SECTION III

INFORMATION GATHERING AND MAPPING

A. Data Collection and Mapping Process

Data for this project were obtained from a wide range of local, state, and federal agencies and were generated by Borton-Lawson Engineering. Data sources include the Bucks County Planning Commission, Bucks County Department of Health, Delaware River Basin Commission, Environmental Resource and Research Institute, Pennsylvania Department of Environmental Protection, Pennsylvania Geologic Survey, United States Geological Survey, United States Fish and Wildlife Service, United States Environmental Protection Agency, and the Natural Resource Conservation Service. Data were obtained by downloading files via the Internet, e-mail communications, digital media (CD ROM disks and Zip drives) and hardcopy maps.

Water resources data including problem areas, water supply, and wastewater discharge data were collected from the participating municipalities. The data were evaluated to determine if they covered the Study Area. Digital, georeferenced data were compiled in a Geographic Information System (GIS) and all data were projected into a common coordinate system (Pennsylvania State Plane feet south, North American Datum 1983-SPNAD83). Data not received in digital format (e.g., handwritten problem area survey forms) were plotted on georeferenced maps and digitized into the GIS.

Data format included TIF and JPEG image files with accompanying project reference files (world files) ESRI ArcINFO export files (e00 files) and ESRI shape files. The data files were used to create GIS layers using ArcINFO and ArcView GIS software.

Appropriate datasets (GIS layers) were grouped to create specific ArcView maps referred to as "Views." Processing digital elevation data was conducted using Spatial Analysis. Clipping the regional data to the extent of the Study Area, assigning symbology to the data (i.e., creating map legends), and creating map layouts were accomplished using ArcView 3.2. The ArcView layouts were converted to portable document files (PDF files) using Adobe Acrobat and uploaded onto the PACC's web page on Hilltown Township's website at *http://hilltown.org/pacc/gismaps.htm* .

The horizontal accuracy of GIS data are usually developed to meet National Map Accuracy standards, but is still only as accurate as the original data source. For the purposes of this study, the original GIS data had a National Map Accuracy standard of plus or minus 50 feet horizontally. The maps and data in this report should therefore only be used as a planning tool. Field verification of mapped features would be required for site specific design or analysis.

B. Base Map

The GIS base map **(**Figure I-1 – Study Area Map**)** showing roads, streams, lakes, and political boundaries was generated from the PennDOT 1997 Pennsylvania Cartographic GIS data that were downloaded from the Pennsylvania Spatial Data Access (PASDA) website. The base map provides spatial reference for the Study Area data.

C. Topography

The topography of the Study Area was determined using USGS 7.5 minute topographic maps in digital format (digital raster graphics, referred to as DRGs) and the USGS digital elevation model (DEM) for Bucks County. The DRG maps illustrate contour lines, roads, streams, structures and other physical features. The DEM map provides elevation data (height above mean sea level) in digital format.

Eight USGS DRG maps were merged to create a seamless topographic map of the entire Study Area. The DRG maps used were Milford Square, Quakertown, Bedminster, Lumberville, Perkiomenville, Telford, Doylestown and Buckingham (see **Figure III-1**, below).

