ is 218 ppm in water from the Brunswick Formation and 206 ppm in water from the Lockatong Formation.

INTRODUCTION

PURPOSE AND SCOPE

Prior to 1940, the area in Montgomery and Berks Counties that lies to the north and northwest of Philadelphia, Pa., consisted chiefly of small towns surrounded by farm land. The industrialization and urbanization of this area increased rapidly after the Second World War. For example, the population of Montgomery County as determined by the 1940 census was only 289,247, but by 1960 the population had risen to 516,682, almost double the 1940 figure. Most of the population increase and industrial investment occurred in the southern part of Montgomery County while the northern part retained its rural character.

The development of new ground-water supplies to meet the increased demands of industries, municipalities, and individual consumers in this rapidly growing area has been seriously handicapped by a lack of geologic and hydrologic data. Having recognized that maximum utilization of the available supply depends on understanding the occurrence, movement, and distribution of the ground water in the area, a study of the occurrence of ground-water in the Triassic rocks of southeastern Pennsylvania was begun in 1956 by the U.S. Geological Survey in cooperation with the Pennsylvania Topographic and Geologic Survey.

This report deals chiefly with the ground-water resources of the Brunswick Formation in Montgomery and Berks Counties, although some attention is directed to the water-bearing properties of the Lockatong Formation in the same area. It is one of a series of reports that will eventually describe the ground-water resources of the rocks of Triassic age in southeastern Pennsylvania. The first of these, a report on the Stockton Formation in southeastern Pennsylvania, was published in 1962 (Rima, D. R., and others, 1962).

LOCATION OF THE AREA

The area covered by this report is in Montgomery and Berks Counties, in southeastern Pennsylvania, between lat. 40°08′ and 40°27′ N. and long. 75°09′ and 75°56′ W. (See Fig. 1.) The area extends for 41 miles from the eastern border of Montgomery County to its most western point, on

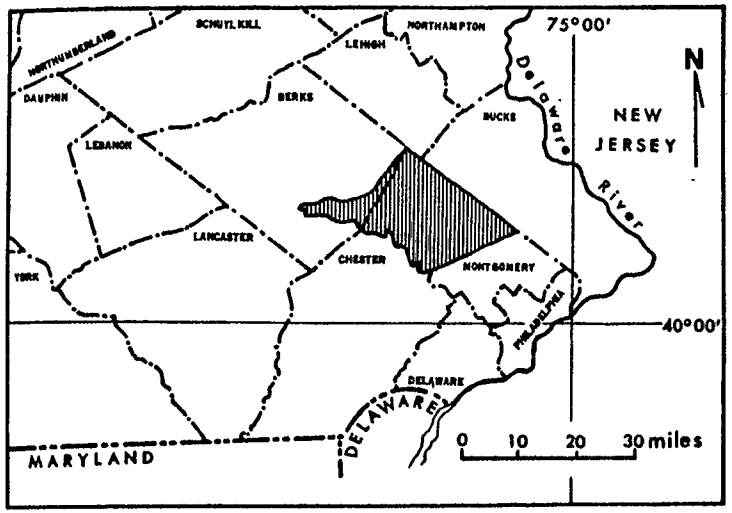

Figure 1. Map of southeastern Pennsylvania showing location of area covered by this report.

the Schuylkill River near Reading, Pa. It is 16 miles wide in eastern Montgomery County and narrows to less than 1 mile wide near Reading. The total area covered by the report is 347 square miles, of which 300 square miles is in Montgomery County and 47 square miles is in Berks County.

METHODS OF THIS INVESTIGATION

An inventory was made of nearly all municipal and industrial wells and about 70 rural and domestic wells in the area covered by this report. The records for 322 wells are given in table 6, and the well locations are shown in Plate 1.

Pumping tests ranging in duration from 3 to 101 hours (and making use of observation wells) were made at six locations. Short-term pumping tests (generally of 1-hour duration and without the use of observation wells) were made at 15 wells. Three test wells were drilled in order to obtain geologic data and to provide sites for pumping tests.

Ground-water samples were collected from 42 wells, and complete chemical analyses of the samples were made by the Quality of Water Branch, U.S. Geological Survey.

PREVIOUS INVESTIGATIONS

The ground-water resources of the Brunswick and Lockatong Formations in Berks and Montgomery Counties were described very briefly by Hall (1934) who made a reconnaissance investigation of the ground-water resources of southeastern Pennsylvania. Rima (1955) investigated the ground-water resources of the Brunswick Formation in the vicinity of

Lansdale. Greenman (1955) described the ground-water resources of the Brunswick and Lockatong Formations in adjoining Bucks County. Barksdale and others (1958) prepared a report covering the ground-water resources in the tri-state region adjacent to the lower Delaware River, which discussed the water-bearing properties of the Brunswick and Lockatong Formations.

The geology of the Quakertown and Doylestown 15-minute quadrangle was described and mapped by Bascom and others (1931). Bascom and Stose (1938) described the geology of the Phoenixville 15-minute quadrangle. Since 1932, D. B. McLaughlin has written many articles describing the geology of the Brunswick and Lockatong Formations in southeastern Pennsylvania. These articles are summarized in the report on the geology of the Mesozoic rocks in Bucks County (McLaughlin, 1959) which describes in detail the geology of the Brunswick and Lockatong Formations in southeastern Pennsylvania.

ACKNOWLEDGMENTS

The writers acknowledge with appreciation the cooperation and assistance received from well drillers, industries, home owners, water companies, and local, state, and federal governmental agencies.

Appreciation is expressed to Leeds and Northrup Co., North Wales, who permitted their wells to be used for water-level measurements, assisted in aquifer tests, and supplied drillers logs of wells. Nice Ball Bearing Co., Kulpsville; Kawecki Chemical Co., Boyertown; Douglassville Development Corp., Douglassville; Pennhurst State School, Spring City; and Charles Johnson County Home, Royersford; permitted their wells to be used in pumping tests and made available sites for additional test wells. Acknowledgment is made to Souderton Borough for providing sites for water-level recorders and permitting the use of their wells in aquifer tests.

Most of the data for the geologic map (Pl. 1) was obtained from unpublished geologic maps by Dr. Dean B. McLaughlin, University of Michigan.

WELL-NUMBERING SYSTEM

All wells used in this report have an identification number and a location number. The identification number consists of two parts. The first part is a two-letter symbol that identifies the county in which the well is located. For example, wells in Montgomery County are identified by the symbol Mg and those in Berks County are identified by the letters Be. The second part of the identification number is a serial number that was assigned at the time the well was first visited during the field investigation.

Each well identified in the manner described is located by means of a three-part well-location number. The first two parts are obtained by superimposing a grid network on the area of investigation. The network is constructed of 1-minute parallels of latitude and meridians of longitude. Thus, it consists of a series of 1-minute quadrangles each of which can be identified by two three-digit numbers. The first number, which identifies the latitude bounding the quadrangle on the south, is formed by the last digit used in the number of degrees latitude and the two digits used in the number of minutes. The second three-digit number is obtained in a similar way by using the degrees and minutes of the longitude bordering the quadrangle on the east. The third part is a serial number assigned to distinguish the wells from others in the same quadrangle.

For example, a well in Montgomery County given identification number Mg-633 bears the location number 015-520-10. This well is located in the 1-minute quadrangle that is bounded on the south by latitude 40°15′ and on the east by longitude 75°20′. The serial number 10 indicates that this well was the tenth well visited within that 1-minute quadrangle.

CLIMATE

Pennsylvania has a humid climate and moderate temperatures. Most of the weather disturbances that affect Pennsylvania are carried from the interior of the continent by prevailing westerly winds. However, coastal storms occasionally affect day-to-day weather in the southeastern part of the state (Kauffman, 1960, p. 2). Differences in elevation within the area in this report are not great enough to cause any major differences in climate.

Temperatures in southeastern Pennsylvania generally range from 0°F to 100°F. The summers are long, and daily temperatures reach 90°F or above on an average of 25 days during the summer. The winters are mild, and the minimum temperatures go below 32°F an average of less than 100 days a year. The average annual temperature for the report area, based on data for Phoenixville, is 54.3°F. Mean monthly temperatures at Phoenixville range from 33.1°F in February to 76.7°F in July. (Data from U.S. Weather Bureau climatic summaries.) The freeze-free season usually ranges from 170 to 200 days.

The average annual precipitation from 1931 to 1955, based on records from several stations within the area, was about 44 inches. The minimum annual precipitation recorded within the report area is 26.45 inches at Pottstown in 1930. The maximum annual precipitation recorded for the area is 71.32 inches at Pottstown in 1889.

Precipitation is fairly well distributed throughout the year, but occasionally dry spells persist for several months with very little rainfall. The average seasonal snowfall is about 30 inches; the ground is covered by snow about one-third of the time during the winter.

Occasional severe coastal storms have caused a normal 1-month rainfall to occur within a period of 48 hours. Floods have been caused by these

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coastal storms and by melting snow and heavy rain in the spring. Major flooding occurred along the Schuylkill River in 1902, 1935, 1942, and 1955.

GEOLOGY

NEWARK GROUP

Rocks of Triassic age occupy a series of disconnected, downfaulted basins that extend from Nova Scotia to North Carolina. These rocks, known as the Newark Group, often have a reddish color and consist principally of conglomerate, arkose, sandstone, siltstone, argillite, and shale. They are interbedded with basaltic lava flows and are intruded by diabase dikes and sills.

McLaughlin (1957, p. 1492-1493) believes that the Newark Group is of Late Triassic age. Paleontologic data support this conclusion (Wherry, 1959, p. 124). Rocks of the group overlie Paleozoic and Precambrian rocks unconformably, and in New Jersey the Newark Group is overlain unconformably by Cretaceous rocks.

The Triassic rocks of Montgomery and Berks Counties are part of the largest Triassic basin in the eastern United States. This basin extends from the Hudson River in southeastern New York, across New Jersey, southeastern Pennsylvania, Maryland, and into northern Virginia. In Pennsylvania the width of the basin ranges from about 30 miles in eastern Montgomery County to about 4 miles southeast of Lebanon, Pa.

In southeastern Pennsylvania and western New Jersey the Newark Group has been divided, proceeding from the oldest sediments to the youngest, into the Stockton, Lockatong, and Brunswick Formations. (See Pl. 1.) These formations were described at the type locality in New Jersey by Kummel (1897). The Stockton Formation is composed of interbedded arkosic sandstone and conglomerate, red shale, and red siltstone. The Stockton is overlain to the north by the Lockatong Formation, which is made up principally of dark gray argillite. The Lockatong is overlain to the north by the Brunswick Formation, which consists chiefly of red shale and siltstone although there is some interbedded sandstone and conglomerate near the north border of the outcrop. The Brunswick Formation is equivalent to the Gettysburg Shale in Adams, York, and Lancaster Counties, Pa., the two formations having been deposited almost contemporaneously.

Although the sum of the thicknesses of the individual formations in the Newark Group is about 18,000 feet, the total thickness of the Newark Group present at any one place in southeastern Pennsylvania probably does not exceed the 12,000 feet believed to be present at the center of the basin (McLaughlin and Willard, 1949, p. 43). The absence of the total

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thickness at any one place is postulated because the floor of the basin probably shelved northward and deposition did not start along the northern edge of the basin until several thousand feet of sediments had accumulated in the central part of the basin. This theory is supported by the fact that the Brunswick Formation was deposited directly upon Paleozoic and Precambrian rocks along part of the northern border of the Triassic basin in Pennsylvania.

LOCKATONG FORMATION

The Lockatong Formation occurs principally in a single continuous belt along the southern edge of the Brunswick Formation. The width of this belt in Montgomery and Berks Counties varies from 4 miles at the Bucks County-Montgomery County line to 1¼ miles at the Schuylkill River. This main body of Lockatong Formation underlies an area of 46 square miles in Montgomery County. A few relatively thin tongues of Lockatong occur well up-section (northward) in the Brunswick Formation, and although most of these tongues do not extend far to the west of the Bucks County line, some of them can be traced for about 30 miles westward to the Schuylkill River.

The Lockatong Formation in Montgomery County consists principally of medium-to dark-gray argillite interbedded with thin beds of gray to black shale, siltstone, and marlstone. Bedding is principally massive. Van Houten (1960, p. 666) indicates that the Lockatong contains a large percentage of analcime (up to 40 percent) along with dolomite, feldspar, and clay. Quartz is a very minor constituent of the Lockatong Formation. Pyrite is scattered throughout the formation and calcite is common, especially in joints.

In the area of this investigation the Lockatong Formation attains its maximum stratigraphic thickness at the Bucks County line. A stratigraphic section measured by McLaughlin (1959, p. 88) at this locality shows a thickness of slightly over 4,000 feet. The Lockatong Formation thins rapidly to the west and is only about 1,500 feet thick at the Schuylkill River (Bascom and Stose, 1938, p. 72).

The Lockatong Formation overlies the Stockton Formation conformably, and probably there is some interfingering of the two formations (McLaughlin, 1959, p. 77). The Lockatong is overlain conformably by the Brunswick Formation, and there is considerable interfingering between these formations—especially in eastern Montgomery County. Where there is interfingering, the percentage of red beds in the section increases upward in the stratigraphic column until the red beds of the Brunswick Formation predominate over the gray shale and argillite of the Lockatong.

The Lockatong Formation grades westward along strike into the typical red shale, mudstone, and siltstone of the Brunswick Formation. This

gradation and thinning westward continues until the Lockatong Formation disappears a few miles west of Phoenixville.

BRUNSWICK FORMATION

In Montgomery and Berks Counties, the Brunswick Formation, together with the associated diabase intrusives, occupies an area of 301 square miles. Two large areas of Brunswick, one of about 25 square miles (lying mostly in Upper Hanover Township, Montgomery County) and the other of 50 square miles (lying mostly in Douglass and New Hanover Townships, Montgomery County) are separated from the main body of the Brunswick Formation by diabase intrusives.

The Brunswick Formation consists typically of reddish-brown shale, mudstone, and siltstone. A few very thin beds of green shale and brown shale are present in the Brunswick, and in some places they can be used as marker beds for distances up to 1 mile. Van Houten (1960, p. 669) indicates that the Brunswick Formation consists chiefly of feldspar, illite, chlorite, quartz, and calcite. Some beds are finely micaceous. Joints in the Brunswick Formation commonly are partly filled with calcite and quartz. Occasionally barite and pyrite are present as joint filling, and very small crystals of pyrite may be disseminated throughout the rock.

The total apparent thickness of the Brunswick Formation in Bucks County is about 9,000 feet (McLaughlin, 1959, p. 99). The maximum thickness is greater to the west and is about 16,000 feet near Pottstown, Pa. (Bascom and Stose, 1938, p. 76).

Near the base of the Brunswick much of the rock is tough thick-bedded red argillite and is interbedded with dark-gray argillite of the Lockatong Formation. This red argillite grades upward and also along strike into red shale, mudstone, and siltstone. Near the north border of the Triassic basin, the typical shales, mudstones, and siltstones of the Brunswick Formation are interbedded with and grade laterally into sandstone and fanglomerate.

There are many excellent exposures of the Brunswick Formation—especially along streams and railroad cuts. For detailed geologic sections the reader is referred to McLaughlin (1933) and Bascom and Stose (1938). Table 7 contains seven sample logs that illustrate the relatively uniform character of the Brunswick Formation. Some of them (Be-125 for example) show that beds of gray argillite typical of the Lockatong are present also in the Brunswick Formation.

FANGLOMERATES

Fanglomerates occupy about 6 square miles along the northern border of the area of investigation. These fanglomerates were deposited as alluvial fans by streams flowing into the basin from the north. They are mostly limestone breccias consisting of angular gray limestone pebbles in a red-

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dish-brown or buff, fine-grained, sandy-to-argillaceous matrix. Some pebbles of quartzite and other rocks are also present.

These fanglomerates occur at several locations along the northern border and are extensively interbedded with typical shale and siltstone of the Brunswick. The beds of limestone breccia grade along strike into reddish-brown sandstone and then into reddish-brown shale.

Outcrops of fanglomerate are very scarce in Montgomery County; however, in Berks County the area of fanglomerate that crosses the Schulykill River south of Reading is exposed in many places.

The fanglomerates are some of the youngest beds within the Brunswick Formation. However, west of the Schuylkill River, fanglomerates were deposited throughout most of the period of deposition of the Brunswick Formation. Several tongues of fanglomerate extend eastward towards the Schulykill River, and are represented at the river by a few thin sandstone beds.

The areas mapped as fanglomerate on Plate 1 are areas in which breccia and conglomerate are more prevalent than the interbedded shale, siltstone, and mudstone.

METAMORPHISM

Near the diabase intrusives the shales of the Brunswick Formation are altered to dark, tough hornfels. These hornfels closely resemble the Lockatong Formation because of the change of color caused by the reduction of ferric to ferrous oxide. The effect of the metamorphism on the color of the sediments is gradational, the first effect being the change from red to purplish red. With increased baking the beds change from purple to dark gray or blue black.

The width of the altered zone differs greatly from place to place. Adjacent to the smaller dikes the zone is usually between 40 and 100 feet wide, and in the vicinity of the larger intrusives the altered zone may be more than 1 mile wide. The rocks near the outer limit of the altered zone show very little change in lithology.

DIABASE

The Brunswick Formation has been intruded by many diabase dikes and sills in southeastern Pennsylvania. The dikes are generally 5 to 100 feet thick, and their outcrops may extend for several miles. The diabase in these narrow dikes is black, dense, very fine-grained, and consists of 90 to 95 percent labradorite and augite.

The sills, with few exceptions, are much thicker than the dikes. The largest sills in the area are more than 1,000 feet thick. The diabase in the larger intrusives, except in the chilled border zone, is medium to coarse grained, greenish gray, and also consists of 90 to 95 percent labradorite and augite (Ryan, 1959, p. 155).

STRUCTURE

The average dip of the beds in the Brunswick and Lockatong Formations is to the north and northwest at about 20°. Several broad synclines and anticlines, whose axes trend about N. 60° W., are superimposed on this homocline.

The Brunswick and Lockatong Formations have been cut by many faults, most of which are relatively small. Some of these small faults may be observed in the railroad cut south of North Wales. McLaughlin (1942) gives the location of several faults.

The largest fault observed in Berks and Montgomery Counties passes between Hatfield and Souderton in an east-west direction. It has a throw of about 3,000 feet at the Bucks County-Montgomery County line (McLaughlin, 1959, p. 129). The Brunswick Formation is in fault contact with the underlying Paleozoic and Precambrian rocks along part of the northern border of the Triassic basin.

Joint systems are well developed in many of the beds in the Brunswick Formation. A very small set of joints strikes about N. 30° E., and one or both of two additional, less well-developed sets may be observed at most outcrops. These additional sets strike about N. 45° W. and N. 75° E. All of the joints are nearly vertical, and the average distance between joints in most sets is about 6 inches. The strike of the Joint sets appears to be independent of the dip and strike of the beds.

HYDROLOGY

PRINCIPLES

Ground water is the subsurface water in that part of the zone of saturation in which all the interconnected pores, crevices, and voids in the rock are filled with water under pressure equal to or greater than atmospheric. Precipitation is the source of ground water in southeastern Pennsylvania. Although most of the water that reaches the land surface from the atmosphere either runs off as overland flow or is returned to the atmosphere by evaporation and transpiration, some infiltrates downward through the soil to the zone of saturation, where it becomes recharge to the main ground-water body. Upon reaching the zone of saturation, it begins to move downward and laterally toward lower elevations, and eventually it may return to the surface either naturally (through springs) or artificially (through wells). Under natural conditions and over long periods of time, the amount of water that leaves the zone of saturation as discharge is balanced by the amount of water that enters it as recharge.

Ground water may be roughly divided into two classes: (1) that which occurs in the shallow formations, mostly under nonartesian conditions, and (2) that which occurs in the deeper formations, under artesian conditions. Nonartesian conditions are those in which ground water is unconfined, so that its upper surface (the water table) is free to rise and fall. Artesian conditions are those in which the ground water is confined in a permeable formation that is overlain by a relatively impermeable formation, so that the upper surface of the confined water is not free to rise and fall, and the water is under sufficient pressure to rise above the top of the formation that contains it where that formation is penetrated by wells. The imaginary surface to which water will rise in tightly cased wells tapping the artesian aquifer is called the piezometric surface.

In humid areas, such as southeastern Pennsylvania, the water table stands at or near the land surface in valleys and rises toward adjacent topographic divides. The slope of the water table is generally less than that of the land surface; hence, the depth to the water table below the land surface is usually greatest beneath topographic highs and least beneath topographic lows.

The water table does not remain in a fixed position but fluctuates in response to additions to and withdrawals from the zone of saturation. As the seasonal variation in precipitation in southeastern Pennsylvania is small, the dominant factor controlling the fluctuation of the water table in areas remote from pumped wells is the seasonal variation in the rate of evaporation and transpiration. Thus the water table generally declines throughout the warm growing season (April to October) and rises throughout the remainder of the year.

Within the zone of saturation, the rocks of the earth's crust differ greatly in their capacity to store and transmit ground water. Rocks that are capable of yielding usable quantities of ground water to wells are called aquifers. An aquifer may consist of all or part of a geologic formation or group of formations.

Most of ground water, like water in other phases of the hydrologic cycle, is continually in motion. It flows by gravity from intake or recharge areas, where hydraulic potentials are high, through permeable zones or aquifers to points of discharge, where hydraulic potentials are low.

OCCURRENCE OF GROUND WATER IN THE BRUNSWICK FORMATION

The Brunswick Formation is composed of very fine-grained rocks. The pore spaces within the rock matrix are very small and offer great resistance to the flow of ground water. Therefore, the permeability due to the primary porosity of the Brunswick Formation is small.

Most of the ground-water movement within these rocks follows secondary openings that were developed by external forces, following deposition of the beds. Some of these openings are fractures that parallel the bedding planes. They are usually narrow and probably contribute little to the permeability. The most important openings are nearly vertical joint

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planes that cross each other at various angles throughout the beds. These vertical joints provide an interconnected series of channels through which ground water can flow.

The number and width of secondary openings and, consequently, the permeability differ from one bed to another. In a series of beds 100 feet thick there may be only one or two beds in which the secondary openings are well developed. These beds range in thickness from a few inches to a few feet; the average thickness is about 2 feet.

Because of conditions under which the rocks of the Brunswick Formation were deposited, lateral changes in the lithology take place within the formation. The rocks are a series of overlapping lens-shaped beds that are discontinuous in all directions along the plane of bedding. Examination of rock outcrops in the area indicates, however, that many of these lens-shaped beds extend for several thousand feet along strike.

The Brunswick Formation is generally a reliable source of small to moderate supplies of ground water, and in many places wells yield more than 100 gpm.

Analysis of data from 199 wells, which obtain water from only the Brunswick Formation in Montgomery and Berks Counties, indicates that there is a significant relationship between well yields and well depths. (See Fig. 2.) If yields of 100 gpm or more are desired, wells should be drilled at least 200 feet deep. According to the data shown on Figure 2, wells drilled to depths between 200 and 550 feet deep are most likely to obtain maximum yields.

For example, of 35 wells less than 185 feet deep, only 1 well yields more than 100 gpm, and only 5 yield more than 50 gpm. But 45 percent (68 of 151) of the wells between 185 feet and 550 feet deep yield more than 100 gpm, and about 75 percent (115 of 151) of them yield more than 50 gpm.

Thirty-two wells yield 200 gpm or more, and all but two of these wells are between 185 and 545 feet deep. Only seven wells yield more than 300 gpm, and all but one of these are between 200 and 510 feet deep.

Data were obtained for only 14 wells more than 550 feet deep; so, the yields of wells more than 550 feet deep are perhaps not evaluated conclusively in this report.

Data such as these can be misleading if the use of the wells is not considered, because wells drilled for domestic purposes commonly show lower yields than wells drilled for industrial use or public supply. Presumably this is because domestic water needs are small and the drilling of such wells is stopped when a small but adequate water supply is obtained. Also, many domestic wells may not be tested rigorously to determine their maximum yield. This effect of domestic wells is not believed to be significant in the data here discussed, as 174 of the 199 wells shown in Figure 2, and 24 of the 34 less than 185 feet deep, are either used as industrial or public-supply

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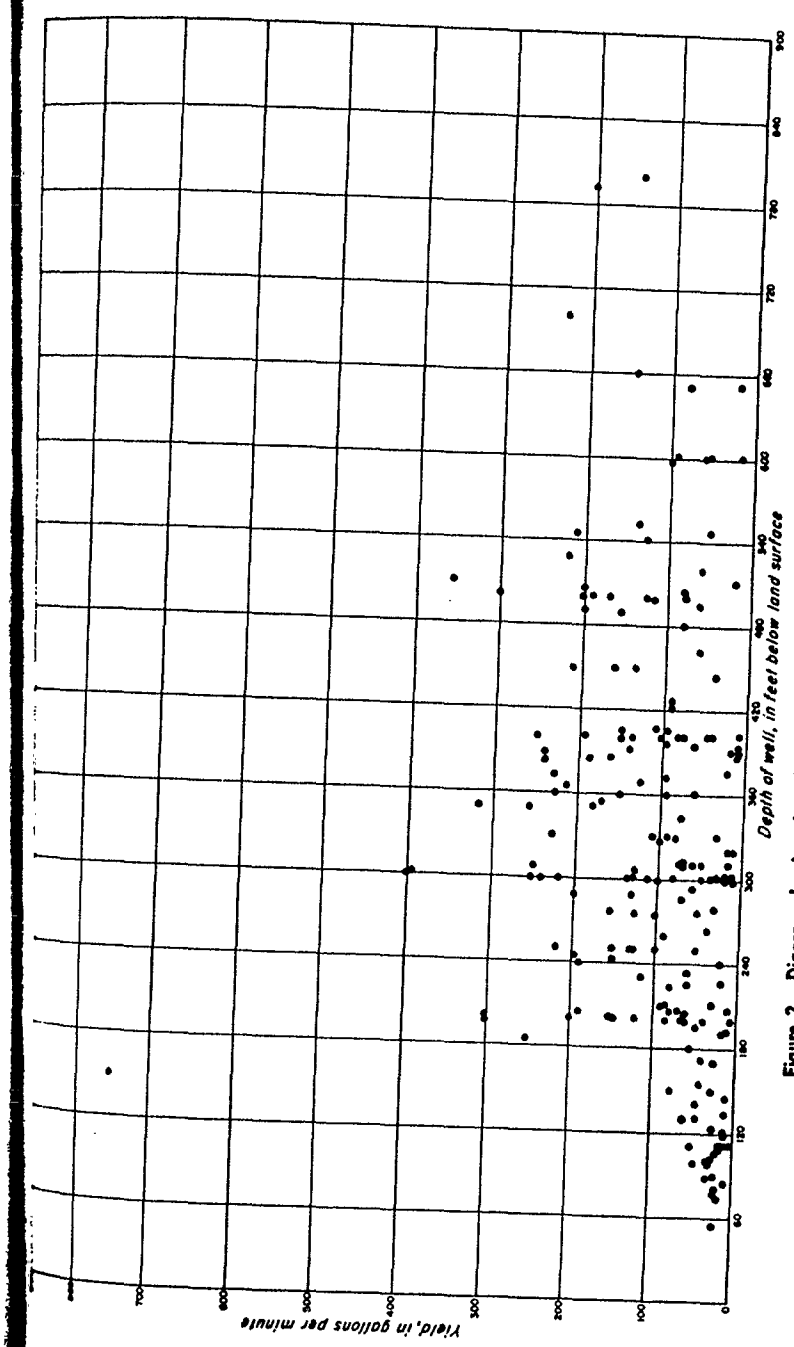

Figure 2. Diagram showing the relation between yields and depths of wells in the Brunswick Formation.

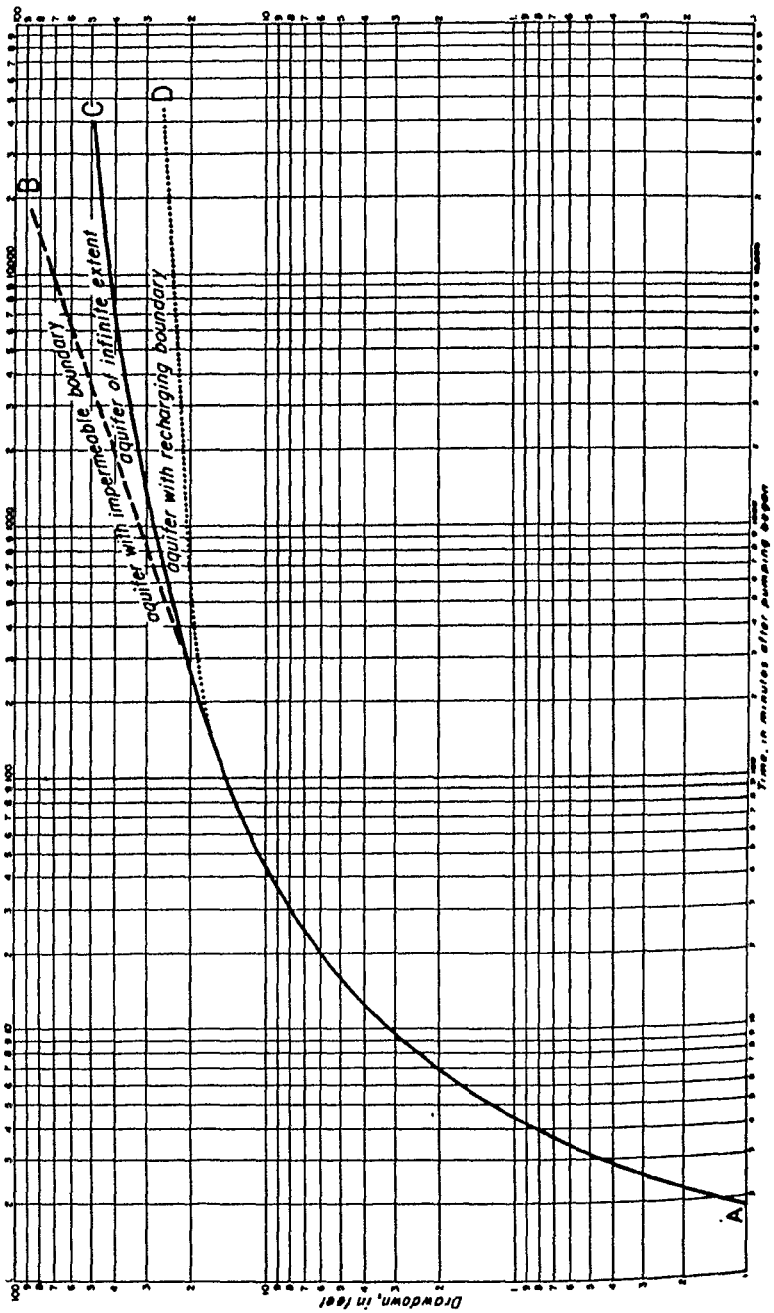

Figure 3. Logarithmic graph of drawdown in a theoretical aquifer

wells or were tested for such use. The data contained in this report, therefore are believed to fairly represent the relationship of well yields versus depth of wells.

The sharply defined increase in the yield of wells at a depth of about 200 feet is believed to be the result of a rather abrupt change in the nature of rock weathering at depth. In the area of this investigation it appears that the zone of greatest decomposition—where the rock voids are believed to be partly plugged with residual clay—lies above a depth of 200 feet. Similar depths of intense weathering in the Brunswick Formation were reported by Barksdale and others (1958, p. 86).

OCCURRENCE OF GROUND WATER IN THE LOCKATONG FORMATION

The lithology and structure of the Lockatong Formation is similar to that of the Brunswick Formation. It consists of interbedded dark-gray argillite and shale that dip to the northwest at an average angle of 20°. The rock is fine grained and well cemented. As in the Brunswick Formation, the interconnected pore spaces are very narrow and most of the ground-water flow is confined to a system of interconnected vertical joints and bedding-plane fractures. However, the fractures are narrower and more widely spaced than those in the Brunswick Formation. Yields of 15 wells that tap the Lockatong Formation ranged from 4 to 40 gpm, and the median yield was 10 gpm.

PUMPING TESTS

When a well is pumped, water levels in the area are lowered and a cone of depression is formed in the piezometric surface or the water table. As pumping continues, the cone of depression enlarges until one of the following conditions exist: (1) The recharge of the aquifer has been increased by an amount equal to the pumping rate, (2) the natural discharge from the aquifer has been decreased by an amount equal to the pumping rate. (3) The sum of the increased recharge and decreased natural discharge is equal to the pumping rate.

Line AC on Figure 3 is a theoretical plot of drawdown against time in a well pumping at a constant rate from a homogeneous isotropic aquifer of infinite areal extent and uniform thickness. Other assumptions made in constructing the theoretical curve are: (1) the discharge well has an infinitesimal diameter and completely penetrates the aquifer; (2) no recharge to the aquifer occurs; (3) the water withdrawn from storage in the aquifer is discharged instantaneously with decline in head; and (4) the coefficient of transmissibility is constant at all places and all times.

A plot of recovery against time would coincide with a plot of drawdown against time. If flow occurs under conditions different from those stated in

the assumptions, the plotted curve will deviate from the theoretical curve. For example, line AD in Figure 3 is one path the plotted data may follow if the cone of depression expands to a recharge boundary and induces recharge from some outside source. The slope of this curve decreases from that of the theoretical curve, indicating that drawdown has been diminished due to the inflow of recharge. If the slope of the plotted curve increases from that of the theoretical curve, as in line AB, the cone of depression has expanded to an impermeable boundary—that is, an area that is less permeable than the part of the aquifer near the pumping well. Many boundary conditions can cause this. For example, the cone of depression reaches the end of the aquifer and lateral expansion of the cone is stopped or retarded. The presence of this type of boundary may be caused by a marked decrease in the permeability of the aquifer at some distance from the well.

By means of a graphical technique that involves matching a theoretical curve to plots of drawdown in wells versus time, it is possible to compute the coefficients of transmissibility and storage for an aquifer.

The coefficient of transmissibility is a measure of the ability of the aquifer to transmit water. It is defined as the quantity of water, in gallons per day, that will flow through a vertical section of the aquifer 1-foot wide and extending the full height of the aquifer under a unit hydraulic gradient at the prevailing temperature of the water.

The coefficient of storage of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. Under water-table conditions, the water released from storage is obtained by draining a part of the aquifer. However, under artesian conditions, water is released from storage by compression of the network of openings within the aquifer in response to a decrease in head at a well. For this reason the coefficient of storage of an artesian aquifer is many times smaller than that of a water-table aquifer. The coefficients of storage for artesian aquifers range from 0.00001 to 0.001, and those of water-table aquifers range from 0.05 to 0.30.

Systematic aquifer tests to determine the hydraulic properties of the Brunswick Formation were made at the following locations: Kulpsville, North Wales, Spring City, Douglassville, Souderton, and Royersford. At each of these sites one well was pumped at a constant rate for a period ranging from several hours to several days while water levels were measured in the pumped well and in one or more adjacent observation wells. After pumping ceased, water levels in all these wells were measured again for an equal length of time. Results of these tests, including the coefficients of transmissibility and storage and the total drawdown during pumping, are shown in Table 1.

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Table 1. Summary of pumping tests with observation wells in the Brunswick Formation.

Area	Observation well	Date	Pumping rate (gpm)	Duration of pumping (hours)	Transmissibility T (gpd/ft)	Storage coefficient S	Boundary type	Total drawdown (feet)	Distance from pumped well
Kulpsville	Mg-631[1]	Aug. 1960	140	48	5,000		Recharge	....	....
	Mg-632	Aug. 1960	140	48	43,000	$10x10^{-5}$	Impermeable	10.6	730
North Wales	Mg-633	Aug. 1960	140	48	180,000	$12x10^{-5}$	Impermeable	4.4	730
	Mg-56[1]	Sept. 1960	127	4	1,100	.....	Recharge	64.4	....
	Mg-180	Sept. 1960	127	4	56,000	$9x10^{-5}$	Impermeable	1.2	1,200
	Mg-223	Sept. 1960	127	4	69,000	$10x10^{-5}$	Impermeable	1.1	1,700
	Mg-223[1]	Oct. 1960	180	101	.....	.....	.....	79	....
	Mg-56	Oct. 1960	180	101	56,000	$12x10^{-5}$	Impermeable	7.4	1,700
	Mg-180	Oct. 1960	180	101	82,000	$9x10^{-5}$	Impermeable	13.8	575
	Mg-167[1]	Oct. 1960	152	4	.....	.....	.....	26.8	....
	Mg-179	Oct. 1960	152	4	51,000	$6x10^{-5}$	Impermeable	3.5	400
Spring City	Ch-181[1]	Apr. 1963	225	72	1,000	.....	Recharge	107.9	....
	Ch-144	Apr. 1963	225	72	6,000	.....	Impermeable	6.5	830
	Ch-145	Apr. 1963	225	72	13,000	$29x10^{-5}$	Impermeable	10.3	1,650
	Ch-147	Apr. 1963	225	72	.....	.....	.....	0.0	1,850
Douglassville	Be-115[1]	July 1962	30	67	100	.....	Recharge	112.2	....
	Be-125	July 1962	30	67	600	$3.8x10^{-5}$	Recharge	14.9	200
	Be-125[1]	June 1963	21	4.5	1,100	.....	None	18.9	....
	Be-115	June 1963	21	4.5	1,500	$3.3x10^{-5}$	None	7.3	200
Souderton	Mg-665[1]	Mar. 1961	150	69	3,500	.....	Recharge	80.5	....
	Mg-679	Mar. 1961	150	69	9,000	$4x10^{-5}$	Impermeable	27.6	400
Royersford	Mg-542[1]	Jan. 1962	55	3	.....	.....	.....	....	....
	Mg-541	Jan. 1962	55	3	30,000	$6x10^{-5}$	Impermeable	.61	1,200

[1] Pumped well.

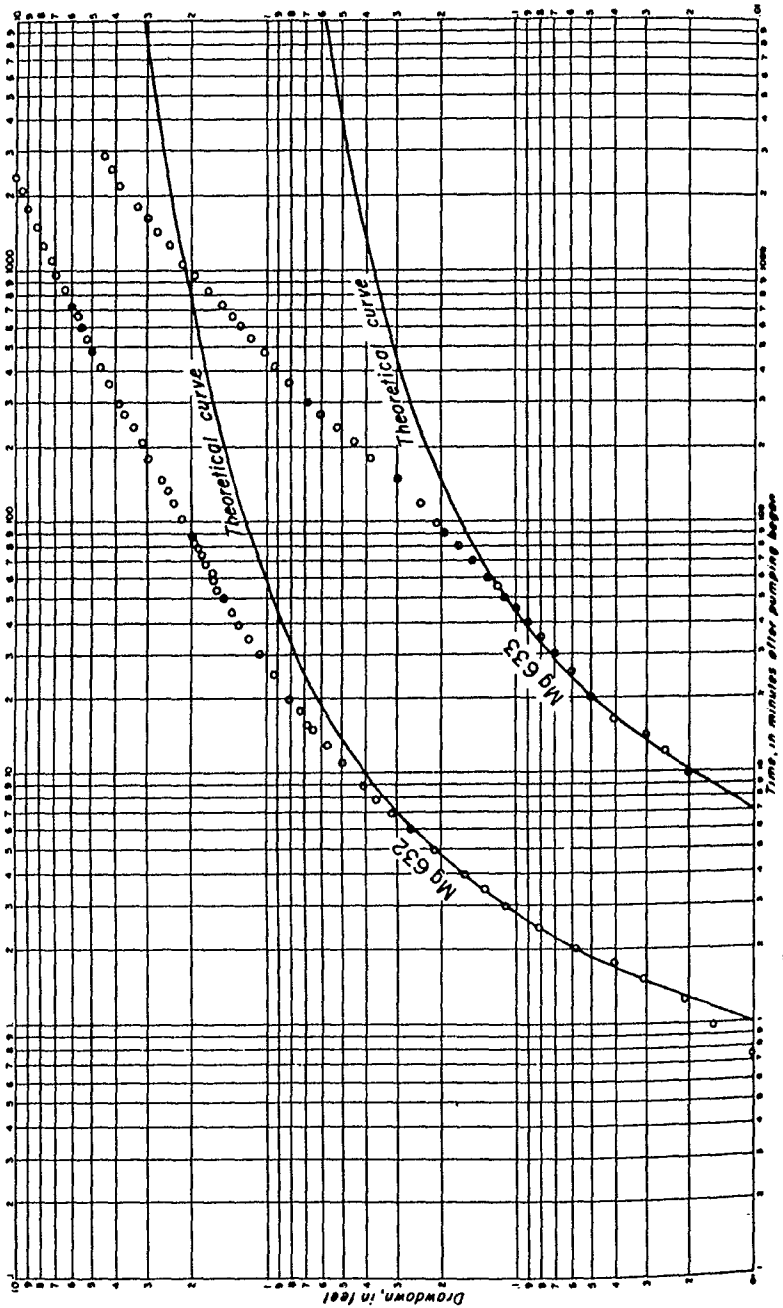

Figure 4 Logarithmic graph drawdown in wells Mg-632 and Mg-633.

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Because hydrologic conditions in the Brunswick Formation do not fulfill the assumptions for an ideal aquifer, the coefficients of transmissibility and storage calculated from these tests do not truly represent the aquifers tested. Calculated transmissibility at a pumped well may be lower than the actual transmissibility of the aquifer because of well entrance losses during the test. On the other hand, excessively high transmissibilities computed at observation wells for almost all the pumping tests show clearly the poor hydraulic connection between the pumped wells and the observation wells. Despite this poor hydraulic connection, the measurement of water levels in in observation wells and the calculation of transmissibility and storage coefficients are useful for estimating the effect of pumping upon nearby wells —where the effect is controlled by recognizable geologic or topographic features.

Tests at Kulpsville.—In August 1960 well Mg-631, at Kulpsville, was pumped for 48 hours at a constant rate of 140 gpm and wells Mg-632 and Mg-633 were used for observation. Coefficients of transmissibility and storage calculated from these tests are shown in Table 1. Observation well Mg-632 is 730 feet from the pumped well in a direction parallel to the strike of the beds, whereas observation well Mg-633 is the same distance from the pumped well along a line perpendicular to the strike. Consequently, well Mg-632 penetrates the same strata as the pumped well, but well Mg-633 penetrates entirely different strata.

Analysis of data from these wells indicates coefficients of transmissibility of 5,000 gpd per foot at the pumped well (Mg-631), 40,000 gpd per foot at the observation well along strike (Mg-632), and 180,000 gpd per foot at the observation well perpendicular to strike (Mg-633). Poor hydraulic connection between the pumped well and the observation wells is indicated by these high transmissibilities calculated from the observation-well data. A poor hydraulic connection is especially evident at observation well Mg-633, perpendicular to the strike from the pumped well. Drawdown in this observation well is caused by leakage from beds penetrated by the observation well to beds tapped by the pumped well.

The response in observation wells Mg-632 and Mg-633 to pumping at well Mg-631 is shown in Figure 4. The graph shows that drawdown began much sooner and drawdown was much greater in the observation well (Mg-632) penetrating the same strata as the pumped well than in the observation well (Mg-633) penetrating different strata. In both observation wells water levels declined more steeply than the theoretical curve, indicating the presence of an impermeable boundary. Drawdown in the pumped well (not shown) declined more slowly than the theoretical curve, indicating the presence of a recharging boundary.

Tests at North Wales.—Three pumping tests were made in North Wales.

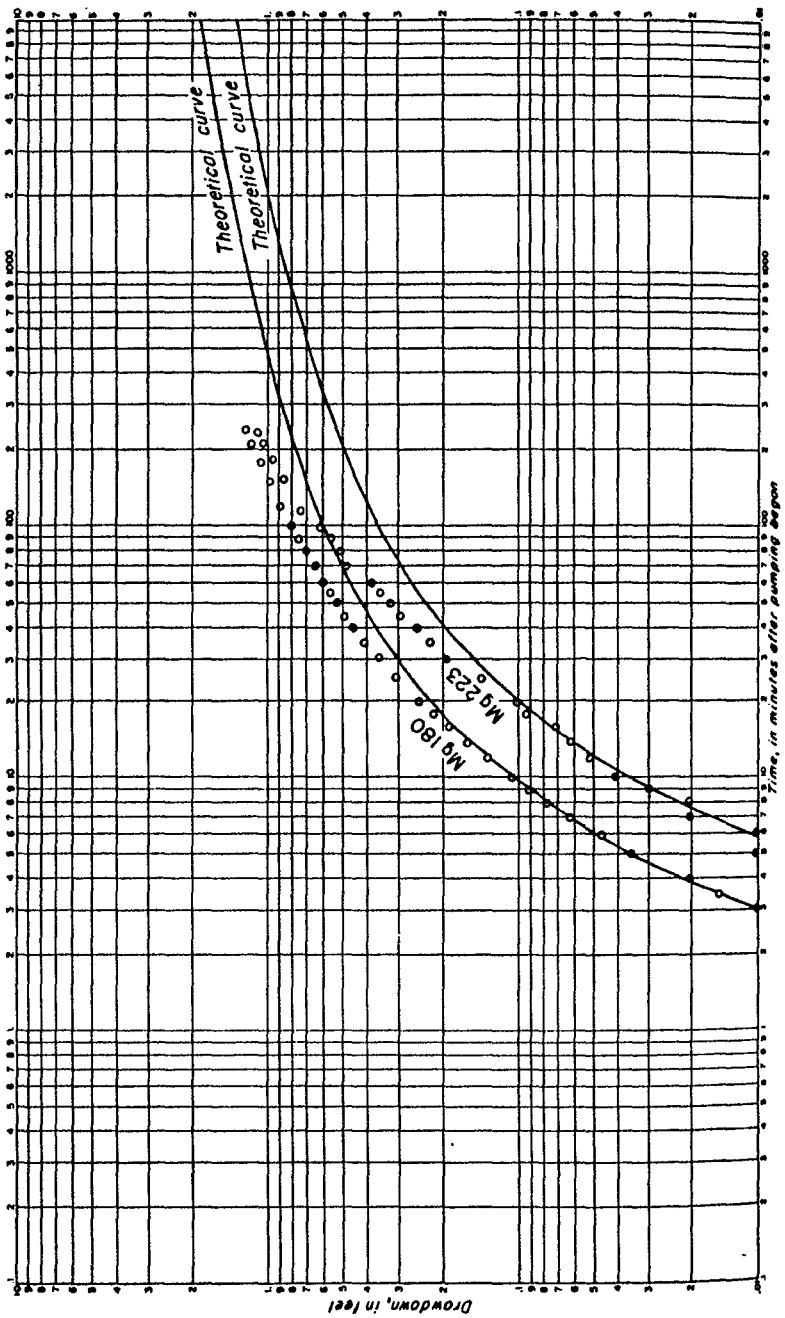

Figure 5. Logarithmic graph of drawdown in wells Mg-180 and Mg-223.

Coefficients of transmissibility and storage calculated from these tests are shown in Table 1. In September 1960, well Mg-56 was pumped for 4 hours at a constant rate of 127 gpm. Water levels were observed in wells Mg-167, Mg-179, Mg-180, and Mg-223.

Analysis of data from the pumped well (Mg-56) indicates a coefficient of transmissibility of 1,100 gpd per foot, which is probably lower than the actual transmissibility of the aquifer because of entrance losses at the well.

No drawdown took place at wells Mg-167 and Mg-179, which are more than 2,500 feet from the pumped well and do not penetrate the same strata as the pumped well.

The coefficient of transmissibility at observation well Mg-180, which is 1,200 feet from the pumped well, is 56,000 gpd per foot. At observation well Mg-223, which is 1,700 feet from the pumped well, the coefficient of transmissibility is 69,000 gpd per foot. The high transmissibilities at the observation wells suggest imperfect hydraulic connection with the pumped well—even though observation well Mg-223 penetrates many of the same strata as the pumped well, and well Mg-180 penetrates some of the same strata. The plots of drawdown in wells Mg-180 and Mg-223 (Fig. 5) show that drawdown started later in well Mg-223 than in well Mg-180, which was nearer to the pumped well. However, after 4 hours of pumping the drawdowns in both wells were almost identical—1.2 feet in Mg-180 and 1.1 feet in Mg-223. The drawdown plot in both observation wells indicated the presence of a discharging boundary, whereas a recharging boundary was observed in the plot of data from the pumped well, Mg-56.

In October 1960, well Mg-223 was pumped at a rate of 180 gpm for 101 hours, and wells Mg-56 and Mg-180 were used as observation wells. The calculated transmissibility was 82,000 gpd per foot at observation well Mg-180 and 56,000 gpd per foot at observation well Mg-56. Drawdown started earlier in well Mg-180, nearest the pumped well, and total drawdown was greater at this well (13.8 feet) then at well Mg-56 (7.4 feet). Drawdown data at both observation wells showed the effects of discharging boundaries.

A third pumping test conducted in October 1960, consisted of pumping well Mg-167 at a constant rate of 152 gpm for 4 hours. Water levels were measured at observation well Mg-179, which is 400 feet from the pumped well and penetrates many of the same strata. Analysis of data from observation well Mg-179 indicates a coefficient of transmissibility of 51,000 gpd per foot. The data from the pumped well were unsuitable for analysis.

Tests in Spring City.—Well Ch-181, at the Pennhurst State School in Spring City, was pumped at a constant rate of 225 gpm for 72 hours in April 1963. Water levels were measured at observation wells Ch-144, Ch-145, and Ch-147.

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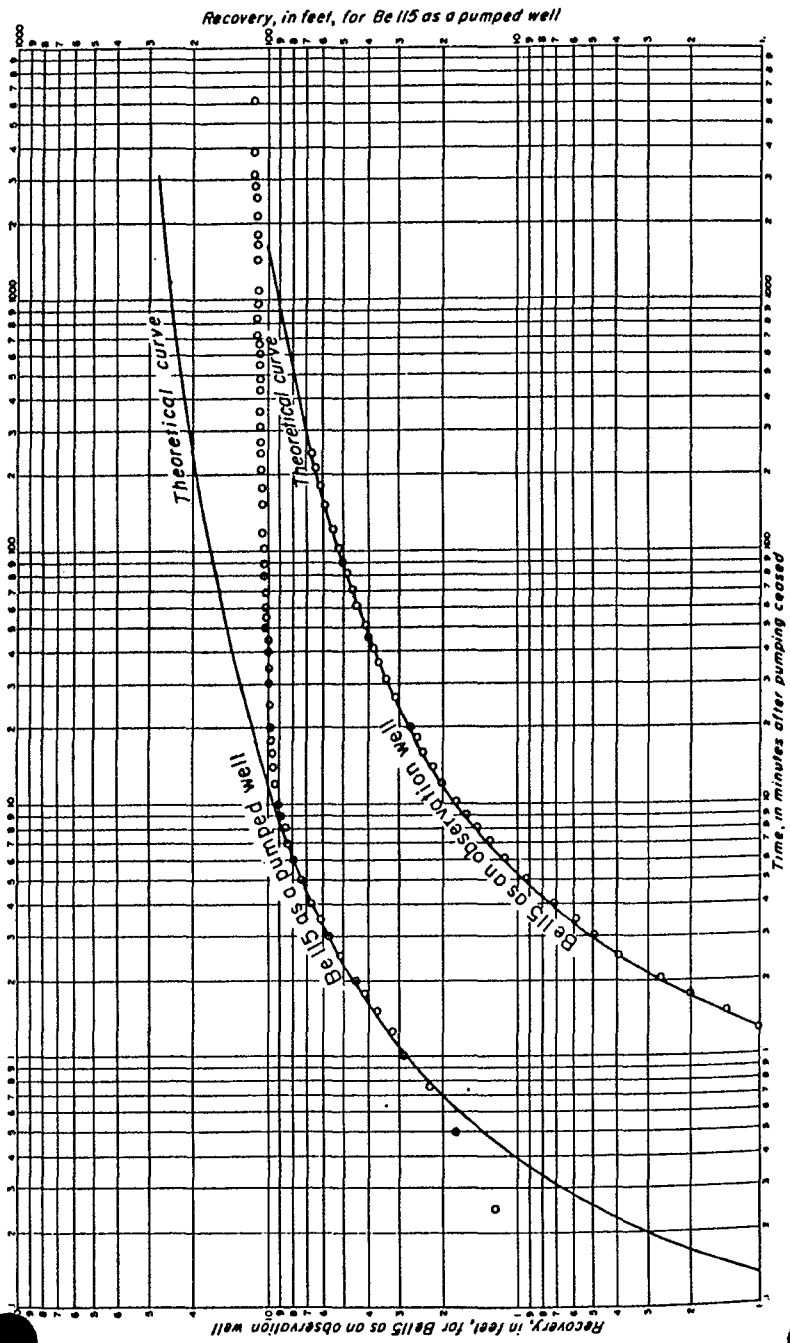

Figure 6. Logarithmic graph of recovery in well Be-115 when used as the pumped well and when used as an observation well.

Analysis of data from the pumped well (Ch-181) indicates a coefficient of transmissibility of 2,000 gpd per foot. Data from observation well Ch-144, which is 830 feet from the pumped well and penetrates many of the same strata, indicates a transmissibility of 6,000 gpd per foot. Data from observation well Ch-145, which is 1,650 feet from the pumped well and penetrates partly the same strata indicates a transmissibility of 13,000 gpd per foot.

The water level was not drawn down in Ch-147, although this well penetrates many of the same strata as the pumped well. This indicates the complexity of the hydrology in this area.

Drawdown commenced considerably earlier and was greater in observation well Ch-145, which was farthest from the pumped well, than in observation well Ch-144. The most distant well (Ch-145) penetrates the same strata as the lower part of the pumped well, whereas well Ch-144 penetrates the same strata as the upper part of the pumped well.

Tests at Douglassville.—Two pumping tests were conducted at Douglassville. In July 1962, well Be-115 was pumped at a rate of 30 gpm for 67 hours, and water levels were observed in wells Be-115 and Be-125. The two wells are 200 feet apart along the strike of the beds and are both 300 feet deep; hence, both wells penetrate the same strata. Analysis of data from these wells indicated a cofficient of transmissibility of 100 gpd per foot at the pumped well (Be-115) and 600 gpd per foot at observation well Be-125. However, when Be-125 was pumped at a rate of 21gpm for 4½ hours in June 1963, analysis of data indicated a transmissibility of 1,100 gpd per foot at Be-125 and 1,500 gpd per foot at observation well Be-115. These determinations of transmissibility are not consistent—but they do indicate a transmissibility of low magnitude.

When well Be-115 was pumped, data for both the pumped well and observation well Be-125 showed recharging boundaries. However, when well Be-125 was pumped, the data plot indicated no boundary conditions for either well. Figure 6 shows two plots of the recovery of water-level in well Be-115—one when the well was used as an observation well, and the other when it was used as the pumped well.

Tests at Souderton.—Well Mg-665, in Souderton, was pumped at a rate of 150 gpm for 69 hours in March 1961. Water levels were measured in well Mg-665 and in observation well Mg-679, 400 feet away. Analysis of data from this test indicated coefficients of transmissibility of 3,500 gpd per foot at well Mg-665 and 9,000 gpd per foot at well Mg-679.

Although these two wells are only 400 feet apart, a dip of 60° measured in a nearby outcrop suggests that the two wells do not penetrate the same strata. However, because all other dips measured in the Brunswick Forma-

tionare considerably less than 60°, this dip of 60° is anomalous and possibly misleading. The relatively large drawdown in the observation well (27.6 feet at the end of 69 hours), the relatively low transmissibility at the observation well as compared with transmissibilities of observation wells at other pumping sites, and the fact that the water level commenced dropping less than 1 minute after pumping began all indicate that these wells probably penetrate the same water-bearing strata.

Another pumping test was made in June 1961 when well Mg-665 was again pumped at 150 gpm for 69 hours, and well Mg-679 was again the observation well. Drawdowns in both wells were considerably greater in June than in March. Drawdown in the pumped well (Mg-665) after 69 hours pumping was 17.5 feet more in June than in March. In the observation well (Mg-679) drawdown after 69 hours was 8.1 feet greater in June than in March. A possible explanation for these differences in drawdown may be the effect of recharge from Skippack Creek, which is less than 100 feet from the wells. In March, Skippack Creek was flowing and was a possible source of induced recharge, but in June, Skippack Creek was dry and was no longer a source of recharge.

Test at Royersford.—Well Mg-542 at the Charles Johnson County Home, Royersford was pumped for 3 hours at a constant rate of 55 gpm in January 1962. Water-level measurements were made at observation well Mg-541, 1,200 feet northwest of the pumped well. Analysis of data from the observation well indicated a transmissibility of 30,000 gpd per foot and the occurrence of an impermeable boundary. At the end of 3 hours of pumping the water level had lowered only 0.61 feet. Because the data obtained from the pumped well was unsuitable, it was not used for analysis.

Miscellaneous tests in the Brunswick Formation.—In addition to the tests that involved the use of observation wells, nine pumping tests were conducted on wells which had no nearby observation wells. The results of these tests are given in Table 2. Calculated coefficients of transmissibility are generally quite low. They range from 150 to 4,000 gpd per foot and the median is 600 gpd per foot. Eight of the nine transmissibilities are less than 1,000 gpd per foot.

Data plots of six tests indicated recharge boundaries, and only one indicated a discharge boundary. One of the tests showed no boundaries, and another test showed drawdown data too irregular for determination of the boundary conditions.

Miscellaneous tests in the Lockatong Formation.—Pumping-test data are available from six wells tapping the Lockatong Formation. (See Table 2.) Five of these wells are in Bucks County, Pa., but results from these tests

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Table 2. Summary of pumping tests without observation wells in the Brunswick and Lockatong Formations

Well	Date	Pumping rate (gpm)	Duration of pumping (hours)	Transmissibility T (gpd/ft)	Boundary type
		Brunswick Formation			
Be-101	June 1963	13.8	4	670	Recharge
113	June 1963	20	4	900	Impermeable
114	June 1963	8.6	4	150	.....
Mg-581	June 1963	17.7	4	600	Recharge
695	June 1963	3.4	1	180	Recharge
696	June 1961	5.1	1	750	Recharge
703	June 1963	22.2	4	500	Recharge
725	July 1962	136	1.25	4,000	None
729	Aug. 1963	14.6	3	140	Recharge
		Lockatong Formation			
Mg-699	June 1961	3.9	1	180	None
Bk-807	April 1961	2.0	1	70	Impermeable
814	May 1961	30	1.2	2,000	Impermeable
812	May 1961	5.5	1	60	Impermeable
822	May 1961	4.1	1	140	None
832	May 1961	2.6	1	160	None

are believed to be representative of the Lockatong Formation in the area covered by this report. Coefficients of transmissibility are extremely low—they range from 60 to 2,000 gpd per foot and the median is 150 gpd per foot. Five of the six wells have transmissibilities of less than 200 gpd per foot.

Discharge boundaries were encountered in three of the pumping tests. In the remaining three tests no boundary conditions were indicated.

Discussion of pumping-test results.—Because the Brunswick and Lockatong Formations are not ideal aquifers, coefficients of transmissibility and storage computed by matching pumping test data to the theoretical curve are not reliable. However, the pumping-tests in these formations do demonstrate the effect of pumping upon water levels in the pumped well and in nearby wells.

The high transmissibilities computed from the observation-well data reflect imperfect hydraulic connection between pumped wells and nearby wells, but they are useful for estimating the effect other pumping wells will have on water levels in their vicinities. They indicate also that interfer-

ence between wells during brief periods of pumping may be somewhat less in the Brunswick Formation than in an ideal aquifer. However, because impermeable boundaries appeared in the test data of almost all observation wells, water levels in wells near a pumping well will probably draw down to a greater extent than predicted by a transmissibility based on data from the early part of a pumping test.

Wells located on a line perpendicular to the strike of the beds will generally show much less interference than wells located on a line parallel to the strike, because the former generally do not penetrate the same strata, but the latter do. Drawdown in observation wells not penetrating the same strata as a pumped well is caused by leakage from beds penetrated by the observation wells to beds tapped by the pumped well.

QUALITY OF WATER

All ground waters contain dissolved minerals; some contain suspended particles and pathogenic organisms. These ground-water constituents are important because if they are present in excessive amounts they may limit the usefulness of the water for some purposes and may necessitate treatment of the water.

The chemicals dissolved in ground water are obtained from many sources. Rain and snow, from which ground water is derived, absorb small amounts of carbon dioxide and other gases in the atmosphere. In addition, small particles of mineral matter in the form of dust are caught and carried along with the precipitation; the quantity of material absorbed in this way, however, is very small.

Upon reaching the land surface the water leaches mineral matter from the organic residue of plants, from agricultural fertilizers, animal and human wastes and from solid and semisolid refuse. The waters percolating downward through the soil zone leach out the soluble products of soil weathering. The quantity of mineral matter dissolved depends primarily on the composition of the soil and of the percolating water which may carry chemicals that stimulate dissolution. For example, carbon dioxide absorbed from the atmosphere and decayed vegetable matter forms carbonic acid, which aids in dissolving minerals from the soil. Other factors controlling the quantity of matter dissolved are the length of time the water is in contact with the soil, the surface drainage structure, the amount of precipitation, and the temperature of the water.

Most of the mineral matter in ground water is dissolved from the rocks through which it flows, because the water remains in contact with this material for a longer time than with the atmosphere and soil. The contact time is dependent on the ground-water velocity and the distance of the ground water from the recharge area. High ground-water velocity occurs in

rocks of high permeability or is associated with flow caused by steep hydraulic gradients—a factor often influenced by the topography. Ground-water velocity tends to decrease as depth below land surface increases, so that the quantity of dissolved solids in the ground water at great depth is usually much greater than that near the surface. The distance of the water from the recharge area is controlled by the geology and physiographic features.

Another major factor controlling the quantity of mineral matter dissolved by the ground water is the composition and texture of the rock itself. Igneous rocks generally contain material less soluble than that in sedimentary rocks. Fine-grained rocks having high porosity tend to increase the opportunity for solvent action because the surface area of rock exposed to solution is very large.

The mineral matter in ground water occurs in very small quantities and exists either as electrically charged particles known as ions or as oxides in the collodial state. Calcium (Ca), magnesium (Mg), sodium (Na), and potassium (K) are commonly occurring positively charged ions or cations. Bicarbonate (HCO_3), carbonate (CO_3), sulfate (SO_4), chloride (Cl), fluoride (F), and nitrate (NO_3) are common negatively charged ions or anions. In addition to these ionized substances, small amounts of colloidal matter—including silica (SiO_2), iron (Fe), and manganese (Mn)—are usually present.

To determine the chemical constitutents of the ground water in the Brunswick and Lockatong Formations in Berks and Montgomery Counties, water samples from 36 wells in the Brunswick and 6 wells in the Lockatong were collected and analyzed. The results of these analyses are shown in Tables 3 and 4.

The chemical character of the ground water in the two formations is classified graphically on the trilinear diagrams of Figures 7 and 8.

In these diagrams the cations in solution are assumed to be calcium, magnesium, sodium, and potassium, and the anions are assumed to be bicarbonate, carbonate, sulfate, and chloride. Any minor constituents present are summed with the major constituents to which they are chemically related.

The concentration of any cation or anion in a solution, in parts per million (ppm) by weight, divided by its equivalent or combining weight yields the equivalent weight of the ion per million parts by weight of the solution and is generally termed equivalents per million (epm). Figures 7 and 8 show the percentage composition of the major cations and anions in percentage equivalents per million.

In the diamond-shaped sections of Figures 7 and 8, points plotted in the upper quarter of the diamond represent waters in which calcium and magnesium are the principal cations and sulfate and chloride are the

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WATER-ANALYSIS DIAGRAM

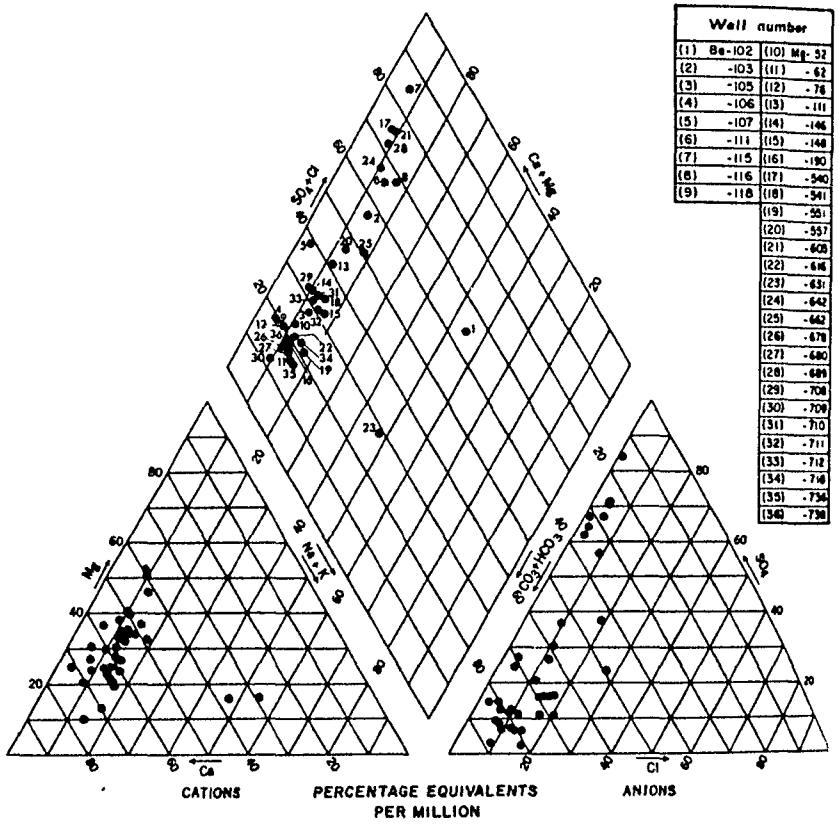

Figure 7. Diagram showing the chemical character of ground water in the Brunswick Formation in Berks and Montgomery Counties, Pa.

principal anions. Those points in the left quarter of the diamond represent waters in which calcium and magnesium are the principal cations and carbonate and bicarbonate are the principal anions.

Figures 7 and 8 show that calcium and magnesium are the major cations in the ground water of both the Brunswick and Lockatong Formations. Except for two samples from the Brunswick Formation, the percentage equivalents per million of calcium plus magnesium exceeds 80 percent of the total cations present. Bicarbonate is the major anion in most of the samples in the Brunswick Formation and in all the samples in the Lockatong Formation. The percentage equivalents per million of bicarbonate exceeds 50 percent in 26 of the 36 samples from the Brunswick.

In all samples except two—those from Mg-739 in the Lockatong Formation and well Mg-631 in the Brunswick Formation—the percentage

WATER-ANALYSIS DIAGRAM

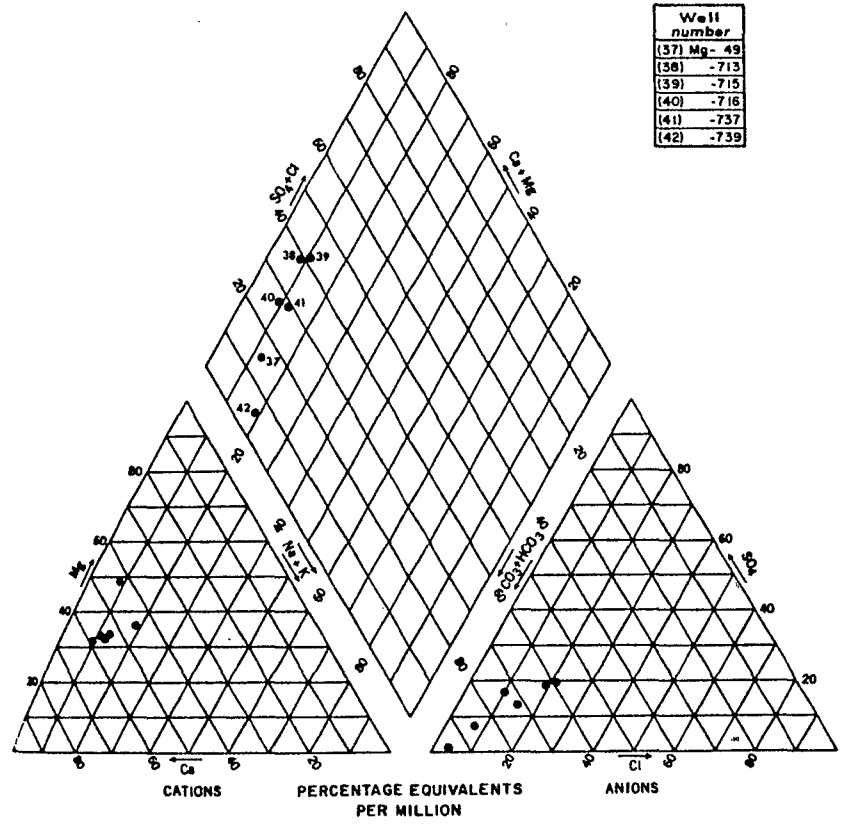

Figure 8. Diagram showing the chemical character of ground water in the Lockatong Formation in Montgomery County, Pa.

equivalents per million of calcium plus magnesium exceeds the percentage of bicarbonate. Therefore, some noncarbonate hardness (calcium or magnesium sulfates and chlorides) exists in all samples except these two. The relative amount of noncarbonate hardness present is indicated by the numerical difference between the percentage of calcium plus magnesium and the percentage of bicarbonate. The noncarbonate hardness for each sample is given in Tables 3 and 4.

A comparison of the chemical quality of the ground water in the two formations is shown in Table 5. The minimum, maximum, and median values were computed from the 36 Brunswick analyses and the 6 Lockatong analyses shown in Tables 3 and 4, respectively. Because the number of water samples from the Lockatong Formation in Montgomery County is small in comparison to the number from the Brunswick Formation, five

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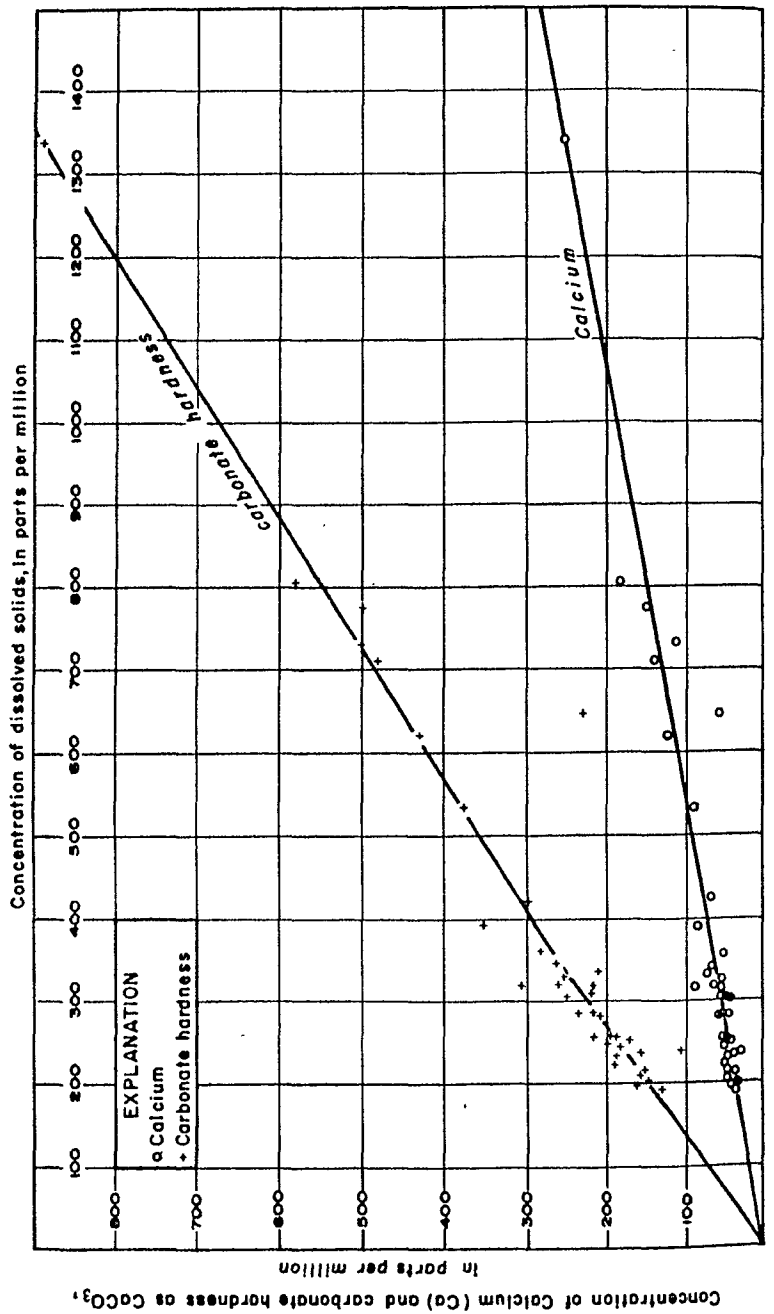

Figure 9. Relation of calcium content and carbonate hardness as $CaCO_3$ to dissolved-solids content.

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analyses of ground water from the Lockatong Formation in Bucks County were also studied. The minimum, maximum and median values of all eleven Lockatong analyses (Table 5) do not differ significantly from those of the six analyses from Montgomery County.

The median values of chemical constituents generally are similar in water from the Lockatong and Brunswick Formations. However, maximum concentrations of several constituents—calcium, sodium, sulfate, dissolved solids, and hardness—are considerably higher in water from the Brunswick Formation than in water from the Lockatong Formation.

Certain of the chemical constituents in the ground water of the Brunswick and Lockatong Formations are directly related to the total dissolved-solids content. In Figure 9 both the calcium content and carbonate hardness as $CaCO_3$ are plotted against the dissolved-solids content. Figure 10 shows the relation of magnesium content to dissolved solids. Figure 11 is a plot of the sodium content against the dissolved solids. The relation of bicarbonate and sulfate content to dissolved solids is shown in Figure 12.

In Figure 9 a single straight line was fitted to the plot of data showing the relation of calcium content to dissolved solids. The calcium content apparently increases linearly as the dissolved-solids content increases.

Appearing also on Figure 9 is a plot showing the relation of carbonate hardness to dissolved-solids content. Carbonate hardness can be seen to increase as dissolved-solids content increases.

Figure 10, a plot of magnesium content against dissolved solids shows that magnesium content increases rapidly as the dissolved solids rise from 200 ppm to 350 ppm. Beyond this concentration, the magnesium content does not show any clear relation to the dissolved-solids content.

Sodium content, as illustrated in Figure 11, tends to increase as dissolved-solids content increases. Figure 12 shows also that the three water samples from the limestone fanglomerate of the Brunswick Formation contain a much smaller amount of sodium than all other samples that contain comparable quantities of dissolved solids.

Figures 9, 10, and 11 illustrate that the cations responsible for increases in dissolved-solids content are calcium, magnesium, and sodium. However, because the calcium content increases much faster than the magnesium and sodium content as the dissolved solids increase, calcium is the major cation causing the increase of dissolved solids.

Figure 13 is a plot of both the bicarbonate and sulfate content against dissolved-solids concentration. The bicarbonate content does not appear to bear any significant relation to the dissolved-solids content. The sulfate content, however, increases linearly as dissolved solids increase throughout the range of dissolved solids shown. Figure 12 shows that bicarbonate is the major anion in waters containing less than 500 ppm dissolved solids,

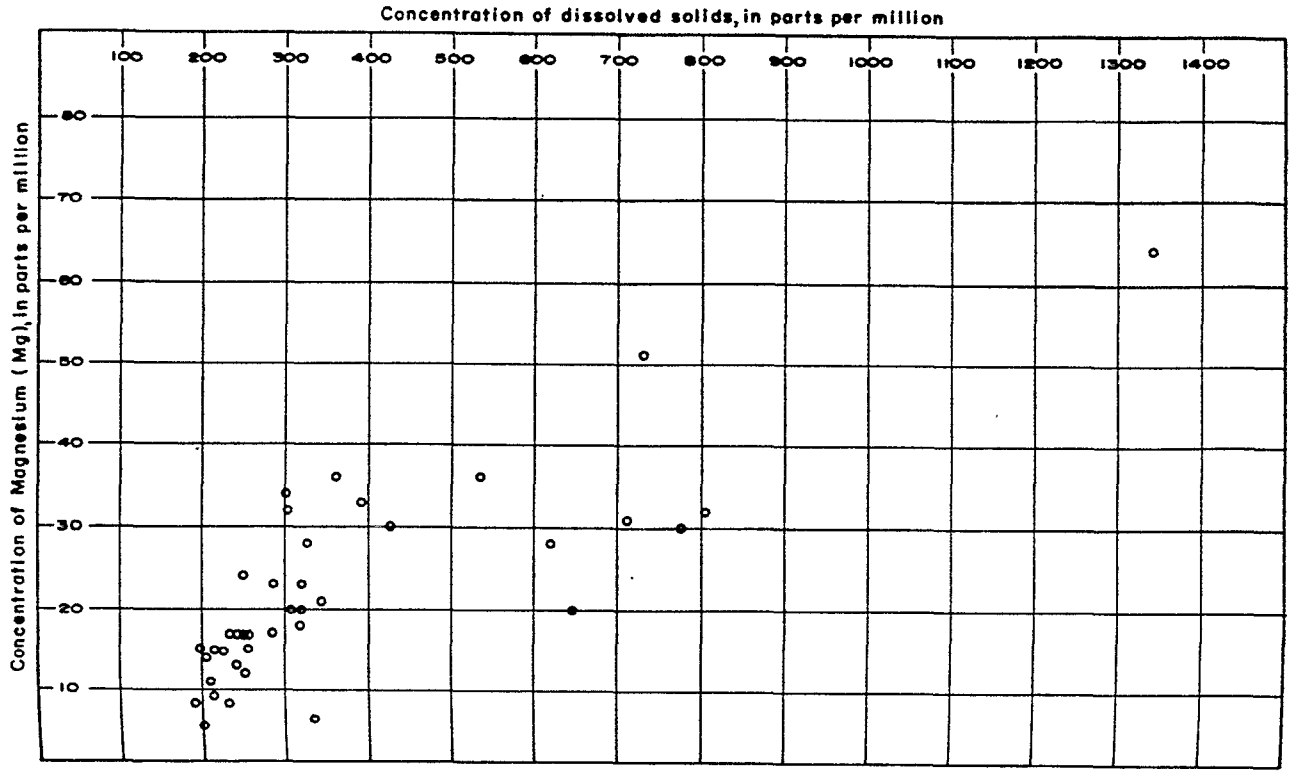

Figure 10. Relation of magnesium content to dissolved-solids content.

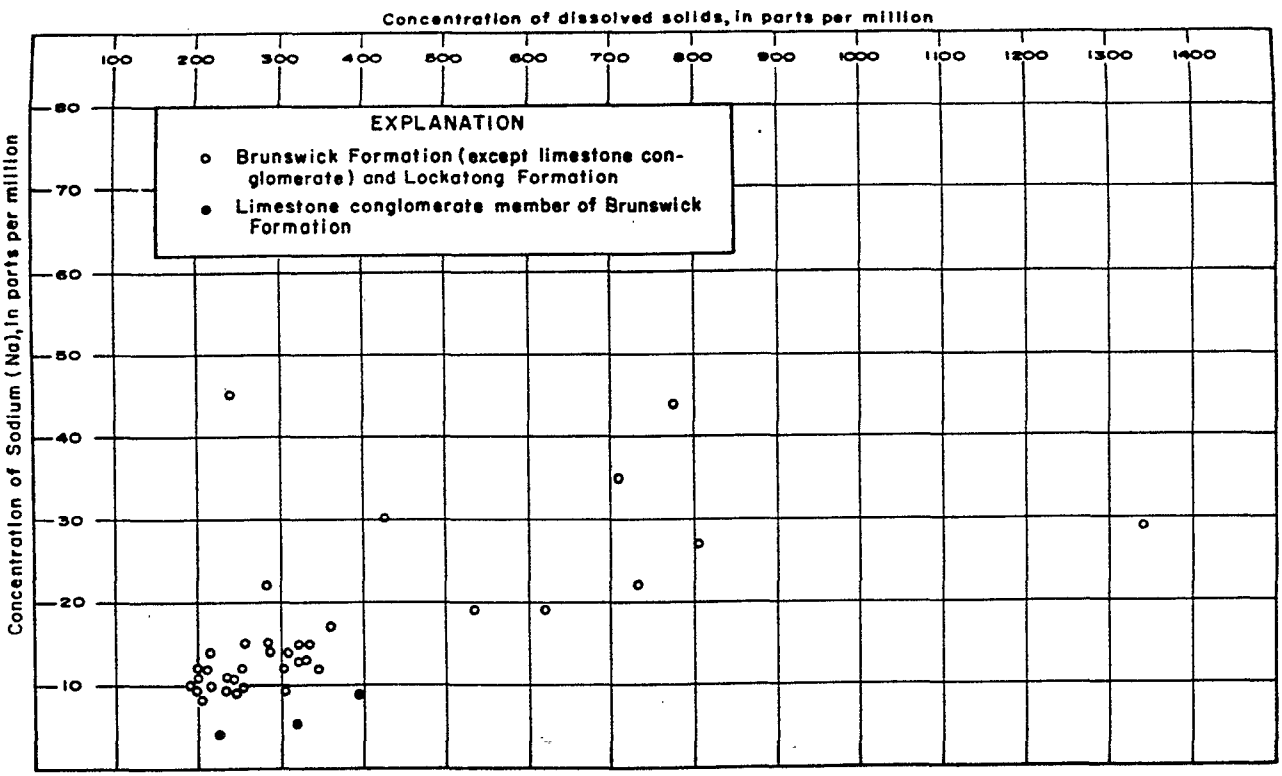

Figure 11. Relation of sodium content to dissolved-solids content.

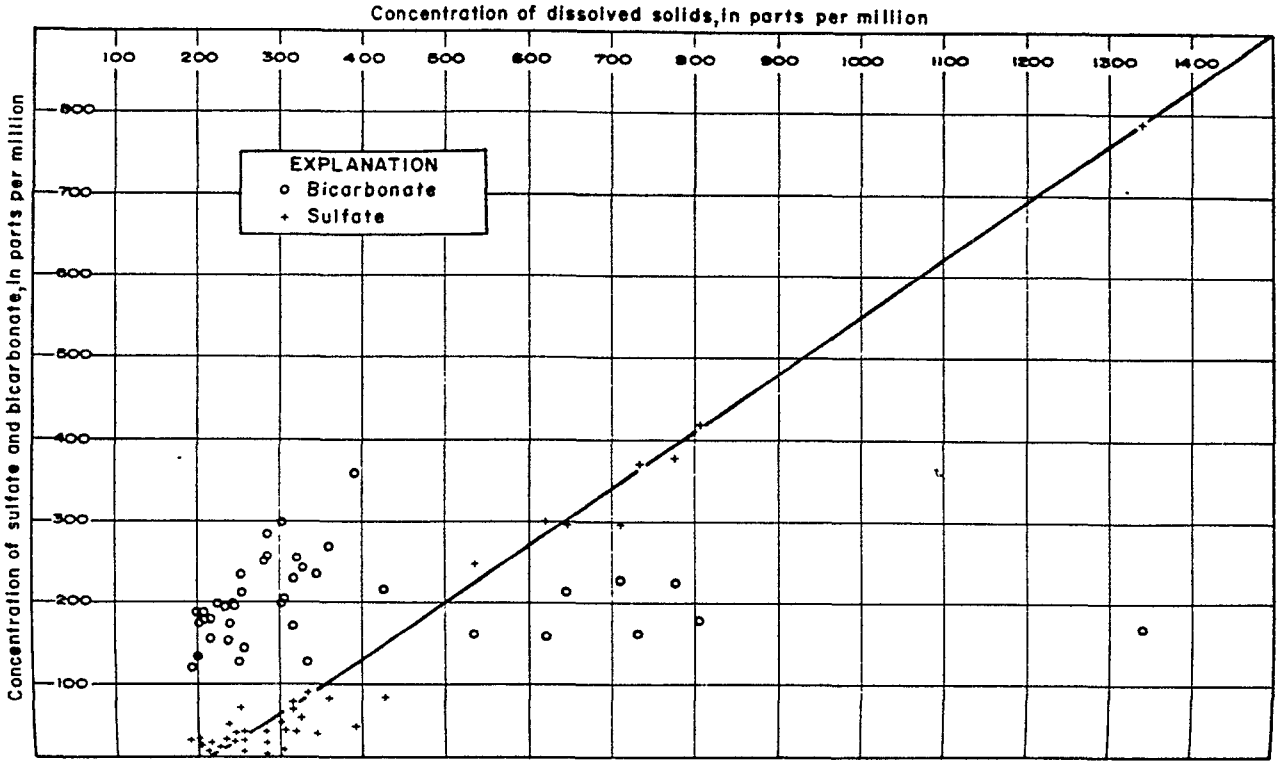

Figure 12. Relation of bicarbonate and sulfate content to dissolved-solids content.

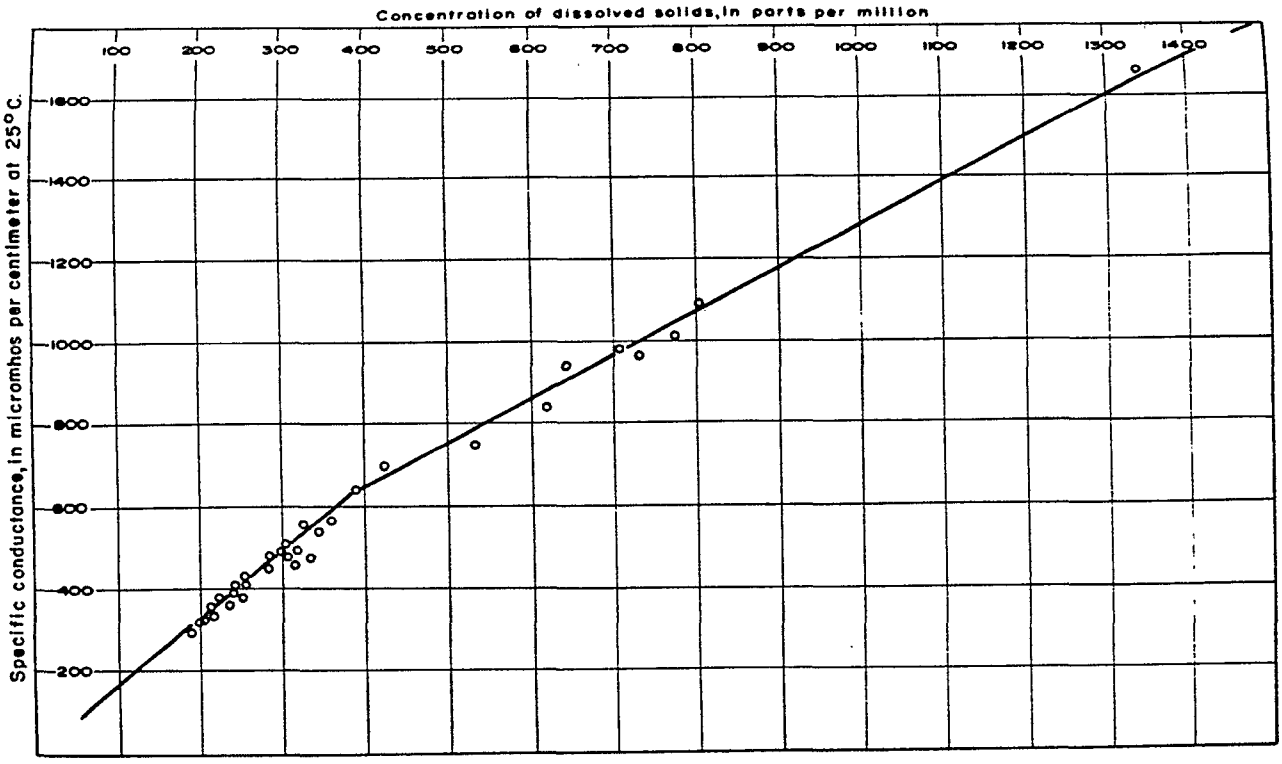

Figure 13. Relation of specific conductance to dissolved-solids content.

whereas sulfate is the major anion in waters containing more than 500 ppm dissolved solids.

The concentration of other ions present—including potassium, chloride, fluoride, and nitrate—bears no relation to the dissolved-solids content. Graphs of these constituents are not shown.

Figure 13 is a plot of the specific conductance against the dissolved-solids concentration of water from the Brunswick and Lockatong Formations. Two straight lines intersecting near 400 ppm dissolved solids were constructed to represent the relation of these two variables.

Specific conductance is defined as the electrical conductance of a cube of material one centimeter on a side and is commonly expressed as micromhos per centimeter. Specific conductance varies with temperature and is, therefore, usually referenced to the standard temperature of 25°C. Because ground-water is a dilute solution containing ionized substances, it is slightly conductive. The specific conductance of such a soluion is related to the quantity of dissolved solids that it contains.

The specific conductances used in Figure 13 were determined in a laboratory. However, with suitable portable equipment the specific conductance can be quickly and accurately measured in the field. The corresponding value of dissolved-solids content can then be estimated by using Figure13. When the dissolved-solids content is known, the probable concentration of several major ionized constituents of most ground-water samples obtained from the Brunswick and Lockatong Formations can be approximated from Figures 9, 10, 11, and 12.

CONCLUSIONS

The yield of wells in the Brunswick Formation depends on the number, thickness, and permeability of beds penetrated. Changes in the lithology from place to place are responsible for variations encountered in well yields. Because of the erratic nature of these changes, the location and extent of the best water-bearing zones cannot be predicted; however, if yields of more than 100 gpm are desired, wells should be drilled at least 200 feet deep—as the highest yields are obtained generally from wells ranging in depth from 200 to 550 feet.

Water sufficient for domestic purposes can be obtained at almost any location, but yields large enough for industrial and municipal purposes are more difficult to obtain. To assure an adequate supply over long periods of time, consideration must be given to factors that influence both the natural and artificially induced flow of ground water. For example, the water table is generally nearer the land surface in valleys than on ridges; hence, the available drawdown at wells of equal depth is greatest for wells in valleys. As natural flow from the aquifer is generally discharged into surface

streams, the opportunity to reduce the natural discharge or to induce flow from a stream to the aquifer by means of wells is greatest in stream valleys.

Unless ground water is recovered by either reducing natural discharge, or inducing additional recharge, water withdrawn from a well reduces the quantity in storage in the aquifer. Wells that draw water from storage over long periods of time cause large cones of depression to develop. Where several pumping wells are closely spaced, the cones of depression overlap. As the total decline in water level at any well equals the sum of the drawdowns produced by each well the interference may be so great that the yield of each well is reduced. This effect is particularly severe at wells oriented along lines parallel to the strike of the beds, because these wells generally penetrate the same beds. Wells should be spaced sufficiently far apart to reduce the effect of interference to an acceptable level. Because geologic hydrologic, and pumping conditions within the Brunswick Formation are complex and variable, the best spacing of wells will differ from place to place. Wells less than 2,000 feet apart in the Brunswick Formation have generally shown some interference.

Yields greater than those required for domestic purposes are not generally available from wells in the Lockatong Formation. Furthermore, because the Lockatong Formation is very resistant to erosion, it underlies areas of high elevation which are generally remote from surface streams. Few situations exist, therefore, where ground water can readily be diverted from points of natural discharge to nearby wells in the Lockatong.

One of the best ways to improve the yield of a well in the Lockatong, or any other aquifer of low permeability, is to increase the volume of water stored in the well bore by enlarging its diameter or drilling to greater depth. Such a well permits the well operator to satisfy his need for water during short periods of peak demand. For example, the volume of storage in 100 feet of 6-inch diameter borehole is approximately 150 gallons, but the volume of storage in 100 feet of a 10-inch diameter well is more than 400 gallons. By installing the pump intake pipe near the bottom of the well, most of the water stored in the well bore can be withdrawn. During periods when water is not being withdrawn, ground water flowing into the well will replenish the stored volume—if given enough time.

The cone of depression developed by pumping wells in the Lockatong Formation is rarely extensive. For this reason interference between wells is not a severe problem.

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Table 3. Chemical analyses of ground water in the Brunswick Formation in Berks and Montgomery Counties, Pennsylvania

(Results in parts per million except as indicated)

Location	Date of collection	Depth of well (ft.)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos/Cm at 25°C)	pH	Color
Berks County																				
Be-102	3- 2-61	375	15	.76	.03	59	20	135	3.5	214	298	7.5	0.3	2.7	645	229	54	941	7.8	2
103	3- 1-61	119	26	.03	.02	75	6.1	15	1.5	128	89	13	0.2	34	334	212	107	476	6.8	2
105	3- 2-61	300	26	.03	.02	37	15	10	1.0	156	20	8.8	0.1	21	216	154	26	335	7.6	3
106	3- 3-61	112	12	.13	.01	51	15	4.1	2.0	198	14	7.5	0.0	19	224	189	26	379	7.3	3
107	3- 3-61	130	14	.08	.05	90	20	5.4	0.5	229	78	6.3	0.0	33	318	307	119	495	7.8	3
111	2- 5-62	528	15	.23	.02	141	31	35	1.0	228	298	35	0.3	3.6	710	480	293	976	7.8	3
115	7-19-62	300	28	.12	.02	252	64	29	2.0	168	788	5.2	0.0	4.8	1340	892	755	1660	7.4	3
116	1-31-62	360	25	.37	.09	151	30	44	2.0	226	378	5.8	0.2	1.7	775	500	315	1010	7.8	3
118	1-30-62	500	10	1.6	.24	86	33	8.9	1.5	358	43	13	0.1	7.2	391	350	57	641	7.3	15
Montgomery County																				
Mg- 52	9-25-25	350	18	.06	..	47	17	9.4	2.1	194	23	13	..	7.5	232	187	28	....	..	..
62*	9-28-25	388	32	.05	..	36	15	11	1.8	173	15	8	..	2.5	201	152	10	....	..	..
76	2-21-52	387	21	.01	..	24	20	6	1.0	150	22	5	..	0.4	....	142	19	321	6.4	2
111	5-10-62	219	30	.37	.00	57	18	13	0.7	171	69	16	0.1	4.9	317	216	76	457	6.6	2
146	4- 7-53	205	13	.26	..	57	28	13	1.0	242	58	18	0.0	9.9	327	257	59	555	7.3	2
148	2- 7-62	373	17	.07	.00	45	5.4	12	1.0	134	26	10	0.1	13.0	200	135	25	313	7.5	3
190	2- 8-62	202	22	.04	.00	55	23	14	1.0	256	19	17	0.1	7.7	285	232	22	480	7.6	3
540	4- 9-62	600	20	.44	.02	116	51	22	0.8	163	370	11	0.1	11	732	500	366	959	7.3	3
541	3- 2-61	300	22	.05	.00	39	8.3	10	1.0	120	24	7.4	0.1	20	192	132	33	295	7.7	2
551	3- 1-61	450	19	.26	.01	47	9.0	14	1.0	179	12	9.3	0.0	18	214	155	8	351	7.8	2
557	4- 9-62	210	24	.00	.17	49	12	12	0.8	128	69	5.8	0.1	13	252	172	67	378	6.8	3
603	3- 2-61	916	28	3.9	.04	180	32	27	1.0	180	420	18	0.2	2.8	805	581	433	1090	7.4	3
616	4-21-49	100	20	.17	..	52	13	11	1.4	198	23	7.0	0.0	12	242	183	21	392	7.5	3
631	2-28-61	500	16	.38	.03	30	8.2	45	0.5	173	48	3.5	0.0	3.7	239	109	0	378	8.0	2
642	3- 1-61	312	28	.02	.03	90	36	19	1.8	162	248	6.0	0.2	2.7	534	373	240	747	7.7	2
662	2-27-61	300	17	.21	.06	71	30	30	1.5	217	84	68	0.1	5.6	426	301	123	695	7.9	4
678	3- 1-61	300	24	.06	.04	39	14	8.3	1.0	178	17	4.2	0.0	8.0	204	155	9	322	7.7	2
680	3- 1-61	500	28	.70	.38	59	17	15	1.0	252	37	4.2	0.1	0.2	283	217	11	447	7.5	6
689	3- 1-61	300	32	.02	.05	126	28	19	2.5	158	300	16	0.6	0.5	620	430	300	838	7.6	3
708	2- 5-62	123	23	.14	.00	70	21	12	1.5	236	32	20	0.1	36	344	261	68	536	7.6	4
709	2- 8-62	80	23	.05	.00	44	34	12	1.0	298	9.7	5.1	0.1	20	302	250	6	490	8.2	3
710	2- 8-62	100	22	.20	.00	55	20	14	2.2	202	40	18	0.2	19	307	219	54	478	7.4	8
711	2- 8-62	81	33	.07	.00	36	17	11	3.0	152	29	13	0.2	8.8	236	160	36	359	7.7	3
712	2- 5-62	157	21	1.6	.00	54	36	17	1.5	268	83	6.4	0.1	3.1	360	283	63	565	7.6	5
718	4- 9-62	133	19	3.0	.12	53	15	15	1.5	211	27	13	0.0	4.0	255	194	21	429	6.9	5
736	9-30-25	111	23	4.9	..	45	11	12	3.0	183	13	12	..	0.88	209	158	8	....	..	..
738	9-30-25	110	25	0.15	..	48	24	12	1.2	234	6.4	19	..	14	252	218	26	....	..	..

* Composite sample from 3 wells (Mg-62, 63, 64).

Table 4. Chemical analyses of ground water in the Lockatong Formation in Montgomery County, Pennsylvania
(Results in parts per million except as indicated)

Location	Date of collection	Depth of well (ft.)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids (residue at 180° C)	Hardness as $CaCO_3$: Calcium, magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos Cm at 25°C)	pH	Color
Montgomery County																				
Mg- 49	9-28-25	157	25	.07	..	40	15	9.8	1.7	187	13	6.8	..	5.2	199	162	9	....	..	..
713	2- 9-62	312	16	.32	.00	47	32	9.5	1.5	200	48	36	0.2	0.7	303	249	85	512	7.8	3
715	4- 9-62	140	16	.02	.00	47	17	9.8	0.8	144	38	16	0.1	26	253	188	70	414	7.3	3
716	4-10-62	200	15	.00	.00	52	17	9.2	1.0	193	36	14	0.0	2.8	246	200	42	410	7.7	3
737	9-28-25	80	13	.27	..	66	23	15	2.7	254	37	22	..	16	320	259	51	....	..	..
739	9-30-25	490	13	17	..	47	23	22	1.9	283	3.8	7.0	..	.21	283	212	0	....	..	..

Table 5. Comparison of the chemical quality of ground water in the Brunswick and Lockatong Formations
(Results in parts per million)

	Brunswick Formation Montgomery County			Lockatong Formation Montgomery County			Lockatong Formation Bucks and Montgomery Counties		
	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median
Dissolved solids (residue at 180°C)	192	1340	302	199	320	268	199	320	253
Silica (SiO_2)	10	33	22	13	25	16	11	25	15
Total iron (Fe)	.00	4.9	.14	.00	17	.17	.00	17	.07
Total manganese (Mn)	.00	.38	.02	.00	.00	.00	.00	.03	.00
Calcium (Ca)	30	252	55	40	66	47	21	66	47
Magnesium (Mg)	5.4	64	20	15	32	20	12	32	17
Sodium (Na)	4.1	135	13	9.2	22	9.8	7	45	12
Potassium (K)	0.5	3.5	1.4	0.8	2.7	1.6	0.6	2.7	1.1
Bicarbonate (HCO_3)	120	358	188	144	283	196	120	283	193
Sulfate (SO_4)	6.4	788	38	3.8	48	36	3.8	61	37
Chloride (Cl)	3.5	68	9.7	6.8	36	15	6.8	36	11
Fluoride (F)	0.0	0.6	0.1	0.0	0.2	0.1	0.0	0.4	0.1
Nitrate (NO_3)	0.2	36	7.6	.21	26	4.0	0.1	26	2.1
Hardness Calcium, magnesium	109	892	218	162	259	206	103	259	187
Hardness Non-carbonate	0	755	45	0	85	47	0	85	42
	Analyses from 36 wells			Analyses from 6 wells			Analyses from 11 wells		

Table 6. Record of wells

Method of construction: Drl, drilled.
Aquifer: Txd, diabase; Txbf, Brunswick Fanglomerate; Txb, Brunswick Formation; Txl Lockatong Formation.

Use: D, domestic; I, industrial; O, observation; PS, public supply; R, recharge; T, test; U, unused; X, destroyed.
Remarks: CA, complete chemical analysis; dd, drawdown; EL, electric log available; FA, field chemical analysis available; H, hydrograph available; SL, sample log.

