# APPENDIX E–SOUTHERN MARYLAND PILOT STUDY

## Introduction

The counties of Southern Maryland have experienced significant population growth over the last thirty years and the Maryland Department of Planning's (MDP) population projections show that the region's growth will continue over the next thirty years (Figure E-1). The Southern Maryland counties were chosen as a pilot study area in an effort to study the relationship between demand for water and the available supply in a rapidly growing region and because the region is representative of the Coastal Plain physiographic province of the State. Coastal Plain hydrogeology shapes the region and as a result the population relies almost exclusively on ground water for water supply. The exceptions are in Prince George's County where the large majority of the population is served by the Washington Suburban Sanitary Commission (WSSC) water utility and a small portion of northern Anne Arundel County where water is provided by Baltimore City. Residents of southern and eastern Prince George's County outside of WSSC's service area, and the majority of Anne Arundel County residents remain dependent on ground water for water supply. Residents of Calvert, Charles, and St. Mary's counties rely solely on ground water.

In Southern Maryland, the predominant source of potable water is ground water. The use of the Chesapeake Bay or the large tidal rivers is not feasible due to their brackish nature. The exception is for thermoelectric and nuclear power generation, which use large quantities of brackish water for once-through cooling. Because the surficial aquifer does not provide an adequate supply for large users, the large majority of ground water use in the region is from the major confined aquifers.

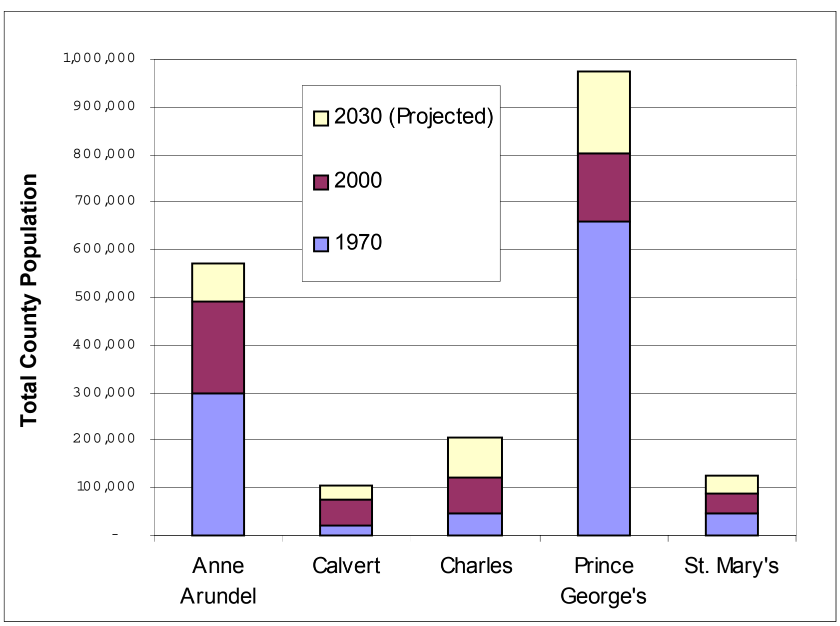


Figure E-1: Population in Southern Maryland - 1970 to 2030
(Source of Data: Maryland Department of Planning)

Conducting a water supply and demand study in this region is difficult due to the complexity involved in predicting recharge for this type of hydrologic system. The basic principles of mass balance apply, i.e. the total water entering the system as recharge equals the amount leaving through discharge. In the confined aquifer system, however, ground water may travel great distances across several counties after it infiltrates in a recharge area. While precipitation is the source of recharge to the aquifers, it does not have an immediate effect on ground water levels due to confining layers of clay or silt that isolate the deeper parts of the aquifers from direct infiltration. Therefore, in order to analyze supply and demand in this complex hydrologic system, it is essential to have adequate data on the aquifer properties as well as water level measurements distributed over space and time. The approach taken in this pilot study is to discuss what is known and documented about the five major water supply aquifers and evaluate previous studies that have predicted their water supply potential.

**Water Supply in Southern Maryland - Occurrence, Distribution, and Properties of the Five Major Aquifers**

The geology of the Southern Maryland region is made up of layers of unconsolidated sediments of sand, clay, silt, and gravel, which gradually become deeper and thicker to the southeast. The sand and gravel layers form water-bearing aquifers, and the silt and clay deposits form confining layers. Major aquifers in the region include (from shallow to deep) the Piney Point, Aquia, Magothy, Upper Patapsco, Lower Patapsco, and Patuxent aquifers (Figure E-2). Sediment layers are underlain by hard bedrock, which is 2,515 feet below sea level at Lexington Park in southern St. Mary's County. The surficial aquifer is used for existing domestic supplies in some locations, but it is not a major source and new users are likely to obtain their water supplies from the confined aquifers.

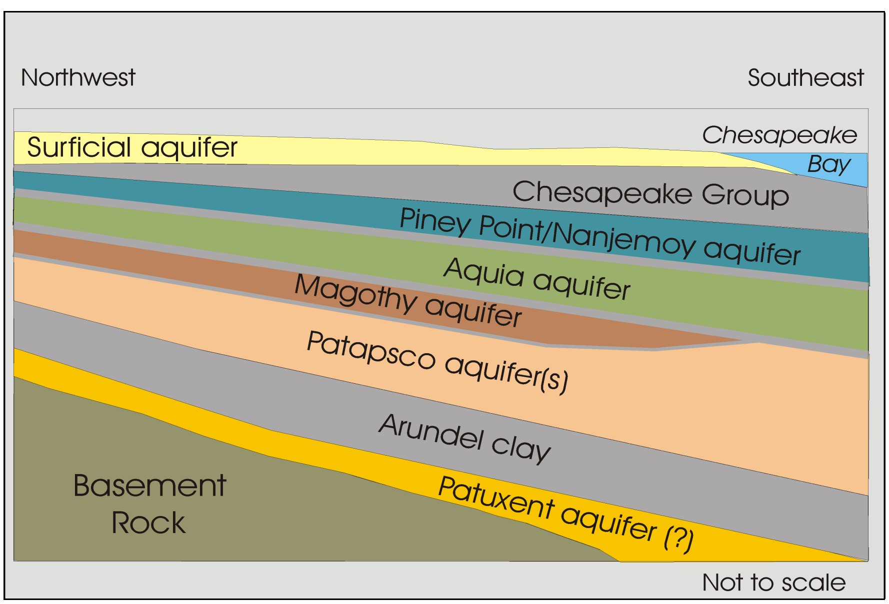


Figure E-2. Generalized cross-section of Southern Maryland, showing the major aquifers.

*Description and Extent of the Aquifers*

The area where the aquifers are exposed at the land surface is known as the outcrop area . The five aquifers outcrop in northeast trending bands of varying widths across the central portions of Prince George's and Anne Arundel Counties, and a small portion of northeastern Charles County. The aquifers extend in the subsurface through the entire five-county region of Southern Maryland, however not every aquifer is present in every location (Figure E-3). The depths to the top of the confined aquifers range from as little as 50 feet below mean sea level (bmsl) near their outcrop areas up to 1,800 feet bmsl where the Patuxent aquifer is mapped at the southern tip of Prince George's county. Aquifer thickness also varies with specific location, but thickness generally increases with depth in a southeasterly direction. Published values for aquifer thickness along with other aquifer properties are given in Table E-1. Each of the aquifers is separated from overlying or underlying aquifers by a confining unit that, while less permeable, still allows exchange of ground water through leakage. These confining units are, in general, laterally continuous. However, where they are non-continuous the aquifers may interact hydraulically.

*Aquifer Properties*

Transmissivity is a measure of an aquifer's ability to produce water and is directly related to the aquifer's physical properties, namely its hydraulic conductivity and thickness. Transmissivity is usually well correlated with the thickness of the aquifer and this holds true for most of the aquifers in Southern Maryland. An exception is the Aquia aquifer, in which the transmissivity is more closely related to the composition and percent of clay, which varies by location. Transmissivity values are determined from localized pump tests that provide a value in a specific location, but these values can be extrapolated to a larger area where the aquifer properties are similar. Transmissivity values for each of the five aquifers have been published throughout the five-county region and the ranges are given in Table E-1. In general, the locations where large users utilize the aquifer are also the locations where transmissivity values are highest.

*Aquifer Modeling*

The aquifers in Southern Maryland have been modeled to predict future ground water conditions in several reports, the most recent of which contain projected demands up to the year 2025 (Fleck and Wilson, 1990, Achmad and Hansen, 1997, Andreason 1999 and 2002). Each report assessed the water supply potential of one or more of the major aquifers within a limited area of Southern Maryland. The aquifers were modeled to predict their response to pumping at various rates in several locations. In some models, the water level response in the overlying aquifer was also modeled based on pumping the underlying aquifer. In general, the pumping scenarios fell under one of several categories based on 1) pumping at current average and maximum permitted withdrawals into the future, 2) increased pumping at existing wellfields using county population growth projections, 3) increased pumping at new wellfield locations using county population projections, and 4) increasing water use in an aquifer based on increased domestic supply use from county population projections.

