SOURCE WATER ASSESSMENT

For The

Maryland American - Bel Air Water System

Prepared by
Maryland Department of the Environment
Water Management Administration
Water Supply Program
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TABLE OF CONTENTS

1.0 SUMMARY

The 1996 Safe Drinking Water Act Amendments require states to develop and implement source water assessment programs to evaluate the potential for contaminants to affect the sources of all public drinking water systems. A Source Water Assessment (SWA) follows a process for evaluating the susceptibility of a public drinking water supply. The assessment does not address the treatment process or the storage and distribution of the water system, which are covered under separate provisions of the Safe Drinking Water Act. The Maryland Department of the Environment (MDE) is the lead state agency in this SWA effort.

There are three main steps in the assessment process: (1) *delineating* the watershed drainage areas that are likely to contribute to the drinking water supply, (2) *identifying* potential contaminants within the areas and (3) *assessing* the vulnerability of the system to those contaminants, and their sources. This document reflects all of the information gathered and analyzed required by those three steps. MDE looked at many factors to determine the susceptibility of this water supply to contamination, including the size and type of water system, available water quality data, the characteristics of the potential contaminants, and the capacity of the natural environment to attenuate any risk.

Maryland American Water Company provides water to the Town of Bel Air. The main source water supply is comprised of surface water from Winters Run, and supplemented by ground water from two supply wells. The surface water source from Winters Run receives runoff from a 23,664-acre watershed that is vulnerable to land use activities occurring within the watershed. Agricultural land makes up the largest percentage of land use followed by residential, with a smaller percentage of commercial land in the watershed. Major roads and the Colonial petroleum pipeline also run through the watershed. The surface water plant is susceptible to turbidity, microbial pathogens, and disinfection by-products. It is not susceptible to routine contamination by inorganic compounds, radionuclides, synthetic organic compounds, or other volatile organic compounds. Winters Run is susceptible to spills that could occur from transportation accidents, handling of pesticides, gasoline, or other commercial products, and pump station sewage failures.

The ground water sources draw water from an unconfined fractured rock aquifer known as the Port Deposit Gneiss Formation. Unconfined aquifers are generally vulnerable to any activity on the land surface that occurs within the wellhead protection areas. The Bynum Run Park ground water supply was determined not susceptible to microbial pathogens, inorganic compounds, synthetic organic compounds, volatile organic compounds, and radionuclides. Should the EPA adopt a drinking water standard for radon-222, the Bynum Run Park Well may be susceptible to this naturally occurring contaminant. Water from the Winters Run Plant Well is combined with the Winters Run surface water prior to treatment, and therefore extensive ground water data is not available to evaluate this well as a separate source. Continued monitoring of contaminants is essential in assuring safe drinking water. Furthermore, in order to maintain and/or improve the quality of the water supply, the Town of Bel Air, Maryland American Water Company, and Harford County are encouraged to implement the recommendations for an active source water protection plan as included in Section 9.0 of this report.

2.0 DEVELOPMENT OF MARYLAND AMERICAN'S WATER SUPPLY

The Town of Bel Air and surrounding areas have used water withdrawn from Winters Run for their source of drinking water since 1954. Prior to that, the Town was solely relying on ground water as a source of water supply. Maryland American Water Company owns and operates a two million gallon per day (MGD) water treatment plant to serve Winters Run. The Winters Run Bell Air provides surface water through an intake structure to the treatment facility located on U.S. Business Route 1 southwest of Bel Air. The Winters Run water treatment plant operates 24 hours a day, treating an average of 1.3 MGD, serving approximately 13,200 people in the Town of Bel Air and surrounding areas. Figure 2-1 depicts the municipal boundary of the Town of Bel Air and Winters Run Watershed. The treatment processes include coagulation, flocculation, sedimentation, filtration and disinfection. Water from Winters Run passes through two screened gates and flows by gravity through two 16-inch diameter pipes to a grit chamber. The water then flows to a pump station and then to the treatment plant. A 540 foot deep well next to the pump station can supplement raw water flow in times of deteriorated water quality in Winters Run (MDE-Comprehensive Performance Evaluation Report).

The raw ground water pumped from the well at the Winters Run Water Plant is mixed with the surface water prior to treatment to provide additional supply to the plant (Figure 2-2). A second well, known as the Bynum Run Park Well, is located near the Town of Bel Air's Department of Public Works Building at 702 Churchville Road (Figure 2-3). Treatment of this well water at the Bynum Run Park Plant consists of disinfection, fluoridation and pH adjustment. A corrosion inhibitor is also fed at this plant. A summary of the current water appropriation and use permits for these surface and ground water supplies is shown in Table 2.1 below.

PERMIT NO. SOURCE	DRAINAGE BASIN OR AQUIFER	DAILY AVERAGE (gpd)	DAILY MAXIMUM (gpd)
HA1976S015 (05) Winters Run	Winters Run	1,400,000	1,700,000
HA1994G060 (03) Winters Run Plant Well	Port Deposit Gneiss	132,000	246,000
HA1996G022 (02) Bynum Run Park Well	Port Deposit Gneiss	230,000	271,000

Table 2.1. Maryland American (Bel Air area) Water Appropriation and Use Permits

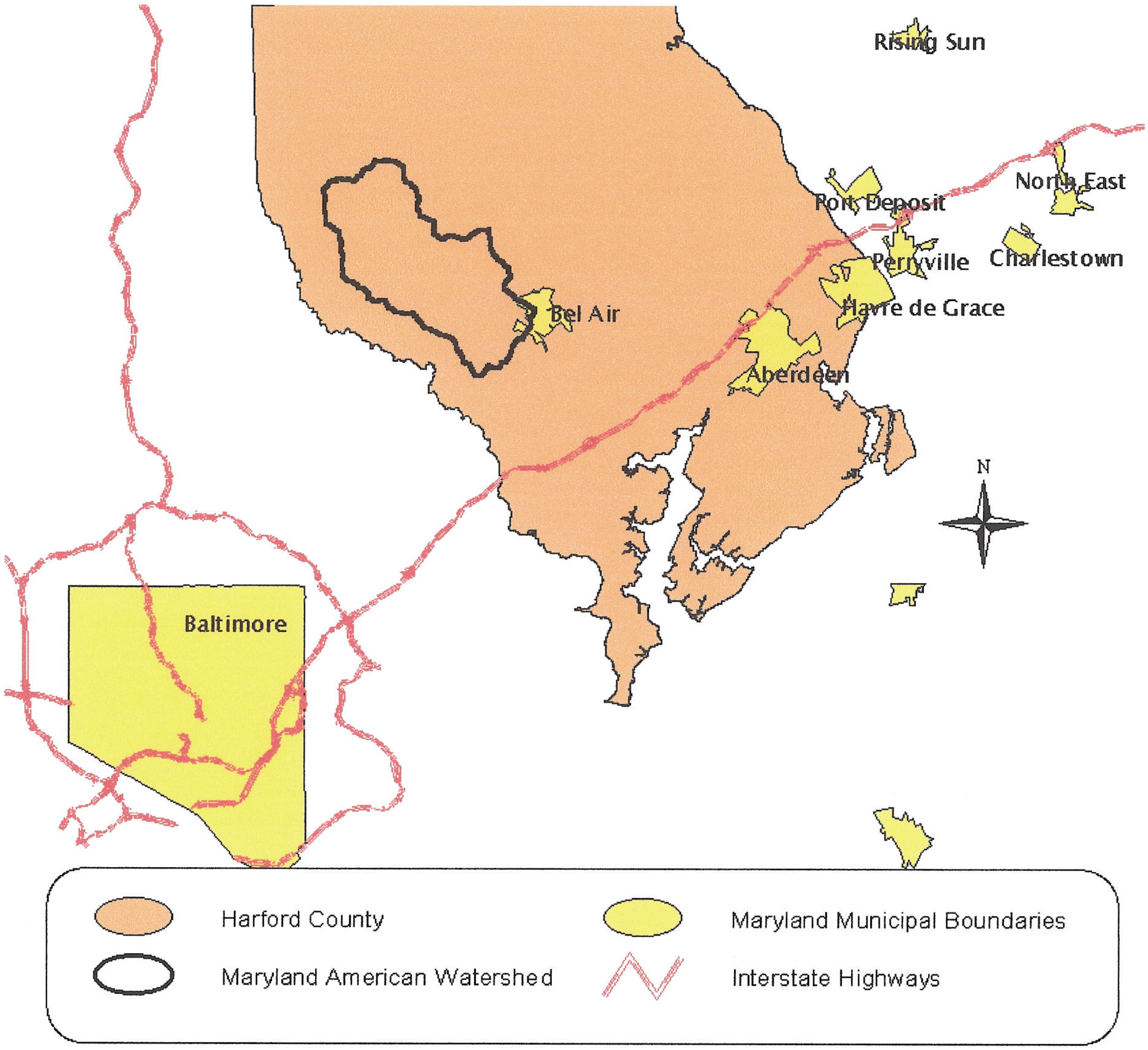


Figure 2–1. Vicinity Map

3.0 SURFACE WATER SUPPLY SOURCE

Winters Run is a spring-fed stream with a drainage area of approximately 37 square miles above the Maryland American's water intake, located in western Harford County. Winters Run is a major tributary of Bush River Watershed and serves as a primary drinking water source for the Town of Bel Air and for the Edgewood portion of the Aberdeen Proving Ground. There are two main streams, the East Branch and West Branch, which drain the upper area near the community of Jarrettsville.

The Winters Run Watershed, located in the Piedmont Plateau that also makes up the northern three-fourths of the county, is a very old upland dissected by many small streams and drainage ways. The underlying geologic formations are primarily metamorphic rocks, schist and gneiss, and lesser amounts of marble. The Soil Survey report in Harford County area indicates that the soil in the watershed area consists mainly of Legore-Neshaminy-Aldino association. The Legore series consists of deep, well drained, nearly level to steep soils on rolling to hilly uplands of the Piedmont Plateau. These soils formed by weathering in place from such dark-colored basic rocks as diabase and gabbro. The Neshaminy series formed in material deeply weathered in place from semi basic rocks or mixed basic and acidic rocks. They are on rolling to hilly uplands. Aldino series consists of moderately well drained, nearly level to moderately sloping soils on uplands of the Piedmont. They formed in material weathered from serpentine bedrock that is overlain by a layer of loamy material, possibly loess.

The Harford County area has a continental type climate with average annual of 41.5 inches of annual rainfall. The month of highest average rainfall is August, and the month of lowest average rainfall is January.

3.1 GROUND WATER SUPPLY SOURCES

Source Information

Well information was obtained from the Water Supply Program's database, site visits, well completion reports, sanitary survey inspection reports and published reports. A review of well data and sanitary surveys of the Maryland American water system indicates that the wells from both the Winters Run, and Bynum Run Park well fields meet current well construction standards for grouting and casing. Table 3.1 contains a summary of the well construction data.

PLANT ID	SOURCE NAME	WELL PERMIT NO.	TOTAL DEPTH (ft.)	CASING DEPTH (ft.)	YEAR DRILLED
01	WINTERS RUN PLANT WELL	HA940142	540	26	1995
02	BYNUM RUN PARK WELL	HA941107	125	42	1996
n/a	BYNUM RUN MONITORING WELL 1	HA941106	605	24	1996
n/a	BYNUM RUN MONITORING WELL 2	HA941108	145	38	1996
n/a	WINTERS RUN MONITORING WELL	HA940143	420	28	1995

Table 3.1 Maryland American (Bel Air area) Well Construction Information

Based on reported pumpage from January thru June 2004, the Winters Run Plant well pumped an average of 52,000 gallons per day (gpd) whereas the Bynum Run Park Well averaged 91,509 gpd during the same timeframe.

Hydrogeology

Based on the Geologic Map of Harford County (Southwick & Owens, 1968), the ground water wells used by Maryland American Water Company serving the Bel Air area are completed in the Port Deposit Gneiss Formation of early Paleozoic age. The Port Deposit gneiss is described as a moderately to strongly deformed intrusive complex composed of gneissic biotite quartz diorite, hornblende-biotite quartz diorite, and biotite granodiorite, with foliation grades into strong cataclastic shearing. The formation is part of a terrain derived from a volcanic-arc environment that was transported to its present location (MGS, 1999). The primary porosity and permeability of this aquifer is very small due to the crystalline nature of the rock. Ground water moves through secondary porosity, fractures, and joint openings, and is recharged by precipitation percolating through the overlying soils, and weathered bedrock called saprolite. The ground water flow may be in several directions at varying velocities due to its size, orientation, and extent of these fractures. The yield of a well in crystalline rock depends primarily on the number of fractures penetrated by the well. Typically, the water table in the aquifer mimics the surface topography. Local ground water flow patterns can be estimated by determining the location, aerial extent, and orientation of earth fractures, referred to as a fracture trace analysis.

4.0 RESULTS OF SITE VISITS

Water Supply Program personnel conducted a site survey of the Town's raw water sources and other raw water facilities in order to accomplish the following tasks:

- To collect information regarding the locations of the wells and intakes by using Global Positioning System (GPS) equipment.
- To determine the general condition and structural integrity of intakes, other raw water facilities, and wells.
- To discuss source water issues and concerns with the Town's water system operators.
- To conduct windshield surveys of the watershed and wellhead protection areas (WHPAs) and to document potential problem areas. (Photographs of the raw water system obtained during the second site survey are shown in Appendix A).

4.1 Intake Integrity/Description

Water is withdrawn from Winters Run through a Gabion-Stream Bank type intake. A low level concrete dam impounds a small pool at the location of the intake. Water from Winters Run passes through two screened gates and flows by gravity to a grit chamber before it pumps to the plant. The dam is listed in the Inventory of Maryland Dams as a low hazard class and receives periodic inspections by MDE's Dam Safety Division.

4.2 <u>Operator Concerns and Observations</u>

The major concerns of the Maryland American Water Company are high turbidity of raw water from Winters Run after heavy rainfalls, cropland, application of chemicals, commercial development including gas stations, county wastewater pumping stations, and Tollgate Landfill located in the Winters Run source water area. Colonial Pipeline and some privately owned wastewater pump stations are also considered as a major concern by the operator.

5.0 SOURCE WATER ASSESSMENT AREA CHARACTERIZATION

5.1 <u>Source Water Assessment Area Delineation Method</u> (Surface Water)

An important aspect of the source water assessment process is to delineate the watershed area that contributes to the source of drinking water. A source water protection area is defined as the whole watershed area upstream of the intake of a water plant (MDE, 1999). The source water area for Winters Run was delineated by using ESRI's Arc View Geographic Information Software (GIS), utilizing existing GIS data, and by collecting location data using a Global Positioning System (GPS). GPS point locations were taken at the water source intake and differentially corrected (for an accuracy of ± 2 meters) at MDE. Once the intake location was established, the contributing area was delineated based on existing Maryland Department of Natural Resources digital watershed data and Maryland State Highway Administration digital stream coverage. Digital USGS 7.5 topographical maps were also used to perform "heads up" digitizing or editing watershed boundaries.