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date measured	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
Be 17	015-543-2	St. Gabriel's Episcopal Church			145	Drl	8	350		Txb		40	75	U	
18	015-543-3	Roy Scherr			155	Drl	6	250		Txb			50	D	
24	019-537-1	J. Y. Shaner			380	Drl	6	85		Txb			8	U	
101	016-548-1	Colorado Fuel & Iron			150	Drl	8	55+		Txb	6- 3-63	17	20	O	EL, H, FA; 13 ft. dd. in 3 hrs.
102	017-547-1	Daniel Boone Homestead		1939	200	Drl	6	375	40	Txb			20+	D	CA
103	019-538-1	Boyertown Packaging Service	C. S. Garber	1954	380	Drl	6	141	51	Txb	5-18-55	10	45+	I	CA
104	026-533-1	Pennsburg Water Co.	F. L. Bollinger	1958	390	Drl	10	150	46	Txb	4- 3-58	8	750	PS	
105	026-533-2	do.	do.	1958	395	Drl	10	300	49	Txb	4- 7-58	6	400	PS	CA
106	018-551-1	Hub Tool Mfg. Machine Co.	C. S. Garber	1958	240	Drl	10	112	83	Txbf		37	10+	I	CA
107	018-544-1	John Bell	C. S. Garber	1955	355	Drl	6	119	40	Txbf	8-12-55	73	10+	D	CA
108	017-551-1	Pendora Tool & Die			200	Drl				Txb				I	FA
109	017-551-2	Exeter Twp. School	Kohl Bros.	1958	220	Drl	6	200	46	Txb	7-31-58	59	74	PS	31 ft. dd. in 6 hrs.
110	020-537-1	Colebrookdale School	do.	1954	350	Drl	6	160	67	Txb	8- ?-54	15	68	PS	
111	020-536-2	Kawecki Chemical Co.	do.	1959	320	Drl	6	528	16	Txb	1959	110	220	I	CA
112	020-536-3	do.	do.	1961	320	Drl	8	660	42	Txb			140	I	
113	020-536-4	do.	do.	1961	320	Drl	6	500	35	Txb	6-10-63	26	20	U	EL, H, FA; 27 ft. dd. in 4 hrs.
114	020-536-7	do.	C. S. Garber	1961	310	Drl	6	400	46	Txb	11-14-61	4	86	U	EL, FA; 35 ft. dd. in 4 hrs.
115	015-544-1	Douglassville Water Co.	do.	1957	190	Drl	6	300	38	Txb	1-31-62	24	30	U	CA; 106 ft. dd. in 67 hrs.
116	016-544-1	do.	do.	1958	250	Drl	6	360	44	Txb	1-31-62	42	60	PS	CA
117	015-543-1	do.	do.	1959	219	Drl	6	262	42	Txb	1959	49	300	PS	
118	018-553-1	Forest Hills Memorial Park	do.	1959	295	Drl	6	500	38	Txbf	1-25-62	45	3	D	CA, EL
121	017-547-3	Clarence C. Kline	Ira Peterseim	1953	245	Drl	5	320	205	Txb	4-10-62	Flows	10	U	EL, FA
122	017-547-2	do.	do.	1953	225	Drl	10	335	6	Txb	7- 5-62	35		U	EL
123	016-542-1	Pine Forge Institute	C. S. Garber	1947	240	Drl	8	240		Txb		76	20+	PS	
125	015-544-2	U. S. Geol. Survey	Kohl Bros.	1962	190	Drl	6	300	40	Txb	6- 4-63	37	20	O	EL, H, SL; 18 ft. dd. in 4 hrs.
126	016-542-2	Pine Forge Institute			225	Drl		277		Txb			30	PS	
Ch 141	011-533-1	Pennhurst State School			235	Drl	8	327		Txb	1948	52	100	PS	218 ft. dd. in 3 hrs.
142	011-533-2	do.			230	Drl	8	529		Txb	1954	190	60	PS	40 ft. dd. in 3 hrs.
143	011-533-3	do.			320	Drl	8	443		Txb	3-12-63	236	40	U	
144	011-534-1	do.			310	Drl	8	421		Txb	1-23-56	115	80	PS	
145	011-534-2	do.			330	Drl	8	404		Txb	3-12-63	212	95	PS	75 ft. dd. in 7 hrs.
146	011-534-3	do.			345	Drl				Txb				X	
147	011-532-4	do.	F. L. Bollinger		298	Drl	12	204	74	Txb	6- ?-48	101	200	PS	60 ft. dd. in 2 hrs.
181	011-534-4	do.	do.	1943	360	Drl	16-10	700	90	Txb	4- 9-63	130	225	PS	106 ft. dd. in 72 hrs.
Mo 1	013-529-1	Eastern State Penitentiary			140	Dug		22		Txb	10-28-31	18		X	H
2	014-529-2	Pottsgrove Manor		1752	150	Dug	48	30		Txb	10-28-47	28		O	
3	014-527-1	Gottfried Oil			170	Dug	48	29		Txb	10-27-47	19		U	
4	011-528-1	Collegeville-Trappe Joint Water Works	Honenberger	1936	195	Drl	12-8	275	24	Txb	4-13-50	24	125	U	84 ft. dd. in 24 hrs.
5	011-528-2	do.	Kohl Bros.	1935	195	Drl	12-8	250	42	Txb	10-31-35	15	200-240	PS	49 ft. dd. in 24 hrs.
6	011-528-3	do.	do.	1942	180	Drl	8	250	40	Txb	5- 6-43	15	150	PS	40 ft. dd. in 4 hrs.
7	011-528-4	do.	do.	1947	190	Drl	8	367	6	Txb	9- 2-47	40	125	U	
8	011-528-5	do.	do.	1947	210	Drl	8-6	357	41	Txb	12-28-47	26	148	PS	99 ft. dd. in 24 hrs.
49	012-516-2	North Wales Water Authority	Ridpath & Potter	1906	391	Drl	8	158	45	Txb, Txl			100	U	CA
52	012-516-3	do.	do.		350	Drl	8	350	30	Txb, Txl			80	PS	CA
56	012-517-1	do.		1945	320	Drl	14-10	384	72	Txb	4-23-45	0	240	PS	135 ft. dd. in 24 hrs.
61	014-516-1	Lansdale Municipal Authority		1892	366	Drl	8	392		Txb	8- 6-54	79	8	U	
62	014-516-2	do.		1903	366	Drl	8	388	22	Txb	8- 6-54	76	8	U	CA
63	014-516-3	do.		1908	366	Drl	8	400	120	Txb	3- 1-43	78	18	U	CA
64	014-516-4	Lansdale Municipal Authority		1910	366	Drl	8	1108	18	Txb	11- 4-54	83	8	U	CA
67	014-517-1	do.	F. L. Bollinger	1923	328	Drl	8	292		Txb	3- 1-47	132	57	PS	
68	014-517-2	do.	do.	1927	322	Drl	8	500		Txb	1-31-47	83	79	PS	
69	014-517-3	do.	William Stothoff	1935	328	Drl	12-8	264	40	Txb	1-31-47	73	39	PS	
70	014-516-8	do.	do.	1937	421	Drl	10-8	391	36	Txb	1-31-47	84	139	PS	129 ft. dd. in 48 hrs.
72	013-516-1	do.	do.	1941	353	Drl	16-10	306	44	Txb	3- 1-47	42	128	PS	
74	014-515-5	do.	do.	1948	403	Drl	12-10	546		Txb	2-24-48	48	50	U	
76	013-516-2	do.	do.	1949	341	Drl	12-10	388	37	Txb	7-18-49	23	240	PS	CA
83	014-517-4	Lansdale Forest Products Co.	F. L. Bollinger	1934	330	Drl	8	425		Txb	11-18-52	74		U	
85	014-517-5	Lansdale Ice & Storage			360	Drl	8	615		Txb	11-18-52	66		U	
90	013-517-1	Lansdale Tube Co.	Philadelphia Drilling Co.	1951	375	Drl	8	500	46	Txb	1-17-51	57	165	I	
91	014-538-18	Joseph Prince		1913	190	Drl	6	299		Txb	10-23-52	59		U	
92	014-538-19	Schulz Baking Co.		1932	190	Drl	8	242		Txb	11- 1-44	70	150	I	69 ft. dd. in 48 hrs.
93	015-538-1	Raymond Nester		1916	165	Drl	6	150		Txb			76	I	
94	014-538-15	Clover Leaf Dairy	Penrose Keller	1926	175	Drl	6	125		Txb				I	
95	014-538-16	do.	do.	1928	170	Drl	6	125		Txb				I	
96	014-538-17	do.	C. S. Garber	1935	160	Drl	8	276		Txb	3- ?-47	55	50	I	2 ft. dd. in 14 hrs.
97	014-538-13	Pottstown Warehouse & Cold Stor. Co.	Groff	1937	150	Drl	8	250	100	Txb	6-17-47	20	125	I	
98	014-538-14	do.	Groff & Kohl Bros.	1938	150	Drl	8	800	120	Txb	6-17-47	20	140	I	
99	014-538-20	Pottstown Plating Works Inc.	C. S. Garber	1943	135	Drl	8	230		Txb	1950	24	115	I	76 ft. dd. in 40 hrs.
100	014-538-21	do.	do.	1951	135	Drl	8	545	40	Txb	8- ?-51	45	210	I	90 ft. dd. in 24 hrs.
101	014-538-7	Doehler-Jarvis Corp.	Penrose Keller		160	Drl	8	90		Txb	6- 3-55	51		O	
102	014-538-8	do.	Joseph Smith	1936	155	Drl	8	300-320		Txb	6- 2-55	53		U	
103	014-538-9	do.	do.	1937	155	Drl	8	300-320		Txb			72	I	
104	014-538-10	Doehler-Jarvis Corp.	do.	1937	155	Drl	8	300-320		Txb			48	I	
105	014-538-11	do.	do.	1938	155	Drl	8	300-320		Txb			71	I	
106	014-538-12	do.	do.	1940	155	Drl	8	300-320		Txb			59	I	
107	014-538-5	Minneapolis-Honeywell Regulator Co.	C. S. Garber	1943	145	Drl	8	300		Txb			220	I	
108	014-538-6	Philadelphia Dry Cleaners Inc.	Joseph Smith	1930	150	Drl	6	199		Txb	10- ?-50	18	60+	I	
110	014-541-1	Pottstown Cement Block Co.	C. S. Garber	1941	170	Drl	8	112		Txb	1941	15	15	I	
111	014-541-2	Pottstown Metal Products Co.	do.	1941	165	Drl	6	219		Txb		34	90	I	CA
112	014-541-3	do.	Charles Merritt	1951	165	Drl	6	120		Txb		34	9	I	
123	012-518-1	Merk, Sharpe & Dohme	F. L. Bollinger	1942	362	Drl	10-6	502		Txb, Txl	5-14-51	34	15	U	
127	013-518-3	do.	Charles Lauman		351	Drl	12-10	300		Txb	11- 3-53	53	130	O	
128	013-518-4	do.	do.		352	Drl	12-10	300		Txb	11- 3-53	58	395	I	
146	019-519-2	Telford Borough	Ridpath & Potter	1928	420	Drl	10	205		Txb	9-16-56	90	190	PS	CA
148	012-528-1	Collegeville-Trappe Joint Water Works	Kohl Bros.	1954	225	Drl	8	373	33	Txb	8- 4-54	8	227	PS	CA; 110 ft. dd. in 24 hrs.
152	015-516-1	American Encaustic Tile Co.		1929	365	Drl	8	203	25	Txb	5- ?-54	98	60	I	60 ft. dd. in 1 hr.
153	015-516-3	do.		1954	365	Drl	10	400		Txb	1- ?-54	101	80	I	

Table 6. Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date measured	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
Mg 167	012-516-1	Leeds & Northrup Co.	Ridpath & Potter	1954	350	Drl	16-10	288	44	Tab	5- ?-60	48	200	I	
179	012-516-4	do.			358	Drl	8	126	60	Tab, Tal	1- ?-47	10	100	U	EL, H
180	013-517-2	do.	Ridpath & Potter	1954	325	Drl	6	250		Tab	11- 2-54	65	100	U	EL, H
190	016-518-1	Hatfield Borough	J. T. Campbell	1928	350	Drl	8	202	36	Tab			150	PS	CA
203	012-517-2	North Wales Water Authority	Kohl Bros.	1955	315	Drl	8	450	27	Tab	1-17-55	12	210	PS	188 ft. dd. in 72 hrs.
204	013-517-3	Precision Tube Co.	Philadelphia Drilling Co.	1955	365	Drl	8	500		Tab	5-19-55	52	190	I	22 ft. dd. in 5 hrs.
221	011-532-3	Krasley Bleach & Dye	Kohl Bros.	1941	130	Drl	8	447	22	Tab			80	U	
222	011-532-4	do.	do.	1941	130	Drl	8	251	28	Tab		23	135	I	
223	013-517-4	Leeds & Northrup Co.	Ridpath & Potter	1955	332	Drl	10	350		Tab	8- ?-55	49	316	I	FA; 81 ft. dd. in 48 hrs.
257	011-517-1	C. W. MacMullin	George Lauman	1950	340	Drl	6	65		Tal	11- 9-55	22	10	D	
258	011-517-2	John F. Gerber		1948	385	Drl	6	80+		Tal			10	D	
274	014-539-1	Pottstown Metal Welding Co.	Michael Kussyk	1956	135	Drl	8	150		Tab				I	
281	011-526-1	Superior Tube Co.	Kohl Bros.		190	Drl	6	460	105	Tab			60	I	
282	011-526-2	do.	do.	1941	190	Drl	8	300	61	Tab	10- ?-41	57	110	I	
283	011-526-3	do.	do.	1951	185	Drl	8	199	101	Tab	10-23-56	87	87	I	
284	011-526-4	do.	do.	1953	185	Drl	8	449	22	Tab	9- ?-53	86	55	I	
292	018-521-2	Horace W. Longacre	A. W. Dorn	1956	390	Drl	6	131	38	Tab	11- 8-56	50	45	I	
293	014-534-1	Saratoga Trailer Park		1946	260	Drl	6	226		Tab	1956	87	20+	PS	
450	011-521-1	Variety Club Camp			410	Drl		175		Tab, Tal				D	
467	011-521-2	do.	Parente Bros.	1949	420	Drl		225		Tab, Tal				PS	
472	010-520-1	P. W. Bookhermer	Charles Lauman	1945	450	Drl		110		Tab, Tal				D	
473	010-519-1	B. Bev	do.	1950	350	Drl		120		Tal			4	D	
478	011-518-1	F. McClure	do.	1944	325	Drl		150		Tal	9- 6-56	10	7	D	
479	011-517-3	E. W. Carlson			330	Drl		160		Tal				D	
480	011-518-2	W. A. Garver		1930	375	Drl		90+		Tab, Tal				D	
481	011-518-3	A. J. Wilson	Patrick Flaherty	1950	417	Drl	6	112	30	Tal	9- 6-56	69	27	D	
482	011-518-4	Henry Krug		1949	370	Drl		120		Tal				D	
483	011-518-5	Joseph Bailiff		1943	360	Drl	6	132	25	Tal	9-25-56	60	12	D	
493	010-520-2	U. S. Army	C. S. Garber	1955	445	Drl		230		Tal		47	7		
494	010-521-1	do.	do.	1955	460	Drl		230		Tal		51	22		
498	015-518-1	Lansdale Municipal Authority	William Stothoff	1957	340	Drl	12	560	90	Tab	9-18-57	77	90	PS	
534	013-525-1	Eastern State Penitentiary	F. L. Bollinger	1928	255	Drl	10	489	10	Tab	7-23-63	234	155	PS	
535	013-525-1	do.	do.	1929	280	Drl	10	552	21	Tab	7-23-63	248	135	PS	11.5 ft. dd. in 73 hrs.
536	013-525-3	do.	do.	1929	280	Drl	10	497	32	Tab	5- ?-62	245	116	PS	11 ft. dd. in 73 hrs.
537	013-526-2	do.	do.	1929	280	Drl	10	596	20	Tab	7-23-63	260	98	PS	12 ft. dd. in 24 hrs.
538	014-526-2	do.	do.	1937	305	Drl	12	512	19	Tab	8- ?-60	204	355	PS	87 ft. dd. in 72 hrs.
539	014-526-3	do.	Artesian Well Drilling	1951	285	Drl	16-8	502	24	Tab	7-23-60	195	300	PS	18 ft. dd. in 48 hrs.
540	013-526-3	do.	F. L. Bollinger	1951	270	Drl	10	600		Tab	4- 9-62	180	90	PS	CA
541	010-520-1	Charles Johnson Home	do.	1949	140	Drl	12-8	300	44	Tab	6- 9-60	18	125	PS	CA
542	010-520-2	do.		1930	240	Drl	8	198		Tab			84	PS	FA
543	010-523-1	Diamond Glass Co.	Ridpath & Potter	1944	110	Drl	16-10	400	60	Tab	8-10-56	30	191	I	FA; 125 ft. dd. in 24 hrs.
544	010-523-2	Spring Ford Foundry & Machine Co.			115	Drl		120		Tab				I	FA
545	010-523-3	Bush Bros.	C. S. Garber	1947	115	Drl	10	223		Tab			60+	I	FA
546	011-523-1	Potts Bros.	do.	1959	227	Drl	6	172	42	Tab	5- ?-59	37	40	I	
547	010-523-4	Royersford Foundry & Machine Co.			120	Drl	6	100+		Tab				I	
548	010-523-5	Bankers Bar	C. S. Garber	1959	160	Drl	6	201	50	Tab			60	D	FA
549	011-531-1	Nelsons Ice Cream Inc.	Kohl Bros.	1925	175	Drl	8	225		Tab			60+	I	FA
550	011-532-2	Cann & Saul Steel Co.	do.	1941	187	Drl	6	235	21	Tab	6- 8-60	11	30	O	EL, H
551	012-522-1	O. J. Hynes			265	Drl	8	450		Tab	3-30-60	63		I	CA
552	012-525-1	John Nast	A. W. Dorn	1957	260	Drl	6	90		Tab	3-30-60	21		D	FA
553	012-525-2	Natalie Schmitt		1959	260	Drl	6	102	38	Tab			25	D	FA
554	012-525-3	McCormie Air Services	Miller Pump Service	1959	285	Drl	6	154	40	Tab	3-30-60	50	40	D	FA
555	012-532-1	S. A. Wetty & Sons	C. S. Garber	1949	260	Drl	6	160	12	Tab	6- 9-60	72		I	FA
556	012-532-2	do.	do.	1956	260	Drl	6	190	21	Tab	8-20-56	69	15	I	
557	012-534-1	Kinsey Distilling Corp.	do.	1934	150	Drl	10	394		Tab			95	I	CA
558	012-534-2	do.	do.	1934	150	Drl	10	360		Tab			225	I	
559	012-534-3	do.	do.	1934	155	Drl	10	328		Tab			107	I	
560	012-534-4	do.	do.	1934	170	Drl	10	145		Tab			10	I	
561	012-534-5	do.	do.	1935	115	Drl	6	179		Tab			55	I	
562	012-534-6	do.	do.	1934	145	Drl	10	365		Tab			213	I	
564	012-534-8	Sanitary Company of America			125	Drl		200+		Tab				I	
565	012-534-9	do.	Wallace Reigner	1959	127	Drl	6	98		Tab				D	
566	013-518-5	Martin Century Farms	F. L. Bollinger	1960	280	Drl	14-10	330	45	Tab	3-17-60	15	226	I	152 ft. dd. in 21 hrs.
567	013-521-1	C. V. Hollis		1943	267	Drl	6	135	50	Tab				D	FA
568	013-521-2	C. W. Boeler		1940	255	Drl	6	110	50	Tab				D	FA
569	013-521-3	do.			255	Drl	6	79	25	Tab	3-31-60	23		U	FA
570	013-521-4	Fischers Pool & Cottages	Patrick Flaherty	1948	195	Drl	8	195	25	Tab		7	48	PS	
571	013-521-5	do.	do.		181	Drl	6	90	25	Tab			20	PS	
572	013-521-6	do.	do.		176	Drl	6	78	25	Tab			20	PS	
573	013-521-7	do.	do.	1935	178	Drl	6	90	25	Tab			20	D	FA
574	013-524-1	John Gregory			270	Dug		19		Tab	3-30-60	8		D	FA
575	013-524-2	Anna Lewandowski	Parente Bros.	1940	210	Drl	6	140		Tab				D	FA
576	013-536-1	Firestone Tire & Rubber Co.	C. S. Garber	1947	152	Drl	14-10	351	38	Tab			180	I	
577	013-536-2	do.	do.	1942	153	Drl	14-10	402	35	Tab			193	I	
578	013-536-3	do.	do.	1947	152	Drl	14-10	342	35	Tab			73	I	
579	013-536-4	do.	do.	1942	147	Drl	14-10	494	75	Tab	9-22-61	52	61	I	EL
580	013-536-5	do.	do.	1942	136	Drl	14-10	276	36	Tab			153	I	
581	013-536-6	do.	do.	1942	190	Drl	14-10	394	32	Tab, Tal	6- 1-60	79	62	U	EL, H, FA
582	013-536-7	do.	do.	1947	130	Drl	14-10	371	37	Tab			94	I	
583	013-536-8	do.	do.	1942	165	Drl	14-10	355	47	Tab			170	I	
584	014-536-1	do.	do.	1942	186	Drl	14-10	406	42	Tab			108	I	
585	014-536-2	do.	do.	1942	157	Drl	14-10	266	50	Tab			70	I	
588	014-515-1	Picolet Dye Works Inc.	Walter Emert		430	Drl	6			Tab, Tal	6-23-60	36		U	
589	014-515-2	do.	do.	1951	430	Drl	6	820		Tab, Tal			4	I	
590	014-515-3	do.	William Stothoff		430	Drl		300		Tab, Tal			20	I	
591	014-515-4	do.	Walter Emert		425	Drl	6	400		Tab, Tal			12	I	FA
592	014-516-7	Lansdale Borough			390	Drl	12-8	235	44	Tab, Tal	5-26-59	87	67	PS	67 ft. dd. in 24 hrs.
593	014-518-3	Lansdale Municipal Authority	Kohl Bros.	1958	320	Drl	12-8	492	76	Tab	9- ?-59	111	200	PS	190 ft. dd. in 48 hrs.
594	014-520-1	H. H. Becker		1925	185	Drl	6			Tab	4-18-60	23		PS	
595	014-520-2	Pa. Turnpike Lansdale Interchange	Thomas G. Keyes	1955	265	Drl	10	135	42	Tab	4-27-60	32	17	D	FA
596	014-525-1	Robert Aldefer	Parente Bros.	1943	275	Drl	6	210	30	Tab	1957	152	30	D	8 ft. dd. in 2 hrs.
597	014-523-1	Pottstown Airport	C. S. Gaber	1958	310	Drl	6	220	40	Tab		90	12	D	
598	014-536-3	Sunnybrook Enterprises	do.	1954	150	Drl	8	262	46	Tab	4- 3-62	8	90	PS	FA

Table 6. Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date measured	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
Mg 599	014-537-1	Dana Corp.			155	Drl	8	385		Trb			160	I	
600	014-537-2	do.			155	Drl	10	287		Trb			130+	I	
601	014-537-3	do.	Joseph Smith	1941	160	Drl	8	540		Trb	1- 7-42	30	125	I	FA
602	014-537-4	do.	do.	1941	150	Drl	8	425		Trb			90	I	
603	014-537-5	do.	Kohl Bros.	1942	150	Drl	6	916	850	Trb			150	I	CA
604	014-538-1	Bethlehem Steel Co.		1916	145	Drl	8	200		Trb		25	200	I	
605	014-538-2	do.		1916	145	Drl	8	200		Trb		25	200	I	
606	014-538-3	Levengood Dairy		1917	165	Drl				Trb				I	
607	014-538-4	do.	Joseph Smith	1932	165	Drl	8	184		Trb			150	I	FA
608	014-540-3	Stanley G. Flagg Inc.		1910	150	Drl		201		Trb	1958	100	120	I	
609	014-540-1	do.	Kohl Bros.	1945	145	Drl	8	200	35	Trb	1958	63	147	I	
610	014-540-2	do.	do.	1947	145	Drl	8	244	82	Trb	1958	86	200	I	67 ft. dd. in 2 hrs.
611	014-540-4	do.	do.	1948	145	Drl	8	350	36	Trb	1958	96	255	U	
612	015-514-1	Lock Seam Tube Inc.			455	Drl				Trb				D	FA
613	015-515-1	Picolet Dye Works Inc.	Walter Emert		370	Drl	6	320		Trb			15	I	
614	015-515-2	do.	do.		375	Drl	6	120		Trb			10	I	
616	013-522-1	Eugene D. Rutter			180	Drl	6	100		Trb			25	I	CA
618	015-516-4	Penndale Inc.	R. L. Knieriem	1958	360	Drl		330		Trb			30	I	
619	015-516-5	American Encaustic Tile Co.			335	Drl		88		Trb	6-8 -56	74		U	
620	015-516-6	do.	William Stothoff	1955	360	Drl	10	400	116	Trb	3-28-58	94	100+	I	
621	015-516-7	do.	do.	1957	335	Drl	10	400		Trb	1957	58		I	
622	015-516-8	A. M. Kulp School	Miller Pump Service	1956	297	Drl	8-6	600	100	Trb	10- 9-57	24	55	PS	FA; 50 ft. dd. in 24 hrs.
623	015-517-9	Lansdale Municipal Authority	William Stothoff	1957	330	Drl	10	507	97	Trb	12-18-62	41	200	U	EL
624	015-517-13	J. W. Rex Inc.	F. L. Bollinger	1958	315	Drl	8	504	85	Trb	1958	105	9	U	
625	015-517-14	do.	do.	1958	320	Drl	8	384	62	Trb	4- ?-60	54	186	I	
627	015-519-1	Paul Clemens			345	Drl	6	125		Trb	4- 1-60	30		D	FA
628	015-519-2	M. L. Dickinson			320	Drl	6	84		Trb	4- 1-60	49		D	FA
629	015-520-1	Christopher Dock Mennonite H. S.			300	Drl	6	101		Trb	3-31-60	54		PS	
630	015-520-2	do.	A. W. Dorn	1959	300	Drl	8	130		Trb	8-10-59	52	60	PS	FA
631	015-520-3	Nice Ball Bearing Co.	Ridpath & Potter	1959	285	Drl	10	500	60	Trb	3-29-60	55	200	I	CA
632	015-520-11	U. S. Geol. Survey	C. S. Garber	1960	285	Drl	6	500	31	Trb	8-29-63	71		T	EL, H, SL
633	015-520-10	do.	C. S. Garber & Kohl Bros.	1962	270	Drl	6	500	32	Trb	8-29-63	62	125	T	EL, H, SL
634	015-520-4	Elwell Davies			310	Drl	8	198		Trb	4- 4-60	55		D	FA
635	015-520-5	John Felver			300	Drl	6	167		Trb				D	FA
636	015-520-6	William Delp			257	Drl	6	87		Trb	4- 1-60	49		D	FA
637	015-520-7	Abram Ziegler	Miller Pump Service	1930	220	Drl	8	105		Trb	4- 1-60	22		D	FA
638	015-520-8	Frank Wambold	Patrick Flaherty	1958	235	Drl	8	100	16	Trb			40+	D	FA
639	015-520-9	William Delp			240	Dug		35		Trb				D	FA
640	015-528-1	Schwenksville Water Co.	F. L. Bollinger	1940	238	Drl	8	503		Trb	1960	135	80	PS	
641	015-528-2	do.			260	Drl	6	213		Trb				U	
642	015-528-3	do.	F. L. Bollinger		250	Drl	8	312		Trb	1960	120	70	PS	CA
643	016-517-1	Girard Knitting Mills			330	Drl	6			Trb				D	
644	016-517-4	Hatfield Borough	William Stothoff	1957	330	Drl	10	400-500		Trb			160	PS	
645	016-522-1	Alderfer Bologna Co.	A. W. Dorn	1959	280	Drl		206	27	Trb	7-15-59	36	70	I	FA
646	016-523-1	Harleysville Insurance Co.		1949	335	Drl				Trb				I	FA
647	016-523-2	Lower Salford Twp. School		1912	280	Drl	6	160		Trb				PS	
648	016-523-3	do.		1936	280	Drl	6	200		Trb			5	PS	FA
649	017-517-1	Hunter Spring Co.	Kohl Bros.	1960	370	Drl	10	400	42	Trb, Trl	2- ?-60	8	105	I	EL; 100 ft. dd. in 16 hrs.
650	017-518-1	Walter Forest	A. W. Dorn	1945	345	Drl		75		Trb			16	PS	FA
651	017-518-2	do.	do.	1957	345	Drl		170		Trb			25	PS	
652	017-518-3	Schlosser Steel Inc.		1958	370	Drl		87		Trb				I	
653	017-518-4	A. Steiert & Son Inc.		1937	390	Drl	10	205	30	Trl		25		I	
654	017-519-1	Souderton Borough	F. L. Bollinger	1956	380	Drl		300		Trl			10	U	
655	017-520-1	do.			375	Drl		300		Trl			10	U	
656	017-524-1	NYCE Manufacturing Co.	Parente Bros.	1925	300	Drl	6			Trb, Trl	5-24-60	9		I	FA
658	018-518-1	R. T. French Co.	F. L. Bollinger	1956	390	Drl	8	400	40	Trb			100	I	
659	018-518-2	Souderton Borough		1915	525	Drl		600-700		Trl				I	
660	018-518-4	do.		1929	455	Drl	10	300	13	Trb	12- ?-53	39	45	U	
662	018-519-1	do.	F. L. Bollinger	1948	320	Drl		300		Trb	5- ?-60	75	50	PS	
663	018-519-2	do.	William Stothoff	1958	340	Drl	8	300	40	Trb	4- ?-59	16	110	PS	CA
664	018-519-3	do.		1957	340	Drl	10	400	30	Trb			45	PS	
665	018-519-4	do.	F. L. Bollinger	1954	360	Drl	12	300	21	Trb			80	PS	
666	018-519-5	Souderton Steam Laundry		1929	390	Drl	8	88		Trb			30	I	
667	018-519-6	Eastern Mennonite Home	J. W. Shaw	1917	460	Drl	6	192		Trb, Trl	5-23-60	111	10	PS	FA
668	018-519-7	Granite Hosiery Mills			390	Drl	8-6	208		Trb	6-14-57	65	11	I	FA
669	018-519-8	Souderton Borough			395	Drl	8	112	20	Trb	1952	48	50	U	
670	018-519-9	do.		1936	410	Drl	12	205	25	Trb	5- ?-60	125	50	PS	
671	018-519-10	do.		1911	410	Drl	8	224	120	Trb	1-16-61	54	80	U	EL
672	018-519-11	do.			395	Drl		600-700		Trb			15	U	
673	018-519-12	do.			415	Drl	6	300-350		Trb				X	
674	018-519-13	Souderton Borough			390	Drl	6	92		Trb				U	
675	018-519-14	M. B. Bergey Hosiery Mill			500	Drl	6	750		Trb, Trl				U	
676	018-519-15	Goodman Silk Mill			390	Drl	6	90		Trb				U	
677	018-519-16	H. S. Souder			480	Drl	6	300		Trb				I	
678	026-532-1	Henry L. Landis Estate	F. L. Bollinger	1959	315	Drl	14-10	300	60	Trb	6-20-59	14	240	PS	CA; 94 ft. dd. in 72 hrs.
679	018-519-17	East Greenville Borough	William Stothoff	1960	360	Drl	12-8	308	43	Trb	2-15-61	12	250	O	EL, H, SL; 71 ft. dd. in 4
680	018-532-1	Souderton Borough		1952	365	Drl		500		Trb				PS	CA
681	018-521-1	New Hanover Twp. School	Parente Bros.	1939	475	Drl	6	280		Trb				PS	FA
682	018-531-1	Franconia Twp. School			325	Drl	6	60		Trb				PS	
683	018-531-2	Mennonite Home for the Aged	Mayer	1956	325	Drl	8	175		Trb				PS	
684	019-519-1	do.	Ridpath & Potter		420	Drl	10	240		Trb			190	PS	
686	019-519-5	Telford Borough			450	Drl		600		Trb			12	U	
687	019-537-1	Souderton Borough	Kohl Bros.	1948	340	Drl	6	400	50	Trb	6- ?-48	8	150	I	FA
688	019-537-2	Fashion Hosiery Mills Inc.	do.	1948	340	Drl	8	600	10	Trb	5- ?-48	7	60	R	143 ft. dd. in 1 hr.
689	020-528-1	do.	Campbell		320	Drl		300		Trb			20	PS	CA
690	020-528-2	Maranatha Park	do.	1950	325	Drl		310		Trb		100		PS	
691	013-516-5	do.	V. D. Kohler	1960	355	Drl	6	171		Trb				D	
692	018-522-1	R. D. Gillen	Joseph Mayer	1960	300	Drl		150		Trb				D	
693	018-522-2	Keller's Creamery	A. W. Dorn	1950	300	Drl		150		Trb				I	
695	016-517-5	do.			340	Drl	6	55		Trb	6-13-61	10		D	FA
696	017-523-1	Dorsey Shultz		1941	240	Drl	6	78		Trb	6-15-61	16		D	FA
697	012-522-2	Harvey Koffel	Miller Pump Service	1956	230	Drl	6	85	43	Trb	6-14-61	18		D	FA
698	015-521-1	Gordon Wilkie	Charles Lauman		200	Drl	6	80		Trb	6-14-61	23		D	
699	020-522-1	Earl Ehrhart	A. W. Dorn	1946	480	Drl	6	81		Trb	6-12-61	28		D	FA
700	014-540-5	R. L. Koehler	Kohl Bros.	1961	145	Drl	8	650	88	Trb	11-20-61	22	75	I	EL, SL; 200 ft. dd. in 40
		Stanley G. Flagg Inc.													

Table 6. Record of wells—Continued

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter of casing (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date measured	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
Mg 701	020-536-1	Kawecki Chemical Co.	Kohl. Bros.	1957	320	Drl	6	405	19	TRb	1957	20	150	I	180 ft. dd. in 40 hrs.
702	020-536-5	do.	C. S. Garber	1961	310	Drl	6	300	60	TRb	11- 7-61	8	100	I	EL
703	020-536-6	do.	do.	1961	315	Drl	6	400	30	TRb	11- 7-61	36	40	U	EL
704	015-517-15	Lansdale Municipal Authority	F. L. Bollinger	1962	310	Drl	14-10	400	80	TRb	12- 4-61	25	135	PS	EL, SL; 135 ft. dd. in 40 hrs.
705	024-528-1	Upper Hanover Twp.	C. S. Garber	1957	480	Drl	6	275	21	TRb	5- 4-57	Flows	100	D	
708	022-534-1	H. J. Beitler	Hunsicker	1943	495	Drl	6	123	14	TRb	1955	80	24+	D	CA
709	018-523-1	S. P. Godshall	Stover		330	Drl	6	80		TRb	2- 8-62	51		D	CA
710	018-527-1	Frank Seal	C. S. Garber	1950	430	Drl	6	100+		TRb	2- 8-62	18		D	CA
711	023-527-1	A. T. Goadby	W. W. Wonsidler	1957	480	Drl	6	81	30	TRb	10- ?-57	12	20	D	CA
712	017-535-1	E. F. Barndt	C. S. Garber	1940	260	Drl	6	157	40	TRb	2- 5-62	7	10	D	CA
713	013-514-1	N. T. Cummings	Miller Pump Service	1956	450	Drl	6	312	40	TRl	1956	80	7	D	CA
714	014-538-22	Ferro-Phos Co.			175	Drl	6	138		TRb		40		I	FA
715	015-524-1	Stanley Slemmer		1951	300	Drl	6	140	30	TRl	1951	25	20	D	CA
716	010-523-1	Florence A. Plummer	Charles Lauman	1937	410	Drl	6	200		TRl			40	D	CA
717	010-523-2	do.		1927	410	Drl	8	280		TRl				D	
718	013-531-1	Fred Tyson	Tenney	1950	295	Drl	6	133		TRb	4- 9-62	21	10	D	CA
720	011-530-2	Bechtel's Dairy	Kohl Bros.	1955	230	Drl	6	300	38	TRb	6- ?-55	53	70	I	
721	011-530-1	do.	do.	1944	200	Drl	8	325	15	TRb	10- ?-44	60	40	I	
723	018-521-3	H. W. Longacre	A. W. Dorn	1958	395	Drl	8	328	29	TRb	10-13-58	76	80	I	FA
724	018-521-4	do.			395	Drl	6			TRb				I	
725	015-527-1	Schwenksville Water Co.	F. L. Bollinger	1962	145	Drl	8	300	30	TRb	7-30-62	14	250	PS	EL, SL
726	014-536-4	American Telephone & Telegraph Co.	C. S. Garber	1961	185	Drl	6	300	52	TRb		56	37	I	154 ft. dd. in 8 hrs.
727	014-536-5	do.	do.	1961	185	Drl	6	300		TRb			30	I	
728	020-536-8	Kawecki Chemical Co.	do.	1961	320	Drl	6	360	21	TRb	1961	140	90+	D	
729	023-530-1	Perkiomen School		1907	340	Drl	6	1000		TRb	7-24-62	Flows	20	U	
730	020-536-9	Kawecki Chemical Co.			315	Drl	6	125	14	TRb	9-25-62	4		X	EL
731	017-517-2	Hunter Spring Co.	Thomas G. Keyes	1962	360	Drl	8	400	22	TRb, TRl	1962	6	110	I	EL; 191 ft. dd. in 24 hrs.
732	017-517-3	do.	do.	1962	360	Drl	8	403		TRb	1962	0	7	U	EL
733	020-525-1	E. E. Endy	Joseph Mayer		420	Drl	6	42		TRd	8- 6-63	18	2	U	18 ft. dd. in 3 hrs.
734	020-526-1	Delmont Scout Reservation			275	Drl	6	125		TRd	8- 9-63	14	20	PS	26 ft. dd. in 2 hrs.
735	020-526-2	do.			275	Drl	6	45		TRd	8- 9-63	14		D	
736	011-526-5	Linwood Yost			115	Drl	6	111		TRb		50	4	D	CA
737	014-514-3	John Wright			445	Drl	6	80		TRl		11	15	D	CA
738	013-531-2	Limerick School			305	Drl	6	110		TRb		30	15	D	CA
739	009-524-1	Eagleville Sanatorium			425	Drl	6	511		TRl			9	U	CA
740	019-529-1	Upper Perkiomen Valley Park	F. L. Bollinger	1960	320	Drl	6	415		TRd	9- 5-63	35	20	PS	114 ft. dd. in 1 hr.
741	020-529-1	do.	do.	1947	230	Drl	6	359		TRd	8-23-63	30	50	PS	151 ft. dd. in 2 hrs.
742	020-529-2	do.	do.	1940	290	Drl	6	250		TRd			13	PS	
743	012-527-1	Techalloy Co.	C. S. Garber	1961	210	Drl	6	235	42	TRb	12- ?-61	65	30	I	
					305	Drl	6	65	40	TRd	8-22-63	31	5	D	4 ft. dd. in 3 hrs.
744	019-530-1	R. B. Brooks			340	Drl	6	68		TRd	8-22-63	25	3	D	6 ft. dd. in 3 hrs.
745	020-530-1	M. H. Gulack			250	Drl	6	38		TRd	8-16-63	13	3	D	1.4 ft. dd. in 2 hrs.
746	018-528-1	J. L. Beck			350	Drl	6	132		TRd	8-30-63	3	3	D	3 ft. dd. in 3 hrs.
747	020-533-1	Ralph Levits		1963	420	Drl	6	110		TRd	8-28-63	17	0.3	D	
748	020-532-1	Joseph Kulp		1963	420	Drl	6	42		TRd	8-28-63	16		U	
749	020-532-2	do.	Michael Kuszyk	1963	190	Drl	6	313	20	TRd	8-19-63	14	0.1	D	
753	016-527-1	John Lesher	Philadelphia Drilling Co.	1952	275	Drl	6	106	35	TRb	3-25-53	5	20	D	
754	017-515-1	Atlantic Refining Co.	Kohl Bros.	1963	150	Drl	10	595	47	TRb	6-13-63	30	430	I	150 ft. dd. in 18 hrs.
755	014-540-6	Stanley G. Flagg Inc.													

Table 7. Sample logs of wells in the Brunswick Formation in Berks and Montgomery Counties, Pa.

Well Be-125

Owner: U.S. Geological Survey

Description	Depth (feet)
Soil, red	0 — 2
Shale, red	2 — 30
Shale, red, moderately calcareous; calcite and quartz joint filling	30 — 35
Shale, red, slightly calcareous; calcite and quartz joint filling	35 — 38
Shale, red	38 — 50
Shale, red, moderately calcareous; calcite joint filling	50 — 55
Shale, red, moderately calcareous	55 — 60
Shale, red, moderately calcareous; calcite and quartz joint filling	60 — 70
Shale, red, slightly calcareous	70 — 75
Shale, red, slightly calcareous; quartz joint filling; goethite	75 — 80
Shale, red; calcite joint filling	80 — 90
Shale, red, slightly calcareous; calcite joint filling	90 — 105
Shale, red, moderately calcareous; calcite joint filling	105 — 110
Shale, purplish-gray, slightly calcareous	110 — 115
Shale, red; calcite joint filling	115 — 120
Shale, red, slightly calcareous; calcite joint filling	120 — 125
Shale, red, slightly calcareous	125 — 130
Shale, red, slightly calcareous; calcite and quartz joint filling	130 — 135
Shale, red, moderately calcareous; calcite joint filling	135 — 140
Shale, red, slightly calcareous; calcite and quartz joint filling	140 — 145
Shale, red, slightly calcareous; calcite joint filling	145 — 150
Siltstone, red, slightly calcareous	150 — 155
Shale, red, slightly calcareous; calcite and quartz joint filling; pyrite	155 — 160
Shale, red, slightly calcareous; calcite joint filling	160 — 165
Shale, red, moderately calcareous; calcite joint filling	165 — 170
Shale, red, slightly calcareous	170 — 175
Argillite, light gray, moderately calcareous; calcite joint filling; pyrite	175 — 178
Shale, red, slightly calcareous; calcite and quartz joint filling	178 — 182
Shale, red, slightly calcareous; calcite joint filling; pyrite	182 — 185
Shale, red, slightly calcareous; calcite joint filling	185 — 190
Shale, red, moderately calcareous; calcite joint filling; pyrite and goethite	190 — 195
Shale, red, slightly calcareous; calcite joint filling	195 — 200
Shale, red, slightly calcareous; calcite and quartz joint filling	200 — 205
Shale, red; calcite joint filling	205 — 215
Shale, red, slightly calcareous	215 — 220
Argillite, purple and a few streaks of brown and green; calcite and quartz joint filling; goethite	220 — 225
Shale, red, slightly calcareous; calcite joint filling	225 — 227
Shale, red, slightly calcareous; calcite and quartz joint filling	227 — 230
Shale, red, slightly calcareous; calcite joint filling	230 — 240
Shale, red, moderately calcareous; calcite joint filling	240 — 243
Shale, red, slightly calcareous; calcite joint filling	243 — 265
Shale, red, slightly calcareous; calcite joint filling pyrite and goethite	265 — 273
Shale, red, slightly calcareous; calcite joint filling	273 — 280
Shale, gray-brown, moderately calcareous; calcite joint filling; goethite	280 — 282
Argillite, blue-gray, moderately calcareous; calcite joint filling; goethite	282 — 285
Argillite, greenish-gray, moderately calcareous; calcite joint filling; goethite; very fine grained sandstone, yellow, moderately calcareous	285 — 287

Table 7. Sample logs of wells in the Brunswick Formation—Continued

Well Be-125—Continued

Argillite, greenish-gray, moderately calcareous; calcite joint filling; pyrite	287 — 288
Argillite, purplish-brown; goethite	288 — 290
Shale, red, moderately calcareous; calcite joint filling	290 — 292
Shale, red, slightly calcareous; calcite joint filling	292 — 294
Shale, red	294 — 296
Shale, red, slightly calcareous; calcite joint filling	296 — 300

Well Mg-632

Owner: U.S. Geological Survey

Description	Depth (feet)
Soil, red	0 — 2
Shale, red, moderately calcareous; calcite joint filling	2 — 5
Shale, red, slightly calcareous	5 — 10
Shale, red, slightly calcareous; calcite joint filling	10 — 15
Shale, red, slightly calcareous	15 — 18
Shale, red, slightly calcareous; calcite joint filling	18 — 25
Shale, red, moderately calcareous; calcite joint filling	25 — 30
Shale, red, slightly calcareous; calcite joint filling	30 — 40
Shale, red, slightly calcareous	40 — 45
Shale, red, moderately calcareous; calcite joint filling	45 — 52
Shale, red, slightly calcareous; calcite joint filling	52 — 85
Shale, red, moderately calcareous; calcite joint filling	85 — 90
Shale, red, slightly calcareous, micaceous; calcite joint filling	90 — 95
Shale, red, slightly calcareous, micaceous; quartz and calcite joint filling	95 — 100
Shale, red, slightly calcareous, micaceous; calcite joint filling	100 — 110
Siltstone, red, moderately calcareous, micaceous; calcite and quartz joint filling	110 — 120
Shale, red, slightly calcareous; calcite and quartz joint filling	120 — 125
Shale, red, moderately calcareous, micaceous; calcite joint filling	125 — 130
Shale, red, moderately calcareous; calcite joint filling	130 — 135
Shale, red, moderately calcareous	135 — 140
Shale, red, slightly calcareous; calcite joint filling	140 — 170
Shale, red, slightly calcareous; calcite and quartz joint filling	170 — 185
Shale, red, moderately calcareous; calcite joint filling	185 — 200
Siltstone, red, slightly calcareous, micaceous; calcite joint filling	200 — 210
Shale, red, slightly calcareous, micaceous; quartz joint filling	210 — 215
Shale, red, slightly calcareous, micaceous; quartz and calcite joint filling	215 — 220
Shale, red, slightly calcareous; calcite and quartz joint filling	220 — 225
Shale, red, slightly calcareous; calcite joint filling	225 — 235
Shale, red, slightly calcareous	235 — 240
Shale, red; calcite joint filling	240 — 250
Shale, red; calcite and quartz joint filling	250 — 260
Shale, red, slightly calcareous; calcite joint filling	260 — 290
Shale, red, moderately calcareous	290 — 300

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Table 7. Sample logs of wells in the Brunswick Formation—Continued

Well Mg-632—continued

Shale, red, slightly calcareous	300—310
Shale, red, slightly calcareous; quartz and calcite joint filling	310—315
Siltstone, buff, moderately calcareous; red shale; quartz joint filling	315—320
Shale, red, slightly calcareous, micaceous; calcite joint filling	320—325
Shale, red, slightly calcareous, micaceous; calcite and quartz joint filling	325—330
Shale, red, slightly calcareous; calcite joint filling	330—335
Shale, red, micaceous; calcite and quartz joint filling	335—340
Shale, red moderately calcareous; calcite and quartz joint filling	340—345
Shale, red, moderately calcareous; calcite joint filling	345—350
Shale, red, slightly calcareous; calcite joint filling	350—360
Shale, red, micaceous; calcite and quartz joint filling	360—363
Shale, red, moderately calcareous; calcite joint filling	363—370
Shale, red, slightly calcareous	370—375
Shale, red, slightly calcareous; calcite joint filling	375—379
Shale, green, moderately calcareous	379—381
Shale, red, slightly calcareous; calcite joint filling	381—385
Shale, red, slightly calcareous	385—405
Shale, red, slightly calcareous; calcite joint filling	405—425
Shale, red, slightly calcareous	425—450
Shale, red, slightly calcareous; calcite joint filling	450—460
Shale, red, slightly calcareous; calcite and quartz joint filling	460—465
Shale, red, slightly calcareous	465—470
Shale, red, slightly calcareous; calcite joint filling	470—475
Shale, red, moderately calcareous; calcite joint filling	475—480
Shale, red, slightly calcareous	480—490
Shale, red, moderately calcareous; calcite joint filling	490—500

Well Mg-633

Owner: U.S. Geological Survey

Description	Depth (feet)
Shale, red; quartz joint filling	0—5
Shale, red, slightly calcareous, calcite joint filling	5—20
Shale, red, moderately calcareous; calcite joint filling	20—25
Shale, red, slightly calcareous; calcite joint filling	25—30
Shale, red, moderately calcareous	30—35
Shale, red, moderately calcareous; calcite joint filling	35—40
Shale, red; calcite joint filling	40—45
Shale, red, slightly calcareous; calcite joint filling	45—55
Shale, red, slightly calcareous; goethite	55—60
Shale, red, slightly calcareous; calcite joint filling	60—70
Shale, red, slightly calcaerous	70—90
Shale, red, moderately calcareous; calcite joint filling	90—100
Shale, red; calcite joint filling	100—105
Shale, red, slightly calcareous; abundant quartz and calcite joint filling. Quartz is in crystals up to half an inch long	105—108
Shale, red, slightly calcareous; calcite joint filling	108—110
Shale, red, slightly calcareous; abundant calcite joint filling	110—112
Shale, red, slightly calcareous; calcite and quartz joint filling and goethite	112—115

Table 7. Sample logs of wells in the Brunswick Formation—Continued

Well Mg-633—continued

Shale, red; calcite joint filling	115—118
Shale, red	118—120
Shale, red, slightly calcareous	120—123
Shale, red	123—125
Shale, red, moderately calcareous; calcite joint filling	125—128
Shale, red, slightly calcareous	128—138
Shale, red, slightly calcareous; calcite joint filling	138—140
Shale, red, slightly calcareous	140—142
Shale, red, slightly calcareous; calcite joint filling	142—148
Shale, red, slightly calcareous	148—150
Shale, red, slightly calcareous; calcite joint filling and goethite	150—152
Shale, red, slightly calcareous; calcite joint filling	152—165
Shale, red, slightly calcareous	165—168
Shale, red, slightly calcareous; calcite joint filling	168—170
Shale, red; calcite joint filling	170—172
Shale, red	172—175
Shale, red, moderately calcareous	175—178
Shale, red, moderately calcareous; calcite joint filling	178—185
Shale, red; calcite joint filling	185—205
Shale, red, slightly calcareous; calcite joint filling	205—210
Shale, red; calcite joint filling	210—212
Shale, red, slightly calcareous; calcite joint filling	212—215
Shale, red, slightly calcareous; calcite and quartz joint filling	215—220
Shale, red, slightly calcareous; calcite joint filling	220—225
Shale, red; calcite joint filling	225—230
Shale, red; calcite and quartz joint filling and goethite	230—232
Shale, red, moderately calcareous; quartz and calcite joint filling	232—233
Shale, red; calcite joint filling	233—235
Shale, red, moderately calcareous; calcite joint filling	235—237
Shale, red; calcite joint filling	237—240
Shale, red, slightly calcareous; calcite joint filling	240—243
Shale, red, slightly calcareous	243—245
Shale, red; calcite joint filling	245—263
Shale, red, slightly calcareous; calcite joint filling	263—270
Shale, red	270—275
Shale, red, slightly calcareous; calcite joint filling	275—278
Siltstone, red, moderately calcareous; calcite joint filling	278—280
Shale, red, slightly calcareous; calcite joint filling	280—283
Shale, red; calcite joint filling	283—288
Shale, red, slightly calcareous; calcite joint filling	288—290
Shale, red, slightly calcareous	290—295
Shale, red; calcite joint filling	295—300
Shale, red	300—302
Shale, red; calcite joint filling	302—307
Shale, red, slightly calcareous; calcite joint filling	307—310
Shale, red, moderately calcareous; calcite joint filling	310—312
Shale, red, slightly calcareous	312—314
Shale, red, slightly calcareous; calcite joint filling	314—325
Shale, red, slightly calcareous; quartz joint filling	325—327
Shale, red, slightly calcareous	327—330
Shale, red	330—335
Shale, red; calcite joint filling	335—348
Shale, red, slightly calcareous; calcite joint filling	348—350
Shale, red, slightly calcareous	350—355
Shale, red, slightly calcareous; calcite joint filling	355—358

Table 7. Sample logs of wells in the Brunswick Formation—Continued

Well Mg-633—Continued

Shale, red; calcite joint filling	358 — 360
Shale, red, moderately calcareous	360 — 362
Shale, red, slightly calcareous; calcite and quartz joint filling	362 — 365
Shale, red; calcite joint filling	365 — 380
Shale, red, moderately calcareous	380 — 383
Shale, red, moderately calcareous, micaceous	383 — 385
Shale, red, slightly calcareous; calcite joint filling	385 — 390
Shale, red, slightly calcareous	390 — 392
Shale, red	392 — 395
Shale, red, slightly calcareous	395 — 402
Shale, red, moderately calcareous; calcite joint filling	402 — 405
Shale, red, slightly calcareous; calcite and quartz joint filling	405 — 408
Shale, red, moderately calcareous	408 — 410
Shale, red, slightly calcareous	410 — 412
Shale, red, slightly calcareous; calcite joint filling	412 — 415
Shale, red, moderately calcareous; calcite joint filling	415 — 417
Shale, red, slightly calcareous; calcite joint filling, pyrite and goethite	417 — 420
Shale, red, slightly calcareous	420 — 422
Shale, red, slightly calcareous; calcite joint filling	422 — 428
Shale, red, slightly calcareous	428 — 430
Shale, red	430 — 432
Shale, red, slightly calcareous; calcite joint filling	432 — 435
Shale, red, moderately calcareous; calcite joint filling	435 — 437
Shale, red, slightly calcareous; calcite joint filling	437 — 460
Shale, red; calcite joint filling	460 — 465
Shale, red; calcite joint filling, pyrite and goethite	465 — 467
Shale, red, slightly calcareous; calcite and quartz joint filling	467 — 470
Shale, red, slightly calcareous	470 — 473
Shale, red, slightly calcareous; calcite joint filling	473 — 497
Shale, red	497 — 500

Well Mg-679

Owner: Souderton Borough

Description	Depth (feet)
Shale, red	0 — 40
Shale, red, moderately calcareous; calcite joint filling	40 — 100
Shale, dark reddish-gray, slightly calcareous	100 — 110
Shale, red, slightly calcareous; calcite joint filling and pyrite	110 — 120
Shale, red, slightly calcareous; calcite joint filling	120 — 130
Shale, dark red, moderately calcareous	130 — 140
Shale, red, slightly calcareous; calcite joint filling	140 — 180
Argillite, blue-gray, slightly calcareous; calcite joint filling. Thin beds of red shale are in this interval	180 — 190
Argillite, blue-gray, moderately calcareous; calcite and quartz joint filling. About 4 feet of this interval is red shale	190 — 200
Sandstone, gray, very fine grained; calcite joint filling and pyrite	200 — 210
Argillite, blue-gray, moderately calcarous; calcite joint filling and pyrite	210 — 230
Argillite, blue-gray, slightly calcareous; pyrite and geothite	230 — 260

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Table 7. Sample logs of wells in the Brunswick Formation—Continued

Well Mg-679—Continued

Siltstone, blue-gray, slightly calcareous; pyrite	260 — 270
Argillite, blue-gray, moderately calcareous; pyrite. Red shale, moderately calcareous; calcite joint filling and pyrite	270 — 278
Argillite, blue-gray, moderately calcareous; pyrite	278 — 285
Shale, reddish-brown, moderately calcareous; About 4 feet of this interval is blue-gray, moderately calcarous argillite	285 — 308

Well Mg-700

Owner: Stanley G. Flagg, Inc.

Description	Depth (feet)
Fill	0 — 20
Sandstone, buff, fine grained. About half of this interval is red shale	20 — 30
Shale, red, micaceous	30 — 60
Shale, red	60 — 90
Shale, red, slightly calcareous; quartz joint filling	90 — 100
Shale, red, slightly calcareous	100 — 130
Shale, dark brown, slightly calcareous	130 — 140
Shale, red, slightly calcareous	140 — 150
Shale, red, moderately calcareous	150 — 160
Shale, red; calcite joint filling	160 — 170
Shale, red, slightly calcareous	170 — 190
Shale, red, moderately calcareous	190 — 200
Shale, red, moderately calcareous, micaceous; calcite joint filling	200 — 250
Shale, red, micaceous; calcite joint filling	250 — 260
Shale, red, slightly calcareous; calcite joint filling	260 — 280
Shale, gray-brown, slightly calcareous; micaceous; calcite joint filling	280 — 290
Shale, red, slightly calcareous; calcite joint filling	290 — 330
Siltstone, red, slightly calcareous; calcite joint filling	330 — 340
Shale, red, moderately calcareous	340 — 350
Shale, red, moderately calcareous; calcite joint filling	350 — 360
Siltstone, red, moderately calcareous; calcite joint filling	360 — 370
Shale, red, moderately calcareous; calcite joint filling	370 — 390
Shale, red, moderately calcareous; calcite and quartz joint filling	390 — 400
Shale, red, moderately calcareous; calcite joint filling	400 — 456
Sandstone, white, fine grained	456 — 461
Shale, red, moderately calcareous; calcite joint filling	461 — 480
Argillite, blue-gray, moderately calcareous, interbedded with about 3 feet of buff sandstone	480 — 500
Sandstone, light-brown, fine grained	500 — 510
Sandstone, light-brown, medium grained	510 — 520
Shale, brown, slightly calcareous, micaceous; calcite joint filling	520 — 530
Shale, brown, slightly calcareous, micaceous; quartz joint filling	530 — 540
Shale, red, moderately calcareous; calcite joint filling	540 — 560
Shale, red, moderately calcareous; calcite and quartz joint filling	560 — 600
Shale, red, slightly calcareous; calcite joint filling	600 — 610
Shale, red, moderately calcareous; calcite joint filling. About 1 foot of this interval is buff, fine grained sandstone	610 — 620
Shale, red, moderately calcareous; calcite joint filling	620 — 640

Table 7. Sample logs of wells in the Brunswick Formation—Continued

Well Mg-704

Owner: Lansdale Municipal Authority

Description	Depth (feet)
Shale, red	0 — 10
Shale, red, slightly calcareous; calcite joint filling	10 — 20
Shale, red	20 — 40
Shale, red, slightly calcareous	40 — 50
Shale, red, slightly calcareous; calcite joint filling	50 — 70
Shale, red, moderately calcareous; calcite joint filling	70 — 80
Shale, red, slightly calcareous; calcite joint filling	80 — 140
Shale, red, moderately calcareous; calcite joint filling	140 — 190
Shale, red, slightly calcareous; calcite joint filling	190 — 200
Shale, red, slightly calcareous; calcite joint filling and pyrite	200 — 210
Shale, red, slightly calcareous; calcite joint filling	210 — 220
Siltstone, red, slightly calcareous; goethite	220 — 230
Argillite, blue-gray to greenish-gray, slightly calcareous; calcite joint filling and goethite	230 — 240
Shale, gray-brown, slightly calcareous; calcite joint filling and goethite	240 — 250
Shale, red, moderately calcareous; calcite joint filling and goethite	250 — 260
Shale, red, moderately calcareous; calcite joint filling	260 — 290
Shale, red, slightly calcareous; calcite joint filling, pyrite and goethite	290 — 310
Shale, red, slightly calcareous; calcite joint filling	310 — 330
Argillite, blue-gray, moderately calcareous; calcite joint filling and pyrite	330 — 360
Argillite, blue-gray, moderately calcareous; calcite joint filling and goethite	360 — 370

Well Mg-725

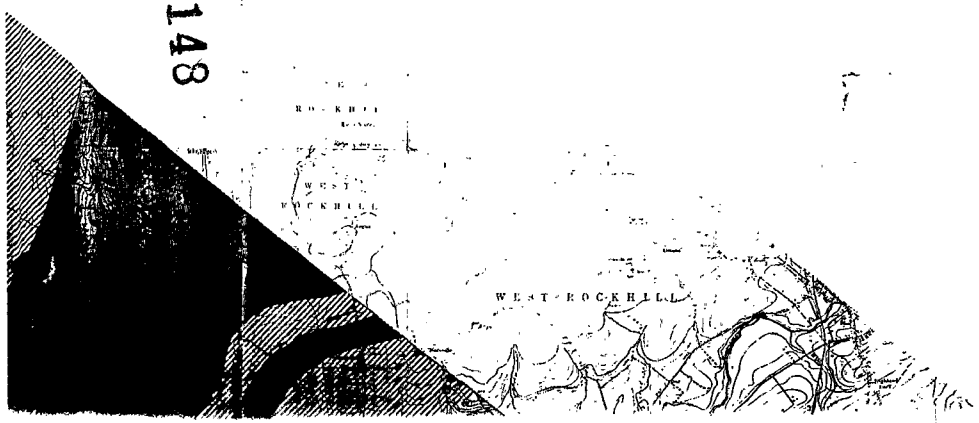
Owner: Schwenksville Water Co.

Description	Depth (feet)
Shale, red, slightly calcareous; calcite joint filling	0 — 20
Shale, red, slightly calcareous; quartz joint filling, pyrite and goethite	20 — 30
Shale, red, moderately calcareous; calcite joint filling, pyrite and goethite	30 — 40
Shale, red, slightly calcareous; joint filling	40 — 50
Shale, red, a few green spots, moderately calcareous	50 — 60
Shale, red, moderately calcareous. About 4 feet of this interval is purplish-brown	60 — 70
Shale, red, slightly calcareous; calcite joint filling	70 — 80
Shale, red, moderately calcareous; calcite and quartz joint filling	80 — 90
Shale, red, slightly calcareous; quartz joint filling	90 — 100
Shale, red, moderately calcareous; calcite joint filling	100 — 110
Shale, red, slightly calcareous; calcite and quartz joint filling	110 — 120
Shale, red, slightly calcareous; calcite joint filling	120 — 150
Shale, red, slightly calcareous	150 — 160
Shale, red, slightly calcareous; calcite joint filling	160 — 180

Table 7. Sample logs of wells in the Brunswick Formation—Continued

Well Mg-725—Continued

Shale, red, slightly calcareous; calcite and quartz joint filling	180 — 190
Shale, red, slightly calcareous; calcite joint filling	190 — 200
Shale, red, moderately calcareous; calcite and quartz joint filling	200 — 210
Shale, red, moderately calcareous; calcite joint filling	210 — 220
Shale, red, slightly calcareous; calcite joint filling	220 — 240
Shale, red; calcite joint filling	240 — 250
Shale, red, slightly calcareous; calcite joint filling	250 — 290



EXPLANATION

Upper Triassic — TRIASSIC

Basalt

Lava flows. Not tapped by wells

Diabase

Dikes and sills. Yields water for domestic use; median reported yield is 3 gpm

Ꞧb

Brunswick Formation

Red shale and siltstone and a few sandstone beds (Ꞧb). Red massive argillite near base grades laterally into Lockatong Formation. Altered to dark hornfels (shown by red cross-hatch) near diabase intrusives and basalt. Generally yields sufficient water for industrial and municipal use; median reported yield is 75 gpm. Red, brown, and purple calcareous fanglomerate and a few beds of quartzite fanglomerate (Ꞧbf). Water-bearing properties are unknown

Lockatong Formation

Dark-gray massive argillite and subordinate platy dark-gray mudstone and black shale; grades laterally into Brunswick Formation. Altered to black hornfels (shown by red cross-hatch) near diabase intrusives. Yields water for domestic use; median reported yield is 11 gpm

Ꞧs

Stockton Formation

Arkosic sandstone and conglomerate interbedded with red siltstone and shale. This information has not been studied in this report

PRECAMBRIAN TO ORDOVICIAN

p€CO

Rocks of Precambrian to Ordovician age

These rocks have not been studied in this report

SYMBOLS

Contact; accuracy not defined

U
D

Fault; accuracy not defined

U, upthrown side; D, downthrown side

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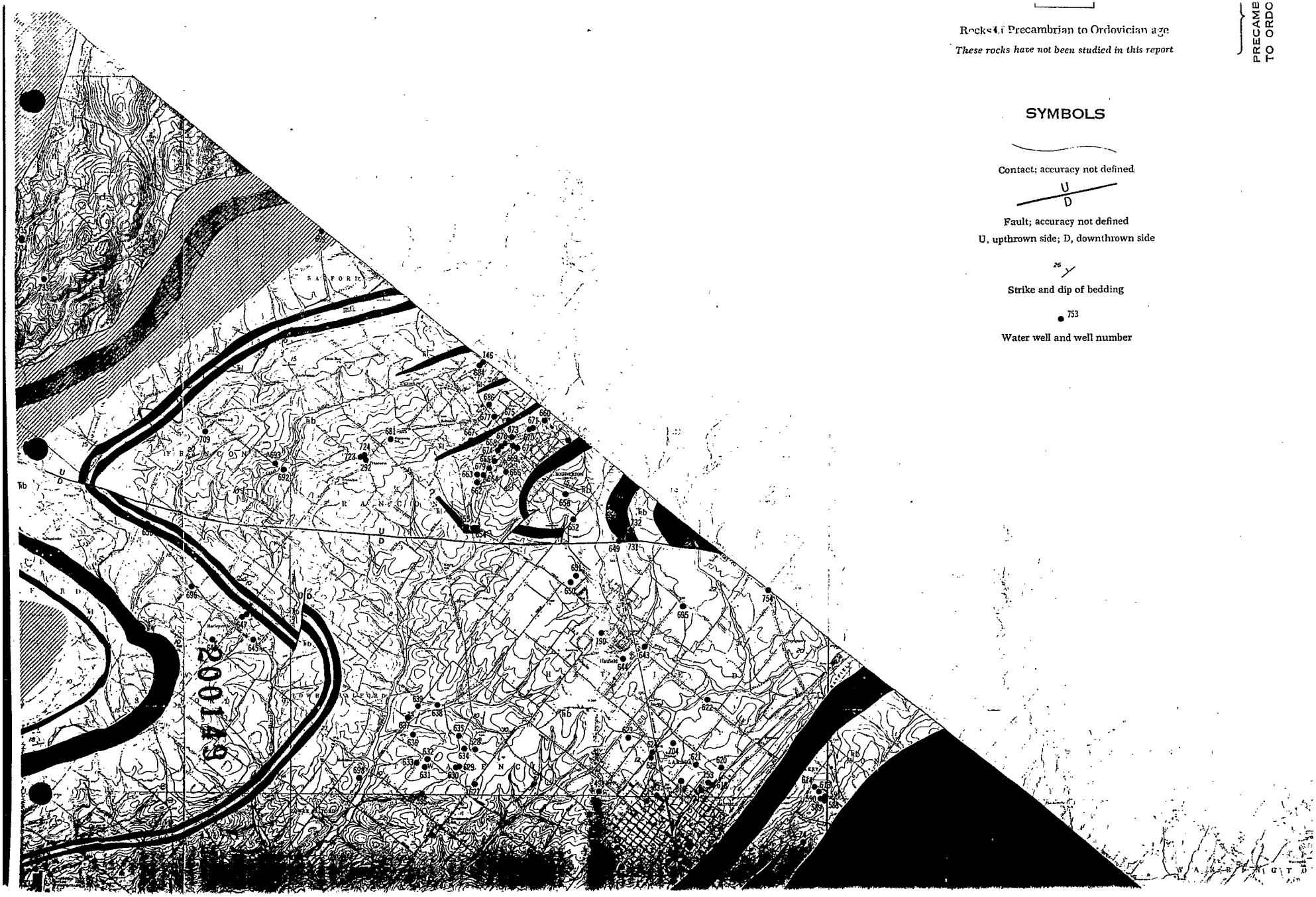
Rocks of Precambrian to Ordovician age
These rocks have not been studied in this report
PRECAMB TO ORDO
SYMBOLS
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Fault; accuracy not defined
U, upthrown side; D, downthrown side
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Strike and dip of bedding
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Water well and well number
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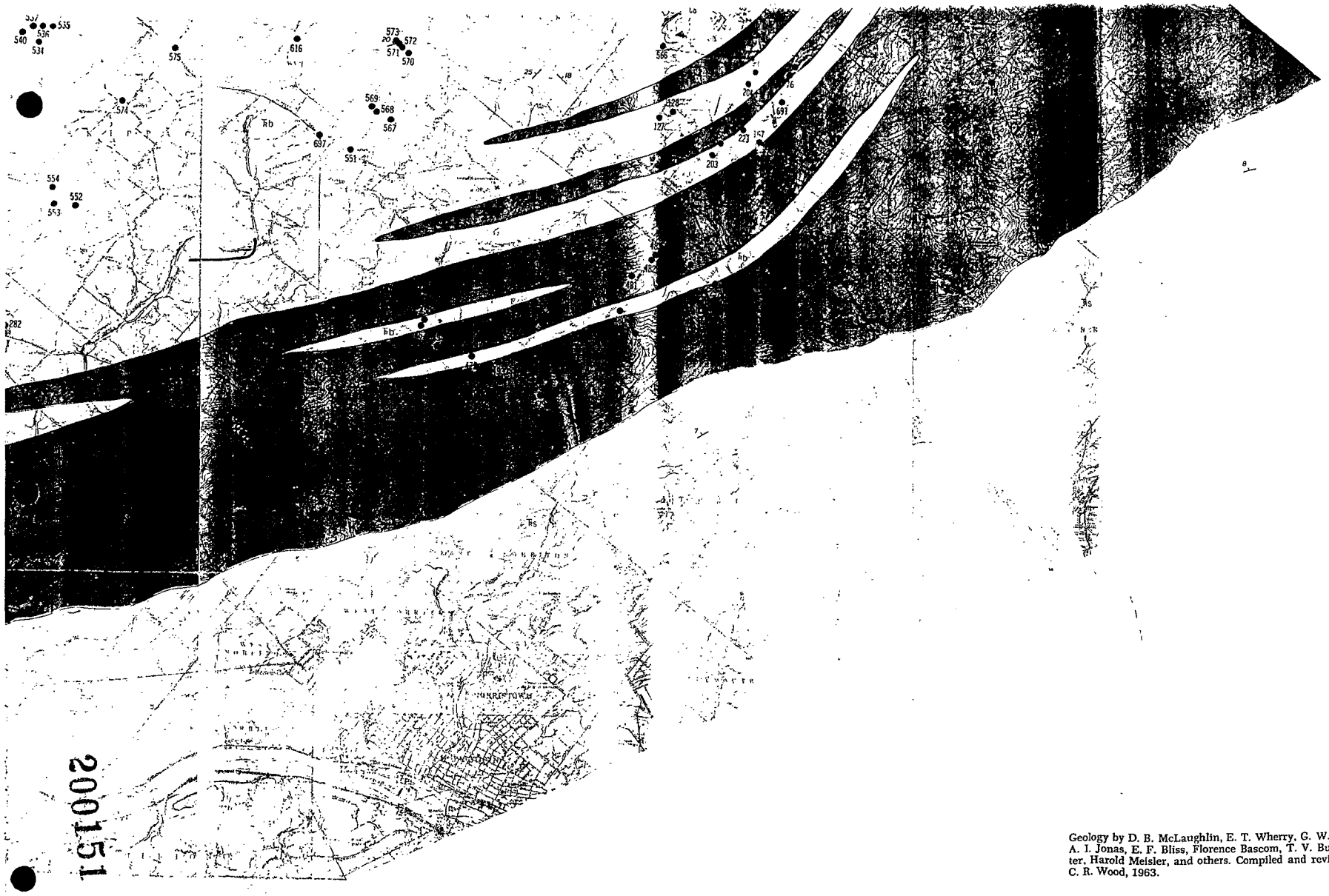

Geology by D. B. McLaughlin, E. T. Wherry, G. W. Stose, A. I. Jonas, E. F. Bliss, Florence Bascom, T. V. Buckwalter, Harold Meisler, and others. Compiled and revised by C. R. Wood, 1963.

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REFERENCE 5

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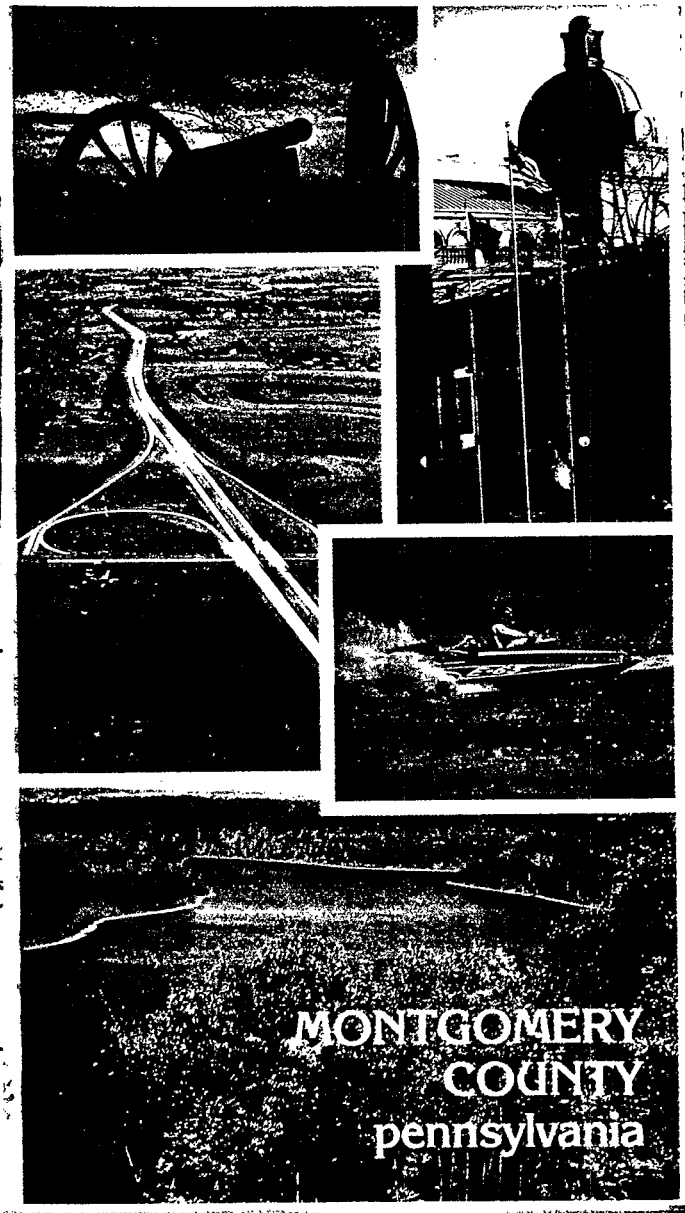
SEE APPENDIX C

REFERENCE 6



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REFERENCE 7

200156

Bulletin W 29

Ground-Water Resources of Montgomery County, Pennsylvania

by Thomas G. Newport
U. S. Geological Survey

Prepared by the United States
Geological Survey Water Resources Division
in cooperation with the
Pennsylvania Geological Survey

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GROUND-WATER RESOURCES OF MONTGOMERY COUNTY, PENNSYLVANIA

by

Thomas G. Newport
U.S. Geological Survey
Water Resources Division

ABSTRACT

The bedrock formations in Montgomery County range in age from Quaternary to Precambrian. The Quaternary and Tertiary rocks are thin, discontinuous, and small in areal extent, and are not considered as aquifers. The Brunswick and Stockton Formations of Triassic age occur over a large part of the county. Other Triassic rocks, the diabase and Lockatong Formation, have a smaller areal extent. The rocks of Paleozoic age occur in a narrow band near the southern border of Montgomery County. These Paleozoic rocks are grouped as one unit on the geologic map. Precambrian rocks are also grouped together in this report.

Ground water in the bedrock occurs largely in secondary openings, such as joint planes or solution openings. These secondary openings are more abundant in the Brunswick and Stockton Formations and wells in these formations will yield sufficient water for industrial and municipal supplies. The Lockatong Formation and the diabase have fewer joints and, consequently, yield only enough water for domestic supplies. Large solution openings have been encountered at different places in the carbonate rocks, and wells with very high yields have been developed. Well yields in the igneous and metamorphic rocks are generally small. Data are tabulated for more than 800 wells in Montgomery County.

Chemical analyses are available for ground water from 121 wells in Montgomery County. Ground water in the Triassic rocks is largely of the calcium-bicarbonate type. However, water from these rocks having concentrations of dissolved solids greater than 500 mg/l (milligrams per liter) are of the calcium-sulfate type. Ground-water quality differs greatly from one unit to another in the Paleozoic rocks. Dissolved-solids content ranges from 32 mg/l in the quartzites to 243 mg/l in the carbonate rocks. Hardness ranges from 15 mg/l in the quartzites to 270 mg/l in the carbonates. The quality of water from the igneous rocks is generally good. The quality of water from metamorphic rocks differs considerably between formations. In some of these rocks the water is very highly mineralized and is not used.

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INTRODUCTION

LOCATION AND GENERAL GEOGRAPHIC FEATURES

Montgomery County occupies an area of 491 square miles in southeastern Pennsylvania (Figure 1), immediately to the northwest of Philadelphia. Norristown is the county seat and largest borough.

The area is predominantly an undulating plain, with relief provided by low hills and ridges. The land slope and drainage is to the southeast, toward the Delaware River. Most of the county is drained by the Schuylkill River and its tributaries, but the eastern section of the county is drained by Neshaminy, Pennypack, and Tacony Creeks, which flow directly into the Delaware River.

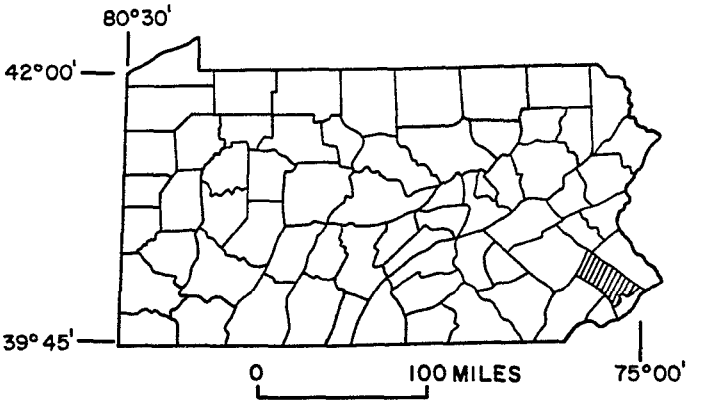

Figure 1. Location of Montgomery County.

POPULATION GROWTH AND POPULATION DENSITY

Census records show that there were 23,000 inhabitants in the county in 1790. The number had increased to 70,000 in 1860, and to 350,000 by 1950. Since 1950 the rate of population growth has increased rapidly. Between 1950 and 1970, a peak period of growth, the population grew to 618,017, an increase of more than 76 percent.

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Forecasts made by the Montgomery County Planning Commission indicate that the population of the county will increase to 933,000 by the year 1985. This growth will, of course, require additional development of water supplies.

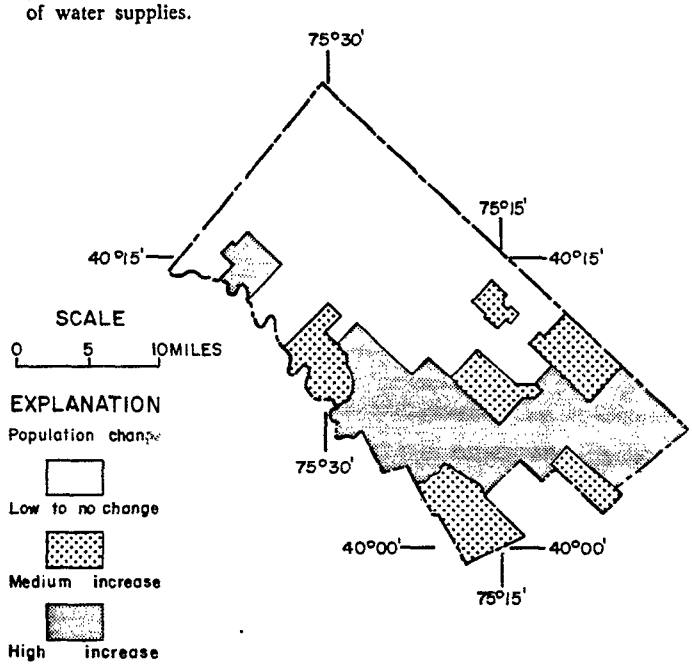

Figure 2. Population density increase, 1920-1960.

Population distribution in Montgomery County ranges from very dense in the southern part to sparse in the north. The pattern of population density increase (Figure 2) reflects a northward transition from highly urban Philadelphia to its suburban communities and finally to the rural areas of northern Montgomery County. Some areas along the Schuylkill River show only moderate increase in population because the land area is so highly industrialized that there is little room for more housing.

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EFFECTS OF POPULATION GROWTH ON WATER NEEDS

The overall population growth of the county will create a corresponding need for larger supplies of water. Also, based on national averages, the per capita use of water is increasing from ½ to 2 percent per year. There have been water shortages within some areas of the county in the recent past and, without adequate safeguards, such shortages could occur again. Actually, enough water potentially is available for all needs in the foreseeable future. The major problem is in the withdrawal and distribution of all available supplies. It is hoped that this report will supply useful data concerning the availability, development, and protection of ground-water supplies of the area. The sources of water within the county are streams and impoundments and ground water.

Towns, communities, and industrial sites are not always located over good aquifers or near streams of sufficient size for use as a water supply. If streams are nearby, water supplies are readily obtainable; however, the quality and quantity of surface water is subject to much variation over the short term as well as seasonally. Streams are more easily polluted than is ground water, but their quality improves rapidly with dilution and with removal of the polluting agent.

Ground-water supplies are available in varying amounts throughout Montgomery County. In some areas the supplies available are large enough for municipal and industrial supplies. In others, wells may yield only water enough for minimum household use. Even where well yields are very small, however, such a supply may be the only one available to many individual homeowners. The amounts available vary seasonally and decline with long periods of drought, but less so than surface water. Consistent quality is the most important attribute of ground water; temperature and chemical quality remain constant, making treatment much simpler. When pollution occurs it is generally long-lived. Since they are visible, surface water supplies appear to be more abundant than ground water. Locally, as along the Schuylkill, this is true. As will be shown later, however, most of the water flowing in streams has drained from the ground-water reservoir. Additionally, because of its low temperature of about 52°F throughout the year and its uniform chemical quality, ground water is highly desirable for use by many industries.

LAND USE IN THE 1960's

The expansion of cities and communities is rapidly changing the land use in Montgomery County. The number of farms has declined in the last few years, and in 1960 the rural population made up less than one-fourth of the total population. Most of the farms in Montgomery County

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are devoted to the production of beef and dairy cattle or poultry products. There is relatively little farming of grain, fruit, or vegetable crops.

Much of the land area is now composed of country estates, housing developments, and part-time farms. These are the homes of persons who commute to nearby cities or industrial parks.

The percentage of land occupied by streets and parkways, which is a measure of the intensity of urbanization, is greatest in the southern part of the county and decreases gradually towards the rural northern part of Montgomery County. The highly suburban character of the southern part of the county also is indicated by the fact that nearly 50 percent of the land is classified as residential, being occupied mainly by single-family houses.

In the past, most of the industry within the area has been concentrated along the Schuylkill River. The more recent trend, which is expected to increase in the future, is the establishment of industrial parks throughout other parts of the county. There are now (1969) 19 such areas, located mostly along the Pennsylvania Turnpike and its extension.

WHERE THE WATER COMES FROM

HYDROLOGIC CYCLE

Water is one of our most important resources and it constitutes the major part of most living things. Man's existence depends upon it, yet water supplies are taken for granted by most individuals. As shown in Figure 3, water evaporates from the oceans and is carried as vapor until it condenses and precipitates. Most of the precipitation on the land is used by vegetation, evaporates back to the atmosphere, or runs overland as streamflow. Part enters the soil and bedrock to recharge water-bearing formations, called aquifers. The water moves at a varying pace, depending on its environment, but eventually it returns to the oceans.

If man interrupts or changes the hydrologic cycle the results may have serious effects for many years. Man's alterations of the hydrologic cycle in Montgomery County are discussed in the following pages.

PRECIPITATION

Precipitation is the source of all fresh water in the county. The average precipitation at Norristown is 42.2 inches per year. Elsewhere in the county, the average annual precipitation ranges from 43 inches in the eastern part to 47 inches in the extreme northern part. (U.S. Department of Commerce Environmental Data Service).

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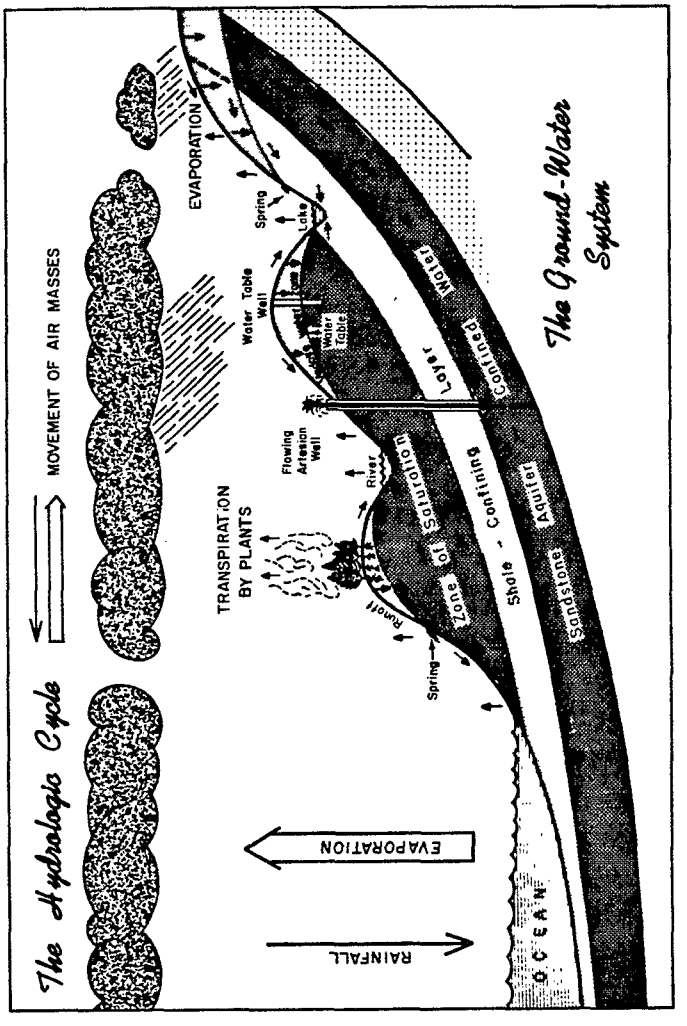

Figure 3. Hydrologic cycle showing movement of water from ocean to land and back to the ocean.

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Figure 3. Hydrologic cycle showing movement of water from ocean to land and back to the ocean.

Precipitation is generally well distributed throughout the year. The wettest month is usually August and the driest month October. More than half the annual precipitation falls during the spring and summer, the period which corresponds favorably with the needs of growing plants. During the period of record the amount of monthly precipitation has ranged from more than 17 inches in August to less than 0.50 inch in October.

The average total annual snowfall received in a season in this county ranges from 20 to 30 inches. The larger amounts fall in the eastern and northern parts of the county, where heavy snows are most likely to occur during late winter.

WHERE THE WATER GOES

EVAPOTRANSPIRATION

Evapotranspiration is a collective term describing the return, through the sun's energy, of water to the atmosphere as vapor. Transpiration returns soil moisture to the atmosphere as a product of plant growth, and evaporation changes water directly from a liquid to a vapor.

The estimated mean annual rate of evaporation from surface-water bodies in Montgomery County is about 33 inches. However, the surface area of water bodies in Montgomery County is small, and the water evaporated from them is only a minor part of the hydrologic system. The total loss by evaporation and transpiration is considerable. About 26 inches of the water falling on the county annually is returned to the atmosphere by these processes. (Parker and others, 1964).

STREAMFLOW

Most of the water not lost through evapotranspiration leaves the county as discharge from streams. This amounts to from 15 to 21 inches of the original precipitation. The larger streams and impoundments and the locations of gaging stations in Montgomery County are shown in Figure 4. Identification numbers are those assigned by the U.S. Geological Survey. A summary of discharge data for the four gaging stations is given in Table 1. More detailed information on streamflow can be obtained from Surface Water Records for Pennsylvania (see selected reference list). Several other streams in Montgomery County are also used for public and industrial water supplies.

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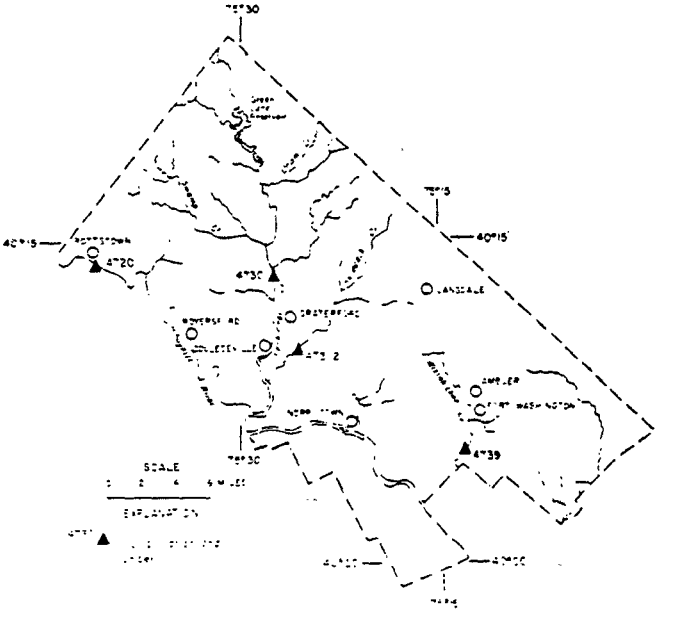

Figure 4. Location of stream-gaging stations.

GROUND WATER

Much of the water falling on the land surface returns to the atmosphere or reaches the streams as overland runoff. The remainder infiltrates through the soil and through fractures and void spaces in the underlying rock. Its downward movement continues until it reaches the zone of saturation, a zone below which all the interconnected voids are filled with water. This is illustrated in Figure 5. After reaching the zone of saturation the water moves downward and laterally toward lower elevations and eventually returns to the surface, either naturally from springs and seeps or from wells.

Ground water in Montgomery County occurs under both water-table (free, unconfined) and artesian (confined, under pressure) conditions. Water-table conditions are those in which ground water is unconfined

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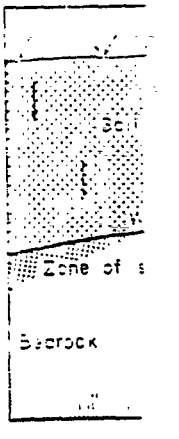

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Table 1. *Discharge data of the gaged streams in Montgomery County*

Schuylkill River at Pottstown, Pa. 1-4720
Average discharge, 41 years of record: 1,805 cfs.[1]
Maximum discharge, May 23, 1943: 50,800 cfs.
Minimum discharge, August 13, 1930: 87 cfs.

Perkiomen Creek at Graterford, Pa. 1-4730
Average discharge, 53 years of record: 370 cfs.
Maximum discharge, July 9, 1935: 39,900 cfs.
Minimum discharge, October 5, 1941: 4.7 cfs.

Skippack Creek near Collegeville, Pa. 1-4731.2
Average discharge, 2 years of record: 65.5 cfs.
Maximum discharge, March 7, 1967: 4,620 cfs.
Minimum discharge, September 12, 1967: 0.1 cfs.

Wissahickon Creek at Fort Washington, Pa. 1-4739
Average discharge, 6 years of record: 43.2 cfs.
Maximum discharge, March 7, 1967: 3,490 cfs.
Minimum discharge, September 2, 1963: 2.9 cfs.

[1] Cubic feet per second

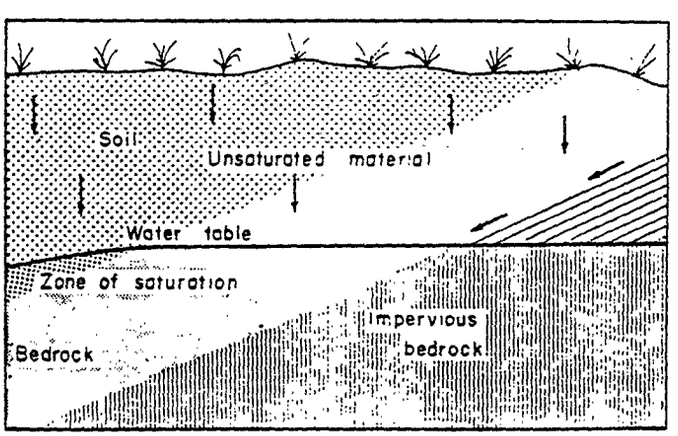

Figure 5. Downward movement of water through soil and rock to the water table.

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and the upper surface of the water is free to rise or fall. Artesian conditions exist where the ground water is confined in a permeable (having interconnected openings) formation that is overlain by a relatively impermeable formation. The upper surface is not free to rise or fall, but the water is under enough pressure to rise above the containing aquifer in wells penetrating it. The imaginary surface to which water will rise in wells tapping an artesian aquifer is called the piezometric surface in this report.

The water table fluctuates according to the relative amounts of recharge (additions to the aquifer) and discharge (losses to seeps, springs and wells). Because of the heavy evapotranspiration losses through the growing season (April to October) little recharge reaches the zone of saturation and water levels decline; water levels generally rise throughout the rest of the year.

Water levels in the county are at or near the land surface in the valleys and rise toward the drainage divides. The rate of water level rise, however, is less than that of the land surface, so wells on the higher elevations must be drilled deeper to reach the water table than those in the valleys.

The occurrence and movement of ground water is in and through interconnected openings (Figure 6) either primary or secondary in nature. Primary openings are void spaces between the individual grains of material, such as in sandstone and shale. In a coarse-grained sandstone the openings are relatively large; in a shale the grains and openings are very small. The larger interconnecting openings allow much more ground-water movement than the smaller ones.

Secondary openings are those formed subsequent to the deposition and consolidation of the formations. In Montgomery County they result from the fracture or solution of rock. The fractures are the result of external forces that caused rupture of the rock; solution cavities are formed by the solution and removal, by water, of parts of rocks such as limestone. Large quantities of water move through connected fractures and solution cavities.

HOW AND WHERE THE WATER IS FOUND

SUBSURFACE WATER

Ground water in Montgomery County is found in both artesian and water-table aquifers. These aquifers yield water to wells at various rates which vary over a wide range, both from one geologic formation to another and within the same geologic formation. Well yields range from a fraction of a gallon per minute to more than 1,500 gpm (gallons per minute). Data on seven hundred wells drilled in the various geologic

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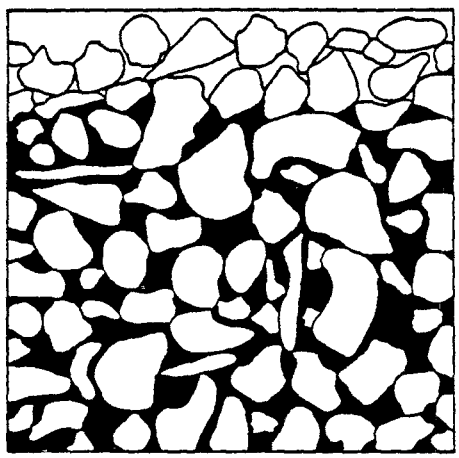
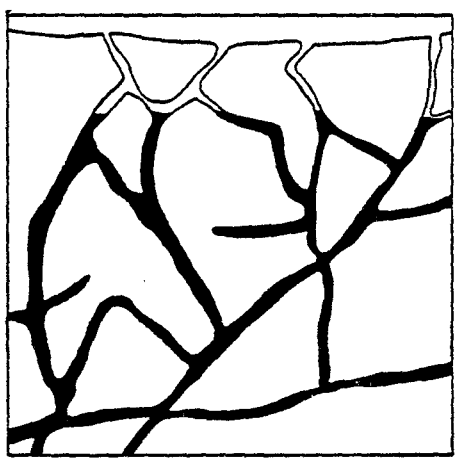


Primary openings in unconsolidated material



Secondary openings in consolidated rock

Figure 6. How water occurs in the rocks.

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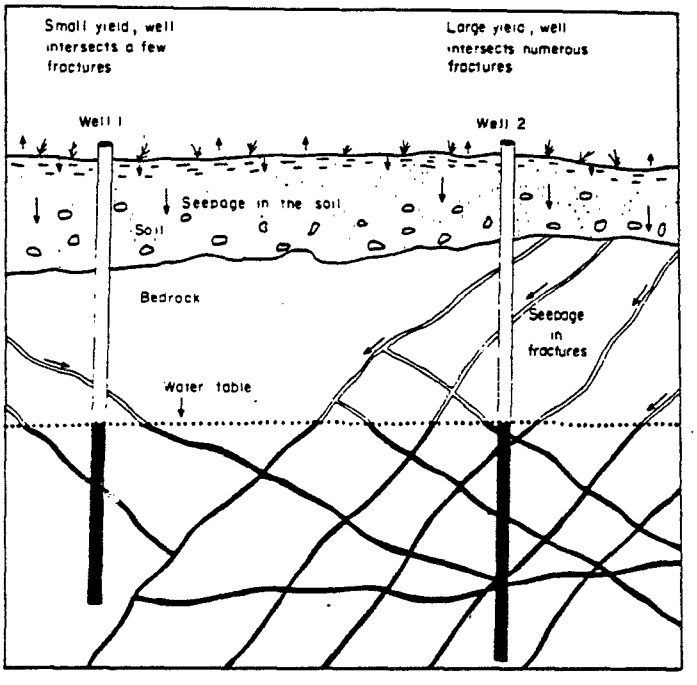

Figure 7. How fractures in bedrock formations will affect the yield of wells.

formations that underlie the county have been described in several published reports. (See Selected References)

When precipitation has reached the zone of saturation it moves by gravity down the hydraulic gradient toward points of discharge. The direction of movement is determined by the slope of the water table or the piezometric surface. The movement of ground water is through interconnected openings in the rock, and, as these openings are normally small, they do not allow rapid movement of water.

The aquifers in Montgomery County are primarily consolidated rocks, and water occurs in fractures, bedding planes, or solution openings. Small amounts of ground water occur in the pore spaces in the weathered

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zone but this weathered material is thin and discontinuous. Wells drilled into consolidated rock will yield water if they intersect saturated openings in the rock. This is illustrated in Figure 7. Well No. 1 intercepts only one fracture below the water table, and the yield of this well would be less than the yield of well No. 2 because the latter well intersects several fractures below the water table.

A geologic column for Montgomery County (Table 2) is shown below and is followed by a generalized geologic map. (Figure 8)

Table 2. *Geologic section for Montgomery County, Pennsylvania*

Era, System and Epoch	Formation	Thickness (feet)	Character
Cenozoic Quaternary Holocene	Alluvium	0-10	Soil, sand, gravel, and clay; deposits in stream valleys.
Pleistocene	Pensauken Formation	0-10	Sand, gravel, clay, yellowish-brown; small areal extent.
Tertiary Pliocene (?)	Bryn Mawr Gravel	0-10	Sand and gravel; small areal extent.
Mesozoic Cretaceous	Patapsco Formation	0-10	Clay and sand, highly colored; small areal extent.
Triassic	Diabase	5-1,800	Medium to coarse grained igneous rock, dark gray, occurs as dikes and sills.
	Brunswick Formation	9,000-16,000	Shale, mudstone, sandstone, and conglomerate beds; reddish-brown.
	Lockatong Formation	0-2,000	Argillite, mudstone, and shale; dark gray to black, thick bedded.
	Stockton Formation	1,000-6,000	Shale and siltstone in upper member; sandstone, fine-to coarse-grained, arkosic, middle member; conglomerate lower member.

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Table 2. *(Continued)*

Era, System and Epoch	Formation	Thickness (feet)	Character
Paleozoic			
Ordovician	Conestoga Limestone	500-800	Limestone, impure, thin-bedded upper part; middle dark graphitic phyllite, lower limestone, granular thick-bedded, dark gray.
Cambrian			
	Elbrook Formation	800	Limestone, fine-grained, light gray to cream-colored, thin-bedded.
	Ledger Dolomite	1,000	Dolomite, granular, gray to bluish gray.
	Harpers Formation	500-800 (?)	Phyllite, fine-grained, greenish-gray, some beds of quartzite and schist.
	Chickies Quartzite	500-1,000	Quartzite, vitreous, light-colored thick-bedded, conglomerate at base.
Precambrian (?)	Wissahickon Formation	—	Schist, albite chlorite, and oligoclase mica, includes hornblende gneiss and phyllite.
Precambrian	Granite gneiss	—	Composed chiefly of quartz, feldspar, biotite, and hornblende.
	Hornblende gneiss	—	Composed of quartz, feldspar, and hornblende.
	Serpentine	—	Soft, fine grained, green.

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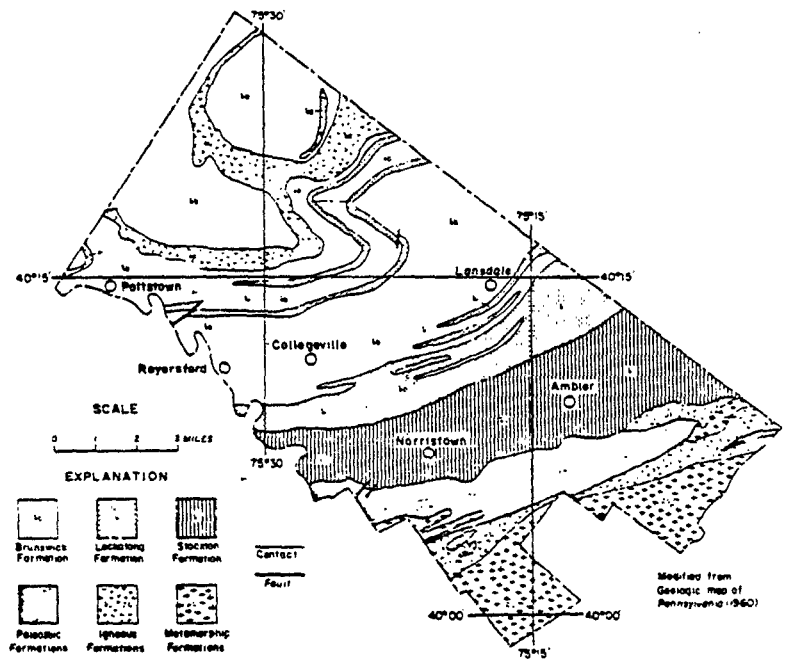

Figure 8. Generalized geologic map.

The water-bearing characteristics of the mapped units are summarized in the following pages.

Brunswick Formation

Lithology and structure

The Brunswick Formation in Montgomery County consists of consolidated reddish-brown shale and sandstone. Along the northern edge of the county conglomerate is interbedded with the shale and sandstone. The beds of the Brunswick Formation generally dip an average of 20° to the north and northwest, but several broad synclines and anticlines

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have been superimposed on the major structure. The Brunswick Formation has been cut by many small faults and one or two large ones. There is a well-developed system of nearly vertical joints in many of the beds of the Brunswick Formation. Sample logs of wells in the Brunswick Formation are listed in Table 3.

Water-bearing characteristics

Because pore spaces in the Brunswick Formation are very small, most of the ground water occurs in and moves through secondary openings and the nearby vertical joints that intersect at various angles throughout the formation. The number and width of these vertical joints differ from bed to bed within the formation; thus, some beds yield much more water to wells than others. These vertical joints also allow downward percolation of precipitation to recharge the aquifer.