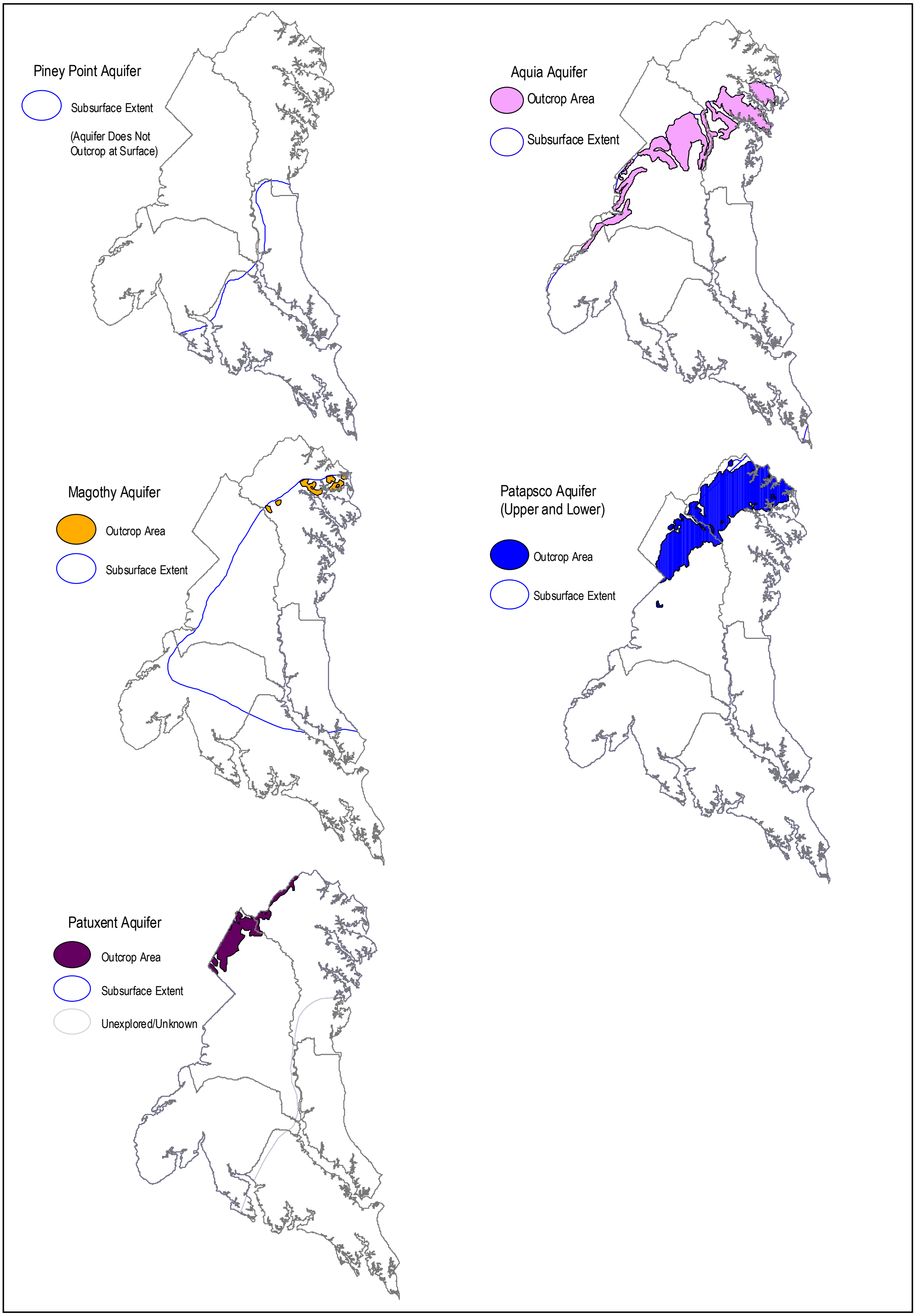


Figure E-3. Areal Extent of the Five Major Aquifers in Southern Maryland

Table E-1. Characteristics of the Five Major Aquifers in Southern Maryland

| Aquifer Name | Overlying Confining Unit | Thickness (feet) | Transmissivity ($feet^2$/day) | Counties of Primary Use |
|---|---|---|---|---|
| Piney Point | Chesapeake Group Clays | 10 -130 | 100 - 500 | St. Mary's, Calvert |
| Aquia | Marlboro Clay | 125 - 200 | 0 - 3,000 | Calvert, Anne Arundel, St. Mary's |
| Magothy | Brightseat and Matawan Fms. | 50 - 200 | 1,000 - 12,000 | Anne Arundel, Prince George's, Charles |
| Patapsco Upper Lower | Patapsco Fm. Clays | 50 - 250 | 1,000 - 10,000<br>1,000 - 5,000 | Charles, Anne Arundel |
| Patuxent | Arundel Clay | 20 – 250(?*) | 200 - 8,000 | Anne Arundel, Charles |

*Total thickness of the Patuxent formation is an unknown in many areas.

In some instances, the models also provide estimates of recharge, a water budget, or a total available supply for an aquifer based on inflow and outflow estimates. Recharge was estimated from the outcrop areas, leakage from the adjacent confined aquifers or the water table aquifer, and storage. Outflow was estimated from pumping wells and natural discharge. Since the relationship between aquifer recharge and yield is complex in these confined systems, it is difficult to estimate a total amount of available water in each aquifer. The total available amount is likely to vary based on the location of pumping centers and the assumptions made about recharge and storage in the aquifer. The aquifer's response to pumping is the best indicator of an aquifer's reliability. Water level declines at specific locations are affected by transmissivity, storage, recharge, leakage, and proximity to aquifer boundaries, which impose a practical limit on aquifer yield despite sufficient recharge rates.

**Sustainable Withdrawals**

Water levels in the Aquia, Magothy and Patapsco aquifers have declined over the years due to increases in use. Water levels measured in an aquifer provide an indication of the impacts of pumpage on the aquifer's water-producing capabilities. Changes in water level s also provide a measure of the reduction in recharge due to development in outcrop areas. As pumpage from an aquifer increases, water levels will decline; the amount of decline for a given time period is called the drawdown. Measured water levels in an aquifer, when related to sea level and plotted on a map, show the potentiometric surface of the aquifer, which is the level to which water in a given aquifer rises in a well that is screened in that aquifer. The potentiometric surface is above the top of the aquifer because the water in the aquifer is under pressure. Each aquifer has its own potentiometric surface and these are mapped annually through cooperative programs of the U.S. Geological Survey, Maryland Geological Survey, and participating agencies.

The deep water levels near large pumping centers produce an inverted cone shape in the potentiometric surface, which is referred to as a cone of depression.

The total sustainable withdrawal rate of a confined aquifer is determined by the rate at which the aquifer is recharged and the hydraulic characteristics of the aquifer, primarily the transmissivity. Unlike a water table aquifer, the total available water in a confined aquifer is not necessarily the primary limiting factor for its productive use. Therefore, management strategies have been adopted that utilize the best-known limiting factors for water use in the confined aquifers. In a confined aquifer, it is critical that water levels do not drop below the top of the aquifer. The current method used in regulating water use in the confined aquifers in Maryland is the 80% Management Level. The 80% Management Level represents 80% of the drawdown from the pre-pumping potentiometric surface to the top of the aquifer (Figure E-4).

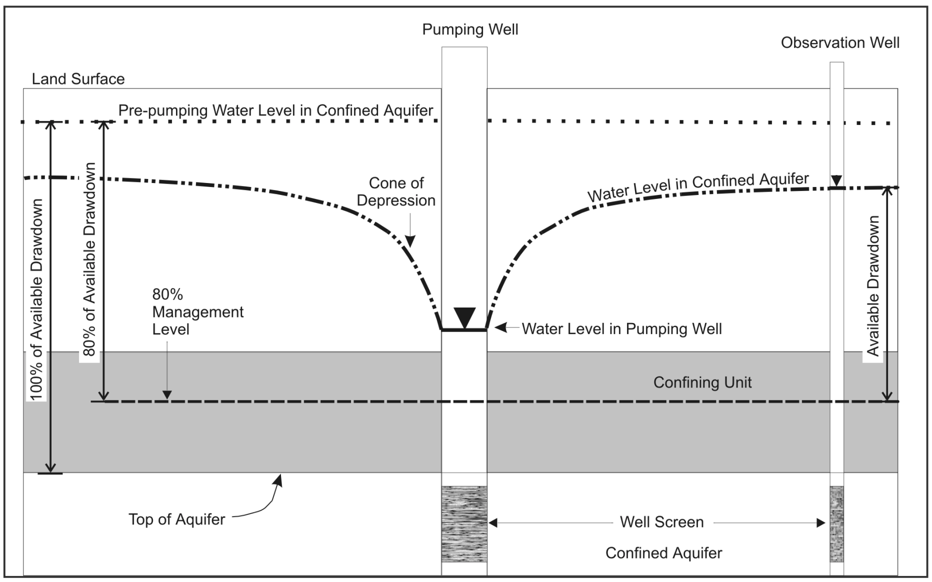


Figure E-4. Schematic Illustration of the 80% Management Level in the Confined Aquifers. The water level rises above the top of the aquifer because it is under pressure and is lowered due to withdrawals from the pumping well. The water level measured at the pumping well is much lower than the water level in the observation well due to the formation of a cone of depression.

### *Water Level Trends in the Confined Aquifers*

In order to assess the effects of long-term ground water use in the Southern Maryland pilot study area, hydrograph records were examined for each aquifer. Figures E-5 through E-10 present the results of this evaluation for each of the major aquifers from shallowest to deepest. Each hydrograph record is plotted with the pre-pumping water level and the derived 80% management level at the given location. Monitoring wells were chosen to represent the extent of the aquifer as well as areas where there are significant users in the aquifer. The locations also attempt to cover a cross-sectional area of the aquifer to capture the differences in water level trends in the areas of the aquifer closest to the outcrop and down gradient from the outcrop (known as the updip and downdip areas, respectively). A limitation of this analysis was the availability of pre-pumping measurements in proximity of the monitoring well. A long-term monitoring