5.2 <u>Source Water Assessment Area Delineation Method</u> (Ground Water)

For ground water systems, a Wellhead Protection Area (WHPA) is considered the source water assessment area for the system. Ground water flow in unconfined fractured rock aquifers is complex and cannot be accurately modeled by a homogeneous analytical model. Consistent with the recommended delineation methodology in the Maryland Source Water Assessment Plan (MDE, 1999), the watershed drainage area that contributes ground water to the supply wells was used as a first step.

The final delineation areas accounted for surface water bodies, topography, ground water drainage divides, and fracture trace analyses completed by R.E. Wright (REWEI, 1995, 1997). A fracture trace analysis identifies specific features on the surface that are expressions of near vertical closely spaced joints and fractures in the subsurface bedrock. R.E. Wright identified several primary and secondary fractures near the Bynum and Winters Run well sites (Figure 5-2). The delineated WHPAs are considered the areas in which any contaminant present could ultimately reach the wells.

<u>Bynum Run Park WHPA</u>
The Bynum Run Park WHPA is irregularly shaped, and has an area of 460 acres (Figure 5-2). The boundaries of the WHPA extend outward from the well to include the inferred fracture traces, stream boundaries, and topographic highs. In addition, the annual average recharge needed to supply the well was also calculated. A drought condition recharge value of 500

gpd per acre (or approximately 6.8 inches per year) was used to estimate the total ground water contribution area required to supply the well. The current Water Appropriation Permit for the Bynum Run Park Well is for an average daily withdrawal of 230,000 gallons. The total ground water contribution area was calculated from the following equation:

Recharge Area (acre) = Average Use (gpd) / Drought Condition Recharge (gpd/acre)

From the above equation, the total ground water contributing area during a drought is approximately 460 acres, which is consistent with the area delineated. The general ground water flow direction is toward the northeast in the vicinity of the Bynum Run Park Well.

Winters Run Plant WHPA

The Winters Run Plant WHPA is shell-shaped, and has an area of 95.2 acres (Figure 5-2). The WHPA boundary extends northeastward from the well in the direction of a topographic high. The upgradient limits were based on cone of depression contours determined after five days of pumping the supply well at 123 gallons per minute (MGS, 1999). The well captures ground water in the area upgradient and northeast of the well to the 0 ft. drawdown contour (Appendix B). No observation wells were available to the west of Winters Run during the MGS study, so it is unknown if the recharge boundary crosses the stream. Therefore, it is assumed that Winters Run acts as the downgradient recharge limit of the well (Figure 5-2). It is possible that the well is also recharged by Winters Run, which is fed by Heavenly Waters stream to the north of this area.

5.3 Land Use Characteristics

The drainage area above the Winters Run intake encompasses approximately 37 square miles (23,664 acres) of mixed land use in Harford County. Figure 5-1 shows the land use within the Winters Run Watershed above the intake of Maryland American Water Treatment Plant.

Based on the Maryland Department of Planning's 2000 land use data, the land use distribution in Winters Run Watershed is summarized in Table 5.1.

Year 2000 MDP Land Use	Acres	Percent
Low-density residential	5226.8	22.1%
Medium-density residential	1147.7	4.8%
High-density residential	121.9	0.5%
Commercial	603.8	2.6%
Open urban land	359.1	1.5%
Cropland	8844.3	37.4%
Pasture	1063.3	4.5%
Orchards/vineyards/horticulture	28.7	0.1%
Feeding operations	152.9	0.6%
Forest	6104.4	25.8%
Barren land	10.8	0.0%
Total	**23664**	**100%**

Table 5.1. Winters Run Watershed Land Use Distribution

5.4 Localized Characteristics

The Maryland-American Water Company owns approximately 10 acres of land that covers Winters Run Water Treatment Plant property and the area immediately above the intake along Winters Run. At the vicinity of the intake, the topography of the surrounding area consists of steep slopes. A large concentration of low and medium density residential housings on the top of the hill located near the intake. U.S. Route 1 is located above the intake of Winters Run Water Treatment Plant.

The Maryland Department of Planning's 2000 digital land use map for Harford County was used to determine the predominant types of land use in the Bel Air WHPAs (Figure 5-3). The land use categories were calculated separately for the Winters Run Plant and Bynum Run Park WHPAs respectively. The breakdown of land use types for each WHPA is shown in Tables 5.2, and 5.3. Note that residential lands make-up the largest portion of land use in both WHPAs with smaller areas split between pasture, open urban land, and forest. Commercial land makes up 22.6 % of the Bynum Run Park WHPA, but is absent in the Winters Run WHPA. Likewise, cropland accounts for 9.1 % of the Winters Run WHPA, but is absent in the Bynum Run Park WHPA (Tables 5.2 & 5.3).

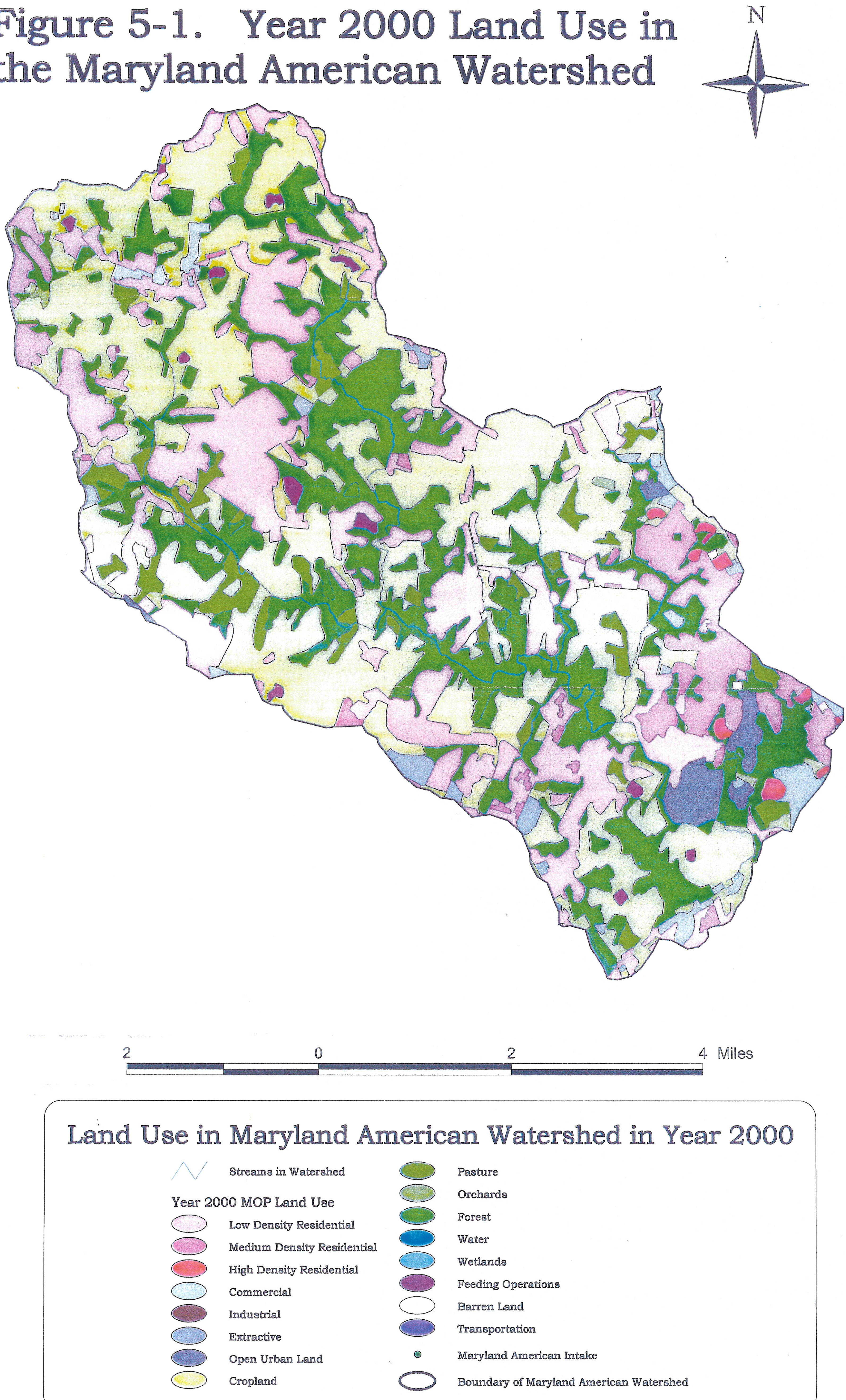
LAND USE TYPE	TOTAL AREA (acres)	PERCENTAGE OF WHPA
Low Density Residential	43.84	46.05
Medium Density Residential	15.60	16.38
Open Urban Land	2.85	3.00
Cropland	8.63	9.06
Pasture	14.34	15.06
Forest	9.95	10.45
Total Area	95.21	100.00

Table 5.2. Land Use in the Winters Run Plant WHPA (See Figure 5-3)

LAND USE TYPE	TOTAL AREA (acres)	PERCENTAGE OF WHPA
Medium Density Residential	259.13	56.40
High Density Residential	4.74	1.03
Commercial	103.86	22.60
Open Urban Land	53.03	11.54
Pasture	6.00	1.31
Forest	32.70	7.12
Total Area	459.46	100.00

Table 5.3. Land Use in the Bynum Run Park WHPA (See Figure 5-3)

Figure 5-1. Year 2000 Land Use in the Maryland American Watershed



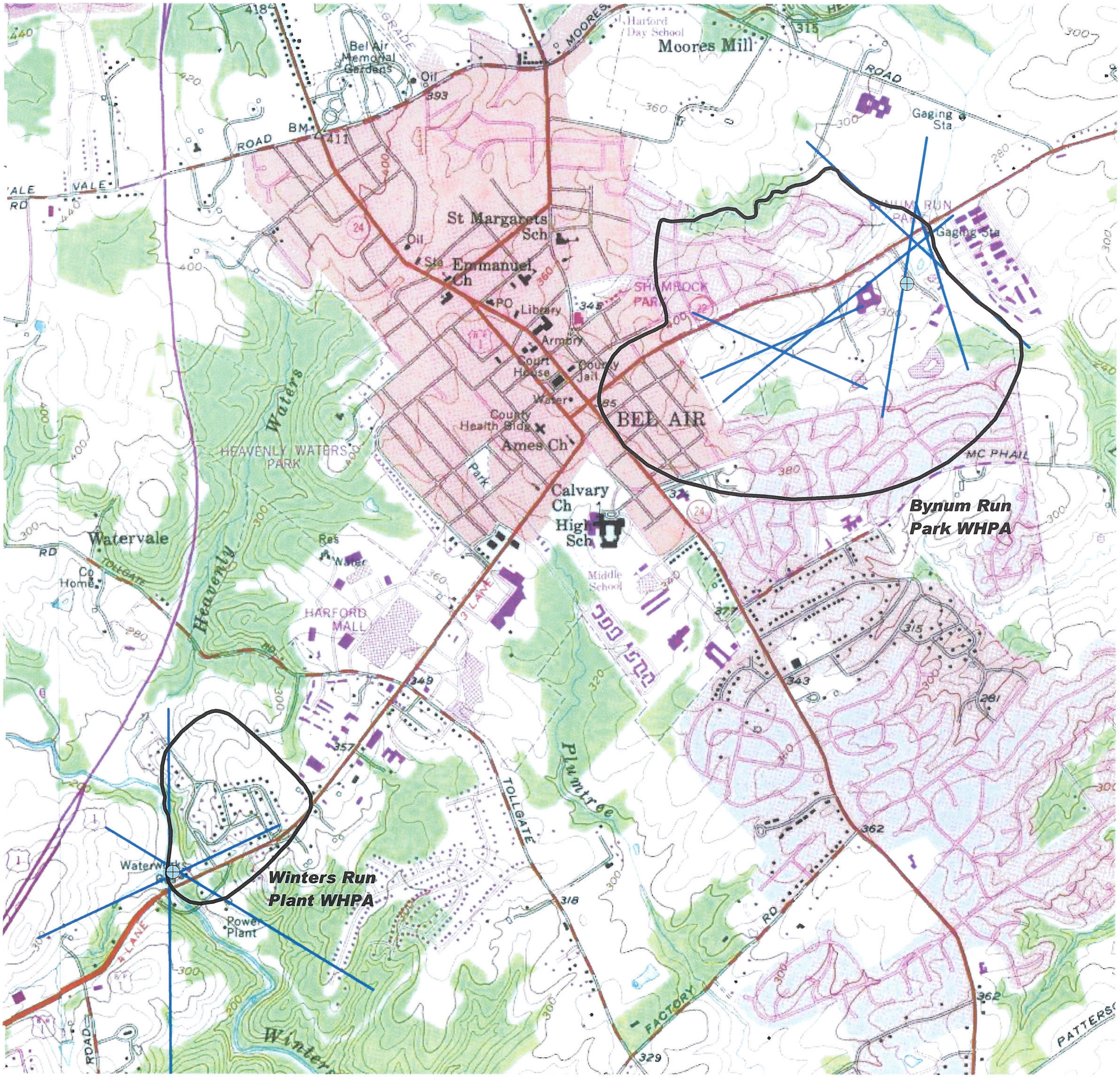


Figure 5-2. Maryland American - Bel Air Wellhead Protection Areas

LEGEND

Supply Wells

Fracture Trace

Wellhead Protection Areas

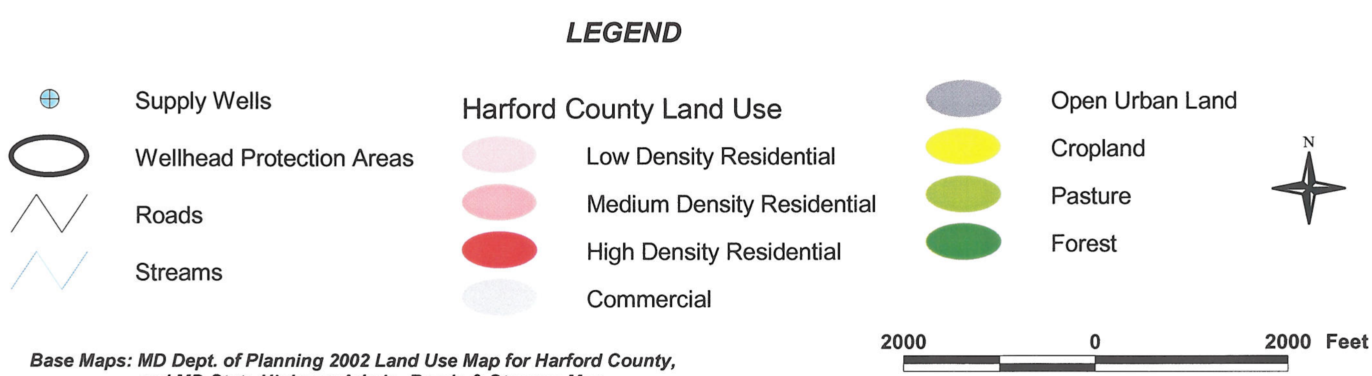
N

2000 0 2000 Feet

Fracture traces re-generated from R.E. Wright Environmental Hydro Evaluations, 1995, 1997

Base Map: USGS 7.5 Minute Series Quads for Bel Air & Jarrettsville

Figure 5-3. Land Use in the Maryland American - Bel Air Wellhead Protection Areas



Base Maps: MD Dept. of Planning 2002 Land Use Map for Harford County, and MD State Highway Admin. Roads & Streams Map

6.0 POTENTIAL SOURCES OF CONTAMINATION

Potential sources of contamination are categorized as either point or non point sources. Examples of point sources of contamination are leaking underground storage tanks, landfills, discharge permit sites, wastewater treatment plants, large scale feeding operations and known ground water contamination sites. These sites are generally associated with commercial or industrial facilities that use chemical substances that may, if inappropriately handled, contaminate ground water via a discrete point location. Non-point sources of contamination are associated with certain types of land use practices such as the use of pesticides, application of fertilizers, animal wastes, residential runoff, septic systems, and erosion and disturbance of vegetation along the headwater of the reservoirs that may lead to ground water contamination over a larger area. Figure 6-1 depicts the roads and potential point contaminant sources in the Winters Run Water Treatment Plant source water assessment area.