Table 3. *Sample logs of wells in the Brunswick Formation in Montgomery County, Pennsylvania*

Well Mg-632

Owner: U.S. Geological Survey

Description	Depth (feet)
Soil, red	0 — 2
Shale, red, moderately calcareous; calcite joint filling	2 — 5
Shale, red, slightly calcareous	5 — 10
Shale, red, slightly calcareous; calcite joint filling	10 — 15
Shale, red, slightly calcareous	15 — 18
Shale, red, slightly calcareous; calcite joint filling	18 — 25
Shale, red, moderately calcareous; calcite joint filling	25 — 30
Shale, red, slightly calcareous; calcite joint filling	30 — 40
Shale, red, slightly calcareous	40 — 45
Shale, red, moderately calcareous; calcite joint filling	45 — 52
Shale, red, slightly calcareous; calcite joint filling	52 — 85
Shale, red, moderately calcareous; calcite joint filling	85 — 90
Shale, red, slightly calcareous, micaceous; calcite joint filling	90 — 95
Shale, red, slightly calcareous, micaceous; quartz and calcite joint filling	95 — 100
Shale, red, slightly calcareous, micaceous; calcite joint filling	100 — 110
Siltstone, red, moderately calcareous, micaceous; calcite and quartz joint filling	110 — 120
Shale, red, slightly calcareous; calcite and quartz joint filling	120 — 125
Shale, red, moderately calcareous, micaceous; calcite joint filling	125 — 130
Shale, red, moderately calcareous; calcite joint filling	130 — 135
Shale, red, moderately calcareous	135 — 140

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Table 3. *(Continued)*

Description	Depth (feet)
Shale, red, slightly calcareous; calcite joint filling	140 — 170
Shale, red, slightly calcareous; calcite and quartz joint filling	170 — 185
Shale, red, moderately calcareous; calcite joint filling	185 — 200
Siltstone, red, slightly calcareous, micaceous; calcite joint filling	200 — 210
Shale, red, slightly calcareous, micaceous; quartz joint filling	210 — 215
Shale, red, slightly calcareous, micaceous; quartz and calcite joint filling	215 — 220
Shale, red, slightly calcareous; calcite and quartz joint filling	220 — 225
Shale, red, slightly calcareous; calcite joint filling	225 — 235
Shale, red, slightly calcareous	235 — 240
Shale, red; calcite joint filling	240 — 250
Shale, red; calcite and quartz joint filling	250 — 260
Shale, red, slightly calcareous; calcite joint filling	260 — 290
Shale, red, moderately calcareous	290 — 300
Shale, red, slightly calcareous	300 — 310
Shale, red, slightly calcareous; quartz and calcite joint filling	310 — 315
Siltstone, buff, moderately calcareous; red shale; quartz joint filling	315 — 320
Shale, red, slightly calcareous, micaceous; calcite joint filling	320 — 325
Shale, red, slightly calcareous, micaceous; calcite and quartz joint filling	325 — 330
Shale, red, slightly calcareous; calcite joint filling	330 — 335
Shale, red, micaceous; calcite and quartz joint filling	335 — 340
Shale, red, moderately calcareous; calcite and quartz joint filling	340 — 345
Shale, red, moderately calcareous; calcite joint filling	345 — 350
Shale, red, slightly calcareous; calcite joint filling	350 — 360
Shale, red, micaceous; calcite and quartz joint filling	360 — 363
Shale, red, moderately calcareous; calcite joint filling	363 — 370
Shale, red, slightly calcareous	370 — 375
Shale, red, slightly calcareous; calcite joint filling	375 — 379
Shale, green, moderately calcareous	379 — 381
Shale, red, slightly calcareous; calcite joint filling	381 — 385
Shale, red, slightly calcareous	385 — 405
Shale, red, slightly calcareous; calcite joint filling	405 — 425
Shale, red, slightly calcareous	425 — 450
Shale, red, slightly calcareous; calcite joint filling	450 — 460
Shale, red, slightly calcareous; calcite and quartz joint filling	460 — 465
Shale, red, slightly calcareous	465 — 470
Shale, red, slightly calcareous; calcite joint filling	470 — 475
Shale, red, moderately calcareous; calcite joint filling	475 — 480
Shale, red, slightly calcareous	480 — 490
Shale, red, moderately calcareous; calcite joint filling	490 — 500

Well Mg-633

Owner: U.S. Geological Survey

Description	Depth (feet)
Shale, red; quartz joint filling	0 — 5

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Table 3. *(Continued)*

Description	Depth (feet)
Shale, red, slightly calcareous, calcite joint filling	5 — 20
Shale, red, moderately calcareous; calcite joint filling	20 — 25
Shale, red, slightly calcareous; calcite joint filling	25 — 30
Shale, red, moderately calcareous	30 — 35
Shale, red, moderately calcareous; calcite joint filling	35 — 40
Shale, red; calcite joint filling	40 — 45
Shale, red, slightly calcareous; calcite joint filling	45 — 55
Shale, red, slightly calcareous; goethite	55 — 60
Shale, red, slightly calcareous; calcite joint filling	60 — 70
Shale, red, slightly calcareous	70 — 90
Shale, red, moderately calcareous; calcite joint filling	90 — 100
Shale, red; calcite joint filling	100 — 105
Shale, red, slightly calcareous; abundant quartz and calcite joint filling. Quartz is in crystals up to half an inch long	105 — 108
Shale, red, slightly calcareous; calcite joint filling	108 — 110
Shale, red, slightly calcareous; abundant calcite joint filling	110 — 112
Shale, red, slightly calcareous; calcite and quartz joint filling and goethite	112 — 115
Shale, red; calcite joint filling	115 — 118
Shale, red	118 — 120
Shale, red, slightly calcareous	120 — 123
Shale, red	123 — 125
Shale, red, moderately calcareous; calcite joint filling	125 — 128
Shale, red, slightly calcareous	128 — 138
Shale, red, slightly calcareous; calcite joint filling	138 — 140
Shale, red, slightly calcareous	140 — 142
Shale, red, slightly calcareous; calcite joint filling	142 — 148
Shale, red, slightly calcareous	148 — 150
Shale, red, slightly calcareous; calcite joint filling and goethite	150 — 152
Shale, red, slightly calcareous; calcite joint filling	152 — 165
Shale, red, slightly calcareous	165 — 168
Shale, red, slightly calcareous; calcite joint filling	168 — 170
Shale, red; calcite joint filling	170 — 172
Shale, red	172 — 175
Shale, red, moderately calcareous	175 — 178
Shale, red, moderately calcareous; calcite joint filling	178 — 185
Shale, red; calcite joint filling	185 — 205
Shale, red, slightly calcareous; calcite joint filling	205 — 210
Shale, red; calcite joint filling	210 — 212
Shale, red, slightly calcareous; calcite joint filling	212 — 215
Shale, red, slightly calcareous; calcite and quartz joint filling	215 — 220
Shale, red, slightly calcareous; calcite joint filling	220 — 225
Shale, red; calcite joint filling	225 — 230
Shale, red; calcite and quartz joint filling and goethite	230 — 232
Shale, red, moderately calcareous; quartz and calcite joint filling	232 — 233
Shale, red; calcite joint filling	233 — 235

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Table 3. *(Continued)*

	Depth (feet)
.....	5 — 20
.....	20 — 25
.....	25 — 30
.....	30 — 35
.....	35 — 40
.....	40 — 45
.....	45 — 55
.....	55 — 60
.....	60 — 70
.....	70 — 90
.....	90 — 100
.....	100 — 105
joint	
.....	105 — 108
.....	108 — 110
.....	110 — 112
z and	
.....	112 — 115
.....	115 — 118
.....	118 — 120
.....	120 — 123
.....	123 — 125
.....	125 — 128
.....	128 — 138
.....	138 — 140
.....	140 — 142
.....	142 — 148
.....	148 — 150
ie	150 — 152
.....	152 — 165
.....	165 — 168
.....	168 — 170
.....	170 — 172
.....	172 — 175
.....	175 — 178
.....	178 — 185
.....	185 — 205
.....	205 — 210
.....	210 — 212
.....	212 — 215
ng	215 — 220
.....	220 — 225
.....	225 — 230
.....	230 — 232
filling	232 — 233
.....	233 — 235

Description	Depth (feet)
Shale, red, moderately calcareous; calcite joint filling	235 — 237
Shale, red; calcite joint filling	237 — 240
Shale, red, slightly calcareous; calcite joint filling	240 — 243
Shale, red, slightly calcareous	243 — 245
Shale, red; calcite joint filling	245 — 263
Shale, red, slightly calcareous; calcite joint filling	263 — 270
Shale, red	270 — 275
Shale, red, slightly calcareous; calcite joint filling	275 — 278
Siltstone, red, moderately calcareous; calcite joint filling	278 — 280
Shale, red, slightly calcareous; calcite joint filling	280 — 283
Shale, red; calcite joint filling	283 — 288
Shale, red, slightly calcareous; calcite joint filling	288 — 290
Shale, red, slightly calcareous	290 — 295
Shale, red; calcite joint filling	295 — 300
Shale, red	300 — 302
Shale, red; calcite joint filling	302 — 307
Shale, red, slightly calcareous, calcite joint filling	307 — 310
Shale, red, moderately calcareous; calcite joint filling	310 — 312
Shale, red, slightly calcareous	312 — 314
Shale, red, slightly calcareous; calcite joint filling	314 — 325
Shale, red, slightly calcareous; quartz joint filling	325 — 327
Shale, red, slightly calcareous	327 — 330
Shale, red	330 — 335
Shale, red; calcite joint filling	335 — 348
Shale, red, slightly calcareous; calcite joint filling	348 — 350
Shale, red, slightly calcareous	350 — 355
Shale, red, slightly calcareous; calcite joint filling	355 — 358
Shale, red; calcite joint filling	358 — 360
Shale, red, moderately calcareous	360 — 362
Shale, red, slightly calcareous; calcite and quartz joint filling	362 — 365
Shale, red; calcite joint filling	365 — 380
Shale, red, moderately calcareous	380 — 383
Shale, red, moderately calcareous, micaceous	383 — 385
Shale, red, slightly calcareous; calcite joint filling	385 — 390
Shale, red, slightly calcareous	390 — 392
Shale, red	392 — 395
Shale, red, slightly calcareous	395 — 402
Shale, red, moderately calcareous; calcite joint filling	402 — 405
Shale, red, slightly calcareous; calcite and quartz joint filling	405 — 408
Shale, red, moderately calcareous	408 — 410
Shale, red, slightly calcareous	410 — 412
Shale, red, slightly calcareous; calcite joint filling	412 — 415
Shale, red, moderately calcareous; calcite joint filling	415 — 417
Shale, red, slightly calcareous; calcite joint filling, pyrite and goethite	417 — 420
Shale, red, slightly calcareous	420 — 422
Shale, red, slightly calcareous; calcite joint filling	422 — 428

200179

Table 3. *(Continued)*

Description	Depth (feet)
Shale, red, slightly calcareous	428 — 430
Shale, red	430 — 432
Shale, red, slightly calcareous; calcite joint filling	432 — 435
Shale, red, moderately calcareous; calcite joint filling	435 — 437
Shale, red; slightly calcareous; calcite joint filling	437 — 460
Shale, red; calcite joint filling	460 — 465
Shale, red; calcite joint filling, pyrite and goethite	465 — 467
Shale, red, slightly calcareous; calcite and quartz joint filling	467 — 470
Shale, red, slightly calcareous	470 — 473
Shale, red, slightly calcareous; calcite joint filling	473 — 497
Shale, red	497 — 500

Well Mg-679

Owner: Souderton Borough

Description	Depth (feet)
Shale, red	0 — 40
Shale, red, moderately calcareous; calcite joint filling	40 — 100
Shale, dark reddish-gray, slightly calcareous	100 — 110
Shale, red, slightly calcareous; calcite joint filling and pyrite	110 — 120
Shale, red, slightly calcareous; calcite joint filling	120 — 130
Shale, dark red, moderately calcareous	130 — 140
Shale, red, slightly calcareous; calcite joint filling	140 — 180
Argillite, blue-gray, slightly calcareous; calcite joint filling. Thin beds of red shale are in this interval	180 — 190
Argillite, blue-gray, moderately calcareous; calcite and quartz joint filling. About 4 feet of this interval is red shale	190 — 200
Sandstone, gray, very fine grained; calcite joint filling and pyrite	200 — 210
Argillite, blue-gray, moderately calcareous; calcite joint filling and pyrite	210 — 230
Argillite, blue-gray, slightly calcareous; pyrite and goethite	230 — 260
Siltstone, blue-gray, slightly calcareous; pyrite	260 — 270
Argillite, blue-gray, moderately calcareous; pyrite. Red shale, moderately calcareous; calcite joint filling and pyrite	270 — 278
Argillite, blue-gray, moderately calcareous; pyrite	278 — 285
Shale, reddish-brown, moderately calcareous; About 4 feet of this interval is blue-gray, moderately calcareous argillite	285 — 308

Well Mg-700

Owner: Stanley G. Flagg, Inc.

Description	Depth (feet)
Fill	0 — 20
Sandstone, buff, fine grained. About half of this interval is red shale	20 — 30
Shale, red, micaceous	30 — 60

200180

Table 3. *(Continued)*

Description	Depth (feet)
Shale, red	60 — 90
Shale, red, slightly calcareous; quartz joint filling	90 — 100
Shale, red, slightly calcareous	100 — 130
Shale, dark brown, slightly calcareous	130 — 140
Shale, red, slightly calcareous	140 — 150
Shale, red, moderately calcareous	150 — 160
Shale, red; calcite joint filling	160 — 170
Shale, red, slightly calcareous	170 — 190
Shale, red, moderately calcareous	190 — 200
Shale, red, moderately calcareous, micaceous; calcite joint filling	200 — 250
Shale, red, micaceous; calcite joint filling	250 — 260
Shale, red, slightly calcareous; calcite joint filling	260 — 280
Shale, gray-brown, slightly calcareous; micaceous; calcite joint filling	280 — 290
Shale, red, slightly calcareous; calcite joint filling	290 — 330
Siltstone, red, slightly calcareous; calcite joint filling	330 — 340
Shale, red, moderately calcareous	340 — 350
Shale, red, moderately calcareous; calcite joint filling	350 — 360
Siltstone, red, moderately calcareous; calcite joint filling	360 — 370
Shale, red, moderately calcareous; calcite joint filling	370 — 390
Shale, red, moderately calcareous; calcite and quartz joint filling	390 — 400
Shale, red, moderately calcareous; calcite joint filling	400 — 456
Sandstone, white, fine grained	456 — 461
Shale, red, moderately calcareous; calcite joint filling	461 — 480
Argillite, blue-gray, moderately calcareous, interbedded with about 3 feet of buff sandstone	480 — 500
Sandstone, light-brown, fine grained	500 — 510
Sandstone, light-brown, medium grained	510 — 520
Shale, brown, slightly calcareous, micaceous; calcite joint filling	520 — 530
Shale, brown, slightly calcareous, micaceous; quartz joint filling	530 — 540
Shale, red, moderately calcareous; calcite joint filling	540 — 560
Shale, red, moderately calcareous; calcite and quartz joint filling	560 — 600
Shale, red, slightly calcareous; calcite joint filling	600 — 610
Shale, red, moderately calcareous; calcite joint filling. About 1 foot of this interval is buff, fine grained sandstone	610 — 620
Shale, red, moderately calcareous; calcite joint filling	620 — 640

Well Mg-704

Owner: Lansdale Municipal Authority

Description	Depth (feet)
Shale, red	0 — 10
Shale, red, slightly calcareous; calcite joint filling	10 — 20
Shale, red	20 — 40
Shale, red, slightly calcareous	40 — 70
Shale, red, slightly calcareous; calcite joint filling	50 — 70
Shale, red, moderately calcareous; calcite joint filling	70 — 80

	Depth (feet)
	428 — 430
	430 — 432
	432 — 435
	435 — 437
	437 — 460
	460 — 465
	465 — 467
	467 — 470
	470 — 473
	473 — 497
	497 — 500

	Depth (feet)
	0 — 40
	40 — 100
	100 — 110
	110 — 120
	120 — 130
	130 — 140
	140 — 180
in beds	
	180 — 190
rtz joint	
	190 — 200
vrite	200 — 210
ling and	
	210 — 230
	230 — 260
	260 — 270
:, moder-	
	270 — 278
	278 — 285
t of this	
	285 — 308

	Depth (feet)
	0 — 20
red shale	20 — 30
	30 — 60

200181

Table 3. *(Continued)*

Description	Depth (feet)
Shale, red, slightly calcareous; calcite joint filling	80 — 140
Shale, red, moderately calcareous; calcite joint filling	140 — 190
Shale, red, slightly calcareous; calcite joint filling	190 — 200
Shale, red, slightly calcareous; calcite joint filling and pyrite	200 — 210
Shale, red, slightly calcareous; calcite joint filling	210 — 220
Siltstone, red, slightly calcareous; goethite	220 — 230
Argillite, blue-gray to greenish-gray, slightly calcareous; calcite joint filling and goethite	230 — 240
Shale, gray-brown, slightly calcareous; calcite joint filling and goethite	240 — 250
Shale, red, moderately calcareous; calcite joint filling and goethite	250 — 260
Shale, red, moderately calcareous; calcite joint filling	260 — 290
Shale, red, slightly calcareous; calcite joint filling, pyrite and goethite	290 — 310
Shale, red, slightly calcareous; calcite joint filling	310 — 330
Argillite, blue-gray, moderately calcareous; calcite joint filling and pyrite	330 — 360
Argillite, blue-gray, moderately calcareous; calcite joint filling and goethite	360 — 370

Well Mg-725

Owner: Schwenksville Water Co.

Description	Depth (feet)
Shale, red, slightly calcareous; calcite joint filling	0 — 20
Shale, red, slightly calcareous; quartz joint filling, pyrite and goethite	20 — 30
Shale, red, moderately calcareous; calcite joint filling, pyrite and goethite	30 — 40
Shale, red, slightly calcareous; joint filling	40 — 50
Shale, red, a few green spots, moderately calcareous	50 — 60
Shale, red, moderately calcareous. About 4 feet of this interval is purplish-brown	60 — 70
Shale, red, slightly calcareous; calcite joint filling	70 — 80
Shale, red, moderately calcareous; calcite and quartz joint filling	80 — 90
Shale, red, slightly calcareous; quartz joint filling	90 — 100
Shale, red, moderately calcareous; calcite joint filling	100 — 110
Shale, red, slightly calcareous; calcite and quartz joint filling	110 — 120
Shale, red, slightly calcareous; calcite joint filling	120 — 150
Shale, red, slightly calcareous	150 — 160
Shale, red, slightly calcareous; calcite joint filling	160 — 180
Shale, red, slightly calcareous; calcite and quartz joint filling	180 — 190
Shale, red, slightly calcareous; calcite joint filling	190 — 200
Shale, red, moderately calcareous; calcite and quartz joint filling	200 — 210
Shale, red, moderately calcareous; calcite joint filling	210 — 220
Shale, red, slightly calcareous; calcite joint filling	220 — 240
Shale, red; calcite joint filling	240 — 250
Shale, red, slightly calcareous; calcite joint filling	250 — 290

200182

	Depth (feet)
.....	80 — 140
.....	140 — 190
.....	190 — 200
.....	200 — 210
.....	210 — 220
.....	220 — 230
joint	
.....	230 — 240
·thite	240 — 250
te	250 — 260
.....	260 — 290
ethite	290 — 310
.....	310 — 330
: and	
.....	330 — 360
g and	
.....	360 — 370

	Depth (feet)
.....	0 — 20
goethite	20 — 30
ite and	
.....	30 — 40
.....	40 — 50
.....	50 — 60
terval is	
.....	60 — 70
.....	70 — 80
illing	80 — 90
.....	90 — 100
.....	100 — 110
ıg	110 — 120
.....	120 — 150
.....	150 — 160
.....	160 — 180
ng	180 — 190
.....	190 — 200
: filling	200 — 210
.....	210 — 220
.....	220 — 240
.....	240 — 250
.....	250 — 290

Well depths and yields

The Brunswick Formation is a reliable source of small to moderate supplies of ground water. Some wells yield more than 200 gpm, and if yields of 100 gpm or more are desired wells should be drilled to depths of at least 200 feet. According to Longwill and Wood (1965, p. 12), . . . "wells drilled to depths between 200 and 550 feet deep are most likely to obtain maximum yields."

Sufficient water for domestic purposes can be obtained at almost any location from wells that are drilled 40 or 50 feet below the water table, but yields large enough for industrial and municipal purposes are more difficult to obtain. If large supplies are sought, test wells should be drilled to find the best site for a production well.

Well location and spacing

Wells located in the valleys, where the water table is close to the land surface, have more available drawdown than wells of the same depth located on hills. This is illustrated in Figure 9. Well spacing is generally not critical when water is being pumped for domestic purposes, but wells should be spaced as far apart as is necessary, within economic limits, when wells are pumped for industrial and municipal purposes. Where several pumping wells are closely spaced, the cones of depression coalesce and the interference may be so great that the yield of each well is reduced. Wells less than 2,000 feet apart in the Brunswick Formation have generally shown some interference. In the Brunswick Formation, interference between wells is greatest between wells that are located parallel to the strike of the beds, because the boreholes penetrate the same beds and fracture systems.

Water quality

Ground water in the Brunswick Formation is of the calcium bicarbonate type when the concentrations of dissolved solids are less than 500 mg/l (milligrams per liter) and of the calcium sulfate type when the dissolved solids are greater than 500 mg/l. The median dissolved-solids content is about 300 mg/l. Median hardness as $CaCo^{3}$ is about 220 mg/l. Almost all the water meets U.S. Public Health Service standards for mineral content.

200183

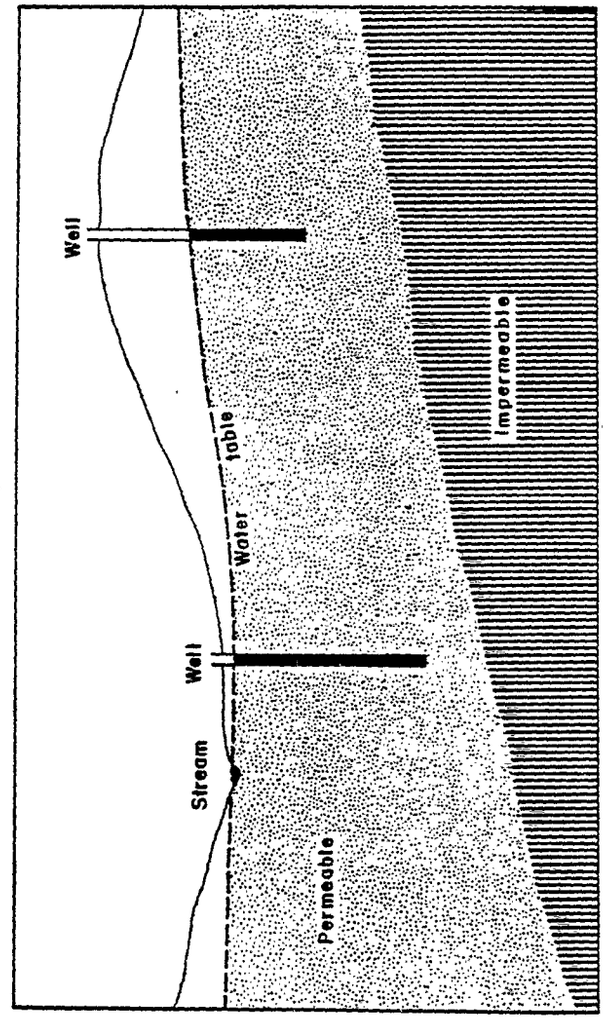

Figure 9. Wells in valleys have more available drawdown than wells on hills.

200184

Figure 9. Wells in valleys have more available drawdown than wells on hills.

Lockatong Formation

Lithology and structure

The Lockatong Formation lies immediately below the Brunswick Formation. It consists of thick-bedded argillite (very dense shale and mudstone). The Lockatong Formation is resistant to erosion and forms a low ridge where it is exposed along the south edge of the Brunswick Formation. Thinner beds of similar black argillite are interbedded with the overlying Brunswick Formation. Like the Brunswick Formation, the Lockatong dips to the northwest an average of 20°.

Water-bearing characteristics

The pore spaces in the Lockatong Formation are very small, and most of the ground water moves through a system of interconnected joints and fractures. The fractures are narrower and more widely spaced than those in the Brunswick Formation.

Well depths and yields

The yields of wells in the Lockatong Formation are low because of the smallness and scarcity of fractures. Well yields range from 4 to 40 gpm, and the average yield is about 7 gpm. Yields greater than those required for domestic purposes are not available from wells in this formation. Large-diameter wells drilled in this formation will yield larger volumes of water than small-diameter wells for short periods of time because the amount of water stored in the well is greater in the large-diameter wells. Aside from the storage factor, the drilling of deeper wells in the Lockatong Formation does not materially increase the potential yields of wells. Pumps should be set near the bottom of wells because drawdown is large.

Well location and spacing

Because the Lockatong Formation is resistant to erosion, it forms ridges. Therefore, wells pumping water from this formation will not usually divert water from the streams. The cones of depression developed by pumping wells in the Lockatong Formation are not extensive because of the poor water-bearing characteristics, therefore, interference between wells is not a problem. A typical cone of depression in the Lockatong Formation is shown in Figure 10.

200185

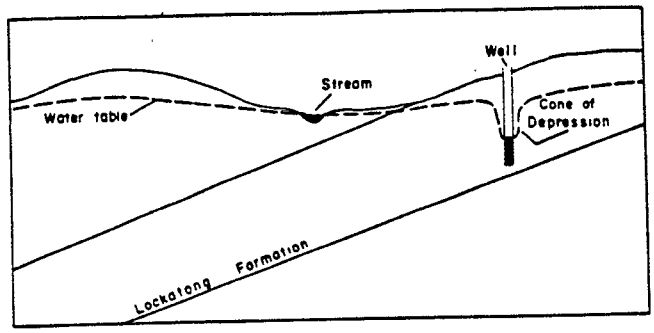

Figure 10. Cone of depression in the Lockatong Formation.

Water quality

The water in the Lockatong Formation is very similar in quality to that in the Brunswick Formation, but it has a slightly lower hardness and dissolved-solids content.

Stockton Formation

Lithology and structure

The Stockton Formation which immediately underlies the Lockatong, is made up of three distinct members: (1) A lower member consisting chiefly of sandstone and conglomerate, (2) a middle member consisting chiefly of sandstone, and (3) an upper member consisting chiefly of red shale. The outcrop of the three members of the Stockton Formation is shown in Figure 11. The formation dips to the north and northwest an average of 12°.

Sample logs of wells in the Stockton Formation are given in Table 4.

Water-bearing characteristics

Water in the Stockton Formation occurs in pore spaces between the grains and in secondary openings (such as fractures) in the rock. The size of the openings between the grains differs with the degree of sorting

200186

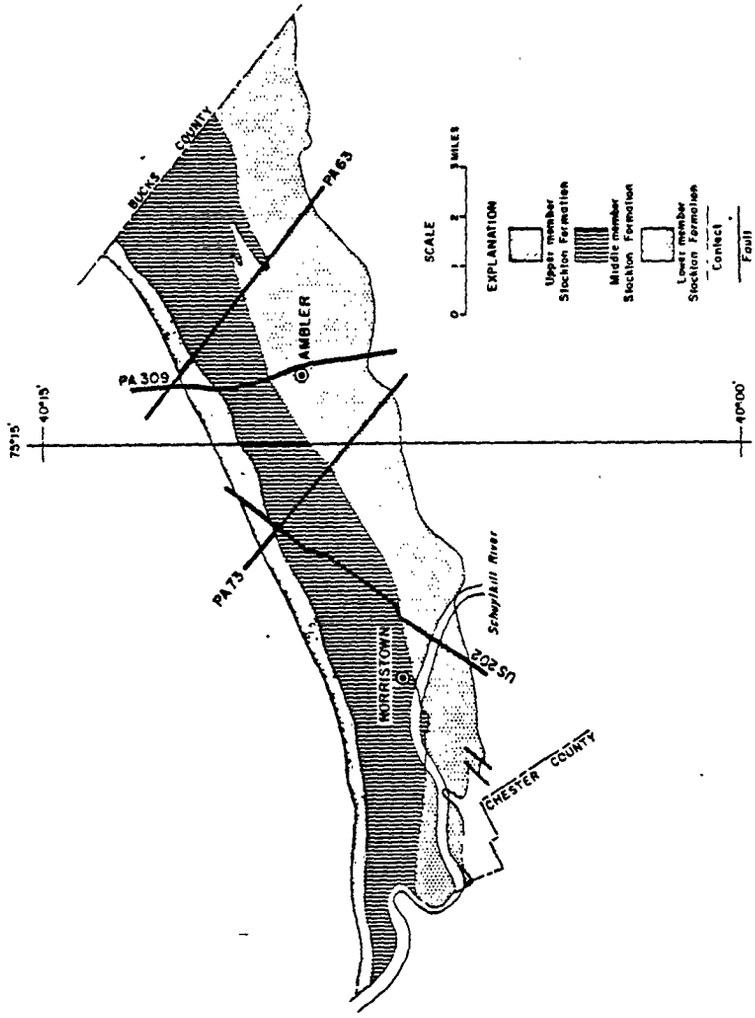

Figure 11. Outcrop of the three members of the Stockton Formation.

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Table 4.

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200187

of the original material and with the amount of cementation that binds the grains together. The three members differ in their water-bearing characteristics because of the difference in the grain size and the degree of sorting. The middle member consists of well-sorted sandstone and is the best water-producing unit. The lower member is less well sorted and, therefore, does not yield as much water to wells. The upper member of the Stockton Formation is the poorest producer because the fineness of the sediments allows little water storage or movement.

Table 4. *Sample logs of wells in the Stockton Formation in Montgomery County, Pennsylvania*

Well Mg-216

Owner: Hatboro Borough Authority
Driller: Stothoff

Description	Depth (feet)
Soil	0 — 5
Middle arkose member:	
Shale, red	5 — 80
Sandstone, arkosic, gray, fine- to medium-grained, weakly cemented	80 — 100
Shale, red	100 — 176
Sandstone, arkosic, gray, well-cemented	176 — 182
Shale, red	182 — 196
Sandstone, arkosic, gray	196 — 203
Shale, red	203 — 230
Sandstone, arkosic, gray, fine- to medium-grained, weakly cemented	230 — 260
Shale, red, and gray arkosic sandstone	260 — 274
Shale, red	274 — 280
Sandstone, arkosic, gray, and red shale	280 — 297

Well Mg-219

Owner: Hatboro Borough Authority
Driller: Stothoff

Description	Depth (feet)
No Sample	0 — 21
Middle arkose member:	
Siltstone, gray to red, sandy	21 — 38
Sandstone, arkosic, gray, fine- to medium-grained	38 — 78
Sandstone, arkosic, buff-colored, medium-grained; some brown siltstone	78 — 115
Sandstone, arkosic, gray, fine-grained, calcareous	115 — 128
No Sample	128 — 143
Sandstone, arkosic, buff-colored, fine- to medium-grained, calcareous	143 — 158
Siltstone, reddish-brown, sandy, calcareous	158 — 164

200188

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their water-bearing
size and the degree
·rted sandstone and
r is less well sorted
The upper member
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:ion in Montgomery

	Depth (feet)
.....	0 — 5
.....	5 — 80
.emented	80 — 100
.....	100 — 176
.....	176 — 182
.....	182 — 196
.....	196 — 203
.....	203 — 230
.emented	230 — 260
.....	260 — 274
.....	274 — 280
.....	280 — 297

	Depth (feet)
.....	0 — 21
.....	21 — 38
.....	38 — 78
brown	78 — 115
.....	115 — 128
.....	128 — 143
:lcareous	143 — 158
.....	158 — 164

Table 4. *(Continued)*

Description	Depth (feet)
Sandstone, arkosic, gray, medium-grained, calcareous	164 — 200
Siltstone, reddish-brown, sandy	200 — 215
Sandstone, arkosic, gray, medium-grained; some reddish-brown siltstone	215 — 265
Sandstone, arkosic, reddish-brown, medium-grained	265 — 275
Sandstone, arkosic, gray, fine- to medium-grained, calcareous	275 — 300

Well Mg-230

Owner: Blue Bell Water Works
Driller: Ridpath and Potter

Description	Depth (feet)
Soil, yellowish-brown	0 — 5
Middle arkose member:	
Siltstone, grayish-red, weakly cemented	5 — 25
Sandstone, arkosic, light-brown, very fine to fine-grained	25 — 40
Siltstone, grayish-red, firmly cemented	40 — 65
Sandstone, arkosic, pale-brown, fine- to coarse-grained	65 — 89
Siltstone, brownish-gray	89 — 100
Sandstone, arkosic, brownish-gray, medium-grained, weakly cemented; some brownish-gray siltstone	100 — 120
Siltstone, reddish-brown and brownish-gray	120 — 155
Sandstone, arkosic, pale-orange, medium- to coarse-grained	155 — 160
Siltstone, brownish-gray and grayish-red	160 — 175
Sandstone, arkosic, pale-brown, fine-to medium-grained	175 — 195
Siltstone, grayish-red, sandy, firmly cemented	195 — 200
Sandstone, arkosic, brownish-gray and yellowish-brown, very fine to fine-grained, firmly cemented	200 — 235
Siltstone, brownish-gray, sandy, firmly cemented	235 — 250

Well Mg-270

Owner: Blue Bell Water Works
Driller: Ridpath and Potter

Description	Depth (feet)
Silt, Clayey, light-brown	0 — 20
Middle arkose member:	
Sandstone, arkosic, pale-brown, medium-grained	20 — 27
Silt, brown, clayey	27 — 32
Sandstone, arkosic, yellowish-brown, coarse-grained	32 — 42

200189

Table 4. *(Continued)*

Description	Depth (feet)
Siltstone, brown	42 — 52
Sandstone, arkosic, pale-brown, very fine-grained	52 — 62
Shale, brown, silty, calcareous	62 — 72
Sandstone, arkosic, pale-brown, medium-grained	72 — 102
Sandstone, arkosic, yellow, fine-grained	102 — 112
Sandstone, arkosic, grayish-yellow, medium- to coarse-grained	112 — 122
Sandstone, arkosic, yellowish-gray, fine-grained	122 — 142
Sandstone, arkosic, brownish-gray, very fine-grained	142 — 176
Sandstone, arkosic, brownish-gray, fine- to medium-grained	176 — 203
Siltstone, brownish-gray	203 — 210
Sandstone, arkosic, light-gray, medium-grained	210 — 235
Shale, silty, brownish-gray	235 — 241
Sandstone, arkosic, light-gray	241 — 258
Shale, silty, light-gray, calcareous	258 — 270
Sandstone, arkosic, light-gray	270 — 282
Shale, grayish-red, silty, calcareous	282 — 300
Sandstone, arkosic, grayish-red, medium- to coarse-grained, calcareous	300 — 310

Well Mg-275

Owner: Horsham Township Authority
Driller: Unknown

Description	Depth (feet)
No sample	0 — 50
Middle arkose member:	
Sandstone, arkosic, grayish-red, very fine and fine-grained, clayey	50 — 150
No sample	150 — 160
Sandstone, arkosic, gray, fine-grained, clayey	160 — 170
Limestone, gray, fine-grained	170 — 180
Sandstone, arkosic, brownish-gray, medium-grained	180 — 197
Sandstone, arkosic, grayish-red, very fine and fine-grained	197 — 270
Siltstone, grayish-red, sandy	270 — 350

Well Mg-276

Owner: Horsham Township Authority
Driller: Unknown

Description	Depth (feet)
Middle arkose member:	
Siltstone, red, some very fine gray sandstone	0 — 12
Sandstone, arkosic, brown	12 — 25
Arkose, gray, medium-grained	25 — 50
Siltstone, red	50 — 72

200190

Table 4. *(Continued)*

Description	Depth (feet)
Arkose, gray, medium- to coarse-grained	72 — 80
Arkose, gray, medium-grained	80 — 90
Sandstone, arkosic, yellowish-brown, medium-grained	90 — 140
Siltstone, red, hard; some medium-grained gray arkose	140 — 230
Arkose, gray, fine-grained	230 — 250
Sandstone, arkosic, yellowish-brown, medium-grained	250 — 298
Sandstone, arkosic, yellowish-brown, medium-grained; grayish-red siltstone	298 — 320
Sandstone, arkosic, brown, medium-grained	320 — 340

Well Mg-285

Owner: Fort Washington Industrial Park
Driller: Pennsylvania Drilling Co.

Description	Depth (feet)
Soil, yellowish-brown, sandy	0 — 5
Lower arkose member:	
Siltstone, reddish-brown	5 — 55
Sandstone, arkosic, reddish-brown, fine-grained, silty	55 — 65
Sandstone, arkosic, reddish-brown, medium-grained	65 — 105
Sandstone, arkosic, pale-red, coarse-grained	105 — 115
Sandstone, arkosic, grayish-red, fine- to medium-grained	115 — 145
Sandstone, arkosic, pale-red, medium- to coarse-grained	145 — 175
Sandstone, arkosic, pale-red, very fine to medium-grained	175 — 180
Sandstone, arkosic, pale reddish-brown, medium- to coarse-grained	180 — 198
Siltstone, grayish-red, sandy	198 — 199
Sandstone, arkosic, pale reddish-brown, medium- to coarse-grained	199 — 215
No sample	215 — 220
Siltstone, grayish-red, sandy	220 — 225
No sample	225 — 230
Chickies quartzite:	
Quartzite, white, gray, and red	230 — 290

Well Mg-290

Owner: Borough of Ambler
Driller: Ridpath and Potter

Description	Depth (feet)
Lower arkose member:	
Arkose, gray, medium-grained	0 — 5
Arkose, brown, coarse- to very coarse-grained	5 — 20
Arkose, brown, medium- to coarse-grained	20 — 93
Arkose, brown, medium-grained	93 — 110
Siltstone, grayish-red	110 — 120

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Table 4. *(Continued)*

Description	Depth (feet)
Arkose, brown, medium- to coarse-grained	120 — 135
Diabase: red siltstone	135 — 140
Arkose, brown, coarse-grained	140 — 144
Arkose, gray, medium- to coarse-grained	144 — 161
Arkose, yellowish-brown, coarse-grained	161 — 171
Arkose, yellowish-brown, medium- to coarse-grained	171 — 175
Arkose, gray, medium-grained	175 — 185
Arkose, yellowish-brown, coarse-grained	185 — 195
Shale, grayish-red	195 — 198
Arkose, yellowish-brown and gray, coarse- to very coarse-grained	198 — 250
Arkose, medium- to coarse-grained	250 — 276
Arkose, brownish-gray, fine grained: red siltstone	276 — 286
Siltstone, red	286 — 344
Arkose, coarse- to very coarse-grained	344 — 354
Arkose, medium- to coarse-grained: grayish-red siltstone: diabase	354 — 384
Arkose, yellowish-brown, coarse-grained: grayish-red siltstone	384 — 400
Arkose, pale-orange, medium- to coarse-grained: red siltstone	400 — 410
Siltstone, red	410 — 440
Arkose, gray, coarse-grained: red shale	440 — 450
Arkose, gray, medium-grained	450 — 470
Siltstone, grayish-red	470 — 490
Arkose, gray, medium-grained	490 — 500

Well Mg-500

Owner: North Wales Water Authority
Driller: Ridpath and Potter

Description	Depth (feet)
Lockatong formation:	
Shale, gray	0 — 30
Shale, dark grayish-red; dark-gray shale	30 — 60
Stockton formation:	
Upper shale member:	
Shale, grayish-red	60 — 80
Siltstone, grayish-red; some fine-grained arkosic sandstone	80 — 90
Shale, grayish-red	90 — 355
Sandstone, arkosic, white, fine-grained	355 — 360
Arkose, light-gray, fine- to medium-grained; some red shale	360 — 390
Shale, grayish-red; some grayish-red siltstone	390 — 450
Arkose, light-gray, fine- to medium-grained	450 — 495
Limestone, gray	495 — 500
Sandstone, arkosic, medium-grained	500 — 505
Shale, grayish-red	505 — 520
Sandstone, arkosic, brownish-gray, fine- to medium-grained	520 — 550

200192

Table 4. *(Continued)*

Well Mg-465

Owner: Arvid E. Lyden
Driller: Ridpath and Potter

Description	Depth (feet)
Soil	0 — 2
Lower arkose member:	
Sandstone, arkosic, yellowish-brown, medium- to coarse-grained	2 — 22
Sandstone, arkosic, pale-brown, fine- to medium-grained	22 — 62
Sandstone, arkosic, gray, very coarse-grained	62 — 90
Sandstone, arkosic, brown, very fine-grained	90 — 97
Sandstone, arkosic, brown, medium-grained	97 — 130

Well Mg-489

Owner: U.S. Naval Air Station
Driller: Pennsylvania Drilling Co.

Description	Depth (feet)
Soil, reddish-brown, sandy	0 — 7
Middle arkose member:	
Sandstone, arkosic, yellowish-brown, fine- to medium-grained	7 — 17
Siltstone, grayish-red	17 — 21
Sandstone, arkosic, yellowish-brown, fine- to medium-grained	21 — 29
Sandstone, arkosic, grayish-red, fine-grained	29 — 33
Limestone, light-gray, clayey	33 — 41
Sandstone, arkosic, yellowish-brown, fine-grained	41 — 48
Sandstone, arkosic, yellowish-brown, medium- to coarse-grained	48 — 50
Sandstone, arkosic, grayish-orange, fine- to medium-grained	50 — 60

Well Mg-490

Owner: U.S. Naval Air Station
Driller: Philadelphia Drilling Co.

Description	Depth (feet)
No sample	0 — 22
Middle arkose member:	
Sandstone, arkosic, grayish-orange and yellowish-brown, very fine- to medium-grained, silty	22 — 32
Siltstone, pale-brown and grayish-orange, sandy	32 — 41
Sandstone, arkosic, yellowish-brown, very fine- to fine-grained	41 — 47
Siltstone, brownish-gray, sandy	47 — 51
Arkose, yellowish-gray, very fine- to medium-grained	51 — 67
Siltstone, gray and grayish-red, sandy	67 — 75
Sandstone, arkosic, grayish-orange, very fine- to coarse-grained	75 — 120

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Table 4. *(Continued)*

Description	Depth (feet)
Siltstone, arkosic, grayish-orange and brown, very fine- to medium-grained	140 — 158
Siltstone, gray	158 — 165
Sandstone, arkosic, grayish-orange, medium- to coarse-grained	165 — 178
Siltstone, grayish-red; some orange arkosic sandstone	178 — 185

Well Mg-495

Owner: American Chemical Paint Co.
Driller: Ridpath and Potter

Description	Depth (feet)
Upper shale member:	
Soil and clay	0 — 17
Sandstone, arkosic, light-gray, fine- to medium-grained	17 — 20
Shale, grayish-red, silty	20 — 39
Arkose, yellowish-orange, fine- to medium-grained	39 — 48
Shale, grayish-red, silty	48 — 110
Sandstone, arkosic, grayish-red and brownish-gray, fine-grained	110 — 130
Shale, grayish-red	130 — 150
Middle arkose member:	
Sandstone, arkosic, pale-brown, fine- to medium-grained	150 — 160
Sandstone, arkosic, pale-brown, very fine to fine-grained; some red shale	160 — 180
Arkose, gray, fine- to medium-grained	180 — 190
Sandstone, arkosic, brown, medium- to coarse-grained	190 — 200
Siltstone, grayish red	200 — 210
Siltstone, arkosic, pale-brown, fine- to medium-grained	210 — 245
Shale, grayish-red, silty	245 — 260
Sandstone, arkosic, yellowish-brown, medium-grained	260 — 266

Well Mg-499

Owner: Borough of Ambler
Driller: Ridpath and Potter

Description	Depth (feet)
Lower arkose member:	
Shale, brown and grayish-red	0 — 20
Sandstone, arkosic, brownish-gray and yellowish-brown, very fine- to fine-grained	20 — 30
Siltstone, grayish-brown	30 — 40
Sandstone, arkosic, grayish-red, very fine-grained	40 — 42
Shale, grayish-red, silty	42 — 52
Sandstone, arkosic, light-gray, fine- to medium-grained	52 — 72
Shale, grayish-red, silty	72 — 82

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Table 4. *(Continued)*

Description	Depth (feet)
Sandstone, arkosic, light-gray, medium- to coarse-grained	82 — 115
Sandstone, arkosic, pale-brown, medium- to coarse-grained	115 — 172
Shale, grayish-red, silty	172 — 175
Sandstone, arkosic, gray, coarse-grained	175 — 185
Arkose, light-gray, medium- to coarse-grained	185 — 225
Arkose, yellowish-brown, fine- to medium-grained	225 — 235
Arkose, yellowish-brown, medium- to coarse-grained	235 — 300

Well Mg-500

Owner: Borough of Ambler
Driller: Ridpath and Potter

Description	Depth (feet)
Soil	0 — 5
Lower arkose member:	
Sandstone, arkosic, yellowish-orange, very coarse grained, conglomeratic	5 — 28
Shale, grayish-red, sandy	28 — 40
Sandstone, arkosic, pale-orange, coarse- to very coarse-grained	40 — 70
Sandstone, arkosic, brown, fine-grained	70 — 110
Siltstone, brown, sandy	110 — 120
Sandstone, arkosic, gray, medium- to coarse-grained; some red shale	120 — 150
Shale, grayish-red	150 — 190
Sandstone, arkosic, pale-brown, fine- to medium-grained	190 — 220
Shale, grayish-red	220 — 230

Well Mg-532

Owner: Selas Corporation of America
Driller: Ridpath and Potter

Description	Depth (feet)
Soil, yellowish-brown	0 — 5
Lower arkose member:	
Siltstone, reddish-brown, pebbly	5 — 50
Chickies quartzite:	
Quartzite	50 — 184

Well Mg-533

Owner: A. F. Picolet d'Hermillion
Driller: Ridpath and Potter

Description	Depth (feet)
Soil	0 — 1

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Table 4. *(Continued)*

Description	Depth (feet)
Lower arkose member:	
Silt, dark yellowish-brown	1 — 20
Sandstone, arkosic, brown, very fine- and fine-grained	20 — 32
Sandstone, arkosic, grayish-brown, fine- to coarse-grained	32 — 60
Sandstone, arkosic, brown, coarse- to very coarse-grained; some brown siltstone	60 — 100
Sandstone, arkosic, brown, medium- to coarse-grained	100 — 110
Shale, grayish-red, silty	110 — 112
Sandstone, arkosic, yellowish-brown, coarse-grained	112 — 134

Well depths and yields

The highest yields and specific capacities (yield per unit of drawdown) reported are for wells tapping the middle sandstone member. The average reported for wells in this member is 131 gpm. Next in order of water-yielding capacity is the lower member of the formation, with an average yield of 106 gpm. The lowest average yields (19 gpm) and specific capacities are those reported for wells drilled in the upper shale member. In some of the tests made on wells tapping the Stockton Formation, it was noted from brine tracing tests that some zones were thieving water from zones of higher artesian head. That is, water from a zone of higher artesian head is entering the well, moving up or down to a zone of lower head, and flowing back into the rock.

Well location and spacing

Wells drilled in the Stockton Formation should be located where they will penetrate the greatest saturated thickness of the most permeable bed. This means that a well should not be drilled on the outcrop of the permeable bed but, rather, at a location downdip from the outcrop. This might even require that a well be started in the least permeable bed. Data concerning proper well spacing are lacking, but wells should be as far apart as practicable.

The topography in the area underlain by the Stockton Formation gives good clues concerning its lithology. The more erosion-resistant, coarse-grained beds of the formation stand as ridges; the softer sediments have been more deeply eroded and underline the valleys. Wider ridges tend to indicate the presence of thicker, coarse-grained sections of the

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Stockton and, probably, better sources of water. The best sites for high-yielding wells can be located by combining this information with the knowledge that the formation dips to the northwest. The cross section in Figure 12 shows an application of this knowledge. Well A penetrates the permeable, high-yielding bed as well as the lower impermeable bed. Well B is drilled to the same depth, but, being downdip from the outcrop area, it penetrates a greater thickness of the permeable bed and is likely to yield more water. Penetration of the higher yielding members of the Stockton Formation is more important than well depth.

Water quality

Ground water in the Stockton Formation in Montgomery County is largely of the calcium bicarbonate type. The median dissolved-solids content is 200 mg/1. Median hardness as $CaCO_3$ is 130 mg/1. Water in the rural areas has the lowest median dissolved-solids content, and water in urban areas has the highest. This indicates that contaminants are entering the Stockton Formation in the urban areas.

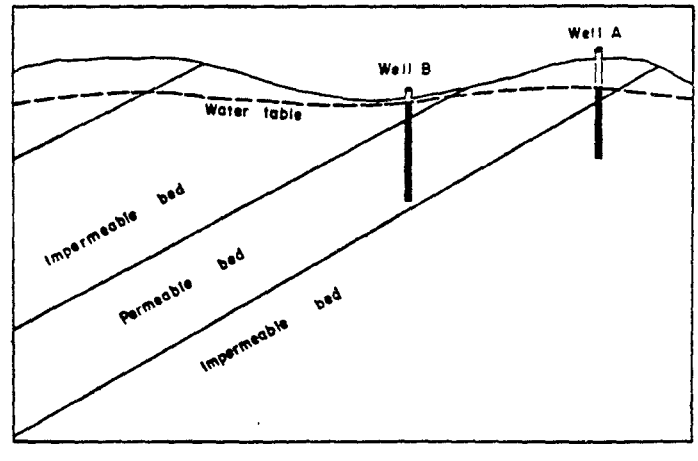

Figure 12. Well (B) drilled to take advantage of more saturated permeable material.

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Paleozoic Rocks

Lithology and structure

Rocks of Paleozoic age underlie the above-mentioned formations, except in the eastern part of the county. Where Paleozoic rocks are exposed in the southeastern part of the county, they consist of limestone and dolomite and sediments that have been metamorphosed (altered by heat and pressure) into very hard, erosion-resistant rock. The beds have been extensively folded and faulted.

Water-bearing characteristics

Most of these formations are so well cemented that little or no interconnected pore space remains. As a result, most water occurs in and moves through secondary openings. In the metamorphosed rocks, these openings consist of fractures; in the carbonate rocks the openings are usually fractures that have been enlarged by solution. The weathered surface of these rocks yields very small amounts of ground water. Thicker deposits of weathered material might occur in stream valleys, and in these areas the water contained in this material would add to the ground-water storage.

Well depths and yields

Most of the wells drilled in Palezoic rocks range in depth from 65 to 600 feet. The yields of wells tapping the secondary openings are directly related to the size and number of saturated openings penetrated by the well; both the size and number of these openings decrease as depth increases, except in the carbonate rocks. Therefore, if a significant amount of water is not obtained by drilling to a depth of 300 feet it would be better to redrill at another site than to drill deeper.

Well yields from the more permeable carbonate rocks range from 25 to more than 1,500 gpm; the larger yields occur where saturated, well-developed solution channels are tapped. The yields of wells drilled in the quartzites or the denser carbonate rocks are usually low, ranging from 2 to 10 gpm; occasionally wells are drilled that yield almost no water at all.

Well location and spacing

Very few data are available to serve as a guide in locating wells in Paleozoic rocks. The spacing of wells to minimize interference between

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wells would depend on the number and size of the saturated solution openings encountered in each well. The location of saturated solution openings cannot readily be determined at the land surface; therefore, test drilling is recommended before the permanent well is drilled. A pumping test would help in determining the proper well spacing.

Water quality

Ground-water quality differs greatly from one unit to another in the Paleozoic rocks. Water from some of the quartzites has a low dissolved-solids content that ranges from 32 to 51 mg/1, and it is low in hardness, which ranges from 15 to 52 mg/1. Dissolved solids in water from the Paleozoic carbonate rocks range from 198 to 243 mg/1, and the hardness ranges from 198 to 270 mg/1.

Igneous Rocks

Lithology and structure

Relatively young igneous rocks have intruded the Triassic rocks in the northern part of Montgomery County, and older igneous rocks are exposed in the southern end of the county. The younger igneous rocks occur as dikes and sills (tabular or sheetlike bodies), which were intruded into the Brunswick Formation. These intrusives are fine to medium-grained diabase. The older, Precambrian igneous rocks are coarse-grained granitic rocks. The total outcrop area of all igneous rocks in Montgomery County is small.

Water-bearing characteristics

Ground water in the igneous rocks occurs in the fracture systems that developed in these rocks after they solidified. Fractures in these igneous rocks are usually narrow and widely spaced and do not extend to great depths.

Well depths and yields

Only small yields can be expected from wells tapping the igneous rocks. Domestic supplies can be obtained, but some failures can be expected. If a significant amount of water has not been obtained at 200 feet it would be better to drill at another site. Below 100 feet very little water is obtained by wells in the diabase. Because the yields from these rocks are low, the spacing and location of wells is of little importance.

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Water quality

The quality of the water from the igneous rocks is generally good. Water from some wells in the Triassic diabase contained as much as 0.5 mg/1 iron. The total dissolved-solids content and hardness is low.

Metamorphic Rocks

Lithology and structure

The metamorphic rocks in Montgomery County consist of gneiss and schist. The upper surface of these rocks has been weathered and is soft, but at depth the rocks are dense and hard.

Water-bearing characteristics

Ground water is found in the fractures in the metamorphic rocks but the fractures are small and widely spaced, and they become smaller with depth.

Well depths and yields

The metamorphic rocks are poor sources of water. The amount of water yielded to wells is small, on the order of 1 or 2 gpm, and many failures have occurred. If a significant amount of water has not been obtained at 300 feet it would be better to redrill at another site. Yields of 50 gpm have been obtained from a few wells in the metamorphic rocks.

Water quality

The quality of water in metamorphic rocks differs considerably from place to place. In some areas water in these rocks is very highly mineralized and is not used. Chemical analyses of ground water in Montgomery County are presented in Table 7.

SURFACE-WATER BODIES

Montgomery County is on the drainage divide between the Delaware River and the Schuylkill River. The largest tributary to the Schuylkill in Montgomery County is Perkiomen Creek, which drains the northern half of the county. Unami Creek, Skippack Creek, and Swamp Creek are tributaries of Perkiomen Creek. Wissahickon Creek drains

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the southern part of the county. The southeastern part is drained by streams that flow into the Delaware River above the Schuylkill River.

Green Lane Reservoir, near the headwaters of Perkiomen Creek, is the largest impoundment in Montgomery County and is operated by the Philadelphia Suburban Water Company. Two proposed reservoirs on Skippack Creek and East Branch of Perkiomen Creek would supply water to the central part of the county. A proposed reservoir on Unami Creek near the Bucks County line would also supply water to central Montgomery County.

HOW MAN HAS CHANGED THE HYDROLOGIC SYSTEM

PRESENT STATUS OF DEVELOPMENT

The hydrologic system in Montgomery County began to change early in the life of the area. Initially, homes were located near readily available water supplies, such as streams and springs. For several reasons, shallow wells soon supplanted these sources: increased population along streams caused pollution; many streams dried up in the summer; high water usually carried a heavy sediment load; and people wished to build homes farther from streams. Eventually, almost every house had a shallow dug well from which water was withdrawn from the upper few feet of the aquifer. As the population increased, many individually-owned wells were abandoned, and public-supply wells were installed. These public-supply wells were, in most cases, drilled wells that pumped water from deep aquifers. Also, several springs were developed for use in the municipal systems. Pollution of the shallow part of the ground-water reservoir by water from septic tanks eventually forced the abandonment of many more wells tapping the upper parts of the aquifers. These wells were replaced by deeper public-supply and industrial wells. As the demand for water increased, wells became concentrated and ground-water levels in the central part of the county started to decline. Waste water is still discharged to septic tanks in many of the housing developments, and pollution of the shallow part of the ground-water reservoir is serious. One means to reduce pollution from septic tanks is to install sanitary sewers in the suburban areas. This will, of course, increase runoff and reduce the recharge to the ground-water reservoir. Some additional lowering of the ground-water levels may result.

Where municipalities and industries are using surface water, they not only reduce the flow of the streams—they also raise the temperature of

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the water they return to the streams. Also, pollution is discharged into the streams in the form of sewage and industrial waste.

GROUND-WATER PUMPAGE

Several Montgomery County municipalities and urban developments use ground water for public supplies. The locations of these communities and other communities using surface water are shown in Figure 13, and ground-water pumpage is summarized in Table 5. Other municipalities in Montgomery County use ground water that comes from wells located in another county. The Philadelphia Suburban Water Company supplies water to several areas in the county, but not all of their supply is from ground water.

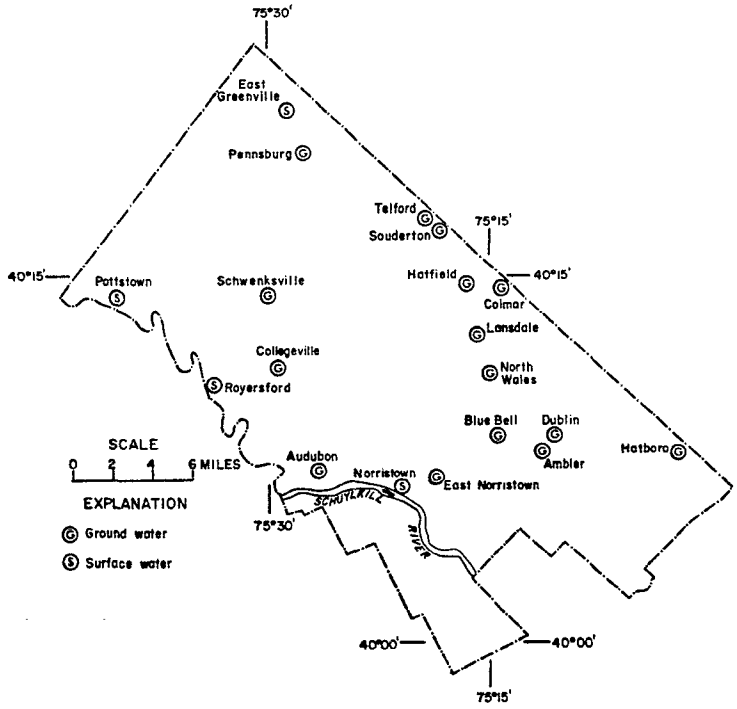

Figure 13. Locations of towns and sources of their water supply.

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It is reported that 4.7 mgd (million gallons per day) of ground water is pumped from the Stockton Formation in Montgomery County. Of this amount, 3.2 mgd is for public supply and 1.5 mgd is for industrial use. Total withdrawal of water from the Brunswick Formation in Montgomery County is estimated to be 11.5 mgd. The total pumpage from the other formations in the county is estimated to be 3.0 mgd.

Table 5. *Summary of ground-water pumpage for municipal and urban developments in Montgomery County, Pennsylvania*

Supplier	Number of wells	Number of springs	Average daily yield for 1967 in millions of gallons
Borough of Ambler	6	1	2.25
Audubon Water Co.	3	—	.09
Collegeville	4	—	.20
Dublin Water Co.	5	—	.09
East Greenville*	1	—	.17
East Norristown Water Co.	2	—	.01
Hatboro Borough	12	—	1.10
Hatfield Borough	4	—	.26
Hatfield Township Colman Water Co.	2	—	.04
Lansdale	17	—	1.75
North Wales Water Authority	4	—	4.0
Pennsburg	2	—	.36
Red Hill	—	1	.40
Schwenksville Water Co.	3	—	.07
Souderton	6	—	.36
Telford	3	—	.25
Whitpain Township Blue Bell Water Co.	4	—	.44

* also uses water from Perkiomen Creek.

Additional supplies of ground water could be developed in many parts of Montgomery County. A map of the county (Plate 1) shows typical yields of wells. Much of the area in the northern and western parts of the county, where moderate yields are obtained, could be developed further.

Data for 887 wells are listed in Table 6, and the location of selected wells are shown in Plate 2.

SURFACE-WATER PUMPAGE

Data from the Pennsylvania Public Utility Commission Rates and Research Bureau gives information on the use of surface water in Montgomery County. Three municipalities supply their own water. The rest

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Table 6. *Record of selected wells—Montgomery County, Pennsylvania*

Location number: First four numbers refer to degrees and minutes of latitude, second four numbers are degrees and minutes of longitude.
Method of construction: Drl, drilled.
Aquifer name: Trd, diabase; Trb, Brunswick Formation; Trl, Lockatong Formation; Trs, Stockton Formation; Ocs, Conestoga Limestone; Ce, Elbrook Formation; Cl, Ledger Dolomite; Ch, Harpers Formation; Cch, Chickies Quartzite; Xgn, Granite gneiss; Xs, Serpentine; Xw, Wissahickon Formation; Xhg, Hornblende gneiss.

Use: A, air-conditioning; D, domestic; I, industrial; Irr, irrigation; O, observation; PS, public supply; S, stock; T, test; U, unused; X, destroyed.
Remarks: CA, chemical analysis; NS, not shown on well-location map.

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
Mg 1	4013-7526	E. State Penitentiary	—	—	140	Dug	—	22	—	Trb	10-28-31	18	—	X	
2	4014-7539	Pottsgrove Manor	—	1752	158	Dug	48	30	—	Trb	10-28-47	28	—	O	
3	4014-7527	Gottfried Ott	—	—	170	Dug	48	29	—	Trb	10-27-47	19	—	U	
4	4011-7528	Collegeville - Trappe	Honenberger	1936	195	Drl	12-8	275	34	Trb	4-13-50	24	125	U	NS
													200-	PS	NS
5	4011-7528	do.	Kohl Bros.	1935	195	Drl	12-8	250	42	Trb	10-31-35	15	240		
6	4011-7528	do.	do.	1942	180	Drl	8	250	40	Trb	5- 6-48	15	150	PS	
7	4011-7528	do.	do.	1947	190	Drl	8	367	6	Trb	9- 2-47	40	125	U	NS
8	4011-7528	do.	do.	1947	210	Drl	8-6	357	41	Trb	12-28-47	26	148	PS	CA
9	4007-7513	Ambler Boro	—	1924	125	Drl	10	65	—	Cl	—	Flow	450	PS	CA
10	4009-7512	do.	Bollinger	1931	280	Drl	10	210	30	Trs	—	37	165	PS	CA, NS
11	4009-7512	do.	Ridpath & Potter	1942	280	Drl	10	300	45	Trs	—	40	380	PS	CA
12	4007-7513	do.	do.	1947	160	Drl	12	300	51	Cl	—	26	850	PS	CA
13	4008-7518	E. Norristown	Parente	1923	245	Drl	8	138	24	Trs	—	Flow	40	PS	
14	4008-7518	do.	do.	1927	245	Drl	8	118	31	Trs	3-10-47	30	30	PS	
15	4008-7519	George Ruth	—	1926	200	Drl	6	73	—	Trs	10-14-52	20	—	U	
16	4007-7522	C. K. Gennaria	—	1910	240	Drl	6	130	—	Trs	10-14-52	21	—	U	
17	4008-7521	Norristown State Hospital	—	—	250	Drl	10	410	—	Trs	9- 8-48	170	100	U	
18	4008-7521	do.	—	—	248	Drl	10	372	—	Trs	10- 6-49	160	120	U	NS
19	4008-7521	do.	—	—	242	Drl	10	382	—	Trs	10- 7-48	156	100	PS	NS
20	4008-7521	do.	—	—	248	Drl	8	474	—	Trs	10- 5-48	160	120	PS	CA
Mg 21	4008-7521	Norristown State Hospital	—	—	250	Drl	8	486	—	Trs	10-15-48	147	120	U	
22	4008-7521	do.													

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11	4009-7514	do.	Ridpath & Potter	1942	280	Drl	10	300	45	Trs	—	10	300	15				
12	4007-7513	do.	do.	1947	160	Drl	12	300	51	Cl	—	26	850	PS	CA			
13	4008-7518	E. Norristown	Parente	'23	245	Drl	8	138	24	Trs	—	Flow	40	PS				
14	4008-7518	do.	do.	27	245	Drl	8	118	31	Trs	3-10-47	30	30	PS				
15	4008-7519	George Ruth	—	1926	200	Drl	6	73	—	Trs	10-14-52	20	—	U				
16	4007-7522	C. K. Gennaris	—	1910	240	Drl	6	130	—	Trs	10-14-52	21	—	U				
17	4008-7521	Norristown State Hospital	—	—	250	Drl	10	410	—	Trs	9- 8-48	170	100	U				
18	4008-7521	do.	—	—	248	Drl	10	372	—	Trs	10- 6-49	160	120	U	NS			
19	4008-7521	do.	—	—	242	Drl	10	382	—	Trs	10- 7-48	156	100	PS	NS			
20	4008-7521	do.	—	—	248	Drl	8	474	—	Trs	10- 5-48	160	120	PS	CA			
Mg 21	4008-7521	Norristown State Hospital	—	—	250	Drl	8	486	—	Trs	10-15-48	147	170	U				
22	4008-7521	do.	—	—	248	Drl	8	484	—	Trs	10- 6-48	150	136	PS	CA			
23	4008-7521	do.	—	—	245	Drl	10	401	—	Trs	—	140	170	X	NS			
24	4008-7521	do.	—	—	180	Drl	8	277	—	Trs	—	61	110	X	CA, NS			
25	4008-7520	do.	—	—	180	Drl	8	321	—	Trs	10-15-52	78	192	U	NS			
26	4008-7520	do.	—	—	179	Drl	12	454	20	Trs	9-23-48	83	100	PS				
27	4008-7520	do.	—	1936	131	Drl	12	310	19	Trs	9-24-48	33	390	U	NS			
28	4008-7520	do.	Artesian Well Co.	1949	135	Drl	12	300	60	Trs	—	4	350	PS	CA			
29	4008-7520	do.	do.	1949	151	Drl	12	351	76	Trs	—	9	375	PS	NS			
30	4007-7521	Norristown Brick Co.	—	1910	200	Drl	6	55	—	Trs	10-15-52	44	—	U	NS			
31	4007-7521	do.	Parente Bros.	1925	200	Drl	6	70	—	Trs	—	40	10	I				
32	4007-7521	Stroehman Bros.	—	1927	135	Drl	6	100	—	Trs	1940	30	40	U	NS			
33	4007-7521	Hannaway & Gordon	—	1925	138	Drl	6	235	—	Trs	10- 6-52	40	35	I	CA			
34	4007-7521	do.	—	1936	138	Drl	8	255	—	Trs	1949	40	60	I	NS			
35	4007-7520	Adam Scheidt Brewing Co.	—	1920	100	Drl	8	325	—	Trs	—	21	30	I	CA			
36	4007-7520	do.	F. L. Bollinger	1930	80	Drl	10	600	—	Trs	—	10	40	I	CA, NS			
37	4007-7520	do.	do.	1931	90	Drl	12	205	—	Trs	—	12	120	I	CA			
38	4007-7520	do.	do.	1937	80	Drl	8	151	—	Trs	10-21-52	23	20	U	NS			
39	4006-7520	Zarcone Market	Parente Bros.	1933	75	Drl	6	172	—	Trs	—	—	8	U				
40	4005-7519	International Paper Co.	Ridpath & Potter	1949	55	Drl	6	250	24	Cl	2-12-49	10	22	U	NS			
41	4006-7519	Allen Iron & Steel Co.	—	—	55	Drl	6	210	—	Cl	—	—	—	I				
42	4006-7519	W. A. Case & Son Mfg.	—	1900	55	Drl	36	16	—	Cl	10-16-52	Dry	—	U	NS			
43	4006-7519	do.	—	1935	55	Drl	6	80	—	Cl	4- 9-52	12	—	U	NS			
44	4006-7519	Pittsburgh Screw & Bolt	—	1915	100	Drl	6	75	—	Trs	10-21-52	40	165	O				
45	4005-7519	National Cylinder Gas Co.	F. L. Bollinger	1937	—	Drl	8	280	—	Ocs	—	4	115	I				
46	4012-7516	North Wales Water Co.	—	1888	440	Drl	6	500	—	Trl	—	—	—	U	NS			
47	4012-7516	do.	Samuel Marwin	1888	389	Drl	8	129	20	Trb	—	—	—	U	NS			
48	4012-7516	do.	Raun and Co.	1893	390	Drl	8	104	20	Trb	—	—	—	U				
49	4012-7516	do.	Ridpath & Potter	1906	391	Drl	8	158	45	Trb, Trl	—	—	100	U	CA			
50	4012-7516	do.	do.	1922	355	Drl	10	448	350	Trb	—	—	—	U	NS			
51	4012-7516	do.	do.	1909	400	Drl	8	800	40	Trl	—	—	—	U	NS			
52	4012-7516	do.	do.	—	350	Drl	8	350	30	Trb, Trl	—	—	80	PS	CA			
53	4012-7516	do.	F. L. Bollinger	1928	388	Drl	8	350	—	Trb	—	—	30	U	NS			
54	4012-7516	do.	do.	1910	392	Drl	18	500	—	Trl	—	—	—	U	NS			
55	4012-7517	do.	—	1929	328	Drl	10	300	77	Trb	—	—	240	PS	NS			
56	4012-7517	do.	—	1945	320	Drl	14-10	384	72	Trb	4-23-45	0	240	PS				
57	4013-7517	Martin Century Farms	Parente Bros.	1929	320	Drl	8	201	30	Trb	6-20-46	45	90	I				
58	4013-7518	do.	do.	1930	322	Drl	8	225	30	Trb	6-21-46	86	95	I	NS			

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Table 6. *Record of selected wells—Montgomery County, Pennsylvania*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
59	4013-7518	do.	do.	1934	320	Drl	8	198	30	Trb	6-25-46	53	53	I	NS
60	4014-7516	Lansdale Boro	—	1883	366	Drl	8	312	80	Trb	—	92	35	PS	
61	4014-7516	do.	—	1892	366	Drl	8	392	—	Trb	8- 6-54	79	8	U	NS
62	4014-7516	do.	—	1903	366	Drl	8	388	22	Trb	8- 6-54	76	8	U	CA, NS
63	4014-7516	do.	—	1908	366	Drl	8	400	120	Trb	3- 1-43	78	18	U	CA, NS
64	4014-7516	do.	—	1910	366	Drl	8	1108	18	Trb	11- 4-54	83	8	U	CA
65	4014-7516	do.	—	1911	376	Drl	8	436	34	Trb	11-14-54	80	—	U	NS
66	4014-7516	do.	F. L. Bollinger	1922	376	Drl	8	378	—	Trb	3- 1-47	92	80	U	NS
67	4014-7517	do.	do.	1923	328	Drl	8	292	—	Trb	3- 1-47	132	57	PS	NS
68	4014-7517	do.	do.	1927	322	Drl	8	500	250	Trb	1-31-47	83	79	PS	
69	4014-7517	do.	William Stothoff	1935	328	Drl	12- 8	264	40	Trb	1-31-47	73	39	PS	NS
70	4014-7516	do.	do.	1937	421	Drl	10- 8	391	36	Trb	1-31-47	84	139	PS	
71	4014-7516	Lansdale Boro	William Stothoff	1939	407	Drl	12- 8	285	43	Trb	1-31-47	70	120	PS	
72	4014-7516	do.	do.	1941	353	Drl	16-10	306	44	Trb	3- 1-47	42	128	PS	NS
73	4013-7515	do.	do.	1944	371	Drl	14-10	525	45	Trb	3- 1-47	46	300	PS	
74	4014-7515	do.	do.	1948	403	Drl	12-10	546	—	Trb	2-24-48	48	50	U	NS
75	4014-7515	do.	do.	1948	384	Drl	12-10	399	40	Trb	9-17-48	57	175	PS	
76	4013-7516	do.	do.	1949	341	Drl	12-10	388	37	Trb	7-18-49	23	240	PS	CA
77	4013-7516	do.	do.	1951	354	Drl	12-10	404	—	Trb	7- 3-51	30	250	PS	NS
78	4014-7515	do.	do.	1951	375	Drl	16-12	430	41	Trb	10-31-52	126	150	PS	
79	4014-7517	Lansdale Electric	Alexander	—	350	Drl	8	279	—	Trb	1-14-54	109	20	I	NS
80	4014-7517	Lansdale Power Plant	Bollinger	1928	325	Drl	8	320	—	Trb	1946	60	80	I	
81	4014-7517	do.	do.	1936	340	Drl	8	350	—	Trb	1946	45	60	I	NS
82	4015-7517	Lansdale Sewage Plant	do.	1933	310	Drl	8	375	—	Trb	1947	20	18	I	NS
83	4015-7517	Lansdale Forest Products	do.	1934	330	Drl	8	425	—	Trb	11- 8-52	74	—	U	NS
84	4015-7517	do.	do.	1947	330	Drl	8- 6	231	—	Trb	—	63	11	I	
85	4014-7517	Lansdale Ice & Storage	—	—	360	Drl	8	615	—	Trb	11-18-52	66	—	U	NS
86	4014-7517	do.	—	1900	355	Drl	8	300	—	Trb	11-18-52	60	—	U	NS
87	4014-7517	do.	Shaw	1921	350	Drl	6	305	—	Trb	1946	60±	35	I	NS

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78	4014-7515	do.	do.	1951	375	Drl	16-12	430	41	Trb	10-31-52	126	150	PS	
79	4014-7517	Lansdale Electric	Alexander		350	Drl	8	279	—	Trb	1-14-54	109	20	I	NS
80	4014-7517	Lansdale Power Plant	Bollinger	3	325	Drl	8	320	—	Trb	1946	60	80	I	
81	4014-7517	do.	do.	1936	340	Drl	8	350	—	Trb	1946	45	60	I	NS
82	4015-7517	Lansdale Sewage Plant	do.	1933	310	Drl	8	375	—	Trb	1947	20	18	I	NS
83	4015-7517	Lansdale Forest Products	do.	1934	330	Drl	8	425	—	Trb	11- 8-52	74	—	U	NS
84	4015-7517	do.	do.	1947	330	Drl	8- 6	231	—	Trb	—	63	11	I	
85	4014-7517	Lansdale Ice & Storage	—	—	360	Drl	8	615	—	Trb	11-18-52	66	—	U	NS
86	4014-7517	do.	—	1900	355	Drl	8	300	—	Trb	11-18-52	60	—	U	NS
87	4014-7517	do.	Shaw	1921	350	Drl	6	305	—	Trb	1946	60±	35	I	NS
88	4014-7517	do.	Bollinger	1936	355	Drl	10	450	—	Trb	1946	60±	40	I	
89	4013-7516	Lansdale Tube Co.	Philadelphia Drill Co.	1949	382	Drl	8	400	40	Trb	9-20-49	50	96	I	
90	4013-7517	do.	do.	1951	375	Drl	8	500	46	Trb	1-17-51	57	165	I	NS
91	4014-7538	Joseph Prince	—	1913	190	Drl	6	299	—	Trb	10-23-52	59	—	U	NS
92	4014-7538	Schulz Baking Co.	—	1932	190	Drl	8	242	—	Trb	11- 1-44	70	150	I	
93	4015-7538	Raymond Nester	—	1916	165	Drl	6	150	—	Trb	—	—	76	I	
94	4014-7538	Clover Leaf Dairy	Penrose Keller	1926	175	Drl	6	125	—	Trb	—	—	—	I	NS
95	4015-7538	do.	do.	1928	170	Drl	6	125	—	Trb	—	—	—	I	NS
96	4014-7538	Clover Leaf Dairy	C. S. Garber	1935	160	Drl	8	276	—	Trb	1947	55	50	I	
97	4014-7538	Pottstown Cold Storage	Groff	1937	150	Drl	8	250	100	Trb	6-17-47	20	125	I	NS
98	4014-7538	do.	Kohl	1938	150	Drl	8	800	120	Trb	6-17-47	20	140	I	
99	4014-7538	Pottstown Plating Inc.	C. S. Garber	1943	135	Drl	8	230	40	Trb	1950	24	115	I	NS
100	4014-7538	do.	do.	1951	135	Drl	8	545	40	Trb	8-1951	45	210	I	
101	4014-7538	Doehler & Jarvic Corp.	Penrose Keller	—	150	Drl	8	90	—	Trb	6- 3-55	51	—	O	NS
102	4014-7538	do.	Joseph Smith	1936	155	Drl	8	300-320	—	Trb	6- 2-55	53	—	U	NS
103	4014-7538	do.	do.	1937	155	Drl	8	300-320	—	Trb	—	—	72	I	
104	4014-7538	do.	do.	1937	155	Drl	8	300-320	—	Trb	—	—	48	I	NS
105	4014-7538	do.	do.	1938	155	Drl	8	300-320	—	Trb	—	—	71	I	NS
106	4014-7538	do.	do.	1940	155	Drl	8	300-320	—	Trb	—	—	59	I	NS
107	4014-7538	Minn.-Honeywell Co.	C. S. Garber	1933	145	Drl	8	300	—	Trb	—	—	220	I	NS
108	4014-7538	Philadelphia Dry Cleaners	Joseph Smith	1930	150	Drl	6	199	60	Trb	1950	18	60	I	
109	4014-7539	Vaughn Knitting Co.	—	1910	—	Drl	48	20	20	Trb	—	10	10	I	NS
110	4014-7541	Pottstown Cement Block	C. S. Garber	1941	170	Drl	8	112	—	Trb	1941	15	15	I	NS
111	4014-7541	Pottstown Metal Products	do.	1941	165	Drl	6	219	—	Trb	—	34	90	I	CA
112	4014-7541	do.	Charles Merritt	1951	165	Drl	6	120	—	Trb	—	34	9	I	NS
113	4015-7540	Joseph Fazekas	—	1920	245	Dug	36	25	—	Trb	10-23-52	7	—	U	
114	4013-7531	Leo Arena Market	—	1900	290	Dug	24	36	—	Trb	10-22-52	30	—	U	
115	4016-7536	Ringing Rock Park	—	1900	470	Drl	6	90	—	Trd	—	—	3	PS	
116	4016-7536	do.	Samuel Garber	1944	470	Drl	6	175	—	Trd	—	—	4	D	
117	4006-7519	Rambo & Reager Inc.	—	1900	—	Dug	96	51	—	Trs	7-20-53	13	—	U	
118	4008-7513	Cruse Kemper	—	—	—	Drl	4	75	—	Trb	8-28-55	13	—	U	NS
119	4009-7513	Keasby & Matteson	—	1910	190	Drl	8	234	234	Trs	—	17	100	I	CA
120	4010-7506	Hatboro Theater	Ridpath & Potter	1937	—	Drl	8	272	11	Trs	7-21-53	37	—	U	NS
121	4013-7517	E. C. Geiger	—	1909	—	Drl	6	100	—	Trb	11-30-53	72	40	I	NS
122	4013-7517	Sharpe & Dohme	—	1915	370	Drl	8	285	—	Trb	—	40	75	I	
123	4012-7518	Mark, Sharpe & Dohme	F. L. Bollinger	1942	362	Drl	10-6	502	—	Trb, Trl	5-14-51	34	15	U	NS
124	4012-7517	do.	C. W. Lauman	1949	329	Drl	12	300	—	Trb	—	—	350	I	NS
125	4012-7518	do.	do.	—	357	Drl	12	300	—	Trb	—	—	140	I	

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
126	4012-7517	do.	do.	—	338	Drl	12	241	—	Trb	5-14-51	167	150	I	NS
127	4013-7518	do.	do.	—	351	Drl	12-10	300	—	Trb	11- 3-53	53	130	O	NS
128	4013-7518	do.	do.	—	352	Drl	12-10	300	—	Trb	11- 3-53	58	395	I	
129	4012-7518	do.	do.	1949	359	Drl	12-10	269	—	Trb	11- 3-53	59	30	U	NS
130	4013-7517	do.	do.	1949	339	Drl	12-10	300	16	Trb	11- 3-53	66	320	I	
131	4001-7518	Shipley School	—	—	—	Dug	45	20	—	Xhg	6-19-53	23	—	D	
132	4000-7517	Autocar Co.	—	—	—	Drl	8	300	—	Xw	6-25-53	14	—	U	
133	4001-7518	Bryn Mawr Hotel	—	—	—	Drl	10	254	—	Wx	11- 6-33	18	—	I	
134	4015-7517	Werner Foundry & Mach.	Pat Flaherty	1920	323	Drl	6	85	—	Trb	—	—	—	A	NS
135	4013-7517	Lansdale Tube Co.	Phila. Drilling Co.	1953	370	Drl	12-8-6	500	—	Trb	8-17-53	85	150	I	
136	4014-7515	Institute of Blind	—	—	435	Dug	24	23	24	Trb	2-25-54	19	—	U	NS
137	4014-7516	Interstate Hosiery	—	—	365	Drl	—	—	—	Trb	—	—	—	U	NS
138	4014-7516	do.	—	—	370	Drl	10	—	—	Trb	—	—	50	I	NS
139	4014-7516	do.	—	—	370	Drl	—	—	—	Trb	—	—	70	I	
140	4013-7518	Martin Century	William Stothoff	1954	293	Drl	8	237	30	Trb	2-25-59	17	200	I	
141	4014-7516	Institute of Blind	—	—	435	Drl	6	—	—	Trb	—	—	—	X	NS
142	4014-7518	Lansdale Borough	William Stothoff	1953	310	Drl	12	500	41	Trb	—	19	50	PS	NS
143	4014-7518	do.	do.	1953	295	Drl	12	400	30	Trb	6- 9-59	8	250	PS	
144	4014-7517	Anadale Corp.	—	—	—	Drl	8	198	6	Trb	2-27-41	84	6.3	I	
145	4009-7513	Ambler Borough	Bollinger	1953	200	Drl	10	305	71	Trs	—	—	114	U	CA
146	4019-7519	Telford Borough	Ridpath and Potter	1928	420	Drl	10	205	35	Trb	9-16-56	90	190	PS	CA
147	4013-7516	Lansdale Tube Co.	Phila. Drilling Co.	1953	370	Drl	8	500	—	Trb	8-26-54	85	150	I	
148	4012-7528	Collegeville - Trappe	Kohl Bros.	1954	225	Drl	8	373	33	Trb	8- 4-54	8.3	150	PS	CA
149	4014-7517	Institute of Blind	—	1954	430	Drl	8	83	—	Trb	7- 2-54	17	—	U	NS
150	4014-7517	J. W. Rex Co.	Bollinger	1954	320	Drl	10	403	—	Trb	8- 5-54	70	58	I	NS
151	4013-7516	Lansdale Tube Co.	Phila. Drilling Co.	1954	365	Drl	8	500	78	Trb	11- 6-54	100	195	I	NS
152	4015-7516	American Encaustic Tile	—	1929	365	Drl	8	203	25	Trb	1954	98	60	I	NS
153	4015-7516	do.	—	1954	365	Drl	10	400	—	Trb	1954	101	80	I	
154	4014-7517	Arcadia Hosiery	Scazetts	1934	353	Drl	6	193	30	Trb	1934	85	20	I	NS
155	4015-7516	Penndale Inc.	Ridpath & Potter	1954	367	Drl	8	600	30	Trb	—	85	30	I	NS
156	4015-7517	Perkins Glue Co.	—	1909	340	Drl	6	206	—	Trb	1909	30	40	I	NS
157	4015-7517	F. M. Weaver Co.	Bollinger	1950	315	Drl	8	285	47	Trb	1950	50	115	I	
158	4015-7517	do.													

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145	4009-7513	Amofer Borough	[illegible]	1928	420	Drl	10	205	35	Trb	9-16-56	90	190	PS	CA
146	4019-7519	Telford Borough	Ridpath and Potter	195[illegible]	370	Drl	8	500	—	Trb	8-26-54	85	150	I	
147	4013-7516	Lansdale Tube Co.	Phila. Drilling Co.	19[illegible]	5	Drl	8	373	33	Trb	8- 4-54	8.5	150	PS	CA
148	4012-7528	Collegeville - Trappe	Kohl Bros.	195[illegible]	30	Drl	8	83	—	Trb	7- 2-54	17	—	U	NS
149	4014-7517	Institute of Blind	—	1954	320	Drl	10	403	—	Trb	8- 5-54	70	58	I	NS
150	4014-7517	J. W. Rex Co.	Bollinger	1954	365	Drl	8	500	78	Trb	11- 6-54	100	195	I	NS
151	4013-7516	Lansdale Tube Co.	Phila. Drilling Co.	1929	365	Drl	8	203	25	Trb	1954	98	60	I	NS
152	4015-7516	American Encanstic Tile	—	1954	365	Drl	10	400	—	Trb	1954	101	80	I	
153	4015-7516	do.	—	1934	353	Drl	6	193	30	Trb	1934	85	20	I	NS
154	4014-7517	Arcadia Hosiery	Scazetts	1954	367	Drl	8	600	30	Trb	—	85	30	I	NS
155	4015-7516	Penndale Inc.	Ridpath & Potter												
156	4015-7517	Perkins Glue Co.	—	1909	340	Drl	6	206	—	Trb	1909	30	40	I	NS
157	4015-7517	F. M. Weaver Co.	Bollinger	1950	315	Drl	8	285	47	Trb	1950	50	115	I	
158	4015-7517	do.	do.	1920	317	Drl	6	100	—	Trb	1950	Dry	—	U	NS
159	4015-7517	Nyce-Crete Co.	—	1940	325	Drl	6	—	—	Trb	—	—	—	U	NS
160	4015-7517	F. M. Weaver	—	—	325	Drl	—	—	—	Trb	—	—	—	U	NS
161	4014-7517	Dexdale Hosiery	Bollinger	—	340	Drl	6	201	30	Trb	2-22-54	125	21	I	NS
162	4014-7517	do.	do.	1935	340	Drl	10	761	30	Trb	—	—	45	I	NS
163	4014-7517	do.	do.	1947	340	Drl	8	301	30	Trb	—	—	15	I	NS
164	4014-7517	do.	do.	1947	342	Drl	8	405	30	Trb	—	—	18	I	NS
165	4014-7517	K & K Laundry Co.	Weley	1939	335	Drl	8	400	—	Trb	1946	90	75	I	
166	4014-7517	do.	—	—	335	Drl	6	147	—	Trb	—	—	5	U	NS
167	4012-7516	Leeds & Northrup Co.	Ridpath & Potter	1954	350	Drl	16-10	288	44	Trb	1960	48	200	I	CA
168	4013-7517	do.	—	—	358	Drl	8	126	—	Trb	1947	10	100	I	NS
169	4012-7517	do.	Ridpath & Potter	1954	336	Drl	4	175	—	Trb	—	—	—	U	CA, NS
170	4014-7517	Tritzel Bakery	—	19[illegible]	—	Drl	6	350	—	Trb	—	—	14	U	NS
171	4013-7517	Precision Tubes	Phila. Drilling Co.	1952	—	Drl	8	500	40	Trb	10-12-54	117	—	I	
172	4012-7517	King Foundries	Schroeder	1917	345	Drl	6	105	—	Trb	—	—	10	I	
173	4013-7516	Kleen Products	—	1920	—	Drl	6	90	20	Trb	10-12-54	Dry	—	U	NS
174	4013-7516	do.	L. G. Findly	1950	348	Drl	6	144	34	Trb	4- 8-50	25	36	I	NS
175	4013-7516	do.	—	—	358	Drl	6	160	—	Trb	10-12-54	Dry	—	U	NS
176	4013-7518	Sam Scott	Pat Flaherty	1941	352	Drl	8	94	12	Trb	1941	28	10	D	
177	4013-7518	Ellis L. Stump	do.	1941	350	Drl	8	96	—	Trb	1950	32	10	D	
178	4013-7516	N. Wales Foundry	—	1945	360	Drl	6	140	—	Trb	11- 8-50	92	10	I	NS
179	4012-7516	Leeds & Northrup	Ridpath & Potter	—	358	Drl	8	126	60	Trb, Trl	1947	10	100	U	NS
180	4013-7517	do.	do.	1954	325	Drl	6	250	—	Trb	11- 2-54	65	100	U	NS
181	4013-7517	Lansdale Brick Prod.	—	—	372	Drl	6	88	—	Trb	—	Dry	—	U	NS
182	4014-7515	Sanford Ulmer	H. L. Gorges	1954	430	Drl	6	125	24	Trb	11- 9-54	70	12	D	NS
183	4014-7515	do.	do.	1954	430	Drl	6	125	24	Trb	11- 9-54	72	10	D	NS
184	4014-7515	do.	do.	1953	440	Drl	6	180	24	Trb	11- 9-54	75	10	D	
185	4014-7516	Music Hall Theatre	—	1948	355	Drl	—	365	—	Trb	—	—	165	X	NS
186	4016-7515	Link-Belt	—	1952	270	Drl	—	300	—	Trb	—	—	85	I	CA
187	4016-7515	do.	A. J. Nicholas	1952	270	Drl	—	300	—	Trb	—	—	60	I	NS
188	4016-7515	do.	—	1952	270	Drl	—	300	—	Trb	—	—	105	I	
189	4016-7517	Hatfield Borough	—	1933	320	Drl	14	200	40	Trb	8-16-33	13	125	PS	CA
190	4016-7518	do.	J. T. Campbell	1928	350	Drl	8	202	36	Trb	—	—	150	PS	CA
191	4017-7517	do.	Wm. Stothoff	—	345	Drl	—	494	—	Trb	—	—	—	PS	
192	4015-7518	Hendricks Dairy	do.	1946	322	Drl	10	352	10	Trb	—	—	50	I	NS
193	4015-7518	do.	—	1927	325	Drl	6	102	—	Trb	1946	49	10	I	
194	4015-7517	Edward Hilpert	—	1936	325	Drl	6	100	—	Trb	11-10-54	10	15	D	NS
195	4015-7517	do.	—	1952	325	Drl	6	75	40	Trb	11-10-54	12	30	Irr.	

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
196	4015-7517	Edward Hilpert	—	—	325	Drl	6	118	—	Trb	11-10-54	14	20	U	NS
197	4016-7519	Hatfield Packing Co.	—	—	295	Drl	6	181	—	Trb	1946	15	55	I	
198	4016-7519	do.	Parente Bros.	1947	300	Drl	—	200	—	Trb	—	—	60	I	
199	4015-7514	L. Weiss & Sons	—	1926	395	Drl	8	54	—	Trb	1926	15	35	I	
200	4016-7517	Hatfield Borough	—	—	320	Drl	6	115	25	Trb	—	15	35	I	
201	4009-7505	A. F. DeLang	Wiley & Buhler	1947	—	Drl	8	141	80	Trs	1947	40	2	D	
202	4013-7516	Lansdale Municipal	Wm. Stothoff	1955	350	Drl	12	647	—	Trb	1-19-55	54	282	PS	NS
203	4012-7517	N. Wales Water Authority	Kohl Bros.	1955	315	Drl	8	450	27	Trb	1-17-55	12	210	PS	
204	4013-7517	Precision Tube Co.	Phila. Drilling Co.	1955	365	Drl	8	500	—	Trb	5-19-55	52	190	I	NS
205	4010-7515	N. Wales Water Authority	Kohl Bros.	1956	245	Drl	12-10	318	—	Trs	—	Flow	300	PS	CA
206	4007-7527	Deltra Flag Co.	—	—	120	Drl	6	80	—	Trs	—	—	15	I	NS
207	4007-7527	do.	Kohl	1946	120	Drl	6	374	—	Trs	—	—	55	I	NS
208	4011-7508	U. S. Naval Air Station	—	—	330	Drl	6	82	—	Trs	—	11	—	U	NS
209	4012-7508	do.	—	1942	310	Drl	—	396	—	Trs	—	48	100	PS	CA, NS
210	4012-7508	do.	—	1942	310	Drl	—	—	—	Trs	—	—	180	PS	CA
211	4010-7506	Hatboro Authority	—	1900	250	Drl	—	—	—	Trs	—	—	120	PS	CA, NS
212	4010-7506	do.	—	—	250	Drl	—	—	—	Trs	—	—	200	PS	CA
213	4010-7506	do.	—	—	250	Drl	—	—	—	Trs	—	—	145	PS	CA, NS
214	4010-7505	do.	Wm. Stothoff	1944	315	Drl	—	400	—	Trs	—	—	—	U	CA, NS
215	4010-7505	do.	do.	1946	240	Drl	—	400	—	Trs	—	—	35	U	NS
216	4011-7506	do.	do.	1947	225	Drl	—	297	—	Trs	—	—	227	PS	CA
217	4010-7506	do.	Ridpath & Potter	1948	220	Drl	—	101	—	Trs	—	—	170	PS	CA
218	4011-7506	do.	William Stothoff	1952	225	Drl	—	306	—	Trs	—	—	160	PS	CA, NS
219	4011-7506	do.	do.	1953	217	Drl	14-10	—	40	Trs	—	—	—	PS	CA
220	4010-7506	do.	Ruian & Cook	1955	225	Drl	—	400	42	Trs	—	—	70	PS	CA
221	4011-7532	Kresley Bleach & Dye	Kohl Bros.	1941	130	Drl	8	449	22	Trb	—	—	80	U	NS
222	4011-7532	do.	do.	1941	130	Drl	8	251	28	Trb	—	23	135	I	
223	4013-7517	Leeds & Northrup	Ridpath & Potter	1955	332	Drl	10	350	—	Trb	1955	49	316	I	NS
224	4013-7517	Tyson Shirt Co.	—	—	70	Drl	6	250	—	Trs	—	—	—	X	NS
225	4008-7521	Norristown State Hospital	Nicholas	1950	165	Drl	12	300	—	Trs	8-15-56	45	75	U	

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214	4010-7505	do.	do.	1946	240	Drl	—	400	—	Trs	—	—	55	U	NS
215	4010-7505	do.	do.		225	Drl	—	297	—	Trs	—	—	227	PS	CA
216	4011-7506	do.	Ridpath & Potter		220	Drl	—	101	—	Trs	—	—	170	PS	CA
217	4010-7506	do.	William Stothoff	[illegible]	225	Drl	—	306	—	Trs	—	—	160	PS	CA, NS
218	4011-7506	do.	do.	1953	217	Drl	14-10	—	40	Trs	—	—	—	PS	CA
219	4011-7506	do.	Rulan & Cook	1955	225	Drl	—	400	42	Trs	—	—	70	PS	CA
220	4010-7506	do.	Kohl Bros.	1941	130	Drl	8	449	22	Trb	—	—	80	U	NS
221	4011-7532	Kresley Bleach & Dye	do.	1941	130	Drl	8	251	28	Trb	—	23	135	I	
222	4011-7532	do.	Ridpath & Potter	1955	332	Drl	10	350	—	Trb	1955	49	316	I	NS
223	4013-7517	Leeds & Northrup													
224	4013-7517	Tyson Shirt Co.	—	—	70	Drl	6	250	—	Trs	—	—	—	X	NS
225	4008-7521	Norristown State Hospital	Nicholas	1950	165	Drl	12	300	—	Trs	8-15-56	45	75	U	
226	4007-7520	Tyson Shirt Co.	—	—	70	Drl	—	250	—	Trs	—	—	—	A	NS
227	4007-7521	Elmer Clemson & Son	Elmer Lauhman	1939	190	Drl	6	80	20	Trs	—	20	20	I	
228	4007-7521	Walt Warehouse	—	1940	65	Drl	8	—	—	Trs	—	—	150	U	NS
229	4007-7521	Perfection Bakery	Kocker Bros.	1939	96	Drl	6	90	—	Trs	—	—	—	U	
230	4009-7517	Blue Bell Water Works	Ridpath & Potter	1953	336	Drl	12-10-8	250	89	Trs	11- 8-55	18	400	PS	CA
231	4009-7516	Maurice J. Potter	do.	1953	340	Drl	16	—	—	Trs	—	—	—	D	NS
232	4009-7516	A. B. Jervis	F. L. Bollinger	1938	350	Drl	6	150	150	Trs	—	—	—	D	NS
233	4008-7516	Robert G. Frozer	—	—	350	Drl	6	100	—	Trs	—	—	10	D	
234	4009-7516	C. V. Blagden	—	1900	305	Dug	36	25	25	Trs	11- 8-55	6	—	D	NS
235	4009-7516	C. V. Blagden	F. L. Bollinger	1950	305	Drl	6	124	—	Trs	—	60	—	D	
236	4008-7516	Thomas Fleming	do.	1953	340	Drl	—	110	—	Trs	—	—	—	D	
237	4008-7516	C. W. Barclay	—	—	340	Drl	6	100	—	Trs	—	—	—	D	NS
238	4010-7517	F. W. Young	—	1930	275	Drl	6	78	—	Trs	—	—	—	D	NS
239	4010-7517	B. L. Herbert	—	1930	275	Drl	—	90	—	Trs	—	15	—	D	
240	4010-7517	F. T. Hoffman	—	1945	285	Drl	6	74	—	Trs	—	—	—	D	NS
241	4010-7516	Gwynllan Valley	—	—	315	Drl	6	175	—	Trs	—	—	20	D, S	NS
242	4010-7516	do.	Parente	1950	315	Drl	6	182	—	Trs	—	—	9	D, S	NS
243	4010-7516	do.	—	1925	345	Drl	6	175	—	Trs	—	45	10	D	
244	4010-7516	do.	—	—	340	Drl	—	—	—	Trs	—	—	10	D, S	NS
245	4010-7516	do.	—	—	280	Drl	—	50	—	Trs	—	—	50	D, S	
246	4010-7516	Gwynllan Valley	—	—	325	Drl	6	180	—	Trs	—	—	—	D, S	NS
247	4010-7516	do.	—	—	325	Drl	6	200+	—	Trs	—	—	50	D, S	NS
248	4010-7516	do.	—	—	310	Drl	6	100+	—	Trs	1955	22	10	D	NS
249	4010-7516	do.	—	—	295	Drl	6	150	—	Trs	1955	81	10	D	
250	4010-7516	do.	—	—	335	Drl	6	180	—	Trs	—	—	10	D	NS
251	4011-7516	James C. Arthur	—	1949	315	Drl	6	—	—	Trs	—	—	10	D, S	
252	4011-7515	George D. Borda	Bollinger	1950	—	Drl	6	—	—	Trs	—	—	5	D	NS
253	4010-7516	Walter W. Pollock	—	—	—	Drl	6	200	—	Trs	—	—	10	D	
254	4011-7515	Thomas J. Hurley	—	1925	—	Drl	—	—	—	Trs	—	—	—	U	NS
255	4011-7515	do.	—	1953	255	Drl	6	93	—	Trs	—	—	10	D	
256	4011-7516	J. B. Haines	—	—	290	Dug	36	30	—	Trs	—	—	10	D	
257	4011-7517	C. W. MacMullen	George Lauman	1950	340	Drl	6	65	—	Trl	11- 9-55	22	10	D	
258	4011-7517	John F. Gerber	—	1948	385	Drl	6	80	—	Trl	—	—	10	D	NS
259	4008-7518	H. W. Care	Mathias	1900	210	Drl	6	100	—	Trs	—	25	10	D, S	
260	4008-7519	J. M. Coulston	C. W. Lauman	1951	235	Drl	6	100	—	Trs	—	—	20	I	
261	4009-7518	B & G Clark	—	1910	285	Drl	6	180	—	Trs	—	30	—	D	
262	4009-7518	Sunny Acres Dairy	Lauman	19[illegible]7	—	Drl	6	138	—	Trs	1954	20	120	I	

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
263	4009-7518	Charley Motor Court	O'Donnell	1948	—	Drl	8	115	—	Trs	11-10-55	43	—	U	
264	4009-7517	do.	—	1950	290	Drl	6	120	60	Trs	—	20	40	D, S	NS
265	4009-7517	do.	—	1950	290	Dug	24	28	—	Trs	—	—	—	U	NS
266	4009-7517	H. J. Copeland	C. Miller	1955	305	Drl	6	—	—	Trs	—	120	—	I	
267	4008-7517	James Almony	Bollinger	1951	275	Drl	6	80	—	Trs	1951	15	40	D	
268	4008-7517	Wm. E. Buehler	—	1925	250	Drl	6	—	—	Trs	—	—	5	D	
269	4008-7515	Wings, Inc.	—	1937	305	Drl	6	195	—	Trs	—	—	100	PS	
270	4009-7516	Blue Bell Waterworks	Ridpath & Potter	1956	348	Drl	12	332	115	Trs	—	—	150	PS	CA
271	4008-7519	Gey Band & Tag Co.	Parente	1955	165	Drl	8	176	14	Trs	—	22	50	PS	
272	4009-7517	C. H. Zimmerman	Bollinger	1939	300	Drl	—	110	—	Trs	—	—	3	D	
273	4009-7517	R. B. Oeste	do.	—	297	Drl	—	85	—	Trs	—	—	5	D	NS
274	4014-7539	Pottstown Metal Weld	M. Kuszyk	1956	135	Drl	8	150	—	Trb	—	—	—	I	
275	4011-7507	Horsham Township	—	—	345	Drl	10	354	40	Trs	—	27	100	PS	CA
276	4011-7507	do.	—	—	300	Drl	—	—	—	Trs	—	—	257	PS	CA, NS
277	4008-7522	Nelson Dairy	Kohl Bros.	—	—	Drl	8	210	20	Trs	—	56	50	I	NS
278	4008-7522	do.	do.	—	—	Drl	8	210	20	Trs	—	56	75	I	CA
279	4008-7522	do.	Parente	—	—	Drl	8	225	20	Trs	—	45	125	I	NS
280	4009-7518	E. E. Callinar	—	—	300	Drl	—	96	—	Trs	—	—	21	Irr.	NS
281	4011-7526	Superior Tube Co.	Kohl Bros.	—	190	Drl	6	460	105	Trb	—	—	60	I	CA, NS
282	4011-7526	do.	do.	1941	190	Drl	8	300	61	Trb	1941	57	110	I	CA, NS
283	4011-7526	do.	do.	1951	185	Drl	8	199	101	Trb	10-23-56	87	87	I	CA
284	4011-7526	do.	do.	1953	185	Drl	8	449	22	Trb	1953	86	55	I	NS
285	4008-7512	Fort Washington Ind. Park	Penn Drilling Co.	1956	182	Drl	10	273	32	Trs	10-18-56	7	25	I	CA
286	4008-7511	do.	do.	1956	175	Drl	6	—	—	Trs	—	—	100	I	
287	4009-7511	do.	do.	1956	215	Drl	10	205	—	Trs	—	—	—	I	CA, NS
288	4006-7511	Phila. Suburban Co.	Thomas Keyes	1955	190	Drl	12	456	54	Co	11- 8-55	36	13	U	
289	4007-7527	Alan Wood Steel Co.	Bollinger & Sons	1956	100	Drl	8	380	40	Trs	11-20-56	29	60	I	
290	4008-7514	Ambler Borough	Ridpath & Potter	1956	290	Drl	10	500	330+	Trs	—	—	62	PS	CA

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280	4009-7518	E. E. Cashner	Kohl Bros.	—	190	Drl	6	460	105	Trb	—	—	60	I	CA, NS
281	4011-7526	Superior Tube Co.	do.	[illegible]	190	Drl	8	300	61	Trb	1941	57	110	I	CA, NS
282	4011-7526	do.	do.	[illegible]	185	Drl	8	199	101	Trb	10-23-56	87	87	I	CA
283	4011-7526	do.	do.	[illegible]53	185	Drl	8	449	22	Trb	1953	86	55	I	NS
284	4011-7526	do.	Penn Drilling Co.	1956	182	Drl	10	273	32	Trs	10-18-56	7	25	I	CA
285	4008-7512	Fort Washington Ind. Park	do.	1956	175	Drl	6	—	—	Trs	—	—	100	I	
286	4008-7511	do.	do.	1956	215	Drl	10	205	—	Trs	—	—	—	I	CA, NS
287	4009-7511	do.	Thomas Keyes	1955	190	Drl	12	456	54	Co	11- 8-55	36	13	U	
288	4006-7511	Phila. Suburban Co.	Bollinger & Sons	1956	100	Drl	8	380	40	Trs	11-20-56	29	60	I	
289	4007-7527	Alan Wood Steel Co.	Ridpath & Potter	1956	290	Drl	10	500	330+	Trs	—	—	62	PS	CA
290	4008-7514	Ambler Borough													
291	4010-7510	Thomas Bannon	Buehler & Sons	1956	345	Drl	8	70	35	Trs	1956	20	15	D	NS
292	4018-7521	H. W. Longarce	A. W. Dorn	1956	390	Drl	6	131	38	Trb	11- 8-56	50	45	I	
293	4014-7534	Saratoga Trailer Park	—	1946	260	Drl	6	226	—	Trb	1956	87	20	PS	
294	4010-7514	Kuhn Greenhouses	—	—	230	Dug	108	18	18	Trs	—	—	5	I	
295	4010-7505	Sylvania Electric Co.	Ridpath & Potter	1951	280	Drl	10	700	—	Trs	—	—	15-30	I	
296	4010-7505	Sylvania Electric Co.	Ridpath & Potter	1951	280	Drl	10	700	—	Trs	12- 5-56	29	—	U	NS
297	4010-7505	Reiniger Florist	—	—	270	Dug	72	6	—	Trs	—	Flows	15	Irr.	NS
298	4010-7505	do.	—	1900	270	—	6	118	—	Trs	—	20	75	Irr.	
299	4010-7506	Sunhemer's Bakery	Wiley & Buehler	1930	225	Drl	6	100	—	Trs	—	—	50	I	NS
300	4011-7515	North Wales Authority	Ridpath & Potter	1958	260	Drl	8	570	20	Trs	—	—	80	O	
301	4007-7527	Synthene Corp.	Artesian Well Drill	1929	—	Drl	6	375	—	Trs	—	50	160	I	NS
302	4007-7527	do.	Bollinger	1936	—	Drl	8	375	—	Trs	—	50	190	I	CA, NS
303	4007-7527	do.	Kohl Bros.	1954	100	Drl	10	425	—	Trs	—	—	500	I	CA
304	4007-7527	B. F. Goodrich Co.	—	1929	—	Drl	8- 6	330	25	Trs	—	—	100	I	CA, NS
305	4007-7527	Peerless Paper Mills	—	1930	115	Drl	6	151	40	Trs	5- 3-55	35	22	I	NS
306	4007-7527	do.	Kohl Bros.	1942	110	Drl	10	610	—	Trs	—	—	85	U	NS
307	4007-7527	do.	do.	1942	110	Drl	8	225	27	Trs	—	—	48	U	NS
308	4007-7527	Hoslett Chute & Conveyor	—	1926	100	Drl	6	125	—	Trs	—	—	40	I	NS
309	4009-7513	Keasby Mattison	—	—	—	Drl	—	—	—	Trs	—	—	—	U	NS
310	4009-7513	do.	—	—	—	Drl	—	—	—	Trs	—	—	—	U	NS
311	4008-7514	C. M. Kline	Alexander	1941	—	Drl	12- 8	375	100	Trs	—	Flow	—	S	
312	4008-7514	do.	do.	1943	—	Drl	—	275	—	Trs	—	Flow	—	S	NS
313	4008-7514	do.	do.	1943	—	Drl	—	275	—	Trs	—	Flow	—	S	NS
314	4008-7514	do.	do.	1953	—	Drl	12	375	—	Trs	—	—	—	S	NS
315	4008-7514	do.	do.	—	—	Drl	—	—	—	Trs	—	—	—	—	NS
316	4007-7527	Piersol & Pine Mfg.	—	1956	100	Drl	6	125	—	Trs	—	—	—	I	
317	4009-7520	Posen Kline Tube Co.	—	—	350	Drl	6	180	—	Trs	—	—	15	I	
318	4009-7520	do.	—	—	—	Dug	48	30	—	Trs	—	—	—	U	NS
319	4009-7520	do.	—	—	—	Dug	—	—	—	Trs	—	—	—	U	NS
320	4008-7514	Dr. Steinbach	—	—	270	Drl	—	—	—	Trs	—	—	—	D, S	NS
321	4008-7514	M. F. Newcomb	—	1918	260	Dug	36	21	—	Trs	—	—	—	D	
322	4008-7513	Roosevelt Farm	—	1919	250	Dug	—	10	—	Trs	7-18-56	8	—	D, S	
323	4008-7513	do.	—	1919	240	Dug	—	14	—	Trs	7-18-56	5	—	D, S	NS
324	4008-7513	A. P. Keegan	Bollinger	1956	215	Drl	—	125-150	—	Trs	—	—	12	D	NS
325	4008-7513	Wm. Spoyd	Ridpath & Potter	1920	200	Drl	—	—	—	Trs	7-18-56	35	—	D	NS
326	4008-7513	Wm. Spoyd	—	—	190	Drl	—	—	—	Trs	—	—	—	O	NS
327	4007-7513	Harrington	O'Donnell	1929	180	Drl	8	660	—	Trs	7-18-56	23	6	D	
328	4008-7513	do.	do.	1929	180	Drl	8	480	—	Trs	7-18-56	30	2	D	
329	4007-7513	F. Altmus	Bollinger	1956	200	Drl	6	135	—	Trs	—	—	—	D	NS