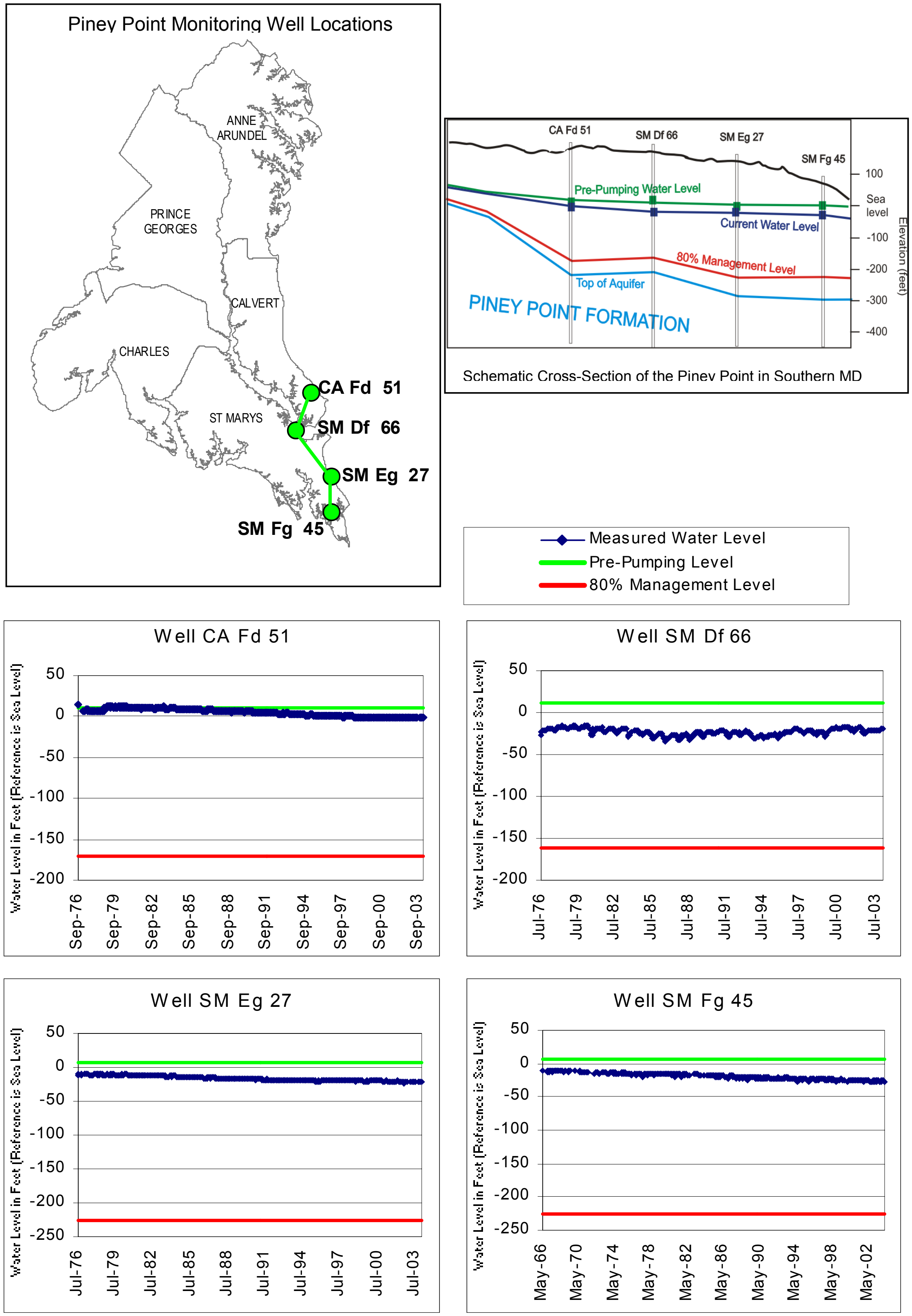


Figure E-5. Hydrograph Records of USGS/MGS Monitoring Wells in the Piney Point Formation Showing Current Water Levels, Pre-pumping conditions and the 80% Management Level.

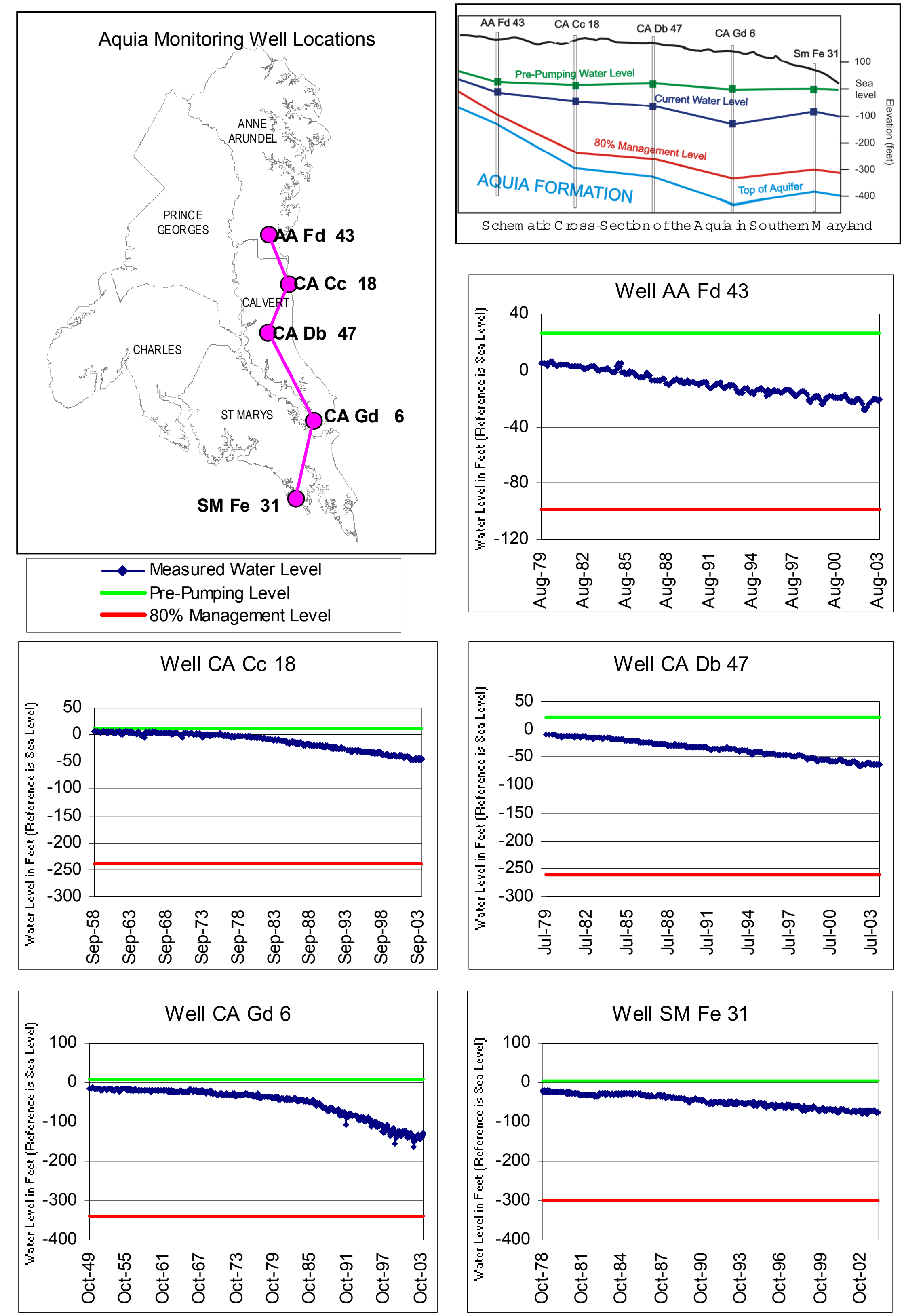


Figure E-6. Hydrograph Records of USGS/MGS Monitoring Wells in the Aquia Formation Showing Current Water Levels, Pre-pumping conditions and the 80% Management Level.

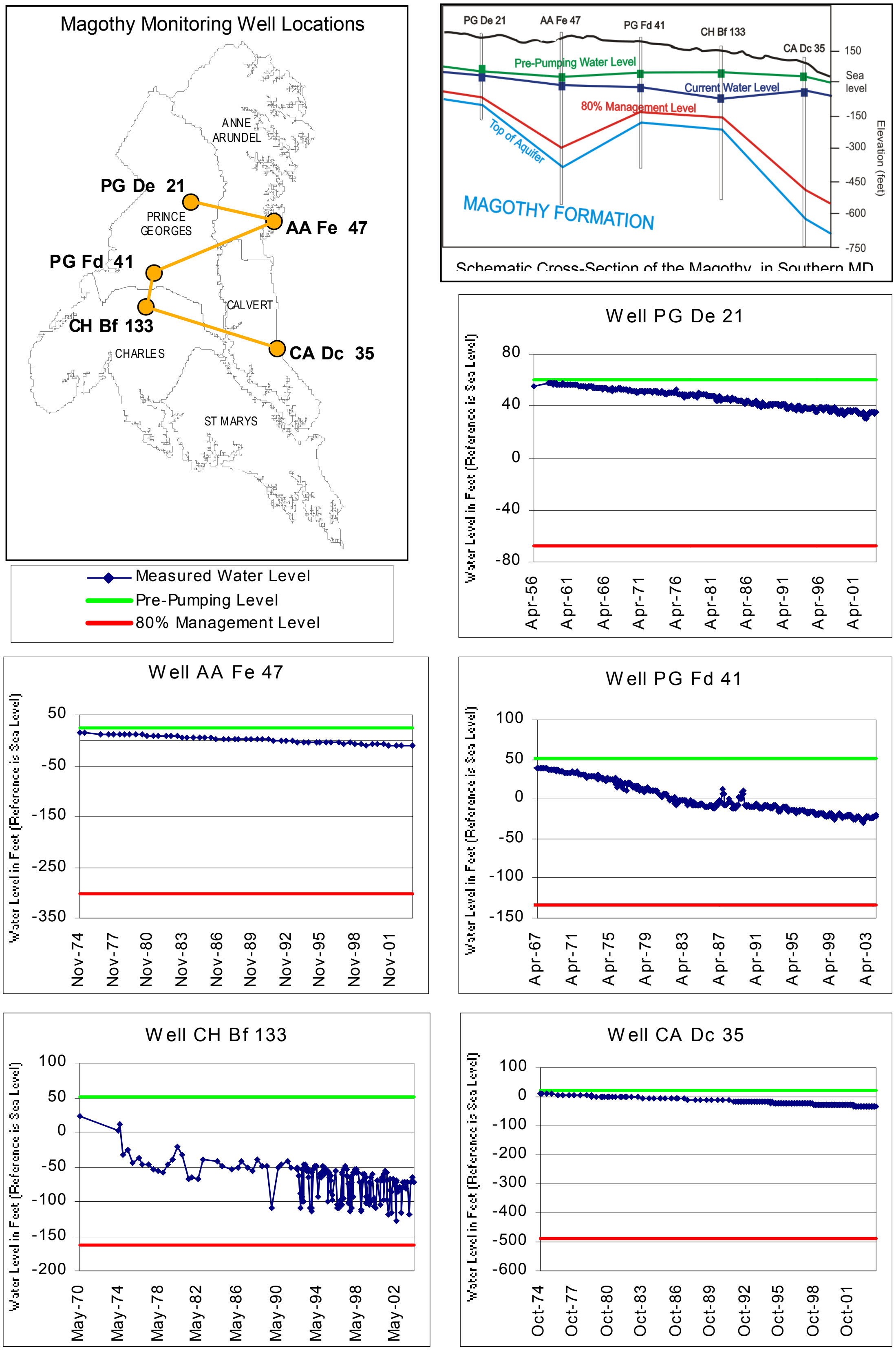


Figure E-7. Hydrograph Records of USGS/MGS Monitoring Wells in the Magothy Formation Showing Current Water Levels, Pre-pumping conditions and the 80% Management Level.

