APPENDIX 6

AMITY TOWNSHIP
GROUNDWATER RECHARGE

AMITY TOWNSHIP GROUNDWATER RECHARGE

There are numerous factors that can influence the amount of water that an aquifer receives as recharge. Groundwater recharge is directly connected to the hydrologic cycle. In a very simple form, the hydrologic cycle can be described of as water being transported from the ocean to the atmosphere by evaporation; then from the atmosphere to land surface by precipitation; from the land, water can take several routes, but eventually the water returns to the ocean. Due to the finite quantity of water that is present on our planet, the hydrologic cycle is considered a closed system. Once precipitation reaches land surface by rainfall or snowfall, numerous factors control its eventual migration back to the ocean. Basically, the precipitation will follow three routes; storage in surface depressions such as lakes, overland runoff to streams or subsurface infiltration (groundwater recharge). This section of the plan investigates the amount of groundwater recharge (subsurface infiltration) that is available in Amity Township.

Once the water infiltrates the earth's surface, some of the water will replenish the soil moisture, some will be utilized to sustain vegetation and the remaining amount will percolate downward to replenish the groundwater aquifer(s). Numerous factors can influence the amount of precipitation that will recharge the groundwater supply. Some of these factors include soil type, soil moisture content, duration and intensity of the precipitation event, temperature, time of year, slopes and man-made impacts. Of these numerous factors, groundwater recharge is most directly controlled by the frequency of the precipitation events and the soil conditions. The underlying rock type largely derives the soil conditions. Due to the complexities involved, groundwater recharge cannot be directly measured.

Although direct measurement options for groundwater recharge are not available, recharge can be estimated by the natural groundwater discharge to a stream (baseflow of a stream). The assumption utilized for calculating the groundwater recharge of an extended area is that the long-term stream baseflow equals the long-term rate of groundwater recharge. The stream baseflow separation method is considered a conservative approach for obtaining groundwater recharge values. Modified groundwater recharge values from a 1996 U.S. Geological Survey (USGS) Study of the Neshaminy Creek Basin (Schreffler 1996: 12) were utilized for calculating the available recharge for Amity Township. Conservative (1 in 10 year) recharge rates were used that reflect dry conditions. Basically, the recharge rates used for this study will be exceeded during 90 percent of the years.

Spatially, Amity Township covers 18.41 square miles. The quantity of groundwater recharge for the study area is calculated by multiplying the geologic recharge rate by the surface area of each type of geologic rock unit. The USGS recharge rates are subdivided into the following four categories: Brunswick and Lockatong Formations, Stockton

Formation, Carbonate rocks and Crystalline rocks. The study area includes all of these aquifer types. Uniquely, the Brunswick Formation in Amity Township does not directly conform to the combination of the Brunswick and Lockatong Formations described in the 1996 USGS Study. The Brunswick and Lockatong Formations in the USGS Study is primarily composed of shales, mudstones and siltstones. Due to a different depositional environment, the Amity Study Area contains more sandstone units that have a higher groundwater recharge rate. The Amity Area is located along the northern border of the Triassic Lowland Physiographic Province. As classified by Longwill, "*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*".

This is supported by over eight (8) percent of the study area being underlain by the Brunswick limestone fanglomerate rock unit. Another difference with the USGS Study, is that the Amity area only contains less than one (1) percent of the Lockatong Formation. Based on the greater proportion of sandstone beds and the minimal coverage of the Lockatong Formation, the groundwater recharge value for the Brunswick Formation more closely correlates to the recharge values of the Stockton Formation. The Stockton Formation is a regional aquifer that is comprised of shale, siltstone and sandstone rocks. The groundwater recharge rate for the Stockton Formation is 342,000 gallons per day per square mile (Schreffler 1996: 12). We cross-referenced the Stockton groundwater recharge value with a 1982 R.E. Wright (REW) Study commissioned by the Delaware River Basin Commission (DRBC). In the REW Study, the mean recharge rate between the shale/siltstone unit and the sandstone unit is 340,000 gallons per day per square mile, which is consistent with the Stockton Formation in the USGS Study.

Based on the USGS 1 in 10 year recharge rates, the average groundwater recharge for Amity Township is 6.3 million gallons per day. Table 1 presents the square mile area of the geologic units and the groundwater recharge that were utilized to calculate the recharge values.

TABLE 1
AMITY TOWNSHIP
GROUNDWATER RECHARGE RATES

Geologic Unit	Area (mi^2)	Recharge Rate ($mg/d/mi^2$)
Brunswick	16.84	343,000
Lockatong & Martinsburg	0.03	189,000
Carbonate Rocks	0.9	408,000
Crystalline Rocks	0.64	302,000

GROUNDWATER WITHDRAWAL

This section of the joint comprehensive plan provides estimates for the average daily groundwater withdrawals for Amity Township as well as the projected future demands. This data, coupled with the recharge data is valuable to assess the relative condition of the groundwater resources for the study area. The compilation and review of this data is a tool for making informed decisions on the future management of the water resources. In simple terms, effective groundwater management monitors the rate of groundwater withdrawal vs. the rate of groundwater recharge for a given hydrologic area.

Known and projected groundwater withdrawals for the study area along with projected population estimates were utilized to calculate the total volume of groundwater that is being withdrawn on a daily basis. A combination of public water supply wells and on-lot domestic wells withdraw water from within the Township. The public water supply system is metered and monitored on a daily basis. From a water management viewpoint, greater control and management of a public water supply system can be obtained compared to the individual on-lot wells.

The estimated water withdrawal in Amity Township in the year 2000 is 835,900 gallons per day (gpd).

For the year 2000 in Amity Township, the groundwater withdrawal was calculated by the following assumptions:

- Total Population 8,867 (2000 census),
- Citizens Water System serves an estimated population of 4,428 with an average daily withdrawal of 392,000 gpd.

- The remainder of the population, 4,439 was multiplied by 100 gpd/person, which equates to 443,900 gpd. The 100 gpd/person figure is a very conservative approach that takes into account residential wells along with commercial and industrial water users. Citizens Utilities Water Company averages 88 gallons of water per person per day.

Based on the public water system expanding by 150 connections per year over the next 10 years, the estimated population served by public water in 2010 is 8,478. Utilizing the current 88 gallons per person per day, the estimated groundwater withdrawal of the water system is 0.8 mgd. If the Amity population served by on-lot water expands by 10 percent, the estimated water withdrawal is 0.4 mgd. The total estimated groundwater withdrawal in Amity Township for the year 2010 is 1.2 mgd.

Based on a groundwater recharge estimate of 6.3 mgd and a year 2010 groundwater withdrawal of 1.2 mgd, Amity Township has sufficient groundwater resources to support the projected populations. Even with the available groundwater supply, it does not eliminate well pumping interference issues, particularly during dry periods. These well interference issues may be more evident in areas underlain by diabase such as Monocacy Hill. The diabase generally is a poor aquifer with the majority of the stored water contained in the shallow weathered zones of the bedrock. Also, the Brunswick Formation produces an anisotrophic cone-of-depression with preferential groundwater flow along geologic strike. Wells located along strike are more likely to be impacted by pumping than wells located perpendicular to strike.