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
330	4007-7513	Eaton	do.	1952	190	Drl	—	120	—	Trs	—	—	6	D	NS
331	4007-7513	C. M. Codwaldwer	—	1917	200	Drl	—	125-150	—	Trs	—	—	—	U	NS
332	4010-7510	Dr. Woods	—	—	380	Drl	—	120	—	Trs	7-19-56	39	—	D	
333	4010-7510	do.	—	—	390	Dug	36	—	—	Trs	7-19-56	28	—	U	NS
334	4009-7509	J. Heard	Lyman	1945	350	Drl	6	116	—	Trs	—	—	—	D	
335	4009-7509	do.	—	1932	350	Drl	6	116	—	Trs	—	—	—	D	NS
336	4009-7510	Broadburd	—	1930	370	Drl	—	60	—	Trs	—	—	—	D, S	NS
337	4009-7510	Wm. Engle	—	1942	350	Drl	6	150	—	Trs	—	—	10	D	NS
338	4009-7510	J. Dardzinski	—	1928	360	Drl	6	130	99	Trs	—	—	15	D, S	NS
339	4009-7510	do.	—	—	330	Drl	6	108	—	Trs	—	—	10	D	NS
340	4009-7510	R. L. Alexander	—	1926	340	Drl	—	85-90	—	Trs	7-19-56	22	—	D	
341	4009-7510	R. C. Poden	O'Donnell	1929	330	Drl	8	118	15	Trs	7-19-56	11	6	D	NS
342	4009-7510	Fred Reis	do.	—	330	Drl	6	97	—	Trs	7-19-56	18	—	D	NS
343	4010-7509	College Settlement	—	1941	330	Drl	6	90	—	Trs	—	—	—	D	NS
344	4010-7509	do.	—	—	330	Drl	6	—	—	Trs	7-20-56	14	—	D	
345	4010-7509	Kuhn Day Camp	Muslemen	—	—	Drl	—	105	—	Trs	7-20-56	17	—	D	NS
346	4010-7509	do.	do.	—	300	Drl	—	65	—	Trs	—	—	—	D	NS
347	4010-7509	do.	do.	—	310	Drl	—	80	—	Trs	—	—	5	D	
348	4010-7508	Mizner	—	—	340	Dug	72	16	—	Trs	—	—	—	D	NS
349	4010-7508	do.	—	—	315	Dug	72	16	—	Trs	7-20-56	14	—	D	
350	4010-7508	J. W. Cox	—	—	320	Drl	—	—	—	Trs	7-20-56	16	—	D	NS
351	4010-7508	Thomas	—	—	320	Drl	—	—	—	Trs	7-20-56	10	—	U	NS
352	4010-7508	do.	—	—	320	Drl	—	—	—	Trs	—	—	—	D	NS
353	4010-7508	E. A. Johnston	—	—	320	Drl	6	50	—	Trs	1954	7	—	D	
354	4009-7514	J. A. Sheets	—	—	290	Drl	6	150	—	Trs	—	—	—	D	
355	4009-7514	Boyers	Bollinger	1954	—	Drl	6	95	—	Trs	—	—	—	D	NS
356	4011-7512	Wm. Coonrod	Parente Bros.	1954	290	Drl	—	90	23	Trs	—	—	—	D	
357	4011-7512	H. Slutsky	—	—	320	Drl	—	75	—	Trs	—	—	—	D	
358	4011-7513	American Chemical Co.	—	—	340	Dug	—	17	—	Trs	1953	15	—	U	NS
359	4011-7513	do.	Ridpath & Potter	1953	340	Drl	—	160	—	Trs	7-29-56	70	25	D, Irr.	CA
360	4011-7513	do.	—	—	360	Drl	—	70	—	Trs	—	Dry	—	U	NS
361	4011-7512	H. B. Brown	Ridpath & Potter	1956	310	Drl	6	278	—	Trs	—	—	—	D, S	
362	4011-7512	do.	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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349	4010-7508	[illegible]	—	—	320	Drl	—	—	—	Trs	7-20-56	16	—	D	NS
350	4010-7508	J. W. Cox	—	—	320	Drl	—	—	—	Trs	7-20-56	10	—	U	NS
1	4010-7508	Thomas	—	—	0	Drl	—	—	—	Trs	—	—	—	D	NS
352	4010-7508	do.	—	—	320	Drl	6	50	—	Trs	1954	7	—	D	
353	4010-7508	E. A. Johnston	—	—	290	Drl	6	150	—	Trs	—	—	—	D	
354	4009-7514	J. A. Sheets	Bollinger	1954	—	Drl	6	95	—	Trs	—	—	—	D	NS
355	4009-7514	Boyers	Parente Bros.	1954	290	Drl	—	90	23	Trs	—	—	—	D	
356	4011-7512	Wm. Coonrod	—	—	320	Drl	—	75	—	Trs	—	—	—	D	
357	4011-7512	H. Slutsky	—	—	340	Dug	—	17	—	Trs	1953	15	—	U	NS
358	4011-7513	American Chemical Co.	Ridpath & Potter	1953	340	Drl	—	160	—	Trs	7-29-56	70	25	D, Irr.	CA
359	4011-7513	do.													
360	4011-7513	do.	—	—	360	Drl	—	70	—	Trs	—	Dry	—	U	NS
361	4011-7512	H. B. Brown	Ridpath & Potter	1936	310	Drl	6	278	—	Trs	—	—	—	D, S	
362	4011-7512	do.	do.	1936	320	Drl	6	278	—	Trs	—	—	—	D, S	
363	4011-7512	do.	—	1954	310	Drl	—	—	—	Trs	7-24-54	15	—	D	CA
364	4009-7514	—	Bollinger	1947	—	Drl	—	175	—	—	—	—	—	D	
365	4011-7511	C. Huston	P. H. Flaherty	1947	340	Drl	27	105	—	Trs	—	—	—	D	
366	4011-7511	—	C. S. Garber	1956	310	Drl	6	86	39	Trs	—	—	—	D	NS
367	4011-7511	Van Stemlick	—	1936	280	Drl	6	—	—	Trs	7-15-56	9	—	D	CA
368	4011-7512	Oak Terrace Country Club	—	—	300	Drl	—	—	—	Trs	7-25-56	56	—	PS	
369	4011-7512	do.	—	—	340	Drl	4	—	—	Trs	7-25-56	50	—	D	NS
370	4011-7511	L. Young	O'Donnell	—	270	Drl	6	90	—	Trs	7-25-56	14	15	D	
371	4011-7511	H. K. Rossler	—	1930	260	Drl	6	103	—	Trs	—	—	—	D	NS
372	4011-7510	P. H. Burgdorf	—	1900	310	Drl	6	100	—	Trs	—	—	—	D	NS
373	4012-7510	W. J. Diener	O'Donnell	1956	260	Drl	—	151	—	Trs	1956	30	—	D	
374	4012-7509	Joseph Wood Jr.	—	—	310	Drl	—	—	—	Trs	7-25-56	31	—	D	NS
375	4012-7509	F. C. Segessenman	—	1900	310	Drl	—	60	—	Trs	1956	30	—	D, S	
376	4011-7510	G. Fox	—	1951	340	Drl	8	85	—	Trs	—	—	—	D	
377	4011-7510	W. L. MacMurtie	—	1931	325	Drl	—	—	—	Trs	—	—	—	D, S	NS
378	4011-7510	E. A. Stanford	—	1700	330	Dug	30	23	—	Trs	2-24-56	14	—	D, S	
379	4011-7510	G. H. Clement	—	1940	320	Drl	6	120	—	Trs	—	—	—	D	NS
380	4011-7510	John Jordan	Musselman	1954	300	Drl	8	90	20	Trs	—	Flow	15	D	
381	4007-7520	American News Co.	—	—	—	Drl	—	1500	—	Trs	—	—	—	U	
382	4009-7514	Bruntrager	—	1950	—	Drl	—	—	—	Trs	—	—	—	D	NS
383	4011-7508	J. Pryce	—	1951	340	Drl	6	80	—	Trs	7-25-56	21	—	A	NS
384	4011-7508	do.	—	1951	340	Drl	—	—	—	Trs	—	—	—	D	
385	4011-7509	Stanley Laner	—	1949	340	Drl	6	65	40	Trs	7-25-56	12	—	D	
386	4009-7511	Penna. Sch. of Horticulture	—	—	350	Drl	6	110	—	Trs	—	—	—	D	
387	4010-7511	Schofforth Bros.	—	1931	325	Drl	6	87	40	Trs	7-27-56	14	70	D, Irr.	
388	4010-7512	J. J. McIlhinney	Carlson Bros.	1956	355	Drl	8	92	60	Trs	7-27-56	Flow	18	D	NS
389	4010-7510	E. Jones	—	—	370	Dug	36	20	—	Trs	7-27-56	15	—	D	NS
390	4010-7510	do.	O'Donnell	1941	380	Drl	—	125	—	Trs	—	—	—	D	NS
391	4007-7511	O. Kalpenbacker	—	1944	250	Drl	—	125	—	Cch	—	—	—	D	CA
392	4007-7510	D. D. Evero	—	1955	330	Drl	—	190	—	Cch	—	100	—	D	CA, NS
393	4007-7510	J. N. Godman	Phila. Artesian Water Co.	1941	320	Drl	6	213	22	Cch	1954	84	—	D	NS
394	4008-7511	J. Bode	O'Donnell	1955	190	Drl	6	271	69	Trs	—	—	10	D	CA
395	4008-7510	Cobre Adam	—	1945	250	Drl	6	87	—	Trs	—	—	—	D	
396	4008-7508	H. M. Crokett	O'Donnell	1951	290	Drl	6	105	—	Xgn	—	—	—	D	
397	4007-7511	Joseph Myer	H. L. Gorges	1955	290	Drl	6	165	18	Cch	—	65	20	D	
398	4007-7510	Donald Tunnell	Ridpath & Potter	1954	340	Drl	6	245	40	Cch	—	—	12	D	NS

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
399	4007-7510	Mfg. Club	Ridpath & Potter	1954	350	Drl	8	400	—	Cch	3-31-54	72	73	D	CA
400	4007-7510	Mfg. Country Club	—	—	350	Drl	8	525	—	Cch	11-10-53	60	8.5	U	NS
401	4007-7510	do.	—	—	340	Drl	8	600	—	Cch	—	—	8.5	U	NS
402	4009-7511	E. Egner	Dorn	1952	170	Drl	6	80	—	Trs	—	—	—	D	
403	4008-7511	Pinetown Golf Club	O'Donnell	1949	280	Drl	6	200	—	Trs	—	—	—	D	
404	4008-7511	do.	do.	—	270	Drl	—	—	—	Trs	—	—	—	U	NS
405	4009-7511	B. L. Bryner	—	—	255	Drl	—	110	—	Trs	—	—	—	D, S	NS
406	4009-7510	F. M. King	O'Donnell	1955	255	Drl	6	202	60	Trs	8- 1-56	8	17	D	CA
407	4009-7511	Wents Turkey Farm	B. Christ	1950	260	Drl	6	215	—	Trs	8- 1-56	15	6	S	
408	4009-7511	do.	—	—	260	Drl	—	55	—	Trs	—	—	—	S	NS
409	4009-7510	Thomas Barlow	O'Donnell	—	220	Drl	—	130	—	Trs	—	—	—	D	NS
410	4010-7508	Willow Ridge Farm	—	—	270	Drl	9	600	—	Trs	8- 1-56	17	—	I	
411	4009-7510	Jarrettown Elem. School	O'Donnell	1953	295	Drl	6	250	—	Trs	—	—	40	PS	NS
412	4008-7509	E. Wolf	—	—	250	Drl	—	—	—	Trs	—	—	—	D	NS
413	4009-7509	Tyoon Bros.	—	1860	295	Dug	72	22	—	Trs	—	—	—	D, S	
414	4008-7509	F. Y. Ueltzen	C. Laman	—	260	Drl	—	90	—	Trs	—	—	12	D	CA
415	4009-7509	H. Zieger & Son	—	—	320	Drl	8	254	—	Trs	8- 2-56	34	120	Irr.	
416	4009-7509	do.	—	—	320	Drl	6	250	—	Trs	—	—	500	Irr.	NS
417	4008-7509	A. Shuttle Co.	H. M. Walsh	—	230	Drl	6	90	43	Trs	—	75	—	D, I	
418	4008-7509	N. Schmidt	—	—	240	Drl	—	150	—	Trs	—	—	—	U	
419	4008-7510	Allied Concrete Supply	Lauman	—	230	Drl	—	90	—	Trs	—	—	30	I	CA
420	4008-7509	Robert Walker	Carl Richter	1943	230	Drl	6	186	186	Trs	—	—	16	I	NS
421	4001-7519	K. K. Stuart	—	—	400	Drl	—	35	—	Trl	—	—	70	—	—
422	4008-7512	J. A. Van Son	Bundar & Christ	—	260	Drl	6	125	20	Trs	8- 2-56	8	20	D, S	
423	4009-7511	W. Burlein	—	—	320	Drl	6	200	—	Trs	8- 2-56	26	—	D	
424	4009-7511	E. W. Edwards	—	—	350	Drl	6	220	40	Trs	—	—	—	D	
425	4010-7509	J. S. Armentrout	O'Donnell	1944	355	Drl	6	150	—	Trs	—	—	—	D	
426	4011-7521	Tom Benner	Parente	1949	—	Drl	—	70	—	Trl	—	—	—	D	
427	4013-7511	Whitemarsh Cemetary	—	1931	360	Drl	10	100	—	Trs	8- 6-56	25	—	D, Irr.	
428	4013-7511	do.	—	1941	352	Drl	10	90	—	Trs, Trl	—	—	—	Irr.	NS
429	4012-7511	do.	—	—	351	Drl	8	100	—	Trs	—	—	—	Irr.	NS
430	4012-7511	do.	—	—	361	Drl	8	90	—	Trs	—	—	—	D	

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418	4008-7509	N. Schmidt	—													
419	4008-7510	Allied Concrete Supply	Lauman	—	230	Drl	—	90	—	Trs	—	—	30	I	CA	
420	4008-7509	Robert Walker	Carl Richter	[illegible]	330	Drl	6	186	186	Trs	—	—	16	I	NS	
421	4001-7519	K. K. Stuart	—		400	Drl	—	35	—	Trl	—	—	70	—	—	
422	4008-7512	J. A. Van Son	Bundar & Christ	—	260	Drl	6	125	20	Trs	8- 2-56	8	20	D, S		
423	4009-7511	W. Burlein	—	—	320	Drl	6	200	—	Trs	8- 2-56	26	—	D		
424	4009-7511	E. W. Edwards	—	—	350	Drl	6	220	40	Trs	—	—	—	D		
425	4010-7509	J. S. Armentrout	O'Donnell	1944	355	Drl	6	150	—	Trs	—	—	—	D		
426	4011-7521	Tom Benner	Parente	1949	—	Drl	—	70	—	Trl	—	—	—	D		
427	4013-7511	Whitemarsh Cemetary	—	1931	360	Drl	10	100	—	Trs	8- 6-56	25	—	D, Irr.		
428	4013-7511	do.	—	1941	352	Drl	10	90	—	Trs, Trl	—	—	—	Irr.	NS	
429	4012-7511	do.	—	—	351	Drl	8	100	—	Trs	—	—	—	Irr.	NS	
430	4012-7511	do.	—	—	361	Drl	8	90	—	Trs	—	—	—	D		
431	4012-7511	do.	—	—	354	Drl	—	—	—	Trs	8- 6-56	16	—	D	NS	
432	4008-7516	C. S. Wurts	Bollinger	1925	345	Drl	—	90	—	Trs	—	—	—	D		
433	4008-7516	do.	do.	—	355	Drl	—	180	—	Trs	—	—	—	D	NS	
434	4008-7516	E. C. Quin	do.	—	310	Drl	6	300	—	Trs	—	—	—	D	NS	
435	4008-7515	C. S. Chestan	—	—	271	Drl	—	—	—	Trs	—	—	—	D		
436	4013-7510	F. I. Donohue	—	1953	330	Drl	—	110	—	Trs	—	—	—	D	NS	
437	4013-7510	M. Connely	Wiley	1947	321	Drl	6	130	16	Trs	1947	32	5	D	NS	
438	4013-7510	S. Gibson	Baker & Haltman	—	319	Drl	—	150	—	Trs	1955	47	20	D	NS	
439	4013-7510	F. Zaiss	do.	—	312	Drl	—	135	—	Trs	1956	65	12	D		
440	4013-7509	H. P. Boyle	Caroon	1952	270	Drl	7½	86	—	Trs	—	—	—	D		
441	4013-7509	C. Detweiler	H. Gorges	—	240	Drl	—	65	—	Trs	—	—	—	D, S		
442	4012-7509	O. Maurer	Mussleman	—	240	Drl	—	65	—	Trs	—	—	—	D		
443	4012-7509	S. Cops	Kessleman	—	270	Drl	—	125	30	Trs	—	—	—	D		
444	4012-7508	Wm. Zimmerman	—	—	300	Drl	—	98	—	Trs	—	—	—	D, S	NS	
445	4013-7509	Fred Burns	Buehler	1954	300	Drl	6	168	30	Trs	—	—	—	D, S		
446	4013-7511	Novatang	O'Donnell	1940	295	Drl	6	404	—	Trl	—	—	—	D		
447	4013-7510	Camp Shepard	—	1949	325	Drl	—	192	20	Trl	—	—	—	PS		
448	4011-7508	John Lasch	—	1953	—	Drl	—	93	—	Trs	—	22	—	D	NS	
449	4011-7508	John Lasch	Wyle & Sons	1948	—	Drl	—	130	—	Trs	—	Flow	5	D		
450	4011-7521	Variety Club Camp	—	—	410	Drl	—	175	—	Trb, Trl	—	—	—	D	NS	
451	4011-7513	C. Morris	Ridpath & Potter	—	290	Drl	—	150	—	Trs	—	—	—	D	NS	
452	4011-7513	Texaco Ser. Station	—	—	—	Drl	—	90	—	Trs	—	—	—	I	NS	
453	4011-7513	Gulf Service Station	Rulon and Cook	—	270	Drl	4	181	85	Trs	—	—	16	I	CA, NS	
454	4011-7513	Springhouse Elem. School	—	—	316	Drl	6	85	72	Trs	8-15-56	24	—	PS	CA	
455	4011-7512	C. W. Collom	Parente Bros.	1943	—	Drl	6	185	125	Trs	8-16-56	25	—	D, S		
456	4010-7513	Pike Restaurant	Bollinger	—	325	Drl	—	235	—	Trs	—	—	35	I		
457	4010-7513	John Pappas	Bollinger	—	325	Drl	—	185	—	Trs	—	—	35	D		
458	4011-7514	W. G. Mitchel	—	—	320	Drl	—	117	—	Trs	—	—	45	D		
459	4011-7514	J. H. W. Ingersol	—	1900	335	Drl	—	180	—	Trs	8-15-56	75	8	D, S		
460	4010-7513	H. B. Coxe	—	1928	290	Drl	—	160	—	Trs	—	—	35	D		
461	4010-7514	G. Lippincott	Bollinger	1936	267	Drl	—	300	—	Trs	—	—	—	D		
462	4010-7514	Plumb	—	—	270	Drl	—	90	—	Trs	—	—	—	D		
463	4010-7514	W. P. Ware	—	1953	268	Drl	6	—	—	Trs	—	—	—	D	NS	
464	4009-7514	Am. Paint & Chem. Co.	Ridpath & Potter	1942	—	Drl	—	405	—	Trs	8-27-56	64	408	I	CA	
465	4009-7512	Arvid E. Lyden	do.	1957	300	Drl	6	130	—	Trs	—	—	—	D		

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
466	4008-7513	Summer Labs Inc.	—	—	170	Drl	—	160	—	Trs	—	—	—	I	
467	4011-7521	Variety Club Camp	Parente Bros.	1949	420	Drl	6	225	—	Trb, Trl	—	—	—	PS	
468	4010-7519	A. E. Truebiood	Bollinger & Sons	—	360	Drl	6	255	20	Trl	9- 5-56	26	1	D	
469	4010-7519	W. B. McKinney	do.	—	260	Drl	—	300	—	Trs	—	—	35	D	NS
470	4010-7518	Robert Noisoy	Lauman	1952	275	Drl	6	84	25	Trs	—	—	43	D	
471	4010-7518	Maisey	—	—	—	Drl	—	105	—	Trs	—	—	—	D	
472	4010-7520	R. W. Bookheimer	Lauman	1945	450	Drl	—	110	—	Trb, Trl	—	—	—	D	
473	4010-7519	B. Bev.	do.	1950	350	Drl	—	120	—	Trl	—	—	—	D	
474	4009-7507	B. S. Fox	Bollinger	1953	—	Drl	—	108	—	Trs	—	—	—	D	
476	4010-7518	Granese	—	—	270	Drl	—	100	—	Trl	9- 6-56	30	—	D	
477	4010-7518	C. J. Jensen	Bollinger	1944	295	Drl	—	90	—	Trl	—	—	20	D, S	NS
478	4011-7518	F. McClure	Lauman	1944	325	Drl	—	150	—	Trl	9- 6-56	10	7.5	D, S	
479	4011-7517	E. W. Carlson	—	—	330	Drl	—	160	—	Trl	—	—	—	D	
480	4011-7518	W. A. Garver	—	1930	375	Drl	—	90	30	Trb, Trl	—	—	—	D	
481	4012-7519	A. J. Wilson	Flaghter	1950	417	Drl	6	112	—	Trl	9- 6-56	64	27	D	
482	4012-7518	Henry Krug	—	1949	370	Drl	—	120	25	Trl	—	—	—	D	NS
483	4011-7518	Joseph Bainiff	—	1953	360	Drl	6	132	—	Trl	9-25-56	61	12	D	
484	4009-7518	St. Helena School	—	—	—	Drl	6	114	—	Trs	9-25-56	21	—	U	NS
485	4009-7518	S. H. Kline	—	1880	230	Drl	—	85	—	Trs	—	—	—	D	NS
486	4009-7518	J. T. Graeff	Miller	1950	230	Drl	—	90	—	Trs	—	—	—	D	
487	4010-7505	S & P National Corp	—	1926	280	Drl	8	150	—	Trs	—	—	—	I	
488	4010-7505	do.	Heinickey	—	280	Drl	8	200	—	Trs	—	—	60	I	
489	4012-7508	U.S.N. Air Station	Phil. Drlg. Co.	1957	275	Drl	—	—	—	Trs	—	—	—	U	NS
490	4012-7508	do.	do.	1957	280	Drl	10	330	—	Trs	—	—	360	PS	CA
491	4006-7524	Refractory & Inst. Co.	Stothoff	—	90	Drl	8	185	—	Trs	1957	100	50	I	
492	4006-7524	do.	—	—	90	Drl	8	185	—	Trs	1957	100	50	I	NS
493	4010-7520	U.S. Army	C. S. Garber	1955	445	Drl	[illegible]	210	[illegible]	Trl	[illegible]	47	7	PS	CA

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488	4010-7505	do.	Heinickey	—	280	Drl	8	200	—	Trs	—	—	60	I		
489	4012-7508	U.S.N. Air Station	Phil. Drlg. Co.	1957	275	Drl	—	—	—	Trs	—	—	—	U	NS	
490	4012-7508	do.	do.	7	280	Drl	10	330	—	Trs	—	—	360	PS	CA	
491	4006-7524	Refractory & Inst. Co.	Stothoff	-	90	Drl	8	185	—	Trs	1957	100	50	I		
492	4006-7524	do.	—	—	90	Drl	8	185	—	Trs	1957	100	50	I	NS	
493	4010-7520	U.S. Army	C. S. Garber	1955	445	Drl	—	230	—	Trl	—	47	7	PS	CA	
494	4010-7521	do.	do.	1955	460	Drl	—	230	40	Trl	—	51	23	PS	CA, NS	
495	4011-7513	Amer. Chem. & Paint Co.	Ridpath & Potter	1957	305	Drl	8	266	40	Trs	—	25	330	Irr.		
496	4011-7513	Ely	Bollinger	1926	320	Drl	8	1014	523	Trl, Trs	—	—	30	U	NS	
497	4007-7527	Alan Wood Steel Co.	do.	1956	80	Drl	8	—	—	Trs	—	—	—	I	NS	
498	4015-7518	Lansdale Municipal Auth.	Wm. Stothoff	1957	340	Drl	12	560	90	Trb	9-18-57	77	90	PS		
499	4009-7512	Ambler Boro.	Ridpath & Potter	1957	285	Drl	6	300	—	Trs	1957	98	177	PS	NS	
500	4009-7512	do.	do.	1957	290	Drl	6	240	—	Trs	1957	8	342	PS		
501	4001-7507	George Zeitter	J. Carson's Sons	1957	—	Drl	6	100	39	Trs	8-23-57	11	33	D		
502	4011-7508	Wilt Kolin	J. Carson's Sons	1957	—	Drl	6	123	34	Trs	9-17-57	45	12	D		
503	4011-7509	Daniel Tedesco	J. Carson's Sons	1957	—	Drl	6	77	30	Trs	8-22-57	18	30	D		
504	4011-7509	Bailey & Mandalhen	do.	1957	—	Drl	6	82	30	Trs	—	28	30	D	NS	
505	4009-7512	Ambler Boro	—	1957	310	Drl	—	—	—	Trs	—	—	—	—	NS	
506	4009-7515	Boehm's Church	Ridpath & Potter	1956	360	Drl	6	204	—	Trs	11- 1-57	32	50	D		
507	4009-7516	Mavrice Potter	do.	—	360	Drl	—	200	—	Trs	—	—	—	PS	NS	
508	4009-7510	M. M. Ritter	Wm. Musselmen & Son	1957	—	Drl	6	—	30	Trs	9- 5-57	55	14	D	NS	
509	4008-7510	Wm. Schrope	J. Carson's Son	1957	—	Drl	6	104	30	Trs	9- 5-57	30	15	D	NS	
510	4010-7508	Benjamin P. W. Park	do.	1957	—	Drl	6	108	42	Trs	9-12-57	35	15	D	NS	
511	4011-7507	M. C. Hughes	Wm. Musselman & Son	1957	—	Drl	6	85	—	Trs	9-13-57	25	25	D		
513	4010-7507	Robert Timby	J. Carson's & Son	1957	—	Drl	6	92	30	Trs	10-19-57	45	15	D	NS	
514	4010-7508	Floyd Troutman	R. A. Kessinger	1957	—	Drl	6	53	30	Trs	9-27-57	38	—	D	NS	
515	4010-7508	Anton Kinsch	J. Carson's Sons	1957	—	Drl	6	150	31	Trs	9- 9-57	45	10	D	NS	
516	4010-7508	Frank Murphy	Wm. Musselman	1957	—	Drl	6	84	42	Trs	8-30-57	20	20	D	NS	
517	4009-7512	Howard Mahoney	Ridpath & Potter	1957	—	Drl	—	90	—	Trs	9- 7-57	34	20	D		
518	4010-7508	Mand Kiley	J. Carson's & Son	1957	—	Drl	6	75	40	Trs	11- 8-57	38	18	D	NS	
519	4010-7508	Paul Eisfild	do.	1957	—	Drl	6	63	44	Trs	11- 2-57	15	20	D		
520	4012-7511	E. Behrens, Jr.	do.	1957	—	Drl	6	110	30	Trs	10-15-57	30	15	D		
521	4012-7512	G. T. Norton	Wm. Musselman	1957	—	Drl	6	92	25	Trl	10-29-57	15	15	D		
522	4011-7510	Charles Boteler	do.	1957	—	Drl	6	88	32	Trs	10- 3-57	30	20	D		
523	4009-7510	Bastel Sutter	F. E. Ruchler & Son	1957	—	Drl	6	90	30	Trs	10- 7-57	5	25	D	NS	
524	4010-7507	Albert Hilker	J. Carson's Sons	1957	—	Drl	6	107	32	Trs	11- 5-57	55	10	D		
525	4010-7512	Albert Ambrosch	do.	1957	—	Drl	6	96	30	Trs	9-19-57	35	14	D		
526	4010-7511	Blankenkorn	do.	1957	—	Drl	6	85	32	Trs	9-23-57	15	30	D	NS	
527	4011-7509	Rauther	do.	1957	—	Drl	6	—	11	Trs	—	—	25	D		
528	4011-7507	L. Hoffman	do.	1957	—	Drl	6	87	30	Trs	10- 8-57	30	25	D		
529	4011-7506	Royal Grote	J. Carson's Sons	—	—	Drl	6	135	30	Trs	11- 7-57	41	8	D	NS	
530	4011-7506	Christian Renner	do.	—	—	Drl	6	55	35	Trs	10-14-57	30	20	D		
531	4010-7524	M. Eastman	Keyes	1957	—	Drl	6	167	—	Trl	—	—	35	D		

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
532	4008-7510	Selas Corp. of America	Ridpath & Potter	1957	260	Drl	—	—	—	Cch	—	—	60	Air	
533	4008-7516	A. F. Picolet d'Hermillian	do.	1957	295	Drl	—	—	—	Trs	—	—	—	D	NS
534	4013-7525	E. State Penitentiary	F. L. Bollinger	1928	255	Drl	10	489	10	Trb	7-23-63	234	155	PS	NS
535	4013-7525	do.	do.	1929	280	Drl	10	552	21	Trb	7-23-63	248	135	PS	NS
536	4013-7525	do.	do.	1929	280	Drl	10	497	32	Trb	1962	245	116	PS	
537	4013-7526	do.	do.	1929	280	Drl	10	596	20	Trb	7-23-63	260	98	PS	NS
538	4014-7525	do.	do.	1937	305	Drl	12	512	19	Trb	1960	204	355	PS	
539	4014-7525	do.	Artesian Well Drilling	1951	285	Drl	16-8	502	24	Trb	7-23-60	195	300	PS	NS
540	4013-7526	do.	Bollinger	1951	270	Drl	10	600	—	Trb	4- 9-62	180	90	PS	CA
541	4010-7530	Charles Johnson Home	do.	1959	150	Drl	12-8	300	44	Trb	6- 9-60	15	135	PS	CA
542	4010-7530	do.	—	1930	240	Drl	8	198	—	Trb	—	—	84	PS	NS
543	4010-7532	Diamond Glass Co.	Ridpath & Potter	1956	110	Drl	16-10	400	50	Trb	8-10-56	20	191	I	
544	4010-7532	Spring Ford Foundry Co.	—	—	115	Drl	—	120	—	Trb	—	—	—	I	NS
545	4010-7532	Bush Bros.	C. S. Garber	1947	115	Drl	10	223	—	Trb	—	—	60	I	NS
546	4011-7532	Potts Bros.	do.	1959	227	Drl	6	172	42	Trb	1959	37	40	I	NS
547	4011-7532	Royersford Foundry	—	—	120	Drl	6	100	—	Trb	—	—	—	I	NS
548	4011-7532	Bankers Bar	C. S. Garber	1959	160	Drl	6	201	50	Trb	—	—	60	D	
549	4011-7532	Nelson Ice Cream Inc.	Kohl Bros.	1925	175	Drl	8	225	—	Trb	—	—	60	I	NS
550	4011-7532	Cann & Saul Steel Co.	do.	1941	187	Drl	6	235	40	Trb	6- 8-60	11	30	O	
551	4012-7522	O. J. Hynes	—	—	265	Drl	8	450	—	Trb	3-30-60	63	—	I	CA
552	4012-7525	John Nast	A. W. Dorn & Son	1957	260	Drl	6	90	—	Trb	3-30-60	21	—	D	NS
553	4012-7525	Natalie Schmidt	—	1959	260	Drl	6	102	38	Trb	—	—	25	D	NS
554	4012-7525	McCormic Air Service	Miller Pump Service	1959	285	Drl	6	154	40	Trb	3-30-60	50	40	D	
555	4012-7532	S. A. Welty & Sons	C. S. Garber	1949	260	Drl	6	160	12	Trb	6- 9-60	72	—	I	
556	4012-7532	do.	do.	1956	260	Drl	6	190	21	Trb	8-20-56	69	15	I	
557	4012-7534	Kinsey Distilling Corp.	do.	1934	150	Drl	10	394	21	Trb	—	—	95	I	CA
558	4012-7534	do.	do.	1934	150	Drl	10	360	—	Trb	—	—	225	I	NS
559	4012-7534	do.	do.	1934	155	Drl	10	328	—	Trb	—	—	107	I	NS
560	4012-7534	do.	do.	1934	170	Drl	10	145	—	Trb	—	—	10	I	NS
561	4012-7534	do.	do.	1935	115	Drl	6	170	—	Trb	—	—	55	I	NS

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552	4012-7523	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
553	4012-7525	Natalie Schmidt	—	1959	260	Drl	6	102	38	Trb	—	—	25	D	NS
54	4012-7525	McCormic Air Service	Miller Pump Service	19[illegible]	285	Drl	6	154	40	Trb	3-30-60	50	40	D	
55	4012-7532	S. A. Welty & Sons	C. S. Garber	19[illegible]	[illegible]0	Drl	6	160	12	Trb	6- 9-60	72	—	I	
556	4012-7532	do.	do.	19[illegible]	[illegible]60	Drl	6	190	21	Trb	8-20-56	69	15	I	
557	4012-7534	Kinsey Distilling Corp.	do.	1934	150	Drl	10	394	21	Trb	—	—	95	I	CA
558	4012-7534	do.	do.	1934	150	Drl	10	360	—	Trb	—	—	225	I	NS
559	4012-7534	do.	do.	1934	155	Drl	10	328	—	Trb	—	—	107	I	NS
560	4012-7534	do.	do.	1934	170	Drl	10	145	—	Trb	—	—	10	I	NS
561	4012-7534	do.	do.	1935	115	Drl	6	179	—	Trb	—	—	55	I	NS
562	4012-7534	do.	—	—	145	Drl	10	365	—	Trb	—	—	213	I	NS
563	4012-7534	Sanitary Co. of America	—	—	135	Drl	—	—	—	Trb	—	—	—	PS	NS
564	4012-7534	do.	—	—	125	Drl	—	200	—	Trb	—	—	—	I	
565	4012-7534	do.	Wallace Reigner	1959	127	Drl	6	98	—	Trb	—	—	—	D	NS
566	4013-7518	Martin Century Farms	F. L. Bollinger	1960	280	Drl	14-10	330	45	Trb	3-17-60	15	226	I	
567	4013-7521	C. V. Hollis	—	1943	267	Drl	6	135	50	Trb	—	—	—	D	NS
568	4013-7521	C. W. Bosler	—	1940	255	Drl	6	110	50	Trb	—	—	—	D	NS
569	4013-7521	do.	—	—	255	Drl	6	79	25	Trb	3-31-60	23	—	U	
570	4013-7521	Fischers Pool	P. Flaherty	1948	195	Drl	8	195	25	Trb	—	7	48	PS	
571	4013-7521	do.	do.	—	181	Drl	6	90	25	Trb	—	—	20	PS	NS
572	4013-7522	do.	do.	—	176	Drl	6	78	25	Trb	—	—	20	PS	NS
573	4013-7522	do.	do.	1935	178	Drl	6	90	25	Trb	—	—	20	D	NS
574	4013-7524	John Gregory	—	—	270	Dug	—	19	—	Trb	3-30-60	8	—	D	
575	4013-7524	Anna Lewandouski	Parente Bros.	1940	210	Drl	6	140	—	Trb	—	—	—	D	
576	4013-7336	Firestone Tire & Rubber Co.	C. S. Garber	1947	152	Drl	14-10	351	38	Trb	—	—	180	I	NS
577	4013-7536	do.	do.	1942	153	Drl	14-10	402	35	Trb	—	—	193	I	CA
578	4013-7536	do.	do.	1947	152	Drl	14-10	342	25	Trb	—	—	73	I	NS
579	4013-7536	Firestone Tire & Rubber Co.	C. S. Garber	1942	147	Drl	14-10	494	75	Trb	9-22-61	52	61	I	NS
580	4013-7536	do.	do.	1942	136	Drl	14-10	276	36	Trb	—	—	153	I	CA
581	4013-7536	do.	do.	1942	190	Drl	14-10	394	48	Trb, Trl	6- 1-60	79	62	U	NS
582	4013-7536	do.	do.	1947	130	Drl	14-10	371	37	Trb	—	—	94	I	NS
583	4013-7536	do.	do.	1942	165	Drl	14-10	355	47	Trb	—	—	170	I	CA, NS
584	4014-7536	do.	do.	1942	186	Drl	14-10	406	42	Trb	—	—	108	I	CA, NS
585	4014-7336	do.	do.	1942	157	Drl	14-10	266	50	Trb	—	—	70	I	CA
586	4014-7514	The Mart	—	1953	—	Drl	—	—	—	—	—	—	—	D	
587	4014-7514	do.	—	1953	—	Drl	—	—	—	—	—	—	—	D	NS
588	4014-7515	Picolet Dye Works	Walter Emert	—	430	Drl	6	—	—	Trl, Trb	6-23-66	36	—	U	NS
589	4014-7515	do.	do.	1951	430	Drl	6	820	—	Trl, Trb	—	—	4	I	NS
590	4014-7515	do.	Wm. Stothoff	—	430	Drl	—	300	—	Trl, Trb	—	—	20	I	NS
591	4014-7515	do.	Walter Emert	—	425	Drl	6	400	—	Trl, Trb	—	—	12	I	
592	4014-7316	Lansdale Borough	—	—	390	Drl	12-8	235	44	Trl, Trb	5-26-59	87	67	PS	NS
593	4014-7318	do.	Kohl Bros.	1958	320	Drl	12-8	492	76	Trb	1959	111	200	PS	
594	4014-7320	H. H. Becker	—	1925	185	Drl	6	—	—	Trb	4-18-60	23	—	PS	
595	4014-7525	State of Pennsylvania	T. G. Keyes	1955	265	Drl	10	135	42	Trb	4-27-60	32	17	D	
596	4014-7525	Robert Alderfer	Parente Bros.	1943	275	Drl	6	210	30	Trb	1957	152	30	D	

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
597	4014-7533	Pottstown Airport	C. S. Garber	1958	310	Drl	6	220	40	Trb	—	90	12	D	
598	4014-7536	Sunnybrook Enterprises	do.	1954	150	Drl	8	262	46	Trb	4- 3-62	8	90	PS	
599	4014-7537	Dana Corp.	—	—	155	Drl	8	385	40	Trb	—	—	160	I	NS
600	4014-7537	do.	—	—	155	Drl	10	287	—	Trb	—	—	130	I	NS
601	4014-7537	do.	Joseph Smith	1941	160	Drl	8	540	40	Trb	1- 7-42	30	125	I	
602	4014-7537	do.	do.	1941	150	Drl	8	425	40	Trb	—	—	90	I	NS
603	4014-7537	do.	Kohl Bros.	1942	150	Drl	6	916	850	Trb	—	—	150	I	CA
604	4014-7538	Bethlehem Steel Co.	—	1916	145	Drl	8	200	—	Trb	—	25	200	I	
605	4014-7538	do.	—	1916	145	Drl	8	200	—	Trb	—	25	200	I	NS
606	4014-7538	Levengood Dairy	—	1917	165	Drl	—	—	—	Trb	—	—	—	I	NS
607	4014-7538	do.	Joseph Smith	1932	165	Drl	8	184	—	Trb	—	—	150	I	NS
608	4014-7539	S. G. Flagg Inc.	—	1910	150	Drl	—	201	40	Trb	1958	100	120	I	
609	4014-7540	do.	Kohl Bros.	1945	145	Drl	8	200	85	Trb	1958	63	147	I	NS
610	4014-7540	do.	do.	1947	145	Drl	8	244	82	Trb	1958	86	200	I	NS
611	4014-7540	do.	do.	1948	145	Drl	8	350	36	Trb	1958	96	255	U	NS
612	4015-7514	Lock Seam Tube Co.	—	—	455	Drl	—	—	—	Trb	—	—	—	D	
613	4015-7515	Picolet Dye Works	Walter Emert	—	370	Drl	6	320	—	Trb	—	—	15	I	NS
614	4015-7515	do.	do.	—	375	Drl	6	120	—	Trb	—	—	10	I	
616	4013-7522	E. D. Rutter	—	—	180	Drl	6	100	—	Trb	—	—	25	I	CA
618	4015-7516	Penndale Inc.	R. L. Knieriem	1958	360	Drl	—	330	—	Trb	—	—	30	I	NS
619	4015-7517	American Encaustic Tile	—	—	335	Drl	—	88	—	Trb	6- 8-56	74	—	U	NS
620	4015-7516	do.	Wm. Stothoff	1955	360	Drl	10	400	116	Trb	3-28-58	94	100	I	
621	4015-7516	do.	do.	1957	335	Drl	10	400	—	Trb	1957	58	—	I	NS
622	4016-7516	A. M. Kulp School	Miller Pump Service	1956	297	Drl	8-6	600	100	Trb	10- 9-57	24	55	PS	
623	4015-7517	Lansdale Municipal	Wm. Stothoff	1957	330	Drl	10	507	97	Trb	12-18-62	41	200	U	NS
624	4015-7517	J. W. Rex Inc.	F. L. Bollinger	1958	315	Drl	8	504	85	Trb	1958	105	9	U	NS
625	4015-7517	do.	do.	1958	320	Drl	8	384	62	Trb	1960	54	186	I	
627	4015-7519	Paul Clemens	—	—	345	Drl	6	125	—	Trb	4- 1-60	30	—	D	
628	4015-7519	M. L. Dickinson	—	—	320	Drl	6	84	—	Trb	4- 1-60	49	—	D	NS
629	4015-7520	Christopher Dock High School	—	—	300	Drl	6	101	—	Trb	3-31-60	54	—	PS	
630	4015-7520	do.	A. W. Dorn	1959	300	Drl	8	130	—	Trb	8-10-59	52	60	PS	NS
631	4015-7520	Nice Ball Bearing	Ridpath & Potter	1959	285	Drl	10	500	60	Trb	3-24-60	55	200	I	CA

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619	4015-7517	American Encaustic Tile	—	—	335	Drl	—	88	—	Trb	6- 8-56	74	—	U	NS
620	4015-7516	do.	Wm. Stothoff	1953	360	Drl	10	400	116	Trb	3-28-58	94	100	I	
621	4015-7516	do.	do.	37	335	Drl	10	400	—	Trb	1957	58	—	I	NS
622	4016-7516	A. M. Kulp School	Miller Pump Service	1956	297	Drl	8-6	600	100	Trb	10- 9-57	24	55	PS	
623	4015-7517	Lansdale Municipal	Wm. Stothoff	1957	330	Drl	10	507	97	Trb	12-18-62	41	200	U	NS
624	4015-7517	J. W. Rex Inc.	F. L. Bollinger	1958	315	Drl	8	504	85	Trb	1958	105	9	U	NS
625	4015-7517	do.	do.	1958	320	Drl	8	384	62	Trb	1960	54	186	I	
627	4015-7519	Paul Clemens	—	—	345	Drl	6	125	—	Trb	4- 1-60	30	—	D	
628	4015-7519	M. L. Dickinson	—	—	320	Drl	6	84	—	Trb	4- 1-60	49	—	D	NS
629	4015-7520	Christopher Dock High School	—	—	300	Drl	6	101	—	Trb	3-31-60	54	—	PS	
630	4015-7520	do.	A. W. Dorn	1959	300	Drl	8	130	—	Trb	8-10-59	52	60	PS	NS
631	4015-7520	Nice Ball Bearing	Ridpath & Potter	1959	285	Drl	10	500	60	Trb	3-24-60	55	200	I	CA
632	4015-7520	U.S. Geological Survey	C. S. Garber	1960	285	Drl	6	500	31	Trb	8-29-63	71	—	T, O	NS
633	4015-7520	do.	do.	1962	270	Drl	6	500	32	Trb	8-29-63	62	125	T, O	
634	4015-7520	Ewell Davies	—	—	310	Drl	8	198	—	Trl	4- 4-60	55	—	D	NS
636	4015-7520	William Delp	—	—	257	Drl	6	87	—	Trb	4- 1-60	49	—	D	NS
637	4015-7520	Abram Ziegler	Miller Pump Service	1930	220	Drl	8	105	—	Trb	4- 1-60	22	—	D	
638	4015-7520	Frank	Patrick Flaherty	1958	235	Drl	8	100	16	Trb	—	—	40	D	NS
639	4015-7520	William Delp	—	—	240	Dug	—	35	—	Trb	—	—	—	D	NS
640	4015-7528	Schwenksville Water Co.	F. L. Bollinger	1940	238	Drl	8	503	41	Trb	1960	135	80	PS	
641	4015-7528	do.	—	—	260	Drl	6	213	—	Trb	—	—	—	U	NS
642	4015-7528	do.	F. L. Bollinger	—	250	Drl	8	312	—	Trb	1960	120	70	PS	CA
643	4016-7517	Girard Knitting Mills	—	—	330	Drl	6	—	—	Trb	—	—	—	D	
644	4016-7517	Hatfield Borough	William Stothoff	1957	330	Drl	10	400-500	—	Trb	—	—	160	PS	
645	4016-7522	Alderfer Bologna Co.	A. W. Dorn	1959	280	Drl	—	206	27	Trb	7-15-59	36	70	I	
646	4016-7523	Harleysville Insurance Co.	—	1949	335	Drl	—	—	—	Trb	—	—	—	I	NS
647	4016-7523	Lower Salford School	—	1912	280	Drl	6	160	—	Trb	—	—	—	PS	NS
648	4016-7523	do.	—	1936	280	Drl	6	200	—	Trb	—	—	5	PS	
649	4017-7517	Hunter Spring Co.	Kohl Bros.	1960	370	Drl	10	400	42	Trb, Trl	1960	8	105	I	CA
650	4017-7518	Walter Forest	A. W. Dorn	1945	345	Drl	—	75	—	Trb	—	—	16	PS	NS
651	4017-7518	do.	do.	1957	345	Drl	—	170	—	Trb	—	—	25	PS	
652	4017-7518	Schlosser Steel Co.	—	1958	370	Drl	—	87	—	Trb	—	—	—	I	NS
653	4018-7518	A. Steiert & Sons, Inc.	—	1937	390	Drl	10	205	30	Trl	—	25	—	I	
654	4017-7519	Souderton Borough	F. L. Bollinger	1956	380	Drl	—	300	—	Trl	—	—	10	U	CA
655	4017-7520	do.	—	—	375	Drl	—	300	—	Trl	—	—	10	U	
656	4017-7524	NYCE Manufacturing Co.	Parente Bros.	1925	300	Drl	6	—	—	Trl, Trb	5-24-60	9	—	I	
657	4017-7524	do.	do.	1925	—	Drl	6	—	—	Trb	—	—	—	PS	NS
658	4018-7518	R. T. French Co.	F. L. Bollinger	1956	390	Drl	8	400	40	Trb	—	—	100	I	NS
659	4018-7518	Souderton Borough	—	1915	525	Drl	6	600-700	—	Trl	—	--	—	U	NS
660	4018-7518	do.	—	1929	455	Drl	10	300	13	Trb	1953	39	45	PS	
661	4018-7518	do.	—	—	—	Drl	—	80	—	Trb	—	—	—	X	NS
662	4018-7519	do.	F. L. Bollinger	1948	—	Drl	—	300	—	Trb	1960	75	200	PS	CA
663	4018-7519	do.	William Stothoff	1958	340	Drl	8	300	40	Trb	1959	16	110	PS	NS
664	4018-7519	do.	—	1957	340	Drl	10	400	30	Trb	—	—	45	PS	NS
665	4018-7519	do.	F. L. Bollinger	1954	360	Drl	12	300	21	Trb	—	—	80	PS	NS

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
666	4018-7519	Souderton Steam Laundry	—	1929	390	Drl	8	88	—	Trb	—	—	30	I	
667	4018-7519	Eastern Mennonite Home	J. W. Shaw	1917	460	Drl	6	192	—	Trb, Trl	5-23-60	111	10	PS	
668	4018-7519	Granite Hosiery Mills	—	—	390	Drl	8-6	208	—	Trb	6-14-57	65	11	I	NS
669	4018-7519	Souderton Borough	—	—	395	Drl	8	112	20	Trb	1952	48	50	U	NS
670	4018-7519	do.	—	1936	410	Drl	12	205	25	Trb	1960	125	80	PS	NS
671	4018-7519	do.	—	1911	410	Drl	8	224	120	Trb	1-16-61	54	80	U	NS
672	4018-7519	do.	—	—	395	Drl	—	600-700	—	Trb	—	—	15	U	NS
673	4018-7519	do.	—	—	415	Drl	6	300-350	—	Trb	—	—	—	X	NS
674	4018-7519	M. N. Bergey Hosiery Mill	—	—	390	Drl	6	92	—	Trb	—	—	—	U	NS
675	4018-7519	Goodman Silk Mill	—	—	500	Drl	6	750	—	Trl, Trb	—	—	—	U	NS
676	4018-7519	H. S. Souder	—	—	390	Drl	6	90	—	Trb	—	—	—	U	NS
677	4018-7519	H. L. Landis Estate	—	—	480	Drl	6	300	60	Trb	—	—	—	I	
678	4024-7531	E. Greenville Borough	F. L. Bollinger	1950	315	Drl	14-10	300	43	Trb	6-20-59	14	240	PS	CA
679	4018-7519	Souderton Borough	William Stothoff	1960	360	Drl	12-8	308	—	Trb	2-15-61	12	250	O	
680	4018-7532	New Hanover Township School	—	1952	365	Drl	—	500	—	Trb	—	—	—	PS	CA
681	4018-7521	Franconia Township School	Parente Bros.	1939	475	Drl	6	280	—	Trb	—	—	—	PS	
682	4018-7531	Mennonite Home for Aged	—	—	325	Drl	6	60	—	Trb	—	—	—	PS	NS
683	4018-7531	Mennonite Home for Aged	Mayer	1956	325	Drl	8	175	—	Trb	—	—	—	PS	
684	4019-7519	Telford Borough	Ridpath & Potter	—	420	Drl	10	240	—	Trb	—	—	190	PS	
686	4019-7519	Souderton Borough	—	—	450	Drl	—	600	—	Trb	—	—	12	U	NS
687	4019-7537	Fashion Hosiery Mill	Kohl Bros.	1948	340	Drl	6	400	50	Trb	1948	8	150	I	
688	4019-7537	do.	do.	1938	340	Drl	8	600	10	Trb	1948	7	60	R	NS
689	4020-7528	Maranatha Park	Campbell	—	320	Drl	—	300	—	Trb	—	—	20	PS	CA
690	4020-7528	do.	do.	1950	325	Drl	—	310	—	Trb	—	100	—	PS	NS
691	4013-7516	R. D. Gillen	V. D. Kohler	1960	355	Drl	6	171	—	Trb	—	—	—	D	
692	4018-7522	Keller's Creamery	Joseph Mayer	1960	300	Drl	—	150	—	Trb	—	—	—	D	
693	4018-7522	do.	A. W. Dorn	1950	300	Drl	—	150	—	Trb	—	—	—	I	NS
694	4017-7522	do.	J. M. Mayer	1961	—	Drl	—	—	—	Trb	—	—	—	I	NS
695	4017-7517	Dorsey Shutz	—	—	340	Drl	6	55	—	Trb	6-13-61	10	—	D	

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687	4019-7537	Fashion Hosiery Mill	Kohl Bros.	1948	340	Drl	6	400	50	Trb	1948	8	150	I		
688	4019-7537	do.	do.	[illegible]	340	Drl	8	600	10	Trb	1948	7	60	R	NS	
689	4020-7528	Maranatha Park	Campbell		520	Drl	—	300	—	Trb	—	—	20	PS	CA	
690	4020-7528	do.	do.	[illegible]	325	Drl	—	310	—	Trb	—	100	—	PS	NS	
691	4013-7516	R. D. Gillen	V. D. Kohler	1960	355	Drl	6	171	—	Trb	—	—	—	D		
692	4018-7522	Keller's Creamery	Joseph Mayer	1960	300	Drl	—	150	—	Trb	—	—	—	D		
693	4018-7522	do.	A. W. Dorn	1950	300	Drl	—	150	—	Trb	—	—	—	I	NS	
694	4017-7522	do.	J. M. Mayer	1961	—	Drl	—	—	—	Trb	—	—	—	I	NS	
695	4017-7517	Dorsey Shutz	—	—	340	Drl	6	55	—	Trb	6-13-61	10	—	D		
696	4017-7523	Harvey Koffel	—	1941	240	Drl	6	78	—	Trb	6-15-61	16	—	D		
697	4012-7522	Gordon Wilkie	Miller Pump Service	1956	230	Drl	6	85	43	Trb	6-14-61	18	—	D		
698	4015-7521	Earl Ehrhart	Charles Lauman	—	200	Drl	6	80	—	Trb	6-14-61	23	—	D		
699	4021-7522	R. L. Koehler	A. W. Dorn	1946	480	Drl	6	81	—	Trb	6-12-61	28	—	D		
700	4014-7540	S. G. Flagg Inc.	Kohl Bros.	1961	145	Drl	8	650	88	Trb	11-20-61	22	75	I		
701	4020-7536	Kowecki Chemical Co.	do.	1957	320	Drl	6	403	19	Trb	1957	20	150	I	NS	
702	4020-7536	do.	C. S. Garber	1961	310	Drl	6	300	60	Trb	11- 7-61	8	100	I		
703	4020-7536	do.	do.	1961	315	Drl	6	400	30	Trb	11- 7-61	36	40	U	NS	
704	4015-7517	Lansdale Municipal Authority	F. L. Bollinger	1962	310	Drl	14-10	400	83	Trb	12- 4-61	25	135	PS	CA	
705	4024-7528	Upper Hanover Township	C. S. Garber	1957	480	Drl	6	275	21	Trb	5- 4-57	Flow	100	D		
706	4016-7539	Leroy Fillman	do.	1962	—	Drl	6	320	24	Trb	1-11-62	218	8	D		
707	4016-7539	C. H. Ross	do.	1962	—	Drl	6	300	25	Trb	1- 9-62	109	5	D	NS	
708	4022-7534	H. J. Beitler	Hunsicker	1943	495	Drl	6	123	14	Trb	1955	80	24	D	CA	
709	4018-7523	S. P. Godshall	Stover	—	330	Drl	6	80	—	Trb	2- 8-62	51	—	D	CA	
710	4018-7527	Frank Sear	C. S. Garber	1950	430	Drl	6	100	—	Trb	2- 8-62	18	—	D	CA	
711	4023-7527	A. T. Goodby	W. W. Wonsidler	1957	480	Drl	6	81	30	Trb	1957	12	20	D	CA	
712	4017-7535	E. F. Barndt	C. S. Garber	1940	260	Drl	6	157	40	Trb	2- 5-62	7	10	D	CA	
713	4013-7514	N. T. Cummings	Miller Pump Service	1956	450	Drl	6	312	40	Trl	1956	80	7	D	CA	
714	4014-7538	Ferro-Phos Co.	—	—	175	Drl	6	138	—	Trb	—	40	—	I		
715	4015-7524	Stanley Stemmer	—	1951	300	Drl	6	140	30	Trl	1951	25	20	D	CA	
716	4010-7523	F. A. Plummer	Charles Lawman	1937	410	Drl	6	200	—	Trl	—	—	40	D	CA	
717	4010-7523	do.	—	1927	410	Drl	8	280	—	Trl	—	—	—	D	NS	
718	4013-7531	Fred Tyson	Tenny	1950	295	Drl	6	133	—	Trb	4- 9-62	21	10	D	CA	
720	4011-7530	Bechtel's Dairy	Kohl Bros.	1955	230	Drl	6	300	38	Trb	1955	53	70	I		
721	4011-7530	do.	do.	1944	200	Drl	8	325	15	Trb	1944	60	40	I		
723	4018-7521	H. W. Longacre	A. W. Dorn	1958	395	Drl	8	328	29	Trb	10-13-58	76	80	I		
724	4018-7521	do.	—	—	395	Drl	6	—	—	Trb	—	—	—	I	NS	
725	4015-7527	Schwenksville Water Co.	F. L. Bollinger	1962	145	Drl	8	300	30	Trb	7-30-62	14	250	PS	CA	
726	4014-7536	Amer. Telephone and Telegraph	C. S. Garber	1961	185	Drl	6	300	52	Trb	—	56	37	I		
727	4014-7536	do.	do.	1961	185	Drl	6	300	—	Trb	—	—	30	I	NS	
728	4020-7536	Kowecki Chemical Co.	do.	1961	320	Drl	6	360	21	Trb	1961	140	90	D		
729	4024-7530	Perkiomen School	—	1907	340	Drl	6	1,000	—	Trb	7-24-62	Flow	20	U		
730	4020-7536	Kowecki Chemical Co.	—	—	315	Drl	6	125	14	Trb	9-25-62	4	—	X		
731	4017-7517	Hunter Spring Co.	Thomas Keyes	1962	360	Drl	7	400	22	Trl, Trb	1962	6	110	I		
732	4017-7517	do.	do.	1962	360	Drl	8	403	—	Trb	1962	0	7	U	NS	
733	4020-7525	E. E. Endy	J. Mayer	—	420	Drl	6	42	—	Trd	8- 6-63	18	2	U		

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
734	4020-7526	Delmont Scout Res.	—	—	275	Drl	6	125	—	Trd	8- 9-63	14	20	PS	
735	4020-7526	do.	—	—	275	Drl	6	45	—	Trd	8- 9-63	14	—	D	
736	4011-7526	Linwood Yost	—	—	115	Drl	6	111	—	Trb	—	50	4	D	CA
737	4014-7514	John Wright	—	—	445	Drl	6	90	—	Trl	—	11	15	D	CA
738	4013-7531	Limerick School	—	—	305	Drl	6	110	—	Trb	—	30	15	D	CA
739	4009-7524	Eagleville Sanatorium	—	—	425	Drl	6	511	—	Trl	—	—	9	U	CA
740	4019-7529	Upper Perkiomen Valley Park	F. L. Bollinger	1960	320	Drl	6	415	—	Trd	9- 5-63	35	20	PS	
741	4020-7529	do.	do.	1947	230	Drl	6	359	—	Trd	8-23-63	30	50	PS	CA
742	4020-7529	do.	do.	1940	290	Drl	6	250	—	Trd	—	—	13	PS	
743	4012-7527	Techalloy Co.	C. S. Garber	1961	210	Drl	6	235	42	Trb	1961	65	30	I	
744	4019-7530	R. B. Brooks	—	—	305	Drl	6	65	40	Trd	8-22-63	31	5	D	
745	4020-7530	M. H. Gulack	—	—	340	Drl	6	68	—	Trd	8-22-63	25	3	D	
746	4018-7528	J. L. Beck	—	—	250	Drl	6	38	—	Trd	8-16-63	13	3	D	
747	4020-7523	Ralph Levitz	—	—	350	Drl	6	132	—	Trd	8-30-63	3	3	D	
748	4020-7532	Joseph Kulp	—	1963	420	Drl	6	110	—	Trd	8-28-63	17	.3	D	
749	4020-7532	do.	—	1963	420	Drl	6	42	—	Trd	8-28-63	16	—	U	NS
750	4022-7524	Camp Skymount	Ridpath & Potter	1946	—	Drl	10	53	34	Trd	6-17-46	Flow	15	D	
751	4022-7524	do.	—	—	—	Drl	—	—	—	Trd	—	—	—	D	CA
752	4022-7524	do.	—	—	—	Drl	—	—	—	Trd	—	—	—	D	NS
753	4016-7527	John Lesher	Michael Kuszyk	1963	190	Drl	6	313	20	Trd	8-19-63	14	.1	D	
754	4017-7515	Atlantic Refining Co.	Philadelphia Drilling Co.	1952	275	Drl	6	106	35	Trb	3-25-53	5	20	D	
755	4014-7540	S. G. Flagg, Inc.	Kohl Bros.	1963	150	Drl	10	595	47	Trb	6-13-63	30	430	I	
756	4004-7511	Century Vault Co.	Philadelphia Drilling Co.	1948	—	Drl	6	81	15	Xw	1948	13	25	I	NS
757	4004-7511	Metallurgical Lab. Inc.	Ridpath & Potter	1909	410	Drl	6	437	177	Xw	7-31-42	6	40	I	
758	4006-7512	Henry Bass	—	—	—	Drl	6	385	—	Cl	—	—	—	I	CA
759	3959-7515	Sem. of St. Charles Barraneo	Quinn & Herron	1915	—	Drl	8	600	—	Xgn	—	120	13	PS	
760	3959-7515	E. Baptist Seminary	Ridpath & Potter	1924	—	Drl	10	300	69	Xgn	10-21-24	9	92	U	NS
761	3959-7515	Sem. of St. Charles Barraneo	do.	1927	—	Drl	10	378	52	Xgn	—	43	90	PS	
762	4001-7515	W. Laurel Hill Cemetery	Harper	1910	—	Drl	8	365	10	Xw	—	18	20	D	

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756	4004-7511	Century Vault Co.	Philadelphia Drilling Co.	1948	—	Drl	6	81	15	Xw	1948	13	25	I	NS
757	4004-7511	Metallurgical Lab. Inc.	Ridpath & Potter	1[illegible]	410	Drl	6	437	177	Xw	7-31-42	6	40	I	
758	4006-7512	Henry Bass	—		—	Drl	6	385	—	Cl	—	—	—	I	CA
759	3959-7515	Sem. of St. Charles Barraneo	Quinn & Herron	1[illegible]	—	Drl	8	600	—	Xgn	—	120	13	PS	
760	3959-7515	E. Baptist Seminary	Ridpath & Potter	1924	—	Drl	10	300	69	Xgn	10-21-24	9	92	U	NS
761	3959-7515	Sem. of St. Charles Barraneo	do.	1927	—	Drl	10	378	52	Xgn	—	43	90	PS	
762	4001-7513	W. Laurel Hill Cemetary	Harper	1910	—	Drl	8	365	10	Xw	—	18	20	D	
763	4004-7517	Quaker Chemical Corp.	—	1930	—	Drl	6	165	—	Ocs	9-28-50	16	150	I	CA
766	4010-7510	Dublin Water Co.	—	—	—	Drl	6	244	52	Trs	—	—	253	PS	
767	4010-7511	do.	F. L. Bollinger & Sons	—	—	Drl	8	300	51	Trs	—	20	163	PS	
768	4008-7526	Audubon Water Co.	—	—	—	Drl	8	356	37	Trs	10-18-51	90	52	PS	
769	4008-7526	do.	—	—	—	Drl	6	160	56	Trs	2- 8-60	31	40	PS	NS
770	4008-7526	do.	—	—	—	Drl	6	240	40	Trs	10-17-69	20	175	PS	
771	4009-7516	Blue Bell Water Co.	Ridpath & Potter	1953	—	Drl	8	250	90	Trs	—	20	302	PS	NS
772	4008-7516	do.	do.	1961	—	Drl	8	400	68	Trs	2-27-61	24	148	PS	
773	4005-7514	Phila. Suburban Water Co.	T. G. Keyes	1955	—	Drl	10	260	178	Ocs	—	40	100	U	NS
774	4007-7508	do.	Schultas Drilling Co.	1956	—	Drl	8	465	424	Cl	—	10	1,016	PS	
775	4007-7508	do.	Thomas Keyes	—	—	Drl	—	175	—	Cl	—	—	—	A	NS
776	4006-7511	do.	do.	1957	—	Drl	14	351	92	Ocs	12- 2-57	31	200	PS	
777	4006-7512	do.	do.	1959	—	Drl	12	300	145	Ce	12- 8-59	41	707	PS	CA
778	4007-7510	do.	do.	1959	—	Drl	12	300	78	Ocs	8-25-60	70	900	PS	CA
779	4007-7517	do.	do.	1960	—	Drl	8	600	40	Trs	8-12-60	49	135	PS	NS
780	4005-7514	do.	Layne New York	1963	—	Drl	10	502	405	Ocs	7- 6-63	58	448	PS	CA
781	4004-7524	do.	do.	1963	—	Drl	8	600	77	Ocs	1963	96	—	A	NS
782	4004-7524	do.	do.	1963	—	Drl	8	220	187	Ocs	—	—	—	X	NS
783	4004-7524	do.	do.	1964	—	Drl	12	502	328	Ocs	8-17-64	112	949	PS	
784	4004-7523	do.	do.	1964	—	Drl	12	493	185	Ocs	—	—	—	T	
785	4008-7517	Phila. Suburban Water Co.	T. G. Keyes	1962	—	Drl	10	463	30	Trs	6-28-62	22	350	PS	
786	4007-7511	do.	—	—	—	Drl	6	600	284	Cl	—	66	150	PS	
787	4007-7511	do.	T. G. Keyes	1964	—	Drl	12	436	253	Cl	7- 7-64	78	950	PS	CA
788	4009-7508	do.	do.	1960	—	Drl	8	410	43	Trs	11-17-60	55	150	PS	
789	4004-7523	Phila. Suburban Water Co.	Layne New York	1964	—	Drl	—	500	—	Ocs	—	—	—	T	
790	4005-7517	do.	Keyes	1960	—	Drl	20	500	21	Ocs	—	44	10	U	
791	4013-7525	E. State Penitentiary	R. Bollinger	1964	—	Drl	8	500	43	Trb	7-28-64	50	45	PS	
792	4014-7526	do.	do.	1965	—	Drl	8	500	42	Trb	1- 4-65	74	318	PS	
793	4006-7527	St. Gabriels Hall	Ridpath & Potter	1929	—	Drl	8	445	65	Trs	—	45	87	D	CA
794	4006-7527	do.	do.	1929	—	Drl	8	500	62	Trs	1951	151	85	D	CA
795	4004-7519	W. Conshohoken Gas Co.	Bollinger	1950	—	Drl	10	500-600	180	Ocs	—	—	—	U	NS
796	4004-7519	do.	do.	1950	—	Drl	8	600	—	Ocs	—	12	35	U	NS
797	4004-7519	do.	do.	1950	—	Drl	10	820	80	Ocs	—	—	79	I	
798	4007-7528	Penco Metal Products	Kohl Bros.	1959	—	Drl	8	290	82	Trs	3-26-59	40	125	I	
799	4005-7521	R. E. Lamb Inc.	do.	1960	—	Drl	6	247	42	Ocs	8- 2-60	150	6	I	

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
800	4006-7525	Valley Forge Park	do.	1963	—	Drl	8	400	55	Trs	10-30-63	70	110	I	
801	4008-7512	Fort Washington Chem.	Ridpath & Potter	1943	—	Drl	8	408	—	Trs, Cch	1-18-43	6	17	I	
802	4004-7518	Raint Theater	do.	1945	—	Drl	10	608	63	Xw	3- 6-45	83	2	I	NS
803	4004-7518	Flexton Corp.	do.	1950	—	Drl	10	405	225	Ocs	9-28-50	13	25	I	
804	4005-7519	Prosper War	do.	1948	—	Drl	8	93	44	Ocs	—	17	60	I	
805	4005-7519	F. P. Schofield	do.	1947	—	Drl	8	230	11	Ce	1- 8-47	51	14	D	
806	4006-7520	Energetic Worsted	do.	1941	—	Drl	10	170	18	Trs	5- 6-41	4	114	I	CA
807	4006-7520	Kurtz Bros.	—	—	—	Drl	—	73	—	Trs	—	—	—	U	NS
808	4004-7517	Lee Rubber & Tire	Ridpath & Potter	1942	70	Drl	8	330	—	Ocs	1950	20	480	I	NS
809	4004-7517	do.	do.	1946	70	Drl	20	219	160	Ocs	9-28-50	60	180	I	
810	4004-7517	do.	do.	1938	70	Drl	20	280	183	Ocs	1950	65	289	I	NS
811	4004-7517	do.	do.	—	—	Drl	—	198	20	Ocs	—	—	450	I	NS
812	4005-7517	do.	do.	1952	—	Drl	16	102	78	Ocs	2- 1-52	22	650	I	
813	4004-7517	do.	do.	1947	—	Drl	8	130	13	Ocs	—	54	—	T	NS
814	4004-7517	do.	do.	1947	—	Drl	16	200	21	Ocs	4-25-47	54	427	I	NS
815	4004-7517	Lee Rubber & Tire	Parente	1940	—	Drl	—	235	—	Ocs	—	—	25	U	NS
816	4004-7517	do.	Ridpath & Potter	1947	—	Drl	—	210	—	Ocs	—	—	15	X	NS
817	4004-7517	do.	do.	1946	—	Drl	16	200	22	Ocs	6-16-46	19	300	I	NS
818	4009-7510	G. L. Burnett	do.	1939	—	Drl	6	100	13	Trs	—	—	37	D	
819	4007-7515	Peter Romano	do.	1958	—	Drl	6	150	44	Trs	4-29-58	10	37	D	
820	4003-7519	S. M. Toben	T. G. Keyes	1954	—	Drl	6	200	18	Xhg	—	30	20	D	CA
821	4009-7516	Meadowlands Golf Club	do.	1964	—	Drl	—	—	—	Trs	5-27-64	20	17	D	
822	4000-7512	Connelly Containers	do.	1963	—	Drl	5	232	42	Xw	—	45	2	I	
823		Green Lane Hosiery	Ridpath & Potter	1948	—	Drl	8	620	14	Trd	—	16	13	I	NS
824		do.	do.	—	—	Drl	10	356	13	Trd	—	16	4	I	NS
825		Nicholas Fechyk	Philadelphia Drilling Co.	1948	—	Drl	6	89	—	Trd	—	80	—	D	NS
827	4004-7519	Westfield River Paper Co.	—	—	—	Drl	8	658	—	Xw	—	—	Dry	U	
828	4004-7519	Titus & Taylor	—	—	—	Drl	8	200	—	Xw	—	—	Dry	U	NS
829	4006-7520	Daring Paper Mfg.	Ridpath & Potter	1946	—	Drl	10	571	24	Trs	1946	9	200	I	
832	4005-7502	Valley View Apts.	—	—	—	Drl	6	186	—	Gh	—	152	5	D	CA
833	4004-7518	do.	Ridpath & Potter	1935	—	Drl	8	175	17	Ocs	—	—	77	I	
834	4003-7519	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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821	4009-7516	Meadowlands Golf Club	do.	1964	—	Drl	—	—	—	Trs	5-27-64	20	17	D	
822	4000-7512	Connelly Containers	do.	1963	—	Drl	5	232	42	Xw	—	45	2	I	
823		Green Lane Hosiery	Ridpath &	1948	—	Drl	8	620	14	Trd	—	16	13	I	
824		do.	do.	—	—	Drl	10	356	13	Trd	—	16	4	I	NS
825		Nicholas Fechyk	Philadelphia Drilling Co.	1948	—	Drl	6	89	—	Trd	—	80	—	D	NS
827	4004-7519	Westfield River Paper Co.	—	—	—	Drl	8	658	—	Xw	—	—	Dry	U	
828	4004-7519	Titus & Taylor	—	—	—	Drl	8	200	—	Xw	—	—	Dry	U	NS
829	4006-7520	Daring Paper Mfg.	Ridpath & Potter	1946	—	Drl	10	571	24	Trs	1946	9	200	I	
832	4005-7502	Valley View Apts.	—	—	—	Drl	6	186	—	Gh	—	152	5	D	CA
833	4004-7518	do.	Ridpath & Potter	1935	—	Drl	8	125	17	Ocs	—	—	72	I	
834	4002-7518	G. G. Clarke	do.	1949	—	Drl	10	243	29	Xhg	—	51	50	D	
835	4006-7519	P. F. Laumer Bros.	Bollinger	—	55	Drl	8	50	2	Ce	4-9-51	3	50	I	
836	4004-7517	Reilly, Whiteman & Walton	Philadelphia Drilling Co.	—	—	Drl	8	105	30	Ocs	1958	6	60	I	
837	4004-7516	W. C. Hamilton & Sons	Ridpath & Potter	1951	—	Drl	10	400	55	Ocs	3-26-51	9	676	I	
838	4004-7517	Philadelphia Steel & Iron	—	1940	50	Drl	6	125	—	Ocs	—	20	—	I	NS
839	4004-7517	John Wood Co.	—	1914	50	Drl	6	200	—	Ocs	—	25	150	I	NS
840	4002-7519	A. J. Baranzano	Keyes	1954	—	Drl	6	61	53	Xgn	—	6	30	D	
841	4002-7518	R. A. Jones	T. G. Keyes	1958	—	Drl	5	70	26	Xgn	—	20	8	D	
842	4005-7521	Marco Products	do.	1965	—	Drl	6	165	108	Ocs	—	—	100	I	
843	4004-7521	Bassett Steel & Tube	T. G. Keyes	1961	—	Drl	6	260	217	Xw	—	—	Dry	U	NS
844	4004-7521	do.	do.	1961	—	Drl	5	120	102	Xw	—	—	3.5	U	
845	4006-7526	Baldwin-Ehret-Hill	—	1903	—	Drl	6	600	—	Cl	—	—	—	I	
846	4005-7521	Highway Materials Inc.	Kohl Bros.	1946	—	Drl	8	400	40	Cl	—	70	120	I	
847	4015-7539	Philadelphia Dairy Products	do.	1950	—	Drl	8	1,002	31	Trb	—	16	130	I	
848	4015-7539	do.	do.	—	—	Drl	—	701	—	Trb	12-17-48	29	45	I	NS
849		Jones Motor Co.	do.	1946	—	Drl	—	250	24	Trb	—	20	260	I	NS
850	4011-7532	Cann & Saul Steel Co.	do.	1941	—	Drl	6	300	33	Trb	—	33	36	I	NS
851	4011-7526	Superior Tube Co.	do.	1956	—	Drl	8	555	17	Trb	—	135	120	I	NS
852	4024-7530	E. Greenville Borough	F. L. Bollinger	1965	400	Drl	8	550	—	Trb	—	—	40	I	
853	4014-7519	Peter Roberts Inc.	do.	1961	—	Drl	8	300	—	Trb	—	—	—	I	
854	4016-7523	Sparks Corp.	Miller	—	—	Drl	—	150	—	Trb	—	—	200	I	
855	4004-7517	Walker Bros.	F. L. Bollinger	—	—	Drl	6	562	562	Ocs	—	—	—	U	NS
856	4004-7517	do.	do.	—	—	Drl	8	55	55	Ocs	—	—	200	I	
857	4004-7517	do.	do.	—	—	Drl	8	350	100	Ocs	—	—	100	I	NS
858	4009-7516	Blue Bell Water Co.	do.	1965	—	Drl	14	500	60	Trs	—	—	350	PS	
859	4010-7510	Dublin Water Co.	do.	1961	—	Drl	12-8	350	53	Trs	1961	45	39	U	NS
860	4009-7510	do.	do.	1965	—	Drl	14-10	300	40	Trs	—	—	327	PS	
861	4007-7527	Montgomery Co. Sewage Auth.	do.	—	—	Drl	—	192	—	Trs	—	—	25	D	
863	4004-7518	Jones Wollen Mill	do.	—	—	Drl	—	300-400	—	Ocs	—	—	—	I, Dr	NS
864	4004-7518	do.	do.	—	—	Drl	—	300-400	—	Ocs	—	—	—	I, Dr	NS
865	4006-7520	Summerville Tube Co.	do.	—	—	Drl	8	820	—	—	—	—	11	I	NS
866	4006-7520	do.	do.	—	—	Drl	8	525	—	—	—	—	21	I	
867	4006-7520	do.	do.	—	—	Drl	8	815	—	—	—	—	490	I	
868	4006-7520	Burdett Oxygen	—	—	—	Drl	—	240	—	Trs	—	—	60	I	NS
869	4024-7529	Upper Perkiomen Rec. Co.	Mayer	—	—	Drl	—	250	—	Trb	—	—	—	PS	
870	4024-7530	E. Mettalurgical Assoc.	—	—	—	Drl	10	300	—	Trb	—	—	130	I	
871	4009-7515	Meadowlands Golf Club	F. L. Bollinger	1954	305	Drl	10	300	38	Trs	—	—	118	Irr.	

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Table 6. *Continued.*

Well number	Location number	Owner	Driller	Date completed	Altitude above sea level (feet)	Method of construction	Diameter (inches)	Total depth (feet)	Depth to bottom of casing (feet)	Aquifer name	Static water level: Date of measurement	Static water level: Depth below land surface (feet)	Yield (gpm)	Use	Remarks
872	4009-7515	do.	do.	1954	—	Drl	10	300	40	Trs	—	—	30	D	
873	4007-7524	Valley Forge Industrial Park	Kohl Bros.	1959	—	Drl	12	400	54	Trs	—	39	119	I	
874	4007-7524	do.	do.	1960	—	Drl	12	400	62	Trs	9- 5-60	30	245	I	
875		North Wales Water Authority	Miller Pump	1964	—	Drl	12-8	500	—	Trb, Trl	—	—	750	PS	NS
876		American Electronics Lab.	—	—	—	Drl	—	300	—	Trb	—	—	300	I	NS
877	4005-7521	Phila. Suburban Water Co.	T. G. Keyes	1965	—	Drl	—	—	—	Ocs	—	—	—	X	NS
878	4005-7520	do.	Layne New York	1965	—	Drl	18-14	505	204	Ce	—	204	961	PS	CA
879	4004-7520	do.	T. G. Keyes	1965	—	Drl	—	—	—	Ocs	—	—	—	X	NS
880	4005-7517	do.	do.	1965	—	Drl	—	—	—	Ocs	—	—	350	PS	
881		do.	Layne New York	1965	—	Drl	—	500	—	Ocs	—	—	760	PS	NS
882	4005-7524	do.	do.	1965	93	Drl	18-12	275	140	Cl	6-28-65	12	1,810	PS	
883	4007-7504	do.	T. G. Keyes	1956	—	Drl	8	338	74	Xgn	—	Flow	43	PS	
884	4013-7518	Merck, Sharpe & Dohme	—	1965	351	Drl	12-10	600	—	Trb	2-22-65	93	—	O	NS
885	4007-7512	McNeil Laboratories	Rulont Cook	—	—	Drl	—	—	—	Cl	—	—	—	D	NS
886	4007-7512	do.	do.	1958	—	Drl	10	205	137	Cl	—	54	500	I	
887		Standard Pressed Steel Co.	—	—	230	Dug	120	39	—	Xw	5- 4-51	34	—	U	NS
888		do.	Artesian Well Drilling	1944	230	Drl	8	300	—	Xw	12-27-49	60	100	I	NS
889		do.	Ridpath & Potter	1945	230	Drl	12-8	326	—	—	—	38	30	I	NS
890		do.	do.	1945	230	Drl	8	582	—	Xw	9-22-45	32	50	I, U	CA, NS
891		do.	J. H. Rulon	1951	—	Drl	16-10	400	—	Xw	—	15	32	I	NS
892		do.	do.	1951	—	Drl	10	480	—	Xw	—	—	30	I	NS
893		Meyers Dairy	—	1928	—	Drl	6	250	—	—	1947	25	120	I	NS
894		St. Mary's Home for Children	—	—	—	Drl	10	92	—	Trs	—	—	90	PS	NS
895		Reniger & Son Florists	—	—	—	Drl	6	119	—	Trs	1947	0.1	250	I	NS
896		Roberts & Mander	—	—	—	Drl	4	565	—	Trs	1947	65	25	I	NS
897		do.	—	—	—	Drl	4.5	285	—	Trs	1947	65	25	I	NS
898		Firestone Aircraft Co.	—	—	—	Drl	8	126	—	—	1947	14	15	I	NS
899	4012-7508	U.S. Naval Air Station	Bollinger	1942	—	Drl	16-10	397	—	—	1942	8	231	PS	CA, NS
900	4012-7508	do.	do.	1942	—	Drl	16-10	351	—	—	10- 5-42	14	231	PS	CA

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of the municipalities in Montgomery County using surface water are supplied by private companies. The amount of surface water pumped for selected municipalities is shown below:

Supplier	Stream	Pumpage in millions of gallons during 1968
East Greenville	Perkiomen Creek	* 57.42
Royersford		
(Home Water Co.)	Schuylkill River	320.27
Norristown	Schuylkill River	2,875.74
Pottstown	Schuylkill River	880.00

* Part supplied from ground water.

The Philadelphia Suburban Water Company uses both ground-water and surface-water sources and supplies many cities and towns in Montgomery County. There is no breakdown of the amounts of water from each source used by this company. Surface-water supplies in Montgomery County are adequate for the present needs.

WATER PROBLEMS RESULTING FROM THE ACTIVITIES OF MAN

Three water problems that have resulted from the activities of man in Montgomery County are (1) declining ground-water levels, (2) changes in streamflow caused by urbanization, and (3) contamination of ground-water reservoirs by domestic and industrial wastes.

DECLINING GROUND-WATER LEVELS

When water is withdrawn from a well, either by pumping or by artesian flow, the ground-water reservoir is modified. Two effects of pumping that cause concern are declining ground-water levels in the vicinity of the pumping wells and lower yields from the pumped wells and nearby wells. The cumulative drawdown effect from closely spaced pumping wells affects the yields of all wells in the cone of depression. A cross section showing drawdown (lowering of ground-water levels) in the vicinity of a pumping well and the effect on the water level of a nearby well is shown in Figure 14. The amount of interference depends upon the complex relationship between the rate and duration of pumping, distance between wells, and the hydraulic properties of the aquifer.

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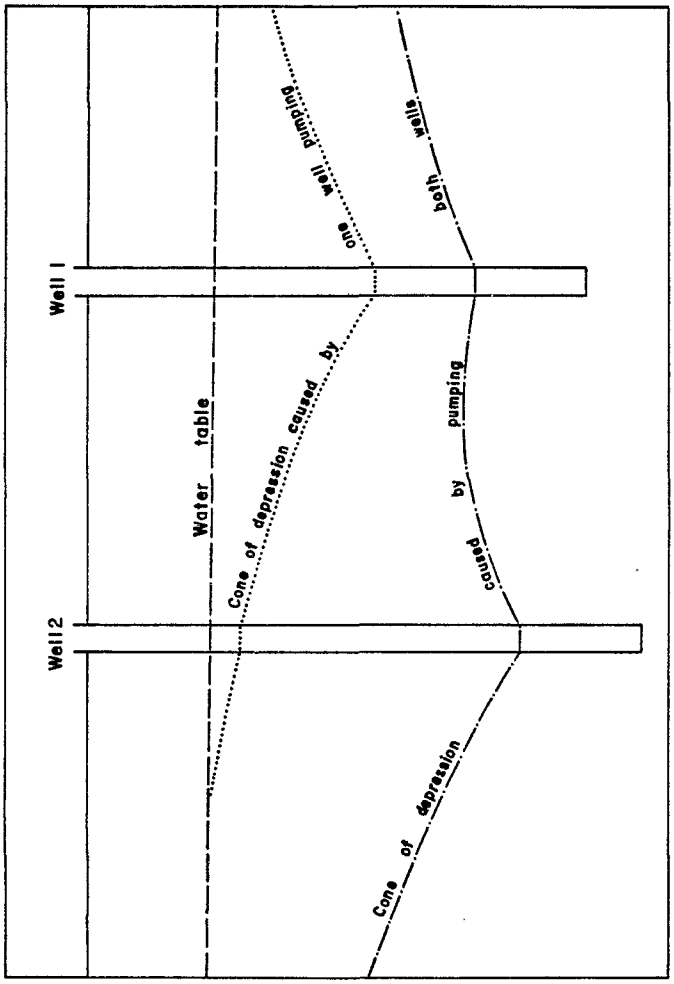

Figure 14. Effects on the water table when wells are pumped.

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Figure 14. Effects on the water table when wells are pumped.

CHANGES IN STREAMFLOW CAUSED BY URBANIZATION

The effects of urbanization on streams in Montgomery County are not yet readily apparent, but changes will probably become more noticeable as the county continues to urbanize. The flood-flow peaks will get higher as development increases. As more land area is covered by roads, buildings, sidewalks, and parking lots, the runoff will increase. The time between rainfall and runoff will shorten, and the flood crests will be higher. Drainage patterns will be modified to move the water faster. The low flood of streams will decrease because reduced infiltration, faster and more complete runoff, and more evaporation from paved surfaces will reduce the amount of ground water available for low-flow discharge into stream channels.

The quality of the water in the streams will be seriously degraded unless the disposal of domestic and industrial wastes is controlled by intelligent planning and strict enforcement of standards.

CONTAMINATION OF SHALLOW GROUND WATER

Contamination of ground water in Montgomery County occurs in several ways. In areas where there has been much housing construction, and no sanitary sewer systems have been installed, septic-tank discharge pollutes the shallow aquifers. Leakage or spillage of hydrocarbons from oil storage tanks and pipelines can pollute the aquifers. Hydrocarbons are very difficult to remove from the aquifer, and the pollution effects last a long time. The disposal of solid waste by the landfill procedure can cause pollution of the shallow aquifers in Montgomery County. Precipitation on the waste material moves downward, leaching pollutants into the shallow aquifers. Pollution leaching from landfill areas also runs overland into surface-water bodies.

In Table 7 chemical analyses of ground water in Montgomery County are presented to give a background for the ranges of various elements in these waters. In urban and other heavily pumped areas periodic chemical analysis of the ground water would be advisable as a check on possible contamination. Polluted water generally moves slowly through consolidated rocks, but it can move rather rapidly through fractures in this type of rock.

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Table 7. *Chemical analyses of ground water in Montgomery County, Pennsylvania*

(Results in milligrams per liter except as indicated)

Well number	Date of collection	Temperature (°F)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Noncarbonate	Specific conductance (micromhos at 25° C)	pH	Color
Mg 8	1947	—	—	0.0	—	—	—	—	—	—	—	5.0	—	14.0	200	86	—	—	7.0	15
9	1957	54	11	.01	.00	53	24	8.4	2.7	234	33	11	.0	9.0	282	—	39	466	7.9	1
10	1956	55	24	.31	—	49	8.0	6.9		150	28	6.0	.1	7.4	232	155	29	330	8.3	3
11	1956	54	25	.03	—	42	6.5	2.1		111	28	7.0	.1	7.2	213	132	41	296	8.0	2
12	1947	—	—	.23	—	—	—	—	—	—	—	7.6	—	1.9	341	174	122	—	7.7	—
17	1925	55	30	.06	—	72	49	20	3.5	156	279	7.2	—	.69	570	—	—	—	—	—
20	1956	55	26	.01	—	69	27	34		145	116	80	.1	6.7	475	283	164	719	7.7	1
22	1957	54	23	.41	.03	82	28	22	1.4	142	193	34	.1	.10	478	320	203	695	8.1	1
24	1925	55	30	.06	—	72	49	20	3.5	156	279	7.2	—	.69	570	381	—	—	—	—
28	1956	57	29	.16	.00	74	18	28		155	136	30	.1	6.9	454	259	128	627	8.3	1
33	1956	57	30	.17	.00	59	17	17		154	47	28	.1	48	351	217	91	539	7.2	2
35	1947	—	—	1.7	—	77	15	—	—	—	143	72	—	27	—	256	—	—	7.1	15
36	1947	—	—	.1	—	109	10	—	—	—	158	72	—	7	—	314	—	—	7.6	5
37	1933	—	—	.6	—	87	22	—	—	—	87	40	—	—	—	310	—	—	7.7	3
49	1925	52	25	.7	—	40	15	9.8	1.7	187	13	6.8	—	5.2	199	162	—	—	—	—
52	1925	54	18	.06	—	47	17	.41	.05	194	23	13	—	7.5	232	187	—	—	—	—
62[a]	1925	—	32	.05	—	36	15	11	5.1	1.8	173	15	8	—	2.5	201	152	—	—	—
76	1952	55	21	.01	—	24	20				150	22	5	—	.4	—	142	19	321	6.4	2
111	1962	56	30	.37	.00	57	18	13	.7	171	69	16	.1	4.9	317	216	76	457	6.6	2
119	1956	—	29	.04	—	233	16	25		118	558	16	.2	.7	1,040	647	550	1,230	7.9	5
145	1956	55	22	.70	—	190	14	13		147	409	7.5	.1	2.3	789	532	411	979	7.6	1
146	1953	54	13	0.02	—	57	28	13	1.0	242	58	18	0.0	9.9	327	257	59	444	7.3	2
148	1962	—	17	.07	.00	45	5.4	12	1.0	134	26	10	.1	13	200	135	25	313	7.5	2
167	1955	—	—	.02	—	—	—	—	—	154	—	22	—	—	270	154	148	—	7.8	—
169	1954	—	—	.06	—	—	—	—	—	138	—	16	—	—	234	138	114	—	7.8	—
186	1954	—	13	.13	—	90	52	—	—	—	4.0	6.5	—	—	—	142	—	—	8.5	—
189	1933	—	—	.1	—	—	—	—	—	—	—	12	—	1.6	167	—	—	—	—	10
190	1962	54	22	.04	.00	55	27	14	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

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111	1962	56	30	.37	.00	57	18	13		.7	171	69	10	.1	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
119	1956	—	29	.04	—	233	16		25		118	558	16	.2	.7	1,040	647	550	1,230	7.9	5
145	1956	55	22	.70	—	190	14		13		147	409	7.5	.1	2.3	789	532	411	979	7.6	1
146	1953	54	13	0.02	—	57	28	13		1.	242	58	18	0.0	9.9	327	257	59	444	7.3	2
148	1962	—	17	.07	.00	45	5.4	12		1.0	134	26	10	.1	13	200	135	25	313	7.5	2
167	1955	—	—	.02	—	—	—	—		—	154	—	22	—	—	270	154	148	—	7.8	—
169	1954	—	—	.06	—	—	—	—		—	138	—	16	—	—	234	138	114	—	7.8	—
186	1954	—	13	.13	—	90	52	—		—	—	4.0	6.5	—	—	—	142	—	—	8.5	—
189	1933	—	—	.1	—	—	—	—		—	—	—	12	—	1.6	167	—	—	—	—	10
190	1962	54	22	.04	.00	55	23	14		1.0	256	19	17	.1	7.7	285	232	22	480	7.6	3
205	1956	—	20	.02	—	28	16		9.9		169	11	1.2	.1	.5	187	136	0	288	6.8	2
209	1956	58	23	.07	.00	31	20		8.1		144	40	8.0	.1	7.4	225	160	42	350	7.5	2
210	1956	54	27	.02	.00	31	14		15		137	20	19.0	.1	9.6	217	135	23	317	7.2	2
211	1952	—	—	1.2	—	—	—	—		—	—	44	17.0	—	3.2	226	—	—	—	6.9	—
212	1956	54	22	.15	.00	39	6.5		27		113	50	17.0	.1	17	274	123	31	367	7.1	1
213	1953	—	—	.1	—	—	—	—		—	—	43	17.0	—	4.0	230	101	—	—	6.6	—
214	1950	—	—	.1	—	—	—	—		—	—	25	6.0	—	1.0	184	134	—	—	7.5	—
216	1956	55	32	.1	—	38	11		17		138	25	14.0	.1	13	264	140	20	243	8.4	1
217	1956	57	24	.2	—	31	10		39		138	70	8.5	.1	6.5	279	118	5	403	7.6	1
218	1956	54	29	.04	.00	41	10		29		140	64	11	.1	11	274	143	29	407	8.2	1
219	1956	55	26	.11	.00	40	5.2		18		137	23	10	.1	13	197	121	9	286	8.0	1
220	1955	—	—	.10	—	—	—	—		—	—	26	12	—	2.0	210	175	—	—	7.7	—
230	1956	57	28	.13	.0	27	15		11		143	12	6.5	.1	9.7	191	129	5	292	8.5	1
270	1957	54	24	.30	.04	23	17	6.8		.7	145	12	4.1	.1	2.8	162	129	9	264	8.1	2
275	1956	57	23	0.01	—	36	10		8.6		126	15	9.0	.1	22	187	131	—	300	7.8	1
276	1956	57	20	.01	—	25	12		12		127	15	6.5	.1	6.3	165	112	4	261	8.3	1
278	1956	58	33	.14	—	41	15	15		—	145	25	22	.1	26	260	160	45	407	8.2	1
281	1952	—	—	.1	—	—	—	—		—	—	33	11	—	41	—	200	50	—	7.4	5
282	1952	—	—	.1	—	—	—	—		—	—	20	6	—	9	—	132	34	—	7.6	5
283	1952	—	—	.1	—	—	—	—		—	—	48	14	—	57	—	220	52	—	7.4	10
285	1956	—	36	.24	—	6.5	3.2	35		—	49	42	7.0	4.0	3.2	197	29	0	232	6.8	2
287	1956	56	19	.13	—	25	9.2	23		—	142	20	6.2	1.6	.2	181	100	0	283	7.6	2
290	1963	—	—	2.0	2.0	—	—	—		—	—	—	9.0	—	.5	260	145	—	—	7.4	5
302	1956	56	12	.5	.00	42	19		12		166	45	10	.1	5.3	260	183	40	425	8.4	1
303	1955	—	20	.0	—	100	46	—		—	—	52	13	—	—	—	146	—	—	6.9	—
304	1956	58	26	.9	.00	34	13		46		104	124	13	.1	5.7	272	187	0	437	8.5	1
359	1956	—	23	.83	.00	42	20		28		253	12	10	.1	5.7	272	187	—	437	8.5	1
363	1956	—	26	.15	.01	16	5.6		12		72	17	5.5	.1	5.2	124	182	—	187	7.5	1
367	1956	54	25	.17	.00	25	14		9.4		144	11	4.0	.1	6.5	173	120	2	265	8.2	2
391	1956	—	8.9	.40	—	4.9	4.8		.7		22	9.4	3.4	.1	.8	45	32	14	69	7.3	1
392	1955	—	20	1.0	—	—	—	—		—	—	—	—	—	—	—	—	—	—	6.0	—
394	1956	—	23	.49	.19	38	20		39		155	65	24	.2	4.0	324	177	50	510	7.3	2
399	1956	—	9.1	.00	—	9.8	5.5		4.8		49	11	3.5	.1	.8	69	47	7	115	7.6	3
406	1956	—	18	.07	—	35	5.9		16		97	29	10	.1	27	212	112	32	397	7.8	1

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Table 7. *Continued*

(Results in milligrams per liter except as indicated)

Well number	Date of collection	Temperature (° F)	Silica (SiO_2)	Total iron (Fe)	Total manganese (Mn)	Calcium (Ca)	Magnesium (Mg)	Sodium (Na)	Potassium (K)	Bicarbonate (HCO_3)	Sulfate (SO_4)	Chloride (Cl)	Fluoride (F)	Nitrate (NO_3)	Dissolved solids	Hardness as $CaCO_3$: Calcium magnesium	Hardness as $CaCO_3$: Non-carbonate	Specific conductance (micromhos at 25° C)	pH	Color
414	1956	—	17	.20	.00	15	4.8	16		26	27	9.5	.1	37	137	57	36	206	7.2	1
419	1956	54	10	0.30	—	35	10	5.8		122	20	6.8	0.1	13	168	128	28	267	7.2	1
453	1956	55	26	.30	—	43	14	15		184	19	16	.1	6.5	236	160	14	385	7.6	1
454	1956	55	32	.18	—	6.9	2.3	12		36	8.4	5.6	.1	8.9	94	27	0	104	7.2	2
464	1954	—	—	.30	—	620	50	—	—	431	4.3	6	—	.3	980	670	—	—	7.4	—
490	—	—	—	—	—	85	20	25		135	195	—	—	—	490	300	—	—	—	—
493	1961	—	15	.05	.00	51	21	9.9	1.0	208	41	12	.1	5.9	262	214	43	432	7.8	1
494	1961	—	36	1.8	.00	12	40	10	1.0	53	6.7	5.3	.0	11	109	47	3	138	6.5	1
540	1962	56	20	.44	.02	116	51	22	.8	163	370	11	.1	11	732	500	366	959	7.3	3
541	1961	54	22	.05	.00	39	8.3	10	1.0	120	24	7.4	.1	20	192	132	33	295	7.7	2
551	1961	54	19	.26	.01	47	9.0	14	1.0	179	12	9.3	.0	18	214	155	8	351	7.8	2
557	1962	—	24	.00	.17	49	12	12	.8	128	69	5.8	.1	13	252	172	67	378	6.8	3
577	1946	—	—	—	—	112	112	—	—	—	116	2.5	—	—	—	—	—	—	7.5	—
580	1946	—	—	—	—	87	45	—	—	—	76	2.5	—	—	—	—	—	—	7.3	—
583	1946	—	—	—	—	114	94	—	—	—	—	4.0	—	—	—	—	—	—	7.5	—
584	1946	—	—	—	—	30	16	—	—	—	16	3.5	—	—	—	—	—	—	7.5	—
585	1946	—	—	—	—	100	116	—	—	—	68	6.0	—	—	—	—	—	—	7.5	—
603	1961	58	28	3.9	.04	180	32	27	1.0	180	420	18	.2	2.8	805	581	433	1,090	7.4	3
616	1949	54	20	.10	—	52	13	11	1.4	198	23	7.0	.0	12	242	183	21	392	7.5	3
631	1961	54	16	.38	.03	30	8.2	45	.5	173	48	3.5	.0	3.7	239	109	0	378	8.0	2
642	1961	55	28	.02	.03	90	36	19	1.8	162	248	6.0	.2	2.7	534	373	240	747	7.7	2
649	1960	—	12	—	.0	—	—	—	—	—	16.8	8.0	.0	.08	298	232	70	—	—	—
654	1964	—	—	0.2	0.0	—	—	—	—	—	—	10	0.0	2.8	350	255	—	—	7.6	0
662	1961	52	17	.21	.06	71	30	30	1.5	217	84	68	.1	5.6	426	301	123	695	7.9	4
678	1961	54	24	.06	.04	39	14	8.3	1.0	178	17	4.2	.0	8.0	204	155	9	322	7.7	2
680	1961	56	28	.70	.38	59	17	15	1.0	252	37	4.2	.1	.2	283	217	11	447	7.5	6
689	1961	53	32	.02	.05	126	28	19	25	158	300	16	.6	.5	620	430	300	838	7.6	3
704	1961	—	—	.02	—	—	—	—	—	—	—	3.0	—	.1	170	140	—	—	7.9	5
708	1962	54	23	.14	.00	70	21	12	1.5	236	32	20	.1	36	344	261	68	536	7.6	4

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649	1960	—	12	—	.0	—	—	—	—	—	16.8	8.0	.0	.08	298	232	70	—	—	—
654	1964	—	—	0.2	0.0	—	—	—	—	—	—	10	0.0	2.8	350	255	—	—	7.6	0
662	1961	52	17	.21	.06	71	30	30	.5	217	84	68	.1	5.6	426	301	123	695	7.9	4
678	1961	54	24	.06	.04	39	14	8.3	.0	178	17	4.2	.0	8.0	204	155	9	322	7.7	2
680	1961	56	28	.70	.38	59	17	15	1.0	252	37	4.2	.1	.2	283	217	11	447	7.5	6
689	1961	53	32	.02	.05	126	28	19	25	158	300	16	.6	.5	620	430	300	838	7.6	3
704	1961	—	—	.02	—	—	—	—	—	—	—	3.0	—	.1	170	140	—	—	7.9	5
708	1962	54	23	.14	.00	70	21	12	1.5	236	32	20	.1	36	344	261	68	536	7.6	4
709	1962	55	23	.05	.00	44	32	12	1.0	298	9.7	5.1	.1	20	302	250	6	490	8.2	3
710	1962	—	22	.20	.00	55	20	14	2.2	202	40	18	.2	19	307	219	54	478	7.4	8
711	1962	—	33	.07	.00	36	17	11	3.0	152	29	13	.2	8.8	236	160	36	359	7.7	3
712	1962	—	21	1.6	.00	54	36	17	1.5	268	83	6.4	.1	3.1	360	283	63	563	7.6	5
713	1962	55	16	.32	.00	47	32	9.5	1.5	200	48	36	.2	.7	303	249	85	512	7.8	2
715	1962	56	16	.02	.00	47	17	9.8	.8	144	38	16	.1	26	253	188	70	414	7.3	3
716	1962	—	15	.00	.00	52	17	9.2	1.0	193	36	14	.0	2.8	246	200	42	410	7.7	3
718	1962	58	19	3.0	.12	53	15	15	1.5	211	27	13	.0	4.0	255	194	21	429	6.9	5
725	1962	—	—	.00	—	62	102	—	—	—	35	10	—	1.0	160	164	—	—	7.6	0
736	1925	—	23	4.9	—	45	11	12	3.0	183	13	12	—	.88	209	158	—	—	—	—
737	1925	54	13	.27	—	66	23	15	2.7	254	37	22	—	16	320	259	—	—	—	—
738	1925	52	25	.15	—	48	24	12	1.2	234	6.4	19	—	14	252	218	—	—	—	—
739	1925	54	13	.17	—	47	23	22	1.9	283	3.8	7.0	—	.21	283	212	—	—	—	—
741	1949	—	31	1.0	—	22	9.6	6.1	.9	78	25	12	.1	.2	144	94	31	218	7.2	4
757	1965	—	22	0.77	0.55	24	12	20	2.9	60	47	40	0.0	5.1	236	108	61	347	6.1	3
758	1965	—	11	.02	.00	51	36	8.5	2.5	208	47	9.2	.0	83	394	275	105	575	7.6	2
763	1964	—	11	.09	.00	56	25	24	1.8	233	52	28	.0	20	345	243	52	567	7.4	2
777	1959	—	—	.31	.09	—	—	—	—	—	—	5.3	—	2.3	194	139	—	—	8.2	3
778	1960	—	—	.20	.06	51	35	—	—	—	—	12.5	—	3.9	335	270	—	—	7.5	4
780	1963	—	—	.05	.00	—	—	—	—	—	—	8.5	—	.93	264	210	—	—	7.6	2
787	1964	—	—	.17	.05	—	27	—	—	—	—	12	—	1.5	252	221	—	—	7.7	8
793	1929	—	—	.2	—	—	—	—	—	—	—	8.0	—	6.0	—	80	—	—	7.8	5
794	1930	—	—	.3	—	—	—	—	—	—	—	7.0	—	4.0	—	60	—	—	6.8	0
806	1941	—	—	.2	—	—	—	—	—	—	—	35	—	7.0	619	165	108	—	—	—
820	1965	—	16	.09	.00	21	8.3	10	1.2	22	60	11	.1	8.4	154	87	69	233	6.8	2
832	1925	—	23	4.9	—	45	11	12	3.0	183	13	12	—	.88	209	—	—	—	—	—
878	1966	—	—	.14	.1	88	28	—	—	—	—	83	.0	1.6	440	315	—	—	7.5	—
890	1950	—	—	.1	—	—	—	—	—	130	8.2	7.1	—	.0	110	—	74	—	6.4	—
899	1942	—	5.0	3.0	—	16	3.4	—	—	—	—	5	—	1.0	—	—	124	175	8.2	10
900	1942	—	—	0	—	—	—	—	—	—	—	14	—	2.0	—	—	120	170	8.2	0

* Combined samples from 3 wells.