6.1 Non-Point Sources in the Watershed

According to Department of Planning land use data, 9,908 acres are used for agricultural purposes (37% cropland, 4.5% pastures and feeding operations). Land used to grow crops can be a source of nutrients (from fertilizer) synthetic organic compounds (herbicides) and sediment load. Pastures used as a recipient of animal waste and for grazing livestock are sources of nutrients and pathogenic protozoa (*giardia* and *cryptosporidium*), viruses and bacteria. Feeding operations are also a potential source of contaminants associated with animal wastes. Developed land (residential, commercial, industrial) accounts for 30% of Winters Run Watershed. Sediment, nutrients, pathogens (*giardia* and c*ryptosporidium*), deicing compounds, and heavy metals are the most significant concerns from runoff in developed areas. Lawn and pavement in residential areas result in increased storm water velocity and cause streambed and streambank erosion.

6.2 Non-Point Sources in the WHPAs

The use of private septic systems and lawn maintenance and landscaping activities in residential, and park areas are potential non-point sources of microbial pathogens, nitrates, and Synthetic Organic Compounds to ground water. Commercial areas are associated with facilities that may have point sources of contamination as described in the next section. There is very little agricultural land within the wellhead protection areas as shown in Tables 5.2 and 5.3, but these areas in the Winters Run Plant WHPA may also contribute nitrates to ground water.

The Maryland Department of Planning's 2003 Harford County Sewer Map was used to break down the sewerage coverages within the Maryland American-Bel Air WHPAs (Figure 6-2). The sewer service categories were calculated separately for the Winters Run Plant and Bynum Run Park WHPAs respectively. Tables 6.1 and 6.2 summarize the breakdown of sewer service for each of the WHPAs. As shown, the Bynum Run Park WHPA is almost entirely in an existing sewer service area, and 89.1% of the Winters Run Plant WHPA has plans for sewer service within the next six to ten years. The southernmost 9.7% of the Winters Run Plant WHPA is the only area with no planned sewer service (Figure 6-2).

SEWER SERVICE TYPE	TOTAL AREA (acres)	PERCENTAGE OF WHPA
No Planned Service	9.20	9.66
Existing Service Area	1.15	1.21
Area Programmed for Service within 6 to 10 Years	84.86	89.13
Total Area	95.21	100.00

Table 6.1. Sewer Service Coverage in the Winters Run Plant WHPA (see Figure 6-2)

SEWER SERVICE TYPE	TOTAL AREA (acres)	PERCENTAGE OF WHPA
Existing Service Area	451.76	98.32
Area Programmed for Service within 6 to 10 Years	7.70	1.68
Total Area	459.46	100.00

Table 6.2. Sewer Service Coverage in the Bynum Run Park WHPA (see Figure 6-2)

6.3 Point Sources in the Watershed

A review of MDE's municipal and industrial discharge permit programs indicates there is one industrial discharger located within the source water assessment area (Figure 6-1).

This permit is issued for a ground water remediation system of a closed Tollgate Landfill. The site was used during the period from 1954 through 1987 as a municipal landfill. It is unlined and has no leachate collection system. Ground water monitoring has indicated the presence of organic contaminants. In an attempt to minimize the off-site migration of contaminated ground water, a line of ground water extraction wells have been placed along the western border of the site and between the landfill and Tollgate Road. The wastewater passes through a treatment system and the treated effluent is discharged through a drain line to a series of stormwater management ponds. Overflow from the pond discharges to an unnamed tributary to Winters Run. Currently, the maximum permitted discharge is 130,000 gallons per day, with number of effluent limits such as BOD, COD, TOC, TSS and other chemicals that are well below the drinking standards. The treatment for this ground water remediation system consists of pH adjustment, air stripping and carbon adsorption.

A review of daily monitoring report from January of 2000 through August of 2004 for the above facility shows that Tetrachloroethylene exceeded the limits once on June 30, 2004 and Total Organic Carbon exceeded twice on March 31, 2003 and September 30, 2003 respectively.

Tetrachloroethylene is a manufactured chemical that is widely used for dry cleaning of fabrics and for metal degreasing. Other names for Tetrachloroethylene include perchloroethylene, PCE, and tetrachloroethene. The current drinking water standards for this chemical is 0.005 mg/L and the maximum limit for the Tollgate Landfill ground water treatment system set by the NPDES Permit is 0.0017 mg/L. The total organic carbon is a measurement of carbon dioxide produced from organics when water sample is atomized into a combustion chamber. The NPDES Permit limits for total organic carbon are established to be less than 1.0 mg/L.

Review of the available data from USGS gage #01581700 at Winters Run near Benson, Maryland indicates that recent median daily stream flow for the month of October 2004 based on 36 years of record varies from 20 to 25 CFS (approximately 13 mgd-16 mgd). The permitted discharge from Tollgate Landfill is approximately one percent of the total flow in the Winters Run approximately 1 mile above the intake. The exceedences of NPDES permit levels for these chemicals (tetrachloroethylene and total organic carbon) are below the levels set by the drinking water standard and currently are the chemicals of concern.

There are eight sewage pump stations and a network of sewer systems located at the lower portion of the watershed that is served by public sewer (see Figure 6-1). Sewage overflow from the pump stations and leakage from the sewers may be potential sources of the contamination.

6.4 Point Sources in the WHPAs

A review of MDE contaminant databases and field inspections by MDE staff revealed some potential point sources of contamination in and adjacent to the WHPAs. Facilities that have underground storage tanks (USTs), or are classified as controlled hazardous substance generators (CHS) are located within or near the WHPAs. In addition, miscellaneous sites (MISC) such as auto body and repair shops, auto dealerships, rental services, medical centers, and fire stations that handle and use chemicals are also shown in Figure 6-3. Many of the facilities are located just outside of the respective WHPAs, and therefore do not pose an immediate threat to the Maryland American-Bel Air ground water supply, but do represent a potential threat of contamination to the local aquifer. Several other commercial facilities located along Business Route 1 within the Town's limits to the northeast and southwest of the respective WHPAs were not mapped. Ponds located near the Bynum Run Park Well were also mapped because they have the potential of introducing contaminants from storm water runoff, total organic carbon, and microbiological pathogens from the observed geese roaming the area.

Table 6.3 lists the facilities identified and their potential types of contaminants. The contaminants are based on generalized categories and often the potential contaminant depends on the specific chemicals and processes being used or which had been used at the facility. The potential contaminants are not limited to those listed. Potential contaminants are grouped as Volatile Organic Compounds (VOC), Synthetic Organic Compounds (SOC), Heavy Metals (HM), and Microbiological Pathogens (MP).

ID	Type[1]	Site Name	Address	Potential Contaminant[1]
1	MISC	Bel Air Auction	803 Baltimore Pike	VOC, HM
2	CHS	Midas Muffler	809 Baltimore Pike	VOC, HM
3	MISC	Harford Rental Service	731 Baltimore Pike	VOC, HM
4	CHS	Meineke Muffler	732 B Baltimore Pike	VOC, HM
5	CHS	Weavers Body & Fender	728 Baltimore Pike, Unit 123	VOC, HM
6	CHS	Village Volvo, Dodge, Fiat	728 Baltimore Pike	VOC, HM
7	CHS	Auto Village Olds - Cadillac	716 Baltimore Pike	VOC, HM
8	UST	Wawa	709 Baltimore Pike	VOC
9	UST	Bel Air High School	100 Heighe St.	VOC
10	UST	Bel Air Branch Office	37 S. Main St.	VOC
11	UST	Bel Air Shell	121 S. Bond St.	VOC
12	UST	Harford Co. Office Bldg.	29 W. Courtland St.	VOC
13	MISC	Bel Air Volunteer Fire Co.	Main St.	VOC, HM
14	UST	Bel Air Mobil	28 E. Churchville Rd.	VOC
15	MISC	Colonnade Imaging Center	100 Fulford Ave.	VOC,HM,SOC
16	MISC	Neuro Diagnostic Assoc. of MD	407 E. Churchville Rd.	VOC,HM,SOC
17	UST	John Carroll School	730 E. Churchville Rd.	VOC
18	MISC	Pond	Bynum Run Park	MB,HM,SOC
19	UST	Bel Air Dept. of Public Works	705 E. Churchville Rd.	VOC
20	MISC	Pond	Aquila Scott Park	MB,HM,SOC

Table 6.3. Potential Contaminant Point Sources within or near the Bel Air Wellhead Protection Areas (see Figure 6-3 for location sites ID 1 through 20)

[1] UST = underground storage tanks, LUST = leaking underground storage tanks
CHS = controlled hazardous substance generators, MISC = miscellaneous sites
VOC = volatile organic compounds, SOC = synthetic organic compounds
MP = microbiological pathogens, HM = Heavy Metals

6.5 Transportation and Other Related Concerns

Another potential source of contamination to the Winters Run intake is transportation, including highways, roads, petroleum and gas pipelines. Routes 1, 23, 152 and 165 are used heavily for commercial traffic and cross the major tributaries of Winters Run. All of these routes, especially Route 1, pose potential spill danger to Winters Run because of their close proximity to Maryland-American Water Company's raw water intake. Transportation lines running through the Maryland American-Bel Air WHPAs include Business Route 1, MD Routes 22, and 924 (Figure 6-3).

Colonial Pipeline, an interstate carrier of petroleum products, crosses the Winters Run Watershed. Pipeline accidents and leaking of petroleum products can cause contamination of raw water with oil products and volatile organic compounds. More than half of the land within the WHPAs is for residential use (Figure 5-3). Underground residential heating oil tanks also pose a threat of VOC contamination to the aquifer in the event of a spill or leak.

6.6 Land Use Planning Concerns

A comparison between 1994 and 2000 Maryland Department of Planning land use data shows changes in watershed land development. Land use percentages are shown below:

MDP Land Use	Year 2000	Year 1994	Percent Change	Largest Change
Low-density residential	5226.765	3643.878	43%	+1600
Medium-density residential	1147.67	1242.248	-8%	
High-density residential	121.86	72.118	69%	
Commercial	603.785	451.357	34%	
Industrial	0	5.585	-100%	
Open urban land	359.086	266.166	35%	
Cropland	8844.313	9622.315	-8%	-800 acres
Pasture	1063.286	1233.2	-14%	-170 acres
Orchards/vineyards/horticulture	28.747	30.374	-5%	
Feeding operations	152.877	187.237	-18%	
Forest	6104.412	6773.087	-10%	-600 acres
Barren land	10.766	136.003	-92%	

Table 6.4. Winters Run Watershed Land Use Data Comparison between 1994 and 2000

The most significant change is the increase in residential land use over the past seven years. This land use trend is seen in the rest of Harford County. The loss of 10% of forested land and approximately 22% of agricultural (cropland and pasture) land in Winters Run watershed during this period and the increase in developed land remains the main land use concern. The entire Winters Run watershed is located in the Town of Bel Air and Harford County. The comprehensive plan for the Town of Bel Air and Harford County's Master Plan are effective planning tools that provide direction for accommodating desirable growth while maintaining the quality of life. An understanding of existing local land use and water resources management plan and related State and federal programs is an important component of the source water protection.

Figure 6-1. Roads and Potential Contamination Sources in the Maryland American Watershed