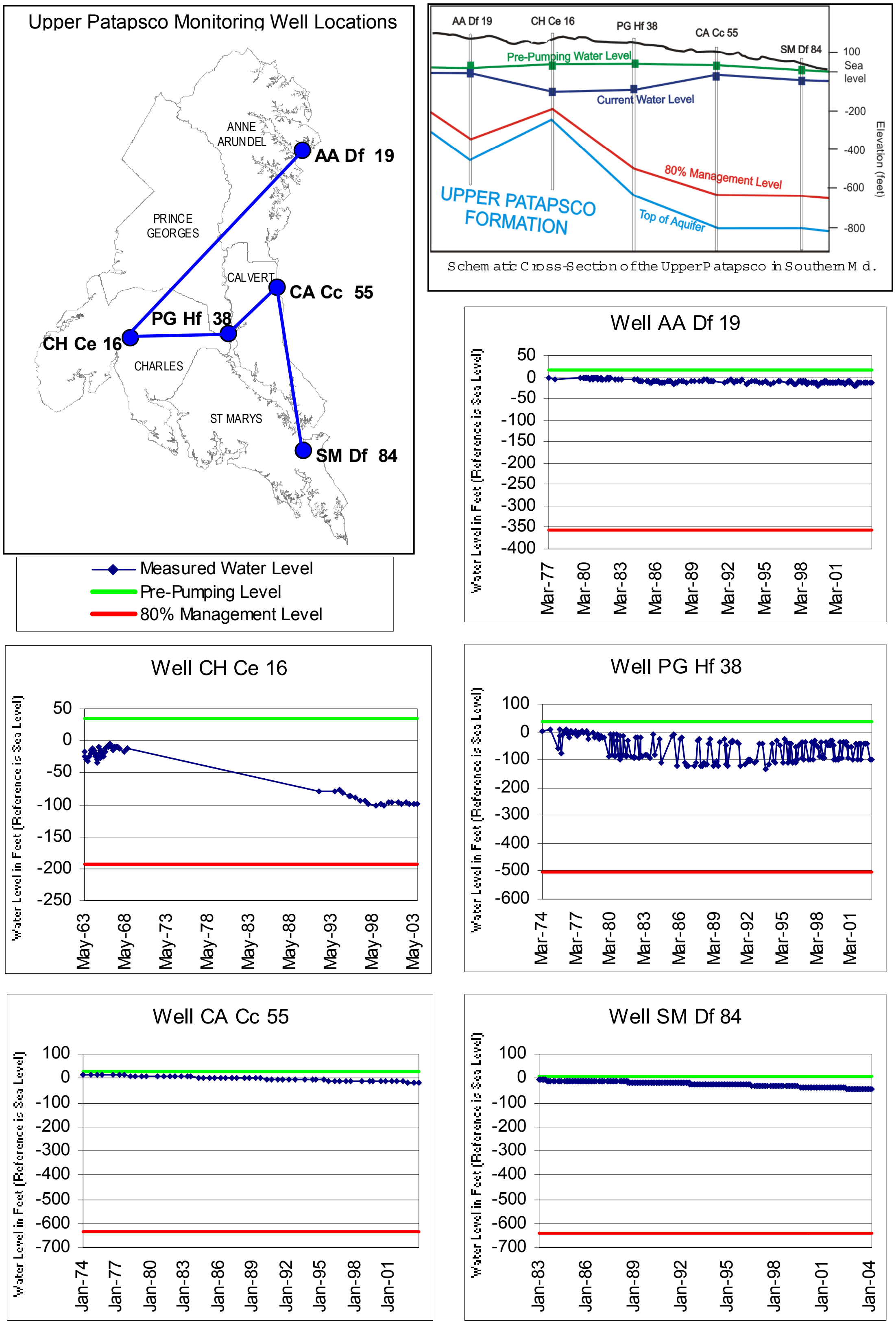


Figure E-8. Hydrograph Records of USGS/MGS Monitoring Wells in the Upper Patapsco Formation Showing Current Water Levels, Pre-pumping conditions and the 80% Management Level.

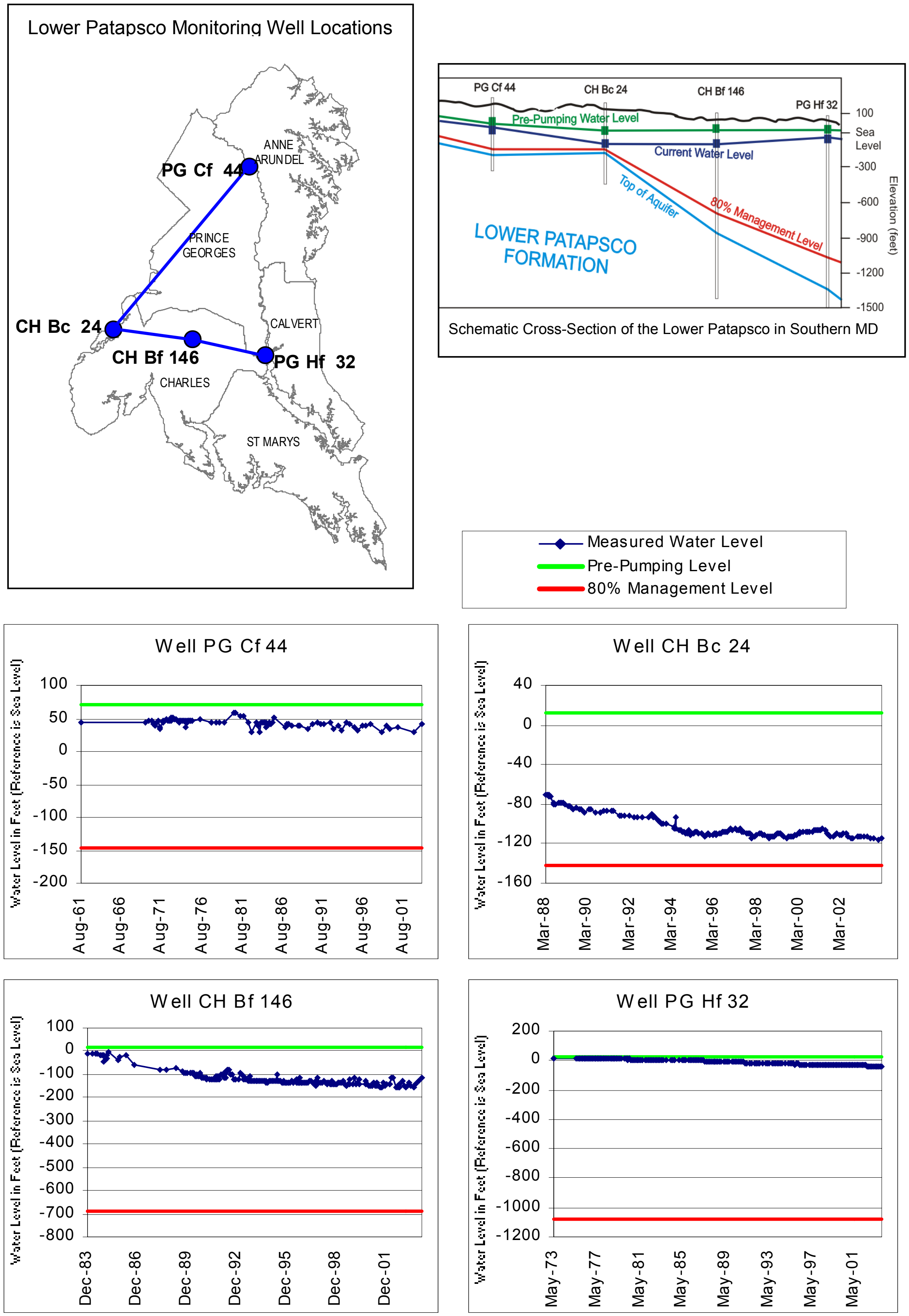


Figure E-9. Hydrograph Records of USGS/MGS Monitoring Wells in the Lower Patapsco Formation Showing Current Water Levels, Pre-pumping conditions and the 80% Management Level.