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DEVELOPMENT OF WELLS

DRILLING METHODS

The first wells completed in Montgomery County were dug by hand. As dug wells can be completed only 2 or 3 feet below the water table, the yield is usually small. Dug wells are being replaced by drilled wells, and two methods are used to drill most of the wells in Montgomery County.

In the cable-tool percussion method, wells are drilled by lifting and dropping a heavy string of drilling tools in the borehole. The drill bit breaks or crushes the rock into small fragments, which are then removed from the hole with a bailer. The rotary drilling method drills wells by crushing the rock with a rotating bit and removing the rock chips by circulating water, drilling mud, or air.

WELL-DEVELOPMENT METHODS

In Montgomery County, well development usually consists of pumping the borehole for a period of time to clean out the drill cuttings. In consolidated rocks, higher well yields might be obtained through development techniques such as mechanical surging, use of explosives, treating the well with chemicals, or by hydrofracking.

Mechanical surging is simply operating a piston in a cylinder with the well bore casing acting as the cylinder and the surge block as the piston. Raising and lowering of the surge block in the well forces the water in and out of openings in the rock. Any loose rock chips or sand grains are drawn into the well bore and can be cleaned out after the surging has stopped. This method is most successful in sandstone and conglomerate. The middle and lower member of the Stockton Formation and some of the sandstone beds in the Brunswick Formation might yield more water to wells if they were developed by surging.

An explosion in a well will fracture the rock and permit freer passage of water into the borehole. Explosives are not always successful in developing higher well yields, but this method may be tried in the denser and more brittle sedimentary rocks. In the more resistant rocks in Montgomery County, such as the Lockatong Formation and some of the Paleozoic rocks, explosives could be used to develop higher well yields.

Developing wells by using chemicals can increase well yields in certain types of rock. In carbonate rocks acid is pumped down the bore-

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hole and forced into the openings in the rock. The acid reacts with the rock and enlarges the openings. The acid is then pumped out of the well and the enlarged openings will allow more water to enter the borehole. Detergents can be used in wells where very fine grained material is plugging the fractures in the aquifier. The detergents loosen the small particles so that they can be pumped out of the well, thereby opening up the fractures.

Hydrofracking is a well-development method where a mixture of the water and sand is introduced into the well under high pressure. The water and sand is forced into fractures, then the pressure is released and the sand grains keep the fractures from closing, thereby allowing more water to pass through the fractures.

MANAGEMENT OF WATER SUPPLIES

PROTECTION FROM OVERDRAFT

The Lansdale area, served entirely by local municipal wells, has had the problem of declining water yields. Part of the cause of this situation is the concentration of wells in a relatively small area and a prolonged drought.

The two most obvious solutions are to connect the city lines with those of another water supply and to space new wells farther apart.

A third possibility is the construction of recharge wells, through which water could be forced into the aquifer during periods when an excess is available. Artificial recharge of the aquifer would help insure a greater available supply during times of heavy usage or drought. Finding a source of the recharge water, however, might be a problem more difficult than using more obvious solutions. Water would have to be pumped from reservoir, or a small stream (none of which are nearby) could be impounded to serve as a source for recharge water. The development of recharge areas should be investigated further.

As a fourth alternative, more water supply can be developed from surface-water sources by construction of reservoirs on some of the streams. Potential reservoir sites and their watersheds should be set aside now to assure their availability for such use in the future.

PROTECTION FROM POLLUTION

A primary consideration in protecting a ground-water supply is to keep it free of harmful bacteria. Pollutants may be carried downward from the land surface by infiltrating water. Because ground-water move-

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ment is relatively slow, such pollution is slow to accumulate, but it is just as slow to clear up when the polluting source is removed. The part of the aquifer updip from the wells and other nearby recharge areas should be investigated for possible sources of pollution such as sanitary landfills and septic tanks.

Government agencies are becoming increasingly active in the field of pollution prevention; for example, the Pennsylvania Department of Health has set standards for the length and the cementing of casing in wells. But it is everyone's responsibility to protect water supplies from pollution.

WHERE TO GET INFORMATION ABOUT WATER

The Pennsylvania Topographic and Geologic Survey has information on the geology of Montgomery County and has published reports that describe in detail some of the aquifers that underlie Montgomery County and the chemical quality of the ground water. Well-drillers' logs and reports on new wells that have been drilled in the county are also available.

The Private Water Supply section, Division of Sanitation, Pennsylvania Department of Environmental Resources, can supply information on proper well-construction requirements, biological reports on well water, and the chemical quality of ground water in Montgomery County. The Pennsylvania Department of Health, through various regional offices, can test water samples for bacterial pollution. The nearest regional Health Department testing laboratory is in Philadelphia. They also can advise corrective measures when pollution is reported.

The Water Resources section of the Forest and Waters Division Pennsylvania Department of Environmental Resources has information on stream discharges, flood data, reservoir requirements, and power plant discharges.

The Public Utility Commission, Bureau of Rates and Research, has information on some municipal water supplies, including source, average daily use, total annual use, and estimated future needs.

The Water Resources Division of the U.S. Geological Survey has data on wells, springs, and streams, and on the chemical quality of water.

When requesting information on water supplies, give an accurate location of the site about which you wish information. This will help the above-listed agencies to assist you with your problem.

The local well drillers and pump installers can provide prices and suggest the type of equipment needed to develop a water supply. Local well drillers will know the well depth necessary to obtain certain yields and

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how much surface casing is required. They can also suggest the proper well diameter for the necessary pumping equipment. Pump installers can supply information concerning the size of the pump, depth of the pump setting, and the pressure-tank capacity.

If chemical analysis of the well water indicates treatment is necessary, any of the commercial water-treatment companies can provide the necessary information and equipment. Equipment for water treatment can be purchased or rented, and it will be serviced by the supplier if desired.

GLOSSARY

Aquifer: A formation, group of formations, or a part of a formation that yields water to wells in usable quantities.

Artesian water: Ground water that occurs under sufficient hydrostatic head to rise above the level at which it was encountered in a well.

Base flow: Discharge entering stream channels as effluent from the ground water reservoir, the fair-weather flow of streams.

Cubic feet per second: The discharge of a stream of rectangular cross section, 1 foot wide and 1 foot deep, whose velocity is 1 foot per second; equivalent to 448.8 gallons per minute.

Cone of depression: A conical depression, on a water table or piezometric surface, produced by pumping a well.

Direct runoff: The water that moves over the land surface directly to streams immediately after rainfall or snowmelt.

Discharge, ground-water: The process by which water is removed from the zone of saturation; also the quantity of water removed.

Drawdown: The lowering of the water table or piezometric surface caused by pumping (or artesian flow).

Evapotranspiration: Process of water withdrawal from a land area by direct evaporation from water surfaces and moist soil and by plant transpiration.

Fanglomerate: A rock composed of heterogeneous materials that were originally deposited in an alluvial fan but which have since been cemented into solid rock.

Fault: A fracture or fracture zone along which there has been displacement of the two sides relative to ane another. The displacement may be a few inches or many miles.

Fracture: Breaks in rocks due to intense folding or faulting.

Ground-water reservoir: An aquifer or a group of related aquifers.

Head (hydrostatic head): The height of a vertical column of water, the weight of which, in a unit cross section, is equal to the hydrostatic pressure at a point.

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Homocline: A structural condition in which the beds dip uniformly in one direction.

Hydraulic gradient: The rate of change of hydrostatic head per unit of distance of flow at a given point and in a given direction.

Perched ground water: Ground water separated from an underlying body of ground water by unsaturated deposits.

Permeability: The capacity of a material to transmit a fluid.

Piezometric surface: The surface to which the water from a given aquifer will rise under its full head.

Porosity: The ratio of the aggregate volume of void space in a rock or deposit to its total volume, expressed as a percent.

Recharge, ground-water: The process by which water is added to the zone of saturation, also the quantity of water added.

Runoff: The water draining from an area.

Saturation, zone of: The zone in which interconnected voids are filled with water under pressure equal to or greater than atmospheric.

Specific capacity: The yield of a well, in gallons per minute, divided by the drawdown in the well, in feet.

Stream-gaging station: A gaging station where a record of discharge of a stream is obtained. Within the Geological Survey this term is used only for those gaging stations where a continuous record of discharge is obtained.

Surface water: Water on the surface of the earth.

Transpiration: The quantity of water absorbed and transpired and used directly in the building of plant tissue, in a specified time; also the process by which water vapor escapes from the living plant, principally the leaves, and enters the atmosphere.

Underflow: The movement of water in the ground-water reservoir; also the quantity of water moving in the ground-water reservoir through any vertical plane.

Water table: The upper surface of the zone of saturation, except where the surface is formed by an impermeable body.

Water-table conditions: The condition under which water occurs in an aquifer that is not overlain by an impermeable body and that has a water table.

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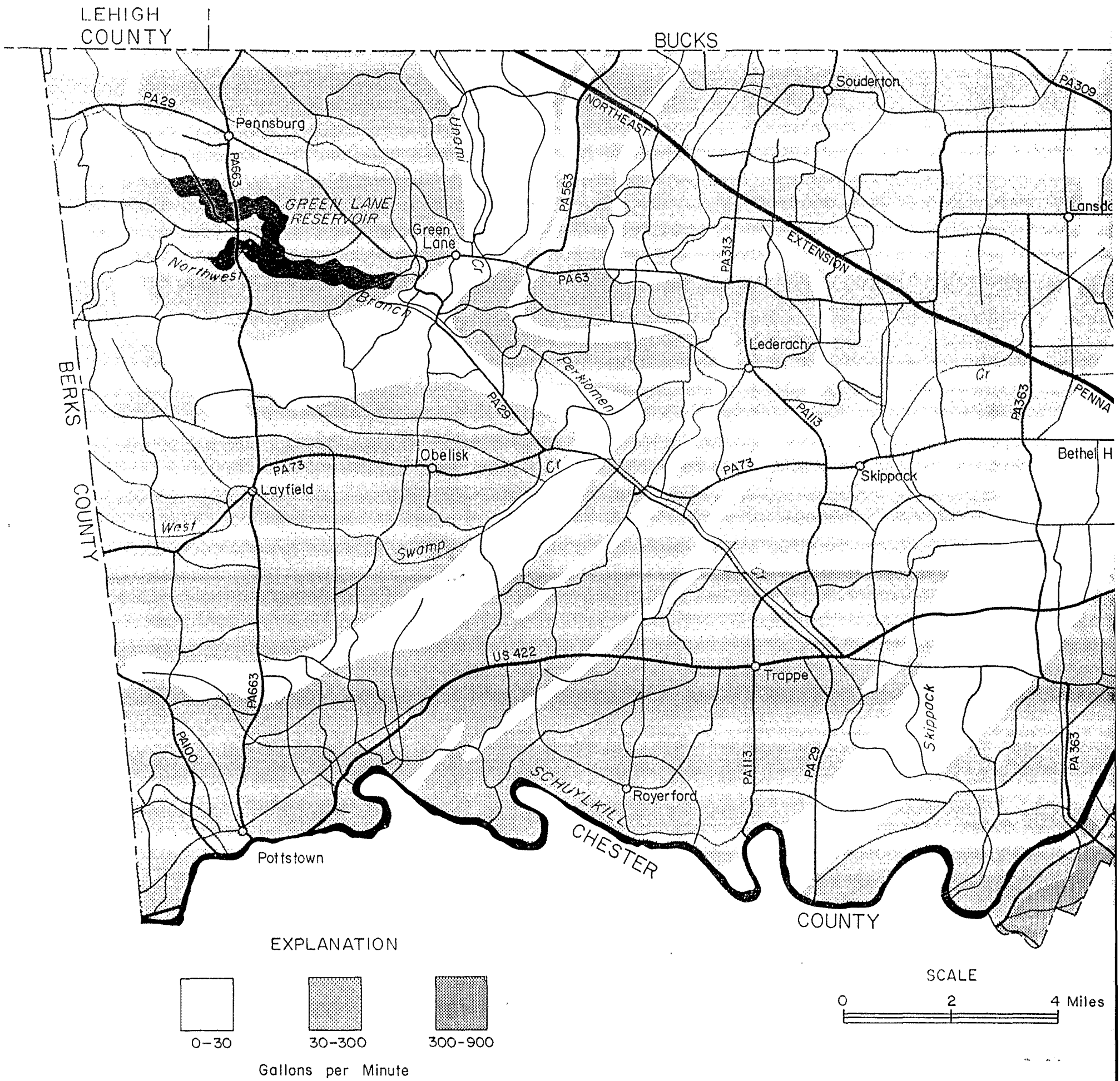

Plate 1. Typical yield of wells in Montgon

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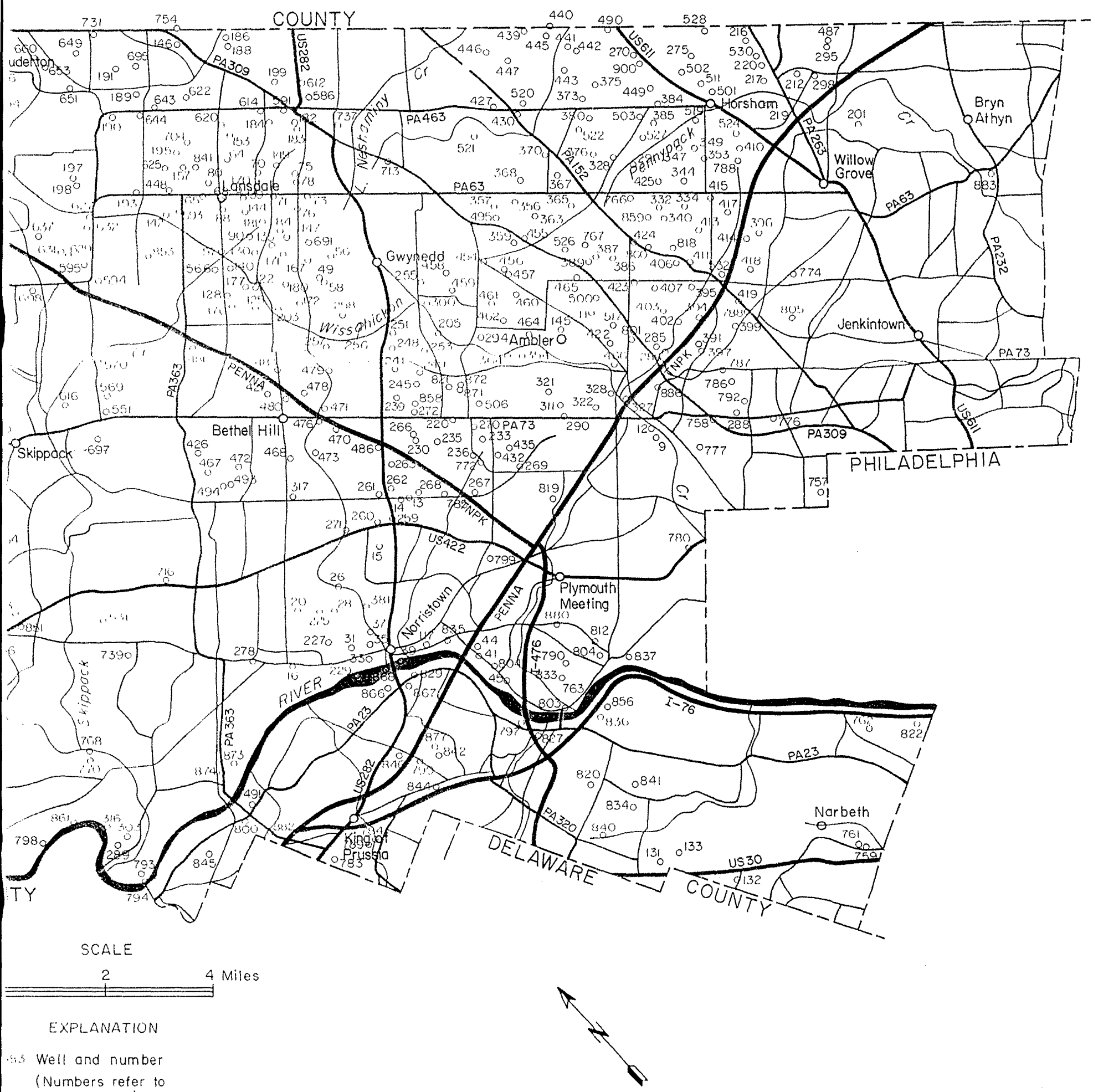

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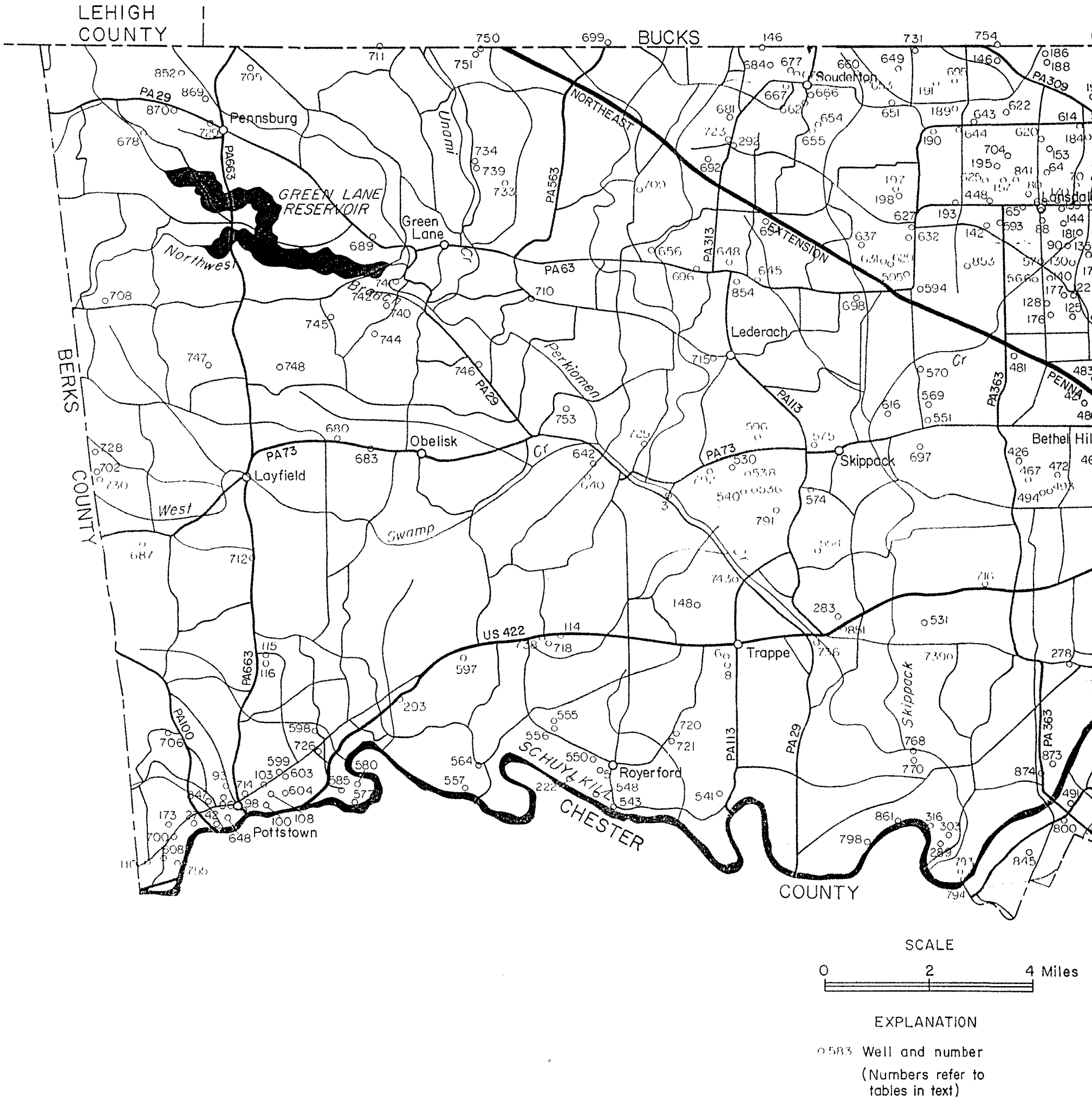

Plate 2. Locations of selected wells in Mont

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SITE DISCOVERY OF
GROUNDWATER CONTAMINATION IN THE
NORTH PENN AREA
PREPARED UNDER

TDD NO. F3-8512-31
EPA NO.
CONTRACT NO. 68-01-6699

FOR THE

HAZARDOUS SITE CONTROL DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

JULY 7, 1986

NUS CORPORATION
SUPERFUND DIVISION

SUBMITTED BY	REVIEWED BY	APPROVED BY
TIMOTHY SILAR GEOLOGIST	THOMAS FROMM ASSISTANT MANAGER	GARTH GLENN MANAGER, FIT III

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Site Name: North Penn Area
TDD No.: F3-8512-31

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Site Name: North Penn Area
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SECTION I

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1.0 INTRODUCTION

1.1 Authorization

NUS Corporation performed this work under Environmental Protection Agency Contract No. 68-01-6699. This specific report was prepared in accordance with Technical Directive Document No. F3-8512-31 for the North Penn Area site located in north-central Montgomery County, Pennsylvania.

1.2 Scope of Work

NUS FIT III was tasked to perform a high priority site discovery using available information, from the North Penn Water Authority (NPWA), EPA, and the Pennsylvania Department of Environmental Resources (PA DER). Presented herein are the findings of the available information search.

1.3 Summary

NPWA is a major water supplier in central Montgomery County. In 1979, NPWA discovered that 8 of their production wells were contaminated with the volatile organic chemicals (VOC) trichloroethylene (TCE) and tetrachloroethylene (PCE). These contaminated wells were shut down to prevent additional contamination of the distribution system. The discovery led to the initiation of an extensive research program by NPWA to locate the potential sources and responsible parties of the VOC contamination. In addition, PA DER and EPA have conducted studies in the North Penn area.

It was determined by FIT III that there are 12 distinct areas of groundwater contamination in the North Penn area. NPWA has wells in 9 of the 12 contaminated areas. To date, 18 of 53 NPWA wells are contaminated by VOCs. After reviewing EPA and PA DER files, meeting with officials from NPWA, and conducting a reconnaissance of the study area, a list of 51 potentially responsible parties was compiled. The areas of groundwater contamination, NPWA contaminated wells, and potentially responsible parties for the VOC contamination are presented herein. Section 4 discusses each contamination plume area in detail, and section 5 presents a summary of the contaminated NPWA wells and the potentially responsible parties identified.

SECTION 2

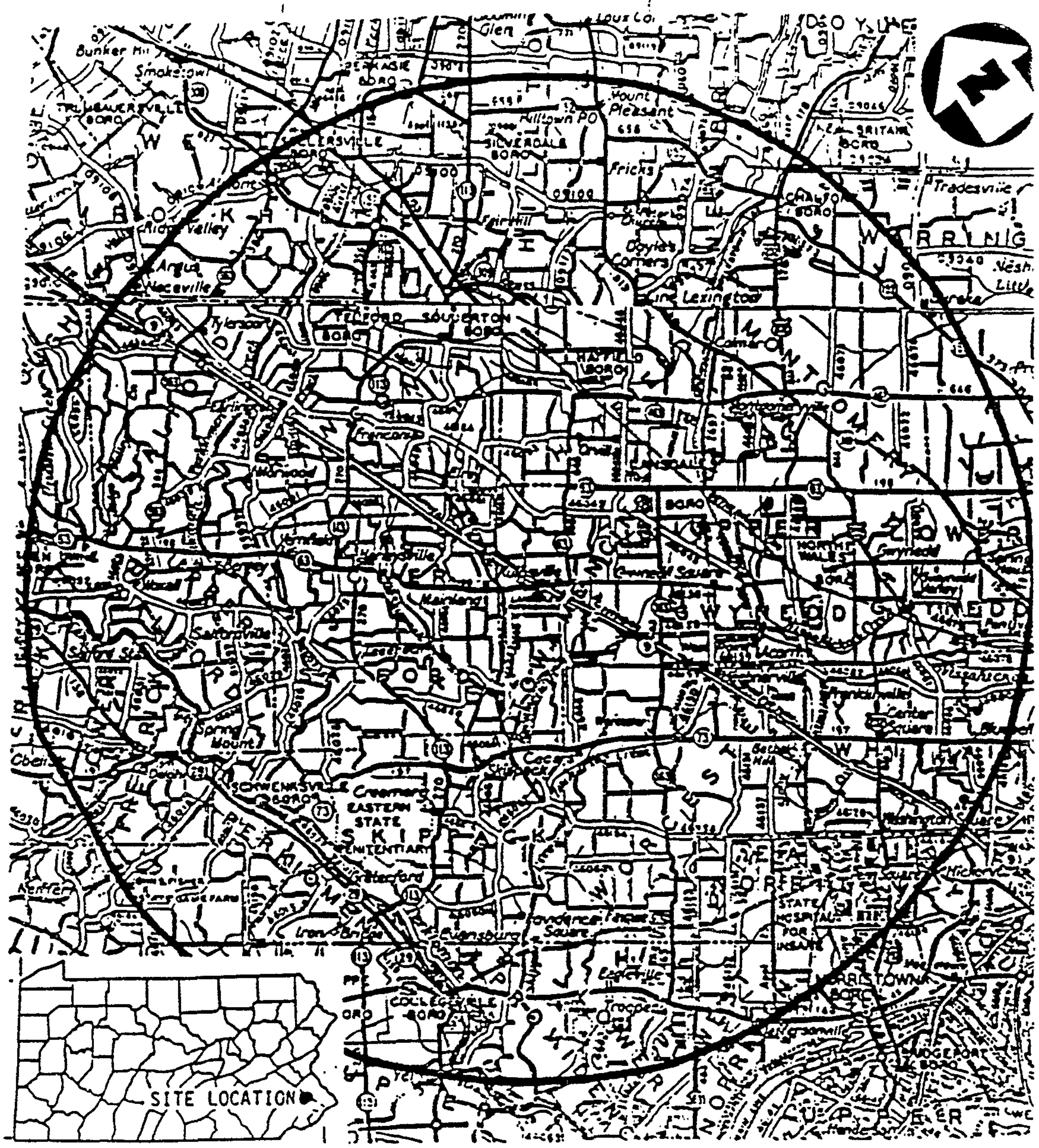
2.0 THE SITE

2.1 Location

The North Penn area is located primarily in central Montgomery County. The area includes the Perkiomenville, Collegeville, Lansdale, and Telford quadrangles. An 8.5-mile radius is utilized to encompass the study area. The center point of the radius is located about 1,000 feet south of the Pennsylvania Turnpike, Lansdale Interchange (see map, page 2-2). The radius includes the above-mentioned area plus a portion of south central Bucks County, and the eastern portion of the Doylestown and Ambler quadrangles. These areas are not served by NPWA but are of concern since they lie within a 3-mile radius of several contamination plumes (see map, page 2-3). The total area of concern is 227 square miles.[10]

The study area includes the metropolitan areas of Lansdale, Souderton, Unionville, Harleysville, Mainland, Kulpsville, Colmar, Fortuna, Skippack, Creamery, and Center Point. These towns are of primary concern since NPWA supplies water to these towns. Rural areas lie between these towns. Some are supplied by NPWA and some rely on private wells (see appendix B).[1,10]

Other metropolitan areas within the 8.5-mile radius include Norristown, Trooper, Collegeville, and Sellersville. These areas are within the area of concern but rely on groundwater sources other than NPWA for water.[1,10]



SITE LOCATION MAP
approximate scale
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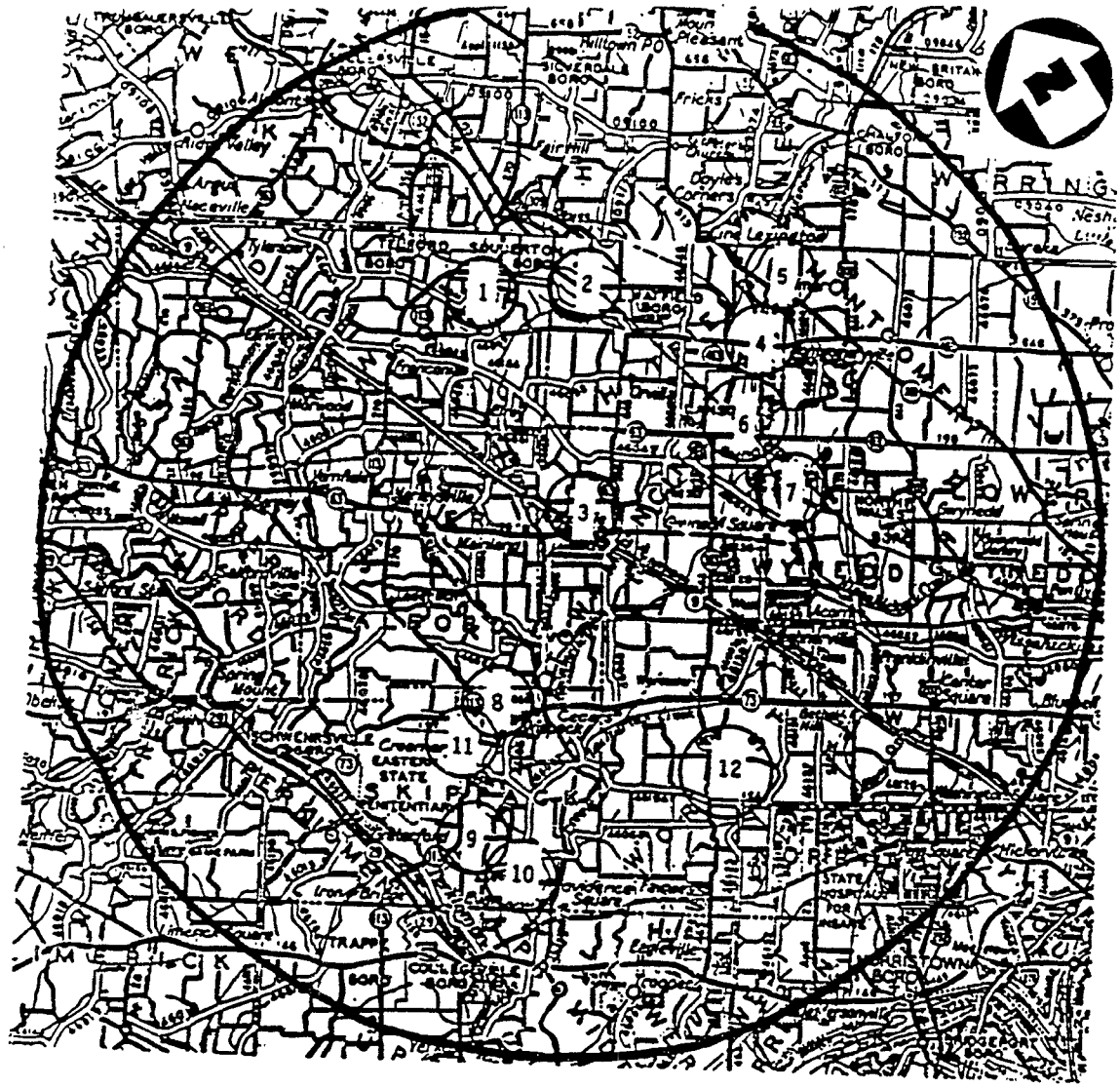

SITE LOCATION MAP WITH AREAS OF CONTAMINATION

approximate scale

1"=2.25 miles

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SECTION 3

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3.0 ENVIRONMENTAL SETTING

3.1 Water Supply

This study involves NPWA; therefore, their service district is of major concern. A distribution map of NPWA is included in appendix B. Areas between NPWA distribution lines rely on private wells for water, except for Hatfield Borough, which has a municipal supply utilizing groundwater. NPWA presently utilizes 53 wells, which produce an average yield of 3.6 million gallons per day (mgd). An additional 1.6 mgd are purchased from Keystone Water Authority and North Wales Water Authority to meet daily demands. In 1984, NPWA customers included 13,384 domestic, 557 commercial, 164 industrial, 78 public, and 1 utility, with an average demand of 5.2 mgd. The majority of the NPWA distribution system is interconnected; however, there are 6 satellite systems within the NPWA distribution system (see appendix B).[1]

NPWA has 18 wells that are contaminated with VOCs. Nine of the 18 wells have VOC concentrations above the proposed limits of 5 ug/l for TCE and 10 ug/l for PCE, suggested by EPA. Five of the 9 wells that are over the proposed limit are inactive. The remaining 4 wells are either treated or mixed with cleaner water to bring the VOC concentration level below the proposed limit. NPWA loses approximately 0.6 mgd of available water due to VOC contamination.[1]

Other public water suppliers in the 3.5-mile radius study area include Hatfield Water Department, North Wales Water Authority, Telford Borough Water Authority, Schwenksville Borough Water Authority, Lower Frederick Township Water Company, Collegeville-Trappe Joint Water Works, and Keystone Water Company. These municipalities primarily use groundwater for public water supply, with the exception of Keytone Water Company, which has surface water intakes outside the study area.[20]

3.2 Surface Water

The study area is situated in the Schuylkill River drainage basin. Major creeks which flow through the study area into the Schuylkill River include Perkiomen Creek, Skippack Creek, Neshaminy Creek, Wissahickon Creek, Towamencin Creek, and Indian Creek. These creeks flow predominantly south to the Schuylkill River, which in turn flows southeast to the Delaware River. Surface water is not used for public water supply in the study area.[12]

3.3 Geology and Soils

The North Penn area lies entirely within the Triassic Lowland Section of the Piedmont Physiographic Province. Topography of the area is characterized by a gently sloping upland ranging from an altitude of 500 to 200 feet above mean sea level (MSL). The relief in the area probably reflects the resistance to weathering of the underlying bedrock. This differential weathering formed northeast-southwest trending ridges of resistant rock and intervening lowlands from the less resistant rock. The majority of the study area occupies the lowlands. Streams in the area are found in topographic low areas and collectively form a dendritic drainage pattern. Stream flow is generally northeast-southwest, parallel to the principal topographic features.[17,18]

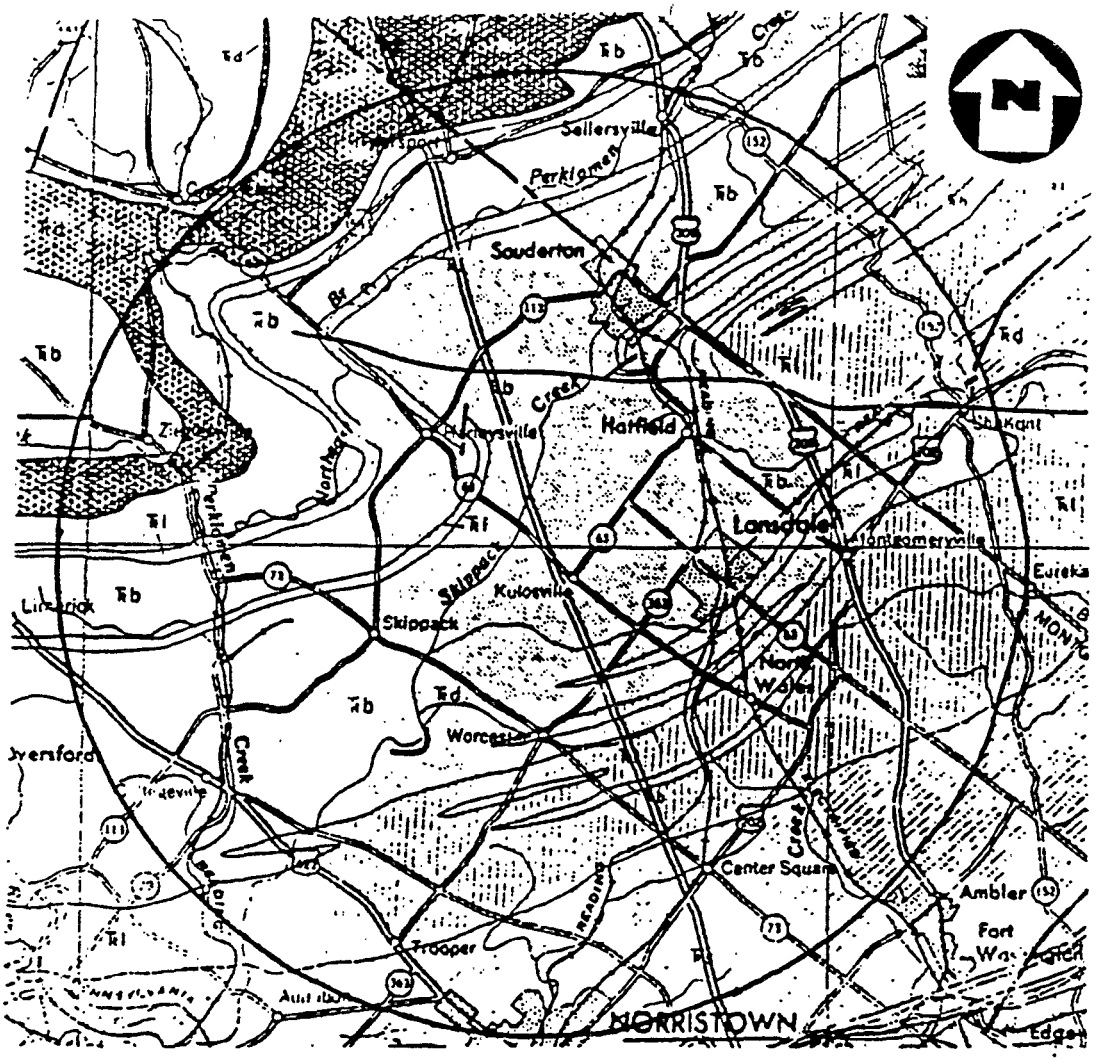
Rocks of Triassic age underlie the study area (see map, page 3-4). These rocks, known as the Newark Group, form the largest Triassic Basin in the eastern United States, extending from Nova Scotia to North Carolina. The basin was formed in a postorogenic depositional environment. Rocks of the Newark Group are generally red conglomerate, arkose, sandstone, siltstone, argillite, and shale, locally, with interbedded basaltic lava flow and intruded diabase dikes and sills. The Newark Group has been divided, proceeding from oldest to youngest, into the Stockton, Lockatong, and Brunswick Formations. The Brunswick and Lockatong Formations are of primary concern in the study area, since all contaminated areas are underlain by these 2 formations.[11,18]

The Brunswick Formation consists generally of soft reddish-brown shale, interbedded with reddish-brown sandstone, and siltstone. The shale beds are locally sandy and silty and interbedded with gray, brown, and greenish shale. Shales of the Brunswick Formation consist primarily of feldspar, illite, chlorite, quartz, and calcite and are locally micaceous. The fractures within the Brunswick are commonly filled with calcite and quartz, with occasional occurrence of barite and pyrite. Beds are generally thin with irregular and discontinuous bedding planes.[15,17,18]

The Brunswick Formation is relatively uniform, although some facie changes have been documented. In the Lansdale area, thin limestone conglomerate, limestone pebbles in a shaly matrix, subcrop. In addition, some beds of calcareous sandstone have been reported to occur within the Brunswick. The limestone conglomerate and calcareous sandstone units are unimportant to this study since they are very localized and discontinuous.

The Brunswick Formation is reported to reach a thickness of 9,000 to 16,000 feet in the area. The rocks generally strike N 45° E to N 55° E and dip 5 to 15 degrees northwest in the study area. Near the base of the Brunswick Formation, the rock is a tough, thick-bedded red argillite and is interbedded with dark-gray argillite of the Lockatong Formation. The Brunswick also grades laterally into the Lockatong Formation.[15,17,18]

The Lockatong Formation subcrops over a small portion of the study area, principally south and southeast of Lansdale, in the Souderton area, and in 2 thin bands in Salford Township. The Lockatong Formation consists principally of medium to dark gray argillite, interbedded with thin beds of gray to black shale, siltstone, and marlstone. The Lockatong consists of up to 40 percent anacline, along with dolomite, feldspar, and clay. Fractures are commonly filled with quartz, calcite, or pyrite. Bedding is generally massive, with an average dip of 10 degrees toward the northwest. The Lockatong is up to 4,000 feet thick.[15,17,18]



TRIASSIC

Diabase

Brunswick Formation or Gettysburg Formation

Lockatong Formation

Stockton Formation or New Oxford Formation

GEOLOGIC MAP OF SITE AREA (no scale)
FROM REFERENCE 11

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The Stockton Formation subcrops in the southernmost section of the study area. The Stockton Formation, which underlies the Lockatong Formation, consists of 3 distinct members: the lower member consists of coarse, arkosic sandstone and arkosic conglomerate; the middle member consists of medium-grained arkosic sandstone; and the upper member consists of red shale, siltstone, and very fine-grained arkosic sandstone. The thickness of the Stockton Formation ranges from 1,000 to 6,000 feet.[15,16]

A diabase sill intrudes the Brunswick Formation in the northwestern portion of the study area. The diabase is medium to coarse grained, greenish gray, and consists of 90 to 95 percent labrodorite and augite. The sill is estimated to be in excess of 1,000 feet thick. Near the diabase sill, local metamorphism of the Brunswick Formation has occurred. The shales of the Brunswick Formation are altered to dark, tough hornfels in the metamorphic zone. The width of the altered zone in the study area averages about 1 mile.[15,18]

A major structural feature in the study area is the Chalfont fault. This fault is about 4.5 miles north of Lansdale and generally trends east-west. The Chalfont fault and its associated faults appear to have significant vertical and lateral displacement, as seen by the truncation of the Lockatong Formation along the fault (see geologic map, page 3-4).[11,18]

Soils

General soil associations in the study area include the following:

Reaville-Penn-Klinesville Association is a shallow to moderately deep, well drained to somewhat poorly drained soil, which is generally underlain by shale and found on rolling uplands.[12,13]

Abbottstown-Readington-Croton Association is a deep, moderately well drained to poorly drained soil, generally underlain by shale and sandstone, and found on undulating uplands.[12,13]

Lawrenceville-Chalfont-Doylestown Association is a deep, moderately well drained to poorly drained soil that is generally formed in wind-blown silt deposits and found on undulating uplands.[12,13]

Lehigh-Brecknock-Croton Association is a moderately deep to deep, poorly drained to well drained soil, which is generally underlain by metamorphosed shale and found on uplands.[12,13]

These 4 associations are generally level to sloping and are found on undulating uplands. The location of the 4 associations does not correlate with the location of the contaminated areas or possible responsible parties.

3.4 Groundwaters

Groundwater in the North Penn area is obtained primarily from the Brunswick Formation. The Brunswick Formation is composed of very fine-grained rock; therefore, primary porosity is very low.[14,17]

Groundwater flow is largely through secondary openings that were developed after the deposition of the strata. These secondary openings are usually bedding planes, fractures, and joints. Bedding plane fractures are usually narrow and contribute little to the total permeability of the formation. Of greater importance are joints and fractures which criss-cross throughout the beds. These openings comprise a network through which water may flow. The number and size of these openings vary laterally from bed to bed. Lithologic differences within the lens-shaped deposits of the Brunswick Formation also contribute to lateral changes in flow. Therefore, the interconnected network of openings provided by joint, fractures, and bedding planes may be locally altered by structural anomalies and/or lithologic differences.[14,17]

Therefore, aquifer parameters of the Brunswick Formation may vary greatly from place to place. Depth to water-bearing zones and direction of groundwater flow are 2 factors which vary from place to place throughout the Brunswick Formation. The variable nature of Brunswick aquifers is shown in well depths (65 to 663 feet) and yields (4 to 55 gallons per minute (gpm)).[14,15,17]

The lithology and structure of the Lockatong Formation are similar to the Brunswick Formation. Groundwater flow is largely through secondary openings, bedding-planes, fractures, and joints. Since fractures are smaller and more widely spaced in the Lockatong Formation than in the Brunswick Formation, wells drilled into the Lockatong generally have lower yields than those drilled in the Brunswick.[15,16]

There is substantial formation contact and interfingering between the Lockatong and Brunswick in the North Penn area. These contact areas generally have a greater number of fractures. Fractures enhance secondary porosity; thus, there is more groundwater flow. Wells drilled in these areas generally have greater yields than those drilled solely in the Brunswick Formation.[14,15,17]

NPWA wells in the study area penetrate the Brunswick and/or Lockatong Formations. Well depths range from 216 to 668 feet. All wells are constructed as "open holes," which means that the well is cased only from the surface to 20 to 50 feet into bedrock. The rest of the well (bottom of casing to total depth) is not cased; therefore it is "open." This method of well construction allows the well to draw groundwater from all saturated openings encountered by the borehole in the uncased (open) zone. A summary of NPWA wells and some well logs can be found in appendix D.[1,14]

Two additional formations are encountered in the study area, diabase and the Stockton Formation. The water-bearing characteristics of these rocks will be discussed briefly, since they are of lesser concern for the purposes of this study.[11]

Groundwater flow in the diabase is also through secondary porosity. The best water-bearing area in the diabase is in the highly weathered upper zone, generally less than 100 feet below the surface. Well yields from the diabase range from 0.1 to 50 gpm; the average yield is 3 gpm.[14]

Groundwater flow in the Stockton Formation occurs in pore spaces between the grains and secondary openings in the rock. The lithology and sorting of the Stockton contribute to the primary porosity. This primary, intergranular porosity enables the Stockton Formation to be the most productive aquiferous formation in the study area.[15,16]

In general, groundwater flow is difficult to predict throughout the study area due to variable secondary porosity. The difficulty of predicting groundwater flow is enhanced by industrial and municipal wells which pump large quantities of water. A cone of depression generally forms around these wells, interfering with the normal movement of groundwater. However, with proper data collection and testing, groundwater flow on a local level may be predicted.

3.5 Climate and Meteorology

This area of Pennsylvania is generally considered to have warm humid summers, moderately cold winters, and ample rainfall. Temperatures generally range between 0°F to 100°F, with an average yearly temperature of 54°F. Summers are warm, with an average of 25 days per year when temperatures rise above 90°F. In general, winters are comparatively mild, with an average 101 days with minimum temperatures below the freezing point.[12,13]

Precipitation is well distributed throughout the season. The greatest monthly variation in precipitation (2 inches) occurs between the wettest month, August, and the driest month, October. Annual precipitation ranges from 43 to 47 inches in the study area. This yields a net average annual precipitation of 17 inches per year.[12,13]

3.6 Land Use

Land use throughout the 227-square-mile study area varies. Most of the land is still farmed, although an increasing number of new housing developments is depleting the farm land. Some recreational and undisturbed woodlands are also located in the study area. In addition, there are metropolitan and industrial pockets located throughout the area, such as the boroughs of Lansdale and Souderton.

200267

3.7 Population Analysis

The greatest population densities in the study area are found within town and borough limits. These areas include, but are not limited to, Lansdale, Souderton, Telford, Hatfield, Harleysville, Collegeville, North Wales, and Norristown. The NPWA serves approximately 52,000 people.[1]

3.8 Critical Environments

There are no critical environments within the study area. Two federally endangered birds may be found as transient visitors in the area. They are the bald eagle (Haliaeetus leucocephalus), and peregrine falcon (Falco peregrinus). There are no critical habitats for these birds in the study area.[19]

In addition, the small whorled pogonia (Isotria medeoloides), an endangered plant, may exist in the study area.[19]

SECTION 4

200269

4.0 AREAS OF CONTAMINATION

4.1 Introduction

Through the available information search, 12 areas of VOC contamination have been identified. The contaminated areas were identified by employees of NPWA. EPA and PA DER performed work at some of the contaminated areas following the initial discovery by NPWA. Therefore, NPWA resources, along with EPA and PA DER files, were utilized to identify contamination plumes and potentially responsible parties.

NPWA has 18 contaminated wells throughout 9 of the 12 contaminated areas. The remaining 3 areas were discovered and mapped solely by testing private wells. All 12 areas are discussed in the following sections. The discussion includes location and mapping of contaminated areas, wells located in each area, and potentially responsible parties of VOC contamination.

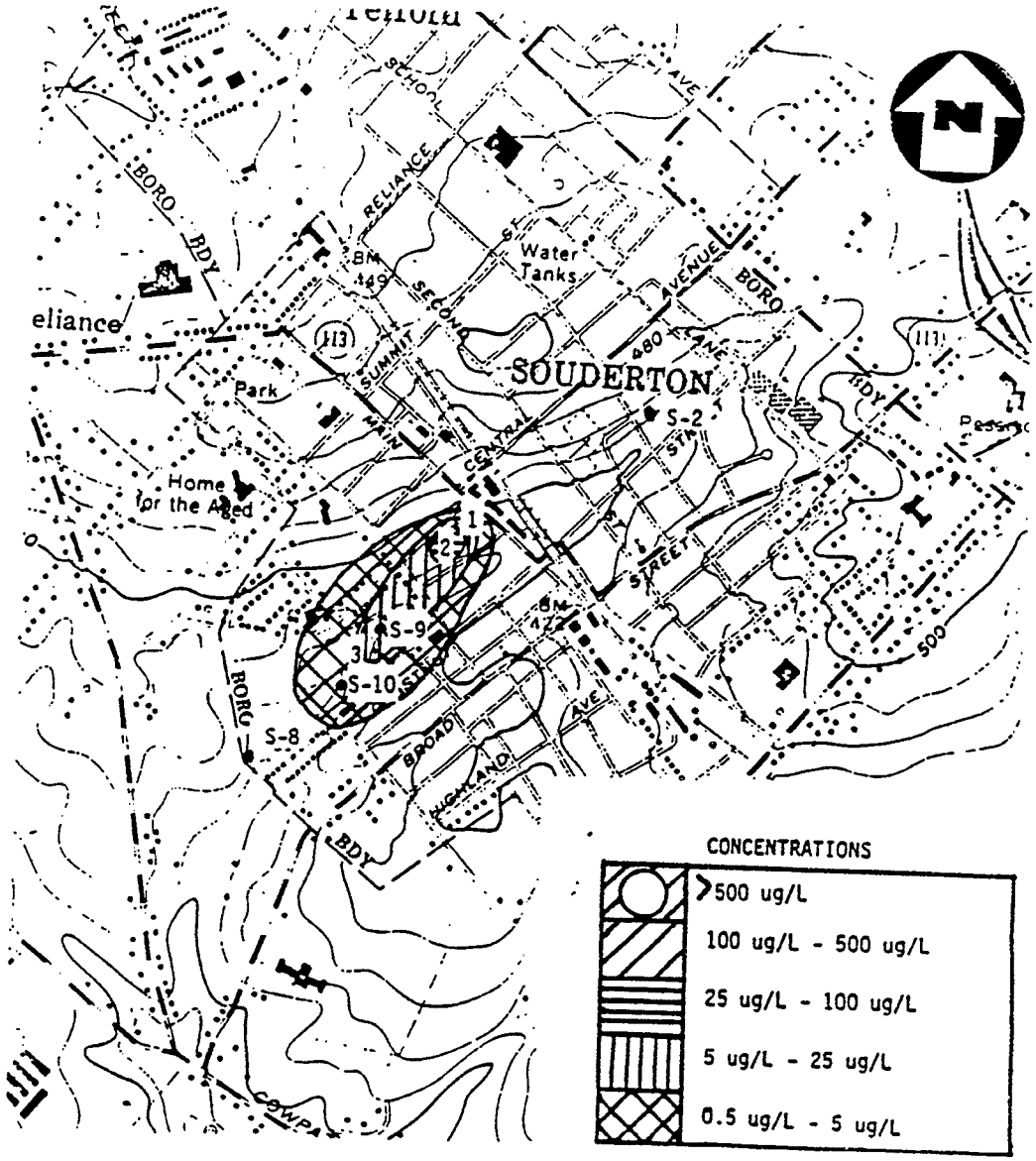
4.2 Area 1

Area 1 lies within the Souderton Borough limits in the Telford quadrangle (see map, page 4-3). The area is served by NPWA and there are no known home wells in the area. PCE contamination was discovered in this area in August 1979. Service of NPWA well S-9 was discontinued at that time. Present PCE concentrations in well S-9 are up to 24.7 ug/l, exceeding the proposed PCE limit of 10 ug/l. During a recent pump test, PCE concentrations fell from 24.7 ug/l to 10.6 ug/l after 24 hours of pumping (see page 4-4). In addition, NPWA well S-10 is contaminated with PCE with concentrations ranging from 1.2 ug/l to 2.6 ug/l (see page 4-5)[1].

Both wells S-9 and S-10 are 300 feet deep. Well S-9 has a permitted capacity of 144,000 gallons per day (gpd), while S-10 is permitted for 115,200 gpd. NPWA wells S-2 and S-8, located north and south, respectively, of the contamination plume, are not contaminated to date (see page 4-2).[1]

According to NPWA officials, potentially responsible parties for the PCE contamination include Gentle Cleaners, Incorporated, Granite Knitting Mills, Incorporated, and the Parkside Apartments. Gentle Cleaners, a dry cleaning service, is a known user of PCE. Gentle Cleaners is located at the topographic high north of the plume, thus establishing a natural pathway for contaminant movement to the low-lying areas of S-9 and S-10. Granite Knitting Mills, Incorporated is also a known user of PCE. The well on their property is reported by NPWA to be contaminated with 61 ppb of PCE. In addition, a dry cleaning service, now Parkside Apartments owned by Paul Derstein, is believed to be a potentially responsible party. The dry cleaners may have had an underground storage tank for PCE. Field identification of this tank was not verified by NUS FIT III. The Parkside Apartments are located about 100 feet south of S-9; thus, they are a likely additional source of the contamination problem.[1]

Considering the topography of the area, it can be hypothesized that there is a natural pathway for contaminant movement from Gentle Cleaners and Granite Knitting Mills to S-9 and S-10. Considering the concentrations of PCE in the Granite Mills well, there is a decreased concentration gradient moving downslope from the Granite Mill well. This supports the theory of contaminant movement from upslope (Gentle Cleaners and Granite Knitting Mills) to low-lying areas (S-9 and S-10).



AREA 1
(no scale)

1 GENTLE CLEANERS INC.
2 GRANITE KNITTING MILLS INC.
3 PARKSIDE APARTMENTS

FROM REFERENCE 5

NUS CORPORATION
A Halliburton Company

200272

S-9 PUMPING TEST, 1986

LOCATION	DATE	MIN FR START	SAMP #	ug/L PCE	C-1,2-DCE	TCE	1,1,1-TCA
S-9 TEST, 1 MIN	27-Jan-86	0.017	261	24.7	0.7	0.7	<0.5
S-9 TEST, 10 MIN	27-Jan-86	0.17	262	18.6	0.6	0.6	<0.5
S-9 TEST, 1 HOUR	27-Jan-86	1	263	13.7	0.5	0.5	<0.5
S-9 TEST, 7 HRS	28-Jan-86	7	272	10.6	0.5	<0.5	0.5
S-9 TEST, 24 HRS	28-Jan-86	24	275	10.6	<0.5	<0.5	0.6
S-9 TEST END	29-Jan-86	45	282	13.6	<0.5	<0.5	0.6

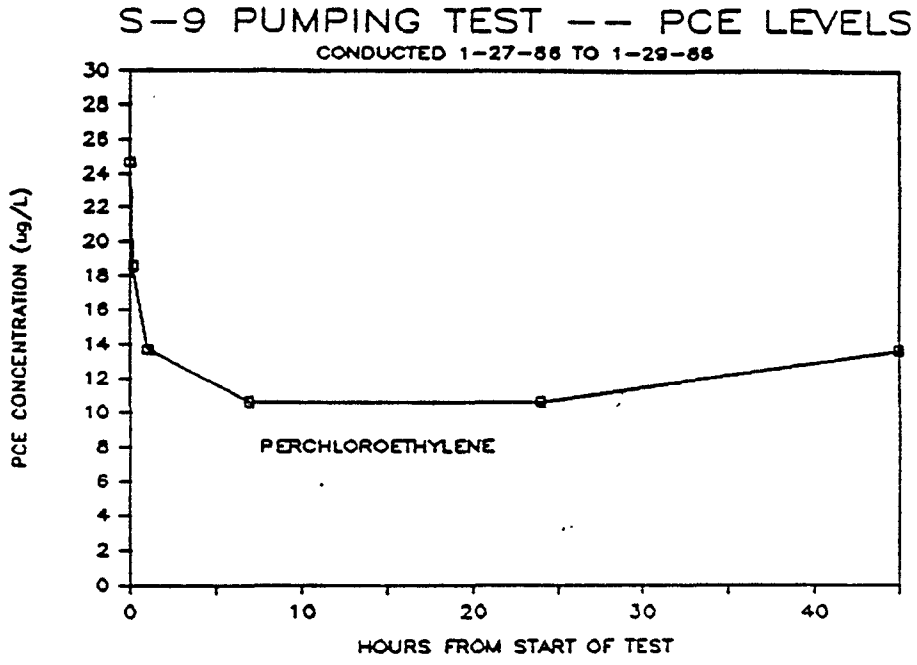


Fig #1

From Reference 1

200273

S-10 RESULTS FOR 1985 ug/L

DATE	DAY #	SAMPLE #	TCE	PCE	1,1,1-TCA
07-Jan-85	7	63	0.7	1.5	<0.5
21-Jan-85	21	148	<0.5	2.1	<0.5
11-Feb-85	42	354	<0.5	1.9	<0.5
25-Feb-85	56	443	<0.5	2.3	<0.5
11-Mar-85	70	532	<0.5	2.4	<0.5
25-Mar-85	94	682	<0.5	1.7	<0.5
22-Apr-85	112	834	<0.5	1.5	<0.5
06-May-85	126	971	<0.5	1.8	<0.5
20-May-85	140	1063	<0.5	2.1	<0.5
03-Jun-85	154	1160	<0.5	2.2	<0.5
17-Jun-85	168	1247	<0.5	1.9	<0.5
24-Jun-85	175	1286	<0.5	2.6	<0.5
08-Jul-85	189	1351	<0.5	1.2	<0.5
22-Jul-85	203	1466	<0.5	1.8	<0.5
05-Aug-85	217	1534	<0.5	2.3	0.6
19-Aug-85	231	1645	<0.5	1.8	0.6
03-Sep-85	246	1759	<0.5	2.0	<0.5
16-Sep-85	259	1853	<0.5	2.2	0.5
07-Oct-85	280	1954	<0.5	1.3	<0.5
21-Oct-85	294	2123	<0.5	1.8	<0.5
04-Nov-85	308	2202	<0.5	1.3	<0.5
09-Dec-85	343	2539	<0.5	1.7	<0.5
30-Dec-85	364	2670	<0.5	2.4	<0.5

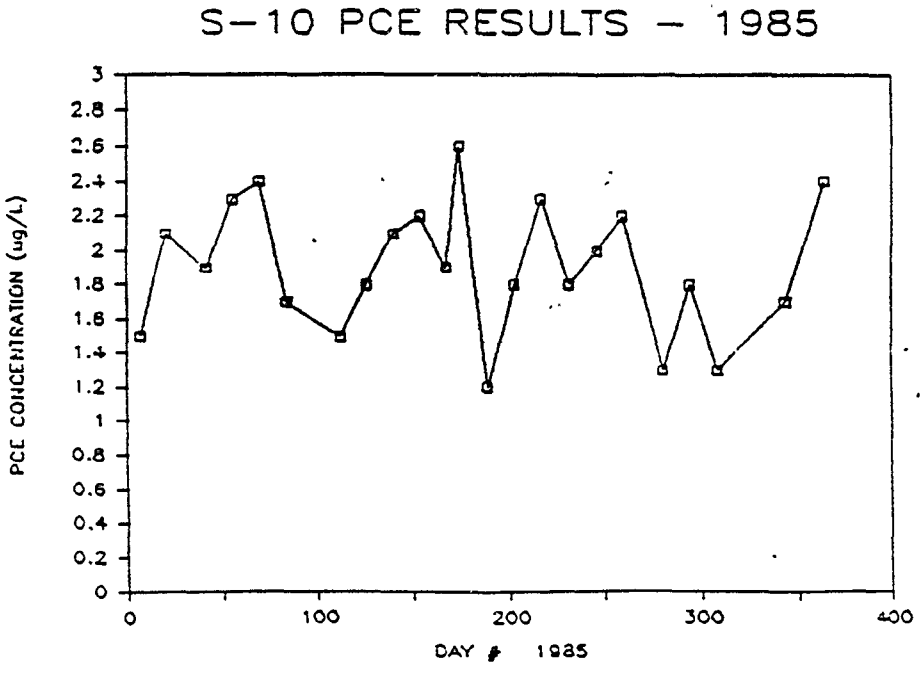


Figure #1 From Reference 1

200274

REFERENCE 10

200275

Note: This document lacks every other page of the original document.

R-585-9-6-7

A HAZARD RANKING SYSTEM FOR GENTLE CLEANERS, INCORPORATED PREPARED UNDER

TDD NO. F3-8607-07 → PA-2043
EPA NO. PA-2043
CONTRACT NO. 68-01-6699

FOR THE

HAZARDOUS SITE CONTROL DIVISION
U.S. ENVIRONMENTAL PROTECTION AGENCY

SEPTEMBER 26, 1986

NUS CORPORATION
SUPERFUND DIVISION

SUBMITTED BY	REVIEWED BY	APPROVED BY
TIMOTHY SILAR GEOLOGIST	BRUCE R. PLUTA SENIOR STAFF SCIENTIST	GARTH GLENN MANAGER, FIT III

1001

200276

Facility Name: Gentle Cleaners, Incorporated

Location: Souderton, Montgomery County, Pennsylvania

EPA Region: III

Person(s) in Charge of the Facility: Mr. Harry M. Maurer

Name of Reviewer: Timothy Silar
NUS Corporation

Date: September 26, 1986

General Description of the Facility:

The Gentle Cleaners, Incorporated site is located in Souderton, Pennsylvania. The facility is a dry cleaning service which occupies one building on approximately 0.1 acre.

Contamination of groundwater with perchloroethylene (PCE) was discovered by North Penn Water Authority (NPWA) in 1979. Presently, NPWA well nos. S-9 and S-10 are contaminated with PCE. Gentle Cleaners used PCE from 1953 until 1983. Presently, they use PCE along with 1,1,1-trichloroethane (1,1,1-TCEA). Recently, 1,1,1-TCEA was discovered in a private well 200 feet south of the site. It appears that inadequate containment and/or sloppy housekeeping of hazardous wastes at the cleaners has contaminated the groundwater in the area.

The site is located 800 feet northwest of Skippack Creek, which is used for recreational purposes. Geologically, the site is located in the Brunswick Formation, which is considered to be hydrogeologically interconnected to the Lockatong Formation within the study area. Therefore, for Hazard Ranking System purposes, these two formations comprise the aquifer of concern. Groundwater serves over 74,700 people within a 3-mile radius of the site and is the only source of potable water; thus, it is the route of major concern.

Scores: $S_M = 35.57$ ($S_{gw} = 61.54$ $S_{sw} = 0$ $S_a = 0$)

$S_{FE} = 0$

$S_{DC} = 0$

FIGURE 1

HRS COVER SHEET

1002

200277

DOCUMENTATION RECORDS
FOR
HAZARD RANKING SYSTEM

INSTRUCTIONS: The purpose of these records is to provide a convenient way to prepare an auditable record of the data and documentation used to apply the Hazard Ranking System to a given facility. As briefly as possible, summarize the information you used to assign the score for each factor (e.g. "Waste quantity equals 4,230 drums plus 800 cubic yards of sludges"). The source of information should be provided for each entry and should be a bibliographic-type reference that will make the document and for a given point easier to find. Include the location of the document and consider appending a copy of the relevant page(s) for ease in review.

FACILITY NAME: Gentle Cleaners, Incorporated

LOCATION: Souderton, Montgomery County, Pennsylvania

COORDINATES:

Latitude 40° 18' 39"

Longitude 75° 19' 31"

1003

200278

The Brunswick and Lockatong Formations are conformable (ref. no. 8 (pgs. 7 and 8)). Considerable interbedding of the two takes place along contacts (ref. nos. 8 (pg. 7) and 23 (pg. 30)). An interpretive geologic cross section has been included in reference no. 26 to indicate the nature of bedding near transitional boundaries between the Brunswick and Lockatong Formations. The above occupy a series of disconnected and downfaulted basins (ref. nos. 20 (pg. 6) and 13 (pg. 24)) in which they dip to the north-northwest, the Brunswick and Lockatong dipping an average of 20 degrees (ref. no. 7 (pgs. 15 and 25)). The trace of a large normal fault, which trends east-west, transects the three-mile radius; the fault trace may be located on site (ref. no. 14).

Both formations are generally composed of fine-grained rocks, where primary porosity is small and associated permeability is low. As such, most groundwater in the region is found within, and transmitted through, secondary porosity features such as fractures, joints, faults, and bedding plane partings (ref. nos. 7 (pgs. 10 and 13), 8 (pgs. 11 to 15), and 13 (pgs. 31, 32, and 34)). Wells of the region have been completed as open rock holes (ref. no. 14 (pg. 34)).

Within the Brunswick Formation, the most important of these openings are the nearly vertical joint planes, which criss-cross each other at various angles; these openings provide for an interconnection of channels for groundwater flow. However, both the number and width of these openings vary from bed to bed. As a result of the depositional environment, the rocks form a series of overlapping lens-shaped beds (ref. no. 8 (pgs. 11 and 12)).

Secondary permeability features displayed within the Lockatong are similar to that of the Brunswick; yet, here the openings tend to be more narrow and more widely spaced (ref. nos. 7 (pg. 25) and 8 (pg. 15)).

Interconnection of the above formations is carried out in large part via secondary features (joints and fractures), which allow for the majority of groundwater transmission and storage. These formations have also been documented as contemporaneous; interbedding of the Lockatong and Brunswick is well documented. From work completed in similar geologic settings, experts have indicated that, most likely, the Brunswick and Lockatong behave as a single hydrologic unit (ref. nos. 21 and 22).

Depth(s) from the ground surface to the highest seasonal level of the saturated zone (water table(s)) of the aquifer of concern:

N/A

Depth from the ground surface to the lowest point of waste disposal/storage:

N/A

Net Precipitation

Mean annual or seasonal precipitation (list months for seasonal):

N/A

1004

200279

4 WASTE CHARACTERISTICS

Toxicity and Persistence

Compound(s) evaluated:

	Toxicity	Persistence	Matrix Value
1,1-Dichloroethylene	3	2	15
TCE	2	2	12
PCE	2	2	12
1,1,1-TCEA	2	2	12
1,1-Dichloroethane	2	2	12

Reference nos. 1, 2, and 15

Compound with highest score:

1,1-Dichloroethylene

A value of 15 was assigned.

Hazardous Waste Quantity

Total quantity of hazardous substances at the facility, excluding those with a containment score of 0 (Give a reasonable estimate even if quantity is above maximum):

Inadequate containment or sloppy housekeeping of hazardous material at the site contaminated groundwater in the area. However, the exact quantity of hazardous substance disposed or spilled at the site is unknown; due to the fact that groundwater contaminants have been attributed to the site, a value of 1 was assigned.

A value of 1 was assigned.

Reference nos. 1, 2, and 4

Basis of estimating and/or computing waste quantity:

N/A

10[illegible]

200280

Computation of land area irrigated by supply well(s) drawing from aquifer(s) of concern within a 3-mile radius, and conversion to population (1.5 people per acre):

There is no known use of groundwater for land irrigation.

Reference nos. 20 and 21

Total population served by groundwater within a 3-mile radius:

The total population is 74,703.

A submatrix value of 5 was assigned.

A matrix value of 40 was assigned.

Reference no. 1

100C

200281

SURFACE WATER ROUTE

1 OBSERVED RELEASE

Contaminants detected in surface water at the facility or downhill from it (5 maximum):

No surface water sampling was conducted and there is no documented surface soil contamination that can migrate from the site; therefore, the surface water route has not been evaluated.

Rationale for attributing the contaminants to the facility:

N/A

* * *

2 ROUTE CHARACTERISTICS

Facility Slope and Intervening Terrain

Average slope of facility in percent:

N/A

Name/description of nearest downslope surface water:

N/A

Average slope of terrain between facility and above-cited surface water body in percent:

N/A

Is the facility located either totally or partially in surface water?

N/A

Is the facility completely surrounded by areas of higher elevation?

N/A

1007

200282

AIR ROUTE

1 OBSERVED RELEASE

Contaminants detected:

No air monitoring was conducted on site; therefore, the route has not been evaluated.

Date and location of detection of contaminants:

N/A

Methods used to detect the contaminants:

N/A

Rationale for attributing the contaminants to the site:

N/A

* * *

2 WASTE CHARACTERISTICS

Reactivity and Incompatibility

Most reactive compound:

N/A

Most incompatible pair of compounds:

N/A

Toxicity

Most toxic compound:

N/A

FIRE AND EXPLOSION

1 DOCUMENTED THREAT

If either a state or local fire marshal has certified that the facility presents a significant fire or explosion threat to the public or to sensitive environments, document the certification:

Name/affiliation of fire marshal:

Paul Stoudt is the fire marshal for Souderton Borough. The facility is not certified as a fire or explosion threat to the public.

Reference no. 22

Date of Certification:

N/A

Comments:

N/A

If there is a demonstrated fire and explosion threat based on field observations, document the threat:

Inspectors reporting the threat:

N/A

Date of observations:

N/A

Methods used to document the threat:

N/A

Comments:

N/A

009

200284

DIRECT CONTACT

1 OBSERVED INCIDENT

Pertinent details of incident:

N/A

Location:

N/A

Date:

N/A

* * *

2 ACCESSIBILITY

Accessibility to Hazardous Substance

Measure(s) taken to limit access by humans or animals to the hazardous substances:

No inspection was performed at the site. Accessibility is unknown; therefore, the direct contact section is not evaluated.

Reference no. 23

* * *

3 CONTAINMENT

Containment

Indicate whether the hazardous substance itself is accessible to direct contact:

N/A

1010

200285

REFERENCES

Reference No.	Description of Reference
1.	Uncontrolled Hazardous Waste Site Ranking ··stem; A User's Manual.
	National Oil and Hazardous Substances Contingency Appendix A (40 CFR 300) (47 FR 31219),
2.	North Penn Water Authority. Laboratory data (sample nos. 1825-86 to 1855-86) and Quality Assurance Program. (Sample location maps furnished by NUS Corporation.)
3.	Coyle, Judith A., North Penn Water Authority. Quality Assurance Program for Analysis of Trihalomethanes and other Volatile Organic Chemicals. August 20, 1985.
4.	Jaczun, Grabowski, and Leonard, attorneys for General Cleaners, Incorporated. Response to 104 E letter from EPA. July 7, 1986.
5.	Risner, Robert, Chemist for ADCO, Incorporated, with Timothy Silar, NUS FIT III. Telecon. September 9, 1986.
6.	Souder, Rosenberger, Lapp, and Bricker, attorneys for Granite Knitting Mills, Incorporated. Response to 104 E letter from EPA. July 17, 1986.
7.	Newport, Thomas G., United States Geological Survey. Groundwater Resources of Montgomery County, Pennsylvania. Bulletin W-29. First printing, 1971; second printing, 1973.
8.	Longwill, Stanley, M., and Charles R. Wood, United States Geological Survey. Groundwater Resources of the Brunswick Formation in Montgomery and Berks Counties, Pennsylvania. Bulletin W22, 1965.
9.	Rima, Donald R., United States Geological Survey. Groundwater Resources of the Lansdale Area, Pennsylvania. Progress Report 146, 1955.
10.	Rima, Donald R., Harold Meisler, and Stanley Longwill, United States Geological Survey. Geology and Hydrology of the Stockton Formation in Southeastern Pennsylvania. Bulletin W 14, 1962.

Reference No.	Description of Reference
11.	Wood, Charles, Geologist, United States Geological Survey, Malvern, Pennsylvania District Office, with Richard Wroblewski, EPA. Telecon. June 12, 1986. (Also included are a map and a telecon between Tony Lee, of MITRE Corporation, and Scott Renneisen, of NUS FIT III.)
12.	Wood, Charles, Geologist, United States Geological Survey, Malvern, Pennsylvania District Office, with Richard Wroblewski, EPA. Telecon. June 13, 1986.
13.	Greenman, David W., Pennsylvania Department of Internal Affairs, Topographic and Geologic Survey. Groundwater Resources of Bucks County, Pennsylvania. Bulletin W 11, 1955.
14.	Longwill, Stanley, M., and Charles R. Wood. Geologic Map of the Brunswick and Lockatong Formations in Berks and Montgomery Counties, Pennsylvania; Kammerer, J.C. Groundwater Resources of Bucks County, Pennsylvania. (Three-mile radius added by NUS Corporation.)
15.	Sax, N. Irving. Dangerous Properties of Industrial Materials. Fifth Edition, 1979.
16.	Richenbach, Dale, Engineer for North Penn Water Authority, with Timothy Silar, NUS FIT III. Meeting. July 29, 1986.
17.	Hickson, Robert, Superintendent of Hatfield Borough Water Authority, with Timothy Silar, NUS FIT III. Meeting. July 29, 1986.
18.	Beck, Donald, Superintendent of Telford Borough Water Authority, with Timothy Silar, NUS FIT III. Meeting. July 30, 1986.
19.	United States Geological Survey. Telford, Pennsylvania Quadrangle, 7.5. Minute Series. Topographic Map. 1960, photorevised 1973. Perkiomenville, Pennsylvania Quadrangle, 7.5 Minute Series. Topographic Map. 1960, photorevised 1973.
20.	Tindall, David, Bucks County Soil Conservation Service, with Timothy Silar, NUS FIT III. Telecon. August 4, 1986.
21.	Reber, Paul, Penn State Agricultural Extension Service, with William Hose, NUS FIT III. Telecon. August 8, 1986.

Reference No.	Description of Reference
22.	Stoudt, Paul, Souderton Borough Fire Department, with Timothy Silar, NUS FIT III. Telecon. August 5, 1986.
23.	Timothy Silar, NUS FIT III, to file. Windshield site investigation. August 6, 1986.
24.	North Penn Water Authority. Souderton Borough Distribution Map. September 27, 1973; revised December 22, 1983.
25.	NUS Corporation, FIT III. Site discovery report; section 4. TDD No. F3-8512-31, July 1986.
26.	Gannett, Fleming, Corddry and Carpenter, Incorporated. Geologic section, Wissahickon Well Field, Lansdale Municipal Authority, Lansdale, Pennsylvania. January 4, 1952.

F3-8607-07

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 1 - SITE LOCATION AND INSPECTION INFORMATION

I. IDENTIFICATION
01 STATE: PA
02 SITE NUMBER: 2043

II. SITE NAME AND LOCATION

01 SITE NAME (Legal, common, or descriptive name of site)	02 STREET, ROUTE NO. OR SPECIFIC LOCATION IDENTIFIER			
Gentle Cleaners, Incorporated	162 North Main Street			
03 CITY	04 STATE	05 ZIP CODE	06 COUNTY	07 COUNTY CODE
Souderton	PA	18964	Montgomery	091

09 COORDINATES
LATITUDE: 40° 18' 39"
LONGITUDE: 75° 19' 31"

10 TYPE OF OWNERSHIP (Check one)
☒ A. PRIVATE ☐ B. FEDERAL ☐ C. STATE ☐ D. COUNTY ☐ E. MUNICIPAL
☐ F. OTHER ☐ G. UNKNOWN

III. INSPECTION INFORMATION

01 DATE OF INSPECTION: N/A (Month Day Year)

02 SITE STATUS: ☒ ACTIVE ☐ INACTIVE

03 YEARS OF OPERATION: 1953 (Beginning Year) | Present (Ending Year) ___ UNKNOWN

04 AGENCY PERFORMING INSPECTION (Check all that apply)
☐ A. EPA ☐ B. EPA CONTRACTOR ☐ C. MUNICIPAL ☐ D. MUNICIPAL CONTRACTOR
☐ E. STATE ☐ F. STATE CONTRACTOR ☐ G. OTHER

05 CHIEF INSPECTOR	06 TITLE	07 ORGANIZATION	08 TELEPHONE NO.
N/A	N/A	N/A	( ) N/A

09 OTHER INSPECTORS	10 TITLE	11 ORGANIZATION	12 TELEPHONE NO.
N/A	N/A	N/A	( ) N/A
NO site inspection was performed			( )
by NUS Corporation, FIT III. The Site Inspection Form was completed			( )
from available information.			( )
			( )

13 SITE REPRESENTATIVES INTERVIEWED	14 TITLE	15 ADDRESS	16 TELEPHONE NO.
N/A	N/A	N/A	( ) N/A
			( )
			( )
			( )
			( )
			( )

17 ACCESS GAINED BY (Check one)	18 TIME OF INSPECTION	19 WEATHER CONDITIONS
☐ PERMISSION ☐ WARRANT	N/A	N/A

IV. INFORMATION AVAILABLE FROM

01 CONTACT	02 OF (Agency/Organization)	03 TELEPHONE NO.
Lorie Acker	EPA	( ) 215 597-3

04 PERSON RESPONSIBLE FOR SITE INSPECTION FORM	05 AGENCY	06 ORGANIZATION	07 TELEPHONE NO.	08 DATE
Timothy Silar	NUS	FIT III	(215) 687-9510	9 12 (Month Day)

EPA FORM 2070-13 (7-81)

200289

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 2 - WASTE INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
PA	2043

II. WASTE STATES, QUANTITIES, AND CHARACTERISTICS

01 PHYSICAL STATES (Check all that apply)

- A SOLID
- B POWDER, FINES
- C SLUDGE
- D OTHER _____ (Specify)
- E SLURRY
- X F LIQUID
- G GAS

02 WASTE QUANTITY AT SITE (Measures of waste quantities must be independent)

TONS: Unknown
CUBIC YARDS: Unknown
NO. OF DRUMS: Unknown

03 WASTE CHARACTERISTICS (Check all that apply)

- X A TOXIC
- B CORROSIVE
- C RADIOACTIVE
- D PERSISTENT
- E SOLUBLE
- F INFECTIOUS
- G FLAMMABLE
- H IGNITABLE
- X I HIGHLY VOLATILE
- J EXPLOSIVE
- K REACTIVE
- L INCOMPATIBLE
- M NOT APPLICABLE

III. WASTE TYPE

CATEGORY	SUBSTANCE NAME	01 GROSS AMOUNT	02 UNIT OF MEASURE	03 COMMENTS
SLU	SLUDGE			
OLW	OILY WASTE			104 E letter from Gentle Cleane
SOL	SOLVENTS	Unknown	N/A	to the United States Environmer
PSD	PESTICIDES			Protection Agency indicates that
OCC	OTHER ORGANIC CHEMICALS			the cleaners use solvents as part
IOC	INORGANIC CHEMICALS			its operation.
ACD	ACIDS			
BAS	BASES			
MES	HEAVY METALS			

IV. HAZARDOUS SUBSTANCES (See Appendix for CAS Numbers)

01 CATEGORY	02 SUBSTANCE NAME	03 CAS NUMBER	04 STORAGE/DISPOSAL METHOD	05 CONCENTRATION	06 MEASURE OF CONCENTRATION
	Tetrachloroethylene	127-18-4	Unknown	Unknown	N/A
	1,1,1-Trichloroethane	71-55-6	Unknown	Unknown	N/A

V. FEEDSTOCKS (See Appendix for CAS Numbers)

CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER	CATEGORY	01 FEEDSTOCK NAME	02 CAS NUMBER
FDS			FDS		
FDS	N/A		FDS		
FDS			FDS		
FDS			FDS		

VI. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

U.S. EPA

EPA FORM 2070-13 (7-81)

1014

200290

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
PA	2043

II. HAZARDOUS CONDITIONS AND INCIDENTS

01 ☐ A. GROUNDWATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: 74,700
02 ☐ OBSERVED (DATE: 1979-present) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

NPWA sampling has revealed PCE contamination in their nearby wells, S-9 and S-10. Recent sampling by NUS FIT III has also determined high levels of 1,1,1-trichloroethane in wells near t facility.

01 ☐ B. SURFACE WATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: Unknown
02 ☐ OBSERVED (DATE: _____) ☒ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

Skippack Creek is 800 feet southeast of the site.

01 ☐ C. CONTAMINATION OF AIR
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ D. FIRE/EXPLOSIVE CONDITIONS
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ E. DIRECT CONTACT
03 POPULATION POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ F. CONTAMINATION OF SOIL
03 AREA POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ G. DRINKING WATER CONTAMINATION
03 POPULATION POTENTIALLY AFFECTED: 74,700
02 ☐ OBSERVED (DATE: 1979-present) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

Municipal and private wells are contaminated with PCE. Some private wells are also contami with 1,1,1-trichloroethane.

01 ☐ H. WORKER EXPOSURE/INJURY
03 WORKERS POTENTIALLY AFFECTED: _____
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ I. POPULATION EXPOSURE/INJURY
03 POPULATION POTENTIALLY AFFECTED: 74,700
02 ☐ OBSERVED (DATE: _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

Within a 3-mile radius of the site, there are 74,700 people which could potentially be affecte by the ingestion of groundwater.

EPA FORM 2070-13 (7-81)

200291

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 3 - DESCRIPTION OF HAZARDOUS CONDITIONS AND INCIDENTS

I. IDENTIFICATION
01 STATE: PA
02 SITE NUMBER: 2043

II. HAZARDOUS CONDITIONS AND INCIDENTS (Continued)

01 ☐ J DAMAGE TO FLORA — 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ K DAMAGE TO FAUNA — 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ L CONTAMINATION OF FOOD CHAIN — 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ M UNSTABLE CONTAINMENT OF WASTES — 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
03 POPULATION POTENTIALLY AFFECTED: 74,700 — 04 NARRATIVE DESCRIPTION

Contamination of groundwater indicates unstable containment of waste.

01 ☐ N DAMAGE TO OFFSITE PROPERTY — 02 ☐ OBSERVED (DATE 1979-present) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

Off-site wells are contaminated.

01 ☐ O CONTAMINATION OF SEWERS STORM DRAINS WWTPs — 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

None known or reported.

01 ☐ P ILLEGAL UNAUTHORIZED DUMPING — 02 ☐ OBSERVED (DATE _____) ☐ POTENTIAL ☐ ALLEGED
04 NARRATIVE DESCRIPTION

Contamination of groundwater indicates illegal dumping.

05 DESCRIPTION OF ANY OTHER KNOWN, POTENTIAL, OR ALLEGED HAZARDS

None known or reported.

III. TOTAL POPULATION POTENTIALLY AFFECTED: 74,700

IV. COMMENTS

The total population potentially affected reflects all groundwater users within a 3-mile radius of the site, including free-flowing municipal systems.

V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

North Penn Water Authority
U.S. EPA

EPA FORM 2070-13 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION
PART 4 - PERMIT AND DESCRIPTIVE INFORMATION

I. IDENTIFICATION
01 STATE: PA
02 SITE NUMBER: 2043

II. PERMIT INFORMATION

01 TYPE OF PERMIT ISSUED	02 PERMIT NUMBER	03 DATE ISSUED	04 EXPIRATION DATE	05 COMMENTS
☐ A. NPDES				
☐ B. UIC				
☐ C. AIR				
☐ D. RCRA				
☐ E. RCRA INTERIM STATUS	N/A			Unknown permit history
☐ F. SPCC PLAN				
☐ G. STATE				
☐ H. LOCAL				
☐ I. OTHER				
☐ J. NONE				

III. SITE DESCRIPTION

01 STORAGE/DISPOSAL	02 AMOUNT	03 UNIT OF MEASURE
☐ A. SURFACE IMPOUNDMENT		
☐ B. PILES		
☒ C. DRUMS, ABOVE GROUND	Unknown	
☒ D. TANK, ABOVE GROUND	Unknown	
☐ E. TANK, BELOW GROUND		
☐ F. LANDFILL		
☐ G. LANDFARM		
☐ H. OPEN DUMP		
☐ I. OTHER		

04 TREATMENT
- ☐ A. INCINERATION
- ☐ B. UNDERGROUND INJECTION
- ☐ C. CHEMICAL/PHYSICAL
- ☐ D. BIOLOGICAL
- ☐ E. WASTE OIL PROCESSING
- ☐ F. SOLVENT RECOVERY
- ☐ G. OTHER RECYCLING/RECOVERY
- ☐ H. OTHER

05 OTHER
- ☒ A. BUILDINGS ON SITE: 1

06 AREA OF SITE: 0.1

07 COMMENTS

N/A

IV. CONTAINMENT

01 CONTAINMENT OF WASTES
☐ A. ADEQUATE, SECURE ☐ B. MODERATE ☐ C. INADEQUATE, POOR ☒ D. INSECURE, UNSOUND, DANGEROUS

02 DESCRIPTION OF DRUMS, DIKING, LINERS, BARRIERS, ETC.

Containment at Gentle Cleaners is not exactly known; however, the contamination of groundw. near the site indicated that containment was insecure.

V. ACCESSIBILITY

01 WASTE EASILY ACCESSIBLE ☒ YES ☐ NO

02 COMMENTS

The site is not totally fenced.

VI. SOURCES OF INFORMATION

North Penn Water Authority
U.S. EPA
NUS FIT III

EPA FORM 2070-13 (7-81)

200293

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

I. IDENTIFICATION
01 STATE: PA
02 SITE NUMBER: 2043

II. DRINKING WATER SUPPLY

01 TYPE OF DRINKING SUPPLY (Check as appropriate)

	SURFACE	WELL
COMMUNITY	A. ☐	B. ☒
NON-COMMUNITY	C. ☐	D. ☒

02 STATUS

	ENDANGERED	AFFECTED	MONITORED
	A. ☐	B. ☒	C. ☒
	D. ☐	E. ☒	F. ☐

03 DISTANCE TO SITE
A. 1,800 ft. (mi)
B. less than (mi)

III. GROUNDWATER

01 GROUNDWATER USE IN VICINITY (Check one)

☒ A. ONLY SOURCE FOR DRINKING ☐ B. DRINKING (Other sources available) COMMERCIAL, INDUSTRIAL, IRRIGATION (Other water sources available) ☐ C. COMMERCIAL, INDUSTRIAL, IRRIGATION (Other water sources available) ☐ D. NOT USED, UNUSABLE

02 POPULATION SERVED BY GROUND WATER: 74,700 within 3 miles
03 DISTANCE TO NEAREST DRINKING WATER WELL: 1,800 ft. (mi)

04 DEPTH TO GROUNDWATER	05 DIRECTION OF GROUNDWATER FLOW	06 DEPTH TO AQUIFER OF CONCERN	07 POTENTIAL YIELD OF AQUIFER	08 SOLE SOURCE AQUIFER
approx. 10 (ft)	Unknown	10 (ft)	Unknown (gpm)	☒ YES ☐ NO

09 DESCRIPTION OF WELLS (Including number, depth, and location relative to population and buildings)

Wells are cased to bedrock then constructed as open-holes (uncased) to total depth.

10 RECHARGE AREA
☐ YES ☐ NO
COMMENTS: Unknown

11 DISCHARGE AREA
☐ YES ☐ NO
COMMENTS: Unknown

IV. SURFACE WATER

01 SURFACE WATER USE (Check one)

☒ A. RESERVOIR, RECREATION, DRINKING WATER SOURCE ☐ B. IRRIGATION, ECONOMICALLY IMPORTANT RESOURCES ☐ C. COMMERCIAL, INDUSTRIAL ☐ D. NOT CURRENTLY USED

02 AFFECTED/POTENTIALLY AFFECTED BODIES OF WATER

NAME	AFFECTED	DISTANCE TO SITE
Skippack Creek	☐	800 feet
	☐	
	☐	

V. DEMOGRAPHIC AND PROPERTY INFORMATION

01 TOTAL POPULATION WITHIN

ONE (1) MILE OF SITE	TWO (2) MILES OF SITE	THREE (3) MILES OF SITE
A. 8,000 (NO. OF PERSONS)	B. 15,000 (NO. OF PERSONS)	C. 35,000 (NO. OF PERSONS)

02 DISTANCE TO NEAREST POPULATION: 50 feet (mi)

03 NUMBER OF BUILDINGS WITHIN TWO (2) MILES OF SITE: 1,200

04 DISTANCE TO NEAREST OFF-SITE BUILDING: 0 feet (mi)

05 POPULATION WITHIN VICINITY OF SITE (Provide narrative description of nature of population within vicinity of site, e.g., rural, village, densely populated urban area)

The site is in a heavily populated urban area.

EPA FORM 2070-13 (7-81)

1016

200294

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 5 - WATER, DEMOGRAPHIC, AND ENVIRONMENTAL DATA

I. IDENTIFICATION
01 STATE: PA
02 SITE NUMBER: 2043

VI. ENVIRONMENTAL INFORMATION

01 PERMEABILITY OF UNSATURATED ZONE (Check one)

☐ A. 10^{-4} - 10^{-6} cm/sec ☒ B. 10^{-4} - 10^{-6} cm/sec ☐ C. 10^{-4} - 10^{-3} cm/sec ☐ D. GREATER THAN 10^{-3} cm/sec

02 PERMEABILITY OF BEDROCK (Check one)

☐ A. IMPERMEABLE (Less than 10^{-6} cm/sec) ☒ B. RELATIVELY IMPERMEABLE (10^{-4} - 10^{-6} cm/sec) ☐ C. RELATIVELY PERMEABLE (10^{-2} - 10^{-4} cm/sec) ☐ D. VERY PERMEABLE (Greater than 10^{-2} cm/sec)

03 DEPTH TO BEDROCK	04 DEPTH OF CONTAMINATED SOIL ZONE	05 SOIL pH
approx. 20 (ft)	Unknown (ft)	Unknown

06 NET PRECIPITATION	07 ONE YEAR 24 HOUR RAINFALL	08 SLOPE: SITE SLOPE	DIRECTION OF SITE SLOPE	TERRAIN AVERAGE SLOPE
approx. 10 (in)	2.4 (in)	1.0 %	South	1.5 %

09 FLOOD POTENTIAL: SITE IS IN N/A YEAR FLOODPLAIN

10: N/A ☐ SITE IS ON BARRIER ISLAND, COASTAL HIGH HAZARD AREA, RIVERINE FLOODWAY

11 DISTANCE TO WETLANDS (5 acre minimum)

ESTUARINE: A. N/A (mi)
OTHER: B. N/A (mi)

12 DISTANCE TO CRITICAL HABITAT (of endangered species)

N/A (mi)
ENDANGERED SPECIES: N/A

13 LAND USE IN VICINITY

DISTANCE TO

COMMERCIAL/INDUSTRIAL	RESIDENTIAL AREAS, NATIONAL/STATE PARKS, FORESTS, OR WILDLIFE RESERVES	AGRICULTURAL LANDS: PRIME AG LAND	AGRICULTURAL LANDS: AG LAND
A. on site (mi)	B. 50 feet (mi)	C. N/A (mi)	D. approx. 1 (mi)

14 DESCRIPTION OF SITE IN RELATION TO SURROUNDING TOPOGRAPHY

The site is relatively flat, there is a downward slope to the south of the site.

VII. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

North Penn Water Authority
NUS FIT III
U.S. EPA

EPA FORM 2070-13 (7-81)

200295

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 6 - SAMPLE AND FIELD INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
PA	2043

II. SAMPLES TAKEN

SAMPLE TYPE	01 NUMBER OF SAMPLES TAKEN	03 SAMPLES SENT TO	03 ESTIMATED RESULTS AV
GROUNDWATER			
SURFACE WATER			
WASTE		evaluated using available data	
AIR			
RUNOFF			
SPILL			
SOIL			
VEGETATION			
OTHER			

III. FIELD MEASUREMENTS TAKEN

01 TYPE	02 COMMENTS
N/A	N/A

IV. PHOTOGRAPHS AND MAPS

01 TYPE ☐ GROUND ☐ AERIAL N/A

02 IN CUSTODY OF N/A

03 MAPS ☒ YES ☐ NO

04 LOCATION OF MAPS NUS Corporation, FIT III

V. OTHER FIELD DATA COLLECTED

Groundwater sampling has been taking place near the site from 1979 until present. NUS FIT III sampled area wells August 28, 1986.

VI. SOURCES OF INFORMATION

North Penn Water Authority
NUS FIT III

EPA FORM 2070-13 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 7 - OWNER INFORMATION

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
PA	2043

II. CURRENT OWNER(S)				PARENT COMPANY			
01 NAME: Helen Swantley		02 D+B NUMBER		08 NAME: N/A		09 D+B NUMBER	
03 STREET ADDRESS: 10 Woodland Drive		04 SIC CODE		10 STREET ADDRESS		11 SIC CODE	
05 CITY: Lansdale	06 STATE: PA	07 ZIP CODE: 19446		12 CITY	13 STATE	14 ZIP CODE	
01 NAME: N/A		02 D+B NUMBER		08 NAME: N/A		09 D+B NUMBER	
03 STREET ADDRESS		04 SIC CODE		10 STREET ADDRESS		11 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE		12 CITY	13 STATE	14 ZIP CODE	
01 NAME		02 D+B NUMBER		08 NAME: N/A		09 D+B NUMBER	
03 STREET ADDRESS		04 SIC CODE		10 STREET ADDRESS		11 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE		12 CITY	13 STATE	14 ZIP CODE	
01 NAME: N/A		02 D+B NUMBER		08 NAME: N/A		09 D+B NUMBER	
03 STREET ADDRESS		04 SIC CODE		10 STREET ADDRESS		11 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE		12 CITY	13 STATE	14 ZIP CODE	

III. PREVIOUS OWNER(S)				IV. REALTY OWNER(S)			
01 NAME: Unknown		02 D+B NUMBER		01 NAME: Unknown		02 D+B NUMBER	
03 STREET ADDRESS		04 SIC CODE		03 STREET ADDRESS		04 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE		05 CITY	06 STATE	07 ZIP CODE	
01 NAME: N/A		02 D+B NUMBER		01 NAME: N/A		02 D+B NUMBER	
03 STREET ADDRESS		04 SIC CODE		03 STREET ADDRESS		04 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE		05 CITY	06 STATE	07 ZIP CODE	
01 NAME: N/A		02 D+B NUMBER		01 NAME: N/A		02 D+B NUMBER	
03 STREET ADDRESS		04 SIC CODE		03 STREET ADDRESS		04 SIC CODE	
05 CITY	06 STATE	07 ZIP CODE		05 CITY	06 STATE	07 ZIP CODE	

V. SOURCES OF INFORMATION

U.S.EPA

EPA FORM 2070-13 (7-81)

200297

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 8 - OPERATOR INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
PA	2043

II. CURRENT OPERATOR (Provide if different from owner)

01 NAME: Gentle Cleaners, Incorporated	02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.): 162 North Main Street	04 SIC CODE:
05 CITY: Souderton	06 STATE: PA
07 ZIP CODE: 18964	
08 YEARS OF OPERATION: Dry Cleaners	09 NAME OF OWNER: Harry M. Maurer

OPERATOR'S PARENT COMPANY (If applicable)

10 NAME: Unknown	11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):	13 SIC CODE:
14 CITY:	15 STATE:
16 ZIP CODE:	

III. PREVIOUS OPERATOR(S) (List most recent first; provide only if different from owner)

01 NAME: Unknown	02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):	04 SIC CODE:
05 CITY:	06 STATE:
07 ZIP CODE:	
08 YEARS OF OPERATION:	09 NAME OF OWNER DURING THIS PERIOD:

PREVIOUS OPERATORS' PARENT COMPANIES (If applicable)

10 NAME: Unknown	11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):	13 SIC CODE:
14 CITY:	15 STATE:
16 ZIP CODE:	

01 NAME: N/A	02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):	04 SIC CODE:
05 CITY:	06 STATE:
07 ZIP CODE:	
08 YEARS OF OPERATION:	09 NAME OF OWNER DURING THIS PERIOD:

10 NAME: N/A	11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):	13 SIC CODE:
14 CITY:	15 STATE:
16 ZIP CODE:	

01 NAME: N/A	02 D+B NUMBER:
03 STREET ADDRESS (P.O. Box, RFD #, etc.):	04 SIC CODE:
05 CITY:	06 STATE:
07 ZIP CODE:	
08 YEARS OF OPERATION:	09 NAME OF OWNER DURING THIS PERIOD:

10 NAME: N/A	11 D+B NUMBER:
12 STREET ADDRESS (P.O. Box, RFD #, etc.):	13 SIC CODE:
14 CITY:	15 STATE:
16 ZIP CODE:	

IV. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

U.S. EPA

EPA FORM 3070-13 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 9 - GENERATOR/TRANSPORTER INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
PA	2043

II. ON-SITE GENERATOR

01 NAME	02 D+B NUMBER
Gentle Cleaners, Incorporated	

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE
162 North Main Street	

05 CITY	06 STATE	07 ZIP CODE
Souderton	PA	18964

III. OFF-SITE GENERATOR(S)

01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
N/A		N/A	

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE

05 CITY	06 STATE	07 ZIP CODE	05 CITY	06 STATE	07 ZIP CODE

01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
N/A		N/A	

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE

05 CITY	06 STATE	07 ZIP CODE	05 CITY	06 STATE	07 ZIP CODE

IV. TRANSPORTER(S)

01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
Safety Kleen Corporation		N/A	

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE
777 Big Timber Road			

05 CITY	06 STATE	07 ZIP CODE	05 CITY	06 STATE	07 ZIP CODE
Elgin	IL				

01 NAME	02 D+B NUMBER	01 NAME	02 D+B NUMBER
N/A		N/A	

03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE	03 STREET ADDRESS (P.O. Box, RFD #, etc.)	04 SIC CODE

05 CITY	06 STATE	07 ZIP CODE	05 CITY	06 STATE	07 ZIP CODE

V. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

U.S. EPA

EPA FORM 2070-13 (7-81)

200299

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 18 - PAST RESPONSE ACTIVITIES

I. IDENTIFICATION
01 STATE: PA
02 SITE NUMBER: 2043

II. PAST RESPONSE ACTIVITIES

01 ☐ A. WATER SUPPLY CLOSED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
NPWA well S-9 has been closed due to contamination.