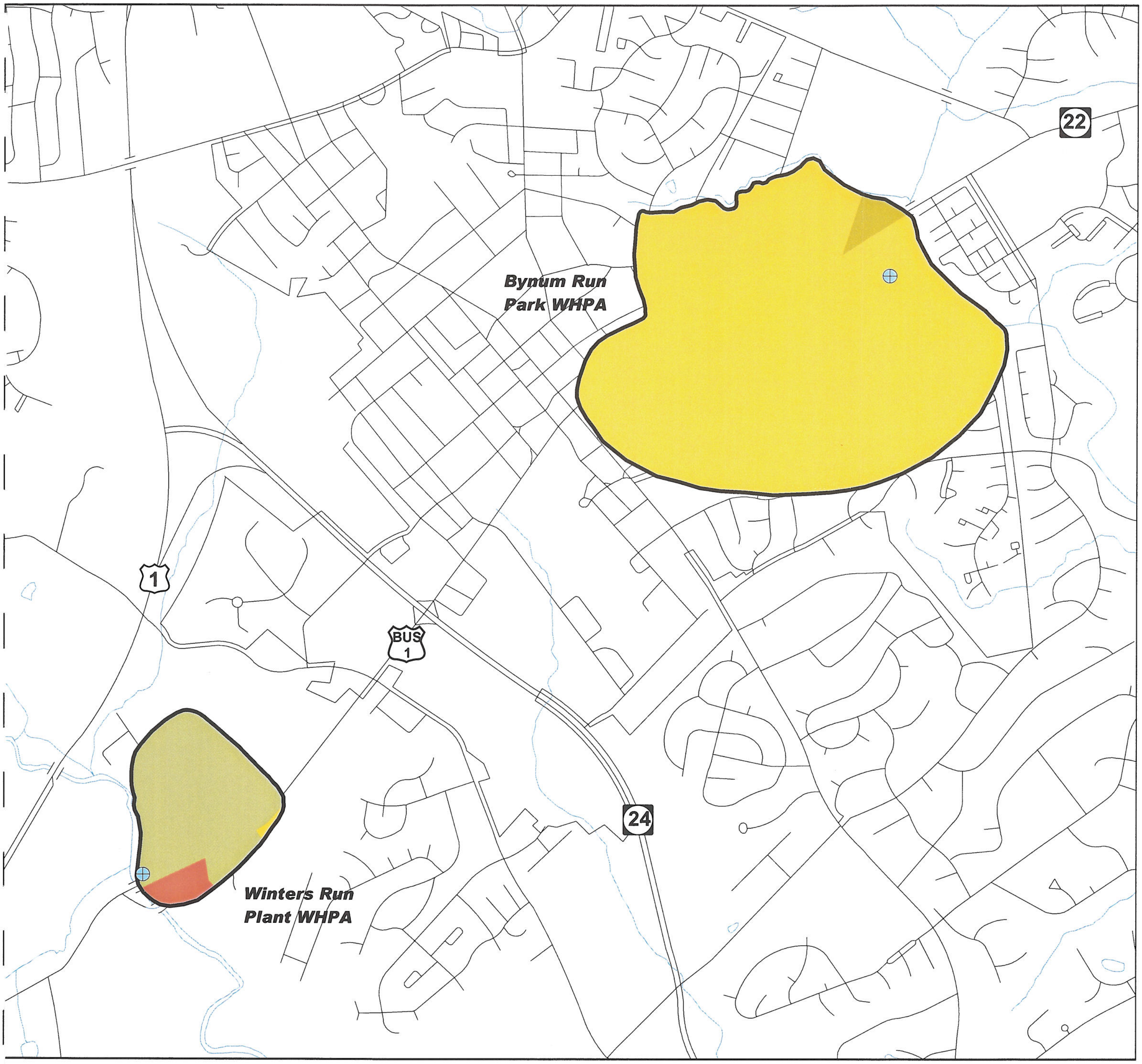
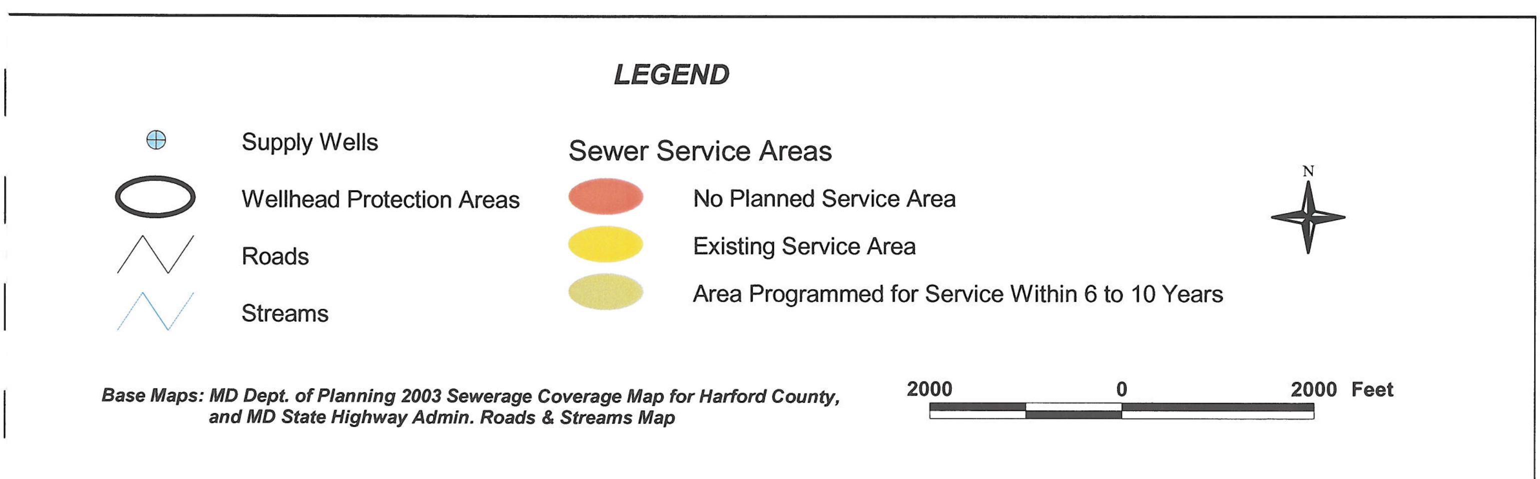


Figure 6-2. Sewer Service Coverage in the Maryland American - Bel Air Wellhead Protection Areas



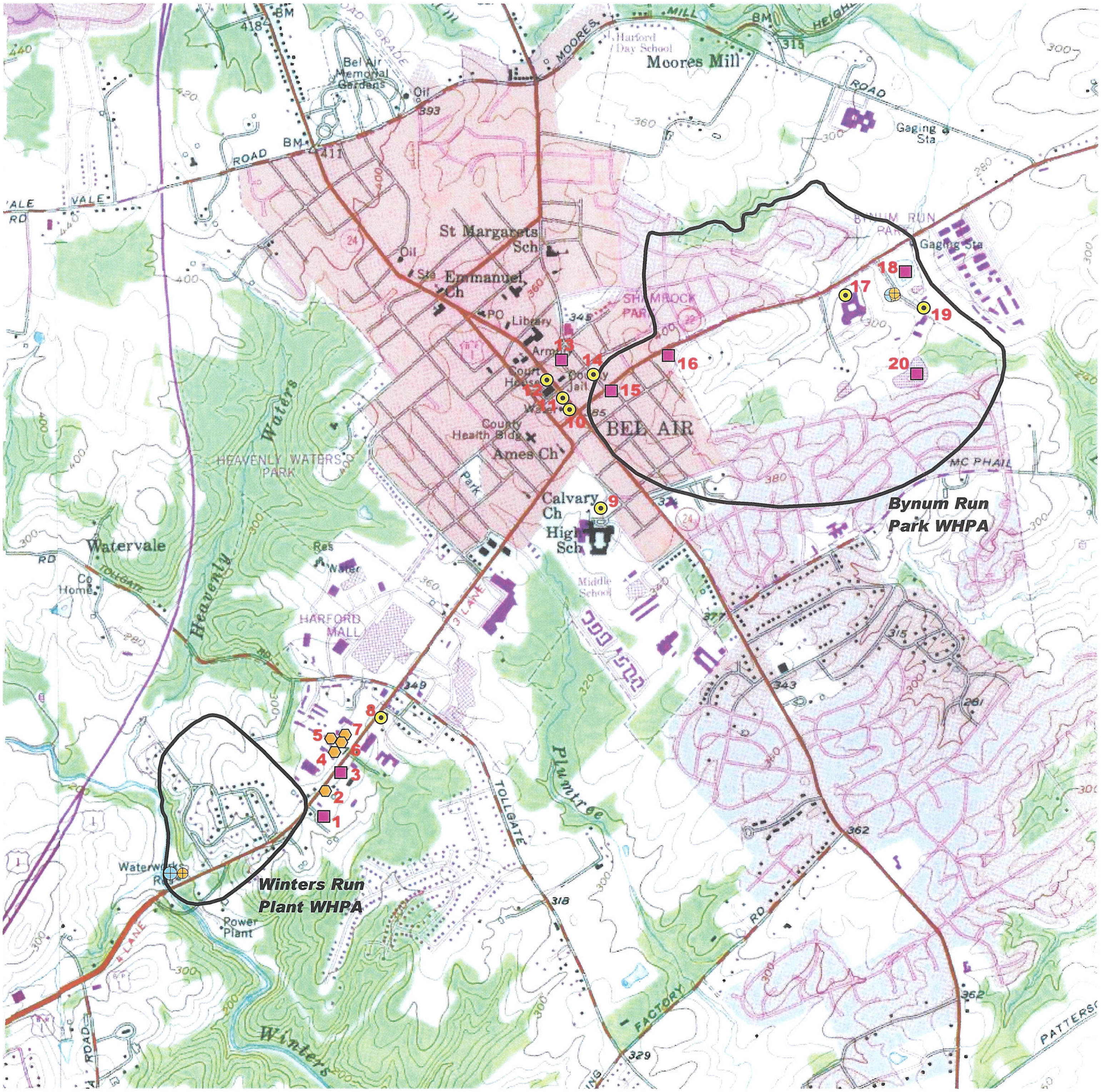


Figure 6-3. Maryland American-Bel Air Wellhead Protection Areas with Potential Contaminant Sources

LEGEND

- Supply Wells
- Monitoring Wells
- Wellhead Protection Areas
- Underground Storage Tanks (USTs)
- Controlled Hazardous Substance Generators
- Miscellaneous Sites

N

2000 0 2000 Feet

Base Map: USGS 7.5 Minute Series Quads for Bel Air & Jarrettsville

7.0 REVIEW OF WATER QUALITY DATA

Several sources of water quality data were reviewed for Maryland American's source water assessment. These include MDE Water Supply Program's database for safe drinking water contaminants and monthly operating reports from the Winters Run Water Treatment Plant. Data from the United States Geological Survey, MD Department of Natural Resources and Maryland American Water Company water quality monitoring program were also reviewed.

Water quality data for Winters Run was compared with the maximum contaminant levels (MCLs) set by the U.S. Environmental Protection Agency. MCLs are established to ensure that drinking water is safe for human consumption. The monitoring data shows that any contaminant is greater than 50% of a MCL for at least 10% of the available data points, a detailed susceptibility analysis will be performed for that contaminant and its potential sources.

Data from the Winters Run Plant (01) reflects the quality of the mixed supply of surface water from Winters Run, and ground water from the Winters Run Plant Well. The Bynum Run Park Plant (02) data represents ground water quality pumped from the Bynum Run Park Well only. For the purpose of this review, all contaminant detects from each plant will be discussed separately below. The data is from finished (treated) water unless otherwise noted.

7.1 <u>Winters Run Treatment Plant Water Quality Monitoring</u> (surface and ground)

Maryland American Water Company routinely tests raw and treated water at the Winters Run Water Treatment Plant for various contaminants. MDE also periodically analyze samples of the raw and treated water for contaminants regulated under the Safe Drinking Water Act. Raw water samples are collected at the plant prior to treatment. Treated samples are collected after the water passes through the treatment plant. A discussion of the raw water testing and compliance sampling follows.

7.1.1 Turbidity, pH and Iron in Winters Run Raw Water

Turbidity is described as a measure of cloudiness of water. It is used to indicate water quality and treatment effectiveness. Higher turbidity level is often associated with higher levels of disease causing microorganisms such as viruses, parasites and bacteria. Turbidity is measured in the raw water at the Winters Run Water Treatment Plant on a continuous basis. The monthly summary statistics for each month during the period 2000-2003 is presented in Table 7.1. For this period, the average daily turbidity was 15.21 nephelometric turbidity units (NTU), the minimum turbidity measured was 2.0 NTU, and the maximum turbidity measured was 330 NTU. The average turbidity of the raw water exceeds the current MCL; therefore, turbidity is a contaminant of concern. The correlation between the rainfall and turbidity from July 2000 through January 2003 is shown in Figure 7.1. The highest turbidity occurs when the rainfall event exceeds the 0.5-inch. During storm events, the surface runoff increases, the increased flow of water can cause soil and other material to erode, increasing the suspended solids and raising the turbidity.

Iron (Fe) is one of the most abundant of all elements. This metal occurs naturally in rocks and soils. Iron found in water can also be the result of corrosive water coming into contact with unprotected steel or iron mains, steel well casings and pumps. It can originate from industrial wastes or from acid runoff from mining operations. Iron is regulated as a secondary drinking water contaminant since there are no known health effects associated with the ingestion of this metal. Iron is primarily a concern from an aesthetic standpoint.

Iron in drinking water can stain plumbing fixtures and laundry. It can also provide a nutrient source for some bacteria, which grow in water distribution mains. These bacteria can cause red colored water, tastes and odors, and equipment failures. Iron solubility is related to many factors such as pH and dissolved oxygen levels. Iron is more soluble in waters with reducing conditions (i.e., low dissolved oxygen).

The monthly average of iron levels during the period 2000-2003 is shown in Table 7.1. The average iron exceeded the drinking water standard of 0.3 mg/l for the months of July and August.

Turbidity, pH and Iron in Raw Water at Winters Run Filter Plant Aggregated by Month for Data from January 2000 Thru October 2003[1]							
	Turbidity (NTU)			PH			Fe mg/L
Month	Max	Min	Average	Max	Min	Average	Average
Jan	113	3	9.02	7.7	7.2	7.3	0.143
Feb	200	3	10.04	7.6	7.0	7.4	0.143
Mar	228	2	19.68	7.8	7.2	7.4	0.223
Apr	57	4	7.56	7.6	7.1	7.5	0.150
May	195	4	17.01	7.8	7.1	7.4	0.155
Jun	315	6	26.05	8.5	7.0	7.4	0.228
Jul	149	6	17.28	8.2	7.0	7.4	0.333
Aug	228	5	20.77	8.0	7.2	7.4	0.327
Sep	177	5	22.85	7.9	7.2	7.4	0.255
Oct	129	4	13.09	7.9	7.1	7.4	0.163
Nov	118	2	9.53	7.6	7.3	7.4	0.120
Dec	330	2	12.46	7.7	7.2	7.4	0.137
Combined	330	2	15.21	8.5	7.0	7.4	0.193

Table 7.1 Turbidity, pH and Iron in Raw Water at the Winters Run Filter Plant

[1] The plant was closed for renovations from 14 March 2000 thru 3 May 2000, so data from March and April 2000 was not included in the analysis. The plant was also shutdown from 2 July 2002 thru 15 October 2002 due to low flows on Winters IRun and data from July, August and September 2002 was not included in the aggregation by month. Data from September 2003 was not available at the time this analysis was preformed and was not included. Averages in this table are based on the average of the monthly averages, rather than an average of the underling data. That is, to get the January average, the average values of January 2000, January 2001, January 2002 and January 2003 were averaged. Where an incomplete month is included (May 2000 and October 2002) the result may differ from the average of the underlying data.