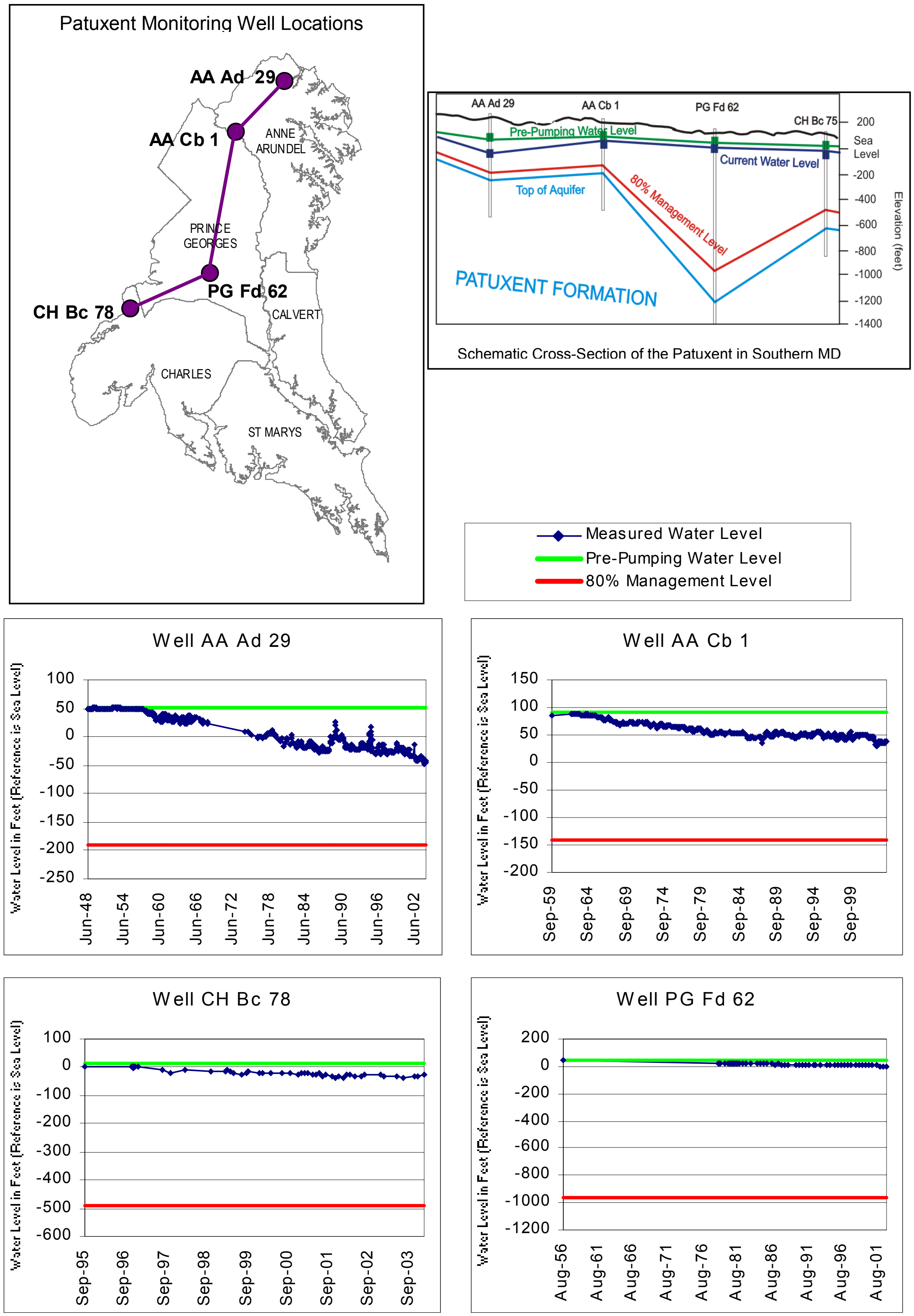


Figure E-10. Hydrograph Records of USGS/MGS Monitoring Wells in the Patuxent Formation Showing Current Water Levels, Pre-pumping conditions and the 80% Management Level.

record of at least twenty years was attempted for each aquifer. Monitoring wells with a shorter period of record were used, if necessary, to capture an area where drawdown is evident due to significant use in the aquifer.

Examination of the hydrograph records for the five major aquifers reveals that drawdown is occurring throughout the aquifers to varying degrees. As expected, drawdown is greatest in close proximity to the largest users. The 80% Management Level is being approached in some aquifers in their updip areas where available drawdown is the smallest. In downdip locations, several hundred feet of drawdown is available for each aquifer. A drawdown rate was calculated for each monitoring well based on the period of record (Table E-2). Well CA Gd 6 (Figure E-6) shows a long-term decline in water levels in an area where there has been continuous growth and increased use of an aquifer. Conversely, in an area of similar growth, well SM Df 66 (Figures E-5 and E-11) shows the effects of shifting pumpage to a deeper aquifer; water levels in the Piney Point aquifer have significantly recovered since 1988.

Table E-2. Drawdown Rates in the Southern Maryland Pilot Study Monitoring Wells

| **Aquifer** | **Average Drawdown Rate in Monitoring Wells (feet/year)** | **Range of Drawdown Rates in Monitoring Wells (feet/year)** |
|---|---|---|
| Piney Point | -0.3 | +0.2 to -0.6 |
| Aquia | -1.6 | -0.9 to -4.4 |
| Magothy | - 1.4 | -0.5 to -2.8 |
| Patapsco - Upper<br>Patapsco - Lower | -3.0<br>-1.8 | -0.4 to -7.4<br>-0.4 to -3.6 |
| Patuxent | -1.9 | -0.8 to -3.8 |

Some areas of Southern Maryland are of concern with respect to managing sustainable ground water levels due to a combination of the effects described above. An example of this is in western Charles County near the Waldorf area (well CH Bf 133, Figure E-7 and well CH Ce 16, Figure E-8). The large use coupled with the updip extents of the Magothy and Upper Patapsco aquifers is resulting in water levels approaching the 80% management level in this area. In a small area of Southern Anne Arundel County that is in close proximity to the outcrop area of the Aquia aquifer (well AA Fd 43, Figure E-6), water levels are approaching, or in some cases have exceeded, the 80% management level due to the combination of localized domestic use and large users in neighboring Calvert County.

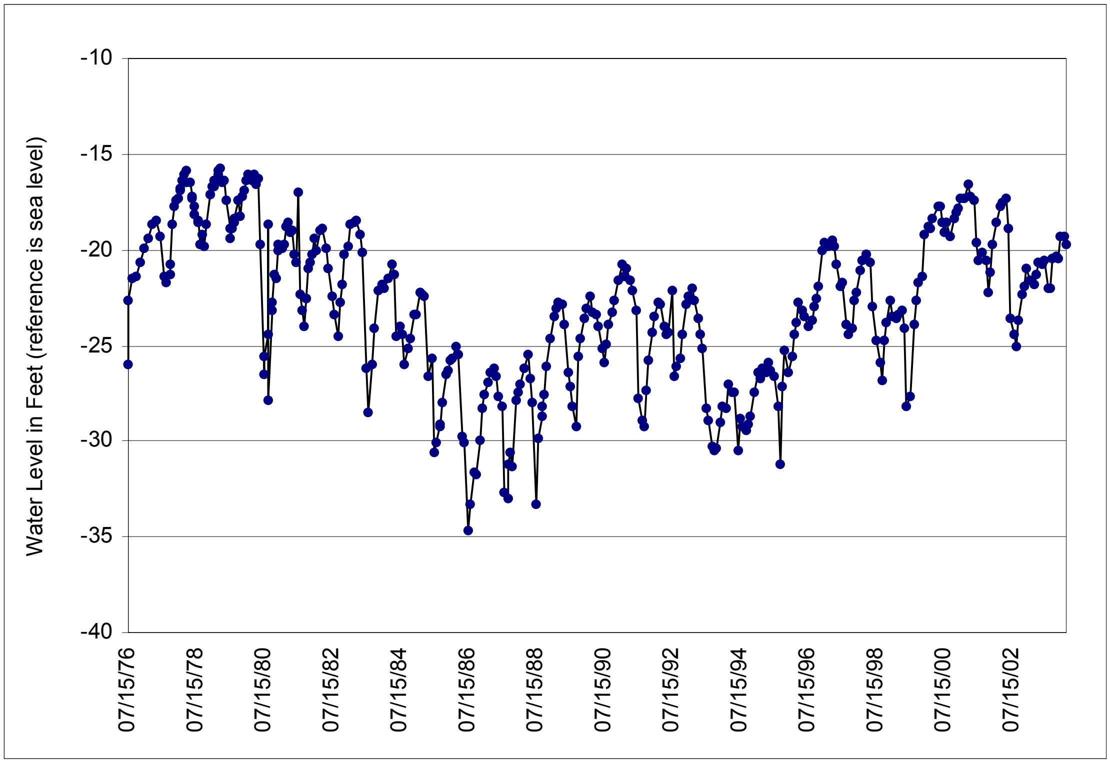


Figure E-11. Hydrograph showing water level decline and recovery in Monitoring Well SM Df 66 in the Piney Point aquifer (see Figure E-5 for well location.)

Figure E-12 shows the potentiometric surface for the Aquia aquifer in 2002. Water withdrawals from major pumping centers at Chesapeake Ranch Estates, Solomons, and Lexington Park have resulted in the development of a large cone of depression. At Lexington Park, near the center of the cone, water levels have declined to about 160 feet below sea level. Between 1982 and 2001, Aquia water levels declined over 100 feet in the Lexington Park area, about 40 to 50 feet in northern St. Mary's County, and 30 to 40 feet in northern Calvert County. A deep cone of depression in the potentiometric surface has developed in the lower Patapsco aquifer in the Waldorf area that extends outward to include the La Plata, Indian Head, and Bryans Road areas of Charles County and the Accokeek and Brandywine areas of Prince George's County (Figure E-13). Water levels exceeding 170 feet below sea level have been recorded. Between 1990 and 2001, water levels declined about 50 feet at La Plata, 30 feet at Waldorf, and 20 feet at Bryans Road. As expected, drawdown is greatest where the use is greatest, as shown by the cones of depression.