01 ☐ B. TEMPORARY WATER SUPPLY PROVIDED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ C. PERMANENT WATER SUPPLY PROVIDED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ D. SPILLED MATERIAL REMOVED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ E. CONTAMINATED SOIL REMOVED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ F. WASTE REPACKAGED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ G. WASTE DISPOSED ELSEWHERE — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ H. ON SITE BURIAL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ I. IN SITU CHEMICAL TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ J. IN SITU BIOLOGICAL TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ K. IN SITU PHYSICAL TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ L. ENCAPSULATION — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ M. EMERGENCY WASTE TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ N. CUTOFF WALLS — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ O. EMERGENCY DIKING/SURFACE WATER DIVERSION — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ P. CUTOFF TRENCHES/SUMP — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ Q. SUBSURFACE CUTOFF WALL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

EPA FORM 2070-13 (7-81)

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 10 - PAST RESPONSE ACTIVITIES

I. IDENTIFICATION	
01 STATE	02 SITE NUMBER
PA	2043

II. PAST RESPONSE ACTIVITIES (Continued)

01 ☐ R. BARRIER WALLS CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ S. CAPPING/COVERING — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ T. BULK TANKAGE REPAIRED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ U. GROUT CURTAIN CONSTRUCTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ V. BOTTOM SEALED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ W. GAS CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ X. FIRE CONTROL — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ Y. LEACHATE TREATMENT — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ Z. AREA EVACUATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ 1. ACCESS TO SITE RESTRICTED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ 2. POPULATION RELOCATED — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

01 ☐ 3. OTHER REMEDIAL ACTIVITIES — 02 DATE _____ — 03 AGENCY _____
04 DESCRIPTION
N/A

III. SOURCES OF INFORMATION (Cite specific references, e.g., state files, sample analysis, reports)

North Penn Water Authority

EPA FORM 2070-13 (7-81)

200301

EPA

POTENTIAL HAZARDOUS WASTE SITE
SITE INSPECTION REPORT
PART 11 - ENFORCEMENT INFORMATION

I. IDENTIFICATION

01 STATE	02 SITE NUMBER
PA	2043

II. ENFORCEMENT INFORMATION

01 PAST REGULATORY/ENFORCEMENT ACTION ☐ YES ☒ NO

02 DESCRIPTION OF FEDERAL, STATE, LOCAL REGULATORY/ENFORCEMENT ACTION

N/A

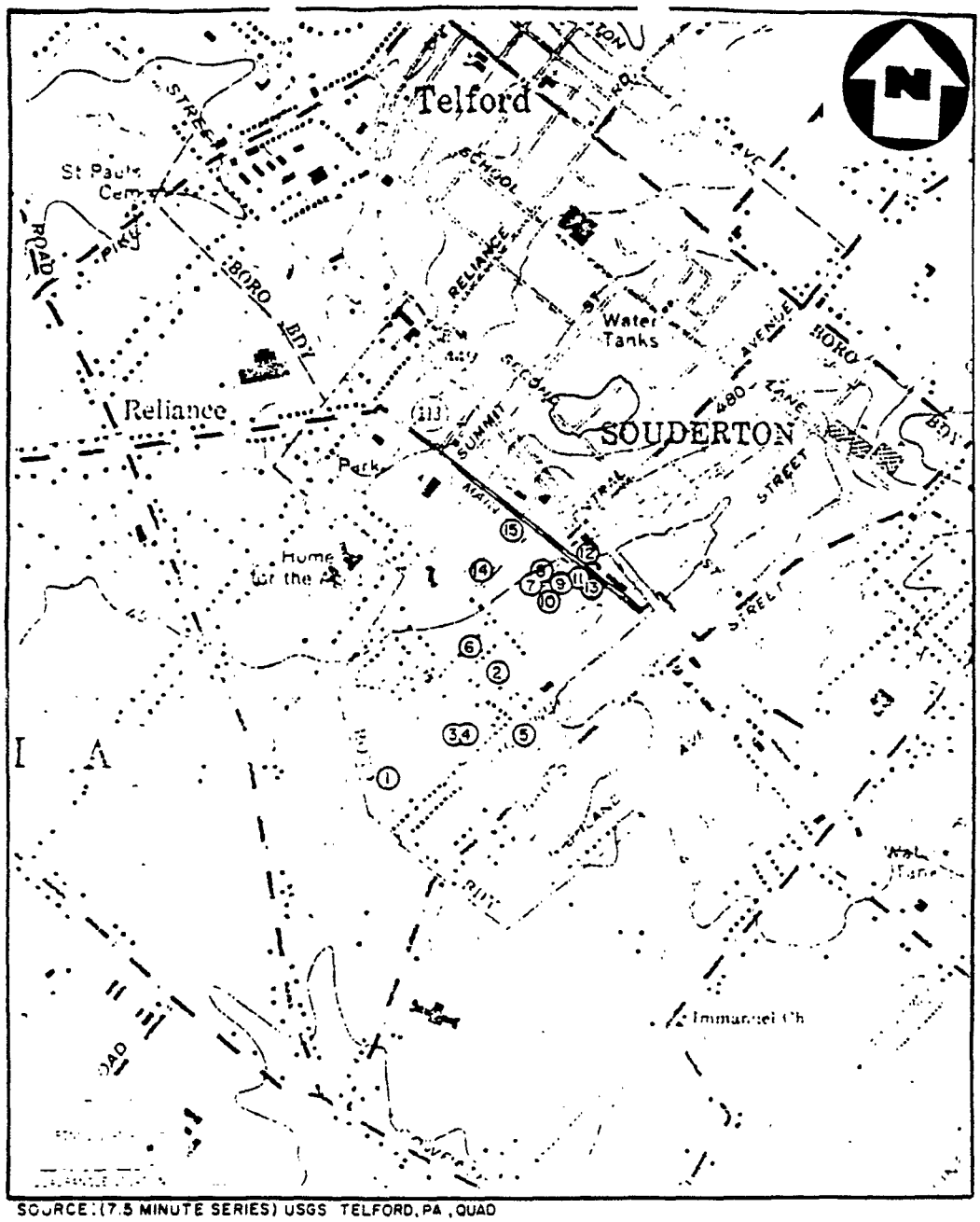
III. SOURCES OF INFORMATION

U.S. EPA
PA DER
North Penn Water Authority

EPA FORM 2070-13 (7-81)

1020

200302



SOURCE: (7.5 MINUTE SERIES) USGS TELFORD, PA, QUAD

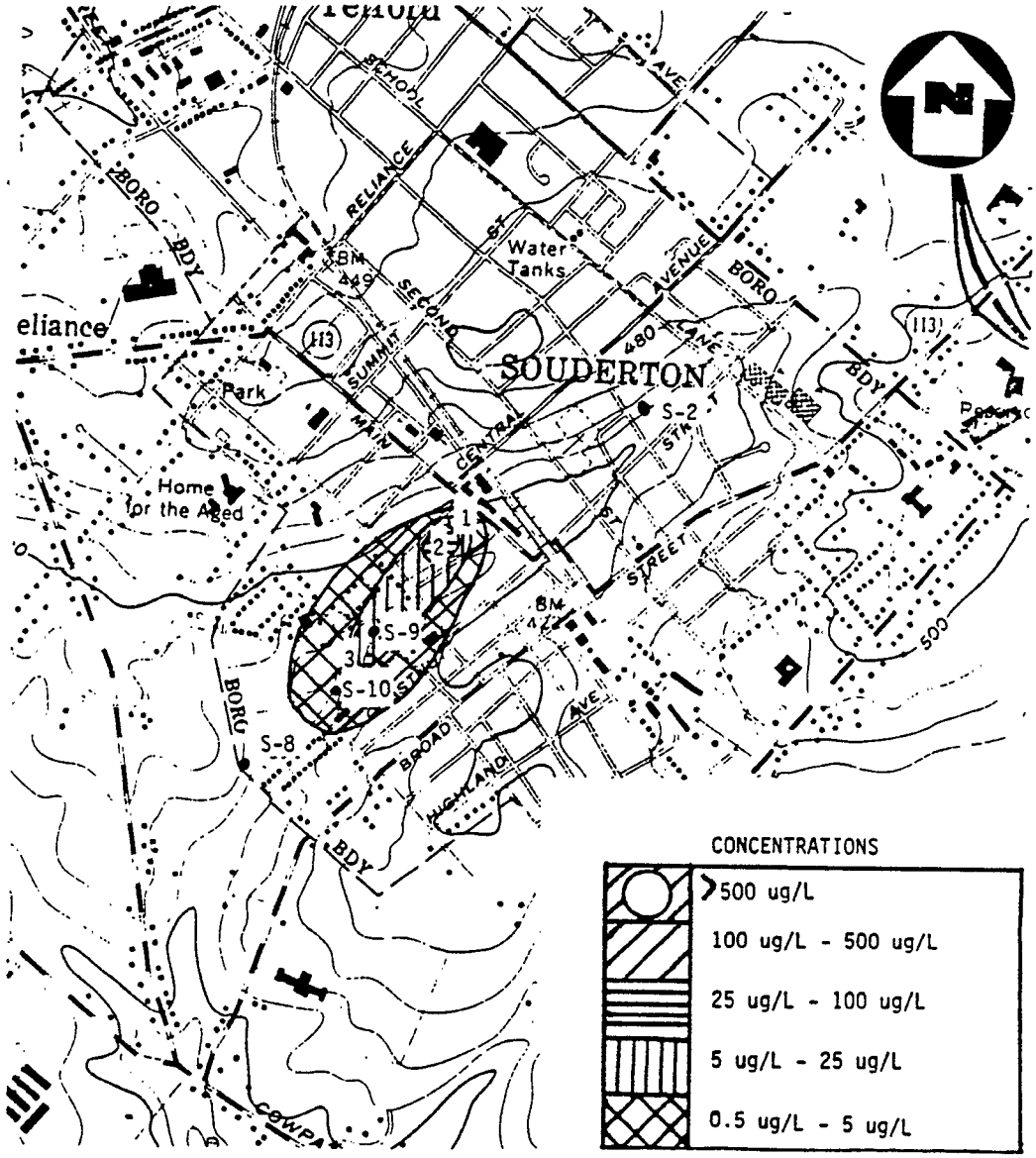
FIGURE - 2

SAMPLE LOCATION MAP
NORTH PENN WATER AUTHORITY (N.P.W.A.)
(NO SCALE)

NUS CORPORATION
A Halliburton Company

1022

200303



AREA 1
(no scale)

1 GENTLE CLEANERS INC.
2 GRANITE KNITTING MILLS INC.
3 PARKSIDE APARTMENTS

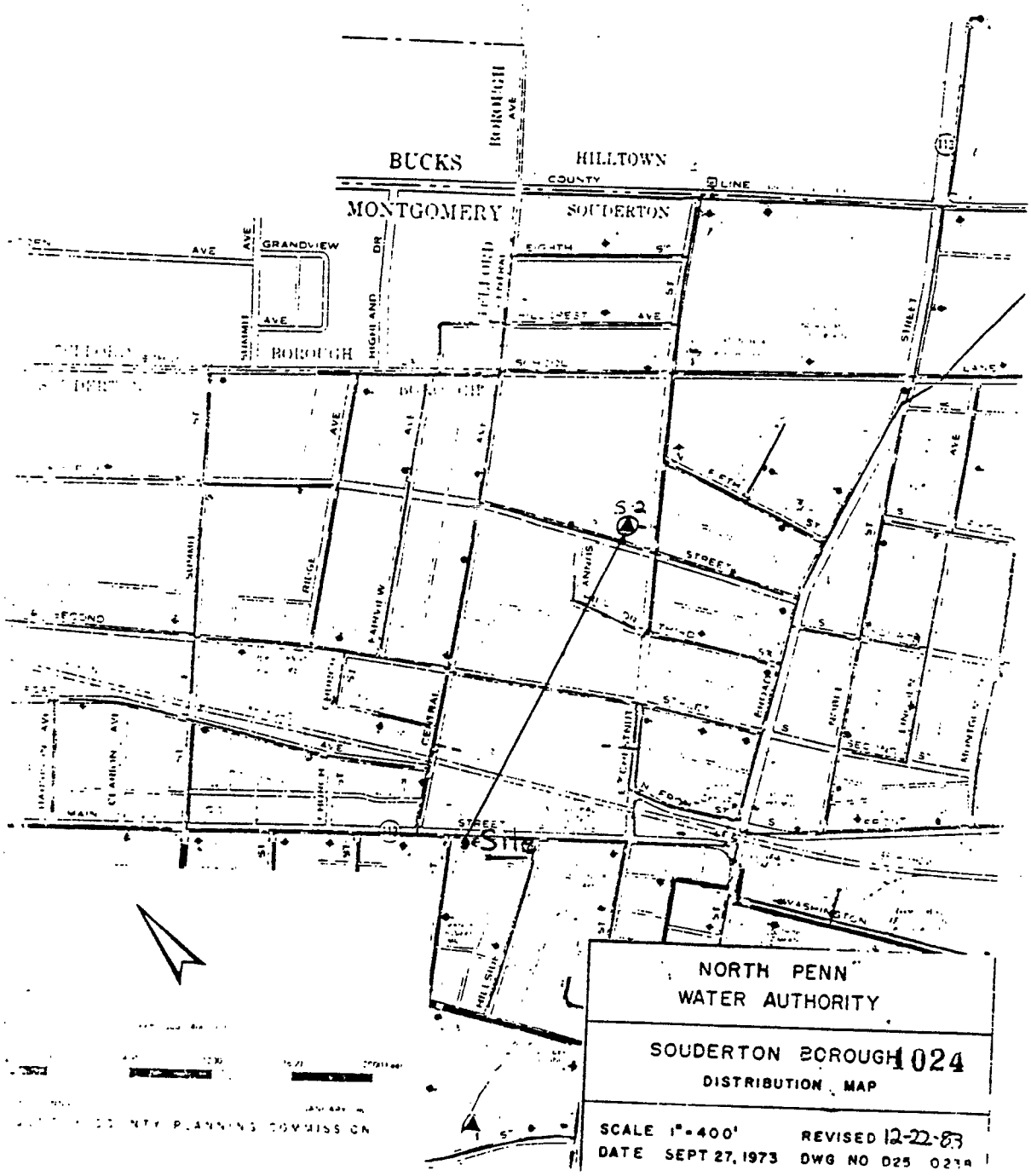
FROM REFERENCE 5

NUS CORPORATION
A Halliburton Company

1023

200304

SOUDERTON BOROUGH
MONTGOMERY COUNTY, PENNSYLVANIA



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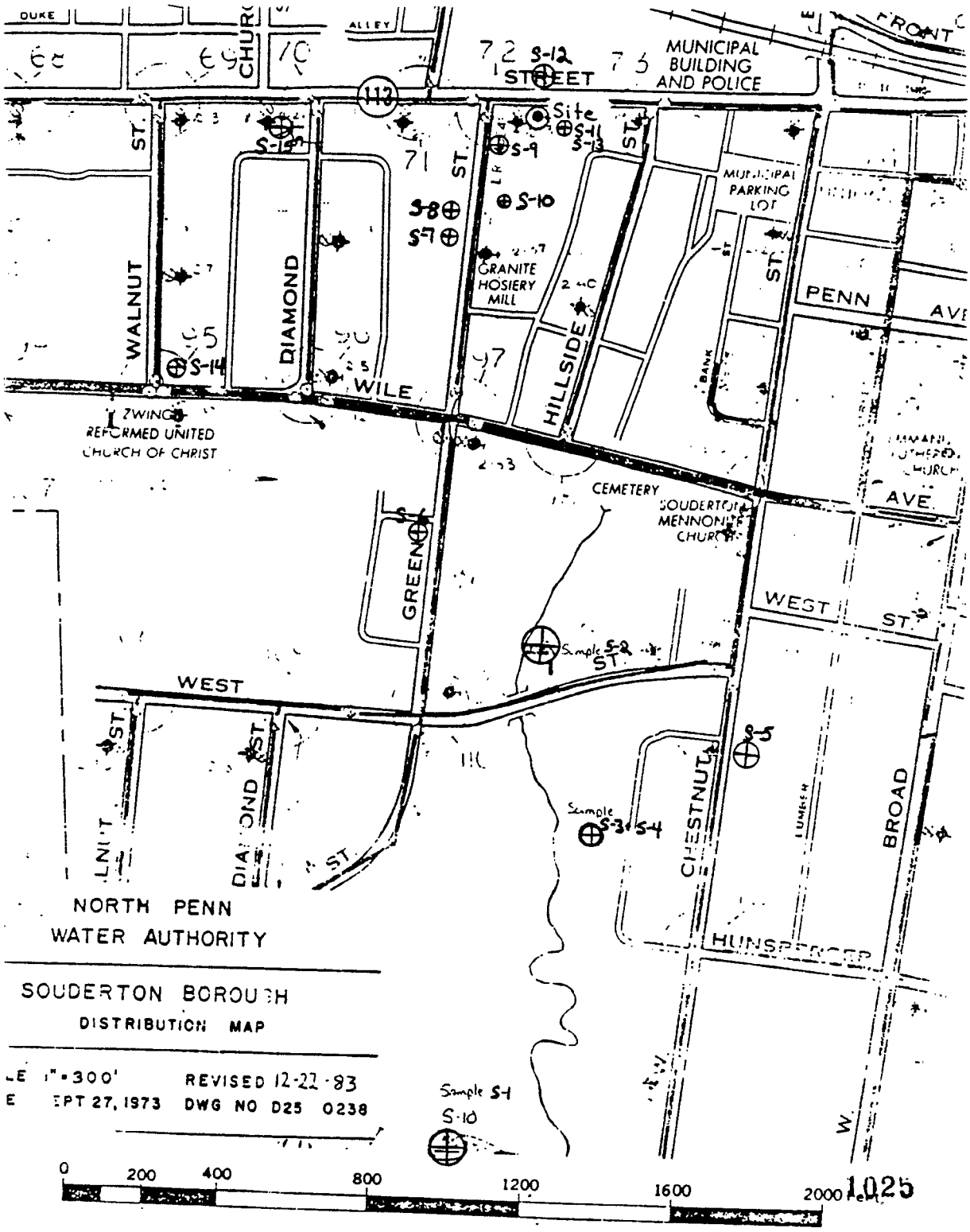
DUKE
ALLEY
FRONT
MUNICIPAL BUILDING AND POLICE
STREET
113
Site
S-12
S-11
S-13
S-9
S-10
S-8
S-7
S-15
S-14
MUNICIPAL PARKING LOT
GRANITE HOSIERY MILL
WALNUT
DIAMOND
WILE
HILLSIDE
PENN
AVE
ZWING REFORMED UNITED CHURCH OF CHRIST
CEMETERY
SOUDERTON MENNONITE CHURCH
GREEN
WEST
ST
Sample S-2
Sample S-3 S-4
CHESTNUT
BROAD
HUNSPERGER
Sample S-1
S-10
NORTH PENN WATER AUTHORITY
SOUDERTON BOROUGH
DISTRIBUTION MAP
REVISED 12-22-83
DWG NO D25 0238
0
200
400
800
1200
1600
2000

200306

JUN 30 1986

Record of Communication on 6/13/86 - Comments to HRS Revera Chemical - Nockamixon Township, Bucks County, PA

Mr. Richard Wroblewski - EPA III
Mr. Anthony Lee - Mitre Corp.

Mr. Charles Wood, Chief
USGS Malvern, PA - District Office

Mr. Wood said the Triassic age Lockatong Formation at this location is an anticline type structure, and in this area the Lockatong is not very thick. The Triassic age Brunswick Formation in places overlies the Lockatong and in other places underlies the Lockatong in this area.

According to Mr. Wood the available data does not clearly identify the degree of interconnection between the Brunswick and Lockatong in the area; however, in his consideration of the following data:

- the Lockatong in this area is not as thick as the main body of Lockatong southeast of the site;

- the Lockatong and Brunswick have the same aquifer characteristics except for an order of magnitude lower transmissivity in the Lockatong;

- the Lockatong and Brunswick are hydrologically one unit in other areas of the Triassic Basin (Montgomery and Bucks County, PA)

In the Triassic Formations there is a shallow water table system and the shallow system is connected with and supplies recharge to the fractures and joints which extend into the formation.

A conservative assumption is that there is sufficient interconnection between the Formations and it is very likely that a deep well in the area would obtain water from both Formations. This is also based on the fact that the wells in the area are completed as open rock holes with only the overburden cased off.

Mr. Wood indicated that pump test data would be evidence of hydrological unit assuming one of the wells showing interference from pumping is constructed in the Brunswick Formation, the pumping well being located in the Lockatong.

LAW OFFICES
JACZUN, GRABOWSKI & LEONARD
ONE SOUTH FIFTH STREET
P.O. BOX 192
PERKASIE, PENNSYLVANIA 18944

VICTOR S. JACZUN (1939-1983)
FRANCIS X GRABOWSKI
NICHOLAS A. LEONARD
MARY C. EBERLE

TELEPHONE 257-8066
AREA CODE 215

July 7, 1986

Lorie Acker
U.S. Environmental Protection Agency,
Region III
Site Investigation and Support (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, PA 19107

RE: Gentle Cleaners, Inc./3HW23

Dear Ms. Acker:

Pursuant to your request of June 24, 1986, my client, Gentle Cleaners, Inc., of Souderton, Pennsylvania has compiled a list of the hazardous chemicals used in its operation, together with all data available in the transportation and disposal of said chemicals. The list is as follows:

1. Perchloroethylene (PCE) - PCE has been used from 1953 to the present. From 1953 to 1983, Gentle Cleaners received shipments of 75 to 100 gallons per month. In 1983, a new dry-cleaning machine was purchased and the PCE use was limited to approximately 50 gallons per month. The PCE has been sent in drums or by tank-fulls. The PCE delivered in tank trucks was held in a storage tank until it was used in the dry-cleaning machine. Any PCE left over after the dry-cleaning process was contained in filters which were removed from the machine periodically. The filters are removed by Safety Kleen Corporation, 777 Big Timber Road, Elgin, Illinois. The PCE is purchased form Ferguson Solvent Company of Philadelphia, Pennsylvania and G & L Supply, Germantown Avenue, Philadelphia, Pennsylvania.

2. American Paint, Oil and Grease Remover - A spotting chemical which contains petroleum distillates and organic solvents. Gentle Cleaners, Inc., has used 6 to 7 gallons per year since 1953. This spotting chemical comes in gallon tins similar to square paint cans.

A PROFESSIONAL CORPORATION

3. Adco Spray Spotter - Spray Spotter is a pre-spotting chemical which contains 50% petroleum distillates. Gentle Cleaners, Inc., uses two 20-gallon drums per year and the chemical remains in these drums except the small amount which are used in the plastic spray bottle applicators.

I have also enclosed copies of OSHA Material Safety Data Sheets on various substances used in my clients dry-cleaning business. A copy of the lease of the Souderton store in question is attached as well. If you need any additional information, please don't hesitate to contact me.

Sincerely,

JACZUN, GRABOWSKI & LEONARD

By: Mary C. Eberle
Mary C. Eberle

MCE:dlm
Enc.

LAW OFFICES
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114-120 EAST BROAD STREET
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ELVIN R. SOUDER
RICHARD A. ROSENBERGER
JOSEPH L. LAPP
ROBERT G. BRICKER
FRANCIS X. BUSCHMAN, JR.
STANLEY R. OTT
JAMES W. MAZA *

*ALSO DISTRICT OF COLUMBIA BAR

AREA CODE 215
723-4374

July 17, 1986

Ms. Lorie Acker
U. S. Environmental Protection Agency, Region III
Site Investigation and Support Section (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, Pennsylvania 19107

Re: Granite Knitting Mills, Inc.

Dear Ms. Acker:

This letter is intended to serve as a response to your correspondence dated June 24, 1986 requesting certain information from Grante Knitting Mills, Inc. as part of your investigation of the contamination of the North Penn Water Authority well in Souderton.

As you are most likely aware, Granite Knitting Mills has been participating in the North Penn Concerned Business Committee and has also been discussing with the North Penn Water Authority the contamination of the well in Souderton and Granite's possible involvement as a "potentially responsible party".

The company has also initiated an internal investigation to determine whether or not Granite may have contributed to the ground water contamination even though such an internal investigation is difficult because the current principals did not own the company prior to 1976. This difficulty is further compounded by the fact that most of the persons currently in supervisory positions were not employed by Granite prior to 1978.

Accordingly, pursuant to the information requests outlined in your letter, we are able to supply you with the following information:

1. Based on available information, the company used perchlorethylene as part of a dry cleaning process at its plant. Attached hereto is a statement from Walter Clemmer who supervised this process. He is now retired and living in North Carolina and is no longer employed with the company.

2. This chemical was obtained from Sterling Chemical Company of Philadelphia and at present, we are uncertain as to when purchases began, or the amounts of said purchases. We have contacted Sterling in order to gain additional information, but they are unable to help us in this matter.

3. Based on an interview with Walter Clemmer when the perchlorethylene solution was distilled or recycled, the waste material generated was stored in 55 gallon drums prior to pick up by a local municipal road crew for spraying on the township roads. These were placed outside the company's plant prior to disposal. No other additional information is available at present regarding the removal of this substance.

4. We know of no correspondence between the company and any regulatory agency other than the EPA.

5. The North Penn Water Authority has corresponded with Granite regarding this alleged contamination and it is understood that this correspondence has been turned over to the EPA.

6. A search has been made of company records for purchase orders or other documentation regarding the purchase, storage, transportation of this material and at present, no such documentation has been located.

7. A copy of a mortgage with a description of the real estate and map is attached hereto.

Rest assured that the company is continuing its efforts to assemble the facts which will provide the requisite information as to whether or not any hazardous substance from Granite may have contaminated the West Street well. If additional material becomes available, the company will furnish the same to your agency promptly.

In return for this disclosure, we would respectfully request that your agency turn over under the Freedom of Information Act, any and all information which may be relevant to the company's investigation of this matter. Based on prior conversations with North Penn Water Authority personnel and limited knowledge of a prior EPA investigation, it is the company's belief that your agency has testing results, interviews and other documents regarding the contamination of the West Street well in Souderton. Specifically,

it is our understanding that other surrounding business establishments may have used hazardous substances and in the past which could have contaminated both the Granite property and the West Street well in Souderton.

Should you have any additional questions or information requests, please do not hesitate to contact me at once.

Sincerely,

JAMES W. MAZA

JWM/mb

Enclosures

cc: Mr. Lake S. Clemmer

Drycleaning at Granite

Purpose: To bulk the Banlon blanks and remove coning oils

Drycleaning Machine was a Permac Böwe purchased from American Permac somewhere in Long Island. XXXXXXXXXXXXX All functions of drycleaning were contained in the single unit. Material went in dry and came out dry.

Materials used by the machine were perchlorethylene and small amounts of softening agent and detergent. I believe the perc. was purchased from Sterling in Phila. and do not remember from whom we purchased the softener and detergent (Ellie would probably remember)

Operation was all automatic and controlled with a programmer. Material to be bulked was entered and machine started. The basket started revolving and a valve opened allowing a predetermined amount of perc. from holding tank to enter the machine along with small amounts of softener and detergent. This washing action went on for abount 8 minutes. The machine then went on centrifuge action whizzing the liquid out of the garments and pumping about 10% to the still and the balance to the holding tank. The next cycle was to get the balance of the liquid out of the material which was accomplished by introducing hot air while the basket was still revolving. This evaporated the balance of the perc. not removed by whizzing. The hot perc. laden air was than passed over a cooling coil to precipitate the perc. out of the air. This too was returned to the holding tank.This completed the action as far as the material goes.

The small amount sent to the still on every cycle was to clean up the perc. by evaporation and cooling and this too was sent to the holding tank. The residue left in the still contained mostly coning oils removed from the material and the detergent. The still was cleaned out , I believe weekly, but before removal it was subjected to live steam injection to remove any XXXXXXX last traces of perc. This waste material (approx. 5 gals. per cleanout) was stored outside the building on the alley side in 5-50 gal drums until removed by either the road dept. of Towamincin Township for keeping down dust on dirt roads or,later, by some waste disposal company. It should be noted that just a trace of perc. was left in the residue. Perc. has a very strong odor, but it was not noticeable in the drums ofwaste oils. Possibly the American Permac people can give you figures on amount of perc. left in the residue.

At no time while I was in charge, was any of the residue dumped down wells orinto storm sewers.

Further people you could contact as to procedure are: Ellie, Ray Wentzel, Norm Jager, Elmer Kulp and Russ Fenstermacher.

NUS CORPORATION
SUPERFUND DIVISION

PROJECT NOTES

TO: File

DATE: 7-29-86

FROM: Timothy Silar

COPIES:

SUBJECT: Hatfield Borough Water Authority

REFERENCE: Bob Hickson

Hatfield Borough Water Company (HBWC) serves approximately 10,000 people.
The system is free-flowing and utilizes 8 to 9 wells at a time.
The borough would have no other source of water if the company were shut-down.
They have no water quality problems at this time (Bob Hickson provided recent sample results for the wells).
All wells are constructed in the Brunswick Formations and are constructed as open-holes.
Bob Hickson provided a distribution map which shows areas served by the company and well locations (map on file at NUS).

Timothy Silar 7-29-86

1033

200314

JS CORPORATION
IP UND DIVISION

PROJECT NOTES

TO: File

DATE: 7-30-86

FROM: Timothy Silar

COPIES:

SUBJECT: Telford Borough Water Authority

REFERENCE: Don Beck

[illegible] people served in the borough
[illegible] people served by the borough (total)

[illegible] quality problems to date

[illegible] allowable withdrawal

[illegible] does not purchase any water, have sold [illegible] to Hatfield on occasion.

[illegible] have no alternative source of water if shut-down.

[illegible] system utilizing 6 wells

[illegible] provided a distribution map with well [illegible] (Map on file at NUS).

All Telford Borough wells are constructed in the Brunswick and/or Lockatong formations
Timothy S. [illegible] 7/2/86

1034

200315

NUS CORPORATION
SUPERFUND DIVISION

PROJECT NOTES

TO: File

DATE: 7-30-86

FROM: Timothy Silar

COPIES:

SUBJECT: HRS package for North Penn Area Study

REFERENCE: Dale Richenbach (Engineer North Penn Water Authority)
North Penn Distribution System (map Available, on file at NUS)

NPWA would have no alternative source of water if totally shutdown.

1) Main system has 13,816 hook-ups. 33 wells are used in the main area, 10 are at time off due to contamination these include S-9, NP-33, NP-21, L-2, L-9, L-10, L-21, L-23, L-25 and L-22

2) Skippack Distribution system has 463 hook-ups. 3 wells are used in this area

3) Harrisontown distribution system (Stump Hill Road, Kerr Road, and Hedrick Road) has 25 hook-ups. 1 well is used in this area

4) Small system directly east of northern Skippack system. This system has 6 hook-ups and used 1 well.

5) Small system east of southern Skippack system. This system has 28 hook-ups and uses 1 well

6) System at West Point and Morris Roads has 132 hook-ups and buys water from North Wales Water Authority

7) Hilltown system (Bucks County) has 15 hook-up and 1 well.

All NPWA well are constructed as open-holes and draw water from the Brunswick and/or Lockatong Fm.

Timothy Silar 9/16/86

1035

NUS 4434 58 1 82

200316

NUS CORPORATION — **TELECON NOTE**

CONTROL NO:	DATE:	TIME:
F3 8607-07	8/5/86	3 00 pm

DISTRIBUTION:

BETWEEN:	OF:	PHONE:
Chief Paul Stoudt	Souderton Borough Fire Department	(215) 721-0911

AND: Timothy Silar (NUS)

DISCUSSION:

Mr Stoudt said that he has had no problems with Gentle Cleaners or Granite Knitting Mill. They are not certified as fire or explosive threat.

Timothy Silar 8/5/86

ACTION ITEMS:

1036

NUS 067 REVISED 0581

200317

NUS CORPORATION
SUPERFUND DIVISION

PROJECT NOTES

TO: File

DATE: 8/6/86

FROM: Timothy Silar

COPIES:

SUBJECT: Accessibility of sites in North Penn Area Study

REFERENCE:

The accessibility of the following sites was determined by a windshield site investigation on 8/6/86

Transicoil is not fenced

Spra-Fin hazardous material at this site is fenced

Keystone Hydraulics is fenced totally

Ametek is totally fenced

American Electronic Laboratories is unknown. We were not able to determine if the facility was fenced no trespassing signs and a guard were present

Bustle Cleaners and Granite Knitting Mills are not fenced.

8/7/86

Timothy Silar
8/6/86

1037

200318

NUS CORPORATION — **TELECON NOTE**

CONTROL NO:	DATE:	TIME:
F3-8607-09	8/7/86	1:30 pm

DISTRIBUTION:

North Penn Projects (Spra-Fin)

BETWEEN:	OF:	PHONE:
Tony Lee	Mitre Corp.	(703) 883-6502

AND:

Scott Rennessen (NUS)

DISCUSSION:

Mr. Lee conveyed the following information:

1) Interconnection between Brunswick & Lockatong was accomplished in other areas of the Triassic

2) Telephone conversations with Chuck Wood were used, however the telecon was specifically used for the Revere Chemical Site.

3) He suggested the following rational:

a) Both units transmitt G-W via the same media (joints & fractures

b) They are contemporaneous FM's.

c) Underwent same metamorphic events

d) In areas of similar geology, they were judged to act as one unit.

4) Suggested proceeding with the rational above but, wanted to make certain that people understood that the telecons were not written specifically for this site

ACTION ITEMS:

1038

200319

NUS CORPORATION AND SUBSIDIARIES — **TELECON NOTE**

CONTROL NO:	DATE: 8/8/86	TIME: 0950

DISTRIBUTION:

BETWEEN: Paul Rebor (PR)	OF: Penn State Agricultural Extension Service	PHONE: (215) 489-4315

AND: Bill Hose

DISCUSSION: PR informed me that there is no irrigation for agricultural crops within the following areas:

1) North Wales and surrounding area
2) Souderton and surrounding area
3) Lansdale and surrounding area
4) Hatfield and surrounding area
5) Worcester Township
6) East and West Norriton Township

Only Graterford State Correctional Institution has any type of crop irrigation; however, that facility lies outside all North Penn Water Authority study areas.

ACTION ITEMS.

1039

Bill Hose 8/8/86

067 REVISED 06-5

200320

NUS CORPORATION — **TELECON NOTE**

CONTROL NO:	DATE:	TIME:
F3-8607-07	Sept. 9, 1986	4:00 PM

DISTRIBUTION:

BETWEEN:	OF:	PHONE:
Robert Risner	ADCO, Inc	(816) 826-3300

AND: Timothy Silar (NUS)

DISCUSSION:

R.R. confirmed that ADCO supplies Gentle Cleaners with chemicals.

R.R. stated that PURO is used to flush other chemicals and to remove grass spots. PURO is 100% Trichloroethane (TCA)

All other trade names used by Gentle Cleaners from ADCO contain less than 5% (TCA).

Timothy Silar 9/9/86

ACTION ITEMS:

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NUS 067 REVISED 0681

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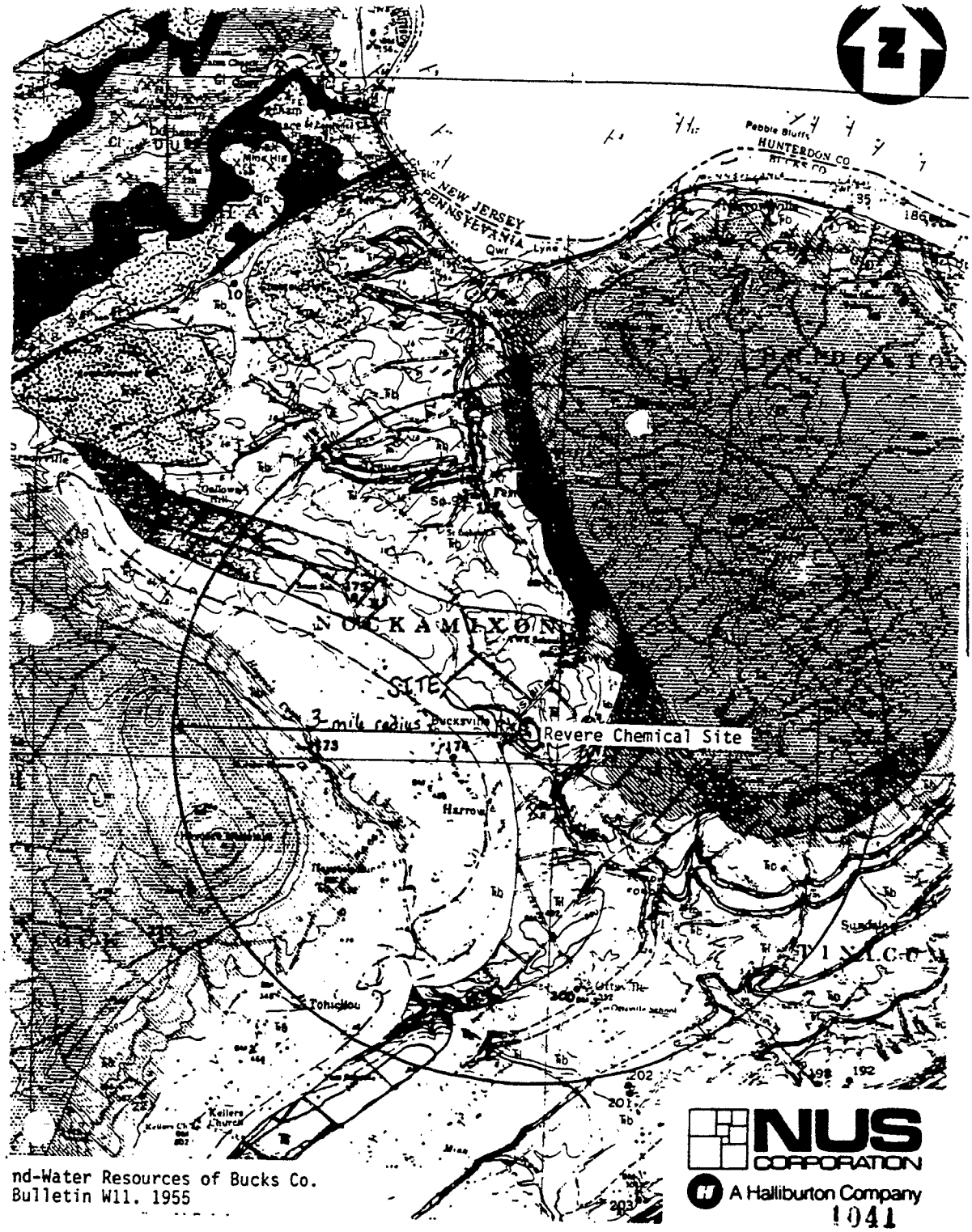

nd-Water Resources of Bucks Co.
Bulletin W11. 1955

NUS CORPORATION
A Halliburton Company

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200322

ATE I. GEOLOGIC MAP OF THE BRUNSWICK AND LOCKATONG FORMATIONS, IN BERKS AND MONTGOMERY COUNTIES, PENNSYLVANIA, SHOWING WELL LOCATIONS.

200323

REFERENCE 11

200324

PENNSYLVANIA
GEOLOGICAL SURVEY
FOURTH SERIES
PROGRESS REPORT 146

GROUND WATER RESOURCES OF THE LANSDALE AREA, PENNSYLVANIA

By
DONALD R. RIMA
U. S. GEOLOGICAL SURVEY

Prepared by
The United States Geological Survey
Ground Water Branch
in cooperation with
The Pennsylvania Geological Survey

DEPARTMENT OF INTERNAL AFFAIRS
GENEVIEVE BLATT, *Secretary*
TOPOGRAPHIC AND GEOLOGIC SURVEY
CARLYLE GRAY, *Acting Director*
1955

2003325

ILLUSTRATIONS

Page

PLATES

PLATE 1. Geologic map of Lansdale and vicinity, showing location of cross sections 4
2. Map of Lansdale and vicinity showing location of wells .....opposite page 6
3. Tentative correlation of electric logs of selected wells along line A-A′ .....opposite page 8
4. Tentative correlation of electric logs of selected wells along line B-B′ .....opposite page 10
5. Tentative correlation of electric logs of selected wells along line C-C′ .....opposite page 12
6. Water-level contour map of the Lansdale area showing the altitude of the water table in late summer, 1954 14
7. Hydrographs of selected wells in the Lansdale area ..... opposite page 14

FIGURES

FIGURE 1. Index map of the area covered 1
2. Photograph of a specimen of the Brunswick shale showing the effect of solution of calcareous material 5
3. Diagram showing the hydraulic conditions that occur during injection of water into a well and pumping water from a well 7
4. Geophysical survey of well Mg-70 8

TABLE

TABLE 1. Chemical analyses of water from wells in the Lansdale area 15

GROUND-WATER RESOURCES OF THE LANSDALE AREA, PENNSYLVANIA

BY

DONALD R. RIMA[1]

INTRODUCTION

The Borough of Lansdale for the past 50 years has obtained its supply of water from wells, and until the late summer of 1952 had experienced no serious shortage. As additional supplies were needed new wells were installed, without detailed knowledge of the depth of the aquifers to be tapped or the yield to be expected. The purpose of this investigation, made with the assistance of the Lansdale Municipal Authority, was to identify the sources of recharge and to describe the occurrence and movement of ground water in the Lansdale area. The results are described in this report, and it is hoped that the information presented will aid in the development of additional water supplies for all purposes.

Data on which this report is based were collected as part of a detailed study of ground-water conditions in the rocks of Triassic age in southeastern Pennsylvania. This and similar ground water investigations in Pennsylvania are made by the United States Geological Survey in cooperation with the Pennsylvania Geological Survey.

LOCATION

The area covered by this report comprises approximately 25 square miles in north-central Montgomery County, Pennsylvania. (See fig. 1.) It includes the boroughs of Lansdale and North Wales, and parts of the sur-

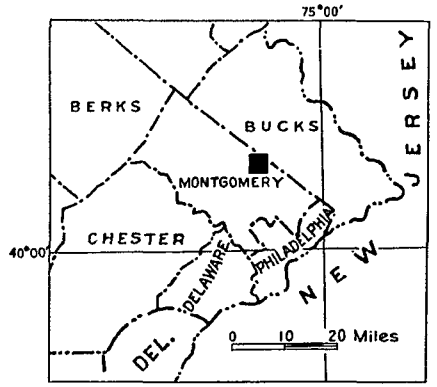

FIGURE 1. Index map of area covered.

[1] Geologist, U. S. Geological Survey, Ground Water Branch.

200326

rounding townships: Hatfield, Montgomery, Upper Gwynedd, and Towamencin. Lansdale is approximately 25 miles northwest of Philadelphia, 30 miles southeast of Allentown, 40 miles east of Reading, and 35 miles west of Trenton, New Jersey. The Lansdale area is served by the Doylestown and Bethlehem branch lines of the Reading Railroad Company, which provides commuter service to Philadelphia in addition to regular freight and passenger service. U. S. Highways 202 and 309 and State Highways 63, 363, and 463 provide convenient routes of transportation by automobile from all directions. The northeast extension of the Pennsylvania Turnpike system now under construction, will pass Lansdale a short distance to the west.

The Lansdale area has a population of slightly more than 20,000. About half this number lives within the borough limits of Lansdale. The most striking cultural feature of the area is the diversification of its industries. More than 200 industrial plants employing more than 8,000 people are located within the area. The list of industries includes foundries, steel fabricators, textile mills, furniture manufacturers, and television tube manufacturers, to name but a few.

PHYSIOGRAPHY

The Lansdale area is situated within the Piedmont physiographic province (Fenneman, 1938). The Piedmont is a gently sloping upland ranging from an altitude of about 900 feet above mean sea level at the foot of the Appalachian Mountains to the northwest, to about 50 feet above mean sea level at the inner edge of the low-lying, almost featureless Atlantic Coastal Plain to the southeast. Relief in the Piedmont is in part the result of differential weathering of the underlying bedrock and in part a consequence of erosion by the major stream systems draining the plateau.

The Lansdale area occupies a position remote from the major streams. Land-surface elevations range from about 200 feet to about 500 feet above mean sea level. The relief of the area is believed to express closely the relative resistance to weathering of the underlying bedrock. The more resistant strata form northeast-southwest trending ridges whereas the less resistant strata underlie the intervening lowlands. The lowlands, though less conspicuous, occupy the greater part of the area.

The area is drained by tributaries of the Delaware River. The southern two-thirds of the area is drained by Wissahickon and Towamencin Creeks, which flow southwesterly and empty into the Schuylkill River, the largest tributary of the Delaware River. The northern third of the area is drained by Neshaminy Creek, which flows northeasterly for a short distance and then turns to the southeast, emptying directly into the Delaware River between Philadelphia and Bristol. Drainage patterns generally trend northeast-southwest, parallel to the principal topographic features, but where the ridges are breached the streams flow southeasterly.

GEOLOGY

The rocks that underlie the Lansdale area are of Triassic age. They form part of the sequence of sedimentary and extrusive igneous rock formations named the Newark group, for exposures in the vicinity of Newark, New Jersey. These formations are exposed in a belt extending from the Hudson River southwestward through New Jersey, Pennsylvania, and Maryland into Virginia. They consist of alternating layers of shale and sandstone having a maximum aggregate thickness greater than 18,000 feet (McLaughlin, unpublished manuscript). The beds have been tilted to the northwest on a northeast-southwest trending axis parallel to their belt of outcrop, and their upturned edges have been beveled by erosion. In many places the rocks have been displaced by faulting and distorted by folding. Igneous rock in the form of dikes, sills, and lava flows are associated with the Newark group.

The Newark group is divided into three formations named, from oldest to youngest, the Stockton formation, the Lockatong formation, and the Brunswick shale. Only the latter two are tapped by wells in the Lansdale area and hence only these are described below.

LOCKATONG FORMATION

The Lockatong formation has a maximum stratigraphic thickness of about 4,000 feet in southeastern Pennsylvania (McLaughlin, unpublished manuscript) and consists mainly of hard shales and compact sandstones that are characteristically dark colored, fine grained, and well cemented. It crops out at the land surface in the southeastern corner of the Lansdale area and forms the prominent ridge trending northeast from North Wales. (See Plate 1.) The formation dips northwestward beneath the Brunswick shale at an angle of about 10 degrees. It contains very few fractures or other types of openings and, consequently, yields little water to wells. The rocks of the Lockatong formation are much more difficult to drill than those of the overlying Brunswick shale.

BRUNSWICK SHALE

The Brunswick shale has a maximum stratigraphic thickness of about 9,000 feet in southeastern Pennsylvania (McLaughlin, unpublished manuscript) and consists mainly of soft red shale interbedded with reddish-brown sandstone and siltstone. Some of the shales are sandy or silty, and there are some beds of gray, brownish, and greenish shales. The beds are thin and the bedding planes are irregular and discontinuous, making it extremely difficult to trace a selected bed more than a few tens or hundreds of feet. The shale is fractured in many places and some of the fractures are filled with calcite, a mineral composed of calcium carbonate.

Wherry (Bascom, et al., 1931, p. 30, 31) noted small cavities in several exposures of beds in the Brunswick shale which he thought were formerly occupied by the mineral glauberite (a double sodium-calcium sulfate). Calcareous concretions the size of marbles also have been noted in the Brunswick (Bascom, et al., 1909, p. 8). Some of the thin beds of sandstone in the Brunswick appear to have been cemented partly by calcite soon after deposition. Thin layers that appear to be limestone conglomerate, limestone pebbles in a shaly matrix, occur in the Brunswick shale in the Lansdale area. Solution openings occur in the rocks wherever they

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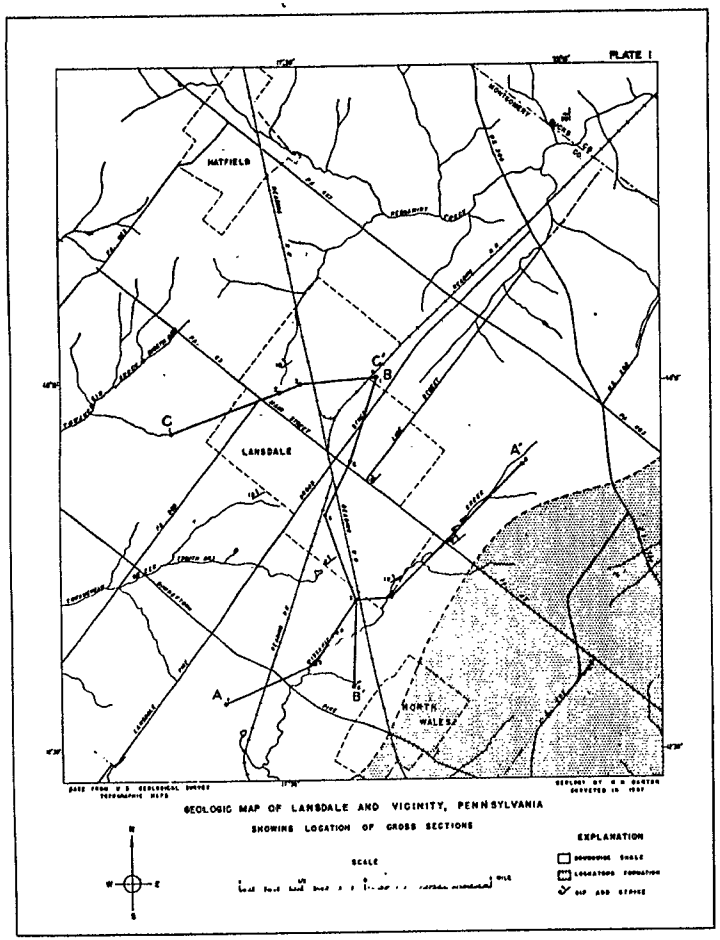

contain soluble material accessible to circulating ground water, and as a result some beds have an almost cellular appearance. (See fig. 2.) These zones yield moderate supplies of water to wells when tapped where they lie below the water table.

GROUND WATER

PRINCIPLES OF OCCURRENCE

Water that occurs beneath the land surface moves through and is stored in the numerous openings in the rocks of the earth's crust. Most rocks have many small openings in the form of pores or crevices, and some have larger openings, such as caverns and open fissures. Below a certain depth all the interconnected openings are saturated with water that is free to move by gravity to wells. The upper surface of the zone of saturation, when not formed by an impermeable body, is called the water table, and the water in the zone is referred to as ground water. The amount of ground water available in any area is controlled by the porosity and permeability of the rocks in the zone of saturation.

A rock formation that will yield ground water in sufficient quantity to supply pumped wells or springs is called an aquifer. Ground water may occur under confined or unconfined conditions. If ground water is not confined, it is said to occur under water table conditions, and the water level in a well marks the top of the saturated zone, or water table. If confined between relatively impermeable strata, ground water is said to occur under artesian conditions, and in tightly cased wells the water level rises above the top of the aquifers they tap. The imaginary surface to

FIGURE 2. Specimen of the Brunswick shale showing the effect of solution of calcareous material

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which the water in an artesian aquifer will rise is called the piezometric surface, and it indicates the pressure head of the water in the aquifer.

Ground water moves by gravity from intake areas toward areas of lower head, and ultimately to points of discharge. The direction of movement is determined by the slope of the water table or the piezometric surface. The flow of ground water is through openings in the rocks and because these openings are usually small and tortuous they offer considerable resistance to the movement of the ground water. Consequently, the rate of movement of ground water is very slow compared to that of surface water, and generally it can be expressed in feet or even fractions of a foot per day.

The ultimate source of fresh ground water is precipitation. Water falling on the land surface either runs off in streams, sinks into the ground, or evaporates into the atmosphere. Of the part that sinks into the ground, some migrates down to the water table and enters the zone of saturation. As more water is added, the water table rises, reflecting the additional volume of water in storage. Under natural conditions the amount of water that enters the zone of saturation is balanced by the amount that discharges from it. Thus, withdrawal of ground water through wells commonly diverts water that might otherwise discharge naturally. By and large, the withdrawal of water provides an opportunity for increased replenishment, or decreased natural discharge, or both. However, continuing declines of water level in an aquifer, year after year, may indicate that recharge is not keeping pace with discharge, and that depletion of the supply is in prospect.

AVAILABILITY OF GROUND WATER IN THE LANSDALE AREA

Ground water in the Lansdale area is derived chiefly from the Brunswick shale. Yields of wells tapping the Brunswick shale range from about 10 gallons per minute to about 350 gallons per minute, the average being about 50 gallons per minute. Data for 120 wells are included in the table of well records (Appendix) at the end of this report and the locations are shown on plate 2. There is no apparent statistical relation between the depth of wells and their yields. The deepest well in the area, which is more than 1,100 feet deep, is reported to yield less than 20 gallons per minute. On the other hand, the highest yield, 350 gallons per minute, is reported for a well that is 367 feet deep. The fact that no single lithologic bed or zone of deposits has heretofore been identified as the principal aquifer has resulted in haphazard development of supplies and a loss of confidence in ground water as a source.

As the Brunswick shale underlies a considerable part of southeastern Pennsylvania and is the only source of water supply in much of the area, information on the occurrence and movement of water in the Brunswick shale is of great value. To obtain information on the nature of the openings that store and transmit water to wells that tap the shale, and the yield characteristics of each lithologic zone within the formation, borehole studies in 24 wells were made by the U. S. Geological Survey using geophysical techniques. These data are applicable in this and other areas underlain by the Brunswick shale and other similar rocks.

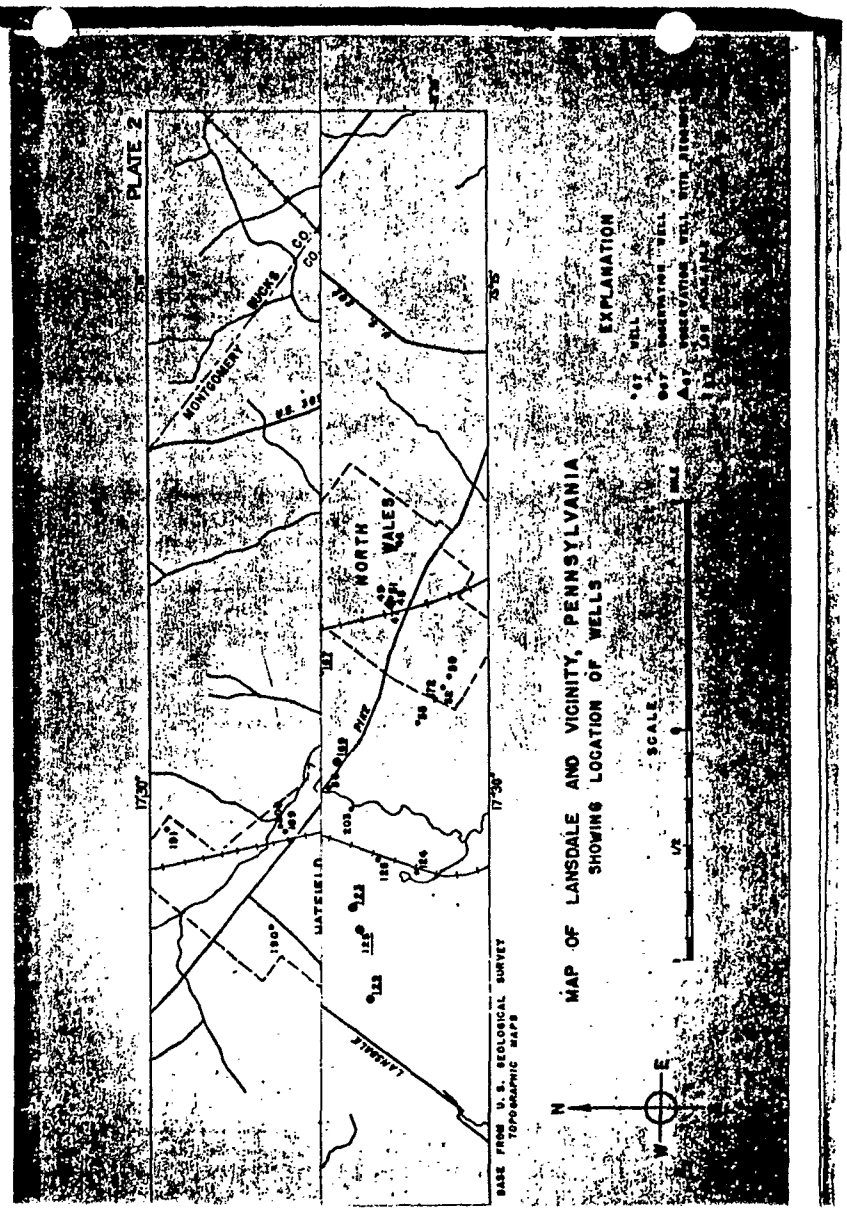

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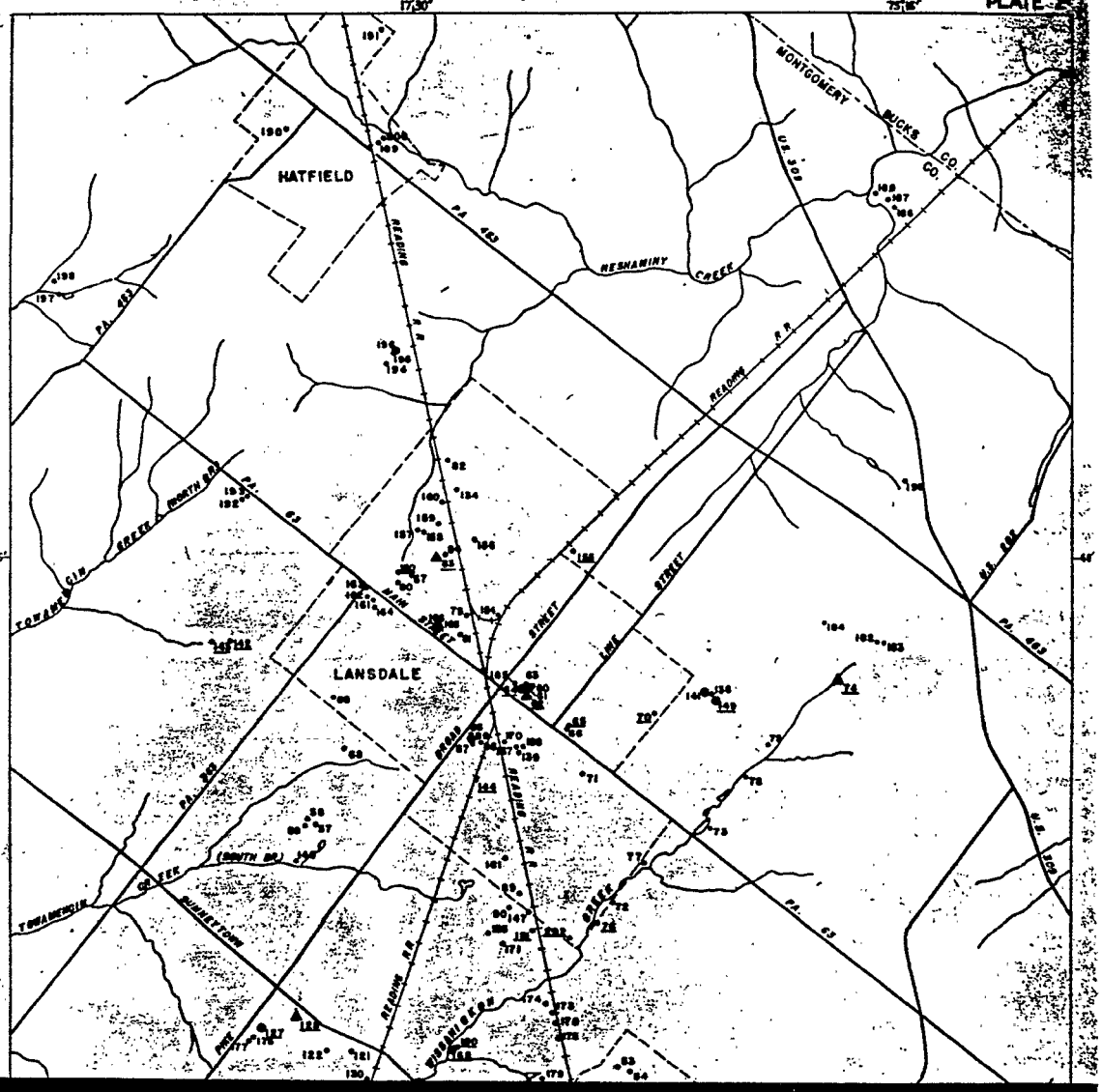
PLATE 2



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EXPLORATION OF WELLS

Geophysical methods applied

Flow-meter tests were made in 12 of the 24 wells studied, caliper logs in 18 of the wells, and electric logs in all the wells. The flow-meter tests were made by injecting water into the wells and measuring the vertical velocity of the water at selected depths using a flow meter. The meter used was a helical turbine of the type designed in 1925 by Carl H. Au of the U. S. Geological Survey. The turbine is supported on a frame inside a cylindrical brass tube which is secured in a short length of 3-inch pipe that is lowered into the well on an electrically insulated cable. A commutator head connected through the insulated cable and a dry cell to earphones worn by the operator indicates each revolution of the meter. As the speed of rotation of the turbine is proportional to the velocity of flow, and as all flow in the test was confined to the meter tube by means of flexible flanges that closed the annular space between the meter tube and borehole wall, the rate of vertical flow at any depth could be determined.

Water injected into a well enters the same permeable zones that yield water to the well when it is pumped. The comparable hydraulic relations

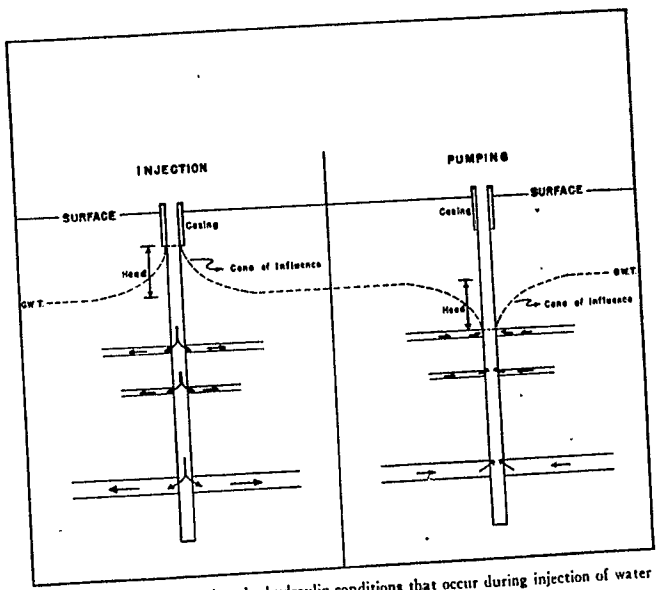

FIGURE 3. Diagram showing the hydraulic conditions that occur during injection of water into a well and pumping water from a well.

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between aquifer and well during injection and pumping are shown on figure 3. The vertical velocity of water movement in the borehole decreases as water leaves the well and enters a permeable zone. By making measurements of the velocity at selected depths in the borehole, the rate of water injection being held constant, the position of the water-bearing zones may be ascertained. Decreases in vertical velocity above the static water level in boreholes indicate the presence of unsaturated permeable zones above the water table. The velocity is generally at a maximum near the top of the well and decreases to zero below the lowest permeable zone penetrated by the well. The velocity measurements are expressed in percent of the maximum velocity measured in the well, and plotted against depth. In this investigation the flow-meter graphs were plotted at the left of the electric logs, as illustrated in figure 4.

Caliper logs (records of borehole-diameter variation with depth) were made prior to the flow-meter tests and were used to select the depths at which the velocity of flow might be measured. Reliable flow-velocity measurements could not be made at those depths where the diameter of the borehole was shown to be significantly larger than the drilled diameter of the well because the flexible flanges on the flow-meter barrel were cut to bit size.

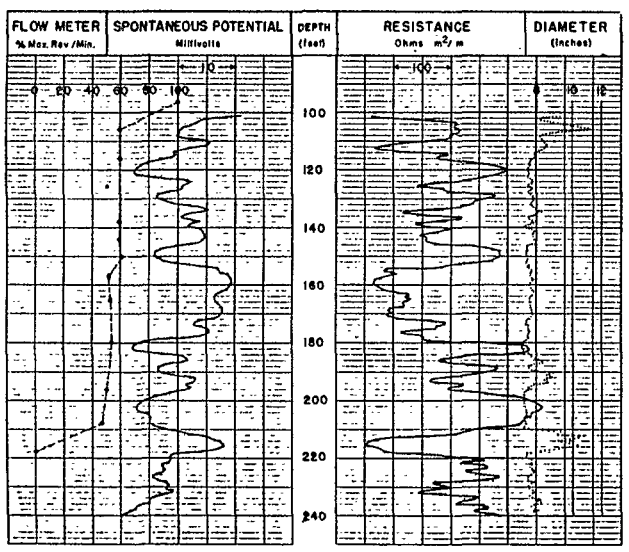

FIGURE 4. Geophysical survey of well Mg-70.

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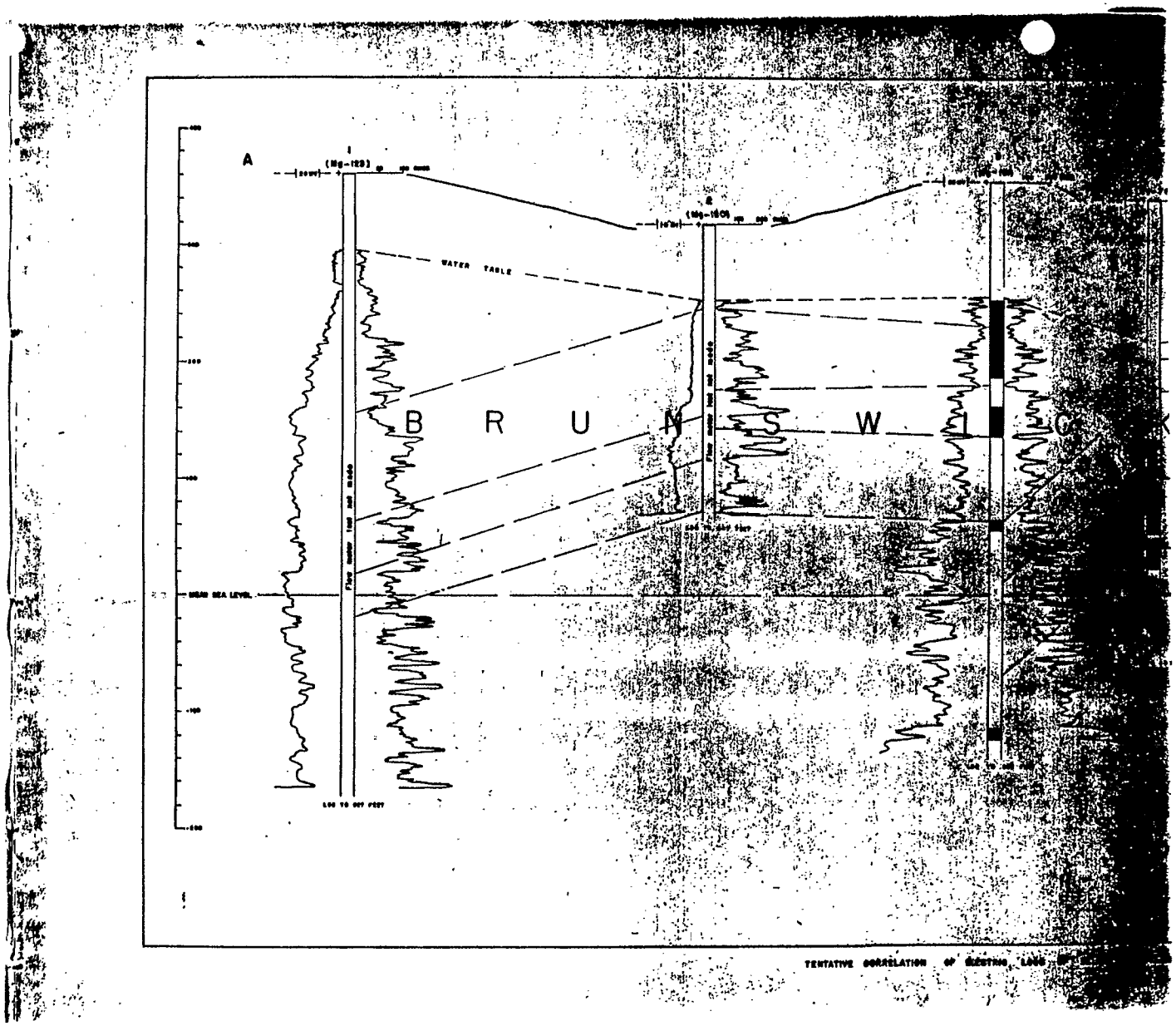

TENTATIVE CORRELATION OF ELECTRIC LOGS

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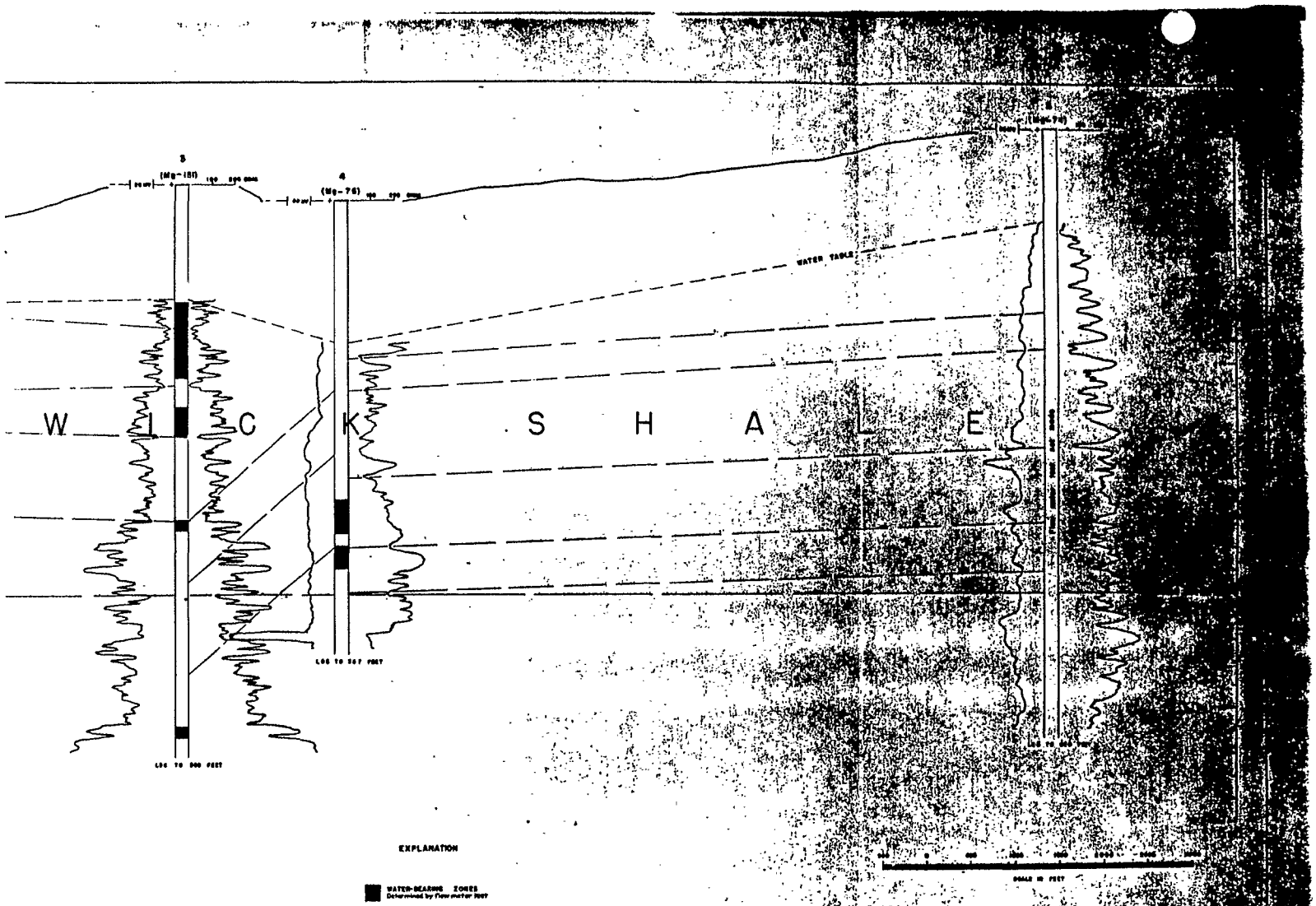

:NTATIVE CORRELATION OF ELECTRIC LOGS OF SELECTED WELLS ALONG LINE A-A' AS SHOWN ON PLATE I

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Electric logs of wells were made as an aid to correlation of beds penetrated. An electric log is a record of the electrical properties of the rock layers traversed by the borehole. Most electric logs are measurements of the spontaneous potential and resistivity or resistance of the rocks.

Spontaneous electric potential is an electromotive force caused by electrochemical and electrokinetic effects present in boreholes. An electrochemical potential is generated when two fluids having different concentrations of ions come in contact. In this instance one fluid is in the borehole and the other is in the rocks penetrated by the borehole. An electrokinetic potential is produced by the movement of an electrolyte, such as slightly mineralized water, through permeable nonconductive rock material. If a borehole penetrates more than one aquifer there is likely to be a difference of pressure head between them, resulting in crossflow through the borehole. Under these conditions an electrokinetic potential is generated in the borehole opposite each of the aquifers. The magnitude of the electrokinetic potential depends on the concentration of ions in the water and the rate of water movement, and the force is in the direction of fluid movement. The algebraic sum of the potentials arising from these two sources comprises the spontaneous potential recorded on the electric log.

The resistance to the flow of an electric current between opposite faces of a unit cube of a substance is defined as its specific resistance or resistivity. In electric logging the unit of measurement is the ohm-meter. The minerals that compose most rocks have extremely high resistivity. Therefore, the factors that determine the resistivity of a water-saturated rock are its interconnected porosity, the distribution of the pores, and the salinity of the contained water. Water resistivities vary inversely with temperature, but are not altered by changes in pressure.

Spontaneous potential and resistivity are recorded continuously by commercial logging equipment at a selected linear scale with depth; the resulting curves show changes that occur in the electrical characteristics of the rock with depth, from one layer to another, as shown on figure 4. Any sequence of beds has a characteristic curve on the electric log. By comparing the electric logs of several neighboring wells that penetrate the same sequence of beds, the stratigraphic relationships between them can be established under favorable conditions. Logs of selected wells are illustrated on sections A-A′, B-B′, C-C′, plates 3-5. Because of the variable lenticular character of the beds, the logs could not be correlated with certainty.

Interpretation of well-exploration data

Geophysical methods of well exploration applied in the Lansdale area have provided useful information on the occurrence of ground water in the Brunswick shale. Some of the information is illustrated on three cross sections (pls. 3, 4, and 5). The location of wells used in the lines of section are shown on plate 2.

Flow meter logs.—The depth and thickness of water-bearing zones were determined by flow meter tests. On the basis of these tests the aquifers that underlie the Lansdale area may be divided into two classes. A water table aquifer that exhibits low permeability through a considerable thick-

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ness occurs to a maximum depth of about 250 feet; below it are one or more artesian or semiartesian aquifers each generally less than 20 feet thick, which have a relatively high permeability, and occur to a maximum depth of about 600 feet.

The water table aquifer was evidenced on the flow-meter log by a small but continuous decline in the velocity of flow with depth. The fact that the velocity gradient was smooth indicates rather uniform permeability and vertical hydraulic continuity throughout this zone.

The artesian or semiartesian aquifers were evidenced by marked changes in the vertical velocity of flow below sections of the borehole in which no change of velocity occurred. A relatively higher rate of infiltration was noted in the artesian aquifers. This could be attributed to lower hydraulic head in them if their permeabilities were comparable to that of the water-table aquifer or to higher permeability, or both. A natural flow from the water table aquifer to an artesian aquifer was noted in one well (Mg-151).

Caliper logs.—Although caliper logs were made primarily to guide the flow meter tests, they were commonly found to indicate the probable depth and thickness of water-bearing zones. In most wells the caliper log recorded a significant enlargement of the borehole in the zones that were later proved to be artesian aquifers.

Electric logs.—Attempts were made to correlate the electric logs of wells in the Lansdale area to determine the areal extent of the water-bearing zones in the Brunswick shale. Logs of closely spaced wells could be correlated tentatively, but the greater the distance between wells the less certain was the correlation. Some of the correlations shown on plates 3, 4, and 5 are not obvious from casual inspection of the electric logs. However, thorough studies involving comparison of logs by superposition on the light table, examination of electric logs of nearby wells not shown on the lines of section, and the mapping of dip and strike in local bedrock outcrops tend to support the correlations shown.

The lack of good correlation for even moderate distances (such as 1,000 feet) is proof of the discontinuity of individual strata composing the Brunswick formation. The strata can be visualized as a series of overlapping lens-shaped beds that pinch out in all directions along the plane of bedding. Hence, a water-bearing zone formed by a selected permeable rock stratum is not likely to be very extensive.

With reference to the identification of aquifers on the electric logs two significant characteristics were noted. The water-table aquifer is characterized by a low resistivity and a moderately positive spontaneous potential. On the other hand, the artesian aquifers usually are characterized by their close association with zones having high to very high resistivity and a spontaneous potential that generally was either strongly negative or strongly positive.

The low resistivity of the water table aquifer is undoubtedly due to its relatively large water content, as compared to that of the dense, impermeable beds below. The resistivity of ground water is much less than that of dense rock, and if the water is uniformly distributed its effect upon the resistivity of a given bed is considerable even though the porosity is no more than a few percent. The gradual increase in resistance with depth

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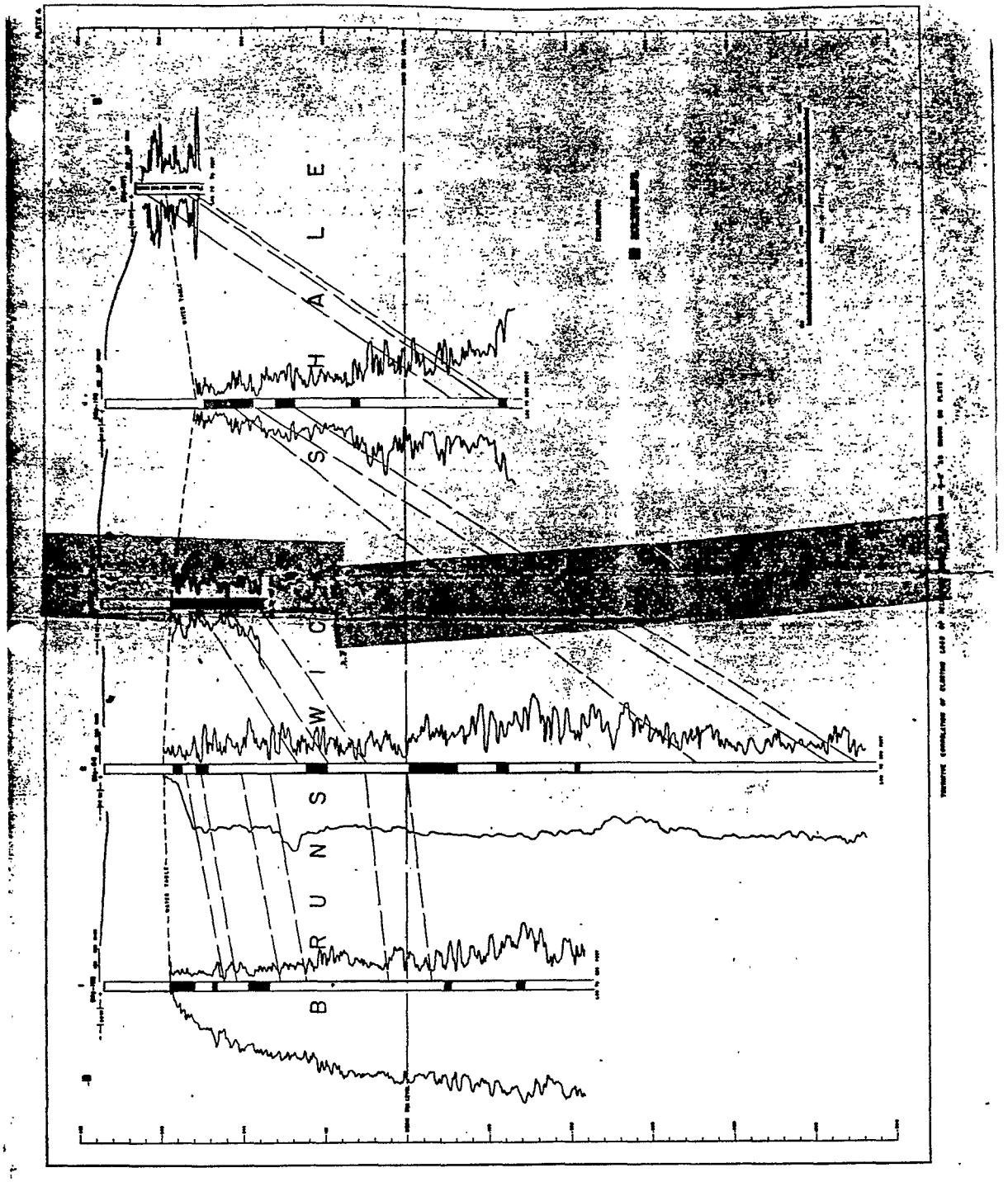

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shows that the interconnected porosity of the water table aquifer decreases with depth. A marked increase in resistance occurs at the base of the water table aquifer. The water-table zone was identifiable by its low resistance on the electric logs of all wells explored in the Lansdale area.

The generally high resistivity of the artesian aquifers is believed to be a result of the generally wide spacing of their water-filled voids. The voids that contain and transmit the water are apparently vertical joint fractures secondarily enlarged by solution. They comprise but a small part of the total volume of the bed, and are separated by dense, impermeable rock having high electrical resistivity. Enlargement of joint fractures by solution can occur only in beds which contain soluble material, and such beds are of limited areal and vertical extent in the Brunswick shale. It is believed that enlargement seldom exceeds 1 or 2 inches, but it is possible that voids a foot or more in width may occur where two joint systems intersect, or the abundance of soluble material in the rock favors enlargement.

HYDRAULIC CHARACTERISTICS OF AQUIFERS

The hydraulic characteristics of an aquifer determine its capacity to store and transmit water. The coefficient of storage of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. In water table aquifers the coefficient of storage is essentially equal to the specific yield, that is, the drainable interconnected pore space. In artesian aquifers the coefficient of storage is related to the elastic properties of the aquifer skeleton and of the water itself, and is much smaller than under water-table conditions. The coefficient of transmissibility is the number of gallons of water per day that will pass through a cross-section of an aquifer 1 mile wide, with a height equal to the saturated thickness of the aquifer, under a hydraulic gradient of one foot per mile. If these coefficients are known it is possible to determine the proper spacing of wells and the optimum pumping rate, and to predict the effects of pumping on water levels.

Coefficients of transmissibility and storage are determined for an aquifer by measuring the effect of withdrawal at a known rate from a given well for a specified period of time upon water levels in other wells tapping the same aquifer at known distances from the pumped well. Mathematical formulas by which these effects are analyzed were derived from the fundamental heat equations under the direction of C. V. Theis (1935). Application of the formula is based upon the assumption that the aquifer is homogeneous in texture, of great areal extent, and hydraulically isotropic. If the aquifer being tested deviates substantially from these basic assumptions the determinations of the coefficients of transmissibility and storage are invalid unless corrections for the deviations can be made.

From the previous descriptions of the two types of aquifers that occur in the Brunswick shale it is apparent that coefficients of transmissibility and storage for them would be of little value. Determinations of the coefficients of transmissibility and storage using wells that tap more than one aquifer are not valid for any of the aquifers individually, nor for the system they compose collectively. If the water level in a well is affected by

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withdrawal from another well in the same vicinity it is evident that both wells tap a common aquifer. However, if one or both of the wells tap two or more aquifers, interference data cannot be used for computation of the hydraulic characteristics of the aquifers. As this is a common occurrence in the Lansdale area, hydraulic tests serve little purpose other than to establish the areal extent of aquifers.

AQUIFER FUNCTION

Recharge

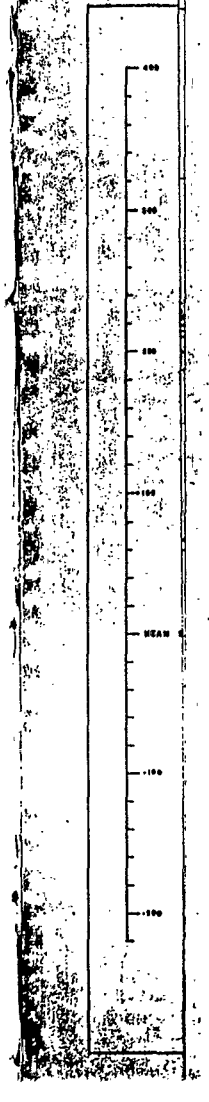
Precipitation in the Lansdale area seeps into the openings in the rocks at the land surface and a part of it migrates downward to the water table. The addition of water to that already in storage causes the water table to rise. The maximum rise of the water table in the Lansdale area occurs during the spring of the year, when the contribution of water from precipitation and snow melt is high and losses through evapotranspiration are low. As the water must move through small, tortuous openings in the rocks, which offer a great deal of resistance to the movement of water, several days or weeks may elapse before the effect of precipitation on ground-water storage can be recognized, as evidenced by rising water levels in observation wells.

The aquifers that occur below the water table zone act mainly as conduits and serve to drain the less permeable beds above them. Thus water in the artesian zone is derived from the water table zone by downward movement through joints, and the limit of the supply available is the volume in water table storage in the immediate locality.

Movement

The direction of movement of ground water is determined by the direction of slope of the water table or piezometric surface. The pattern of ground water circulation prior to the installation of wells is from areas of high elevation—hills and uplands—toward those of lower altitude, principally stream valleys. Because areas of low altitude are along the natural drainageways, ground-water movement has been concentrated beneath present-day stream valleys. Headwater areas of streams are generally less favorable for ground-water development than those downstream, for this reason, because they have been exposed to less ground-water circulation, and enlargement of fracture openings by solution has not been appreciable. In much of the Lansdale area the water table is at a depth of 50 feet or less, but in the vicinity of heavily pumped wells it may be 125 feet or more beneath the land surface. In localities remote from the centers of pumping the water table is commonly less than 20 feet below the land surface. In those localities the configuration of the water table is a subdued replica of the land surface.

The installation of wells in the Lansdale area has altered the natural gradients. The direction of movement of ground water is now a function of the locus and intensity of withdrawals. Many wells tap both water table and artesian aquifers and their withdrawals are derived in part from both sources. Because the artesian aquifers are more permeable than the water table aquifer and contain much less water in storage, the artesian pressure within them tends to decline rapidly with pumping. Conse-



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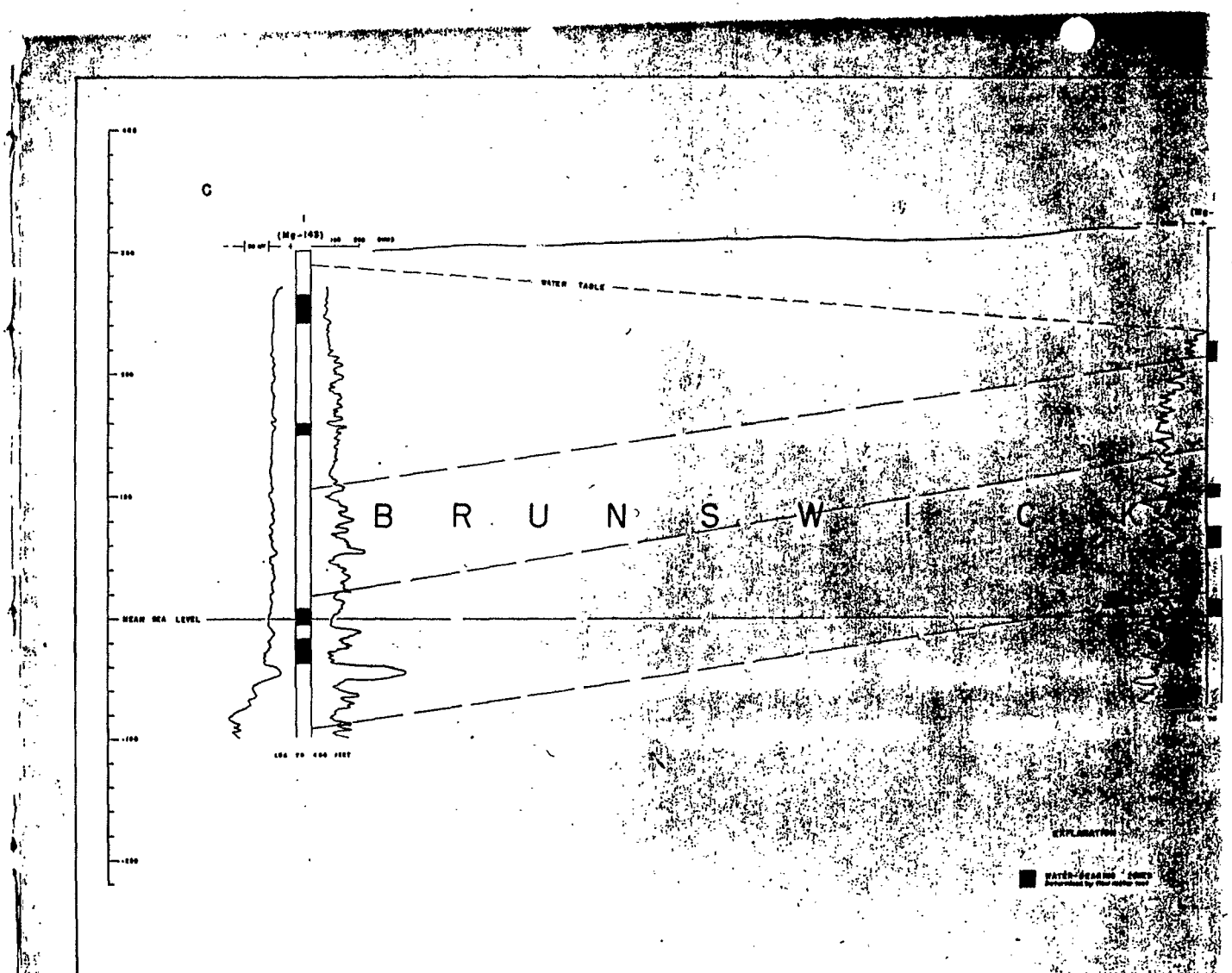

TENTATIVE CORRELATION OF ELECTRIC LOGS OF SELECTED WELLS AL

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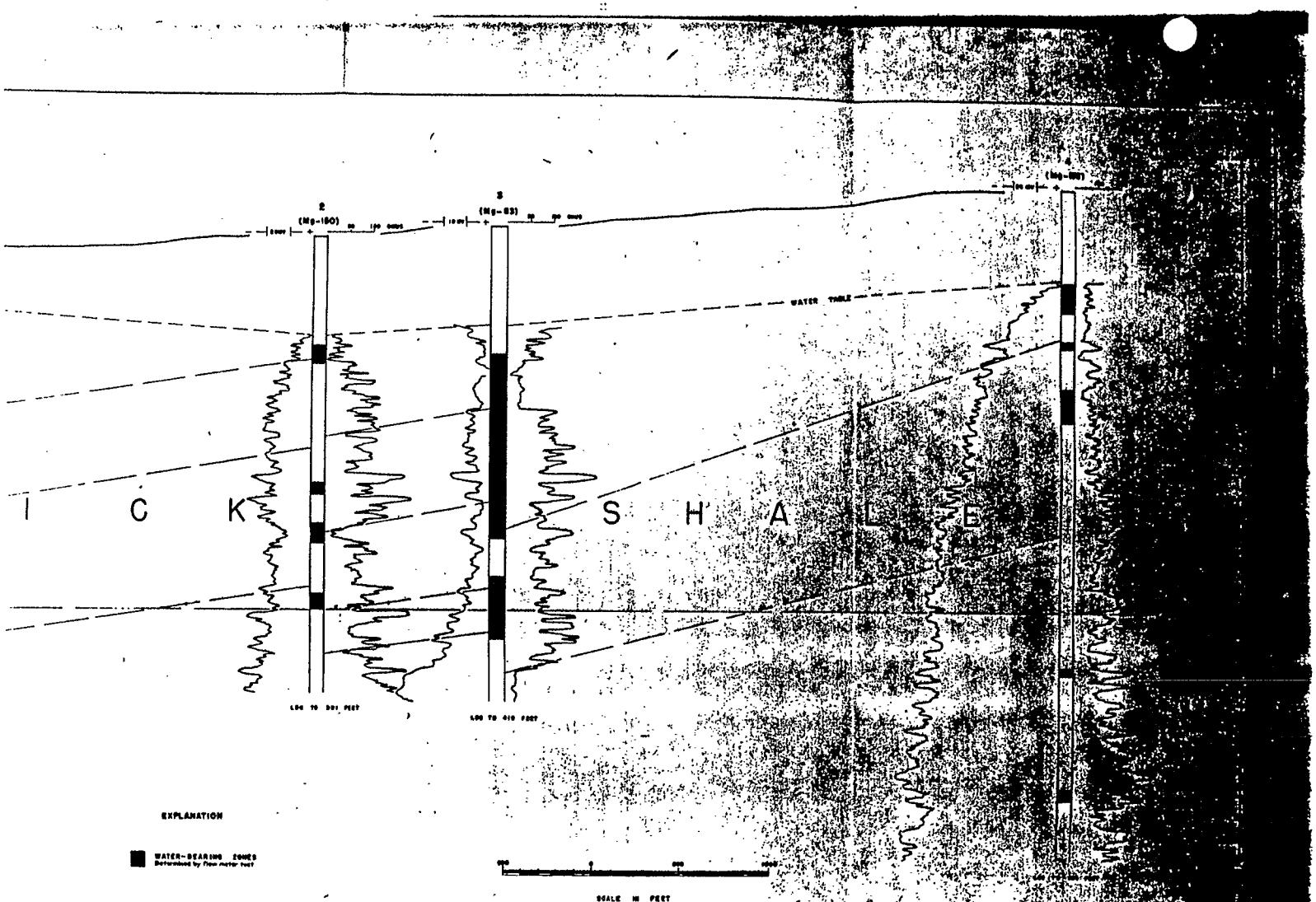

CORRELATION OF ELECTRIC LOGS OF SELECTED WELLS ALONG LINE G—G' AS SHOWN ON PLATE I

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quently, the downward pressure gradient from the water table zone through the semiconfining rocks to the artesian zones below is increased.

The lateral rate of ground-water movement is a function of the slope of the water table or piezometric surface and the permeability of the aquifer. As a consquence of the low permeability of the water table aquifer, the rate of lateral movement of water in it is very slow, even though the gradient may be steep. It is for this reason that water levels in wells less than half a mile from areas of heavy pumping may be relatively unaffected. The local nature of water-level declines is illustrated on plate 6, a generalized water-level contour map showing the conditions in the Lansdale area in the late summer of 1954.

Discharge

Over long periods of time the water recharged to a ground water reservoir is discharged naturally or artificially. Natural discharge takes place mainly through seeps, springs, or streams which are in effect, points of intersection between the water table and the land surface. Artificial discharge occurs through pumped or flowing wells. The withdrawal of ground water from wells in the Lansdale area decreases the amount of water that otherwise would have discharged naturally.

When more water is withdrawn from an aquifer than is recharged to it during any given period the result is a lowering of the water table or piezometric surface. If the decline persists, and especially if it accelerates over a period of several years when the rate of withdrawal is not increased, the withdrawal is obviously in excess of the replenishment, and the area is said to be overdeveloped.

In the Lansdale area the water table is highest in the spring and early summer and lowest in the fall and early winter. This is true in spite of the fact that average rates of precipitation are greatest during the months of June, July, and August. Evaporation and the transpiration of plants reduce soil moisture so much during those months that rainwater is not able to penetrate below the soil and recharge of ground-water is negligible. Also, withdrawals from wells are generally greater during the latter part of the summer when the rate of recharge is at a minimum.

Except in the immediate vicinity of the borough of Lansdale and in the area between Lansdale and North Wales the general level of the water table has declined very little as a result of withdrawals from storage during the past decade. However, marked declines have occurred in the vicinity of closely spaced wells installed during the past few years. (See hydrographs, pl. 7.)

The total daily withdrawal from wells in the Lansdale area has not been inventoried, but records for about 80 wells now in use indicate that about 5 million gallons a day is pumped during the summer months. The yields of new wells generally decline 50 to 70 percent from their initial discharge rates during the first year of operation, and new wells located within about 1,500 feet of existing wells reduce significantly the yields of the older wells.

Drought years, which result in accelerated rates of withdrawal from wells, are also periods of reduced recharge. The combined effects cause critical declines in water levels and reduced yields from wells. Because

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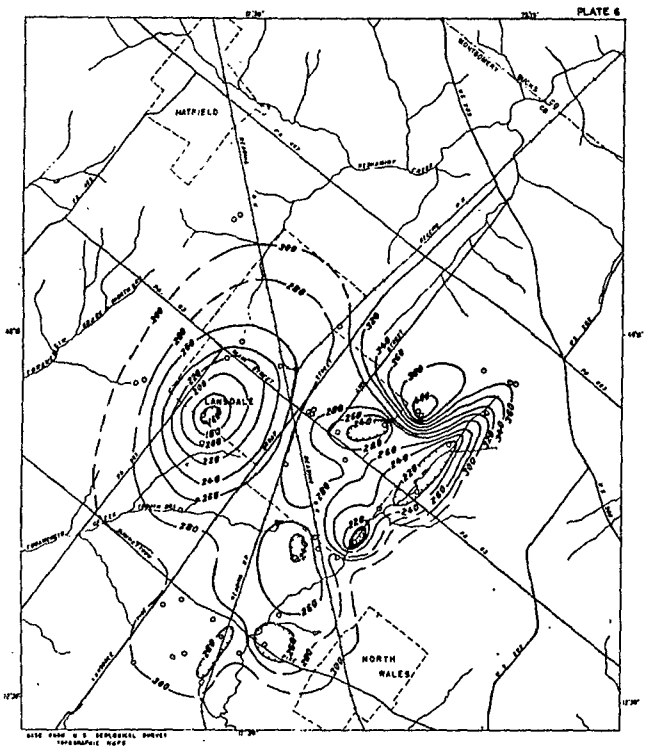

WATER-LEVEL CONTOUR MAP OF THE LANSDALE AREA
SHOWING
ALTITUDE OF THE WATER TABLE IN LATE SUMMER 1954

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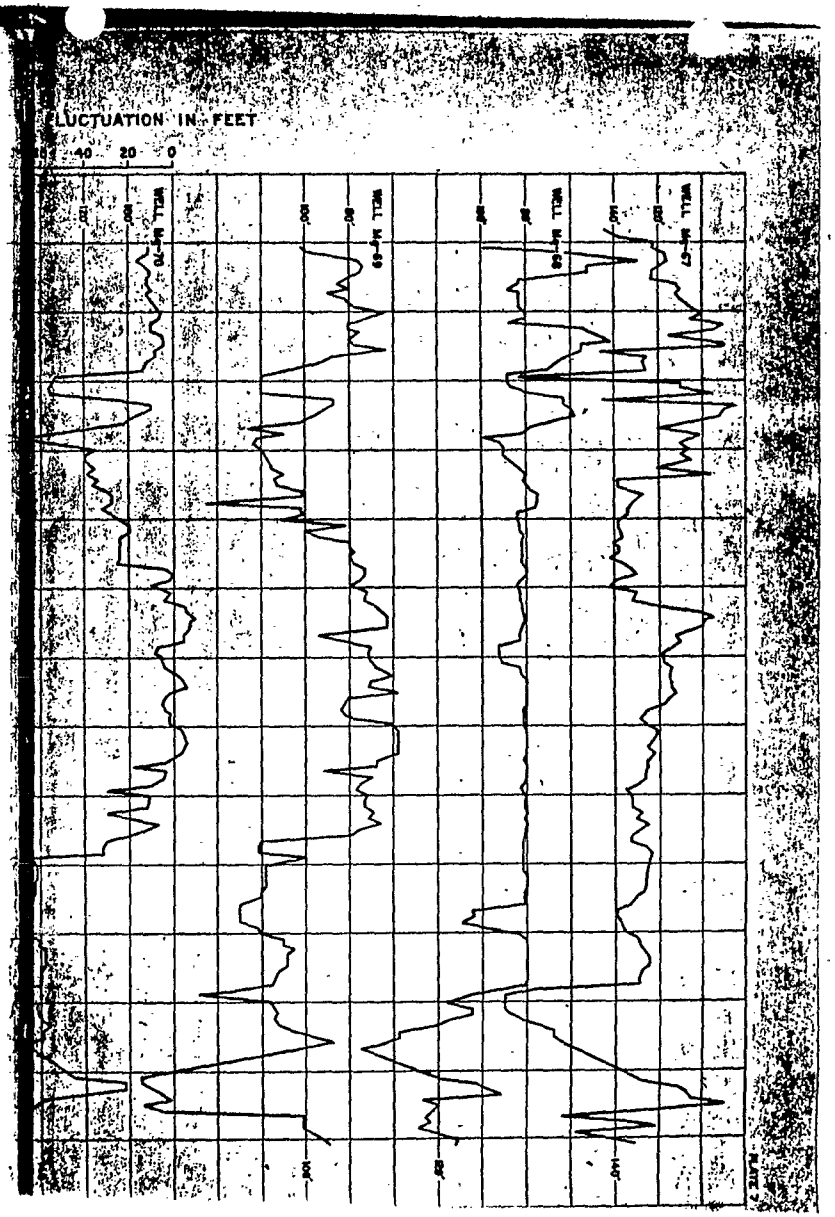
SCALE
1 ½ 0 1 MILE

CONTOUR INTERVAL 20 FEET
DATUM IS MEAN SEA LEVEL



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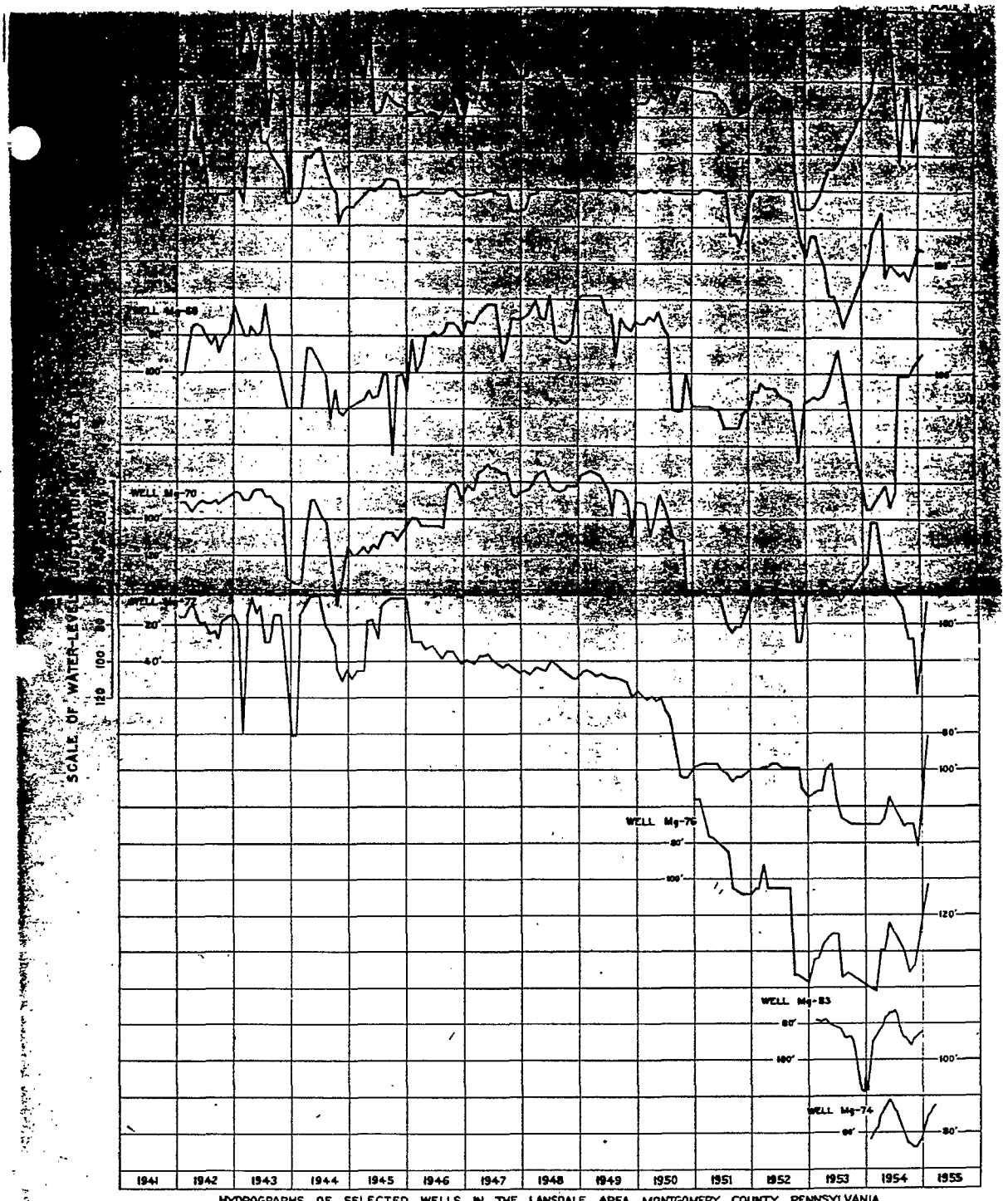

HYDROGRAPHS OF SELECTED WELLS IN THE LANSDALE AREA, MONTGOMERY COUNTY, PENNSYLVANIA

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available ground-water storage is not great the annual increment to storage from precipitation must approximate the annual withdrawal from wells if depletion is to be avoided. Prolonged drought would therefore pose a serious threat to the water supplies of the Lansdale area. The water shortage that occurred in the late summer and fall of 1953 is indicative of the conditions that might prevail.

CHEMICAL QUALITY OF THE GROUND WATER

Ground water from wells that tap the Brunswick shale in the Lansdale area has a relatively low dissolved solids content, is moderately hard, and is slightly acidic. Its iron content is negligible, and its sulfate content (which contributes to non-carbonate or permanent hardness) is not excessive. According to the standards of the U. S. Public Health Service the water is acceptable for use in public supply without treatment.

Although the silica content of the water is not high, it would give trouble if used in high-pressure steam boilers. For most other industrial uses the water would be satisfactory. Its temperature ranges from about 50° F for shallow wells (100-150 feet deep) to about 55° F for deep wells (400-500 feet deep).

Chemical analyses of representative waters from the Brunswick shale are given in the following table.

TABLE 1. Chemical analyses of ground water from the Brunswick shale in the Lansdale area.

Analyses by Geological Survey, United States Department of the Interior
(Parts per million)

	Mg-52	†Mg-62	Mg-76
DATE OF COLLECTION	9/25/25	9/28/25	2/21/52
Silica (SiO_2)	18	32	21
Iron (Fe)	.06	.05	.01
Calcium (Ca)	47	36	24
Magnesium (Mg)	17	15	20
Sodium (Na)	9.4	11	
Potassium (K)	2.1	1.8	5.1
Bicarbonate (HCO_3)	*194	*173	150
Sulfate (SO_4)	23	15	22
Chloride (Cl)	13	8.0	5
Fluoride (F)			
Nitrate (NO_3)	7.5	2.5	.4
Dissolved solids	232	201	
Total hardness as $CaCO_3$	187	152	142
Specific conductance (Kx10³ at 25°C.)			321
pH			6.4
Temperature	54°F.		55°F.

* Includes equivalent of small amount of carbonate.
† Composite sample from 3 wells (Mg-62, 63, 64).

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DEVELOPMENT OF ADDITIONAL GROUND-WATER SUPPLIES

In the development of additional ground-water supplies in the Lansdale area consideration should be given to the several factors described above. The most favorable localities for drilling new wells of high yield in the Lansdale area are near streams or springs remote from other heavily pumped wells. There are several such localities within a 5-mile radius of Lansdale. To the south and west from Lansdale the valleys of the north and south branches of Towamencin Creek offer possibilities. Another favorable locality, northeast of Lansdale, is the valley of the branch of Neshaminy Creek that parallels Line Road.

New wells should be spaced sufficiently far apart to reduce the effect of interference between wells. The proper spacing will vary from one locality to another, as it depends on the hydraulic characteristics of the formation. Wells less than 1,500 feet apart have shown appreciable mutual interference.

Heavy and prolonged pumping of individual wells in the Lansdale area results in considerable reduction of specific capacity. As water levels in a water-table aquifer are lowered appreciably, the effective thickness—and hence the transmissibility of the aquifer—are diminished, resulting in decreased yields from wells.

SUMMARY

In summary, ground water occurs in the Brunswick shale near the surface in a water table aquifer and at greater depth in artesian aquifers. The water-table aquifer comprises a system of fracture openings that are usually larger and more numerous at shallow depths than at greater depths. The artesian aquifers consist of zones of solution openings that are controlled by the local structure and stratigraphy of the formation. They may occur at any depth that is accessible to circulating ground water. The formation of solution openings requires that rocks containing soluble material be intersected by open fractures. All fractures are closed by rock pressure at depth and artesian aquifers are rarely found in the Brunswick shale below a depth of about 600 feet.