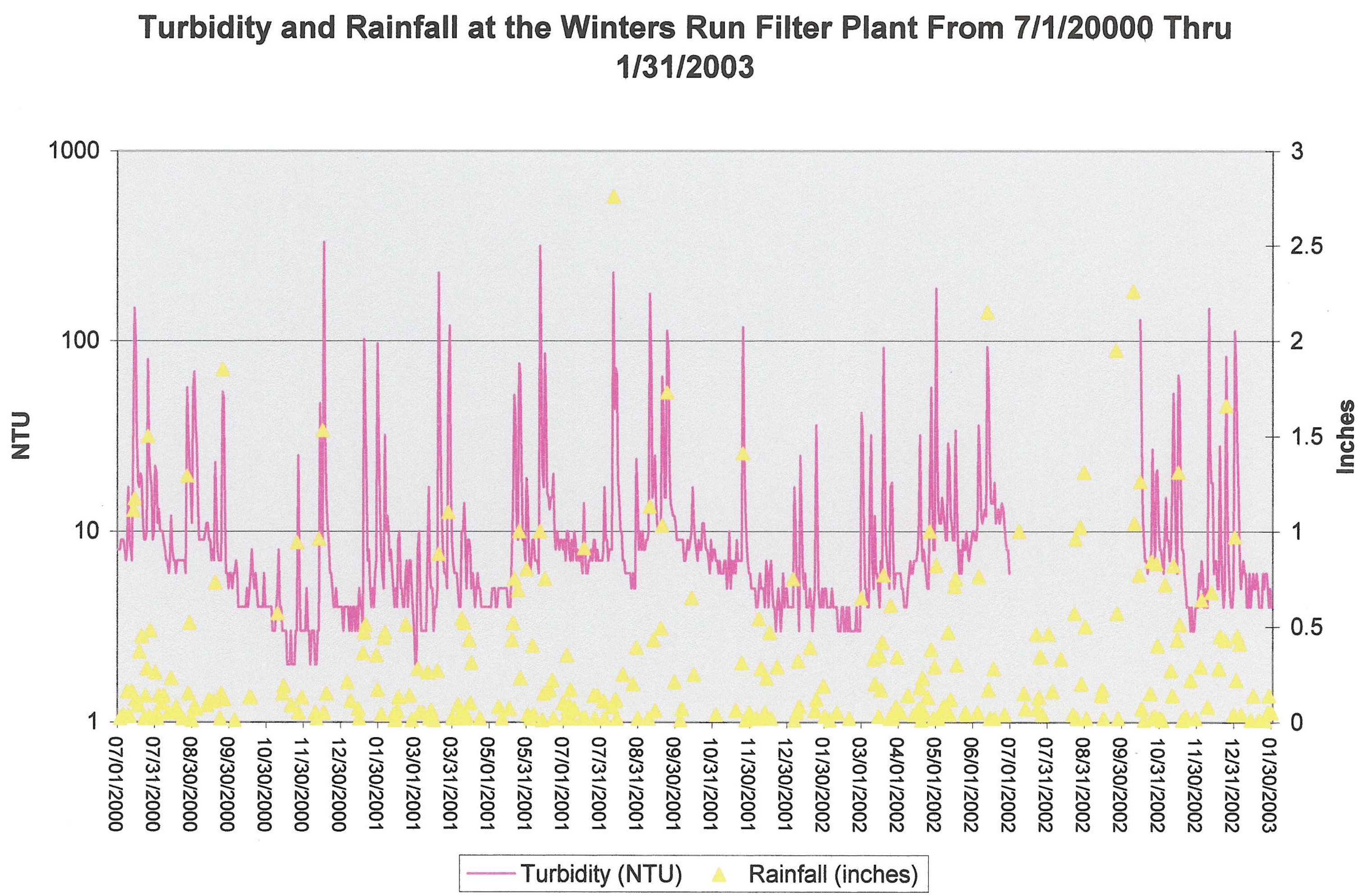


Figure 7-1 Turbidity and Rainfall at the Winters Run Filter Plant

7.1.2 Microbiological Contaminants

Maryland American assayed the raw water for total coliform, often on a daily basis, from July 2000 thru January 2003[2], except during the period from 2 July 2002 thru 15 October 2002 when the plant was shutdown due to low flow on Winters Run. As shown in Table 7-2 (below) and Figures 7-2 and 7-3 total coliform levels vary widely and shows some degree of correlation with turbidity[3]. Total coliform is not a health threat in itself; it is used to indicate whether other potentially harmful bacteria may be present. Lower levels were typically found in the colder months when there is reduced biological activity.

Assays of Total Coliform at the Winters Run Filter Plant Aggregated by Month for Data From 1 July 2000 Thru 31 January 2003[4]			
	Total Coliform (MPN/100mL)		
Month	Average[5]	Max	Min
Jan	392	7300	0
Feb	190	1280	0
Mar	252	1200	0
Apr	359	2900	30
May	881	4000	0
Jun	1607	10000	0
Jul	940	7100	40
Aug	1265	2800	600
Sep	2054	7800	400
Oct	2779	16000	100
Nov	1471	9800	80
Dec	833	11600	20
Combined	1040	16000	0

Table 7.2 Total Coliform at the Winters Run Filter Plant

[2] Raw water assays were also made every few days prior to the renovation of the plant in March, April and May of 2000.
[3] Analysis of the data shows that the correlation between Turbidity and Total Coliform is .38, which is statistically significant for the 496 paired observations.
[4] No data was reported for the period from 2 July 2002 thru 16 October 2002. The plant was shutdown because of low flow on Winters Run from 2 July 2002 thru 15 October 2002.
[5] This is the average of every assay taken in the relevant month.

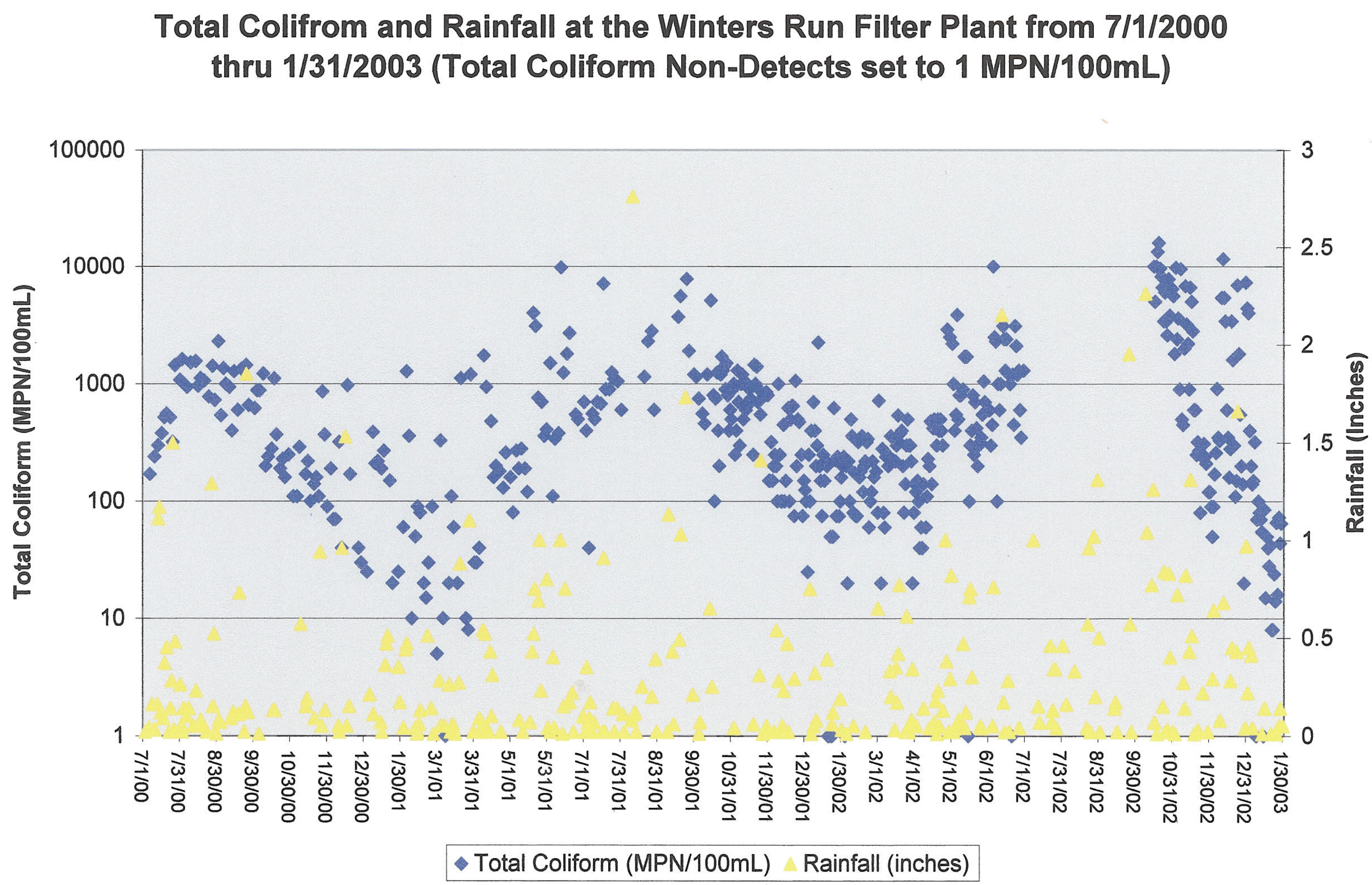


Figure 7-2 Total Coliform and Rainfall at the Winters Run Filter Plant

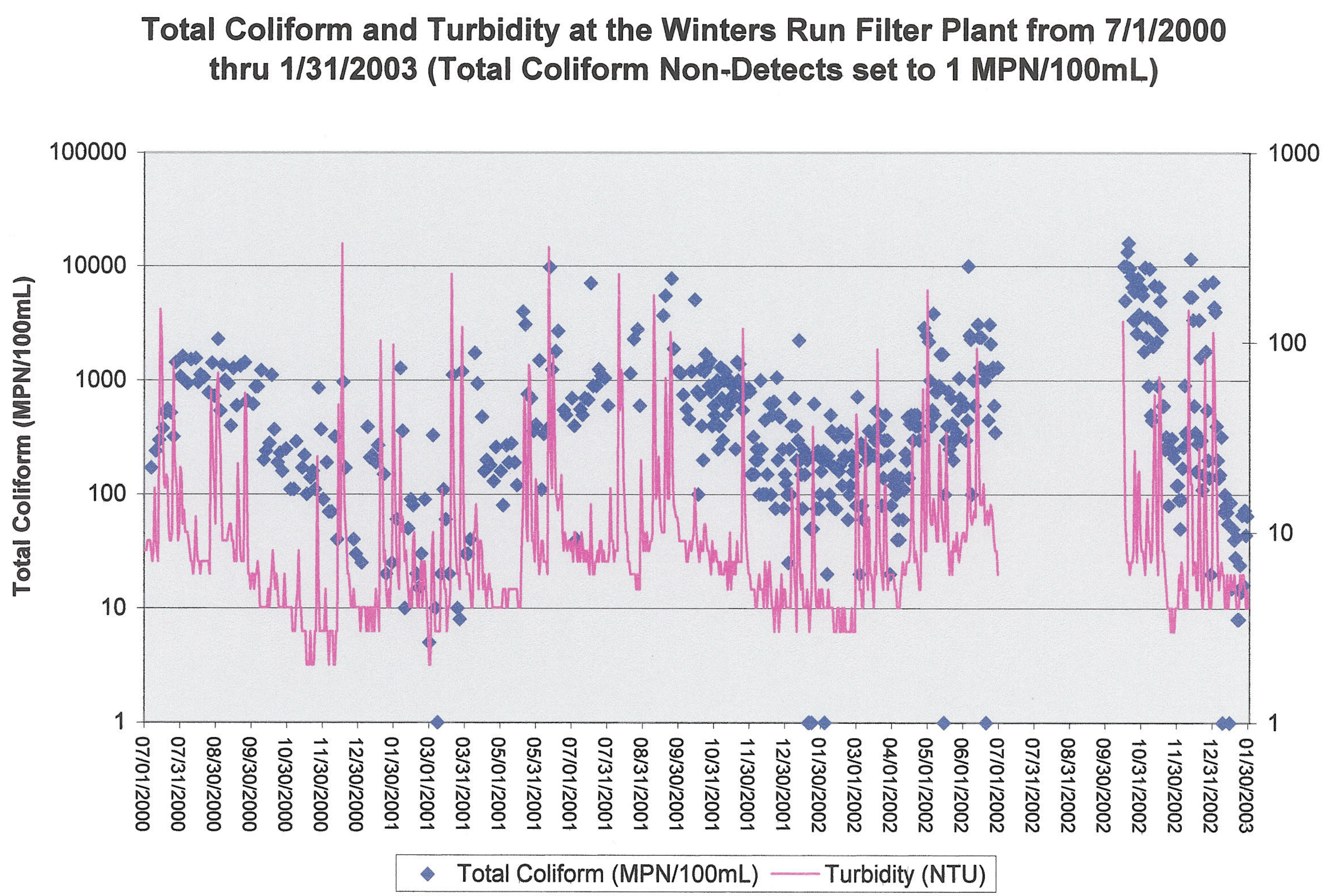


Figure 7-3 Total Coliform and Turbidity at the Winters Run Filter Plant

MDE with cooperation of water systems using surface water as a source of water supply began the raw water bacteriological monitoring program starting in September 2000. Maryland American Water System participated in this program and continues to test the raw water for fecal coliform on a weekly basis. Figure 7-4 shows the results in Most Probable Numbers/100 ml from January 2002 through January 2003 and rainfall intensity in inches. Figure 7-5 depicts the correlation between fecal coliform and raw water turbidity. Higher levels of fecal coliform occurs when the rainfall exceeds 0.5 inches or more.