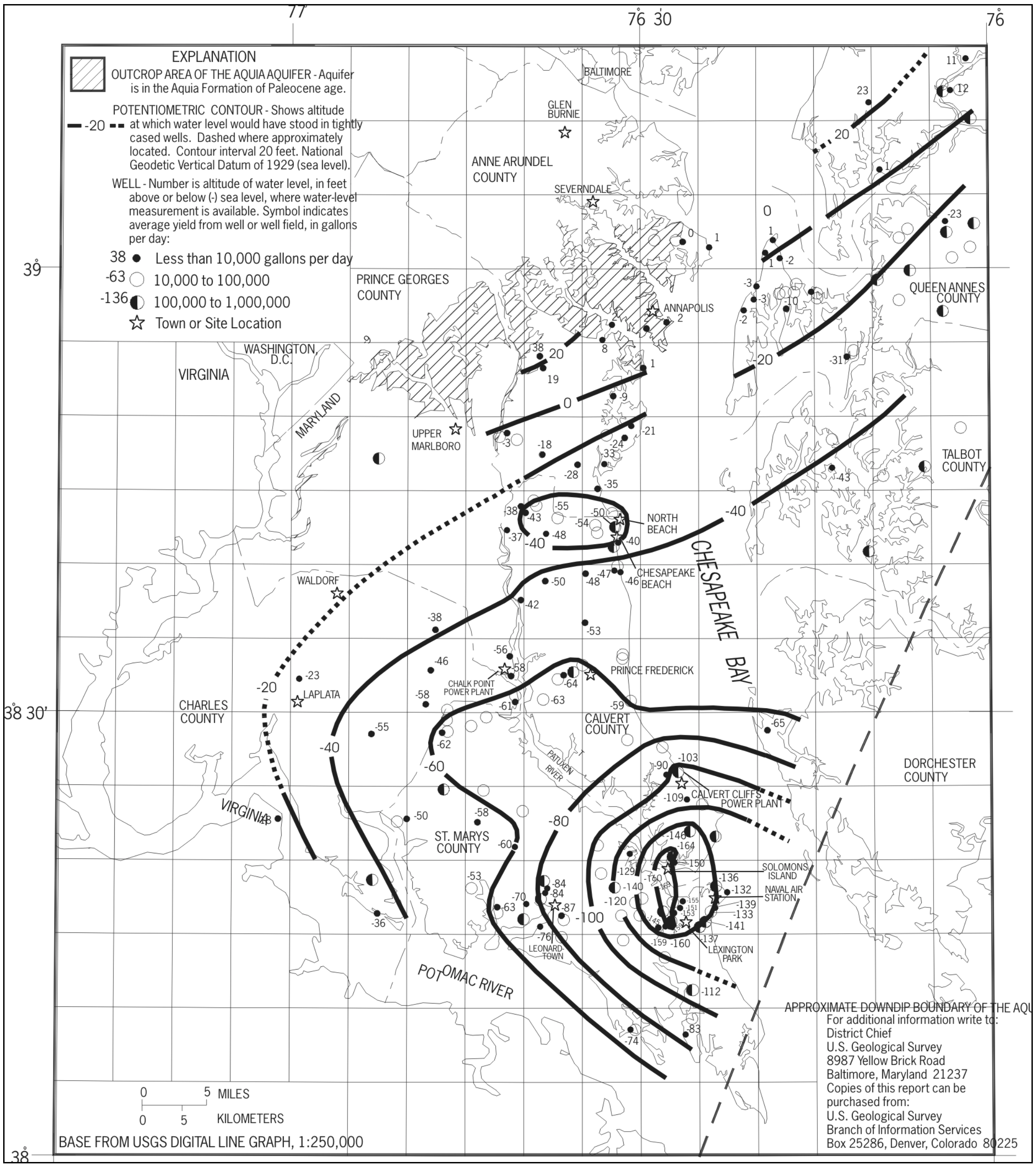


Figure E-12. Potentiometric Surface Map of the Aquia Aquifer (Curtin et al. 2002)

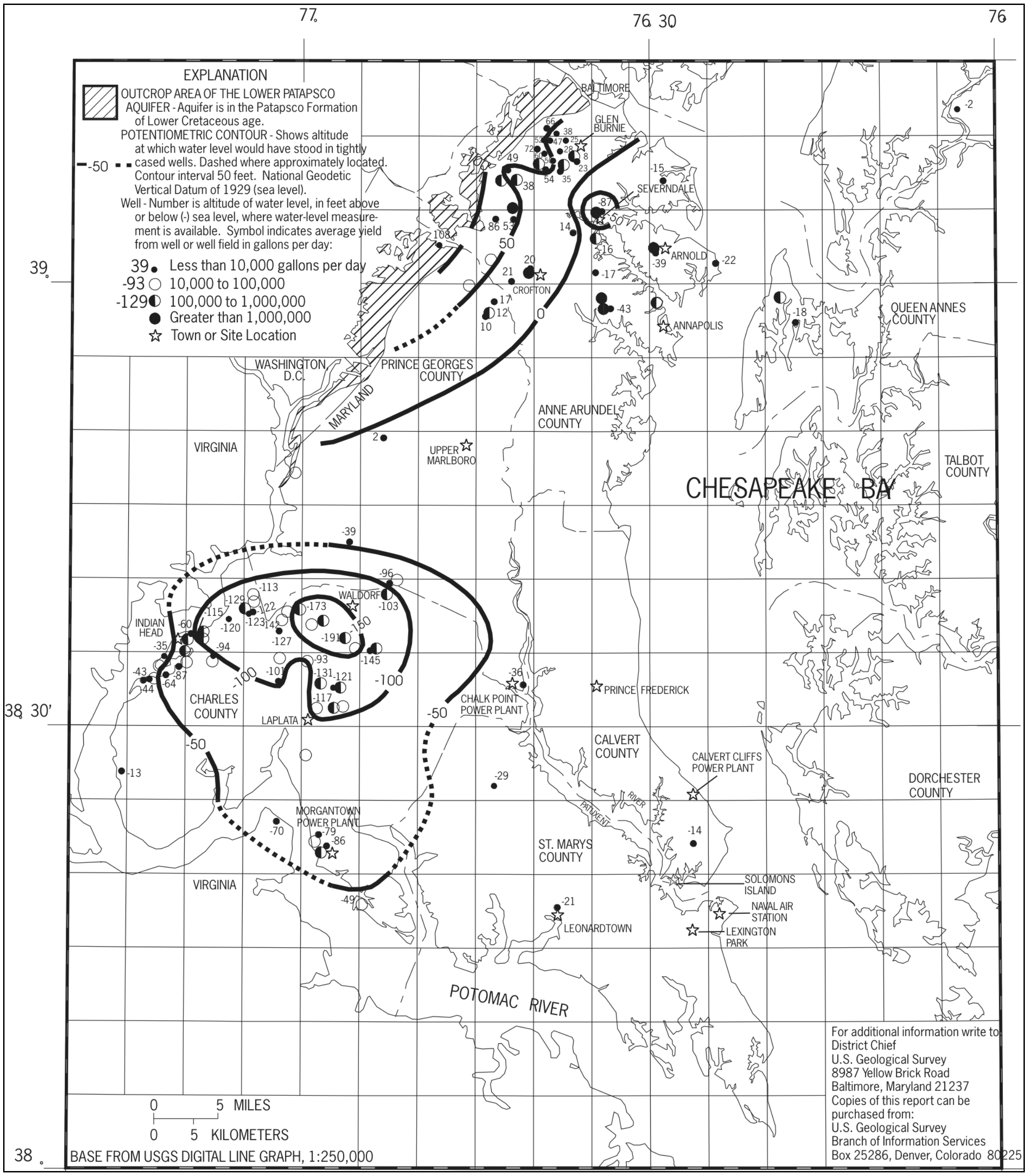

Figure E-13. Potentiometric Surface Map of the Lower Patapsco Aquifer (Curtin et al. 2002)

**Demand Analysis**

Current water demand is separated into several categories based on type of use (Table E-3). Public supply and self-supplied domestic use together make up more than 86% of the total fresh water use in Southern Maryland. Additional water transported to Prince George's County by WSSC, which is withdrawn from the Potomac River and Patuxent Reservoir, was not considered in the demand projections. A significant amount of water is used in thermoelectric power generation, however this is predominantly saline water and is not taken into consideration for the purposes of this pilot study. In order to project water demand in the future, historical records of water use by county were analyzed relative to changes in population. Three categories, public supply, self-supplied domestic, and aquaculture correlated well with changes in population. The other categories did not correlate well with population, as was expected. Future demands cannot be projected for these other categories due to the lack of a definable factor to analyze water use trends. The public supply and self-supplied domestic categories are discussed further in this section, since they represent the most significant use of water in Southern Maryland.

Table E-3. Total water withdrawals by Category and County in 2000 (in MGD)

| | Public Supply* | Commercial | Domestic* | Industrial | | Thermo-electric | | Mining | | Livestock | Aquaculture* | | Irrigation | Total | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| County | Fresh | Fresh | Fresh | Fresh | Saline | Fresh | Saline | Fresh | Saline | Fresh | Fresh | Saline | Fresh | Fresh | Saline |
| Anne Arundel | 31.23 | 3.48 | 10.93 | 1.78 | 0.60 | 0.00 | 778.21 | 0.55 | 0.00 | 0.04 | 0.01 | 0.01 | 0.55 | 48.57 | 778.82 |
| Calvert | 2.30 | 0.50 | 3.69 | 0.05 | 0.00 | 0.41 | 3,270.70 | 0.00 | 0.00 | 0.02 | 0.00 | 0.00 | 0.06 | 7.03 | 3,270.70 |
| Charles | 7.48 | 1.69 | 3.29 | 0.01 | 0.00 | 0.60 | 1,192.55 | 1.13 | 0.00 | 0.05 | 0.00 | 0.00 | 0.08 | 14.33 | 1,192.55 |
| Prince George's | 52.15 | 0.82 | 1.24 | 0.02 | 0.00 | 0.75 | 569.45 | 0.92 | 0.00 | 0.05 | 0.01 | 0.00 | 0.57 | 56.53 | 569.45 |
| St Mary's | 3.68 | 1.44 | 4.40 | 0.01 | 0.00 | 0.00 | 0.00 | 0.44 | 0.01 | 0.10 | 0.00 | 0.79 | 0.16 | 10.23 | 0.80 |
| Total: | 96.84 | 7.93 | 23.55 | 1.87 | 0.60 | 1.76 | 5,810.91 | 3.04 | 0.01 | 0.26 | 0.02 | 0.80 | 1.42 | 136.69 | 5,812.32 |

(*Categories that can be projected based on population correlation.)