The aquifers at depth, formed by solution, are erratic in their occurrence and limited in their areal extent, and their presence can be determined only by test drilling. The best wells usually obtain their supply from both vertical fracture openings in the upper water table zone, and one or more permeable artesian zones at depth. The most favorable areas for the development of additional supplies are near streams and remote from heavily pumped wells.

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Theis, C. V. (1935), *The relation between the lowering of the piezometric surface and the rate and duration of discharge of a well using ground water storage,* Trans. Am. Geophys. Union, vol. 16, pp. 519-524.

APPENDIX

200347

200348

Records of Wells in the Lansdale Area

Numbers correspond with those on Plate 2.
Type of well: Drl, drilled.
Aquifer: Trb, Brunswick shale; Trl, Lockatong formation.

Use of water: Abd, abandoned; Dom, domestic; Ind, industrial; Obs, observation; PS, public supply; S, standby; T, Test; U, unused.

Well Number	Location Number	Owner	Driller	Altitude	Type of well	Diameter (inches)	Depth (feet)	Depth of casing (feet)	Aquifer	Water Level (feet)	Date of measurement	Yield (gpm)	Use
46	J22b-2654	North Wales Water Auth.		440	Drl	6	500		Trl			0	Abd
47	J22b-2652	North Wales Water Auth.	Marwin	389	Drl	8	129	20	Trb			45	Abd
48	J22b-2652	North Wales Water Auth.	Raun & Co.	390	Drl	8	104	20	Trb	84.0	7-1-54		Abd
49	J22b-2652	North Wales Water Auth.	Ridpath & Potter	391	Drl	8	158	45	Trb			100	S
50	J22b-2949	North Wales Water Auth.	Ridpath & Potter	355	Drl	8	148	100	Trb			80	Abd
51	J22b-2652	North Wales Water Auth.	Ridpath & Potter	400	Drl	8	800		Trl	Dry	1909		Abd
52	J22b-2948	North Wales Water Auth.	Ridpath & Potter	350	Drl	8	350	30	Trb			80	PS
53	J22b-2353	North Wales Water Auth.	Bollinger	388	Drl	8	350		Trb			30	Abd
54	J22b-2353	North Wales Water Auth.		392	Drl	8	500		Trl	Dry	1910		Abd
55	J22b-2847	North Wales Water Auth.	Bollinger	328	Drl	10-8	300	77	Trb			240	PS
56	J22b-2444	North Wales Water Auth.	Stothoff	325	Drl	14-10	384½	72	Trb	0.0	4-23-45	280	PS
57	J22b-1239	Martin Century Farms	Parente Bros.	320	Drl	8	201	30	Trb	45	6-20-45	95	Ind
58	J22b-1239	Martin Century Farms	Parente Bros.	322	Drl	8	225	30	Trb	86	6-21-46	95	Ind
59	J22b-1239	Martin Century Farms	Parente Bros.	320	Drl	8	198	30	Trb	53	6-25-46	95	Ind
60	J22b-0649	Lansdale Municipal Auth.		366	Drl	8	312	80	Trb			8	U
61	J22b-0649	Lansdale Municipal Auth.		366	Drl	8	392		Trb	78.9	8-6-54	8	U
62	J22b-0649	Lansdale Municipal Auth.		366	Drl	8	388	22	Trb	75.5	8-6-54	8	U
63	J22b-0649	Lansdale Municipal Auth.		366	Drl	8	400	120	Trb	78	3-1-43	18	U
64	J22b-0649	Lansdale Municipal Auth.		366	Drl	8	1108	18	Trb	83.2	11-4-54	8	U
65	J22b-0751	Lansdale Municipal Auth.		436	Drl	8	436	34	Trb	80.2	11-14-54		Abd
66	J22b-0751	Lansdale Municipal Auth.	Bollinger	376.2	Drl	8	378		Trb	92	3-1-47	60	S
67	J22b-0644	Lansdale Municipal Auth.	Bollinger	328.5	Drl	8	292		Trb	132	3-1-47	57	PS
68	J22b-0841	Lansdale Municipal Auth.	Bollinger	321.8	Drl	8	500		Trb	83	1-31-47	79	PS
69	J22b-0640	Lansdale Municipal Auth.	Stothoff	328	Drl	12-8	264	40	Trb	73	1-31-47	39	S
70	J22b-0755	Lansdale Municipal Auth.	Stothoff	420.9	Drl	10-8	391	36	Trb	84	1-31-47	28	S
71	J22b-0553	Lansdale Municipal Auth.	Stothoff	406.8	Drl	12-8	285	43	Trb	70	1-31-47	46	U
72	J22b-0952	Lansdale Municipal Auth.	Stothoff	352.8	Drl	16-10	306	44.5	Trb	42	3-1-47	128	PS
73	J22b-1257	Lansdale Municipal Auth.	Stothoff	371.4	Drl	14-10	325	45	Trb	46	3-1-47	197	PS
74	J22b-0563	Lansdale Municipal Auth.	Stothoff	403.1	Drl	12-10	546		Trb	48	2-24-48	50	U
75	J22b-0860	Lansdale Municipal Auth.	Stothoff	384	Drl	12-10	399.5	40.3	Trb	57	9-17-48	175	PS

Records of Wells in the Lansdale Area (continued)

Well Number	Location Number	Owner	Driller	Altitude	Type of well	Diameter (inches)	Depth (feet)	Depth of casing (feet)	Aquifer	Water Level (feet)	Date of measurement	Yield (gpm)	Use
76	J22b-1652	Lansdale Municipal Auth.	Stothoff	341	Drl	12-10	387.5	37	Trb	23	7-18-49	240	PS
77	J22b-1354	Lansdale Municipal Auth.	Stothoff	353.8	Drl	12-10	404		Trb	30	7-3-51	328	PS
78	J22b-1059	Lansdale Municipal Auth.	Stothoff	375	Drl	12-10	430.5	41	Trb	126	10-31-52	273	PS
79	J22b-0246	Lansdale Boro Electric Co.	Alexander	350	Drl	8	279		Trb	109	1-14-54	20	Ind
80	J22b-0143	Lansdale Boro Electric Co.	Bollinger	325	Drl	8	320		Trb	60	1946	80	Ind
81	J22b-0346	Lansdale Boro Electric Co.	Bollinger	340	Drl	8	350		Trb	45	1946	60	Ind
82	H22d-8145	Lansdale Boro Sewage	Bollinger	375	Drl	8	375		Trb	20	1947	18	Ind
83	J22b-0045	Lansdale Forest Products Co.	Bollinger	330	Drl	8	425		Trb	73.7	11-18-52		Obs
84	H22d-9145	Lansdale Forest Products Co.	Bollinger	330	Drl	8-6	231		Trb	63	8/47	11	Ind
85	J22b-0846	Lansdale Ice & Storage		360	Drl	8	625		Trb	65.7	11-18-52		Abd
86	J22b-0846	Lansdale Ice & Storage		355	Drl	8	300		Trb	60	11-18-52		Abd
87	J22b-0846	Lansdale Ice & Storage	Shaw	350	Drl	6	305		Trb	60	1946	35	Ind
88	J22b-0847	Lansdale Ice & Storage	Bollinger	450	Drl	10-8-6	450		Trb	60	1946	40	Ind
89	J22b-1548	Lansdale Tube Co.	Phila. Drlg. Co.	382	Drl	8	400	40	Trb	50	9-20-49	96	Ind
90	J22b-1648	Lansdale Tube Co.	Phila. Drlg. Co.	375	Drl	8	500	46	Trb	57	1-17-51	165	Ind
121	J22b-2241	E. C. Geiger		358	Drl	6	100		Trb	71.6	11-30-53	40	Abd
122	J22b-2240	Sharp & Dohme, Inc.		368	Drl	8	247		Trb	40	1947	75	S
123	J22b-2539	Sharp & Dohme, Inc.	Bollinger	362	Drl	10-6	502		Trb	33.8	5-14-51	15	Obs
124	J22b-2740	Sharp & Dohme, Inc.	Lauman	328.6	Drl	12	300		Trb			350	Ind
125	J22b-2538	Sharp & Dohme, Inc.	Lauman	357.1	Drl	12	300		Trb	64	10-28-54	140	Obs
126	J22b-2641	Sharp & Dohme, Inc.	Lauman	338.3	Drl	12	241		Trb	167	5-14-51	275	Ind
127	J22b-2137	Sharp & Dohme, Inc.	Lauman	351.0	Drl	12-10	300		Trb	52.9	11-3-53	130	Obs
128	J22b-2039	Sharp & Dohme, Inc.	Lauman	352.5	Drl	12-10	300		Trb	58.0	11-3-53	395	Obs
129	J22b-2534	Sharp & Dohme, Inc.	Lauman	358.7	Drl	12-10	269		Trb	58.6	11-3-53	30	Obs
130	J22b-2342	Sharp & Dohme, Inc.	Lauman	339	Drl	12	300	16	Trb	65.8	11-3-53	320	Ind
134	H22d-6234	Werner Foundry	Flaherty	323	Drl	6	106.5		Trb			10	Ind
135	J22b-1747	Lansdale Tube Co.	Phila. Drlg. Co.	370	Drl	12-8-6	500		Trb	85	8-17-53	200	Ind
136	J22b-0657	St Mary's Inst.		435	Dug	24	23.5	24	Trb	19.6	2-25-54		Obs
137	J22b-0848	Interstate Hosiery		365	Drl								Abd
138	J22b-0849	Interstate Hosiery		370	Drl	10-10			Trb			50	Ind

Records of Wells in the Lansdale Area (continued)

Well Number	Location Number	Owner	Driller	Altitude	Type of well	Diameter (inches)	Depth (feet)	Depth of casing (feet)	Aquifer	Water Level (feet)	Date of measurement	Yield (gpm)	Use
139	J22b-0849	Interstate Hosiery		370	Drl				Trb			70	Ind
140	J22b-1339	Martin Century	Stothoff	293	Drl	8	237	30	Trb	17.2	2-25-54		Ind
141	H22d-0657	St Mary's Inst.		435	Drl	6			Trb				Abd
142	J22b-0436	Lansdale Municipal Auth.	Stothoff	310	Drl	12	503	41	Trb	15.0	6-9-54	60	PS
143	J22b-0435	Lansdale Municipal Auth.	Stothoff	295	Drl	12	400	30	Trb	8.0	6-9-54	270	PS
144	J22b-1047	Andale Corporation		368	Drl	8	197.6	6	Trb	84.5	2-27-41	6.3	Abd
147	J22b-1649	Lansdale Tube Co.	Phila. Drlg. Co.	370	Drl	8	500		Trb	85	8-26-54	220	Ind
149	J22b-0657	St Mary's Inst		430	Drl	8	83		Trb	17	7-2-54		Obs
150	J22b-0043	J. W. Rex Co.	Bollinger	320	Drl	10	403		Trb	70	8-5-54	58	Ind
151	J22b-1749	Lansdale Tube Co.	Phila. Drlg. Co.	365	Drl	8	500	78	Trb	100	11-6-54	200	Ind
154	J22b-0248	Arcadia Hosiery	Scazetta	353	Drl	6	353		Trb	85	1934	20	Ind
155	H22d-8551	Penndale Inc.	Ridpath & Potter	367	Drl	8	600	30	Trb	79	8-24-54	41	Ind
156	H22d-8546	Perkins Glue Co.		340	Drl	6	206		Trb	30	1909	40	Ind
157	H22d-8544	F. M. Weaver & Co.	Bollinger	315	Drl	8	285	46.6	Trb	50	6/50	115	Ind
158	H22d-8544	F. M. Weaver & Co.	Bollinger	317	Drl	6			Trb	Dry	1950		Abd
159	H22d-8445	Nyce-Crete Co.		325	Drl	6			Trb				Abd
160	H22d-8445	Brook Rota Meter Co.		325	Drl				Trb			10	Abd
161	J22b-0142	Dexdale Hosiery Co.	Bollinger	340	Drl	6	201	30	Trb	125	2-22-54	21	Ind
162	J22b-0142	Dexdale Hosiery Co.	Bollinger	340	Drl	10	761	30	Trb			30	Ind
163	J22b-0142	Dexdale Hosiery Co.	Bollinger	340	Drl	8	301	30	Trb			15	Ind
164	J22b-0242	Dexdale Hosiery Co.	Bollinger	342	Drl	8	405	30	Trb			18	Ind
165	J22b-0345	K & K Laundry Co.	Wiley	335	Drl	8	400		Trb	90	1946	50	Ind
166	J22b-0345	K & K Laundry Co.		335	Drl	6	147		Trb			5	Abd
167	J22b-2349	Leeds & Northrup	Ridpath & Potter	350	Drl	4	80	6	Trb			30	U
168	J22b-2245	Leeds & Northrup	Ridpath & Potter	325	Drl	4	77		Trb			30	U
169	J22b-2145	Leeds & Northrup	Ridpath & Potter	335	Drl	4	150		Trb	80.0	9-15-54	30	Obs
170	J22b-2245	Tritzel Bakery		350	Drl	6	350		Trb			14	U
171	J22b-1748	Precision Tube Co.	Phila. Drlg. Co.	363	Drl	8	500	40	Trb	117.5	10-12-54	100	Ind
172	J22b-2848	King Foundries	Schroeder	345	Drl	6	105		Trb			95	Ind
173	J22b-2050	Kleen Products			Drl	6	90	20	Trb	Dry	10-12-54	20	Abd

Records of Wells in the Lansdale Area (continued)

Well Number	Location Number	Owner	Driller	Altitude	Type of well	Diameter (inches)	Depth (feet)	Depth of casing (feet)	Aquifer	Water Level (feet)	Date of measurement	Yield (gpm)	Use
174	J22b-2049	Kleen Products	Findly & Son	348	Drl	6	144.5	34	Trb	25	4-8-50	36	Ind
175	J22b-2150	Kleen Products		358	Drl	6	160		Trb	Dry	10-12-54		Abd
176	J22b-2151	Sam Scott	Pat Flaherty	352	Drl	8	94	12	Trb	28	1941	107	Dom
177	J22b-2251	Ellis Stump	Pat Flaherty	350	Drl	8	96	10	Trb	32	9/50	300	Dom
178	J22b-2150	North Wales Foundry		360	Drl	6	140		Trb	92.0	11-8-54	20	Ind
179	J22b-2350	Leeds & Northrup		358	Drl	6	126	60	Trb	10	1/47	100	U
180	J22b-2246	Leeds & Northrup	Ridpath & Potter	325	Dr.	6	250		Trb	65	11-2-54	100	T
181	J22b-1348	Lansdale Brick Co.		372	Drl	6	88		Trb	Dry	11/53	30	Abd
182	J22b-0364	Sanford Ulmer	Harry L. Garges	430	Drl	6	125	24	Trb	69.9	11-9-54	12	Dom
183	J22b-0365	Sanford Ulmer	Harry L. Garges	430	Drl	6	125	24	Trb	72.3	11-9-54	10	Dom
184	J22b-0262	Sanford Ulmer	Harry L. Garges	440	Drl	6	180	24	Trb	75.2	11-9-54	10	Dom
185	J22b-0548	Music Hall Theatre		355	Drl		365		Trb			165	Ind
186	H22d-7065	Link-Belt		270	Drl		300		Trb			65	Ind
187	H22d-7065	Link-Belt	Andrew J. Nicholas	270	Drl		300		Trb			85	Ind
188	H22d-6965	Link-Belt		270	Drl		300		Trb			105	Ind
189	H22d-6742	Hatfield Boro		320	Drl	14-10	200	65	Trb	13	8-16-33	150	PS
190	H22d-6638	Hatfield Boro	John T. Campbell	350	Drl	8	202	36	Trb			150	PS
191	H22d-6242	Hatfield Boro	Stothoff	345	Drl				Trb				PS
192	H22d-8336	Hendrick's Dairy	Stothoff	322	Drl	10	352	10	Trb			50	Ind
193	H22d-8336	Hendrick's Dairy		325	Drl	6	102		Trb	49	11/46	10	Dom
194	H22d-7742	Edward Hilpert		325	Drl	6	100		Trb	10	11-10-54	18	Ind
195	H22d-7642	Edward Hilpert		325	Drl	6	75	40	Trb	12	11-10-54	29	Ind
196	H22d-7642	Edward Hilpert		325	Drl		117.8		Trb	14.1	11-10-54	20	Obs
197	H22d-7428	Hatfield Packing Co		295	Drl	6	181		Trb	12-15	1946	55	Ind
198	H22d-7328	Hatfield Packing Co.	Parente Bros.	300	Drl		200		Trb			60	Ind
199	H23b-8400	L. Weiss & Son		395	Drl	8	54		Trb	15	1926	35	Ind
200	H22d-6742	Hatfield Boro		320	Drl	6	115	25	Trb			50	S
202	J22b-1751	Lansdale Municipal Auth.	Stothoff	350	Drl	12	645		Trb	54	1-19-55	282	PS
203	J22b-2443	North Wales Municipal Auth.	Kohl Bros.	315	Drl	8	450	27	Trb	12	1-17-55	210	PS

REFERENCE 12

REFERENCE 13

Guidance on Remedial Investigations Under CERCLA

Prepared for:

Hazardous Waste Engineering Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

and

Office of Emergency and Remedial Response
and
Office of Waste Programs Enforcement
Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, D.C.. 20460

200353

REFERENCE 14

Guidance on Feasibility Studies Under CERCLA

Prepared for:

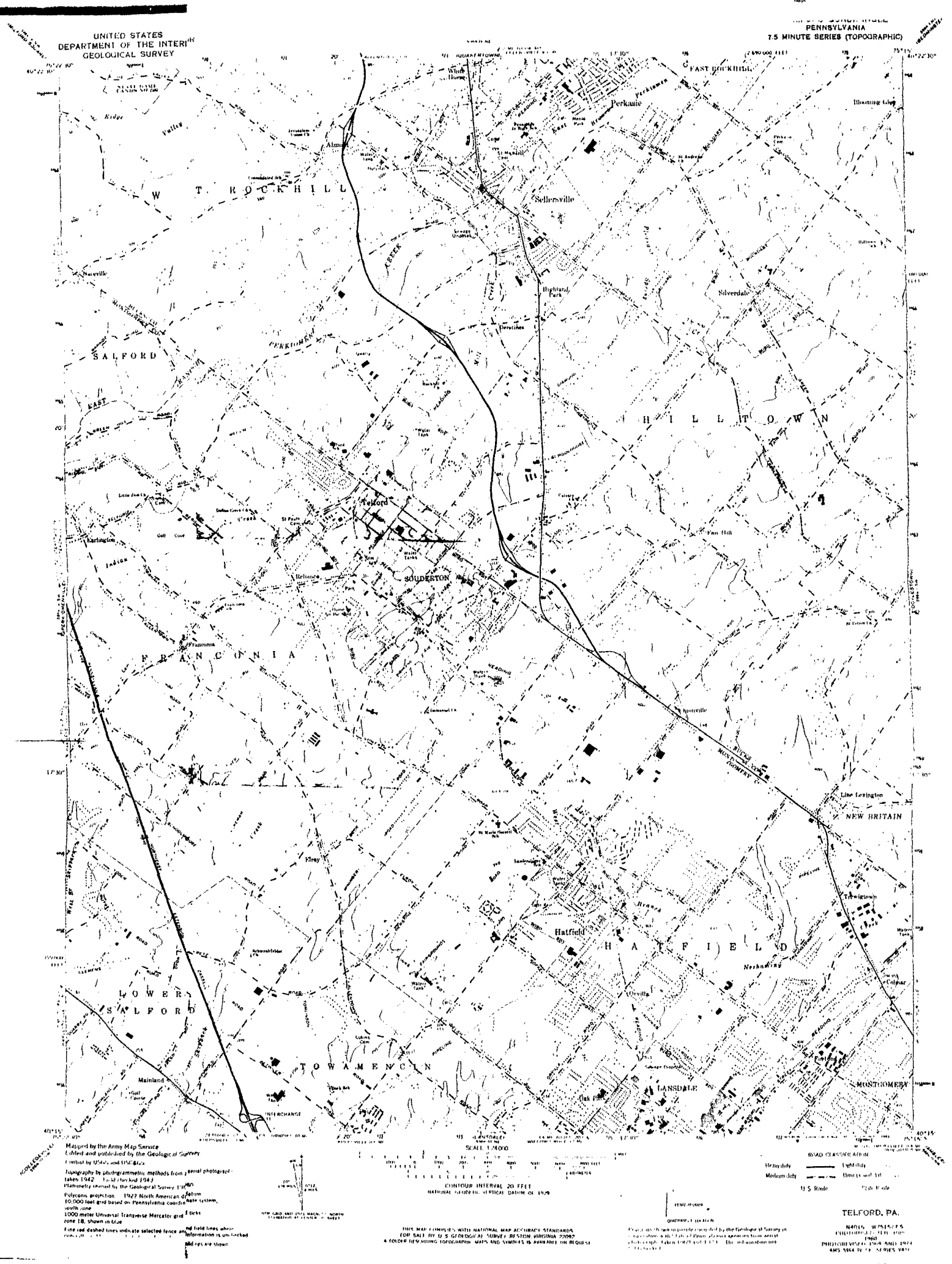
Hazardous Waste Engineering Research Laboratory
Office of Research and Development
U.S. Environmental Protection Agency
Cincinnati, Ohio 45268

and

Office of Emergency and Remedial Response
and
Office of Waste Programs Enforcement
Office of Solid Waste and Emergency Response
U.S. Environmental Protection Agency
Washington, D.C. 20460

200355

REFERENCE 15


UNITED STATES
DEPARTMENT OF THE INTERIOR
GEOLOGICAL SURVEY
PENNSYLVANIA
7.5 MINUTE SERIES (TOPOGRAPHIC)
EAST ROCKHILL
Perkasie
Sellersville
Silverdale
Telford
SOUDERTON
Hatfield
LANSDALE
MONTGOMERY
NEW BRITAIN
Mainland
INTERCHANGE
SALFORD
HILLTOWN
FRANCONIA
TOWAMENCIN
HATFIELD
SCALE 1:24000
CONTOUR INTERVAL 20 FEET
TELFORD, PA.

200357

REFERENCE 16

200358

REFERENCE 17

200359

NORTH PENN WATER AUTHORITY

200 NORTH CHESTNUT STREET
P.O. BOX 591, LANSDALE, PA 19446
TEL: 215-855-3617

DAVID R. LANDREY Chairman, Lansdale Borough
JOHN P. BARKER Vice-Chair, Franconia Township
ERNEST D. YOCUM JR. Sec., Worcester Township
MARVIN A. ANDERS Treasurer, Souderton Borough
JOSEPH B. BECKER Asst. Sec., Towamencin Township
RICHARD A. THOMAS Asst. Treas., Hatfield Township
JOHN W. CLEMENS JR. Lower Salford Township

October 7, 1986

Tim Silar
NUS Corporation
992 Old Eagle School Road
Suite 916
Wayne, PA 19087

Dear Tim:

This is to provide further information in reference to my letter to you of September 3, 1986, in which I reported results of sampling in the Souderton Area. The samples were collected by you on August 28, 1986.

All of the samples were analyzed for volatile organic chemicals in the NPWA laboratory. EPA Method 502.1 for gas chromatography was used. All EPA protocols were followed and the results of our quality control exercises were well within established guidelines. Detailed explanations of the quality control procedures used for these samples were included in our QA Plan, which I submitted with my letter of 9/3/86.

I have attached another copy of the results. Please don't hesitate to let me know if you need any further information.

Sincerely,

NORTH PENN WATER AUTHORITY

Judith A. Coyle
Water Quality Manager

encl

200360

REFERENCE 18

LAW OFFICES
JACZUN, GRABOWSKI & LEONARD
ONE SOUTH FIFTH STREET
P. O. BOX 192
PERKASIE, PENNSYLVANIA 18944

VICTOR S. JACZUN (1939-1983)
FRANCIS X. GRABOWSKI
NICHOLAS A. LEONARD
MARY C. EBERLE

TELEPHONE 257-8066
AREA CODE 215

July 7, 1986

Lorie Acker
U.S. Environmental Protection Agency,
Region III
Site Investigation and Support (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, PA 19107

RE: Gentle Cleaners, Inc./3HW23

Dear Ms. Acker:

Pursuant to your request of June 24, 1986, my client, Gentle Cleaners, Inc., of Souderton, Pennsylvania has compiled a list of the hazardous chemicals used in its operation, together with all data available in the transportation and disposal of said chemicals. The list is as follows:

1. Perchloroethylene (PCE) - PCE has been used from 1953 to the present. From 1953 to 1983, Gentle Cleaners received shipments of 75 to 100 gallons per month. In 1983, a new dry-cleaning machine was purchased and the PCE use was limited to approximately 50 gallons per month. The PCE has been sent in drums or by tank-fulls. The PCE delivered in tank trucks was held in a storage tank until it was used in the dry-cleaning machine. Any PCE left over after the dry-cleaning process was contained in filters which were removed from the machine periodically. The filters are removed by Safety Kleen Corporation, 777 Big Timber Road, Elgin, Illinois. The PCE is purchased form Ferguson Solvent Company of Philadelphia, Pennsylvania and G & L Supply, Germantown Avenue, Philadelphia, Pennsylvania.

2. American Paint, Oil and Grease Remover - A spotting chemical which contains petroleum distillates and organic solvents. Gentle Cleaners, Inc., has used 6 to 7 gallons per year since 1953. This spotting chemical comes in gallon tins similar to square paint cans.

3. Adco Spray Spotter - Spray Spotter is a pre-spotting chemical which contains 50% petroleum distillates. Gentle Cleaners, Inc., uses two 20-gallon drums per year and the chemical remains in these drums except the small amount which are used in the plastic spray bottle applicators.

I have also enclosed copies of OSHA Material Safety Data Sheets on various substances used in my clients dry-cleaning business. A copy of the lease of the Souderton store in question is attached as well. If you need any additional information, please don't hesitate to contact me.

Sincerely,

JACZUN, GRABOWSKI & LEONARD

By: Mary C. Eberle
Mary C. Eberle

MCE:dlm
Enc.

REFERENCE 19

200364

NUS CORPORATION — **TELECON NOTE**

CONTROL NO:	DATE:	TIME:
F3-8607-07	Sept. 9, 1986	4:00 PM

DISTRIBUTION:

BETWEEN:	OF:	PHONE:
Robert Risner	ADCO, Inc	(816)826-3300

AND: Timothy Silar (NUS)

DISCUSSION:

R.R. confirmed that ADCO supplies Gentle Cleaners with chemicals.

R.R. stated that PURO is used to flush other chemicals and to remove grass spots. PURO is 100% Trichloroethane (TCA)

All other trade names used by Gentle Cleaners from ADCO contain less than 5% (TCA).

Timothy Silar 9/9/86

ACTION ITEMS:

1040

NUS 067 REVISED 0681

200365

REFERENCE 20

LAW OFFICES
SOUDER, ROSENBERGER, LAPP & BRICKER
114-120 EAST BROAD STREET
P. O. BOX 739
SOUDERTON, PA. 18964

AREA CODE 215
723-4374

ELVIN R. SOUDER
RICHARD A. ROSENBERGER
JOSEPH L. LAPP
ROBERT G. BRICKER
FRANCIS X. BUSCHMAN, JR.
STANLEY R. OTT
JAMES W. MAZA *

*ALSO DISTRICT OF COLUMBIA BAR

July 17, 1986

Ms. Lorie Acker
U. S. Environmental Protection Agency, Region III
Site Investigation and Support Section (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, Pennsylvania 19107

Re: Granite Knitting Mills, Inc.

Dear Ms. Acker:

This letter is intended to serve as a response to your correspondence dated June 24, 1986 requesting certain information from Grante Knitting Mills, Inc. as part of your investigation of the contamination of the North Penn Water Authority well in Souderton.

As you are most likely aware, Granite Knitting Mills has been participating in the North Penn Concerned Business Committee and has also been discussing with the North Penn Water Authority the contamination of the well in Souderton and Granite's possible involvement as a "potentially responsible party".

The company has also initiated an internal investigation to determine whether or not Granite may have contributed to the ground water contamination even though such an internal investigation is difficult because the current principals did not own the company prior to 1976. This difficulty is further compounded by the fact that most of the persons currently in supervisory positions were not employed by Granite prior to 1978.

Accordingly, pursuant to the information requests outlined in your letter, we are able to supply you with the following information:

1. Based on available information, the company used perchlorethylene as part of a dry cleaning process at its plant. Attached hereto is a statement from Walter Clemmer who supervised this process. He is now retired and living in North Carolina and is no longer employed with the company.

2. This chemical was obtained from Sterling Chemical Company of Philadelphia and at present, we are uncertain as to when purchases began, or the amounts of said purchases. We have contacted Sterling in order to gain additional information, but they are unable to help us in this matter.

3. Based on an interview with Walter Clemmer when the perchlorethylene solution was distilled or recycled, the waste material generated was stored in 55 gallon drums prior to pick up by a local municipal road crew for spraying on the township roads. These were placed outside the company's plant prior to disposal. No other additional information is available at present regarding the removal of this substance.

4. We know of no correspondence between the company and any regulatory agency other than the EPA.

5. The North Penn Water Authority has corresponded with Granite regarding this alleged contamination and it is understood that this correspondence has been turned over to the EPA.

6. A search has been made of company records for purchase orders or other documentation regarding the purchase, storage, transportation of this material and at present, no such documentation has been located.

7. A copy of a mortgage with a description of the real estate and map is attached hereto.

Rest assured that the company is continuing its efforts to assemble the facts which will provide the requisite information as to whether or not any hazardous substance from Granite may have contaminated the West Street well. If additional material becomes available, the company will furnish the same to your agency promptly.

In return for this disclosure, we would respectfully request that your agency turn over under the Freedom of Information Act, any and all information which may be relevant to the company's investigation of this matter. Based on prior conversations with North Penn Water Authority personnel and limited knowledge of a prior EPA investigation, it is the company's belief that your agency has testing results, interviews and other documents regarding the contamination of the West Street well in Souderton. Specifically,

it is our understanding that other surrounding business establishments may have used hazardous substances and in the past which could have contaminated both the Granite property and the West Street well in Souderton.

Should you have any additional questions or information requests, please do not hesitate to contact me at once.

Sincerely,

JAMES W. MAZA

JWM/mb

Enclosures

cc: Mr. Lake S. Clemmer

Drycleaning at Granite

Purpose: To bulk the Banlon blanks and remove coning oils

Drycleaning Machine was a Permac Bowe purchased from American Permac somewhere in Long Island. XXXXXXXXXXXXXX All functions of drycleaning were contained in the single unit. Material went in dry and came out dry.

Materials used by the machine were perchlorethylene and small amounts of softening agent and detergent. I believe the perc. was purchased from Sterling in Phila. and do not remember from whom we purchased the softener and detergent (Ellie would probably remember)

Operation was all automatic and controlled with a programmer. Material to be bulked was entered and machine started. The basket started revolving and a valve opened allowing a predetermined amount of perc. from holding tank to enter the machine along with small amounts of softener and detergent. This washing action went on for abount 8 minutes. The machine then went on centrifuge action whizzing the liquid out of the garments and pumping about 10% to the still and the balance to the holding tank. The next cycle was to get the balance of the liquid out of the material which was accomplished by introducing hot air while the basket was still revolving. This evaporated the balance of the perc. not removed by whizzing. The hot perc. laden air was than passed over a cooling coil to precipitate the perc. out of the air. This too was returned to the holding tank.This completed the action as far as the material goes.

The small amount sent to the still on every cycle was to clean up the perc. by evaporation and cooling and this too was sent to the holding tank. The residue left in the still contained mostly coning oils removed from the material and the detergent. The still was cleaned out , I believe weekly, but before removal it was subjected to live steam injection to remove any XXXXXXX last traces of perc. This waste material (approx. 6 gals. per cleanout) was stored outside the building on the alley side in 6-55 gal drums until removed by either the road dept. of Towamincin Township for keeping down dust on dirt roads or,later, by some waste disposal company. It should be noted that just a trace of perc. was left in the residue. Perc. has a very strong odor, but it was not noticeable in the drums ofwaste oils. Possibly the American Permac people can give you figures on amount of perc. left in the residue.

At no time while I was in charge, was any of the residue dumped down wells orinto storm sewers.

Further people you could contact as to procedure are: Ellie, Ray Dentzel, Norm Yager, Elmer Kulp and Russ Fustermacher.

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REFERENCE 21

PENNSYLVANIA
GEOLOGICAL SURVEY

Fourth Series

BULLETIN W14

GEOLOGY AND HYDROLOGY OF THE STOCKTON FORMATION IN SOUTHEASTERN PENNSYLVANIA

A STUDY OF THE EFFECT OF LITHOLOGY UPON THE YIELD OF WELLS

by

Donald R. Rima, Harold Meisler,
and Stanley Longwill

U. S. Geological Survey

Prepared by
The United States Geological Survey
Ground Water Branch
in cooperation with
The Pennsylvania Geological Survey

DEPARTMENT OF INTERNAL AFFAIRS
GENEVIEVE BLATT, Secretary
TOPOGRAPHIC AND GEOLOGIC SURVEY
ARTHUR A. SOCOLOW, State Geologist
1962

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GEOLOGY AND HYDROLOGY OF THE STOCKTON FORMATION IN SOUTHEASTERN PENNSYLVANIA

by

Donald R. Rima, Harold Meisler,
and
Stanley M. Longwill

ABSTRACT

The Stockton formation underlies two separate, irregularly shaped elongate areas in Bucks, Chester, and Montgomery Counties in southeastern Pennsylvania. It is the oldest sedimentary formation in the Newark group of Triassic age. The formation consists of interbedded arkose, arkosic conglomerate, feldspathic sandstone, and red shale and siltstone.

During the investigation leading to this report, the Stockton formation was mapped in detail in an area extending from the Bucks County-Montgomery County line westward to Phoenixville. In this area the formation was subdivided into three members, as follows: (1) the lower arkose member, which is characterized by the abundance of coarse-grained arkosic sandstone and arkosic conglomerate; (2) the middle arkose member, which is characterized by the abundance of fine-and medium-grained arkosic sandstone; and (3) the upper shale member, which consists mostly of shale and siltstone.

Although locally the sediments become finer grained upward in the formation, sediments of different textures are interbedded irregularly. Beds commonly pinch out or grade laterally into beds of different texture and color. In the area mapped in detail, the thickness of the Stockton formation ranges from 6,000 feet near the Montgomery County-Bucks County line to 2,300 feet at Phoenixville. The beds of the formation dip homoclinally to the north and northwest at an average angle of 12°. The sediments were derived from crystalline highlands to the south and deposited as coalescing alluvial fans upon the piedmont slope at the base of the highlands.

The middle arkose member has the highest yield of the three members of the formation. It has an average specific capacity of 5.0 gpm (gallons per minute) per foot of drawdown and an average reported yield of about 130 gpm. The lower arkose member has an average specific capacity of 3.0 gpm per foot of drawdown and an average reported yield of about 110 gpm. The upper shale member, the poorest aquifer in the formation, has an average specific capacity of 0.5 gpm per foot of drawdown and an average reported yield of about 20 gpm.

Laboratory tests on 12 rock samples indicate that the medium-grained arkosic sandstone has the highest specific yield and porosity and that siltstone and very fine-grained sandstone have the lowest specific yield and porosity. The medium-grained arkosic sandstone is better sorted and consequently more porous than the coarse-grained arkosic sandstones. The siltstones and very fine-grained sandstones are the least porous because they contain much clay, which clogs the pores.

Analyses of pumping tests made at five localities indicated coefficients of transmissibility ranging from 1,000 gpd (gallons per day) per foot to 25,000 gpd per foot and coefficients of storage ranging from 1.9×10^{-3} to 5.4×10^{-4}. Few of the drawdown-time curves used in the analyses matched the type curve beyond the first few hours. Some of the curves indicated recharge boundaries, and others indicated impermeable boundaries.

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Because of the complex hydraulic characteristics of the Stockton formation, as revealed by the pumping tests, results obtained from standard pumping-test procedures cannot be used satisfactorily for predicting long-term water-level trends caused by pumping wells.

Chemical analyses are available for water from 70 wells in the formation. The waters are largely of the calcium bicarbonate type and have a median dissolved-solid content of 202 ppm (parts per million). Concentrations of dissolved-solids greater than 245 ppm are due to the introduction of waters high in sulfate, and water having a dissolved-solids content greater than approximately 400 ppm is predominantly sulfate water. The occurrence of water with a high dissolved-solids content (and its attendant high sulfate content) may be related to industrial contamination associated with urbanization.

INTRODUCTION

Purpose and Scope

Throughout the area underlain by the Triassic rocks in southeastern Pennsylvania, most municipalities and industries depend on ground water for potable water supplies. The lack of information on the occurrence of ground water in these rocks has seriously handicapped development of new supplies to meet increased demands for water. In January 1956, recognizing the urgent need for information to insure the optimum use of available supplies, the U.S. Geological Survey, in cooperation with the Pennsylvania Geological Survey, began a study of the occurrence of ground water in the Triassic rocks of southeastern Pennsylvania.

This report contains the results of an investigation of the occurrence of ground water in the Stockton formation. It is one of several reports that will be prepared concerning ground water in the Triassic rocks of southeastern Pennsylvania.

The Stockton formation underlies two separate, irregularly shaped elongate areas in Bucks, Chester, and Montgomery Counties in southeastern Pennsylvania. (See Fig. 1.) Most of the field work for this investigation was concentrated in the part of the outcrop area in Montgomery County, because it constitutes the area of greatest present and potential use of the Stockton for ground-water supplies. In the remainder of the area of outcrop, the study was more generalized — consisting chiefly of the collection of basic hydrologic data, including records of wells and data on the chemical quality of ground water. Attention is focused on (1) the influence of topography, lithology, and structure upon the occurrence of ground water, (2) the hydraulic characteristics of the formation, and (3) the chemical character of the water being withdrawn from the formation.

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Previous Investigations

One of the earliest written references to the occurrence of ground water in the Stockton formation in Southeastern Pennsylvania appeared in a report by Bascom (1904, P. 53). That report contains a brief discussion of ground-water conditions in the "Triassic belt" and a table of artesian wells in which the Stockton formation is called the "Norristown shale". The same table (with the Stockton formation identified) and an expanded discussion of ground-water conditions in the Triassic rocks was included in a report by Bascom and others (1909, p. 23).

In 1925 Hall began a reconnaissance of the occurrence of ground water in southeastern Pennsylvania. The report on that investigation (Hall, 1934) contains a brief description of the geologic and hydrologic character of each of the rock formations exposed in southeastern Pennsylvania and additional information on ground-water conditions in each county. Hall concluded that the coarse beds of the Stockton formation were generally more permeable than the rocks constituting the rest of the Triassic sequence and would, therefore, yield larger amounts of water.

A report on Middlesex County, N. J., by Barksdale and others (1943, p. 140-148) contains a description of the hydraulic character of the Triassic rocks in that area. Factors affecting yield are cited and estimates concerning the safe yield of these rocks are given.

A discussion of the hydrologic character of the Stockton formation in Bucks County, Pa., appears in a report by Greenman (1955, p. 26-30). Factors controlling the occurrence and movement of ground water are described and average values for the hydraulic properties of the rocks are given. The report also contains a description of the chemical character of water from the Stockton formation.

Reports by Parker and others (in press) and Barksdale and others (1958) describe some aspects of the hydrology of the Stockton formation, but these reports are based largely on the data contained in one or more of the reports previously cited.

Methods of this Investigation

An inventory was made of nearly all large municipal and industrial wells and about 10 percent of the rural and domestic wells tapping the Stockton formation. The well records are presented in Table 6, and the well locations are shown in Plate 1. Geologic information was

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obtained from drillers' logs of wells and drilling samples from newly drilled wells. Abandoned wells that were accessible and some newly drilled wells were explored by means of geophysical-logging techniques such as electric, gamma-ray, and temperature logging. An attempt was made to measure the flow of water through the borehole in one well under non-pumping conditions by releasing salt (NaCl) at various depths in the borehole and tracing its movement with a borehole-resistivity probe. (See Bennett and Patten, 1960)

An areal geologic map of the Stockton formation in Montgomery County and part of Chester County was prepared from observations of rock exposures and float and by projecting lithologic contacts identified in well logs to the surface—using known angles of inclination of the rock strata. (see Plate 2.) Laboratory tests for porosity, specific yield, and permeability were made of 12 rock samples that were considered to be representative of the different beds in the Stockton formation.

Pumping-test data were collected and analyzed by means of the nonequilibrium formula of Theis (1935).

Chemical analyses of ground water were made to identify the characteristic chemical and physical properties of the ground water in the Stockton area.

Well-numbering System

The well-numbering system used in this report includes an identification number and a location number. The well-identification number consists of a two-letter symbol for the name of the county followed by a serial number beginning with 1 in each county. The county symbols used in this report are Bk for Bucks County, Ch for Chester County, and Mg for Montgomery County. For example, Mg-83 identifies the 83rd well scheduled in Montgomery County.

The well-location number is composed of two parts separated by a hyphen—J22b-1205. The first part, "J22B," refers to the coordinate system used to identify the individual 7½-minute quadrangle maps. This system employs the use of the letters A through L (except I) along the west border of the State of Pennsylvania to designate from north to south each 15-minute interval of latitude. Similarly, the numbers 1 through 25 are used along the north border to designate from west to east each 15-minute interval of longitude. Each pair of coordinates designates a 15-minute quadrangle that is subdivided into four parts by using the letters a, b, c, and d to represent the northwest, northeast, southwest, and southeast quarters respectively.

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The second part of the well-location number consists of a four-digit number that identifies the northwest corner of a one-hundredth square-mile area within any 7½-minute quadrangle map. The first two figures refer to the number of tenths of a mile between the northern boundary of the 7½-minute quadrangle map and the northern boundary of the one-hundredth square-mile area containing the well site. The last two figures refer to the distance between the western boundary of the 7½-minute quadrangle map and the western boundary of the one-hundredth square-mile area containing the well site. Thus, a well having the location number J22b-1205 is situated between 1.2 and 1.3 miles south and between 0.5 and 0.6 mile east of the north and west boundaries, respectively, of the 7½ minute quadrangle designated "J22b."

Acknowledgments

The authors are indebted to the numerous organizations, industries, and individual well owners who gave access to their lands, permitted measurements to be made in their wells, and furnished helpful information on the development of water supplies. Mr. Harry Borchers, Superintendent of the North Wales Municipal Authority, permitted the authors to use a municipal well for the purpose of making special tests. Mr. Thomas Mercaldo, President, Blue Bell Water Co.; Mr. Buckingham, President, Langhorne Spring Water Co.; Mr. Barkmeyer, Chief Engineer, Norristown State Hospital; Mr. C. M. Roberts, Chief Engineer, Phoenix Iron and Steel Co.; and Mr. J. G. Tearsall, Engineer, Borough of Doylestown; allowed the use of their well fields for systematic pumping tests.

Ridpath and Potter Drilling Co., F. S. Bollinger and Sons Drilling Co., and the Philadelphia Drilling Co., provided many well logs and drilling samples and gave much other useful information about wells in the Stockton formation.

Climate

The area underlain by the Stockton formation in southeastern Pennsylvania is in a region where temperature extremes are moderate and rainfall is abundant.

The average annual precipitation for the years 1931 through 1952 is 43.23 inches at Doylestown and 46.07 inches at Phoenixville. Precipitation is fairly well distributed throughout the year, although it is greatest during the summer. In the period of 1931-52, approximately

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40 percent of the annual precipitation occurred from May through August. (Data from the U.S. Weather Bureau climatic summaries and monthly climatological data.)

The average yearly temperature at Phoenixville is 54.3°F. Mean monthly temperatures at Phoenixville range from 33.1°F in February to 76.7°F in July. Winters in southeastern Pennsylvania are comparatively mild as, on the average, less than 100 days per year have minimum temperatures below the freezing point. In the summer, temperatures above 100°F are rare. (Data from U.S. Weather Bureau climatic summaries and monthly climatological data.)

GEOLOGY

Newark Group

Sedimentary and associated igneous rocks of Triassic age occupy a series of disconnected, downfaulted basins that extend from Nova Scotia to North Carolina. These rocks are known as the Newark group. The sedimentary rocks are primarily red conglomerate, sandstone, arkose, siltstone, shale and argillite. They were deposited in a shallow-water continental environment and exhibit crossbedding, ripple marks, mud cracks, and raindrop impressions. The sedimentary rocks are interbedded with lava flows and are intruded by diabase dikes and sills.

The rocks of the Newark group have been correlated with Triassic rocks of Europe and are generally considered to be Late Triassic (McLaughlin, 1957, p. 1492-1493). Rocks of the group overlie Paleozoic rocks unconformably and were not involved in the folding near the end of the Paleozoic era. Further evidence of their age lies in the fact that Cretaceous sediments overlie the Newark group unconformably at several localities in New Jersey.

The Newark group in Pennsylvania occupies part of the largest Triassic basin in the eastern United States—a basin that extends for more than 300 miles from southeastern New York to Virginia. In Pennsylvania, the basin is 32 miles wide at the Delaware River and 14 miles wide at the Maryland boundary. Large normal faults along the northern boundary of the basin separate the Triassic sediments from the older rocks to the north. (See Fig 1.) Similar faults do not occur along the southern boundary of the basin, where Triassic sediments unconformably overlie the older Paleozoic and Precambrian rocks.

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In southeastern Pennsylvania and western New Jersey, the Triassic sediments have been divided, in ascending order, into the Stockton, Lockatong, and Brunswick formations. (See Fig. 1.) The Stockton formation consists of interbedded arkose, subarkose, arkosic conglomerate, and red shale and siltstone. It is overlain to the north by the Lockatong formation, which consists of dark-gray, black, and red shale and argillite. The Lockatong formation is overlain to the north by the Brunswick formation, which consists chiefly of soft red shale and thin beds of sandstone. In some places, particularly near the northern border of the basin, the Brunswick formation is composed of sandstone and conglomerate.

Origin of the sediments

The origin of the Triassic basin in Pennsylvania and New Jersey has been attributed variously to downfaulting, downwarping, and erosion. McLaughlin (1957, p. 1491) attributed the origin of the basin to deep erosion of the least resistant beds in the Paleozoic rocks while crystalline highlands remained to the south and an escarpment of Silurian quartzite developed to the north.

The first sediments deposited in the basin were derived from the erosion of igneous and metamorphic rocks in the highlands to the south. These sediments, which constitute the Stockton formation, were deposited as coalescing alluvial fans upon a piedmont slope from the highlands.

During the accumulation of the alluvial fans along the south side of the basin, lakes and swamps occupied the center of the basin. The Lockatong formation was deposited in these lakes and swamps.

Under the load of sediments in the basin, downfaulting along the northern border resulted in the deposition of sediments derived from the north (McLaughlin, 1945). These sediments form the Brunswick formation.

According to Krynine (1950), the climate of the Triassic was warm and humid, and the rainfall had a seasonal distribution. During heavy floods, much slightly weathered material was eroded from the canyon walls and deposited on the alluvial fans as arkosic sand. During weak floods, red soil was eroded from the gentler slopes of the interfluves and deposited on the alluvial fans. The result was an alternation of arkosic sandstone and red shale that is typical of most of the Stockton formation.

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Conglomerate and coarse arkosic sand were deposited nearest the source of the sediments. Decreases in stream gradients, farther away from the source, caused a diminishing of the transporting power of the streams and resulted in the deposition of fine material. As the regional relief was diminished, decrease in erosive activity in the highlands caused chemical decay to be more effective and the red muds that formed the thick red shales in the upper part of the Stockton formation were deposited. Red muds deposited in the reducing environment of lakes ad swamps were changed in color to gray and black; such deposits are typical of the Lockatong formation.

Stockton Formation

General features

The Stockton formation, in its type locality near Stockton, N.J., was described by Kummel (1897, p. 35-36) as interbedded coarse arkosic conglomerate; yellow, micaceous, feldspathic sandstone; quartzite conglomerate; brown-red sandstone; and soft red shale.

During this investigation, the Stockton was mapped in detail in an area extending from the Bucks County-Montgomery County line westward to Phoenixville. (See Plate 2.) This detailed mapping forms the basis for most of the geologic discussion that follows.

Lithology. The Stockton formation is composed chiefly of very fine to coarse-grained arkosic sandstone and arkosic conglomerates, interbedded red shale, and siltstone. Coarse arkosic sandstone and arkosic conglomerate are predominant in the lower beds; fine- and medium-grained arkosic sandstone is predominant in the middle beds; and red shale, siltstone, and very fine-grained arkosic sandstone are predominant in the upper beds. Locally, sediments of different texture are interbedded irregularly, and coarse-grained rocks commonly overlie fine-grained rocks. In addition, beds commonly pinch out or grade laterally into other beds of different texture and color.

The terms arkosic sandstone, arkose, and subarkose in this report follow the classification of Pettijohn (1957, p. 291) and will be used as follows: arkosic sandstone is the group name for sandstone containing feldspar and is subdivided into arkose, which contains 25 percent or more feldspar, and subarkose, which contains less than 25 percent feldspar.

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Exposures and surface expressions. The Stockton formation has few good exposures, as most of the formation is covered by soil, vegetation, and city and suburban developments. The best exposures are in the lower beds, where quarries and railroad cuts expose several excellent sections. The middle and upper beds are poorly exposed except north of Valley Forge — along the Schuylkill River and along the railroad cut west of the river.

Ridges and valleys are commonly parallel to the strike of the beds. In the southern part of the Stockton outcrop area, beds of coarse arkosic sandstone and conglomerate form conspicuous ridges. Very hard shale and argillite in the upper beds and in the overlying Lockatong formation form a prominent ridge along the northern boundary of the Stockton formation. Valleys are commonly underlain by shale. However, the complex stratigraphy of the formation and the scarcity of outcrops obscures the precise relations between topography and lithology.

Thickness. Estimates of the thickness of the Stockton formation differ widely depending upon the method used to determine the thickness. McLaughlin (1937, p. 1492) stated that the thickness calculated from the width of outcrop and average dip of the formation is nearly correct and that the repetition of beds by strike faults is insignificant. He estimated that the formation is 5,000 feet thick in the Delaware Valley. In the area mapped during this investigation, the thickness of the Stockton formation has been estimated from width of outcrop and from average dip of the strata. The formation thins westward from a thickness of more than 6,000 feet near the Montgomery County-Bucks County line to 2,300 feet at Phoenixville. Near Norristown, the formation is 4,000 feet thick. The total thickness of the formation, however, is not present in the subsurface at any one location because the upper beds do not completely cover the lower beds, and the lower beds become thinner to the north.

Stratigraphy

The Stockton formation has been subdivided into three members as follows: (1) the lower arkose member, which is characterized by the abundance of coarse-grained arkosic sandstone and arkosic conglomerate; (2) the middle arkose member, which is characterized by the abundance of fine-and medium-grained arkosic sandstone, and (3) the upper shale member, which is characterized by the predominance of shale and siltstone. Table 1 indicates the distribution of rock types within each member, as determined from sample logs and sections

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measured in the field. The three members are readily traceable from the Montgomery County-Bucks County line to Phoenixville and are shown on the geologic map. (Plate 2).

Table 1. Distribution of rock types within the Stockton formation.

Member	Percentage shale	Percentage fine-and medium-grained arkosic sandstone	Percentage coarse-grained arkosic sandstone and conglomerate
Upper shale	76	24	0
Middle arkose	42	54	4
Lower arkose	24	17	59

Lower Arkose Member

Definition. The lower arkose member of the Stockton formation consists principally of medium to coarse-, coarse-, and very coarse-grained arkosic sandstone and arkosic conglomerate of gray, reddish-brown, and pale-orange color. It contains lesser amounts of interbedded silty and sandy red shale. Fine- and medium-grained arkosic sandstone are common but less abundant than the coarser grained sediments.

Relation to underlying and overlying material. The lower arkose member unconformably overlies Precambrian and Paleozoic rocks. Throughout most of its extent the member overlies Chickies quartzite of Cambrian age and limestone of Cambrian and Ordovician age. However, in the extreme southeastern part of the area the member overlies Precambrian gneiss and gabbro.

The lower arkose member is overlain on the north by the middle arkose member. The contact between the two is transitional upward from coarse arkosic sandstone to fine-grained and medium-grained arkosic sandstone. East of Norristown, interfingering of these two textural types is common, the finer grained arkosic sandstones becoming more abundant upward in the section. West of Norristown, interfingering is less, and the transition from the lower member to the middle member is characterized by a gradual decrease in grain size.

Thickness. The lower arkose member reaches a maximum thickness of 2,700 feet immediately east of Ambler and constitutes 50 percent of the formation. Thinning eastward, the member is 1,500 feet thick near the Bucks County line and constitutes 20 percent of the formation.

DEL.

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It thins westward from Ambler so that at Phoenixville it is 550 feet thick and makes up 23 percent of the formation. The member appears to take the form of an alluvial fan with the apex southeast of Ambler.

Area east of Ambler. East of Ambler, the member consists mainly of coarse-grained arkosic sandstone and lesser amounts of interbedded fine- and medium-grained arkosic sandstone and red shale. Fine- and medium-grained arkosic sandstone beds are especially numerous in the upper part. (See Plate 3, cross sections C-C' and D-D'.) The coarse arkosic sandstone beds in the upper part of the member pinch out eastward or grade laterally eastward into fine- and medium-grained arkosic sandstone. Conglomerate, which is abundant south of Ambler, diminishes rapidly in quantity eastward from Ambler.

Sample logs from five wells (Mg-285, Mg-465, Mg-499, Mg-500, and Mg-532) in this area are given in Table 7.

Area from Ambler to Norristown. South and north of Ambler, the lower arkose member is essentially coarse- and very coarse-grained arkosic sandstone that contains considerable conglomerate. A few miles west of Ambler, the coarse arkosic sandstone in the upper part pinches out, the conglomerate becomes much less abundant, and the member contains a large proportion of fine- and medium-grained arkosic sandstone. Farther west, near Norristown, the member consists chiefly of coarse- and very coarse-grained arkosic sandstone.

Shale lenses are numerous in some parts of the area, as shown by the following geologic section.

Geologic section of the lower arkose member north of Main Street in Norristown

Top of exposure	Thickness (feet)
Shale, red	2
Arkose, coarse- to very coarse-grained	3
Shale, red	4
Arkose, medium-grained	3
Shale, red	2
Arkose, coarse-grained	6
Shale, red	5
Arkose, medium-grained	2
Shale, red	1
Arkose, coarse-grained	1
Shale, red	1

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Geologic section of the lower arkose member north of Main Street in Norristown—continued

	Thickness (feet)
Arkose, medium-grained	4
Shale red	5
Arkose, coarse- to very coarse-grained	2
Shale, red	7
Arkose, medium- to coarse-grained	3
Arkose, coarse-to very coarse-grained	9
Shale, red	8
Arkose, coarse- to very coarse-grained	7
Shale, red	3
Fault	....
Arkose, medium- to coarse-grained	6
Shale, red	10
Arkose, coarse-grained	4
Shale, red	6
Arkose, coarse- to very coarse-grained	4
Bottom of exposure	

A forty-foot section of the upper part of the member is exposed in a quarry east of Norristown: the section consists of pale orange and brownish gray coarse- to very coarse-grained arkose and arkosic conglomerate that contains minor amounts of medium- to coarse-grained arkose and a few thin clay lenses.

Sample logs from two wells in this area (Mg-290 and Mg-533) are given in Table 7.

Area from Norristown to Phoenixville. The lower arkose member, in the area from Norristown to Phoenixville, consists chiefly of coarse-and very coarse-grained arkosic sandstone and some conglomerate. Shale and beds of fine- and medium-grained arkosic sandstone are present but are not as abundant as in areas to the east. Differently textured arkoses interfinger near the top, but the transition from the lower arkose member to the overlying member is sharper here than in areas to the east. (See Plate 3, cross section A-A'.) South of Port Indian (2 miles west of Norristown), faulting has displaced the contact by a half a mile. (See Plate 3.)

Bedrock is well exposed in several places in this area. The bedrock is described in the following stratigraphic sections.

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arkose member north
'own—continued

	Thickness (feet)
.....	4
.....	5
.....	2
.....	7
.....	3
.....	9
.....	8
.....	7
.....	3
.....	....
.....	6
.....	10
.....	4
.....	6
.....	4

:rt of the member is exposed
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:-grained arkose and arkosic
of medium- to coarse-grained

area (Mg-290 and Mg-533)

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:ndstone and some conglom-
:m-grained arkosic sandstone
areas to the east. Differently
but the transition from the
mber is sharper here than in
ction A-A'.) South of Port
:lting has displaced the con-

aces in this area. The bed-
raphic sections.

Geologic section of the lower arkose member in Philadelphia and Western Railroad cut west of Bridgeport (1 mile southwest of Norristown)

	Thickness (feet)
Top of exposure	
Arkose, pale-orange to red, coarse- and very coarse-grained, conglomeratic in places	56
Shale, red	14
Arkose, pale-orange to red, coarse- and very coarse-grained, conglomeratic in places	10
Bottom of exposure	

Geologic section along the west side of the Schuylkill River north of Valley Forge

	Thickness (feet)
Middle arkose member:	
Sandstone, arkosic, red, fine-grained	Unknown
Arkose, pale reddish-brown, coarse-grained	30
Arkose, pale reddish-brown, fine-grained	22
Sandstone, arkosic, red, fine-grained	6
Sandstone, arkosic, red, very fine-grained	8
Arkose, red and reddish-brown, medium-grained	65
Arkose, pale reddish-brown, coarse-grained	2
Sandstone, arkosic, red, fine-grained	13
Arkose, pale reddish-brown, coarse-grained	2
Sandstone, arkosic, red, fine-grained	4
Lower arkose member:	
Arkose, pale reddish-brown, medium- to coarse-grained	2
Arkose, pale reddish-brown, coarse-grained	4
Arkose, pale reddish-brown, medium-grained	2
Arkose, red and pale-brown, coarse-grained	108
Arkose, gray, coarse-grained	120
Arkose, gray, medium-grained	7
Shale, red; coarse-grained arkose	12
Arkose, gray, coarse-grained	5
Sandstone, arkosic, greenish-gray, fine-grained	5
Arkose, gray, coarse-grained	15

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Geologic section along the west side of the Schuylkill River north of Valley Forge—continued

Lower arkose member—continued:	Thickness (feet)
Arkose, gray, coarse- to very coarse-grained	18
Arkose, gray, coarse-grained	13
Arkose, gray, medium- to coarse-grained	10
Arkose, pale reddish-brown, coarse- to very coarse-grained	65
Arkose, red and pale-brown, coarse-grained	40
Arkose, coarse-grained	20
Shale, red, and covered interval	52
Arkose, gray, coarse- to very coarse-grained, conglomeratic	45

Middle Arkose Member

Definition. The middle arkose member consists chiefly of beds of fine- and medium-grained arkosic sandstone and interbedded red shale. The arkosic sandstone is usually pale brown to pale red, gray, and pale orange. In many places, shale is more abundant than arkosic sandstone. A few thick masses of coarse-grained arkosic sandstone of small lateral extent grade into medium-grained arkosic sandstone. Thick beds of shale and siltstone are especially abundant in the upper part of the member.

Thickness. The middle arkose member attains its maximum thickness of 4,200 feet near the Bucks County line, where it constitutes 70 per cent of the Stockton formation. It thins westward to 1,500 feet at Wissahickon Creek, where it makes up 35 percent of the formation. It thickens westward from Wissahickon Creek and attains a thickness of 2,500 feet near Washington Square (2 miles northeast of Norristown), where it constitutes 50 per cent of the formation. Westward from Washington Square, the member thins (as does the entire Stockton formation), but it forms a progressively greater part of the formation. At Phoenixville it is 1,700 feet thick and constitutes about 75 percent of the formation.

Area east of the Wissahickon Creek. In the area east of Wissahickon Creek, the stratigraphy of the middle member is complex. Shale is abundant, particularly in the upper part, and in places is predominant over fine- and medium-grained arkosic sandstone. Interfingering of coarse- and medium-grained arkosic beds in the lower part of the member is common. Thick beds of coarse-grained arkosic sandstone are

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—continued

	Thickness (feet)
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	45

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present also in the middle of the member. (See Plate 2.) Table 7 contains sample logs of wells Mg-216, 219, 275, 276, 489, and 490 in this area.

Area from Wissahickon Creek to Jeffersonville. The stratigraphy of the middle arkose member is less complex in the area from Wissahickon Creek west to Jeffersonville (1 mile northwest of Norristown) than it is east of Wissahickon Creek. Fine- and medium-grained arkosic sandstone is predominant through most of the area. Shale occurs as lenses and thin beds throughout the member, and coarse-grained arkosic sandstone occurs chiefly in the lower part of the unit. (See Plate 3, section B-B'.)

Sample logs from two wells in this area, Mg-230 and 270, (see Plate 1.) are given in Table 7.

Area from Jeffersonville to Phoenixville. In the area from Jeffersonville to Phoenixville, the stratigraphy of the midde arkose member is very similar to that of the area to the east, the member consisting of fine- and medium-grained arkosic sandstone, red shale, very fine red sandstone, and few beds of coarse-grained arkose. (See Plate 3, section A-A'.)

Geologic sections were measured at several extensive outcrops in this area. The geologic section along the Schuylkill River, north of Valley Forge, which contains both the middle and lower members, has been described in the discussion of the lower arkose member. The following geologic sections show the character of the middle arkose member in the area from Jeffersonville to Phoenixville.

Geologic section of middle arkose member in the Reading Railroad cut north of Perkiomen Junction (1 mile north of Valley Forge)

	Thickness (feet)
Top of exposure	
Arkose, pale-orange, fine-grained	25
Shale, red, and covered interval	120
Arkose, reddish-brown, fine-grained	5
Shale, red	25
Arkose, red and reddish-gray, fine-grained	16
Sandstone, arkosic, dark-gray, fine-grained	5
Arkose, reddish-brown, fine-grained	6
Sandstone, arkosic, red, very fine- to fine-grained	11
Arkose, grayish-orange, fine-grained	10
Arkose, pale-orange, medium-grained	13
Arkose, pale-orange and light-gray, medium- to coarse-grained	2

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Geologic section of middle arkose member in the Reading Railroad cut north of Perkiomen Junction (1 mile north of Valley Forge)—continued

Arkose, gray, fine-grained	10
Sandstone, arkosic, red, fine-grained	1
Sandstone, arkosic, red and blackish-red, very fine-grained	10
Arkose, brownish-gray, fine-grained	16
Sandstone, arkosic, red, very fine to fine-grained	7
Sandstone, arkosic, red, very fine-grained	38
Arkose, pale-orange, fine- to medium-grained	15
Bottom of exposure	

Geologic section in Phoenixville, along the west side of Schuylkill River, north of French Creek

	Thickness (feet)
Lockatong formation:	
Shale and argillite, gray and black	300
Covered interval	75
Stockton formation:	
Upper shale member:	
Argillite, red and gray	10
Shale, reddish-gray, fissile	1
Argillite, reddish-gray	2
Shale, grayish-red, fissile	3
Argillite, red	9
Shale, red and black, fissile	3
Middle arkose member:	
Arkose, orange, very fine- to fine-grained	6
Arkose, orange, fine-grained	5
Arkose, orange, very fine-grained	35

Geologic section in the Pennsylvania Railroad cut, north of French Creek, in Phoenixville

	Thickness (feet)
Upper shale member:	
Shale, red	40
Sandstone, arkosic, red, very fine-grained	16
Siltstone, red	12
Middle arkose member:	
Arkose, orange, very fine- to fine-grained	23
Arkose, orange, very fine- to fine-grained	13

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the Reading Railroad cut Valley Forge)—continued

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west side of Schuylkill Creek

	Thickness (feet)
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.....	5
.....	35

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	Thickness (feet)
.....	40
.....	16
.....	12
.....	23
d	13

Geologic section in the Pennsylvania Railroad cut, north of French Creek, in Phoenixville—continued

Arkose, orange, fine-grained	10
Shale, red	35
Arkose, gray, fine-grained, and covered interval	75
Shale, red	40
Arkose, orange, fine-grained	40
Shale, red, fissile	22
Sandstone, arkosic, red, very fine-grained	67
Arkose, orange, fine- to medium-grained	27

Relation to overlying material. The middle arkose member is overlain by the upper shale member. In general the contact between the two members is not sharp, and is defined as the horizon above which shale is predominant.

Upper Shale Member

Definition. The upper shale member of the Stockton formation consists chiefly of red shale, siltstone, and very fine-grained arkosic sandstone. Beds of fine-grained arkosic sandstone are present throughout the member, but they are most abundant in the lower part. In the upper part, much of the shale is hard and is considered to be argillite. Although most of the shale and argillite are red, a few beds of gray shale and argillite are present.

Thickness. The upper shale member is 1,000 feet thick (20 percent of the formation) near Prospectville. From Prospectville (3½ miles northwest of Horsham) it thins eastward to 600 feet (10 percent of the formation) at the Bucks County line and thins westward to 60 feet (3 percent of the formation) at Phoenixville.

Area east of Springhouse. From Springhouse (2 miles north of Ambler) east to the Bucks County line, the upper shale member contains few beds of arkosic sandstone. (See Plate 3, section C-C' and D-D'.)

Area from Springhouse to Perkiomen Creek. From Springhouse west to Perkiomen Creek (3½ miles east of Phoenixville) beds of fine- and medium-grained arkosic sandstone are abundant only near Franklinville and Gwynedd Valley (2½ miles northwest of Ambler). (See Plate 3, section B-B). Well Mg-300 at Gwynedd Valley penetrated in the Lockatong formation, 60 feet of shale, and in the Stockton formation, 360 feet of shale, 115 feet of arkosic sandstone, 10 feet of siltstone, and 5 feet of limestone. (See Table 7 for complete log of this well.)

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Area from Perkiomen Creek to Phoenixville. In the area from Perkiomen Creek west to Phoenixville, the upper shale member contains abundant fine-grained arkosic sandstone, and it is difficult to separate this member from the underlying middle arkose member. (See Plate 3, section A-A'.)

Relation to overlying material. The upper shale member is overlain on the north by the Lockatong formation, which consists of gray fissile shale and black and red argillite. The red argillite in the upper part of the upper shale member is similar to the red argillite of the Lockatong formation. Interbedded arkosic sandstone in the Stockton formation distinguishes this formation from the Lockatong formation. Where the upper shale member does not appear to contain arkosic beds, the base of the lowermost black argillite bed is considered to be the contact between the two formations.

The authors consider the upper shale member to be a transition zone between typical Stockton sediments and typical Lockatong sediments.

Petrography

Some sandstones of the Stockton formation contain as much as 50 percent feldspar. Although in field examination some sandstones appear to contain no feldspar, microscopic examination of thin sections of 12 samples (10 sandstone, 2 shale) taken at various stratigraphic levels show that feldspar constitutes 23 percent or more of each sandstone sample.

The mineral composition of the 12 thin sections is given in Table 2. The feldspar content of the 10 sandstone samples ranged from 23 to 44 percent, but much of the feldspar has weathered to sericite and clay. Untwinned plagioclase was present, and, consequently, it was difficult to evaluate plagioclase-potash feldspar proportions. Twinned plagioclase (albite and oligoclase) constitute 2.6 percent of the 10 sandstone thin sections. Mica constituted approximately 2 percent of the 10 sandstone samples, and opaque iron oxide minerals, commonly hematite and limonite, constituted approximately 2.5 percent of the samples. Small quantities of heavy minerals—particularly zircon, tourmaline, and apatite—were noted in all sandstone thin sections. Large quartz grains were present in the coarse-grained arkose.

Thin sections of shale revealed approximately half hematite-stained clay and half silt-sized particles of quartz and feldspar. It was not possible to determine the proportions of quartz and feldspar.

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Sample Number	Rock type	Stratigraphic position	Grain size	Characteristic color	Composition (percent of sample)					Location of sample
					Quartz	Feldspar	Iron minerals	Mica	Heavy minerals	
1	Arkose	Middle arkose member	Fine	Pale yellowish brown to orange	66	30	3	1	Trace	Quarry between Norristown and Jeffersonville
2	Shale	Middle arkose member	.....	Grayish red	Half-silt - half clay			4	.....	do
3	Sub-Arkose	Lower arkose member	Medium to coarse	Pale yellowish brown	75	23	1	1	Trace	East of Fort Washington
4	Arkose	Lower arkose member	Coarse to very coarse	Pale orange	64	34	1	1	Trace	Susquehanna Road, Ambler
5	Arkose	Lower arkose member	Fine	Pale red to pale brown	51	44	3	2	Trace	do
6	Arkose	Middle arkose member	Fine	Light olive gray	57	39	1	3	Trace	Johnson Highway east of Norristown
7	Argillite	Upper shale member	.....	Grayish red	Half silt - half clay			2	.....	Bethlehem Pike, north of Springhouse
8	Arkose	Middle arkose member	Fine	Pale orange	63	32	3	2	Trace	Norristown Road, southeast of Springhouse
9	Arkose	Middle arkose member	Fine	Pale red to Pale brown	52	33	11	2	Trace	Easton Road, west of Horsham
10	Arkose	Middle arkose member	Medium	Light gray	70	29	1	Trace	Trace	do
11	Arkose	Middle arkose member	Medium	Pale orange	67	32	Trace	1	Trace	Norristown Road, southeast of Springhouse
12	Arkose	Middle arkose member	Very fine	Grayish red to light brownish gray	65	31e	3	1	Trace	Pennsylvania RR cut, north side Schuylkill River, east of Port Indian

Six thin sections of sandstone from the lower beds of the Stockton formation near Valley Forge were studied by R. C. Gerhard (1952). The feldspar content of these thin sections range from zero in quartzose sandstone to 32 percent in arkose. The average composition of the six samples is given below:

Quartz	Feldspar	Rock fragments	Accessory minerals	Matrix	Cement
58%	18%	4%	5%	11%	4%

According to Gerhard (1952), the feldspar minerals, in order of decreasing abundance, were orthoclase, microcline, albite, oligoclase, perthite, and microperthite. The rock fragments were schist and gneiss. The thin sections contained muscovite, biotite, chlorite, sericite, kaolinite-illite, chlorite-sericite paste, authigenic quartz, calcite and accessory heavy minerals. Matrixes were of three distinct types, as follows: (1) hematite and kaolinite-illite; (2) chlorite, sericite, and pulverized quartz grains; and (3) finely disseminate sericite. The cementing materials were authigenic quartz, authigenic feldspar and carbonates (chiefly calcite).

Results of the study of 52 thin sections of samples from near the base of the Stockton formation were supplied by J. D. Glaeser (1958). The thin sections were made from samples taken from the area east of Norristown. Glaeser identified end products of feldspar alteration, and, consequently, his study showed that the thin sections had a low feldspar content and a high sericite content. The feldspar content ranged from zero to 25.2 percent; the sericite content ranged from 1.0 to 50.6 percent; and the feldspar plus sericite content ranged from 9.5 to 50.6 percent. The average percentages of the various minerals in the 52 thin sections was as follows:

Quartz	Feldspar plus sericite	Muscovite	Biotite	Iron minerals	Chert	Rock fragments
68.0	25.2	2.7	0.5	1.1	1.8	.4

Grain sizes in the Stockton formation range from clay particles to cobbles 3 to 4 inches across. Most pebbles and cobbles are composed of quartzite, but feldspar is common. One cobble of chlorite schist was noted.

The arkosic sandstones of the Stockton formation are generally well sorted, but the conglomeratic sandstones are poorly sorted. The sand grains are generally angular to subangular. The quartzite pebbles are generally well rounded, but the feldspar pebbles are angular. The shales of the formation contain abundant silt, and in many places they are probably siltstones, but near the base of the formation the shale is very sandy. The siltstones grade locally into very fine-grained red

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by R. C. Gerhard (1952).
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The average composition of

·· minerals	Matrix	Cement
5%	11%	4%

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sandstones. The coarse clastic sediments range in degree of induration from weakly cemented sand to hard, well-cemented arkosic sandstone. The arkosic sandstone is commonly cross-bedded, but graded bedding has been observed in a few exposures of fine-grained arkosic sandstone.

In the Stockton formation, shale occurs predominantly in thick beds showing no fissility. Beds of fissile shale occur, but they are subordinate. In the upper part of the formation, much of the shale is extremely hard and may be considered to be an argillite.

Sediments of the Stockton formation occur in a variety of colors and hues. Gray, orange, red, brown, and shades and combinations of these are most common. The coarse-grained arkosic sandstones are most commonly light gray and pale orange but may be pale brown and reddish brown. The predominant colors of the medium-grained arkosic sandstones are pale orange, pale brown, and pale reddish brown; gray sandstone is present, but it is not as prominent as it is in the coarse-grained arkosic sandstone. The fine-grained arkosic sandstone is predominantly pale brown to pale red, and pale orange. The very fine-grained arkosic sandstone is usually pale red to pale brown, grayish red, and (less commonly) pale orange. Shale and siltstone is almost invariably red or grayish red, but there are a few reddish-gray and dark-gray beds of shale.

Red coloration is due to hematite staining, but much of the orange coloration is caused by orange-pink feldspar. Gray arkosic sandstone, on the other hand, contains white partly decomposed feldspar.

Structure

Beds in the Stockton formation dip to the northwest in Bucks County and eastern Montgomery County and to the north in western Montgomery County and in Chester County. South and west of Phoenixville, the beds are tilted to the northeast. Dips of the beds range from 5° to 25° in southeastern Pennsylvania and from 5° to 18° in the area mapped in detail for this report. (See Plate 2.) The average dip, as computed from 73 measurements, is 12 , and 50 percent of the dips measured are between 10 and 14°.

Faults are common in the Stockton formation. A major fault forms the southern boundary of the northern belt in Bucks County. (See Fig. 1.) Small normal faults, having displacements of a few feet, are visible at many outcrops.

North of King of Prussia, the basal contact of the Stockton formation is displaced repeatedly by an intricate series of faults. (See Plate 2.) The general trends of these faults are northeast-southwest and

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east-west: the upthrown sides are to the northwest and north respectively. Offsets of individual faults are as much as 0.5 mile. The total offset of the series is 1 mile.

West of Valley Forge and south of Phoenixville, along each of several north-south and northeast-southwest trending faults the basal contact is offset from less than 0.05 to about 0.15 mile. (See Plate 2.) In all but one of these faults, the upthrown side is to the west, which displaces the contact northward on the west side of the faults.

Northwest of Oaks a northeast-trending fault has caused an offset of 0.25 mile in the contact between the Stockton and Lockatong formations. (See Plate 2.)

The extent of major faulting is difficult to evaluate because of the scarcity of outcrops and the complex lateral facies changes within the formation. However, continuity of the upper and lower contacts of the Stockton formation through most of the mapped area indicates that major faulting has not taken place except as described above.

Vertical joints are common in outcrops of the Stockton formation. The most frequently occurring set trends perpendicular to the strike of the bedding. Two other sets occur frequently: one is parallel or nearly parallel to the strike of the bedding, and the other trends northwestward at an angle of approximately 50° to the strike.

Diabase dikes intrude the Stockton in several places. Two dikes are present in the northern belt in Bucks County, and, in the eastern part of the area mapped for this report, one prominent dike extends from Camp Hill northeastward to near Warrington. (See Plate 2.) At the base of the formation, this dike is 90 feet thick, strikes N30 E. and dips 80° NW. Several dikes are present in Chester County, west of the area mapped for this report.

HYDROLOGY

The zone in which all the interconnected openings or voids in the rocks of the earth's crust are filled with water under pressure greater than atmospheric is called the zone of saturation. Precipitation is the source of ground water in southeastern Pennsylvania. Although most of the water that reaches the land surface from the atmosphere either runs off as overland flow or is returned to the atmosphere by evaporation and transpiration, some infiltrates downward through the soil to the zone of saturation, where it becomes recharge to the main ground-water body. Upon reaching the zone of saturation, it begins to move downward and laterally toward lower elevations, and eventually it may return to the surface either naturally (through seeps and springs) or

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artificially (through wells). Under natural conditions and over long periods of time, the amount of water that leaves the zone of saturation as discharge is balanced by the amount of water that enters it as recharge.

Ground water may be roughly divided into two classes: (1) that which occurs in the shallow formations, mostly under nonartesian conditions and (2) that which occurs in the deeper formations under artesian conditions. Nonartesian conditions are those in which ground water is unconfined, so that its upper surface (the water table) is free to rise and fall. Artesian conditions are those in which the ground water is confined in a permeable formation that is overlain by a relatively impermeable formation, so that the upper surface of the confined water is not free to rise and fall, and the water is under sufficient pressure to rise above the top of the formation that contains it where that formation is penetrated by wells. The imaginary surface to which water will rise in tightly cased wells tapping the artesian aquifer is called the piezometric surface.

In humid areas, such as southeastern Pennsylvania, the water table stands at or near the land surface in valleys and rises toward adjacent topographic highs, reaching a maximum height in the vicinity of surface-drainage divides. The slope of the water table is generally less than that of the land surface; hence, the depth to the water table below the land surface is usually greatest beneath topographic highs and least beneath topographic lows.

The water table does not remain in a fixed position but fluctuates in response to additions to and withdrawals from the zone of saturation. As the seasonal variation in precipitation in southeastern Pennsylvania is small, the dominant factor controlling the fluctuation of the water table in areas remote from pumped wells is the seasonal variation in the rate of evaporation and transpiration. Thus, the water table generally declines throughout the warm growing season (April to October) and rises throughout the remainder of the year.

Within the zone of saturation, the rocks of the earth's crust differ greatly in their capacity to store and transmit ground water. Rocks that are capable of yielding usable quantities of ground water to wells are called aquifers. An aquifer may consist of all or part of a geologic formation or group of formations.

Most ground water, like water in other phases of the hydrologic cycle, is continually in motion. It flows by gravity from intake or recharge areas, where hydraulic potentials are high, through permeable zones or aquifers to points of discharge, where hydraulic potentials are low.

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Occurrence of Ground Water in the Stockton Formation

Effect of lithology

Few wells drilled into the Stockton formation penetrate only one type of rock. The sequence of rocks penetrated consists generally of alternating beds of fine- and coarse-textured materials. Furthermore, the relative proportions of fine- and coarse-textured rocks change within rather uniform limits throughout the formation. For example, in the lower part of the formation, wells usually pass through more arkosic sandstone and conglomerate than shale and siltstone; whereas, in the upper part of the formation, the reverse is true. These features, together with the lateral changes in the lithology of the rocks, are responsible for much of the variation in well yields from place to place.

The Stockton formation has been subdivided into three members, as shown on the geologic map (Plate 2.) The relative capacities of these three members to yield ground water is indicated in Table 3, which contains a summary of the yields and specific capacities of wells more than 100 feet deep. The specific capacity of a well is the yield in gallons per minute per foot of drawdown and is generally a useful measure of the capacity of the rocks to yield water to wells.

Table 3.—*Average specific capacities and average reported yields of wells more than 100 feet deep in the Stockton formation*

Member	Average specific capacity (gpm/ft drawdown)	No. of wells	Average reported yield (gpm)	No. of wells
Upper	0.4	2	19	17
Middle	4.8	28	131	90
Lower	3.1	6	106	23

The highest yields and specific capacities reported are for wells tapping the middle arkose member. This member is characterized by alternating beds of arkosic sandstone and shale of nearly equal thickness and a lack or scarcity of conglomerate. The arkosic sandstones are fairly well sorted and weakly cemented, which probably accounts for the high yield of wells tapping this member.

Next in order of water-yielding capacity is the lower arkose member of the Stockton formation. The lower member consists chiefly of coarse-grained arkosic sandstone and conglomerate. The conglomerate and coarse-grained arkosic sandstones, which make up about 60 percent of the member, are, for the most part, poorly sorted and weakly cemented.

The lowest yields and specific capacities have been reported for wells tapping the upper shale member. The upper shale member con-

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R IN THE STOCKTON FORMATION

lithology

on formation penetrate only one type rated consists generally of alternat- materials. Furthermore, the relative red rocks change within rather uni- n. For example, in the lower part s through more arkosic sandstone stone: whereas, in the upper part s. These features, together with of the rocks, are responsible for from place to place.

n subdivided into three members. e 2.) The relative capacities of ater is indicated in Table 3, which d specific capacities of wells more city of a well is the yield in gallons d is generally a useful measure of ter to wells.

s and average reported yields of in the Stockton formation

No. of wells	Average reported yield (gpm)	No. of wells
2	19	17
28	131	90
6	156	23

capacities reported are for wells This member is characterized by and shale of nearly equal thick- nerate. The arkosic sandstones mented, which probably accounts s member.

capacity is the lower arkose mem- lower member consists chiefly of conglomerate. The conglomerate s, which make up about 60 per- part, poorly sorted and weakly

capacities have been reported for The upper shale member contains very few beds of arkosic sandstone; hence, most of the wells tapping this member obtain water chiefly from fractures in beds of shale and siltstone. The few thin beds of arkosic sandstone in the upper shale member of the Stockton formation are among the most permeable zones in the formations, and wells that penetrate even one of them will yield considerably more water than those that do not.

The arkosic sandstones and conglomerates contain both primary and secondary openings through which ground water can circulate. Primary openings are most abundant in beds of well-sorted, loosely cemented materials and least abundant in materials that are well cemented or poorly sorted. Although the addition of cementing material tends to reduce the number of intergranular openings, it makes the rock hard and brittle and, thus, contributes to the development of secondary openings by fracturing and jointing. Most of the beds of arkosic sandstone and conglomerate in the Stockton formation are neither well sorted nor firmly cemented, and, as a result, their permeability is due to a combination of primary and secondary openings. The fine- and medium-grained arkosic sandstones are better sorted than coarse arkosic sandstone and arkosic conglomerate and, therefore, yield more water to wells.

In general the shales and siltstones are too fine grained to contain primary or intergranular openings of sufficient size to permit easy circulation of ground water. Hence, these rocks are relatively impermeable except where they are broken by joints and fractures. As a rule, these secondary openings are most abundant where the shales and siltstones are hard and brittle, but the volume of such openings, even in the brittle materials, constitutes only a small fraction of the total volume of the rock. Consequently, the shales and siltstones probably have a small capability to store and transmit ground water.

Effect of structure

Because of the simple homoclinal dip of the rocks, the stratigraphic interval within economic reach of wells changes continuously along any traverse that crosses the outcrop area of the formation. The maximum change occurs perpendicular to the strike of the formation and is proportional to the inclination of the bedding. For example, at an average dip of 11½° the rate of increase in depth of a given bed is approximately 1 foot for each 5 feet of horizontal distance. This means that an exposed bed is 1,000 feet deep 5,000 feet downdip from the exposure. Obviously, then, wells drilled to a depth of 500 feet and spaced 2,500 feet apart along the dip of the formation will penetrate two entirely different sequences of beds. As a result, their yields will be correspondingly different.

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The hydrologic character of the Stockton formation is complicated further by lateral changes in lithology. These changes are fairly abrupt because the rocks were deposited on alluvial fans. For the most part, the coarse-textured rocks, which constitute the best water-bearing zones, were deposited in stream channels that radiated in a series of stringlike appendages from the apex of each fan. The intervening areas were filled contemporaneously with significantly finer grained materials. Thus, the character of the formation changes erratically along the strike from the coarse materials deposited in stream channels to the fine-textured materials deposited in the interfluves.

Such chaotic structure results in an intricate intermingling of pervious and impervious materials. For this reason, the depth at which water-bearing zones will be penetrated by a well and the quantity of water that will be obtained is uncertain. This is true even where several wells have been drilled in the same vicinity.

Significance of topography

The topography developed upon the Stockton formation provides clues to the lithology and structure of the underlying rocks, and much valuable information concerning the occurrence of ground water can be obtained from a careful examination of topographic features. Elongated ridges and valleys that parallel or nearly parallel the strike of the Stockton formation mark the exposure of alternating beds of coarse- and fine-textured sediments, respectively. The height and width of the ridges are indicative of the lithology and thickness of the ridge-forming sediments. In general, the highest ridges are underlain by the coarsest sediments, and their width indicates the thickness of the coarse-grained sediments. Broad ridges are diagnostic of a thick sequence of arkosic sandstones and conglomerates, whereas narrow ridges imply thin beds of arkosic sandstone or conglomerate interbedded with thick beds of shale and siltstone.

The fact that ridges develop where beds of arkosic sandstone and conglomerate are exposed should not be taken as an indication that wells on the ridges will have higher yields than those in the adjacent valleys. The reverse is more often true, owing to the inclination of the rocks. Although the ridge-forming sediments are generally the most permeable, they do not necessarily extend to any great depth beneath the ridge. This is illustrated in Figure 2, which shows two wells drilled to the same depth. Well A is on a ridge and penetrates the permeable bed at relatively shallow depths. Moreover, a considerable part of the permeable bed lies above the water table and is not completely saturated. Well B, which is in a valley downdip from well A, pene-

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trates the full thickness of the permeable bed in a position well below the water table. Consequently, well A is not benefited by the full capability of the bed to store and transmit ground water. On the other hand, well B is more favorably situated because it penetrates the full saturated thickness of the water-bearing bed.

Although this example is over simplified, it clearly indicates the advantage of drilling wells in valleys rather than on ridges where the permeable beds crop out.

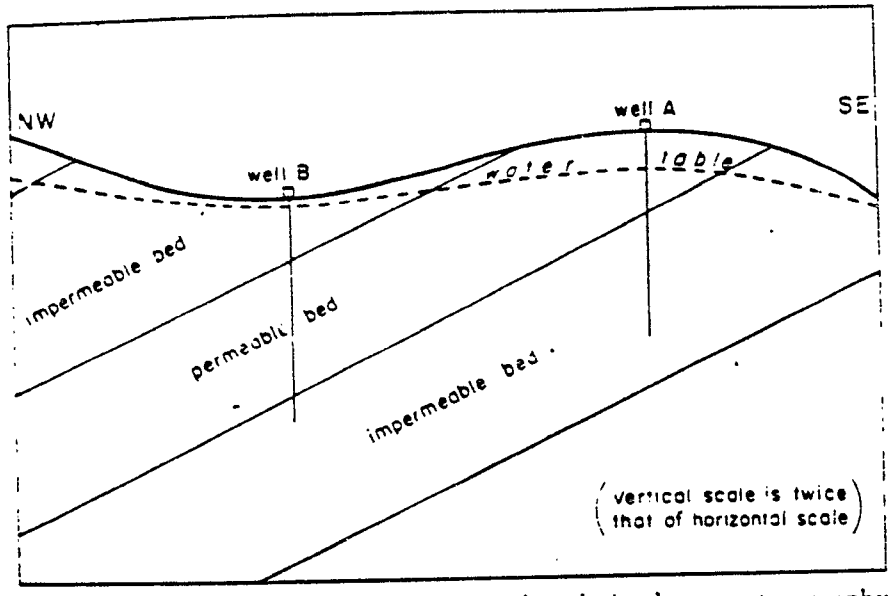

Figure 2. Diagrammatic section showing the relation between topography and the occurrence of permiable and impermiable beds.

Hydraulic Properties of the Stockton Formation

Principles and definitions

Various terms are used by hydrologists to describe the properties of an aquifer. The terms used in this report are the terms defined in the following paragraphs, so that the succeeding discussion can be more easily understood.

Porosity is the ratio of the volume of interstices in a rock to its total volume and is usually expressed as a percentage. As thus defined, porosity includes both primary openings (such as intergranular pore space) formed contemporaneously with the rock and secondary openings (such as joints) formed by processes that modified the rock after it was formed.

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The specific yield of a rock is defined as the amount of water the rock will yield to gravitational forces and is expressed as a percentage of the total volume of the rock.

The capacity of an aquifer to transmit water under pressure is known as permeability. The coefficient of permeability, P, is usually expressed as the number of gallons of water per day that will pass through 1 square foot of water-bearing material under a unit hydraulic gradient at a water temperature of 60°F. At the prevailing temperature of the water, the value is called the field coefficient of permability.

The coefficient of transmissibility of an aquifer is defined as the quantity of water, in gallons per day, that will flow through a vertical section of the aquifer 1 foot wide and extending the full height of the aquifer under a unit hydraulic gradient at the prevailing temperature of the water.

The coefficient of storage of an aquifer is the volume of water it releases from or takes into storage per unit surface area of the aquifer per unit change in the component of head normal to that surface. Under water-table conditions, the water released from storage is obtained by dewatering a part of the aquifer. However, under artesian conditions, water is released from storage by compression of the aquifer skeleton in response to a decrease in head in the aquifer. Thus, the coefficient of storage of an artesian aquifer is considerably smaller than that of a water-table aquifer. The former generally ranges from 0.00001 to 0.001 and the latter from 0.05 to 0.30. The coefficients of transmissibility and storage can be calculated from the results of systematic pumping tests.

Results of laboratory tests on rock samples

Laboratory tests for porosity, specific yield, and permeability were made on 12 rock samples from the Stockton formation. The coefficient of permeability was determined both perpendicular to and parallel to the plane of bedding. The results are given in Table 4.

Figure 3 shows the averages of the laboratory determinations for porosity and specific yield of each grain size plotted as a function of mean size of the samples. Although the two graphs are similar in form, the numerical values for porosity are consistently higher than those for specific yield. This demonstrates that, although the relationship between the porosity and specific yield of the samples is close, not all of the pore space yields water under gravitational force.

As shown by graphs in Figure 3, both porosity and specific yield increase as the grain size decreases through the range of rock textures

Table 4. Laboratory determination of hydraulic properties of rock

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nsmit water under pressure is t of permeability. P is usually f water per day that will pass material under a unit hydraulic At the prevailing temperature coefficient of permeability.

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on rock samples

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Table 4. *Laboratory determination of hydraulic properties of rock samples from the Stockton formation*

Sample no	Location no	Description	Porosity (n) (percent)	Specific yield (percent)	Coefficient of permeability (K) in gpd/ft² Horizontal	Vertical
57PA1	J23a 7423	Conglomerate, very coarse-grained	17.3	11.0	0.009	0.007
57PA2	J23a-7423	Arkose, very coarse-grained	10.9	6.2	.01	.007
57PA3	J23a-7423	do.	19.4	12.8	.01	.009
57PA4	J23a 5724	Arkose, medium-grained	30.6	19.1	.3	.2
57PA5	J23a 5724	Arkose, fine grained	14.4	9.5	.03	.003
57PA6	J23a-5724	Arkose, coarse-grained	19.2	16.2	.03	.04
57PA7	J23a-1801	Conglomerate, very coarse-grained,arkosic	7.1	3.1	.003	.004
57PA8	J23a 4113	Sandstone, arkosic, very fine-grained, brick-red	10.5	0	1/ .4	
57PA9	J23a-3823	Siltstone, sandy grayish-red	9.7	0	.0022	.003
57PA10	J22b-5160	Arkose, medium-grained, buff	25.6	19.3	.02	.01
57PA11	J22b-5061	Arkose, medium grained, tan	16.1	4.0	.001	.001
57PA12	J22b 5061	Arkose, coarse-grained, tan	7.9	1.0	2/ ...	.0003

1/ Sample 57PA8 could not be cored without fracturing Permeability is probably high. Porosity was determined on "undisturbed" chunk

2/ Could not obtain two cores from sample 57PA12.

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from conglomerate to medium-grained sandstone. This is attributed to the fact that the sediments constituting the Stockton formation become better sorted as the grain size decreases. However, the porosity and specific yield decrease as the grain size decreases below the range of medium-grained sandstone. The decrease in porosity and specific yield of the finer grained sediments is attributed to the clogging of pore spaces by clay.

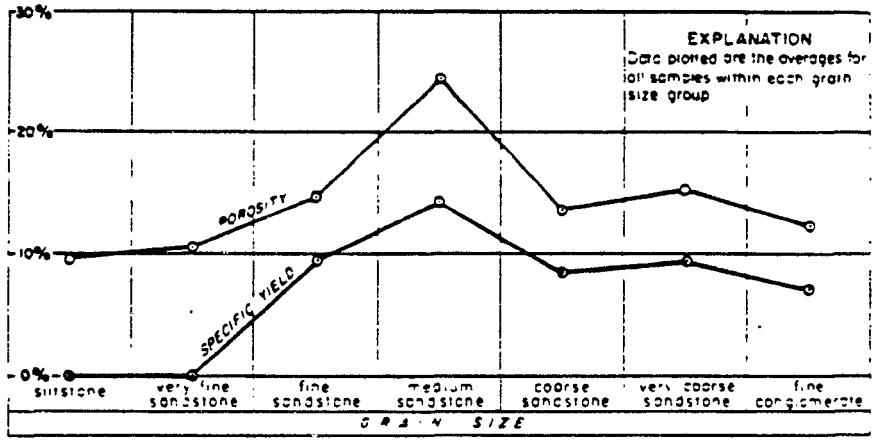

Figure 3. Graph showing the relation of porosity and specific yield to grain size of rock samples from the Stockton formation.

Pumping tests

When a well is pumped, water levels in the area are lowered, and a cone of depression is formed in the piezometric surface or the water table. As pumping proceeds, the cone continues to deepen and broaden until one of the following conditions is realized: (1) recharge to the aquifer is increased in an amount equal to the pumping rate, (2) natural discharge from the aquifer is decreased in an amount equal to the pumping rate, or (3) the sum of the increased recharge and decreased natural discharge is equal to the pumping rate.

Line A-E on Figure 4 is a theoretical plot of drawdown against time in a well pumping from a homogeneous isotropic aquifer of infinite areal extent and uniform thickness. Other assumptions made in constructing the theoretical curve are: (1) the discharge well has an infinitesimal diameter and completely penetrates the aquifer, (2) no recharge occurs, (3) the water taken from storage in the aquifer is discharged instantaneously with the decline in head, and (4) the coefficient of transmissibility is constant at all places and all times. A plot of recovery against time would coincide with a plot of drawdown

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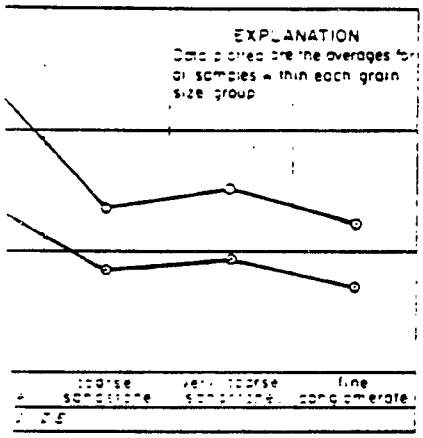

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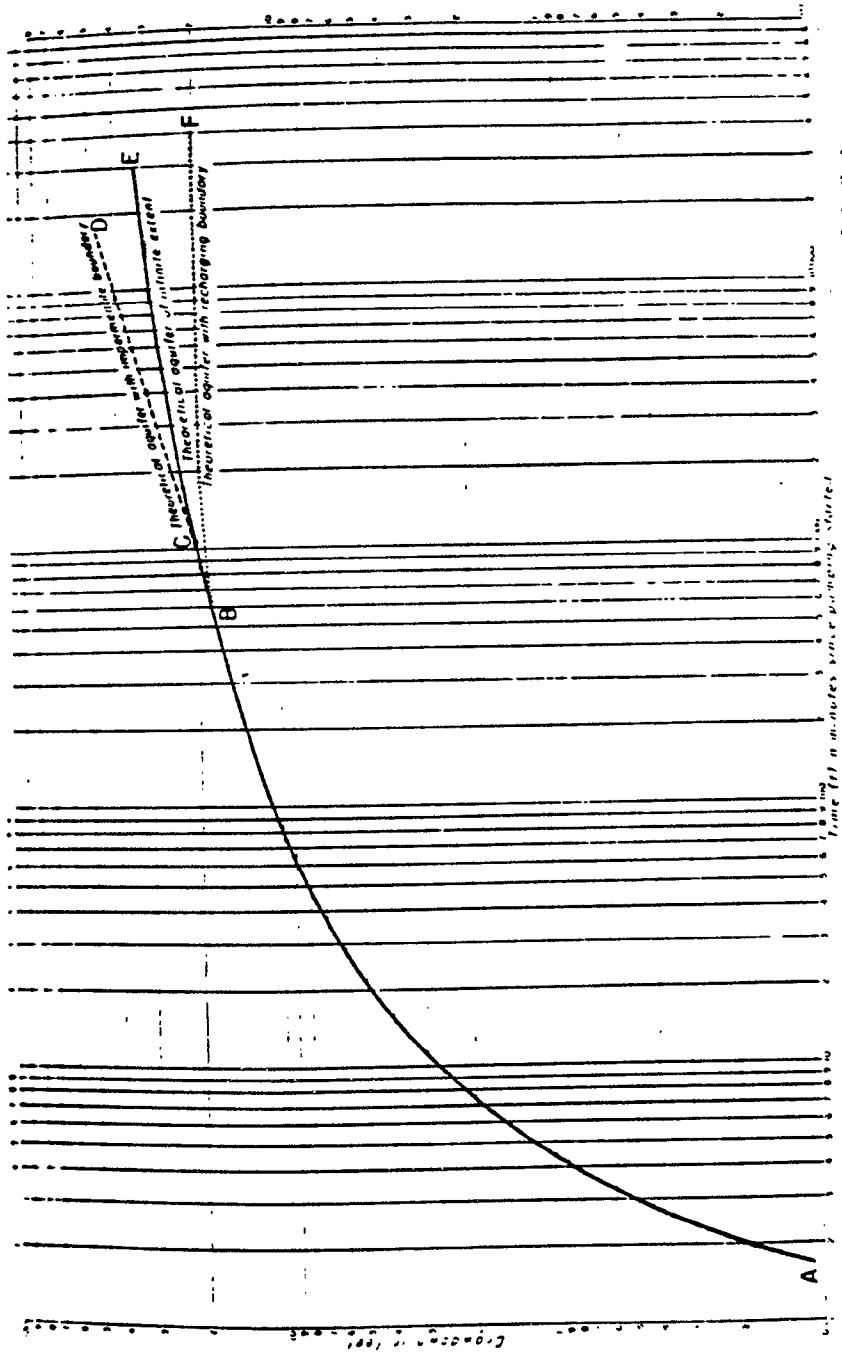

Figure 4. Logarithmic graph of drawdown in a theoretical aquifer of infinite extent showing the effects of an impermeable boundary and a recharging boundary.

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against time. Any deviation from the above assumptions will cause a plotted curve to differ from the theoretical curve. For example, line A-B-F on Figure 4 is a drawdown curve whose slope decreases abruptly from that of the theoretical curve at point B, indicating that expansion of the cone of depression has induced recharge to the aquifer from some outside source. Line A-C-D on Figure 6 is a drawdown curve whose slope increases abruptly from that of the theoretical curve at point C, indicating that the cone of depression has expanded to an impermeable boundary — that is, a boundary formed by a formation that yields less water than the major aquifer. An impermeable-boundary condition may appear, for example, when the cone of depression reaches the end of the aquifer and lateral expansion of the cone is stopped or retarded. An impermeable-boundary condition also may indicate a marked decrease in the permeability of the aquifer caused by a change in the lithology of the aquifer at some distance from the well.

Systematic pumping tests were made at the following five locations, to determine the hydraulic properties of the Stockton formation: Phoenixville, Norristown, Blue Bell, Doylestown, and Langhorne. The locations of pumping-test sites are shown on Figure 5. Results of the tests are given in Table 5.

Two pumping tests were made in Phoenixville. In September 1957, well Ch-152 was pumped for 72 hours at an average rate of 60 gpm, and water levels were observed in wells Ch-151,152, and 153. In October 1957, well Ch-152 was pumped for 72 hours at an average rate of 115 gpm, and water levels were again observed in wells Ch-151, 152, and 153.

Analysis of data from the observations wells indicated coefficients of transmissibility ranging from 13,000 to 18,000 gpd (gallons per day) per foot, and a coefficient of storage ranging from 2×10^{-4} to 2×10^{-5}. Figure 6 shows the recovery in well Ch-151, during the October 1957 tests, plotted against time. The data yield a curve that follows the theoretical curve for the first 40 minutes and then shows the effect of an impermeable boundary that became effective 40 minutes after the pumping stopped. Plots of data from wells Ch-152 and 153 also show the effects of impermeable boundaries.

Two pumping tests were made at the Norristown State Hospital near Norristown. In August 1956, pumping was stopped for 23.5 hours in well Mg-20, which is pumped continuously at an average rate of 118 gpm. The resulting recovery of water level was observed in well Mg-21. Analysis of the data from Mg-21 indicated a transmissibility coefficient of 23,000 gpd per foot, and a storage coefficient

Table 5. Summary of pumping tests made in the Stockton formation

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Table 5. *Summary of pumping tests made in the Stockton formation*

Area	Observation Well	Date	Pumping rate (gpm)	Duration of pumping (hrs.)	Transmissibility T (gpd/ft)	Storage Coefficient S
Phoenixville	Ch-151	Sept. 1957	60	72	15,000	2×10^{-4}
	Ch-151	Oct. 1957	115	72	21,000	2×10^{-4}
	1/ Ch-152	Sept. 1957	60	72	13,000	.....
	1/ Ch-152	Oct. 1957	115	72	17,000	.....
	Ch-153	Sept. 1957	60	72	17,000	2×10^{-5}
	Ch-153	Oct. 1957	115	72	14,000	2×10^{-5}
Norristown	Mg-17	Nov. 1957	110	71	23,000	7×10^{-4}
	Mg-21	Aug. 1956	118	2/ 235	23,000	14×10^{-4}
	Mg-21	Nov. 1957	110	71	24,000	12×10^{-4}
Blue Bell	Mg-270	Sept. 1957	23	64	1,000	.....
Doylestown	Bk-278	Nov. 1958	100	44.5	8,000	2×10^{-4}
	Bk-281	Nov. 1958	100	44.5	16,000	1×10^{-4}
	Bk-282	Nov. 1958	100	44.5	14,000	2×10^{-4}
Langhorne	Bk-723	June 1957	50	69	23,000	5×10^{-4}

1/ Pumped well
2/ Duration of recovery

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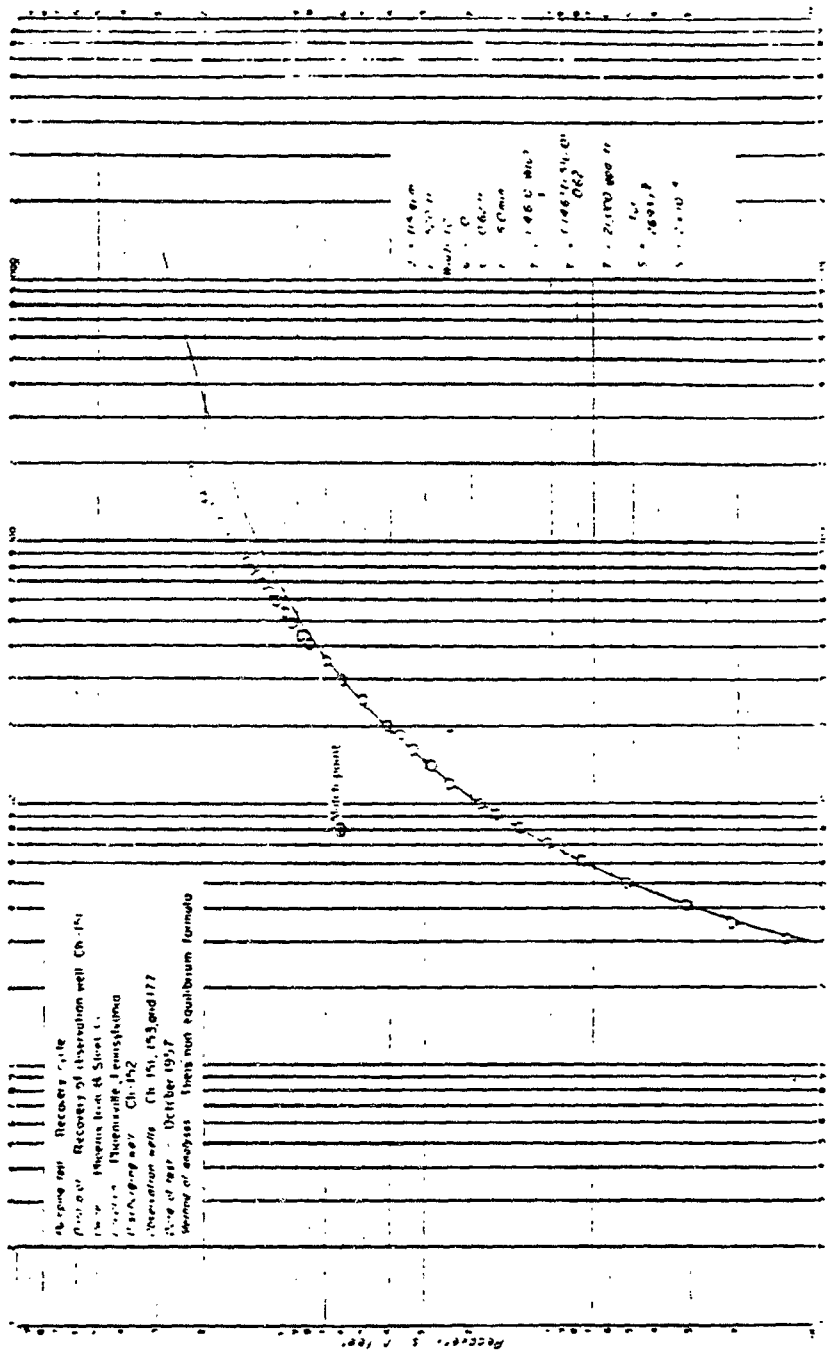

Figure 6. Logarithmic graph of recovery in well Ch-151.