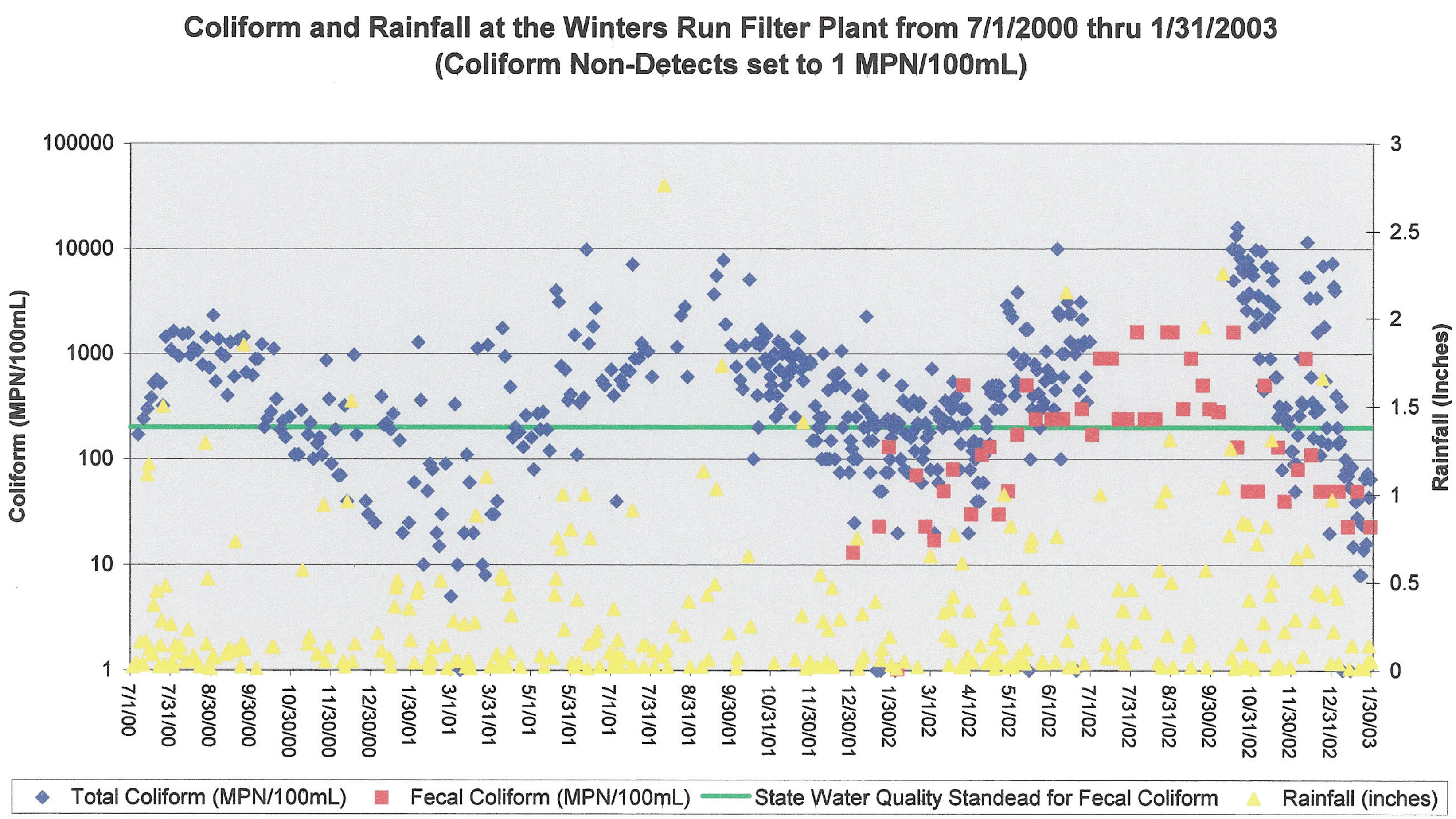


Figure 7-4 Coliform and Rainfall at the Winters Run Filter Plant

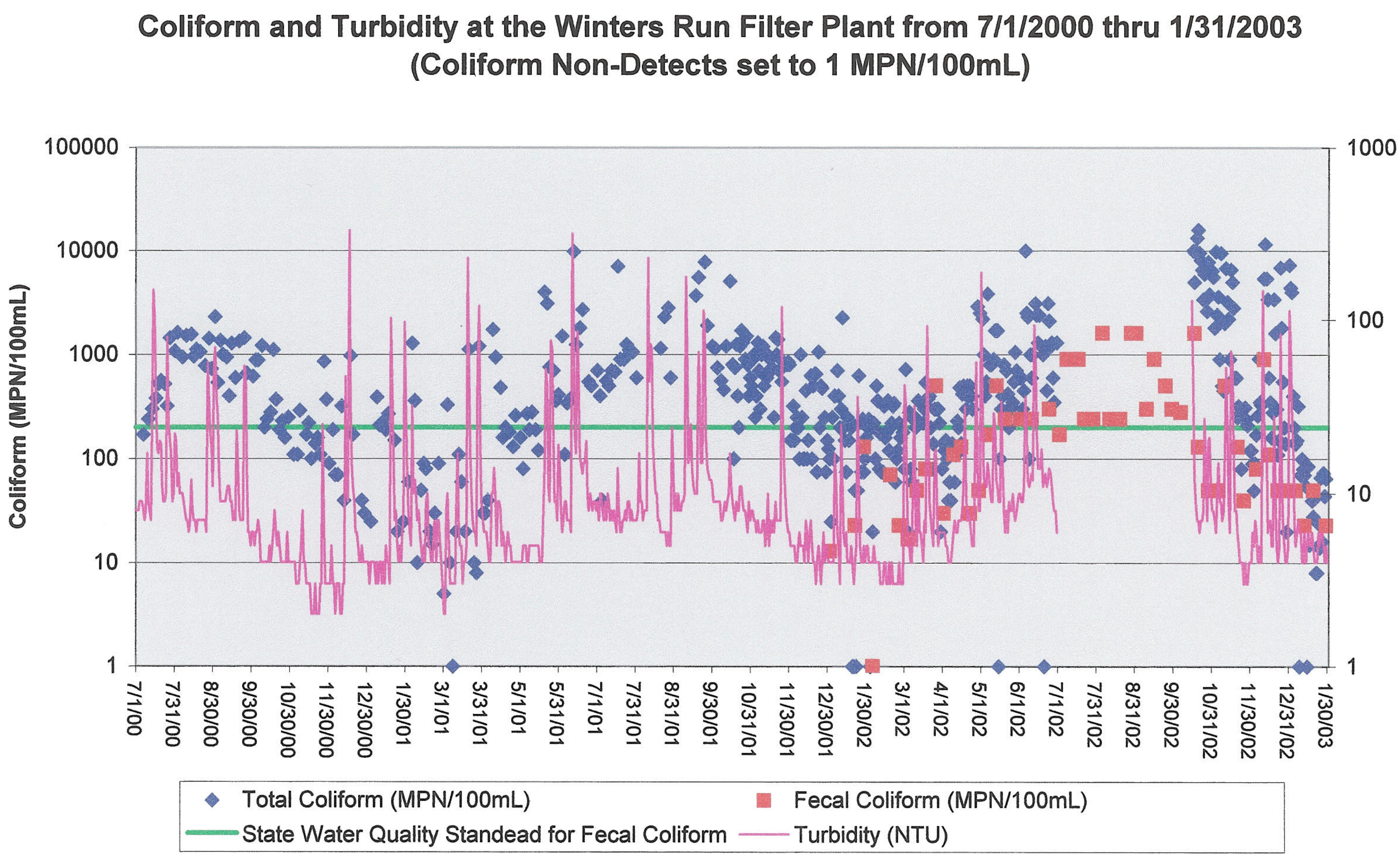


Figure 7-5 Coliform and Turbidity at the Winters Run Filter Plant

7.1.3 Inorganic Compounds (IOCs)

Winters Run plant regularly tests for presence of nitrate and other inorganic compounds in finished drinking water. The treatment process will not remove dissolved inorganic ions, so finished water is generally reflective of raw water for these compounds. Table 7.3 summarizes the results of all sampling from 1993-2003. Fluoride results reflect added fluoride during treatment process; therefore, levels are not reflective of raw water conditions. Thirty samples detected nitrate since 1993. One sample dated September 21, 1993 exceeded the 50% of MCL.

CONTAMINANT NAME	MCL (PPM)	SAMPLE DATE	RESULT (PPM)
ARSENIC	0.01	03/12/1997	0.0007
BARIUM	2	06/13/1995	0.05
BARIUM	2	03/23/1999	0.018
BARIUM	2	03/23/1999	0.014
BARIUM	2	10/13/1999	0.015
BARIUM	2	03/07/2000	0.023
BARIUM	2	10/10/2000	0.017
BARIUM	2	03/13/2001	0.027
BARIUM	2	10/29/2001	0.015
BARIUM	2	03/26/2002	0.019
BARIUM	2	03/25/2003	0.018
CALCIUM		03/12/1997	15
CHLORIDE		03/12/1997	23.9
CHROMIUM	0.1	06/13/1995	0.001
CHROMIUM	0.1	03/12/1997	0.0026
CHROMIUM	0.1	03/12/1997	0.0027
CYANIDE	0.2	06/13/1995	0.02
FLUORIDE	4	06/16/1993	0.8
FLUORIDE	4	06/14/1994	0.74
FLUORIDE	4	06/13/1995	0.2
FLUORIDE	4	06/28/1995	0.84
FLUORIDE	4	03/26/1996	0.85
FLUORIDE	4	03/12/1997	0.82
FLUORIDE	4	05/22/1997	0.8
FLUORIDE	4	10/28/1997	0.89
FLUORIDE	4	03/24/1998	0.79
FLUORIDE	4	03/23/1999	0.73
FLUORIDE	4	10/13/1999	0.92
FLUORIDE	4	03/07/2000	0.9
FLUORIDE	4	10/10/2000	1.07
FLUORIDE	4	03/13/2001	0.99
FLUORIDE	4	10/29/2001	0.99
FLUORIDE	4	03/26/2002	0.89
FLUORIDE	4	03/25/2003	0.95
FLUORIDE	4	05/12/2003	1.02
LEAD	0.015	03/12/1997	0.0003
MAGNESIUM		03/12/1997	5.2
NICKEL		06/13/1995	0.01
NITRATE	10	03/31/1993	2.5

CONTAMINANT NAME	MCL (PPM)	SAMPLE DATE	RESULT (PPM)
NITRATE	10	04/07/1993	2.9
NITRATE	10	06/16/1993	3.1
NITRATE	10	09/21/1993	5.3
NITRATE	10	06/14/1994	3
NITRATE	10	09/13/1994	2.9
NITRATE	10	04/25/1995	2.8
NITRATE	10	06/13/1995	2.5
NITRATE	10	06/28/1995	2.6
NITRATE	10	12/06/1995	3.2
NITRATE	10	03/26/1996	3.1
NITRATE	10	06/25/1996	2.8
NITRATE	10	06/25/1996	2.8
NITRATE	10	03/12/1997	3.12
NITRATE	10	05/22/1997	3
NITRATE	10	10/28/1997	2.16
NITRATE	10	03/24/1998	2.53
NITRATE	10	06/16/1998	2.67
NITRATE	10	09/29/1998	2.79
NITRATE	10	06/22/1999	2.21
NITRATE	10	06/20/2000	3.03
NITRATE	10	09/25/2000	2.98
NITRATE	10	06/18/2001	2.16
NITRATE	10	12/17/2001	2.76
NITRATE	10	03/26/2002	2.73
NITRATE	10	03/25/2003	2.48
NITRATE	10	05/12/2003	2.4
NITRITE	1	09/13/1994	0.007
NITRITE	1	12/06/1995	0.01
NITRITE	1	03/26/2002	0.006
POTASSIUM		03/12/1997	1.6
SELENIUM	0.05	06/13/1995	0.002
SODIUM		06/25/1996	7.3
SODIUM		03/12/1997	7.9
SODIUM		05/22/1997	8.09
SODIUM		10/28/1997	9.1
SODIUM		03/24/1998	7
SODIUM		03/23/1999	11
SODIUM		03/23/1999	23
SODIUM		10/13/1999	8
SODIUM		03/07/2000	9
SODIUM		10/10/2000	8
SODIUM		03/13/2001	18
SODIUM		10/29/2001	8
SODIUM		03/26/2002	9
SODIUM		03/25/2003	10
SODIUM		05/12/2003	9.05
SULFATE		06/16/1993	6.8
SULFATE		06/14/1994	6.6
SULFATE		06/13/1995	7

CONTAMINANT NAME	MCL (PPM)	SAMPLE DATE	RESULT (PPM)
SULFATE		06/28/1995	7.4
SULFATE		03/26/1996	9
SULFATE		06/25/1996	7.7
SULFATE		03/12/1997	8.7
SULFATE		05/22/1997	9.7
SULFATE		10/28/1997	13.5
SULFATE		03/24/1998	9.5
SULFATE		03/23/1999	9.3
SULFATE		03/23/1999	38.4
SULFATE		10/13/1999	8.7
SULFATE		03/07/2000	8.8
SULFATE		10/10/2000	7.6
SULFATE		03/13/2001	8.6
SULFATE		10/29/2001	7.6
SULFATE		03/26/2002	9.7
ANTIMONY	0.006	03/12/1997	0.0002
BERYLLIUM	0.004	06/13/1995	0.001
THALLIUM	0.002	06/13/1995	0.001
ZINC		03/12/1997	0.5
pH		03/26/1996	7.4
pH		05/22/1997	7.4
GROSS ALPHA	15	07/18/2001	0.6
GROSS BETA	50	05/15/2000	3

Table 7.3 IOCs Detected in Winters Run Water Treatment Plant from 1993 through 2003

7.1.4 Synthetic Organic Compounds (SOCs)

SOC samples are collected by Maryland American Water Company and MDE. Below is a summary of SOCs detected for years 1993-2003. Atrazine, a commonly used agricultural herbicide, was detected six times during these years, once above 50% of the MCL.

CONTAMINANT NAME	MCL (PPM)	SAMPLE DATE	RESULT (PPM)
2,4-D	70	05/15/2000	1.06
2,4-D	70	05/15/2000	0.7
ATRAZINE	3	05/15/1995	0.2
ATRAZINE	3	06/10/1997	0.31
ATRAZINE	3	06/10/1997	0.64
ATRAZINE	3	05/17/1999	0.2
ATRAZINE	3	05/15/2000	2.3
ATRAZINE	3	05/29/2001	0.3
DALAPON	200	05/04/1999	0.51
DALAPON	200	10/06/1999	2.9
DI(2-ETHYLHEXYL) PHTHALATE	6	05/17/1999	1.6
DI(2-ETHYLHEXYL) PHTHALATE	6	05/15/2000	0.8
DI(2-ETHYLHEXYL)	6	05/12/2003	0.8

PHTHALATE			
METOLACHLOR		05/15/2000	0.8
OXAMYL (VYDATE)	200	05/18/1998	2
OXAMYL (VYDATE)	200	07/07/1998	2
PENTACHLOROPHENOL	1	05/15/2000	0.45
PENTACHLOROPHENOL	1	05/12/2003	0.02
SIMAZINE	4	05/15/1995	0.3

Table 7.4. SOCs Detected in Winters Run Plant from 1993 through 2003.

Although none of the SOC data exceeds the 50/10 criteria, alachlor, atrazine and simazine are of interest because they are commonly used as herbicides and have been detected frequently in the water from the Winters Run Plant. A review of all available data from several scientific studies (*Triazine Herbicide Concentrations in Water Supplies in Central MD,* January 1986 and *Monsanto Study – Acetochlor Registration Program 1996*) along with plant monitoring data suggests that the usage of herbicides has declined in Winters Run Watershed in the past years. Given the reduction in pesticide application rates, improved management practices and loss of agricultural land over this period, it is likely that these concentrations will continue to decrease in the future. Statewide pesticide statistics prepared by Maryland Department of Agriculture also indicate that the usage of atrazine and other herbicides has declined in Maryland in the past decade.

7.1.5 Volatile Organic Compounds (VOCs)/Disinfection Byproducts (DBPs)

No volatile organic compounds other than disinfection by-products have exceeded more than 50% of MCL in 10% or more of the collected samples. Table 7.5 shows the resulting detection of VOCs from 1993-2003.

CONTAMINANT NAME	MCL (PPM)	SAMPLE DATE	RESULT (PPM)
1,1,1-TRICHLOROETHANE	200	02/17/1993	18
1,1,1-TRICHLOROETHANE	200	07/24/1995	3.1
1,1,1-TRICHLOROETHANE	200	07/25/1995	1
CARBON TETRACHLORIDE	5	03/18/1988	0.3
TOLUENE	1000	06/20/2000	1.2
TOLUENE	1000	07/12/2000	0.7
XYLENES, TOTAL	10000	06/20/2000	2.2
XYLENES, TOTAL	10000	07/12/2000	1.5
XYLENES, TOTAL	10000	07/16/2001	1.2

Table 7.5. VOCs Detected in Winters Run Water Treatment Plant.