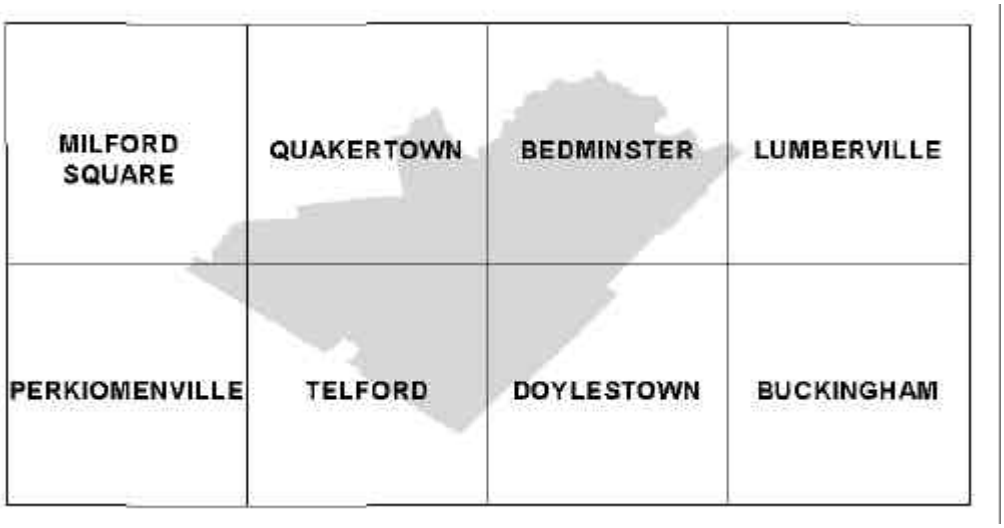

Figure III-1 USGS Topographic Maps Covering the Study Area

The source of the DRG maps is the United States Geological Survey (USGS). A Digital Raster Graphic (DRG) is a raster image of a scanned USGS topographic or planimetric map including the collar information, georeferenced to the Universal TransMercator (UTM) grid. The cropped collar DRGs were reprojected from Albers Conical Equal Area projection to Pennsylvania State Plane projection.

The eight DRGs that cover the study area were tiled together and are used as the base map for Figure III-11 — Gauge and Dam Locations and as an overlay on Figure III-2 — Digital Elevation Model (DEM). The source of DEM map in Figure III-2 was a continuous digital elevation model created by the USGS for all of Bucks County using the most up-to-date 7.5 minute digital elevation model quadrangles.

Figure XII-2 — Slopes and Contours further illustrates Study Area topography. The slopes in Figure XII–2 were derived from the DEM and are discussed in Section XII.

Elevated areas bound the Study Area to the west and east with broad valley running northeast/southwest through the approximate center. Elevations range from approximately 270 feet to 840 feet above mean sea level. The highest point is Rock Hill located in East Rockhill

Township, along the western boundary. The lowest elevations are at the north end of the Study Area along Tohickon Creek and at the south end of the Study Area along the East Branch Perkiomen Creek.

D. Surface Waters And Ordered Subwatershed Boundaries

The Environmental Resource Research Institute (ERRI) at Penn State University created the stream and lakes map data layer by digitizing directly from USGS 7.5 minute quadrangle maps. The ERRI data are generated at a countywide level. The streams and lakes data for Bucks County were downloaded from the PASDA website and then clipped to the limits of the Study Area. The surface water data layers (streams and lakes) are used in all the GIS maps of the Study Area.

The ridge and valley nature of the Study Area creates several drainage divides resulting in numerous subwatersheds within the Study Area. Streams located along the western side of the Study Area flow northward into Lake Nockamixon. Streams in the northern portion flow into the Tohickon Creek. Most other streams flow into East Branch Perkiomen Creek, which runs from the northeast to the southwest in the middle of the Study Area. The East Branch, as it is referred to locally, flows into the Perkiomen Creek at Schwenksville. The Perkiomen then flows into the Schuylkill River near Oaks, Montgomery County. All stream flows from the Study Area ultimately discharge into the Delaware River.

The GIS data showing the general watershed boundaries (Figure I-2) was obtained from the Delaware River Basin Commission. Originally named "Digital drainage basin boundaries of named streams in PA: Delaware, Edition: 1.0," these data were generated by the Pennsylvania Department of Environmental Protection and the United States Geologic Survey. The data show catchment areas for named streams officially recognized by the Board on Geographic Names.

The Study Area does not encompass the entire area of any of the individual watersheds (catchment areas) delineated by PADEP and USGS. ERRI further updated the watershed boundaries, developing subwatershed areas. Subwatersheds are areas that contribute to a limited stream reach. ERRI assigned the stream order designation to the subwatershed. For example, a reach of stream that has no other streams contributing to its flow is a first order stream. A second order stream is one into which first order streams flow. The land area that contributes water into a first order stream is designated as a first order watershed. The subwatershed areas delineated by ERRI in the study area range from first to fifth order. These subareas may also serve as a basis for management areas for implementing water resource strategies. Figure III-3 — Ordered Watershed Subareas shows the ordered streams, the 23 study area delineated subwatersheds, and the eleven DRBC-delineated watersheds (for Integrated Resource Plan purposes).