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of 14×10^{-4}. Plots of recovery and drawdown show the effects of an impermeable boundary. In November 1957, well Mg-22 was pumped for 71 hours at 110 gpm, and water-level measurements were made in wells Mg-17, 18, 19, and 21. Results from wells Mg-18 and 19, however, were not considered to be reliable. Data from wells Mg-17 and 21 gave transmissibility coefficients of 23,000 and 24,000 gpd per foot and storage coefficients of 7×10^{-4} and 12×10^{-4}. Figure 7 shows the drawdown in well Mg-17 plotted against time. The effects of an impermeable boundary appeared in Mg-17 approximately 270 minutes after pumping started.

In September 1957, well Mg-270, at Blue Bell, was pumped for 64 hours at 23 gpm. Analysis of the data indicated a transmissibility coefficient of 1,000 gpd per foot.

Well Bk-277, at Doylestown, was pumped for 44.5 hours in November 1958 at 100 gpm, and wells Bk-278, 281, and 282 were used for observation. Analysis of the data indicated transmissibility coefficients ranging from 8,000 to 16,000 gpd per foot and storage coefficients ranging from 1×10^{-4} to 2×10^{-4}. Most of the plots of drawdown and recovery against time showed the effects of an impermeable boundary.

Well Bk-722, north of Langhorne, was pumped for 69 hours in June 1957 at an average rate of 50 gpm, and water-level observations were made in well Bk-723. Analysis of the data indicated a transmissibility coefficient of 23,000 gpd per foot and a storage coefficient of 5×10^{-4}.

A pumping test was made at well Ch-177 in November 1959 to determine coefficients of transmissibility and storage of each aquifer penetrated by the well. (See Bennett and Patten, manuscript in review.)

Electric logs indicate that two sandstone aquifers are penetrated by the well: one occupies the interval between depths of 68 and 124 feet, and the other occupies the interval between depths of 152 and 184 feet.

Internal flow in the well under nonpumping conditions was determined by introducing a slug of salt into the well and then tracing the movement of the salt slug by the use of a fluid-resistivity probe. Internal flow was calculated to be 8 gpm upward, indicating that the lower aquifer had the higher head under nonpumping conditions and that the upper aquifer acted as a thieving zone.

When pumping of the well commenced, the water level was drawn down quickly from a static level of 5.82 feet below the top of the casing to 13.90 feet below the top of the casing. This lower level was maintained throughout the remainder of the test. Discharge of

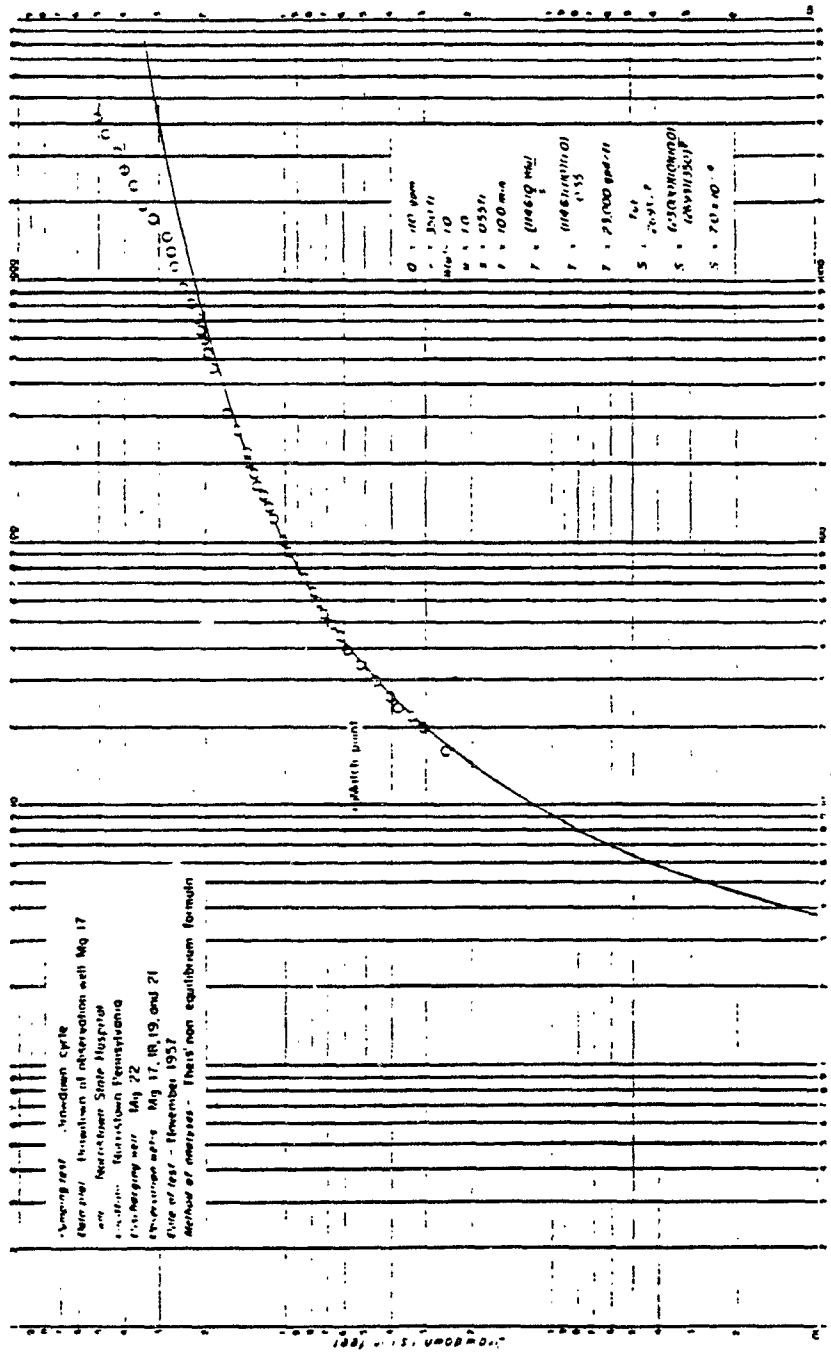


Figure 7. Logarithmic graph of drawdown in well Mg-17.

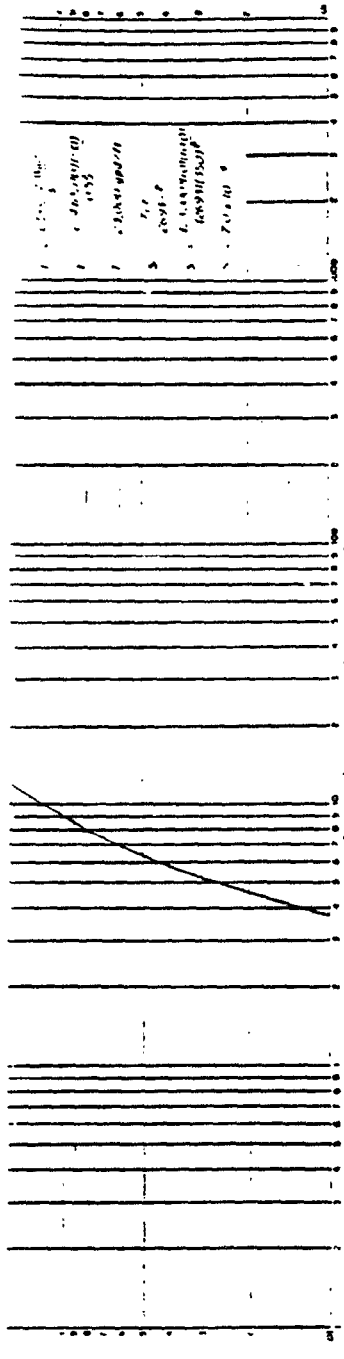


Figure 7. Logarithmic graph of drawdown in well M_{18}-17.

the lower aquifer during pumping was measured by using an Au flowmeter suspended in the well. The transmissibility and storage coefficients and the original hydrostatic head of each aquifer were calculated to be as follows:

Aquifer	Transmissibility coefficient (gpd per foot)	Storage coefficient	Static head (In feet below top of casing)
Upper	10.900	1.37×10^{-4}	8.0
Lower	1.955	0.367	1.8

Bennett and Patten (manuscript in review) noted that the calculated storage coefficient of the lower aquifer was too high and that the difference in transmissibility between the two aquifers was too great. They cite the following sources of error: (1) erroneous flowmeter measurements, (2) well-entrance losses, and (3) incorrect measurement of original internal flow. Nevertheless, they believe that the calculated transmissibilities and aquifer heads are of some value because they have approximate order- of- magnitude significance.

Bennett and Patten (1960) described a method for determining the discharge-drawdown characteristics of each aquifer penetrated by a multiaquifer well. The method makes use of conventional well-logging techniques combined with measurements of flow velocity in the borehole.

Information derived from such tests such as yields, specific capacities, hydrostatic heads, and the location of thieving zones, can be of great importance in the construction and operation of the well or in the development of a well field. For example, such tests can provide data to determine whether or not a thieving zone should be sealed off in a well. In many cases, thieving zones can become producing zones when the head in the well is decreased below that of the thieving zone.

Discussion of pumping-test results. The results of the pumping tests in predicting the amount and rate of declines in water levels caused by pumping from wells leave much to be desired. None of the plots of test data matches the type curve for more than a few hours during the initial period of the test. During the remainder of the test periods, the data plot above or below the type curve, indicating departures from the ideal conditions assumed in analyzing the tests by the Theis nonequilibrium method (Theis, 1935).

The tests prove that the Stockton formation does not respond to pumping as an ideal aquifer would. Two reasons for this are that the formation is not isotropic, and it is not infinite in areal extent. It contains an alternating sequence of materials of grossly different hydraulic properties that are intermingled in such a way as to defy simple

definition by means of coefficients. Even those individual beds that appear to have a uniform permeability throughout their extent do not conform to the ideal-aquifer concept, owing to their lenticular shape and differences in thickness from place to place.

The unreliability of determinations of the coefficients of storage and transmissibility by conventional methods suggests that the hydraulic character of the Stockton formation is too complex to be defined adequately by these coefficients. Among procedures that might yield more satisfactory results are electrical model studies, wherein the hydraulic character of the aquifer is duplicated by electrical circuitry. Before this approach could be used, however, detailed studies would be necessary to establish the parameters of the hydraulic system as it is in nature. Owing to the heterogeneity of the Stockton formation, such an investigation would be extremely difficult, time consuming, and costly. Hence, this approach would not be warranted except in those circumstances where accurate predictions of the effects of pumping are needed to protect a large investment.

QUALITY OF WATER

Dissolved-solids content in ground water is the result of the leaching of soluble material from the atmosphere, soil and rocks through which the water moves. Factors that control the chemical quality of ground water are: the composition of soil and bedrock, climate, temperature, pressure, length of time the water has been in contact with soil and rock, and human activities such as disposal of industrial waste and sewage.

The most common dissolved chemical constituents of ground water are: calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), iron (Fe), bicarbonate (HCO_3), carbonate (CO_3), sulfate (SO_4), chloride (Cl), fluoride (F), and nitrate (NO_3).

Chemical data are available for water from 70 wells in the Stockton formation. (See Table 8.) More than one analysis was available for some wells, but only one relatively recent analysis was used for each well.

The areal distribution of water quality from representative wells is depicted on the map in Plate 4. Figures 8 and 9 are trilinear diagrams showing the percentage composition of important constituents of water samples from the Stockton formation. Sulfate plus chloride is plotted against carbonate plus bicarbonate on one axis; and calcium plus magnesium is plotted against sodium plus potassium on another axis.

200410

REFERENCE 22

REFERENCE 23

ATE I. GEOLOGIC MAP OF THE BRUNSWICK AND LOCKATONG FORMATIONS, IN BERKS AND MONTGOMERY COUNTIES, PENNSYLVANIA, SHOWING WELL LOCATIONS.

200413

REFERENCE 24

Dangerous Properties of Industrial Materials

Fifth Edition

N. IRVING SAX

Assisted by:

Ma. ilyn C. Bracken/Robert D. Bruce/William F. Durham/Benjamin Feiner/
Edward G. Fitzgerald/Joseph J. Fitzgerald/Barbara J. Goldsmith/John H. Harley/
Robert Herrick/Richard J. Lewis/James R. Mahoney/John F. Schmutz/
E. June Thompson/Elizabeth K. Weisburger/David Gordon Wilson

VAN NOSTRAND REINHOLD COMPANY
NEW YORK CINCINNATI TORONTO LONDON MELBOURNE

200415

REFERENCE 25

NUS CORPORATION
SUPERFUND DIVISION

PROJECT NOTES

TO: File

DATE: 7-30-86

FROM: Timothy Silar

COPIES:

SUBJECT: HRS package for North Penn Area Study

REFERENCE: Dale Richenbach (Engineer North Penn Water Authority)

North Penn Distribution System (map Available, on file at NUS)

NPWA would have no alternative source of water if totally shut down.

1) Main system has 13,816 hook-ups. 33 wells are used in the main area, 10 are at time off due to contamination these include S-9, NP-33, NP-21, L-2, L-9, L-10, L-21, L-23, L-25 and L-22

2) Skippack Distribution system has 469 hook-ups. 3 wells are used in this area

3) Harrisontown distribution system (Stump Hill Road, Kerr Road, and Hedrick Road) has 25 hook-ups. 1 well is used in this area

4) Small system directly east of northern Skippack system. This system has 6 hook-ups and used 1 well.

5) Small system east of southern Skippack system. This system has 28 hook-ups and uses 1 well

6) System at West Point and Morris Roads has 132 hook-ups and buys water from North Wales Water Authority

7) Hilltown system (Bucks County) has 15 hook-up and 1 well.

All NPWA well are constructed as open-holes and draw water from the Brunswick and/or Lockatong Fm.

Timothy Silar 9/16/86

1035

NUS 443A 58 1/82

200417

REFERENCE 26

NUS CORPORATION
SUPERFUND DIVISION

PROJECT NOTES

TO: File

DATE: 7-29-86

FROM: Timothy Silar

COPIES:

SUBJECT: Hatfield Borough Water Authority

REFERENCE: Bob Hickson

Hatfield Borough Water Company (HBWC) serves approximately 10,000 people.
The system is free-flowing and utilizes 8 to 9 wells at a time.
The borough would have no other source of water if the company were shut-down.
There are no water quality problems at this time (Mr. Hickson provided recent sample results for the wells).
All wells are constructed in the Brunswick Formations and are constructed as open-holes.
Bob Hickson provided a distribution map which shows areas served by the company and well locations (Map on file at NUS).

Timothy Silar 7-29-86

200419
1033

REFERENCE 27

J[illegible]ORPORATION
[illegible]PE[illegible]FUND DIVISION

PROJECT NOTES

TO: File

DATE: 7-30-86

FROM: Timothy Silar

COPIES.

SUBJECT: Telford Borough Water Authority

REFERENCE: Don Beck

[illegible] people served in the borough
[illegible] people served by the borough (total)

[illegible] water quality problems to date

[illegible] gpd allowable withdrawn

[illegible] does not purchase any water, have sold [illegible] to Hatfield on occasion.

[illegible] have no alternative source of water if shut-down.

[illegible] system utilizing 6 wells.

[illegible] provided a distribution map with well [illegible] (Map on file at NUS).

All Telford Borough wells are constructed in the Brunswick and/or Lockatong formations

[illegible] 7/[illegible]/86

1034

200421

REFERENCE 28

Ref #6

US CORPORATION — **TELECON NOTE**

CONTROL NO:	DATE:	TIME:
F3-8607-08	8/4/86	2 30 PM

DISTRIBUTION:

BETWEEN:	OF:	PHONE:
Dave Tindall	Bucks County Soil Conservation Survey	(215) 348-1166

AND: Timothy Silar (NUS)

DISCUSSION:

Irrigation in Lower Bucks County

Mr. Tindall is the district soil conservationist and is familiar with the study area. He stated that to his knowledge there are no signable irrigation systems in our study area. in fact there are no large crop lands ~~and~~ in the area.

ACTION ITEMS:

Timothy Silar 8/4/86

200423

REFERENCE 29

NUS CORPORATION AND SUBSIDIARIES — **TELECON NOTE**

CONTROL NO:	DATE: 8/8/86	TIME: 0950

DISTRIBUTION:

BETWEEN:	OF:	PHONE:
Paul Reber (PR)	Penn State Agricultural Extension Service	(215) 489-4315

AND: Bill Hose

DISCUSSION:

PR informed me that there is no irrigation for agricultural crops within the following areas:

1) North Wales and surrounding area
2) Souderton and surrounding area
3) Lansdale and surrounding area
4) Hatfield and surrounding area
5) Worcester Township
6) East and West Norriton Township

Only Graterford State Correctional Institution has any type of crop irrigation; however, that facility lies outside all North Penn Water Authority study areas.

ACTION ITEMS:

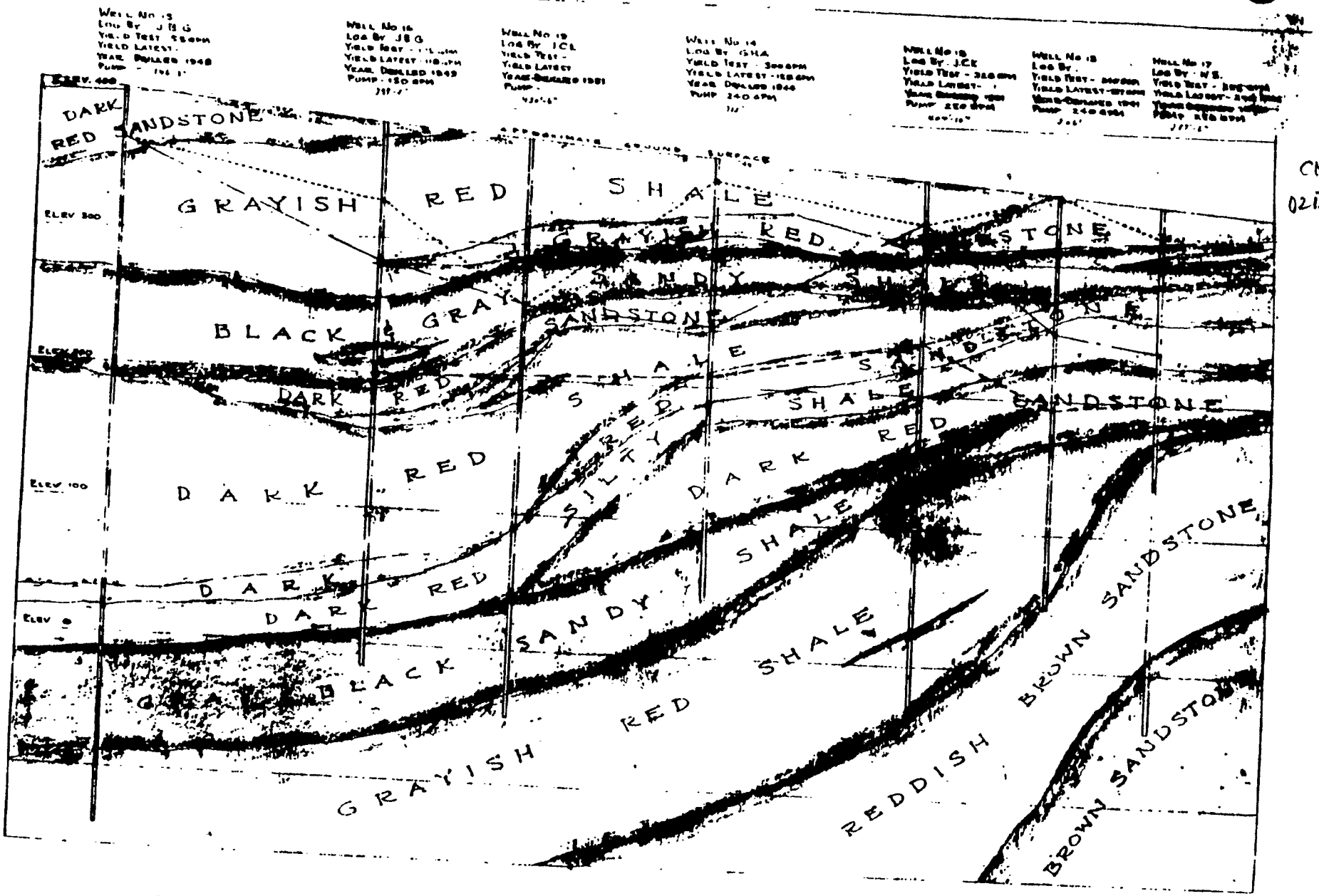
1039

Bill Hose 8/8/86

200425

REFERENCE 30

200426



LEGEND
Original Static Level
Present Static Level
Present Pumping Level

Lansdale Municipal Authority
Lansdale, Pa.
Geological Section
Wissahickon Well Field
Harrisburg, Pa.

CH0358
02D:05

200427

REFERENCE 31

REFERENCE 32

200430

LEASE.

HELEN D. SWARTLEY

TO

GENTLE CLEANERS, INC.

Premises 162 N. Main St.
Souderton, Pa.

Rent, $ 5,400.00 *per* year

Commences July 1, 1985

Expires June 30, 1990

No. 14 Lease K
Yee & Lukens Co., Philadelphia
P 81807

LANDIS, WILLIAMS & KERNS
ATTORNEYS-AT-LAW
425 W. MAIN STREET
P. O. BOX 29
LANSDALE, PENNA. 19446

NO. 14 - LEASE K.
Printed by Yeo & Lukens Co., 11 N. 13th St., Philadelphia

This Agreement Witnesseth, THAT HELEN D. SWARTLEY, Lansdale, Pennsylvania (hereinafter called the lessor), doth hereby let unto GENTLE CLEANERS, INC., t/a MAIN STREET CLEANERS (hereinafter called the lessee),

ALL THAT CERTAIN premises situate at 162 North Main Street, Souderton, Pennsylvania

for the term of five years from the first day of July A. D. 1985 , yielding and paying therefor unto the lessor the annual rent of Fifty-Four Hundred ($5,400.00) Dollars, payable in monthly payments of $450.00 Dollars on the first day of each month in advance, at 10 Woodland Drive, Lansdale, Pa. or at such other place as said lessor may from time to time direct.

AND it is hereby covenanted between the lessor and lessee , for themselves, their respective heirs or successors and assigns as follows:—

1st. The lessee will pay the rents hereby reserved according to the terms of this lease, and will also pay, if said premises are equipped with water meter, all charges in excess of the annual minimum water meter rates, and sewer rents, proportioned monthly, otherwise all charges for water and sewer rent other than for dwelling house purposes, accruing during the continuance of this lease; and all bills for the same, if paid by the lessor, may be distrained for and recovered as rent.

2nd. The lessee shall not occupy the demised premises otherwise than as a dry cleaning and laundry business nor shall the lessee assign this lease, nor underlet the premises or any part thereof. Any transfer by process of law shall be deemed an assignment by the lessee , and the lessee shall not do or knowingly suffer to be done any act, matter or thing, whereby any policy of insurance on the demised premises shall, according to the conditions thereof become avoided or suspended. No sign or signs shall be painted upon any part of the demised premises, other than on glass in windows or doors.

3rd. The lessee shall keep the demised premises in good condition during the continuance of this lease, remove all ashes, rubbish and refuse matter therefrom, replace or repair any electric fixtures or wiring that may be damaged or broken, and at the termination of this lease deliver up the said premises to the lessor in as good order and repair as the same now are, reasonable wear and tear and damage by accidental fire excepted. Any improvements or additions made by the lessee shall not be detached from the property, but shall remain for the benefit of the lessor

4th. Lessee agrees that all goods and property on the demised premises, unless specifically prohibited by law, shall be liable to distress for rent, unpaid water rent, repairs to or replacing electric fixtures and wiring, and for all costs and allowable commissions. Lessee waives the benefit of all laws made or to be made exempting any property, rights, or demands on the demised premises or elsewhere, from levy, attachment, or sale on distress or execution, and such waiver is to extend to distress and sale after removal, and also to executions issued on any judgment for possession or damages recovered upon this lease or entered or confessed under the terms hereof. Lessee waives all right to stay of execution on any such judgment. All goods and chattels removed from the premises shall be liable to distress and sale for 90 days after their removal (unless expressly prohibited by law) in the same manner and subject to the same conditions, provisions, agreements, and waivers as if they were on the premises.

5th. This lease shall expire on June 30, 1990.

~~5th. Either party may determine this lease at the expiration of the term hereby created, by giving to the other .... days' written notice of intention so to do, but in default of such notice, this lease, with all the conditions and covenants thereof, shall continue for the additional term of .... and so on from .... to .... until terminated by either party giving to the other .... days' written notice of intention to terminate said lease at the expiration of the then current term. Provided, however, that if the lessor shall have given .... days' written notice prior to the end of any term of intention to change the conditions of this lease, and the lessee shall hold over after such notice, he shall be considered lessee under the terms and conditions mentioned in such notice, for such further period as he may occupy the demised premises, and until this lease is terminated by notice or otherwise, as before provided. Leaving notice upon the premises shall be a sufficient service.~~

6th. The lessor reserves the right at all times to visit and inspect the demised premises, personally or by agent, and to cause any repairs to be made which he may deem proper; also the right at any time to put up a "For Sale" sign in such place on the premises as he may elect, and a "For Rent" sign immediately, in case notice to quit is given. Prospective purchasers or tenants authorised by Lessor may inspect the premises at reasonable hours at any time.

7th. Lessee waives in favor of Lessor all of Lessee's rights und. all applicable laws to notice of exemption of goods, to appraisement, and to condemnation as well as the right of appeal from, or writ of error or certiorari to any judgment, order, or decree that may be entered against Lessee by any court or magistrate for rent, damages, possession, or otherwise; and does further expressly waive the benefit of any and all stay of execution or exemption laws of every jurisdiction.

8th. If the rent and/or any charges reserved under this lease as rent shall remain unpaid on any day when the same is required to be paid, without otherwise limiting Lessor's remedies to collect by every available legal action all rent hereunder, accelerated, Lessor, in Pennsylvania, may cause a complaint to be filed under Pennsylvania Rules of Civil Procedure No. 2950 et. seq. for the recovery from Lessee of all rent hereunder (including all accelerations of rent permissible under the provisions of this lease) and/or for all charges reserved hereunder as rent, as well as for interest and costs; and Lessee hereby authorizes and empowers Lessor's attorney to file with the said Complaint a confession of judgment against Lessee and to sign the said confession as attorney for Lessee. Such judgment shall be confessed against Lessee for the amount of rent in arrears (including all accelerations of rent permissible under the provisions of this lease) and/or for all charges reserved hereunder as rent, as well as for interest and costs; all together with an attorney's commission of 5% of the full amount of Lessor's claim against Lessee. Neither the right to file such Complaint nor the authority to confess judgment granted herein shall be exhausted by one or more exercises thereof, but successive complaints may be filed and successive judgments may be entered for the aforedescribed sums when or after they become due. In every jurisdiction Lessor shall be entitled to reasonable attorney's fees in addition to all other amounts due.

9th. When this lease shall be terminated (either because of condition broken during the original term of this lease or any renewal or extension thereof and/or when and as soon as the term hereby created or any extension thereof shall have expired), without otherwise limiting Lessor's right to obtain possession by every available legal means, Lessor, in Pennsylvania, may cause an action in ejectment to be filed against Lessee pursuant to Pennsylvania Rules of Civil Procedure No. 2970 et. seq. and to cause the entry of a judgment by confession against Lessee, in such action of ejectment, for possession of the premises demised hereunder. Further, in such action, Lessee hereby authorizes and empowers Lessor's attorney to sign the confession of judgment in ejectment as attorney for Lessee; and a writ of possession may issue forthwith. If for any reason whatsoever after said action shall have commenced the said action shall be terminated and the possession of the premises demised hereunder shall remain in or be restored to Lessee, Lessor shall have the right upon any subsequent default or defaults, or upon the termination of this lease as above set forth, to file complaints to commence successive actions in ejectment and to enter successive judgments in ejectment for possession of the premises demised hereunder.

10th. In the event a Complaint shall be filed pursuant to either Paragraph 8th or 9th of this lease, the original or a photostatic copy or like reproduction of this lease showing Lessee's signature shall be attached to the said Complaint. If the original is not attached Lessor shall aver that the copy attached is a true and correct reproduction of the original. If neither the original lease nor a reproduction can be attached, Lessor shall explain in the Complaint why neither of the same is available.

11th. This Lease shall be governed by the laws of the State in which the demised premises are located. If any provision of this lease shall be declared invalid by judicial determination or legislative action, only such provision so declared invalid shall be affected, and all other provisions not inconsistent therewith or directly dependent thereon shall remain in full force and effect.

12th. The cooling device installed by Lessee in the roof may be removed by lessee at expiration provided the resultant hole is satisfactorily capped and the roof restored to its prior condition.

13. Lessee to pay all utilities without exception and all repairs to the premises without exception for roof repairs and outside repairs. Lessor to carry fire insurance. Lessee to carry plate glass insurance.

14th. Lessor to pay real estate taxes except that Lessee each year shall reimburse*

IN WITNESS WHEREOF, the said parties have hereunto set their hands and seals. Dated the 1st day of July A. D. 1985.

SEALED AND DELIVERED IN PRESENCE OF

GENTLE CLEANERS, INC.

By: Harry M. Maurer (SEAL)
President

Attest: [signature] (SEAL)
Secretary

Helen D. Swartley (SEAL)
Helen D. Swartley

(SEAL)

*Lessor for the amount of real estate taxes for that year ...

200431

from Zone 1
HRS package

OSHA MANUAL

STEP 5

Gentle Cleaners

MATERIAL NAME: AMERICAN PAINT, OIL & GREASE REMOVER (spotting chemical)

RATING NO.	(KEY WORD – RE: HEALTH HAZARD – TOXICITY)
1	Slight health hazard
2	(KEY WORD – RE: COMBUSTIBILITY – FLAMMABILITY) Moderately combustible
0	(KEY WORD – RE: REACTIVITY) Nonreactive

NOTE: Estimates based on known hazards of components and/or use experience.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

MANUFACTURER'S NAME	ADCO, Inc.	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.	816-826-3300
ADDRESS	900 W. Main, Sedalia, MO 65301		
TRADE NAME	AMERICAN PAINT, OIL & GREASE REMOVER		
SYNONYMS	APOG, POG, AMERICAN		

II HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	%	HAZARD DATA
petroleum distillates	54	combustible
organic solvents	26	combustible

III PHYSICAL DATA

BOILING POINT, 760 MM HG	310°F (154°C)	MELTING POINT	N/A
SPECIFIC GRAVITY (H_2O = 1)	0.896/20°C	VAPOR PRESSURE	N/E
VAPOR DENSITY (AIR = 1)		SOLUBILITY IN H_2O, % BY WT	slight
% VOLATILES BY VOL	75	EVAPORATION RATE (BUTYL ACETATE = 1)	N/E
APPEARANCE AND ODOR	clear yellow liquid,	characteristic odor	

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5–28m

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2002
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IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	102-110°F (PM)	AUTOIGNITION TEMPERATURE	N/E
FLAMMABLE LIMITS IN AIR, % BY VOL. N/E	LOWER		UPPER
EXTINGUISHING MEDIA	Carbon dioxide, dry chemical foam or other media for Class B fires.		
SPECIAL FIRE FIGHTING PROCEDURES	Wear self-contained breathing apparatus when fighting fire in confined areas.		
UNUSUAL FIRE AND EXPLOSION HAZARD	Forms combustible and/or explosive mixture with air.		

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION TLV 500 ppm

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE Vapors are intoxicating, narcotic and irritating to mucous membranes of the lungs. Prolonged contact with skin can cause irritation.

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES Flush 15 minutes with water. Call physician if irritation persists.

SKIN: Wash with soap and large quantites of water.

INHALATION: If overcome by vapors, remove victim from contaminated area. If breathing has stopped, give artificial respiration.

INGESTION: DO NOT induce vomiting. Call physician.

NOTES TO PHYSICIAN

Product is a mixture of soap, emulsifiers and organic solvents in a petroleum distillate base.

3/81

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200433

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

Stable under most conditions. Forms combustible and/or explosive mixtures with air and/or oxygen.

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

Does not polymerize.

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Keep from sources of ignition. Spilled material may be pumped into another container or adsorbed with adsorbent.

NEUTRALIZING CHEMICALS None necessary.

WASTE DISPOSAL METHOD

Incineration in accordance with applicable local, state and federal regulations.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

General mechanical ventilation to keep product concentrations within specified time weighted TLV ranges.

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL) Use self-contained or supply air masks for entering areas of concentrated vapor.

EYE

Chemical-type goggles or face shields recommended.

GLOVES

Use rubber gloves impermeable to petroleum solvent.

OTHER CLOTHING AND EQUIPMENT

Availability of safety showers and eye washes in work areas recommended.

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IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

DOT classification: Combustible liquid. Avoid getting into eyes and prolonged contact with skin.

Avoid inhalation of vapors.

OTHER HANDLING AND STORAGE REQUIREMENTS

Keep product containers closed, dry and away from sources of ignition.

Store in well ventilated areas.

PREPARED BY ADCO, Inc. Robert Risner

ADDRESS.

DATE December 11, 1984

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MATERIAL NAME: SPRAY SPOTTER (prespotting chemical)

RATING NO.	(KEY WORD — RE: HEALTH HAZARD — TOXICITY)
1	Slight health hazard
2	(KEY WORD — RE: COMBUSTIBILITY — FLAMMABILITY) Moderately combustible
0	(KEY WORD — RE: REACTIVITY) Nonreactive

NOTE: Estimates based known hazards of compon and/or use experience.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

MANUFACTURER'S NAME ADCO, Inc.	REGULAR TELEPHONE NO. / EMERGENCY TELEPHONE NO. 816-826-3300
ADDRESS 900 W. Main, Sedalia, MO 65301	
TRADE NAME SPRAY SPOTTER	
SYNONYMS none	

II HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	%	HAZARD DATA
petroleum distillates	50	combustible

III PHYSICAL DATA

BOILING POINT, 760 MM HG	220°F	MELTING POINT	N/A
SPECIFIC GRAVITY (H_2O = 1)	0.877/20°C	VAPOR PRESSURE	2.0 mm Hg/20°C
VAPOR DENSITY (AIR = 1)	greater	SOLUBILITY IN H_2O, % BY WT	forms stable emulsion
% VOLATILES BY vol/ wt.	58	EVAPORATION RATE (BUTYL ACETATE = 1)	0.21
APPEARANCE AND ODOR	thick orange-brown liquid w/characteristic odor		

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IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	127 - 132°F (PM)		AUTOIGNITION TEMPERATURE	N/E	
FLAMMABLE LIMITS IN AIR, % BY VOL.		LOWER	0.7	UPPER	6.0
EXTINGUISHING MEDIA	Carbon dioxide, dry chemical foam or other media for Class B fires.				
SPECIAL FIRE FIGHTING PROCEDURES	Wear self-contained breathing apparatus when fighting fire in confined areas.				
UNUSUAL FIRE AND EXPLOSION HAZARD	Forms combustible and/or explosive mixture with air.				

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION: TLV 500 ppm

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE: Vapors are intoxicating, narcotic and irritating to mucous membranes of the lungs. Prolonged contact with skin can cause irritation.

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES: Flush 15 minutes with water. Call physician if irritation persists.

SKIN: Wash with soap and large quantities of water.

INHALATION: If overcome by vapors, remove victim from contaminated area. If breathing has stopped, give artificial respiration.

INGESTION: DO NOT induce vomiting. Call physician.

NOTES TO PHYSICIAN

Product is a mixture of surfac nts, emulsifiers, and organic solvents in a petroleum distillate base.

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VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

Stable under most conditions. Forms combustible and/or explosive mixtures with air and/or oxygen.

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

Does not polymerize.

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Keep from sources of ignition. Spilled material may be pumped into another container or adsorbed with adsorbent.

NEUTRALIZING CHEMICALS None necessary.

WASTE DISPOSAL METHOD

Incineration in accordance with applicable local, state and federal regulations.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

General mechanical ventilation to keep product concentrations within specified time weighted TLV ranges.

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL) Use self-contained or supply air masks for entering areas of concentrated vapor.

EYE Chemical-type goggles of face shields recommended.

GLOVES Use rubber gloves impermeable to petroleum solvent.

OTHER CLOTHING AND EQUIPMENT

Availability of safety showers and eye washes in work areas recommended.

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IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

DOT classification: Combustible liquid. Avoid getting into eyes and prolonged contact with skin.

Avoid inhalation of vapors.

OTHER HANDLING AND STORAGE REQUIREMENTS

Keep product containers closed, dry and away from sources of ignition.

Store in well ventilated areas.

PREPARED BY: ADCO, Inc. Robert Risner

ADDRESS:

DATE December 11, 1984

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MATE AL SAFETY DATA HEET

U. S. DEPARTMENT OF LABOR "ESSENTIALLY SIMILAR" TO FORM LSS-OOS-4

SECTION I

MANUFACTURER'S NAME ADCO, Inc.	EMERGENCY TELEPHONE NO. 800-821-7556
ADDRESS (NUMBER, STREET, CITY, STATE, AND ZIP CODE) 900 W. Main Sedalia, Missouri 65301	
CHEMICAL NAME AND SYNONYMS blended surfactants, water, perfume, optical brighteners, color	TRADE NAME AND SYNONYMS AMAZE
CHEMICAL FAMILY mixture	FORMULA alkylol amine linear aryl sulfate/nonionic blend

SECTIONS II HAZARDOUS INGREDIENTS

PAINTS, PRESERVATIVES, & SOLVENTS	%	TLV (UNITS)	ALLOYS AND METALLIC COATINGS	%	TLV (UNIT
PIGMENTS			BASE METAL		
CATALYST			ALLOYS		
VEHICLE			METALLIC COATINGS		
SOLVENTS			FILLER METAL PLUS COATING OR CORE FLUX		
ADDITIVES			OTHERS		
OTHERS					

HAZARDOUS MIXTURES OF OTHER LIQUIDS, SOLIDS, OR GASES	%	TLV (UNIT

SECTION III PHYSICAL DATA

BOILING POINT (°F.)	212°F	SPECIFIC GRAVITY (H_2O=1) 20°C	1.018
VAPOR PRESSURE (MM HG.)		PERCENT VOLATILE BY VOLUME (%)	80.0
VAPOR DENSITY (AIR = 1)		EVAPORATION RATE (Water = 1)	1.0
SOLUBILITY IN WATER	soluble		

APPEARANCE AND ODOR viscous blue syrupy liquid

SECTION IV FIRE AND EXPLOSION HAZARD DATA

FLASH POINT (METHOD USED) over 200°F C.O.C.	FLAMMABLE LIMITS	LEL	UEL

EXTINGUISHING MEDIA water

SPECIAL FIRE FIGHTING PROCEDURES none

UNUSUAL FIRE AND EXPLOSION HAZARDS none

NOTE:

All information furnished on this form is from the manufacturers specifications for the material or product.

200440

SECTION V HEALTH HAZARD DATA

THRESHOLD LIMIT VALUE	not volatile at normal temperatures
EFFECTS OF OVEREXPOSURE	eye irritant; AMAZE produces no fumes unless it is strongly heated or burned
EMERGENCY AND FIRST AID PROCEDURES	flush eyes thoroughly with water

SECTION VI REACTIVITY DATA

STABILITY	UNSTABLE		CONDITIONS TO AVOID
	STABLE	X	
INCOMPATABILITY (MATERIALS TO AVOID)	none		
HAZARDOUS DECOMPOSITION PRODUCTS	burning may cause formation of carbon dioxide		
HAZARDOUS POLYMERIZATION	MAY OCCUR		CONDITIONS TO AVOID
	WILL NOT OCCUR	X	none

SECTION VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IN CASE MATERIAL IS RELEASED OR SPILLED

wash awaywith water

WASTE DISPOSAL METHOD wash down sewer - product is biodegradable

SECTION VIII SPECIAL PROTECTION INFORMATION

RESPIRATORY PROTECTION (SPECIFY TYPE)	none - does not fume at normal (room) temp.			
VENTILATION	LOCAL EXHAUST	none	SPECIAL	none
	MECHANICAL (GENERAL)	none	OTHER	none
PROTECTIVE GLOVES	none	EYE PROTECTION	goggles, or face mask	
OTHER PROTECTIVE EQUIPMENT	none			

SECTION IX SPECIAL PRECAUTIONS

PRECAUTIONS TO BE TAKEN IN HANDLING AND STORING	avoid fires
OTHER PRECAUTIONS	do not take internally

200441

MATERIAL NAME: PURO (volatile dry solvent)

RATING NO.	(KEY WORD – RE: HEALTH HAZARD – TOXICITY)
1	Slight health hazard

	(KEY WORD – RE: COMBUSTIBILITY – FLAMMABILITY)
1	Slightly combustible

	(KEY WORD – RE: REACTIVITY)
0	Nonreactive

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

MANUFACTURER'S NAME	ADCO, Inc.	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO	816-826-3300
ADDRESS	900 West Main, Sedalia, Missouri 65301		
TRADE NAME	PURO		
SYNONYMS	none		

II HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	%	HAZARD DATA
chlorinated solvent	100	toxic

III PHYSICAL DATA

BOILING POINT, 760 MM HG	165°F	MELTING POINT	N/A
SPECIFIC GRAVITY (H_2O = 1)	1.333/25°C	VAPOR PRESSURE	1.01 mm Hg/20°C
VAPOR DENSITY (AIR = 1)	4.5	SOLUBILITY IN H_2O, % BY WT	.05
% VOLATILES BY VOL	100	EVAPORATION RATE (ether = 100)	37
APPEARANCE AND ODOR	clear, water white liquid - sweet odor		

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IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	none (C.O.C.)	AUTOIGNITION TEMPERATURE	N/A

FLAMMABLE LIMITS IN AIR, % BY VOL.	N/A	LOWER		UPPER	

EXTINGUISHING MEDIA	self extinguishing
SPECIAL FIRE FIGHTING PROCEDURES	N/A
UNUSUAL FIRE AND EXPLOSION HAZARD	Avoid extremely high temperatures (+1300°F), open flames, electrical arcs, etc.

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION	TWA = 350 ppm by wt.
SKIN CONTACT	
SKIN ABSORPTION	
EYE CONTACT	
INGESTION	

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE Exposure to high concentration can cause eye irritation, headache, nausea and unconsciousness.

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES	Flush 15 minutes with water. Call physician if irritation persists.
SKIN:	Wash with soap and large quantities of water.
INHALATION	If overcome by vapors, remove victim from contaminated area. If breathing has stopped, give artificial respiration.
INGESTION	Give 2 glasses of water. Induce vomiting. Repeat if necessary. Call physician.

NOTES TO PHYSICIAN

Product is 100% chlorinated hydrocarbon.

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VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY None

INCOMPATIBILITY Avoid contact with strong alkalis.

HAZARDOUS DECOMPOSITION PRODUCTS

Decomposes to hydrogen chloride and phosgene at extremely high temperatures (+1300°F).

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

Does not polymerize.

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Wipe up all spills or allow to evaporate with adequate ventilation.

NEUTRALIZING CHEMICALS

WASTE DISPOSAL METHOD

Evaporation; dispose of in manner which complies with all state, local and federal regulations.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

Normal

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT Use self-contained or supply air for entering areas of concentrated vapor.
RESPIRATORY (SPECIFY IN DETAIL)

EYE Chemical type goggles or face shield recommended.

GLOVES Gloves of polyvinyl alcohol, polyethylene or neoprene recommended.

OTHER CLOTHING AND EQUIPMENT

Availability of eye washes and safety showers in work area recommended.

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IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

Keep from extremely high temperature (+1300°F).

OTHER HANDLING AND STORAGE REQUIREMENTS

Store in cool, well ventilated area. Keep containers closed.

PREPARED BY ADCO/Robert Risner

ADDRESS

DATE 9/11/84

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MATERIAL NAME: KNOCK OUT (spotting chemical)

RATING NO.	(KEY WORD – RE: HEALTH HAZARD – TOXICITY)
1	Slight health hazard
3	(KEY WORD – RE: COMBUSTIBILITY – FLAMMABILITY) Highly flammable
1	(KEY WORD – RE: REACTIVITY) Slightly reactive

NOTE: Estimates based on known hazards of component and/or use experience.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

MANUFACTURER'S NAME ADCO, Inc.	REGULAR TELEPHONE NO. / EMERGENCY TELEPHONE NO. 816-826-3300
ADDRESS 900 W. Main, Sedalia, Missouri 65301	
TRADE NAME KNOCK OUT	
SYNONYMS ink remover	

II HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	%	HAZARD DATA
petroleum distillates	21	combustible
organic solvents	46	combustible

III PHYSICAL DATA

BOILING POINT, 760 MM HG	N/A	MELTING POINT	N/A
SPECIFIC GRAVITY (H_2O = 1)	.900/24°C	VAPOR PRESSURE	4.39 mm Hg/20°C
VAPOR DENSITY (AIR = 1)	greater	SOLUBILITY IN H_2O, % BY WT	forms emulsion
% VOLATILES BY ~~vol~~ wt.	67	EVAPORATION RATE (BUTYL ACETATE = 1)	.46
APPEARANCE AND ODOR	clear, yellow/orange	liquid w/characteristic odor	

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IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	97°F TCC	AUTOIGNITION TEMPERATURE	N/E

FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER	1.2	UPPER	10.9

EXTINGUISHING MEDIA	Carbon dioxide, dry chemical foam or other media for Class B fires.
SPECIAL FIRE FIGHTING PROCEDURES	Wear self-contained breathing apparatus when fighting fire in confined areas.
UNUSUAL FIRE AND EXPLOSION HAZARD	Forms combustible and/or explosive mixture with air.

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION: No data available on this blended product. Hazard estimates based on data on components or chemically similar products.

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES: Flush 15 minutes with water. Call physician if irritation persists.

SKIN: Wash with soap and large quantities of water.

INHALATION: If overcome by vapors, remove victim from contaminated area. If breathing has stopped, give artificial respiration.

INGESTION: DO NOT induce vomiting. Call physician.

NOTES TO PHYSICIAN

Product is a mixture of surfactants, emulsifiers and organic solvents in a petroleum distillate base.

3/81

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200447

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

Stable under most conditions. Forms combustible and/or explosive mixtures with air and/or oxygen.

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

Does not polymerize.

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Keep from sources of ignition. Spilled material may be pumped into another container or adsorbed with adsorbent.

NEUTRALIZING CHEMICALS

None necessary.

WASTE DISPOSAL METHOD

Incinceration in accordance with applicable local, state and federal regulations.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

General mechanical ventilation to keep product concentrations within specified time weighed TLV ranges.

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL) Use self-contained or supply air masks for entering areas of concentrated vapor.

EYE Chemical-type goggles or face shields recommended.

GLOVES Use rubber gloves impermeable to petroleum solvent.

OTHER CLOTHING AND EQUIPMENT

Availability of safety showers and eye washes in work areas recommended.

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200448

IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

DOT classification: Combustible liquid. Avoid getting into eyes and prolonged contact with skin.

Avoid inhalation of vapors.

OTHER HANDLING AND STORAGE REQUIREMENTS

Keep product containers closed, dry and away from sources of ignition.

Store in well ventilated area.

PREPARED BY ADCO, Inc. Robert Risner

ADDRESS

DATE January 2, 1985

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OSHA MANUAL

STEP 5

MATERIAL NAME: SPEE DEE (spotting chemical)

RATING NO.	(KEY WORD — RE: HEALTH HAZARD — TOXICITY)
1	Slight health hazard
2	Moderately combustible
0	Nonreactive

(KEY WORD — RE: COMBUSTIBILITY — FLAMMABILITY)

(KEY WORD — RE: REACTIVITY)

NOTE: Estimates based o known hazards of compone and/or use experience.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

MANUFACTURER'S NAME	ADCO, Inc.	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.	816-826-3300
ADDRESS	900 W. Main, Sedalia, Missouri 65301		
TRADE NAME	SPEE DEE		
SYNONYMS	none		

II HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	%	HAZARD DATA
petroleum distillates	27	combustible
organic solvents	28.5	combustible

III PHYSICAL DATA

BOILING POINT, 760 MM HG	N/E	MELTING POINT	N/E
SPECIFIC GRAVITY (H_2O = 1)	.944/20°C	VAPOR PRESSURE	N/E
VAPOR DENSITY (AIR = 1)	heavier	SOLUBILITY IN H_2O, %	5%
% VOLATILES BY VOL	45	EVAPORATION RATE (Water = 1)	2.0
APPEARANCE AND ODOR	clear, orange/brown liquid w/characteristic odor		

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5-28m

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IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	108 - 114°F (PM)	AUTOIGNITION TEMPERATURE	N/E
FLAMMABLE LIMITS IN AIR, % BY VOL.	LOWER		UPPER
EXTINGUISHING MEDIA	Carbon dioxide, dry chemical foam or other media for Class B fires.		
SPECIAL FIRE FIGHTING PROCEDURES	Wear self-contained breathing apparatus when fighting fire in confined area.		
UNUSUAL FIRE AND EXPLOSION HAZARD	Forms combustible and/or explosive mixture with air.		

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

INHALATION TLV 500 ppm

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE
ACUTE OVEREXPOSURE
CHRONIC OVEREXPOSURE
Vapors are intoxicating, narcotic and irritating to mucous membranes of the lungs. Prolonged contact with skin can cause irritation.

EMERGENCY AND FIRST AID PROCEDURES

EYES: Flush 15 minutes with water. Call physician if irritation persists.

SKIN: Wash with soap and large quantities of water.

INHALATION: If overcome by vapors, remove victim from contaminated area. If breathing has stopped, give artificial respiration.

INGESTION: DO NOT induce vomiting. Call physician.

NOTES TO PHYSICIAN Product is a mixture of surfactants, emulsifiers and organic solvents in a petroleum distillate base.

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200451

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

Stable under most conditions. Forms combustible and/or explosive mixtures with air and/or oxygen.

INCOMPATIBILITY

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

Will not occur.

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Keep from sources of ignition. Spilled material may be pumped into another container or adsorbed with adsorbent.

NEUTRALIZING CHEMICALS None necessary.

WASTE DISPOSAL METHOD

Incineration in accordance with applicable local, state and federal regulations.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

General mechanical ventilation to keep product concentrations within specified time weighed TLV ranges.

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL) Use self-contained or supply air masks for entering areas of concentrated vapor.

EYE Chemical-type goggles or face shields recommended.

GLOVES Use rubber gloves impermeable to petroleum solvent.

OTHER CLOTHING AND EQUIPMENT

Availability of safety showers and eye washes in work areas recommended.

Recommended MSDS Format — Third Page

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IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

DOT classification: Combustible liquid. Avoid getting into eyes and prolonged contact with skin.

Avoid inhalation of vapors.

OTHER HANDLING AND STORAGE REQUIREMENTS

Keep product containers closed, dry and away from sources of ignition.

Store in well ventilated area.

PREPARED BY ADCO, Inc. Robert Risner

ADDRESS:

DATE January 2, 1985

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MATERIAL NAME: ADCO-LITE CHARGE (drycleaning brightener concentrate)

RATING NO.	(KEY WORD — RE: HEALTH HAZARD — TOXICITY)
1	Slight health hazard
1	(KEY WORD — RE: COMBUSTIBILITY — FLAMMABILITY) Slightly combustible
0	(KEY WORD — RE: REACTIVITY) Nonreactive

NOTE: Estimates based on known hazards of components and/or use experience.

MATERIAL SAFETY DATA SHEET

I PRODUCT IDENTIFICATION

MANUFACTURER'S NAME	ADCO, Inc.	REGULAR TELEPHONE NO. EMERGENCY TELEPHONE NO.	816-826-3300
ADDRESS	900 W. Main, Sedalia, MO 65301		
TRADE NAME	ADCO-LITE CHARGE		
SYNONYMS	none		

II HAZARDOUS INGREDIENTS

MATERIAL OR COMPONENT	%	HAZARD DATA
Product not considered hazardous under		
current Department of Labor regulations.		

III PHYSICAL DATA

BOILING POINT, 760 MM HG	230°F	MELTING POINT	N/A
SPECIFIC GRAVITY (H_2O = 1)	0.971/20°C	VAPOR PRESSURE	N/A
VAPOR DENSITY (AIR = 1)	N/A	SOLUBILITY IN H_2O, % BY WT	slight
% VOLATILES BY VOL	0	EVAPORATION RATE (BUTYL ACETATE = 1)	N/A
APPEARANCE AND ODOR	thick fluorescent orange liquid, bland odor		

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5-26m

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200454

IV FIRE AND EXPLOSION DATA

FLASH POINT (TEST METHOD)	None to 230°F (PM)	AUTOIGNITION TEMPERATURE	N/E

FLAMMABLE LIMITS IN AIR, % BY VOL.	N/A	LOWER		UPPER	

EXTINGUISHING MEDIA	water
SPECIAL FIRE FIGHTING PROCEDURES	none necessary
UNUSUAL FIRE AND EXPLOSION HAZARD	none

V HEALTH HAZARD INFORMATION

HEALTH HAZARD DATA

ROUTES OF EXPOSURE

No data available on this blended product. Hazard estimates based on known hazards of components.

INHALATION

SKIN CONTACT

SKIN ABSORPTION

EYE CONTACT

INGESTION

EFFECTS OF OVEREXPOSURE

ACUTE OVEREXPOSURE: Prolonged contact with skin may cause irritation.

CHRONIC OVEREXPOSURE

EMERGENCY AND FIRST AID PROCEDURES

EYES: Wash 15 minutes with water. Call physician if irritation persists.

SKIN: Wash with soap and large quantities of water.

INHALATION: None necessary

INGESTION: Give two glasses of water; induce vomiting. Repeat until vomit is clear. Call physician.

NOTES TO PHYSICIAN

Product contains a mixture of organic surfactants and emulsifiers.

3/81

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200455

VI REACTIVITY DATA

CONDITIONS CONTRIBUTING TO INSTABILITY

Stable under most conditions.

INCOMPATIBILITY

none

HAZARDOUS DECOMPOSITION PRODUCTS

CONDITIONS CONTRIBUTING TO HAZARDOUS POLYMERIZATION

Will not occur.

VII SPILL OR LEAK PROCEDURES

STEPS TO BE TAKEN IF MATERIAL IS RELEASED OR SPILLED

Flush small spills with adequate amounts of water. Shovel up larger spills into container for disposal.

NEUTRALIZING CHEMICALS

WASTE DISPOSAL METHOD

Incineration in accordance with all local, state and federal regulations.

VIII SPECIAL PROTECTION INFORMATION

VENTILATION REQUIREMENTS

Normal

SPECIFIC PERSONAL PROTECTIVE EQUIPMENT

RESPIRATORY (SPECIFY IN DETAIL) None necessary

EYE Safety glasses, goggles or face shield recommended.

GLOVES Rubber gloves recommended.

OTHER CLOTHING AND EQUIPMENT

Availability of eye washes and safety showers in work area recommended.

Recommended MSDS Format – Third Page

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200456

IX SPECIAL PRECAUTIONS

PRECAUTIONARY STATEMENTS

OTHER HANDLING AND STORAGE REQUIREMENTS

Keep containers closed.

PREPARED BY ADCO, Inc. Robert Risner

ADDRESS:

DATE December 11, 1984

Recommended MSDS Format — Fourth Page

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REFERENCE 33

REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

In Reply Refer to: 3HW23

JUN 24 1986

Mr. Harry M. Maurer, President
Gentle Cleaners, Incorporated
162 North Main Street
Souderton, Pennsylvania 18964

Re: North Penn Water Authority Municipal Well Contamination

Dear Mr. Maurer:

The Environmental Protection Agency (EPA) is seeking information concerning a release, or the threat of a release, of hazardous substances into the environment. Pursuant to the authority of Section 3007 (a) of the Resource Conservation and Recovery Act ("RCRA"), 42 U.S.C. Section 6927 (a), and Section 104 (e) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA"), 42 U.S.C. Section 9604 (e), your company is requested to furnish all information and documents in your possession, custody or control, or in the possession, custody or control of any of the officers, employees or agents which concern, refer, or relate to hazardous substances as defined by Section 101 (14) of CERCLA, 42 U.S.C. Section 9601 (14), particularly any organic compounds which may have been used, transported to, or stored, or disposed of at your facility or in the surrounding area.

All information and documents requested are due to the address listed below within ten (10) calendar days or receipt of this letter.

The response should include, but not be limited to, information and documentation concerning:

1. The types and quantities of the hazardous substances used at or sent to your facility;

2. The date(s) such substances were used at or sent to your facility;

3. The state (i.e., liquid, solid, or gaseous) of the substances used at or sent to your facility, and the manner in which the substances were stored or disposed (i.e., drummed or uncontained, placed in lagoons, landfilled, placed in piles, etc.);

4. Any correspondence between your facility and any regulatory agencies regarding such substances;

5. Any correspondence between your facility and any third party regarding such substances;

6. The identity of, and documents relating to, any other person who generated, treated, stored, transported, or disposed, or who arranged for the treatment, storage, disposal, or transportation of such substances to your facility;

7. Copies of any deeds, rights-of-way, leases, or other real interests which you may have in your possession.

As used herein, the term "documents" means writings (handwritten, typed or otherwise produced or reproduced) and includes, but is not limited to, any invoices, checks, receipts, bills of lading, weight receipts, toll receipts, correspondence, offers, contracts, agreements, deeds, leases, manifests, licenses, permits, bids, proposals, logs, books of original entry, minutes of meetings, memoranda, notes, calendar or diary entries, agendas, bulletins, notices, announcements, charts, maps, photographs, drawings, manuals, brochures, reports of scientific study or investigation, schedules, price lists, telegrams, teletypes, phono-records, magnetic voice or video records, tapes, summaries, magnetic tapes, punch cards, recordings, discs, computer printouts, or other data compilations from which information can be obtained or translated.

You are entitled to assert a claim of business confidentiality covering part of the submitted information, in the manner described in 40 C.F.R. Section 2.203(b). Information subject to a claim of business confidentiality will be made available to the public only in accordance with the procedures set forth in 40 C.F.R. Part 2, Subpart B. Unless a business confidentiality claim is asserted at the time the requested information is submitted, EPA may make this information available to the public without further notice to you.

Please send the required information to:

Lorie Acker
U.S. Environmental Protection Agency, Region III
Site Investigation and Support Section (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, PA 19107

If you have any questions concerning this matter, please contact Lorie Acker at (215) 597-3165.

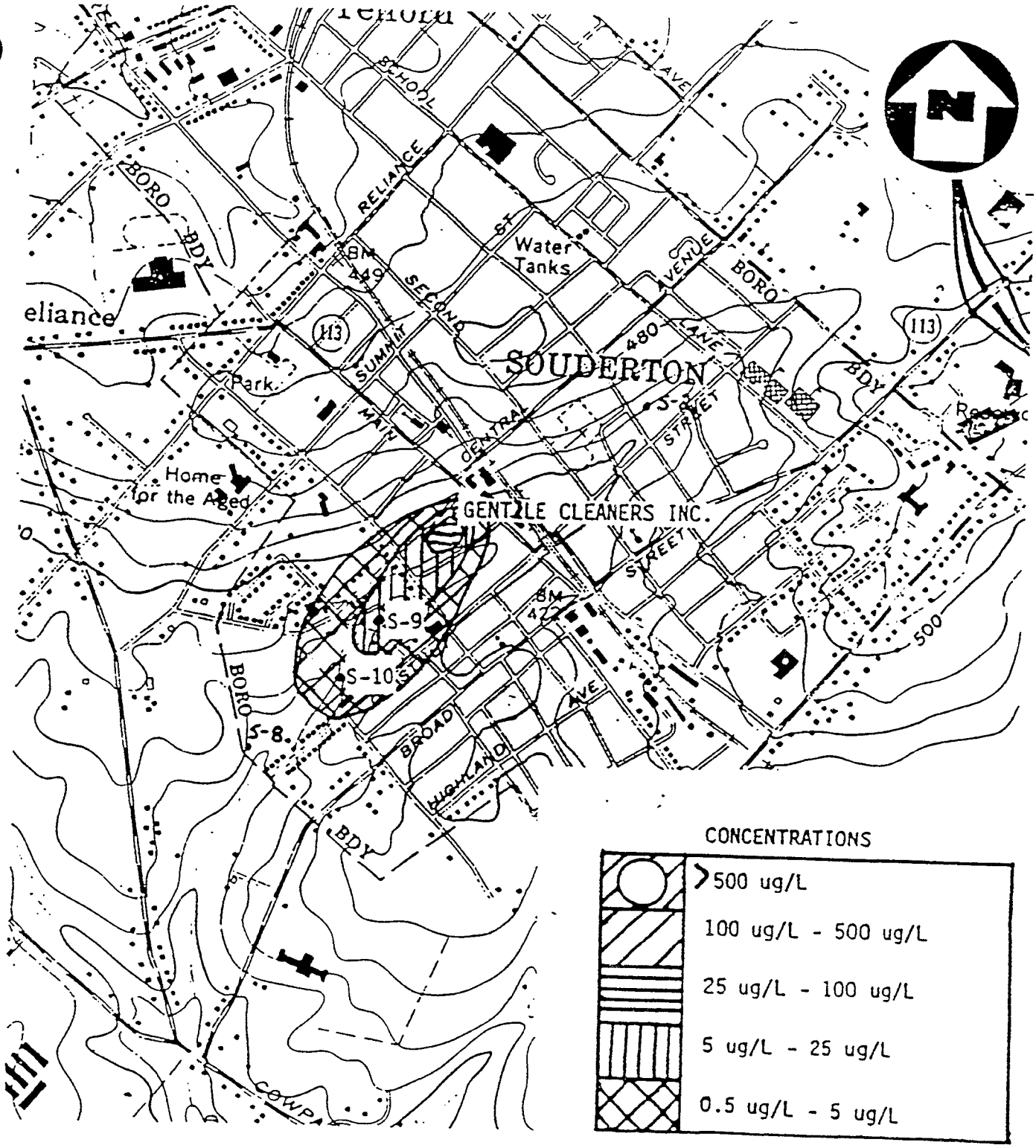
Sincerely,

Thomas C. Voltaggio, Chief
Superfund Branch

Enclosure(s): Location Map

cc: Donald Lazarchik

200461



SOUDERTON
GENTILE CLEANERS INC.
Water Tanks
Home for the Aged
Park
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BORO BDY
RELIANCE
SCHOOL
AVE
SECOND
SUMMIT
MAIN
CENTRAL
AVENUE
LANE
STREET
BM 449
BM 422
480
113
500
S-9
S-10
S-8
BROAD
HIGHLAND
CONCENTRATIONS
>500 ug/L
100 ug/L - 500 ug/L
25 ug/L - 100 ug/L
5 ug/L - 25 ug/L
0.5 ug/L - 5 ug/L

200462

GENTLE CLEANERS
ATTACH'T I
2000 – 2008
3000 – 3002

286 096 266

RECEIPT FOR CERTIFIED MAIL
NO INSURANCE COVERAGE PROVIDED
NOT FOR INTERNATIONAL MAIL
(See Reverse)

Sent to
Harry M. Maurer, Pres.
Street and No.
Gentle Cleaners, Inc.
P.O., State and ZIP Code
162 N. Main St.
Souderton, PA 18964

Postage	$
Certified Fee	
Special Delivery Fee	
Restricted Delivery Fee	
Return Receipt showing to whom and Date Delivered	
Return Receipt showing to whom, Date, and Address of Delivery	
TOTAL Postage and Fees	$
Postmark or Date	

JUN 24 1986

PS Form 3800, June 1985 U.S.G.P.O. 1985-480-794

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200463

release, or the threat or a
Pursuant to the authorit

REFERENCE 34

REFERENCE 35

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

In Reply Refer to: 3HW23

JUN 24 1986

Mr. Lake Clemmer, President
Granite Knitting Mills, Incorporated
P.O. Box 285
Souderton, Pennsylvania 18964

Re: North Penn Water Authority Municipal Well Contamination

Dear Mr. Clemmer:

The Environmental Protection Agency (EPA) is seeking information concerning a release, or the threat of a release, of hazardous substances into the environment. Pursuant to the authority of Section 3007 (a) of the Resource Conservation and Recovery Act ("RCRA"), 42 U.S.C. Section 6927 (a), and Section 104 (e) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA"), 42 U.S.C. Section 9604 (e), your company is requested to furnish all information and documents in your possession, custody or control, or in the possession, custody or control of any of the officers, employees or agents which concern, refer, or relate to hazardous substances as defined by Section 101 (14) of CERCLA, 42 U.S.C. Section 9601 (14), particularly any organic compounds which may have been used, transported to, or stored, or disposed of at your facility or in the surrounding area.

All information and documents requested are due to the address listed below within ten (10) calendar days or receipt of this letter.

The response should include, but not be limited to, information and documentation concerning:

1. The types and quantities of the hazardous substances used at or sent to your facility;

2. The date(s) such substances were used at or sent to your facility;

3. The state (i.e., liquid, solid, or gaseous) of the substances used at or sent to your facility, and the manner in which the substances were stored or disposed (i.e., drummed or uncontained, placed in lagoons, landfilled, placed in piles, etc.);

2004
200466

4. Any correspondence between your facility and any regulatory agencies regarding such substances;

5. Any correspondence between your facility and any third party regarding such substances;

6. The identity of, and documents relating to, any other person who generated, treated, stored, transported, or disposed, or who arranged for the treatment, storage, disposal, or transportation of such substances to your facility;

7. Copies of any deeds, rights-of-way, leases, or other real interests which you may have in your possession.

As used herein, the term "documents" means writings (handwritten, typed or otherwise produced or reproduced) and includes, but is not limited to, any invoices, checks, receipts, bills of lading, weight receipts, toll receipts, correspondence, offers, contracts, agreements, deeds, leases, manifests, licenses, permits, bids, proposals, logs, books of original entry, minutes of meetings, memoranda, notes, calendar or diary entries, agendas, bulletins, notices, announcements, charts, maps, photographs, drawings, manuals, brochures, reports of scientific study or investigation, schedules, price lists, telegrams, teletypes, phono-records, magnetic voice or video records, tapes, summaries, magnetic tapes, punch cards, recordings, discs, computer printouts, or other data compilations from which information can be obtained or translated.

You are entitled to assert a claim of business confidentiality covering part of the submitted information, in the manner described in 40 C.F.R. Section 2.203(b). Information subject to a claim of business confidentiality will be made available to the public only in accordance with the procedures set forth in 40 C.F.R. Part 2, Subpart B. Unless a business confidentiality claim is asserted at the time the requested information is submitted, EPA may make this information available to the public without further notice to you.

Please send the required information to:

Lorie Acker
U.S. Environmental Protection Agency, Region III
Site Investigation and Support Section (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, PA 19107

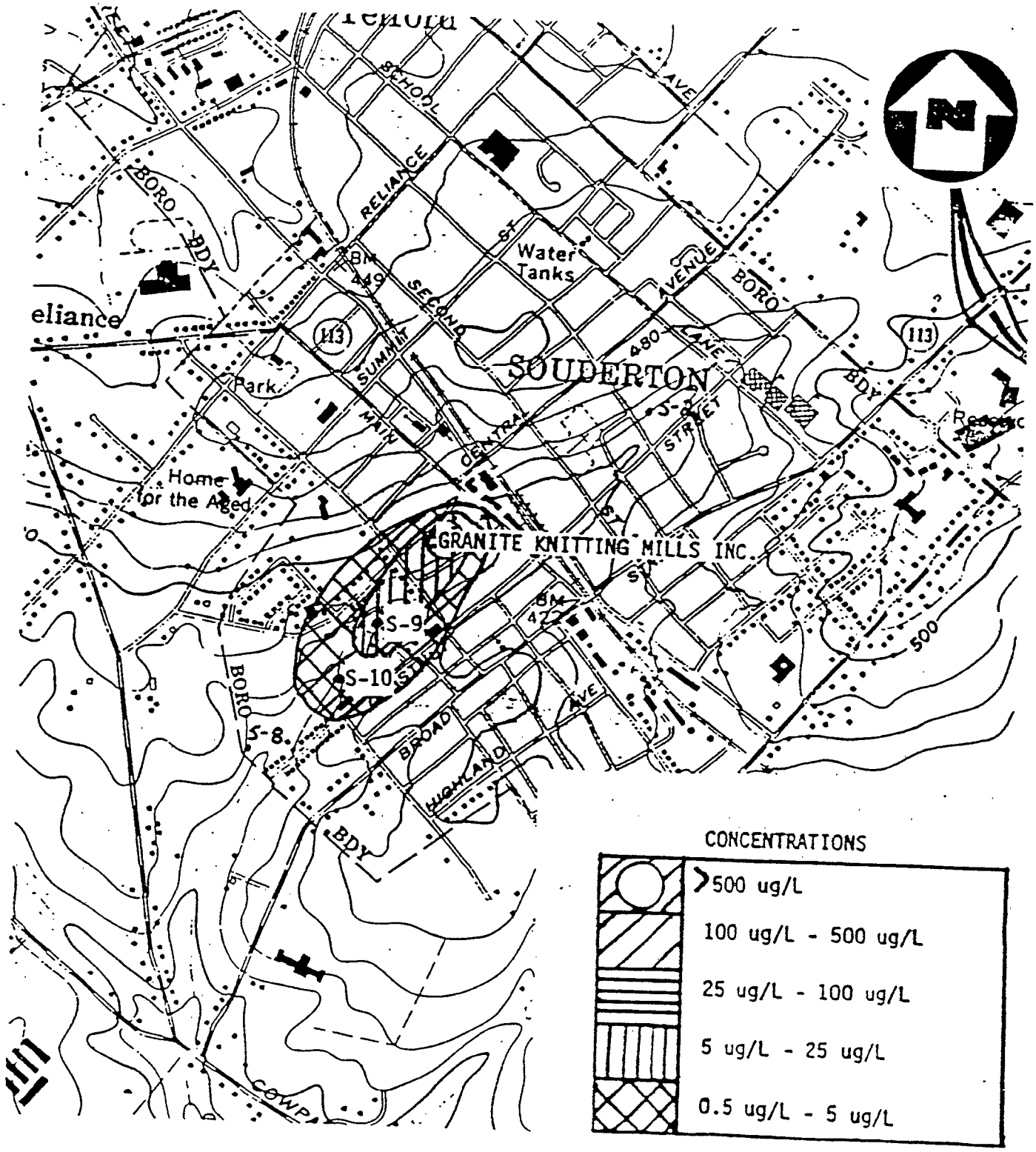
If you have any questions concerning this matter, please contact Lorie Acker at (215) 597-3165.

Sincerely,

Thomas C. Voltaggio, Chief
Superfund Branch

Enclosure(s): Location Map

cc: Donald Lazarchik



SCHOOL
AVE
RELIANCE
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BDY
Water
Tanks
BM
449
SECOND
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AVENUE
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SUMMIT
480
LANE
SOUDERTON
Park
MAIN
CENTRAL
STREET
BDY
113
Home
for the Aged
GRANITE KNITTING MILLS INC.
S-9
BM
422
S-10
500
BORO
S-8
BROAD
AVE
HIGHLAND
BDY
CONCENTRATIONS
>500 ug/L
100 ug/L - 500 ug/L
25 ug/L - 100 ug/L
5 ug/L - 25 ug/L
0.5 ug/L - 5 ug/L

200469

REFERENCE 36

REFERENCE 37

UNITED STATES ENVIRONMENTAL PROTECTION AGENCY
REGION III
841 Chestnut Building
Philadelphia, Pennsylvania 19107

Parkside Apts.

CERTIFIED MAIL
RETURN RECEIPT REQUESTED

JUN 24 1986

In Reply Refer to: 3HW23

Mr. Paul Derstein
220 West Reliance Road
Souderton, Pennsylvania 18964

Re: North Penn Water Authority Municipal Well Contamination

Dear Mr. Derstein:

The Environmental Protection Agency (EPA) is seeking information concerning a release, or the threat of a release, of hazardous substances into the environment. Pursuant to the authority of Section 3007 (a) of the Resource Conservation and Recovery Act ("RCRA"), 42 U.S.C. Section 6927 (a), and Section 104 (e) of the Comprehensive Environmental Response, Compensation, and Liability Act of 1980 ("CERCLA"), 42 U.S.C. Section 9604 (e), your company is requested to furnish all information and documents in your possession, custody or control, or in the possession, custody or control of any of the officers, employees or agents which concern, refer, or relate to hazardous substances as defined by Section 101 (14) of CERCLA, 42 U.S.C. Section 9601 (14), particularly any organic compounds which may have been used, transported to, or stored, or disposed of at your facility or in the surrounding area.

All information and documents requested are due to the address listed below within ten (10) calendar days or receipt of this letter.

The response should include, but not be limited to, information and documentation concerning:

1. The types and quantities of the hazardous substances used at or sent to your facility;

2. The date(s) such substances were used at or sent to your facility;

3. The state (i.e., liquid, solid, or gaseous) of the substances used at or sent to your facility, and the manner in which the substances were stored or disposed (i.e., drummed or uncontained, placed in lagoons, landfilled, placed in piles, etc.);

2107

200472

4. Any correspondence between your facility and any regulatory agencies regarding such substances;

5. Any correspondence between your facility and any third party regarding such substances;

6. The identity of, and documents relating to, any other person who generated, treated, stored, transported, or disposed, or who arranged for the treatment, storage, disposal, or transportation of such substances to your facility;

7. Copies of any deeds, rights-of-way, leases, or other real interests which you may have in your possession.

As used herein, the term "documents" means writings (handwritten, typed or otherwise produced or reproduced) and includes, but is not limited to, any invoices, checks, receipts, bills of lading, weight receipts, toll receipts, correspondence, offers, contracts, agreements, deeds, leases, manifests, licenses, permits, bids, proposals, logs, books of original entry, minutes of meetings, memoranda, notes, calendar or diary entries, agendas, bulletins, notices, announcements, charts, maps, photographs, drawings, manuals, brochures, reports of scientific study or investigation, schedules, price lists, telegrams, teletypes, phono-records, magnetic voice or video records, tapes, summaries, magnetic tapes, punch cards, recordings, discs, computer printouts, or other data compilations from which information can be obtained or translated.

You are entitled to assert a claim of business confidentiality covering part of the submitted information, in the manner described in 40 C.F.R. Section 2.203(b). Information subject to a claim of business confidentiality will be made available to the public only in accordance with the procedures set forth in 40 C.F.R. Part 2, Subpart B. Unless a business confidentiality claim is asserted at the time the requested information is submitted, EPA may make this information available to the public without further notice to you.

Please send the required information to:

Lorie Acker
U.S. Environmental Protection Agency, Region III
Site Investigation and Support Section (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, PA 19107

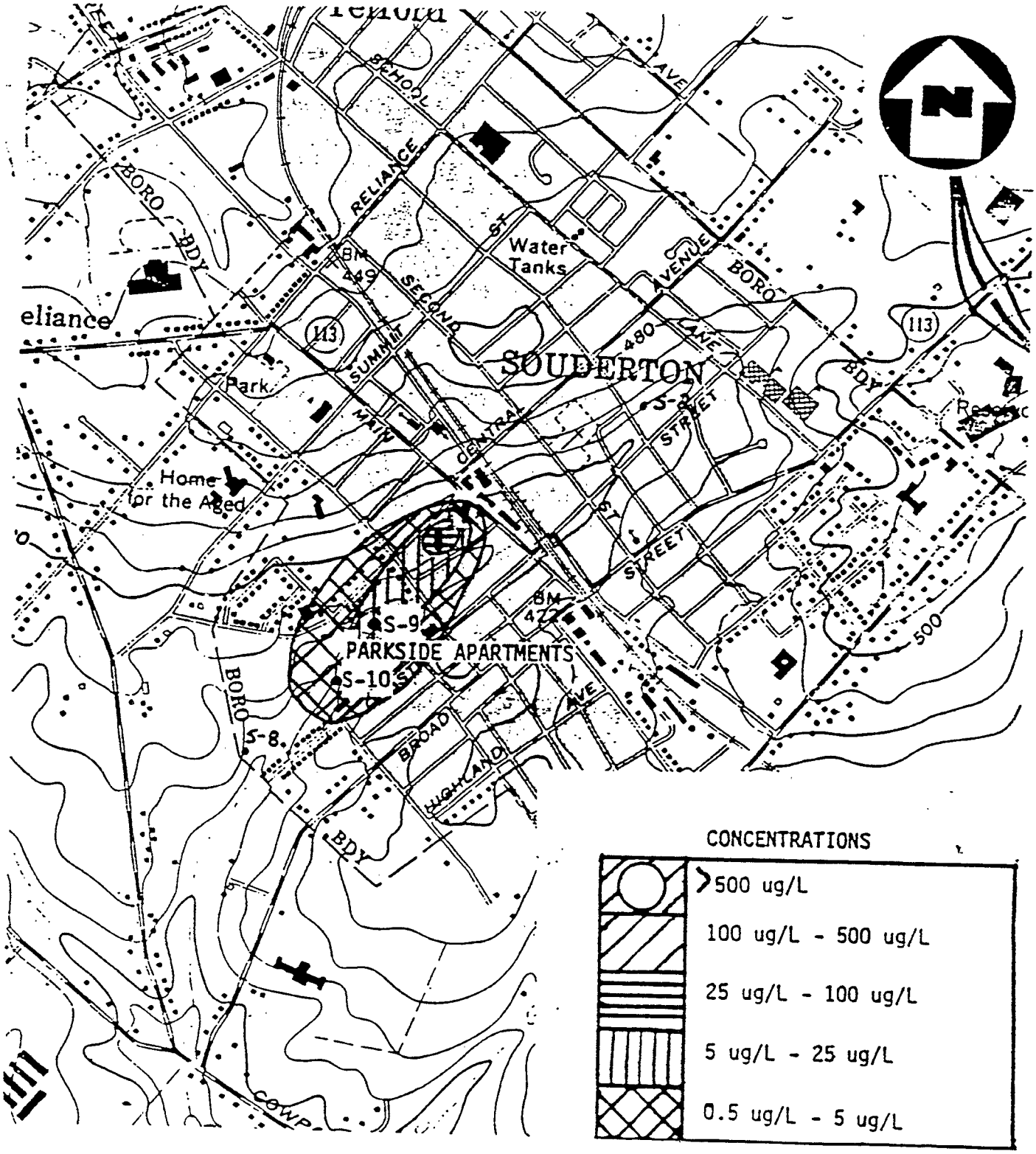
If you have any questions concerning this matter, please contact Lorie Acker at (215) 597-3165.

Sincerely,

Thomas C. Voltaggio, Chief
Superfund Branch

Enclosure(s): Location Map

cc: Donald Lazarchik



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200475

REFERENCE 38

01002

P.O. Box 251
Souderton, Pa. 18964
June 27, 1986

Lorie Acker
U.S. Environmental Protection Agency, RegionIII
Site Investigation and Support Section (3HW23)
841 Chestnut Building, 6th Floor
Philadelphia, Pa. 19107

Gentlemen:

In response to your letter of June 23, 1986, 3HW23, I purchased the property at 142 West Street in 1976 and converted it into apartments. I never received nor used any hazardous substances at this property.

Very truly yours,

PARKSIDE APARTMENTS

Paul G. Derstein

Paul G. Derstein

PGD:rmm

2008

200477

~~On this, the day of 19 , before me~~

~~, the undersigned officer, personally appeared~~

~~known to me (or satisfactorily proven) to be the person described in the foregoing instrument, and acknowledge that he executed the same in the capacity therein stated and for the purposes therein contained.~~

~~In Witness Whereof, I hereunto set my hand and official seal.~~

On this, the -14th- day of -August- 1984, before me, the subscriber, a Notary Public in and for the Commonwealth of Pennsylvania, residing in the Borough of Souderton, the undersigned officer, personally appeared LARE S CLEMMER

who acknowledged himself (herself) to be the President of -GRANITE KNITTING MILLS, INC., a corporation, and that he as such Officer, being authorized to do so, executed the foregoing instrument for the purposes therein contained by signing the name of the corporation by himself (herself) as President

In Witness Whereof, I hereunto set my hand and official seal.

/s/ Shirley R. Clegg

The address - of the within-named Mortgagee is 10 West Broad Street Souderton, PA 18964

/s/ Elvin R. Souder

On behalf of the Mortgagee

COMMOL. ALTH LAND TITLE INSURANCE COMPANY C-736-645-SRL

Mortgage.

GRANITE KNITTING MILLS, INC.

TO

UNION NATIONAL BANK AND TRUST COMPANY OF SOUDERTON

Premises: Souderton Borough, Montgomery County, Pennsylvania

John C. Clark Co., Phila. 1981

ELVIN R. SOUDER
SOUDER, ROSENBERGER, LAPP & BRICKER
114 East Broad St.
P.O. Box 739
Souderton, PA 18964

Recorded in the office for the recording of deeds in and for in Mortgage Book No page &c.

Witness my hand and seal of Office this day of Anno Domini 19

Recorder

Deputy Recorder

200478

This Indenture, Made the — 14th — day of — August — in the year of our Lord one thousand nine hundred and eighty-four (1984). — **Between** GRANITE KNITTING MILLS, INC., a Pennsylvania corporation, with principal office at Second Street and Central Avenue, Souderton, Montgomery County, Pennsylvania, (hereinafter called the Mortgagor), of the one part, and UNION NATIONAL BANK AND TRUST COMPANY OF SOUDERTON, a national banking corporation, with principal office in the Borough of Souderton, County of Montgomery, and State of Pennsylvania, (hereinafter called the Mortgagee), of the other part,

Whereas, the Mortgagor, in and by a certain Obligation or Writing, obligatory under the hand and seal of the Mortgagor, duly executed, bearing even date herewith, stands firmly bound unto the Mortgagee in the sum of ONE HUNDRED SIXTY-TWO THOUSAND FIVE HUNDRED ($162,500.00) Dollars, lawful money of the United States of America, conditioned for the payment to the Mortgagee of the just sum of ONE HUNDRED SIXTY-TWO THOUSAND FIVE HUNDRED DOLLARS ($162,500.00), lawful money as aforesaid, payable within two (2) years from the date hereof, together with interest at the rate of ten and one-quarter percent (10-1/4%) per annum, on the unpaid balance of the principal sum; principal to be payable in monthly installments of Two Thousand Seven Hundred Eight Dollars ($2,708.00), together with interest, payable monthly, at the aforesaid rate, beginning on the 14th day of September, 1984, and the same amount on the 14th day of each month thereafter until such principal and interest are fully paid; the entire outstanding balance to be due and payable on the 14th day of August, 1986;

without any fraud or further delay; and further conditioned to keep and maintain at all times, until the full discharge of the said Obligation, a fire insurance policy or policies, with extended coverage endorsement, in good and approved company or companies, duly assigned as collateral security to the Mortgagee, to an amount not less than One Hundred Sixty-Two Thousand Five Hundred ($162,500.00) Dollars, in form, as shall be required and be satisfactory to Mortgagee, upon the buildings on the premises hereinafter described; and further for the production to the Mortgagee, on or before the first day of December of each and every year, of receipts for all taxes, water rents and sewer rents of the current year assessed upon the mortgaged premises and receipts for all other charges and claims which shall or might have priority in lien or payment to the debt secured hereby; and shall keep and maintain the mortgaged premises in good condition and repair and shall not cause any structural or material change to be made without first having secured the approval, in writing, of the Mortgagee;

Provided, however, and it is thereby expressly agreed, that if at any time default shall be made in the payment of said principal sum or any balance thereof at maturity, or of an installment of principal and of interest as aforesaid, for the space of fifteen (15) days after such payment thereof shall fall due; or, in the prompt and punctual maintenance of fire insurance with extended coverage so assigned as aforesaid; or, in the production to the Mortgagee, on or before the first day of December of each and every year, of receipts for such taxes; water rents and sewer rents of the current year assessed upon the premises mortgaged and receipts for all other charges and claims which shall or might have priority in lien or payment to the debt secured hereby; or, shall fail to keep and maintain the mortgaged premises in good condition and repair, or, without written approval shall cause a structural or material change to be made: then and in such case the whole principal debt aforesaid or so much thereof as shall then remain unpaid shall, at the option of the Mortgagee, become due and payable immediately, and payment of said principal debt, or all unpaid installments thereof and all interest thereon, may be enforced and recovered at once, anything therein contained to the contrary notwithstanding; that thereupon a Writ of Execution is properly issued upon the judgment obtained upon said Obligation, or by virtue of said Warrant of Attorney, or a Complaint or any other legal proceeding is properly filed, based upon this Indenture of Mortgage, that an attorney's commission for collection viz: Five per cent. of the indebtedness or Two Hundred Dollars, whichever is the larger amount, shall be payable, and shall be recovered in addition to all principal and interest besides costs of suit, as in and by the said recited Obligation and the Condition thereof, relation being thereunto had, may more fully and at large appear.

Now this Indenture witnesseth, that the Mortgagor, as well for and in consideration of the aforesaid debt or principal sum of One Hundred Sixty-Two Thousand Five Hundred ($162,500.00) Dollars, and for the better securing the payment of the same, with interest as aforesaid, unto the Mortgagee, in discharge of the said recited Obligation, as for and in consideration of the further sum of One Dollar unto the Mortgagor in hand well and truly paid by the Mortgagee at and before the sealing and delivery hereof, the receipt whereof is hereby acknowledged, hath granted, bargained, sold, released and confirmed, and by these presents doth grant, bargain, sell, release and confirm unto the Mortgagee, its successors and assigns,

2006

200479

PREMISES A

ALL THAT CERTAIN hosiery mill, with the boiler house and other attachments, and tract or piece of land, situate in the aforesaid Borough of Souderton, County of Montgomery and State of Pennsylvania, and according to a recent survey made by Charles N. Gerhart of Telford, Pennsylvania, bounded and described as follows, to wit:

BEGINNING at a corner, a point in the curb line of what is now Green Street, in the aforesaid Borough (being a public road leading from the Harleysville and Souders Station Turnpike Road to the Cowpath Road) on the Southeasterly side thereof and in a line of lands now or late of Samuel W. Brey; thence along the lands of the same South thirty-eight degrees and one-quarter East one hundred fifty feet to a post, a corner; thence still by the same lands and also along lands now of Annie Blank North fifty-one degrees East eighty-four and five one-tenths feet to a post, a corner of lands now or late of Harvey S. Souder; thence along the same South thirty-eight degrees and one-quarter East five feet to a post, a corner; thence still by the same lands North fifty-one degrees East five feet to a post, a corner of lands of Michael B. Bergey; thence along the same South thirty-one degrees and one-half East seventy feet to a stake in an alley, parallel or nearly so with Hillside Avenue; thence along the Northwestern side of said alley South sixty-one degrees and one-quarter West one hundred seventy-eight and eight one-tenths feet to a stake a corner at the intersection of the side of the aforesaid alley with another alley twenty feet wide running from the aforesaid alley to the aforesaid Green Street; thence extending along the last mentioned twenty feet alley on the Easterly side thereof North thirty-eight degrees and one-quarter West one hundred ninety-two and three one-tenths feet to a point in the Southeastern curb line of the aforesaid Green Street, a corner; thence along the said curb line North fifty-one degrees East ninety-six and four one-tenths feet to the place of beginning.

CONTAINING ninety-one and eighty-five one-hundredths square perches of land, more or less.

BEING the same premises which Clayton K. Gotwals and Lillian Gotwals, his wife, by deed dated June 3, 1914, and recorded in the Office for the Recording of Deeds in and for the County of Montgomery, at Norristown, Pennsylvania, in Deed Book No. 716, page 498, granted and conveyed unto M. B. Bergey Company, a Pennsylvania corporation, its successors and assigns, in fee.

PREMISES B

ALL THAT CERTAIN lot or piece of land, situate in the Borough of Souderton, County of Montgomery and State of Pennsylvania, bounded and described as follows, to wit:

BEGINNING at an iron pin on the Northwesterly side of a twelve foot wide alley, a corner of this and other land of the M. B. Bergey Company; thence along the land of the said M. B. Bergey Company North twenty-six degrees West seventy feet to an iron pin, a corner in line of land of Harvey Souder; thence along the same North fifty-nine degrees East one hundred eighteen feet and five one-tenths of a foot to an iron pin in line of said Harvey Souder's land and a corner of other land of the said Kate K. Beale; thence along the said Kate K. Beale's land South twenty-one degrees thirty minutes East eighty-nine and seven one-tenths feet to an iron pin a corner on the northwesterly side of the aforesaid twelve foot wide alley; thence along the same South sixty-eight degrees thirty minutes West one hundred eleven and two one-tenths feet to the place of beginning.

CONTAINING nine thousand one hundred five square feet of land.

BEING the same premises which Katie K. Beale and Earle T. Beale, her husband, by deed dated February 20, 1932, and recorded in the Office for the Recording of Deeds in and for the County of Montgomery, at Norristown, Pennsylvania, in Deed Book No. 1142, page 253,

granted and conveyed unto M. B. Bergey Company, a Pennsylvania corporation, its successors and assigns, in fee.

PREMISES C

ALL THAT CERTAIN messuage and tract of land, situate in the Borough of Souderton, County of Montgomery and State of Pennsylvania, bounded and described as follows, to wit:

BEGINNING at a stake for a corner in the line of a public road and land of a public road and land of Michael B. Bergey (now lands of William Blank); thence along said road, now called Green Street, South fifty degrees West fifty-four feet to a stake a corner of late Michael B. Bergey's land; thence along the same the following two courses and distances viz: South forty degrees East one hundred fifty feet to a stake a corner and North fifty degrees East fifty-four feet to a stake a corner in the line of the aforesaid William Blank's land; thence along the same North forty degrees West one hundred fifty feet to the place of beginning.

CONTAINING eight thousand one hundred square feet of land more or less.

BEING the same premises which Vincent H. Dorn and Lillian M. Dorn, his wife, by deed dated June 17, 1935, and recorded in the Office for the Recording of Deeds in and for the County of Montgomery, at Norristown, Pennsylvania, in Deed Book No. 1196, page 160, granted and conveyed unto M. B. Bergey Company, a Pennsylvania corporation, its successors and assigns, in fee.

PREMISES D

ALL THAT CERTAIN messuage and tract of land along Green Street in the Borough of Souderton, Montgomery County, Pennsylvania bounded and described according to recent survey and plan dated February 18, 1942, as prepared by Stanley F. Moyer, R.S., as follows, to wit:

BEGINNING at a mark in the South curb line of Green Street a forty-four feet wide stre-t said mark being a corner of other land of Grantor and two hundred seventy-one and forty-seven one-hundredths feet Southwest of the intersection of the South curb line of Green Street and the West curb line of Main Street a forty-nine feet wide street; thence along other lands of grantor of which this was a part South forty degrees East the distance of one hundred fifty-six and seventy-five one-hundredths feet to an iron pin a corner in line of lands of the Granite Hosiery Mills, Inc.; thence along the same the next four courses and distances South fifty degrees forty-eight minutes West the distance of ninety-six and fifty one-hundredths feet to an iron pin; thence North forty degrees West the distance of five feet to an iron pin; thence South fifty degrees forty-eight minutes West the distance of thirty and five one-tenths feet to an iron pin; thence North thirty-nine degrees fifteen minutes West the distance of one hundred fifty feet the curb line of Green Street; thence along the same North fifty degrees East the distance of one hundred twenty-five feet to the point of beginning.

CONTAINING nineteen thousand four hundred eighty-five square feet of land more or less.

BEING the same premises which Lizzie Souder, widow; Walter B. Souder and Ada B. Souder, his wife, by deed dated April 20, 1942, and recorded in the Office for the Recording of Deeds in and for the County of Montgomery, at Norristown, Pennsylvania, in Deed Book No. 1459, page 200, granted and conveyed unto Granite Hosiery Mills, Inc., a Pennsylvania corporation, its successors and assigns, in fee.

PREMISES E

ALL THAT CERTAIN tract or piece of land with the buildings and improvements thereon erected situate in the Borough of Souderton, County of Montgomery and State of Pennsylvania, and described according to a recent survey and plan dated June 10, 1955, as prepared by

Stanley F. Moyer, Registered Surveyor and Professional Engineer, Souderton, Pennsylvania, as follows, to wit:

BEGINNING at an iron pin marking the intersection of the center line of Central Avenue (forty feet wide) and North Second Street (thirty-eight feet wide); thence along the center line of North Second Street South thirty-five degrees thirty-nine minutes East the distance of three hundred nineteen and eighty-nine one-hundredths feet to a spike a corner; thence along lands now or late of Electric Realty Company South fifty-five degrees seventeen minutes West the distance of four hundred twenty-nine and fifteen one-hundredths feet to an iron pin in the East side line of the North Pennsylvania Railroad; thence along the same North thirty-five degrees forty-nine minutes West the distance of sixty and fifty one-hundredths feet to a rail monument; thence still along the same North thirty-six degrees nineteen minutes West the distance of two hundred fifty-four and thirty-nine one-hundredths feet to a spike in the center line of Central Avenue; thence along the same North fifty-four degrees thirty-six minutes East the distance of four hundred thirty-two and thirty-three one-hundredths feet to the place of beginning.

CONTAINING three and one hundred thirty-six one-thousandths acres of land, more or less.

BEING the same premises which James S. Clemens and Matilda S. Clemens, his wife, and Abram S. Clemens and Laura F. Clemens, his wife, by deed dated April 8, 1968, and recorded in the Office for the Recording of Deeds in and for the County of Montgomery, at Norristown, Pennsylvania, in Deed Book No. 3506, page 405, granted and conveyed unto Granite Knitting Mills, Inc., a Pennsylvania corporation, its successors and assigns, in fee.

AND the said M. B. Bergey Company and Granite Hosiery Mills, Inc., are now known as Granite Knitting Mills, Inc.

AND TOGETHER WITH all fixtures, and all machinery, equipment and other articles of property of any nature whatsoever owned by the Mortgagor, whether real estate or not, now or at any time hereafter attached to and used or intended to be used in connection with, or in the operation or maintenance of, the real estate or the manufacturing buildings and improvements erected or hereafter erected thereon and owned by the Mortgagor, which shall include, but not be limited to, all lighting, heating, ventilating, air conditioning, sprinkling and plumbing fixtures and systems, water and power systems, engines and machinery, boilers, ranges, furnaces plants or units, communication systems, dynamos, transformers, generators, electrical equipment, storm and screen windows, doors, decorations, awnings, shades, signs, and trees, shrubbery and other plantings.

Together with all and singular the Buildings, Streets, Alleys, Passages, Ways, Water-courses, Rights, Liberties, Privileges, Improvements, Hereditaments and Appurtenances whatsoever thereunto belonging, or in any wise appertaining, and the Reversions and Remainders, Rents, Issues and Profits thereof.

To have and to hold the said Lot or piece of Ground above described, with the Messuage or Tenement thereon erected, Hereditaments and Premises hereby granted, or mentioned and intended so to be, with the Appurtenances, unto the Mortgagee, to and for the only proper use and behoof of the Mortgagee.

Provided always, nevertheless, that if the Mortgagor does and shall well and truly pay, or cause to be paid, unto the Mortgagee, the aforesaid debt or principal sum or balance of principal sum at maturity, or of said principal sum in installments on the days and times hereinbefore mentioned and appointed for payment of the same, together with interest as aforesaid, and shall produce to the Mortgagee, on or before the first day of December of each and every year, receipts for all taxes, water rents, sewer rents of the current year assessed upon the mortgaged premises and receipts for all other charges and claims which shall or might have priority in lien or payment to the debt secured hereby and shall keep and maintain said fire insurance with extended coverage so assigned as aforesaid, without any fraud or further delay, and without any deduction, defalcation, or abatement to be made of anything, herein mentioned to be paid or done, and shall keep and maintain the mortgaged premises in good condition and repair, then, and from thenceforth, as well this present **Indenture** and the estate hereby granted, as the said recited Obligation shall cease, determine and become void, anything hereinbefore contained to the contrary thereof, in any wise notwithstanding.

Provided further, that it shall and may be lawful for the Mortgagee, in case default shall be made for the space of 15 days in the payment of any installment of the said principal sum or interest thereon, or of said principal sum or any balance thereof at maturity, or in the prompt or punctual maintenance of said fire insurance with extended coverage so assigned as aforesaid, or in case there shall be default in the production to the Mortgagee, on or before the first day of December of each and every year, of such receipts for such taxes, water rents, sewer rents of the current year assessed upon the mortgaged premises and receipts for all other charges and claims which shall or might have priority in lien or payment to the debt secured hereby or if the Mortgagor shall fail to keep and maintain the mortgaged premises in good condition and repair or, without written approval shall cause a structural or material change to be made, to sue out forthwith upon a Complaint or any other legal proceeding based upon this Indenture of Mortgage, and to proceed thereon to judgment and execution, for the recovery of the whole of said principal debt, or so much thereof as shall then remain unpaid, and all interest due thereon, together with an attorney's commission for collection, viz: Five per cent. of the indebtedness or Two Hundred Dollars, whichever is the larger amount, besides costs of suit, without further stay, any law, usage or customs to the contrary notwithstanding. **And** the Mortgagor hereby waives and relinquishes unto the Mortgagee all benefit that may accrue to the Mortgagor by virtue of any and every law made or to be made to exempt the above described premises or any other property whatever, or of personal property from levy and sale under execution, or any part of the proceeds arising from the sale thereof, from the payment of the moneys hereby secured, or any part thereof.

In the Event that there is more than one party named herein as Mortgagor or Mortgagee, the word "Mortgagor" or "Mortgagee" wherever occurring herein shall mean the plural. The masculine herein shall refer to and include the feminine as well as the corporate gender. The Obligation, responsibility and liability of each and every party hereto, and also the authority and powers conferred herein, shall be joint and several and shall inure to the benefit of and bind each and every party hereto and his, her, its and their, and each of their respective heirs, executors, administrators, successors and assigns.

In Witness Whereof, the said Mortgagor to these presents has caused this Indenture to be executed under seal the day and year first above written.

Sealed and Delivered
IN THE PRESENCE OF US

/s/ Elwin R. Sandie

/s/ Elizabeth M. Doyle

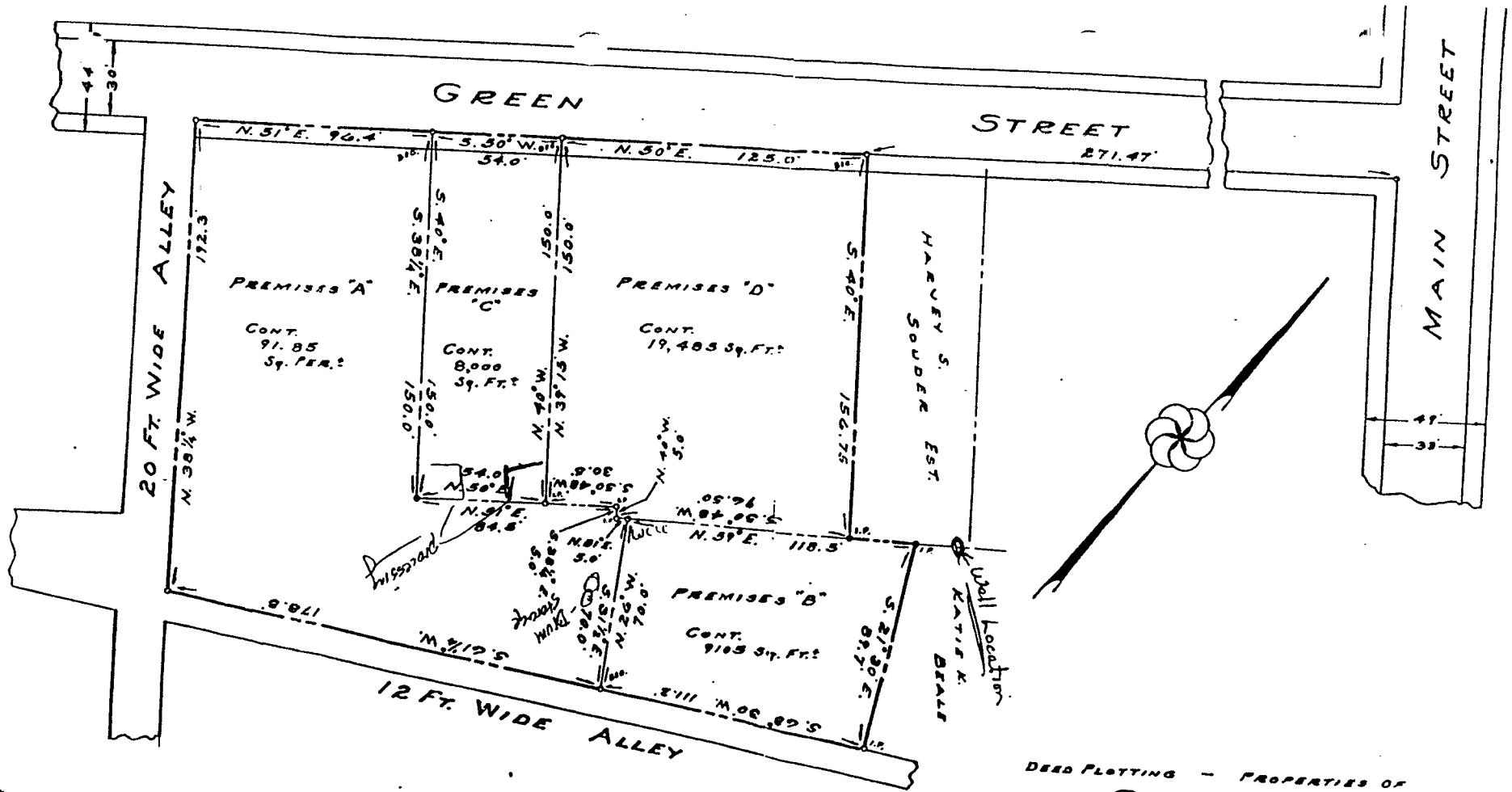
(CORPORATE SEAL)

GRANITE KNITTING MILLS, INC.

By: /s/ Lake S. Clemmer
President

Attest: /s/ Kerry E. Gingrich
Secretary

200483



DEED PLOTTING — PROPERTIES OF

GRANITE KNITTING MILLS, INC.

SOUDERTON BORO. + MONTG. CO. PA.

SCALE: 1" = 40' + AUG. 27, 1984

200484