Levels of disinfection by-products in the distribution exceed 50% of the established MCLs for total THM (0.080 mg/L) and HAA (0.060 mg/L).

The DBPs are total trihalomethanes (TTHMs) and haloacetic acid (HAA). The sum of concentration of four compounds chloroform, bromochloromethane, dibrochloromethane, and bromoform comprise TTHM and the sum of five compounds mono, di, and tri-chloroacetic acids, and mono- and di-bromoacetic acids comprise HAA5. In addition, organic carbon is monitored in raw and treated water.

Maryland American Water Company has been monitoring disinfection by-products (DBPs) in the distribution system to monitor compliance with Stage 1 Disinfectant and Disinfection Byproduct Rule (DBPR) shown below in Table 7.6 and 7.7.

	THM (ug/l)			HAA (ug/l)		
Year	**Average**	**Max**	**Min**	**Average**	**Max**	**Min**
1996	42.75	69.0	-			
1997	32.75	80.4	15.5			
1998	43.40	57.3	31.8			
1999	56.93	122.0	1.9	59.44	99.7	21.3
2000	36.59	88.3	-	33.89	70.6	-
2001	56.21	117.6	18.1	41.39	74.4	14.6
2002	58.02	184.8	8.1	54.79	114.1	11.7
2003	43.88	104.7	12.3	41.06	78.3	12.5
2004	19.53	41.5	7.7	20.76	50.7	7.9
Total	47.52	184.8	-	45.34	114.1	-

Table 7.6. Annual Concentration of Disinfection Byproducts Attributed to Winters Run Water Treatment Plant

	THM (ug/l)			HAA (ug/l)		
Quarter	**Average**	**Max**	**Min**	**Average**	**Max**	**Min**
Jan – Mar	28.53	94.2	7.7	25.05	69.2	7.9
Apr – Jun	37.90	98.2	-	39.81	78.3	-
Jul – Sep	75.96	184.8	18.2	59.10	114.1	15.7
Oct – Dec	46.47	114.8	-	54.25	99.7	12.1
Total	47.52	184.8	-	45.34	114.1	-

Table 7.7. Quarterly Average Concentration of Disinfection Byproducts Attributed to Winters Run Water Treatment Plant

The DBPs are total trihalomethanes (TTHMs) and haloacetic acid (HAA). The sum of concentration of four compounds chloroform, bromochloromethane, dibromochloromethane, and bromoform comprise TTHM and the sum of five compounds mono, di, and tri-chloroacetic acids, and mono- and di-bromoacetic acids comprise HAA5. In addition, organic carbon is monitored in raw and treated water.

Total Organic Carbon is used as surrogate for disinfection by products precursors (DBPPs). The quarterly average concentration of TOC is show in table 7.8 (below).

	Source TOC (mg/l)			Treated TOC (mg/l)			Percent TOC Removed		
Quarter	Average	Max	Min	Average	Max	Min	Average	Max	Min
Jan-Mar	1.12	2.04	0.65	0.92	1.59	0.59	16%	46%	-20%
Apr-Jun	1.48	2.55	1.00	1.17	1.95	0.80	20%	43%	-23%
Jul-Sep	2.03	5.56	1.12	1.51	2.79	0.82	19%	50%	-2%
Oct-Dec	1.49	3.32	0.80	1.21	2.10	0.58	18%	39%	4%
All Data	1.45	5.56	0.65	1.15	2.79	0.58	18%	50%	-23%

Table 7.8. Quarterly Average Concentration of Total Organic Carbon (1996-2004) at the Winters Run Water Treatment Plant.

The raw water TOC values are highest in the third quarter, followed by the fourth quarter. Higher removal efficiencies also occur in the third quarter. A review of the disinfection byproduct data by season (see Table 7.7) indicates that the warmest quarter (July-September) has the highest DBP levels. The average THM values during this period 75.96 mg/L that is less than 80 mg/L MCL established by EPA. Levels of disinfection byproducts in the treated exceed 50% of the MCL at least 10% of available data points. Because of the significance of the DBP issue and the potential role of watershed activities in producing DBP precursors, DBPs and TOCs are considered contaminants of concern.

7.2 Winters Run Watershed Water Quality Data

The United States Geological Survey (USGS) maintains a gauging station on Winters Run near Benson, Maryland. This station is located on the left bank of Winters Run, 30 feet from the bridge on U.S. Highway 1, and covers approximately 35 square miles of drainage area.

This gage is primarily used for measuring the flow as a water stage recorder. Several water quality records for years 1993 through 1995 have been collected at this location. The water quality parameter during this period is presented in Table 7.9.

Date	Parameter	Result	Units
10/07/1993	pH (field)	6.5	pH
10/07/1993	nitrite	<.01	mg/l as N
10/07/1993	nitrite plus nitrate	3.3	mg/l as N
10/07/1993	Ca	9.1	mg/l
10/07/1993	Mg	5.2	mg/l
10/07/1993	Na	7	mg/l
10/07/1993	K	2.2	mg/l
10/07/1993	Chloride	15	mg/l
10/07/1993	Sulfate	6.8	mg/l
10/07/1993	Silica	13	mg/l
10/07/1993	Fe	60	ug/l

Date	Parameter	Result	Units
10/07/1993	Mn	17	ug/l
10/07/1993	Alkalinity	23	mg/l as CaCO3
10/07/1993	Specific Conductance	143	uS @25 C
08/25/1994	pH (field)	7.1	pH
08/25/1994	pH (Lab)	7.4	pH
08/25/1994	nitrite	<.01	mg/l as N
08/25/1994	nitrite plus nitrate	2.7	mg/l as N
08/25/1994	Ca	9.6	mg/l
08/25/1994	Mg	4.8	mg/l
08/25/1994	Na	7.2	mg/l
08/25/1994	K	2.1	mg/l
08/25/1994	Chloride	14	mg/l
08/25/1994	Sulfate	7.3	mg/l
08/25/1994	Fluoride	<.1	mg/l
08/25/1994	Silica	12	mg/l
08/25/1994	Fe	83	ug/l
08/25/1994	Mn	23	ug/l
08/25/1994	Alkalinity	24	mg/l as CaCO3
08/25/1994	Specific Conductance	143	uS @25 C
08/18/1995	pH (field)	6.8	pH
08/18/1995	pH (Lab)	7.5	pH
08/18/1995	nitrite	0.01	
08/18/1995	nitrite plus nitrate	2.4	mg/l as N
08/18/1995	Ca	10	mg/l as N
08/18/1995	Mg	5.3	mg/l
08/18/1995	Na	7.4	mg/l
08/18/1995	K	2.6	mg/l
08/18/1995	Cl	15	mg/l
08/18/1995	Sulfate	5.9	mg/l
08/18/1995	Fluoride	<.1	mg/l
08/18/1995	Silica	11	mg/l
08/18/1995	Fe	56	ug/l
08/18/1995	Mn	36	ug/l
08/18/1995	Alkalinity	26	mg/l as CaCO3
08/18/1995	Specific Conductance	146	uS @25 C

Table 7.9. Water Quality Data from USGS Gage 01581700 – Winters Run Near Benson, MD

7.3 <u>Bynum Run Park Treatment Plant Water Quality Monitoring</u> (ground water only)

A review of the monitoring data since 1996 for the Bynum Run Park Well indicates that the ground water supply meets the current drinking water standards. The water quality sampling results are summarized in Table 7.10.

PLANT NAME	Nitrate		SOCs		VOCs		IOCs (except nitrate)		Radionuclides	
	No. of Samples	No. of samples > 50% MCL	No. of Samples	No. of samples > 50% MCL	No. of Samples	No. of samples > 50% MCL	No. of Samples	No. of samples > 50% MCL	No. of Samples	No. of samples > 50% MCL
Bynum Run	10	0	21	0	23	0	10	0	4	1*

Table 7.10. Summary of Water Quality Samples from the Bel Air Bynum Run Park Ground Water Supply

* Based on lower proposed MCL for radon-222

7.3.1 Inorganic Compounds (IOCs)

The regulated inorganic compounds detected in the Bynum Run Park ground water supply are listed in Table 7.11. Nitrate was the most common inorganic compound detected in the well, however the levels present are below 50% of the nitrate MCL of 10 parts per million (ppm). The other IOCs detected were at levels well below 50% of their respective MCL thresholds.

CONTAMINANT	MCL (ppm)	SAMPLE DATE	RESULT (ppm)
NITRATE	10	5-Aug-96	2.7
LEAD	0.015	5-Aug-96	0.002
NITRATE	10	23-Sep-97	2.6
NICKEL	0.1	23-Sep-97	0.0009
NICKEL	0.1	24-Mar-98	0.01
FLUORIDE	4	24-Mar-98	1.25
BARIUM	2	19-Oct-98	0.002
FLUORIDE	4	19-Oct-98	1.16
NITRATE	10	8-Dec-98	1.99
FLUORIDE	4	23-Mar-99	0.9
NICKEL	0.1	23-Mar-99	0.0006
FLUORIDE	4	13-Oct-99	0.86
BARIUM	2	13-Oct-99	0.002
FLUORIDE	4	7-Mar-00	0.77
BARIUM	2	7-Mar-00	0.001
FLUORIDE	4	10-Oct-00	0.87
BARIUM	2	10-Oct-00	0.002
NITRATE	10	19-Dec-00	2.66
FLUORIDE	4	13-Mar-01	1.37
BARIUM	2	13-Mar-01	0.002
NITRATE	10	14-Mar-01	3.32

NITRATE	10	18-Jun-01	2.88
NITRATE	10	17-Dec-01	3.31
NITRATE	10	26-Mar-02	3.18
FLUORIDE	4	26-Mar-02	1.5
BARIUM	2	26-Mar-02	0.002
NITRATE	10	25-Mar-03	3.48
NITRATE	10	2-Mar-04	4.1

Table 7.11. Regulated IOC Detections in the Bynum Run Park Ground Water Supply

7.3.2 Radionuclides

Radiological contaminants detected in the Bynum Run Park ground water supply are shown in Table 7.12. Gross alpha was detected in three sets of sampling data at levels well below its MCL of 15 picoCuries/Liter (pCi/L). Gross alpha radiation is a measure of alpha particle activity and is used as an indicator for the presence of other natural and man-made radionuclides. Radon-222 was detected at 385 pCi/L from one set of available sampling data. At present, there is no MCL for radon-222, however EPA has proposed an MCL of 300 pCi/L and an alternate MCL of 4000 pCi/L for community water systems if the State has a program to address the more significant risk from radon in indoor air.

PLANT	CONTAMINANT	MCL (pCi/L)	SAMPLE DATE	RESULT (pCi/L)
Bynum Run	GROSS ALPHA	15	5-Aug-96	1.4
	RADON-222	**300***	**5-Mar-98**	**385**
	GROSS ALPHA	15	18-Jul-01	0.5
	GROSS ALPHA	15	13-Dec-01	1

Table 7.12. Radionuclides Detected at the Bynum Run Park Ground Water Supply
* Lower proposed MCL

7.3.3 Synthetic Organic Compounds (SOCs)

Di(2-ethylhexyl phthalate) was the only SOC detected from 21 sets of available sampling data. As shown in Table 7.13, the SOC was detected twice at 0.9 parts per billion (ppb), well below the MCL of 6 ppb. Phthalate was also detected in the laboratory blank samples and therefore the results are not interpreted to represent actual water quality.

CONTAMINANT	MCL (ppb)	SAMPLE DATE	RESULT (ppb)
DI(2-ETHYLHEXYL) PHTHALATE	6	14-Aug-01	0.9
DI(2-ETHYLHEXYL) PHTHALATE	6	1-Jun-04	0.9

Table 7.13 SOC Detections in the Bel Air Bynum Run Park Ground Water Supply

7.3.4 Volatile Organic Compounds (VOCs)

The only VOCs detected from 23 sets of available sampling data were the disinfection byproducts known as trihalomethanes (THMs). As shown in Table 7.14, the sum total of the four trihalomethanes (TTHM) detected from each set of sampling data since 1998 ranged from 0.5 to 76.1 ppb. For regulated systems, the current MCL for TTHMs is 80 ppb. Disinfection byproducts are the result of a reaction between chlorine used for disinfection and organic material in the water supply. No THMS were detected from the latest two sets of available sampling data at this plant.

CONTAMINANT NAME	SAMPLE DATE	RESULT (ppb)	SUM THMs (ppb)
BROMODICHLOROMETHANE	11-Aug-98	14.2	75
DIBROMOCHLOROMETHANE	11-Aug-98	2.7	
CHLOROFORM	11-Aug-98	58.1	
BROMODICHLOROMETHANE	6-Oct-98	12.8	76.1
CHLOROFORM	6-Oct-98	60.7	
DIBROMOCHLOROMETHANE	6-Oct-98	2.6	
CHLOROFORM	8-Dec-98	0.8	0.8
CHLOROFORM	23-Mar-99	0.8	0.8
CHLOROFORM	22-Jun-99	0.6	0.6
CHLOROFORM	19-Dec-00	0.5	0.5
CHLOROFORM	24-Jan-01	0.5	0.5
CHLOROFORM	13-Mar-01	0.6	0.6
CHLOROFORM	18-Jun-01	0.8	0.8
CHLOROFORM	16-Jul-01	2.7	2.7
BROMODICHLOROMETHANE	21-Aug-01	0.6	12.4
CHLOROFORM	21-Aug-01	11.8	

Table 7.14 Disinfection Byproducts in the Bel Air Bynum Run Park Ground Water Supply

7.3.5 Microbiological Contaminants

Raw water samples were collected and tested for bacteria after the Bynum Run Park Well was constructed in 1996 and prior to it being put into service. The testing was conducted after the well was pumped for several hours to determine if the well was under the influence of surface water. A wet weather test was conducted after 2.92 inches of rainfall in 24 hours had occurred. As shown in Table 7.15, the wet and dry weather test results were negative for the presence of total and fecal coliform bacteria. Ground water under direct influence (GWUDI) testing is not required at the Winters Run Plant Well since this raw water is mixed with surface water that is filtered at the plant prior to pumping to the distribution system.

SOURCE NAME	RAIN DATE	RAIN AMOUNT (inches)	REMARK	SAMPLE DATE	pH	TURBIDITY (NTU)	TOTAL COLIFORM (col/100ml)	FECAL COLIFORM (col/100 ml)
Bynum Run Park Well	n/a	0	DRY	15-Oct-96	6.6	0.2	0	0
	n/a	0	DRY	16-Oct-96	6.5	0.3	0	0
	18-Oct-96	2.92	WET	19-Oct-96	6.6	0.3	0	0

Table 7.15. Raw Water GWUDI Test Results for the Bel Air Bynum Run Park Ground Water Supply

8.0 SUSCEPTIBILITY ANALYSIS

8.1 Winters Run Surface and Ground Water Supply

Each class of contaminants that have been detected in the water quality data were analyzed based on the potential they have of contaminating the Winters Run source. This analysis identified suspected sources, evaluated the natural conditions that may decrease or increase the likelihood of contaminants reaching the intake, and evaluate the impacts that future changes within the watershed may have on the susceptibility of the water intake.