E. Soils

Soil associations are groups of soils that exhibit a regularly repeating pattern. The soil mapping data for the Study Area was obtained from the *Bucks County Soil Survey*, published by the U.S. Department of Agriculture's Natural Resources Conservation Service (NRCS) (formerly the Soil Conservation Service). There are three soil associations in the Pennridge Study as listed below.

ABBOTTSTOWN-DOYLESTOWN-READINGTON: Nearly level and gentle sloping, moderately deep and deep, poorly drained to moderately well-drained soils on uplands.

NESHAMINY-LEHIGH-GLENELG: Nearly level to moderately steep, poorly drained to well-drained soils on upland slopes.

UNGERS-PENN-KLINESVILLE: Nearly level to moderately steep, shallow and moderately deep, well-drained soils on uplands.

The distribution of the three associations in the Pennridge Study Area is shown in Figure III-4 — Soil Associations Map. Approximately two thirds of the Study Area (the eastern and central portions) have Abbottstown-Doylestown-Readington soils. Neshaminy-Lehigh-Glenelg soils are found in the western third of the site. Small areas of Ungers-Penn-Klinesville soils are found at the north and south ends of the Study Area.

Hydrologic Soil Groups (HSG) criteria were established by NRCS and assist in determining how soils will affect runoff. The HSGs are broken down into four subgroups (A through D) based on infiltration rate and depth. The Hydrologic Soil Groups (HSGs) in the Pennridge Area are shown in Figure III-5 — Hydrologic Soil Groups**.**

The A soils are the most pervious, have the lowest runoff potential, and are typically sands and gravels. There are only three small areas (two 11-acre areas and one 21-acre area) with A soils. One 11-acre area is in Bedminster Township near the border with Nockamixon Township. The other 11-acre area is in East Rockhill Township along the south slope of Rock Hill. The 21-acre area is northwest of Telford Borough, near the East Branch Perkiomen Creek.

Hydrologic Soil Group B is characterized as having moderate infiltration rates and consist primarily of moderately-deep to deep, moderately well to well-drained soils that exhibit a moderate rate of water transmission. The B soils are found mostly along the western and eastern borders of the Study Area where the topography is less level.

The majority of the soils in the Study Area fall in Hydrologic Soil Group C. The C soils have slow infiltration rates when thoroughly wetted and contain fragipans, a layer that impedes downward movement of water and produces a slow rate of water transmission.

The D soils are tight, low permeable soils with high runoff potential and are typically clay soils. These soils are found throughout the Study Area along the streams and tributaries.

Figure III-6 — Erodible Soils illustrates the relative erodibility to the soils in the Study Area. The erosion characteristic of a soil type is classified by the Natural Resource Conservation Service. Each soil type was rated to have a slight, moderate or severe potential for erosion. The soils with similar erosion potential were divided into three groups according to these general classifications. The soils in the majority of the Study Area are classified as having only a slight potential for erodibility. Several areas have soils with moderate erosion potential and only a few areas have soils with severe erosion potential. The largest area with severe soil erodibility is found in East Rockhill Township, just to the south of Lake Nockamixon.

F. Geology

The geology for the Study Area was determined from the digital geology coverage for Bucks County created by the Environmental Resource Research Institute (ERRI) and supplemented with data from the report, *Groundwater Resources of Bucks County* (Greenman, D.W., 1955). Geology data are displayed graphically in Figure III-7 — Geology.

Geology plays a direct role in establishing a water resource plan because it affects soil types within the watershed through parent material breakdown, and it stores water that percolates from the surface and discharges water to maintain baseflow in streams. There are three primary types of bedrock geology in the Study Area as described below.

BRUNSWICK FORMATION: The Brunswick Formation is composed of reddish-brown shale, siltstone, and mudstone, containing a few green and brown shale interbeds; red and dark-gray, interbedded argillites near base. This formation is highly fractured allowing a large volume of water storage and therefore relatively high-yielding wells. The Brunswick formation underlies the eastern two-thirds of the Study Area and is inter-fingered with the Lockatong Formation.