*Public Supply and Self-supplied Domestic Projections.*

The USGS tracks and compiles water use data across the State annually (Figure E-14). The most recent analysis was completed for 2000 and current water demand figures discussed here are based on this data. Water use data is compiled from two main sources of information: appropriation permits issued by MDE and U.S. Census Bureau population data. Permittees using an average of 10,000 gpd or greater report water use. For permits issued for less than 10,000 gpd, the average daily permitted amount is used as an estimate of water use. Self-supplied domestic use is based on population data from the U.S. Census and is calculated from an average per capita rate of 80 gpd. While the rate of 80 gpd per capita use for self-supplied domestic is widely accepted, this rate is not specific to water use in this region and incorporates some uncertainty into current and projected water demands. Further investigation of domestic water use could improve the confidence in this rate and would improve self-supplied domestic demand figures.

Current ground water use was separated by aquifer (Table E-4). This separation is based on permit data for public supplies and the assumption that self-supplied domestic users are using the shallowest available confined aquifer. Separate totals for each of the

Patapsco and Patuxent formations were tabulated only for the category of public supply water because the available data is insufficient to separate these aquifers for self-supplied domestic use.

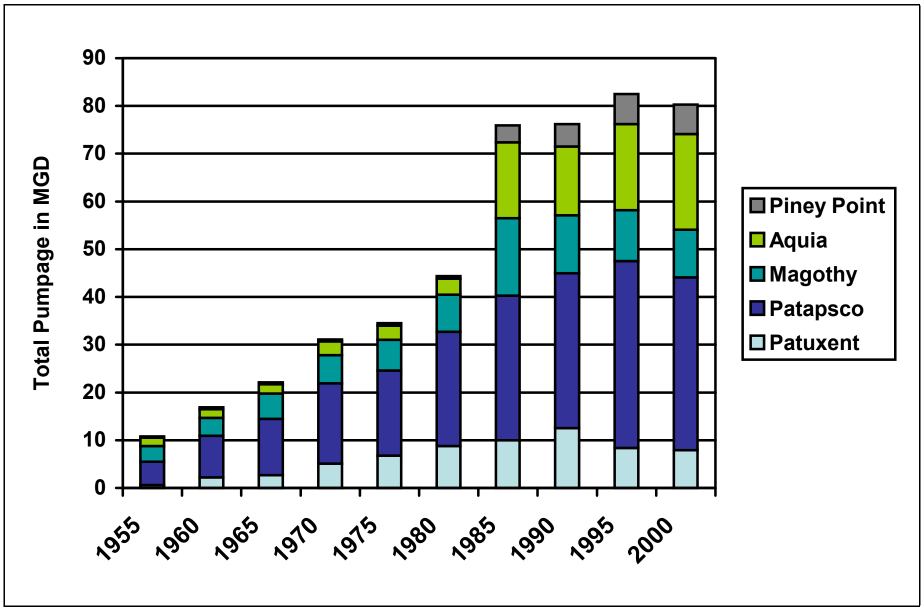


Figure E-14: Pumpage From Major Confined Aquifers in Southern Maryland

To define a relationship between population increases and water use in the pilot study area, water use data compiled by USGS for the years 1985 through 2001 were compared to changes in population during the same period. Ground water use generally correlated well with changes in population and the data was mathematically regressed against public supply and domestic ground water use for each of the Southern Maryland Counties. The regression equations that were developed were then utilized with MDP's population projections for 2020 and 2030 to project public supply and self-supplied domestic ground water uses for each county for the years 2020 and 2030 (Tables E-4, E-5).

In the cases of Prince Georges and Charles Counties, it was found that the correlations between population and self-supplied domestic use were poor or inconclusive. Upon further investigation, it was determined that the poor correlations are due to the tendency to require much of the new growth in water supplies to be connected to public supplies in these two counties. Thus it was concluded that, for the purposes of this pilot study, self-supplied domestic use should remain constant for these two counties from present to 2030. The most recent domestic water use data in these counties verifies this trend (Figure E-15).

The final step in this analysis was to determine the percentage that each aquifer contributed to the total public and self-supplied domestic uses for each county in 2000. For the purposes of this pilot study, future projected demands were distributed among the aquifers in the same proportions determined for current use. This may not be a realistic scenario, however, since there may be a need in the future to utilize the deeper aquifers at a higher percentage rate in order to reduce the impacts of drawdown in the shallower aquifers.

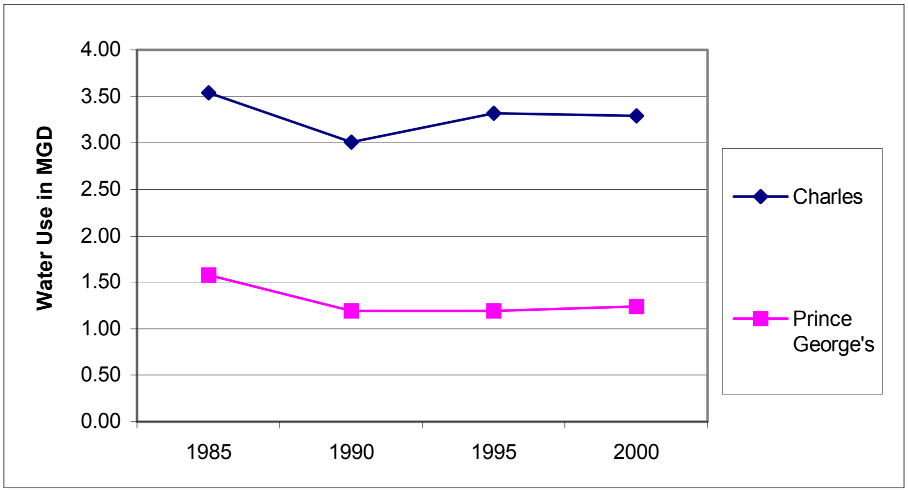


Figure E-15: Self- Supplied Domestic Water Use in Charles and Prince George's Counties

*Meeting Projected Demands: Results of Aquifer Modeling Studies*

By examining the water level trends as discussed previously, the effects of pumping on water levels can be assessed in relation to the 80% management level. Comparison of current potentiomentric surfaces with the 80% management surfaces may indicate potential problem areas, but a method is needed to assess the effects of future increased ground water withdrawal rates. The best available method of determining whether the confined aquifers can meet the projected demands is ground water flow modeling. Building these models requires the accumulation of large amounts of data, proper calibration, and time for analysis. The existing literature was reviewed to determine where ground water flow models have been developed and to decipher what results they provide for evaluating the water supply based on projected demands in the Southern Maryland pilot study area. An initial effort to construct multi-aquifer models in Calvert, St. Mary's, and Charles counties is currently underway by MGS, and is scheduled for completion by September 2005.

Several publications have used ground water flow models to assess the potential of the major aquifers to meet projected water demands in various locations across the Southern Maryland pilot study area. These studies were designed to answer specific questions relating to the effects of increased pumping in certain aquifers over a limited area (Table E-6). Therefore, they cannot incorporate the overall projected water demands derived in this report for each county (Tables E-4, E-5). In addition, these studies generally do not address regional hydrologic issues such as reduced recharge areas or baseflow in aquifer outcrop areas. The literature review indicates that a larger-scale model is needed to understand and manage the water supply in the region as a whole. The localized studies do indicate areas where projected demands can be met for certain aquifers and, conversely, where increased withdrawals may result in significant water level declines in localized areas. Each study simulated a multitude of pumping scenarios and their key results are summarized in the following section.

Table E-4. Current and Projected Public Supply Water Use in Southern Maryland Aquifers ( in MGD)

| | **Anne Arundel** | | | **Prince Georges** | | | **Calvert** | | | **Charles** | | | **St. Marys** | | | **Total Aquifer** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aquifer** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** |
| Piney Point | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.23 | 0.33 | 0.37 | 0.00 | 0.00 | 0.00 | 0.36 | 0.55 | 0.64 | 0.59 | 0.88 | 1.01 |
| Aquia | 0.18 | 0.20 | 0.21 | 0.00 | 0.00 | 0.00 | 1.90 | 2.87 | 3.21 | 0.05 | 0.08 | 0.09 | 3.12 | 4.79 | 3.55 | 5.34 | 7.94 | 9.06 |
| Magothy | 2.11 | 2.43 | 2.47 | 0.46 | 0.39 | 0.37 | 0.08 | 0.12 | 0.13 | 2.52 | 3.96 | 4.46 | 0.00 | 0.00 | 0.00 | 5.17 | 6.90 | 7.43 |
| Patapsco | 21.5 | 24.8 | 25.2 | 1.04 | 0.88 | 0.82 | 0.00 | 0.00 | 0.00 | 4.8 | 7.55 | 8.5 | 0.20 | 0.31 | 0.36 | 27.5 | 33.6 | 34.8 |
| Patuxent | 5.28 | 6.1 | 6.18 | 0.88 | 0.74 | 0.7 | 0.00 | 0.00 | 0.00 | 0.11 | 0.17 | 0.2 | 0.00 | 0.00 | 0.00 | 6.27 | 7.01 | 7.08 |
| Total For County | 29.05 | 33.54 | 34.01 | 2.38 | *2.01 | *1.89 | 2.21 | 3.32 | 3.71 | 7.48 | 11.76 | 13.25 | 3.68 | 5.65 | 6.55 | 44.89 | 56.28 | 59.41 |