LOCKATONG FORMATION: The Lockatong Formation is dark-gray to black, thick-bedded argillite containing a few zones of thin-bedded black shale. It may also have thin layers of impure limestone and calcareous shale. This formation has no primary porosity or permeability. Groundwater flows through tight, poorly connected fractures and fissures which results in relatively low yielding wells.

DIABASE FORMATION: The Diabase Formation is medium to coarse-grained, quartz-normative tholeiite; composed of labradorite and various pyroxenes. It occurs as dikes, sheets, and a few small flows. Diabase is hard and dense and weathers into large boulders which in turn break down into buff-colored, granular sand and ultimately into tight, sticky, red clay. Diabase is slow to weather and forms the hills and ridges found in the western portion of the Study Area. There are few fractures within this formation resulting in very poor yielding wells. Due to the clay-like nature of soil that originates as Diabase, runoff is high, and water recharge is low.

G. Existing Land Use

Land use/land cover data were determined via interpretation of digital, spatially accurate aerial photos (orthophotos) created by the USGS. The flight dates for the orthophotos used for this study vary from 1992 to 1995. Each orthophoto covers one quarter of a 7.5 minute topographic map (approximately 14 square miles). The land use/land cover data were generated by Borton-Lawson by digitizing over the orthophotos and assigning a land use/land cover classification to each delineated area. The land use/land cover data are found in Figure III-8 — Existing Land Use.

The majority of land in the Study Area is used for agricultural purposes or covered by forest. Agriculture and forest each account for approximately 31 percent of the study area (62 percent total). Open space and meadow uses, which are undeveloped land use, account for another 8 percent of the study area. The Study Area was approximately 30 percent developed as of the date of the orthophotos. In 2000, the Delaware Valley Regional Planning Commission sponsored the creation of new orthophotos for the Delaware Valley Region. These orthophotos were not available at the time this plan was prepared. The new orthophotos can be used to update the land use information when available.

The western third of the Study Area is predominantly covered by forest and the eastern two thirds is mostly agricultural, mixed with forest and low density residential. For the most part, the diabase formation underlies the forested areas, while the Brunswick and Lockatong Formations underlie the agricultural areas. Medium- and high-density residential areas and commercial, industrial and institutional areas are clustered around the boroughs of Dublin, Perkasie, Sellersville, Silverdale, and Telford.

Table III-1 shows the overall land use by category within the Pennridge Study Area as derived from Figure III-8 — Existing Land Use**.**

Table III-1 — Approximate Land Use Areas
(Based on GIS Data)

	Acres	Square Miles	Percent of Total
Agriculture	18639	29	31
Commercial	1328	2	2
Farmstead	1220	2	2
Forest	18175	28	31
High Density Residential	506	1	1
Medium Density Residential	2086	3	4
Medium-High Density Residential	1058	2	2
Low Density Residential	9104	14	15
Industrial	771	1	1
Institutional	460	1	1
Meadow	4412	7	7
Mining	276	0	<1
Paved	4	0	<1
Open Space	391	1	<1
Water	894	1	1
Totals (Rounded to nearest whole number.)	**59325**	**93**	**100**

H. Wetlands

Wetlands data for the Study Area are from the National Wetland Inventory (NWI) data created by the U.S. Fish and Wildlife Service. The NWI data are derived by photo interpretation and show major wetland areas. The wetlands data are shown in Figure III-9 — Wetlands**.**

Wetlands are found throughout the Study Area, primarily along streams. Wetlands are formed when the surface soil in an area is saturated for an extended period of time (two weeks or more) during the growing season. This results in the growth and dominance of hydrophytic vegetation (plants that are adapted to saturated soil conditions).

The wetland data for the GIS were generated by the U.S. Fish and Wildlife Service (FWS) to meet the FWS mandate to map the wetland and deepwater habitats of the United States. The purpose of this survey was not to map all wetlands and deepwater habitats of the United States, but rather to use aerial photointerpretation techniques to produce thematic maps that show, in most cases, the larger wetlands and types that can be identified by such techniques. The objective was to provide better geospatial information on wetlands than that found on the U.S.

Geological Survey topographic maps. It was not the intent of the NWI to produce maps that show exact wetland boundaries comparable to boundaries derived from ground surveys. Boundaries are therefore generalized in most cases.

In general, there are five types of wetlands:

Marine	(open ocean and associated coastline)
Estuarine	(salt marshes and brackish tidal water)
Riverine	(rivers, creeks, and streams)
Lacustrine	(lakes and deep ponds)
Palustrine	(shallow ponds, marshes, swamps, sloughs)

The wetlands found in the Pennridge Area are Riverine, Lacustrine and Palustrine. Riverine and Lacustine wetlands may also be considered surface waters, depending on the depth of the water and the ability to support rooted vegetation.

Wetland areas exist within the Study Area that may not appear on the NWI maps. These wetlands may be too small to be seen in aerial photos used to create the NWI maps or they may not exhibit characteristics that allow interpretation from the air. Onsite wetland delineations are needed to accurately establish the presence or absence and extent of wetlands on the ground.

I. Groundwater and Surface Water Withdrawal and Recharge Sites

Digital GIS data showing the locations of groundwater and surface water withdrawal and recharge sites were obtained from the Bucks County Planning Commission, the Bucks County Department of Health, the Delaware River Basin Commission, and the PADEP. These data are shown on Figure III-10 — Groundwater and Surface Water Withdrawal and Recharge Sites.

The withdrawal points shown on Figure III-10 are municipal, industrial, and institutional supply wells that withdraw water from the aquifer and withdrawal points from streams and ponds. Recharge points include sewage outfall locations that discharge treated effluent into surface waters, large septic systems and spray irrigation systems.

J. Gauge And Dam Locations

Figure III-11 — Gauge and Dam Locations shows the locations of dams, rain gauges, USGS stream gauges, and FEMA-calculated flow sites. Six FEMA-calculated flow sites are located along the East Branch Perkiomen Creek and two are located on the Pleasant Springs Creek tributary that flows into the East Branch Perkiomen Creek. These are locations where FEMA determined 100-year flows using empirical methods. Two USGS stream gauging stations are located in the Study Area, one on Tohickon Creek at the northeast corner of the Study Area near Pipersville, and the second one along the East Branch Perkiomen Creek, near Dublin, in the approximate center of the Study Area.

There is one rain gauge in the Study Area, located along PA Route 309 northwest of Sellersville.

There are fifteen dams identified in the Study Area. Four dams are located on Tohickon Creek (two on the upstream side of Lake Nockamixon, one on the lake itself and one below the Lake). There are five dams in the East Branch Perkiomen Creek watershed. There is one dam on both

the Three Mile Run and the West Branch Neshaminy Creek. Ridge Valley Creek (southwest corner of the Study Area) has four dams.

The locations of stream flow gauges and dam locations in the Study Area were determined from digital GIS data obtained from the Bucks County Planning Commission.

K. Hydrogeology

Table III-2 — Hydrogeologic Parameters for the Hydrogeologic Units in Bucks County provides information on the typical water bearing capability of each of the geologic formations across the county.

L. Groundwater Data Sources

Data in the Pennsylvania Groundwater Information System (PaGWIS) database has been consolidated from numerous sources. PaGWIS is designed around a comprehensive modification of the USGS's Groundwater Site Inventory, which is a national database. Definitions of the database fields also mirror GWSI where there is a one-to-one correspondence. In some cases, the PaGWIS field sizes have been increased to allow for more detail. PaGWIS also uses data types, such as date fields, available in Microsoft Access. Well data were also downloaded from the Pennsylvania Spatial Data Access (PASDA) website and received on CD-ROM from the Delaware River Basin Commission. Detailed descriptions of these data are found in the metadata for the respective coverages.

1. PaGWIS Data

a. Water Well Inventory (WWI)

Source: PAGS (version 3.0 CD-ROM)

BLE Shapefile ID: *pwwiwells83s.shp*

This database contains information regarding 165,827 wells throughout Pennsylvania, 123,351 of which have latitude and longitude values. This database was created by the Pennsylvania Geological Survey (PAGS) to manage data supplied to them by water well drillers. BLE shape file *pwwiwells83s.shp* is a subset of the statewide water well inventory and contains 842 well location points.