Table E-5. Current and Projected Self-Supplied Domestic Water Use in the Southern Maryland Aquifers (in MGD)

| | **Anne Arundel** | | | **Prince Georges*** | | | **Calvert** | | | **Charles*** | | | **St. Marys** | | | **Total Aquifer** | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Aquifer** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** | **2000** | **2020** | **2030** |
| Piney Point | 0.03 | 0.03 | 0.04 | .00 | .00 | .00 | 1.85 | 2.38 | 2.55 | 0.01 | 0.01 | 0.01 | 3.30 | 4.23 | 4.65 | 5.19 | 6.65 | 7.25 |
| Aquia | 7.10 | 8.02 | 8.30 | 0.31 | 0.31 | 0.31 | 1.84 | 2.37 | 2.53 | 1.84 | 1.84 | 1.84 | 1.10 | 1.41 | 1.55 | 12.19 | 13.95 | 14.53 |
| Magothy | 2.19 | 2.47 | 2.56 | 0.56 | 0.56 | 0.56 | 0.00 | 0.00 | 0.00 | 0.35 | 0.35 | 0.35 | 0.00 | 0.00 | 0.00 | 3.10 | 3.38 | 3.47 |
| Potomac Group (Includes Patapsco & Patuxent) | 1.61 | 1.82 | 1.88 | 0.37 | 0.37 | 0.37 | 0.00 | 0.00 | 0.00 | 1.09 | 1.09 | 1.09 | 0.00 | 0.00 | 0.00 | 3.07 | 3.28 | 3.34 |
| Total For County | 10.93 | 12.34 | 12.78 | 1.24 | 1.24 | 1.24 | 3.69 | 4.75 | 5.08 | 3.29 | 3.29 | 3.29 | 4.40 | 5.64 | 6.20 | 23.55 | 27.26 | 28.59 |

** Amounts not projected, no correlation*

*Key Results of Modeling Studies*

Lower Patapsco and Upper Patuxent in northwestern Charles County (Andreason, 1999):

- Model simulations for 2020 indicate that an additional (relative to 1997 withdrawals) 0.6 mgd is available from the Lower Patapsco aquifer and a total of 3.4 mgd is available from the Upper Patuxent in northwestern Charles County.
- Model simulations indicate that significant water level declines will result from projected 2020 water use. Water level declines will exceed the Lower Patapsco's 80% management level along the Potomac River in the central part of the Indian Head peninsula and a small area northwest of Bryans Road.
- Model simulations of 3.4 mgd withdrawals in the Upper Patuxent aquifer have minimal impacts on water levels in the Lower Patapsco aquifer.

Magothy and Patapsco Aquifers in Waldorf, north-central Charles County (Fleck and Wilson, 1990)

- Model simulations for 2020 indicate that additional pumpage (relative to 1985 withdrawals) of 4.2 and 1.9 mgd will result in 95 and 225 feet of additional drawdown in the La Plata (Lower Patapsco aquifer) and White Plains (Upper Patapsco) aquifer systems respectively.
- The Waldorf aquifer system (Magothy and Upper Patapsco aquifers) can withstand withdrawal rates of 6.6 mgd before the 80% management level is reached.
- The White Plains aquifer system can withstand a maximum withdrawal rate of 6.1 mgd before the 80% management level is reached.
- The La Plata aquifer system can withstand a maximum withdrawal rate of 15.2 mgd before the 80% management level is reached.

Aquia and Piney Point Aquifers in Calvert and St. Mary's counties (Achmad and Hansen, 1997 and 2001)

- Model simulations for 2025 indicate that total projected withdrawals of 19.5 mgd in St. Mary's and 9.1 mgd in Calvert from the Aquia and Piney Point aquifers could result in significant water level declines. Water levels in the Aquia aquifer in some locations in St. Mary's county exceed 80% management levels, but remain above the 80% management level in locations in Calvert County.
- An alternate model simulation for 2025, which represents moderate increases to 19.9 mgd and 12.2 mgd in St. Mary's and Calvert counties, respectively, result in additional water level declines. Water levels at two locations in the Aquia aquifer in Calvert County reach the 80% management level under these increasingly stressed conditions.
- A second alternate model simulation for 2025, which reduces withdrawals 20% in the Aquia and Piney Point to 15.5 mgd in St. Mary's and 9.7 mgd and assumes deeper aquifers will be used for additional needs, results in substantially higher water levels which remain above the 80% management levels in all locations.

Aquia and Magothy Aquifers in Southern Anne Arundel County (Andreason, 2002)

- Model simulations for 2020 representing an increase of 0.8 mgd in the Aquia aquifer result in water level declines in a 3.5 mile wide area of Southern Anne Arundel County that exceed 80% management levels. In the remainder of the study area, water levels in the Aquia remain above 80% management levels. Identical withdrawals in the Magothy aquifer result in about 20 feet of drawdown, but water levels are considerably above management levels due to the greater amounts of available drawdown.
- When withdrawals in the Aquia aquifer are limited to 2000 withdrawal rates, simulated water levels stabilize in less than one year.
- Increases in withdrawals from the Aquia aquifer will cause water levels to exceed the 80% management levels in the central part of Southern Anne Arundel County. Therefore, as defined by present management level guidelines, the Aquia aquifer in Southern Anne Arundel County has reached its maximum allowable yield.
- The maximum simulated yield of the Magothy aquifer is approximately 38 mgd based solely on available drawdown in the Magothy. This results in water level declines of 22 feet in the Aquia aquifer. Reducing pumpage in the Aquia aquifer will allow a greater amount to be pumped from the Magothy aquifer.
- Simulated withdrawals for 2020 in Calvert and St. Mary's Counties result in water levels in a 3-mile wide band of Southern Anne Arundel County to exceed 80% management levels in the Aquia aquifer.
- Constraining withdrawals in Calvert County will reduce the amount of future drawdown in Southern Anne Arundel County.

The key results in each of these studies provide valuable information, however the model projections for a single study or county cannot adequately incorporate the projections of neighboring users in the region. The 2002 report, for example, incorporates the influences of users in Calvert County on those in Southern Anne Arundel County and suggests that reduced withdrawals in Calvert County will alleviate the water level declines Southern Anne Arundel. However, no alternative for the users in Calvert County is identified. In another example, the 1997 report suggests the use of the Magothy or Upper Patapsco aquifers as alternatives in Calvert and St. Mary's counties, however no attempt can be made to illustrate the effects of this shift in use on users of these aquifers in Charles County. The constraints of ground water flow models result in these shortcomings. In general, as the model area increases, increasing amounts of data are needed to calibrate the model for accurate results. In the past, attempts at modeling large areas resulted in less detailed results. However, with continuing improvements in software and hardware, it is likely that these deficiencies could be remedied and a regional model that incorporates the regional stresses on all of the aquifers could be developed.

These studies have proven invaluable to MDE in issuing appropriation permits and managing the water supply. However, due to the growing demand on the resource, it is clear that these localized studies cannot provide sufficient data to assess regional impacts in the aquifers. Large scale, regional ground water models for the major aquifers are needed to address the management issues associated with regional stresses on the aquifers. Based on these studies, it is evident that without careful management, there will be areas in which the water supply potential (as defined by the 80% management level) of some of the aquifers could be reached in the next 30 years. Some of the various pumping scenarios were constructed to address what best management practices could be used to maximize the potential of the aquifers while minimizing the impacts of drawdown. In some areas, deeper aquifers may have to be explored to avoid such impacts. Without a regional model that incorporates all the aquifers, these issues cannot be adequately resolved or managed.

In general, a model is only as valid as the data that are used and the assumptions that are made to create it. Models give ground water managers predictive tools that allow for different conditions and assumptions, the net results of which are not the absolute effects, but resulting scenarios by which planning decisions can be made. The modeling results listed above show that management levels in some areas have and will be exceeded. This has only occurred in areas where the available drawdown is smallest near recharge areas. The appropriateness of the 80% management level in such areas needs to be addressed, since the impacts of drawdown near outcrop areas are reduced due to available recharge.

Table E-6. Summary of Recent Ground water Modeling Studies in Southern Maryland

| Report | Area Covered | Aquifers Included | Highest Projected Demand Used in Model | Projected to Year(s) | Source of Population Projections |
|---|---|---|---|---|---|
| Andreason (2002) | Southern Anne Arundel | Aquia | 2.6 Mgal/day | 2020, 2025 | Anne Arundel Co. Planning, Calvert Co. Dept. of Planning and Zoning |
| | | Magothy | 0.8 Mgal/day | | |
| Andreason (1999) | Northwestern Charles Co (Indian Head -Bryans Road) | Lower Patapsco | 7.7 Mgal/day | 2020 | Charles Co. Dept. of Planning and Growth Mgmt. |
| | | Patuxent | 7.7 Mgal/day | | |
| Achmad and Hansen (1997) and (2001) | Calvert and St. Mary's Counties | Piney Point | 8.9 Mgal/day | 2020, 2025 | MD. Dept. of Planning, Calvert Co. Dept. of Planning and Zoning, St. Mary's Co. Metro. Commission |
| | | Aquia | 28.6 Mgal/day | | |
| Fleck and Wilson (1990) | North-central Charles Co. (Waldorf) | Magothy/ Patapsco (as the Waldorf aquifer) | 6.6 Mgal/day | 2020 and Total Available Drawdown | Charles Co. Dept. of Public Works |
| | | Patapsco | 15.2 Mgal/day | | |

## Conclusions

The Southern Maryland Pilot Study was conducted, as directed by the Committee, in order to demonstrate the methodologies that could be used in a statewide assessment of water supply and demand. In the process of developing a methodology for assessing the ground water supply in the Southern Maryland Counties, several issues arose that point to a need for additional information and resources to perform an adequate assessment and to extend this analysis to other areas of the State. In order to remedy these issues, the following areas of “need” have been identified:

- A regional, multi-aquifer ground water flow model developed for the entire Coastal Plain, that can be used by ground water managers as a tool for assessing the water supply and the impacts of future applications for withdrawals. The development of this model will require additional data on aquifer leakage and recharge rates, aquifer structure, and water yielding characteristics in some portions of the aquifers.
- Additional monitoring wells near large pumping centers to verify that modeling predictions are correct or to make the necessary adjustments to improve the accuracy of predictive models.
- Better information on domestic wells, including location data, aquifers utilized, and consistent reporting of well abandonment. This could be accomplished by improved coordination between MDE and the Counties by developing standard methods of data collection, storage, and transfer.
- An evaluation of the appropriateness of the 80% management level in aquifers in close proximity to their recharge areas. This management strategy may be too restrictive in certain areas and may result in unwarranted limits on water withdrawals.

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