Data submission began in 1966 using paper forms. Latitude and longitude were determined in the PAGS office by interpreting both handwritten directions and a hand-drawn map supplied by the driller. Temporary employees of the agency have done most of the location and data entry work, so it is of varying reliability. Typically one county was worked on at a time.

No data entry has been done since August of 1994, when York County was updated. Records submitted since the last update are filed by county and township in the Harrisburg offices of the Pa Geological Survey and can be examined by visiting that office. In 1999 the PAGS searched paper files for records that could be located with

Table III-2
Hydrogeologic Parameters for the Hydrogeologic Units in Bucks County

minimum effort. Interns began assigning coordinates and entering the data for these selected wells. That data will be added to PaGWIS once it has been reviewed. The date of the last update for the Water Well Inventory in each county can be found in field *Last_WWI* of the table *tblCountyCodeLU*. Although drillers have been obligated by law since 1966 to submit a completion report for every water well constructed in the state, it is estimated that many thousands go unreported each year.

b. Groundwater Site Inventory (GWSI)

Source: USGS

BLE Shapefile ID:*pgwsiwells83s.shp*

GWSI is part of the United States Geological Survey's (USGS) WATSTORE system, a national database to manage water data. PaGWIS contains information on 44,411 wells and 1,538 springs from this database and is current through July 1998. Locations for all GWSI sites have been determined through a field visit. The BLE shapefile pgwsiwells83s.shp is a subset of this inventory and contains 233 well location points. Twenty-one of these wells are listed as unused.

Most of the data in GWSI resulted from water resource studies conducted by either the Pennsylvania or United States Geological Surveys. Much of this same data and the resulting interpretation can be found in the published reports from these studies. Since 1966 the WWI data, discussed above, has provided the starting point for many of the sites in GWSI, so it is likely that there is some duplication in the two datasets. GWSI contains a wealth of historical data, some dating to the early 1900s.

c. Public Water Supply Wells (PDEPWELLS)

Source: PADEP

BLE Shapefile ID: *pdepwells83s.shp*

The Bureau of Water Supply Management in Pennsylvania's Department of Environmental Protection (PADEP) provided data on selected public water supply wells. PaGWIS contains information regarding 9,067 public water supply wells that were not present in either WWI or GWSI. The BLE shapefile *pdepwells83s.shp* is a subset of this inventory and contains 59 commercial, industrial and public water supply well location points. Many of these wells were constructed prior to the Water Well Inventory. A higher percentage of public water supply wells go unreported to the WWI because drillers mistakenly believe the consultant overseeing the construction will submit the completion report.

2. Pennsylvania Spatial Data Access (PASDA) Website Data

The following data were downloaded from the PASDA website at *www.pasda.psu.edu* .

a. Pennsylvania Groundwater Sources 2001

Source: PASDA website
BLE Shapefile ID: *ppawells200183s.shp*

This coverage of public groundwater sources for Pennsylvania was generated by the PADEP and includes the most recently updated (July 2001) information about water system names, population served, and the types of water system, the sources serves and other attributes from the PADWIS database maintained by the Pennsylvania DEP, Bureau of Water Supply Management, Division of Drinking Water Management. Drinking water source locations are necessary to DEP permitting processes. The PADEP warns that the positional information regarding noncommunity water sources is at times lacking and should not be used with confidence for decision-making. The BLE shapefile *ppawell200183s.shp* contains 106 public well groundwater sources in the Pennridge Area.

b. Delaware River Basin Commission Data of Commercial, Industrial & Public Groundwater Withdrawals

Source: DRBC (*with-cip*) via PASDA website
BLE Shapefile ID: *pwatersupply83s.shp*

These data were obtained from the Delaware River Basin Commission (DRBC) and were created from PADEP files. It is intended for use by the DRBC for various analyses of the Southeast Pennsylvania Groundwater Protected Area. The locations were determined from 1:24000 scale USGS topographic maps. The attribute data were collected from PADEP questionnaires. The BLE shapefile *pwatersupply83s.shp* identifies 154 water supply locations in the Pennridge study area.