8.1.1 Turbidity and Sediment

Highly turbid water can cause additional demands on water treatment plants and sediment can carry harmful microorganisms and compounds into drinking water suppliers. Turbidity is used as a surrogate indicator for the presence of *Cryptosporidium* and *Giardia*, and increased water turbidity is indicative of elevated bacteria concentrations. Turbidity is caused by erosion of materials from the contributing watershed. Turbidity may be from a wide variety of materials, including soil particles and organic matter created by the decay of vegetation. During storm events and/or snowmelts, surface runoff increases. Runoff during a storm event occurs when the rate of precipitation exceeds the rate of infiltration. As runoff increases during a storm and/or snowmelt, the increased flow of water can cause soil and other material to erode, increasing suspended solids and raising the turbidity.

There are several factors in the watershed that can contribute to increased turbidity/sediment. Runoff from paved surfaces (residential and commercial developments) increases the amount of flow in tributaries quickly and leads to bank erosion. Allowing cattle and other livestock unfettered to streams destroys protective vegetation along riparian areas where soils can runoff directly into a waterway. In addition, row cropping on steep slopes and forestry operations throughout the watershed may contribute to increased sediment and turbidity.

Because of occurrence of high turbidity during and after storms, the Winters Run water system is susceptible to turbidity contamination.

8.1.2 Microbiological Contaminants

The consistent presence of total coliform and fecal coliform bacteria in Winters Run indicates susceptibility to pathogenic microorganisms. Winters Run like most surface water sources in

Maryland are potentially susceptible to these contaminants. The potential non-point sources of pathogenic protozoa, viruses, and bacteria in the source water of Winters Run include pasture (livestock), stormwater runoff, residential septic system, sanitary sewer overflow and wildlife.

8.1.3 Inorganic Compounds (IOCs)

Several inorganic compounds (IOCs) have been detected below the maximum contaminant level in the finished water from Winters Run Water Treatment Plant. Nitrates was the most common IOC detected with only one result exceeding the 50% of MCL, with a concentration of 5.3 PPM. Nitrates can enter the water supply via ground water and surface runoff. Fertilizer losses, leachate from septic tanks, animal waste, wastewater effluent, atmospheric deposition and erosion of natural deposits are all sources of nitrates. Data from the past decade shows no discernable trend in nitrate levels. Winters Run is not currently susceptible to IOC contamination. Experience in other urbanizing watersheds, however, has shown that both sodium and chloride levels increase with increased amounts of commercial land use and road miles per watershed. Higher levels were found in winter months, associated with salt applied for deicing. Ongoing monitoring is recommended for sodium and chloride.

8.1.4 Synthetic Organic Compounds (SOCs)

There are several SOC detects at the Winters Run plant, but all results are less than 50% of MCL, with the exception of one atrazine result of 2.3 PPM. Atrazine has been documented to enter streams and rivers in Maryland following springtime herbicide application. Atrazine is water soluble, and residues on soil, vegetation or other surfaces can be easily carried by runoff into streams. Review of Maryland Pesticide Statistics for years 1985, 1988, 1991, 1994 and 1997 prepared by Maryland Department of Agriculture indicates that the usage of atrazine in Harford County decreased from 138,000 pounds in 1991 to 26,000 pounds in 1997. If the trend continues, it is unlikely the atrazine concentration will increase in the future. The Winters Run facility was determined not susceptible to regular SOC contamination. The possibility exists, however, that a spill of pesticides or other chemicals could impact the Winters Run water supply.

8.1.5 Volatile Organic Compounds (VOCs) Disinfection Byproducts (DBPs)

As discussed in Section 7.1.5,no VOCs exceeded the 50% of MCL in at least 10% of the collected samples. The only VOC threat to the watershed is the potential of hazardous spill or local contamination due to leaks in pipeline/pump station. The Winters Run source is not susceptible to regular VOC contamination.

Due to the nature of the watershed, the dynamic status of the Winters Run consistent presence of total organic carbon and occasionally high sample concentrations of HAA and THM, the Winters Run water system is susceptible to disinfection byproducts.

8.2 Bynum Run Park Ground Water Supply

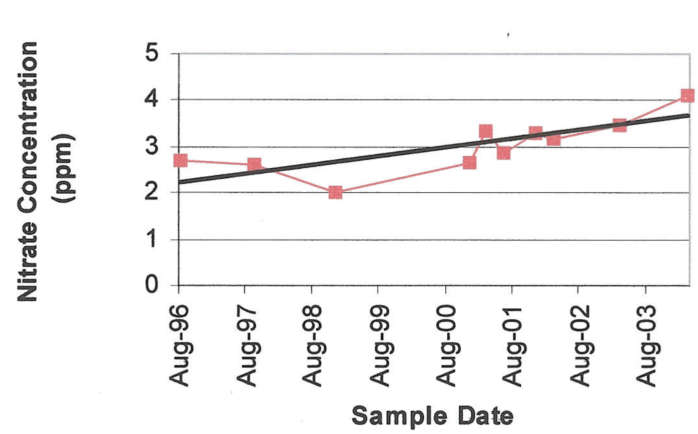
8.2.1 Microbiological Contaminants

Based on raw water bacteriological data soon after the well was drilled (Table 7.15) the Bynum Run Park supply well was determined not to be under the direct influence of surface water. Hence, this well is **not** susceptible to any microbiological contaminant present at the surface including *Giardia and Cryptosporidium*. GWUDI testing was not completed for the Winters Run Plant Well, as water from this well is blended with the surface water source and filtered. Therefore, raw water data is needed in order to properly determine the susceptibility of this well to microbial contamination.

8.2.2 Inorganic Compounds (IOCs)

Nitrate is present in the ground water supply at levels below 50% of its MCL of 10 ppm. The available data shows that the levels have been gradually increasing over the past four years (Chart 8.1). Sources of nitrate can generally be traced back to land use. Fertilizer applied to agricultural fields, ball fields, and residential lawns, and effluent from residential and commercial on-site septic systems are non-point sources of nitrate in ground water. A review of Table 5.3 indicates that cropland does not exist within the Bynum Run Park WHPA, and only 1.3% is used as pasture land. A large portion of the recharge area, however, is covered by the ball fields, and residential areas. Table 6.2 shows that almost all of the WHPA is served by public sewerage. Thus, it can be deduced that the nitrate levels at this well are probably due to fertilization of residential lawns, and/or ball fields.

Chart 8.1. Nitrate Concentration Trend in the Bynum Run Park Well



While the trend of data is increasing, the water quality data from the past eight years indicates nitrate detects below levels of concern, the Bynum Run Park Well at this time is considered **not** susceptible to nitrate contamination. Since nitrate levels have been gradually increasing since

2001, it is recommended that Maryland American monitor these levels, and continue to sample for nitrates at least annually.

Low levels of other inorganic constituents have been detected in the well that may likely represent the naturally occurring levels present in the aquifer from dissolving minerals from the bedrock. Low fluoride levels are the result of this compound being added to the water at the treatment plant. There are no potential contaminant sources within the Bynum Run Park Well WHPA and therefore this source is **not** susceptible to contamination by other inorganic compounds.

8.2.3 Radionuclides

There is currently no MCL for Radon-222, however EPA has proposed an MCL of 300 pCi/L or an alternate of 4000 pCi/L if the State has a program to address the more significant risk from radon in indoor air. Based on one radon sample colleted at the well, the level was above the lower proposed MCL of 300 pCi/L (Table 7.12). The source of radon and other radiological contaminants in ground water can be traced back to the natural occurrence of uranium in rocks. Radon may be prevalent in ground water of crystalline rock aquifers due to radioactive decay of uranium bearing minerals in the bedrock. Gross alpha radiation was detected at very low levels from three sets of water samples (Table 7.12). The results are less than 50% of the 15 pCi/L MCL.

Based on the limited available sampling data, the Bynum Run Park Well **may be** susceptible to radon-222 based on the lower proposed MCL, but is **not** susceptible to other radionuclides as detections were below levels of concern.

8.2.4 Synthetic Organic Compounds (SOCs)

The current land use suggests that the only potential non-point source of SOCs located within the WHPA is residential areas that account for 57.4 percent (Table 5.3). Pesticides and chemicals used on residential lawns and gardens are a potential threat. However, typical lawn maintenance herbicides are very biodegradable and should not pose a significant SOC risk if applied properly. No SOCs relating to water quality were detected from 21 sets of available sampling data at this plant. The low-level phthalate detects in two samples were also detected in the laboratory blanks and therefore do not represent actual water quality. Based on this analysis, the ground water supply at Bynum Run Park is **not** susceptible to SOC contamination.

8.2.5 Volatile Organic Compounds (VOCs)

Volatile Organic Compounds have not been detected in 23 sets of samples since 1996 with the exception of disinfection by-products known as trihalomethanes (THMs). THMs are the result of a reaction between chlorine used for disinfection and organic material in the water supply. Typically, disinfection by-products are associated with finished water at surface water treatment plants. The THMs detected at the Bynum Run Park Plant are shown in Figure 7.14. Only two of the 23 samples had levels of THMs above 50% of the maximum contaminant levels. Those samples were collected in 1998. Since then, all sample results have been well below 50% of the TTHM maximum contaminant level.

Potential VOC point sources were identified within and near the Bynum Run Park and Winters Run Plant WHPAs respectively (Figure 6-3, & Table 6.3). However, these sources do not appear to have any impact on the Bynum Run Park Well based on the absence of VOCs from numerous available data sets. Therefore, the Bynum Run Park ground water supply is **not** susceptible to disinfection by-products or other volatile organic compounds.

9.0 RECOMMENDATIONS FOR SOURCE WATER PROTECTION PLAN

This section of the report is intended to provide guidance to the water supplier as well as the Town of Bel Air and Harford County for enhancing watershed protection efforts within Winters Run from a water supply perspective. Recommendations are also provided to implement protection for Maryland American's ground water sources. Additional data is needed to further understand progress and need for specific source water protection goals.

Form a Local Planning Team

- In order to protect the interests of the Town of Bel Air and Maryland American's water supply, a watershed team should be formed which can include town officials and water system owners, and representatives from the Harford County government, Maryland Department of Natural Resource, Harford County Soil Conservation District, the Maryland Department of the Environment, and interested members of the public, Winters Run Preservation Association, and other environmental groups.
- Develop a formal or informal agreement to engage officials from the County, the Town, and State on a continuing basis.
- Establish clear and achievable goals, objectives, and milestones to ensure the highest quality raw water. The goals of previous efforts such as Bush River Watershed Restoration Strategy (WRAS) and Bush River Watershed Management Plan should be incorporated with the goals of a source water protection program.

Monitoring

- Continue to monitor for all Safe Drinking Water Act contaminants as required by MDE, including raw water when feasible.
- Continue to monitor for fecal coliform in the Winters Run raw water.
- Annual raw water bacteriological sampling of the wells is a good check on well integrity.
- Work with Harford County Environmental Health Department, performing sanitary surveys of septic sewer and failing sewage pumping stations.
- Begin more frequent water quality sampling of sodium and chloride at the water plant.
- Harford County Department of Public Works should report sewage overflow from pumping stations and sewer interceptors in the watershed.

Public Awareness and Outreach

- Future Consumer Confidence Reports need to include the summary of this report and indicate that the entire report is available to the public at the Harford County Public Library, or by contacting the Maryland American Water Company, or the Water Supply Program at MDE.

- Road signs explaining to the public that they are entering a protected drinking water watershed is an effective way of keeping the relationship of land use and water quality in the public eye, and help in the event of a spill notification and response.
- The water supplies should develop a public outreach and education campaign for the property owners within the Bynum Run Park Wellhead Protection Areas, particularly with an eye on the nitrate levels in its well water supply.

Land Acquisition and Easements

- Loans for purchase of land or easements are available from MDE. Loans are offered at zero percent with no administration costs. Sensitive properties could be targeted for such loans.
- Look into the availability of grants or loans and cooperation with conservation organizations to establish forested buffers along the Winters Run and feeder streams in sensitive areas.
- Work with the MD DNR and Harford County to promote agricultural preservation districts and easements through the Maryland Land Agricultural Preservation Fund in the agricultural section of the watershed with the Soil Conservation Service and local farmers.
- Work with the Harford County Soil Conservation District through Soil Conservation Reserve Enhancement Program (CREP) to establish forested buffers in the watershed.

Contaminant Source Inventory Updates / Well Inspections

- Maryland American Water Company and Harford County should periodically conduct their own detailed field survey of the watershed and WHPAs to ensure that there are no new potential sources of contamination.
- Update MDE on potential land use changes that may increase the susceptibility of the drinking water sources to the contaminants.
- Maryland American should continue its regular inspections of the supply wells and monitoring wells to ensure their integrity, and to protect the aquifer from surficial contamination. Damaged or aging wells may provide a direct route for contamination to reach the aquifer.
- The ground surface around the well fields should be graded such that positive drainage away from the wells is maintained at all times to prevent surface water ponding that may occur after precipitation events. This will help prevent any surface water infiltration into the wells.

Planning/New Development

- The Town of Bel Air should continue to work closely with the Harford County Planning Department to conduct site review of new developments in the Winters Run watershed, and WHPAs prior to approval of the developments to ensure water supply source protection.
- Review the State's model wellhead protection zoning ordinance for potential adoption. – ✓?

Changes in Use

- Any increase in pumpage or addition of new wells to the system may require revision of the WHPAs. The system is required to contact the Water Supply Program when an increase in pumpage is applied for and when new wells are being considered.

10.0 REFERENCES

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OTHER SOURCES OF DATA

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MDE Water Supply Program Oracle Database
MDE Waste Management Sites Database
Department of Natural Resources 1998 Digital Orthophoto Quarter Quadrangles for Bel Air and Jarrettsville
USGS 7.5 Minute Series Topographic Maps, Bel Air, & Jarrettsville Quadrangles
Maryland Office of Planning 2000 & 2002 Harford County Digital Land Use Map
Maryland Office of Planning 2003 Harford County Digital Sewerage Coverage Map
Maryland State Highway Administration Roads and Streams Map
Town of Bell Air Comprehensive Plan 2002-2008
Harford County Water and Sewer Plan, 2002
U.S. Dept. of Agriculture, Soil Conservation Service, Soil Survey of Harford Co. MD 1975
Maryland Pesticide Statistics for 1988-1991, 1994, and 1997
USGS Gauge Data 01581700 Winters Run Near Benson, MD

APPENDICES

APPENDIX B
Drawdown & Fracture Trace Maps

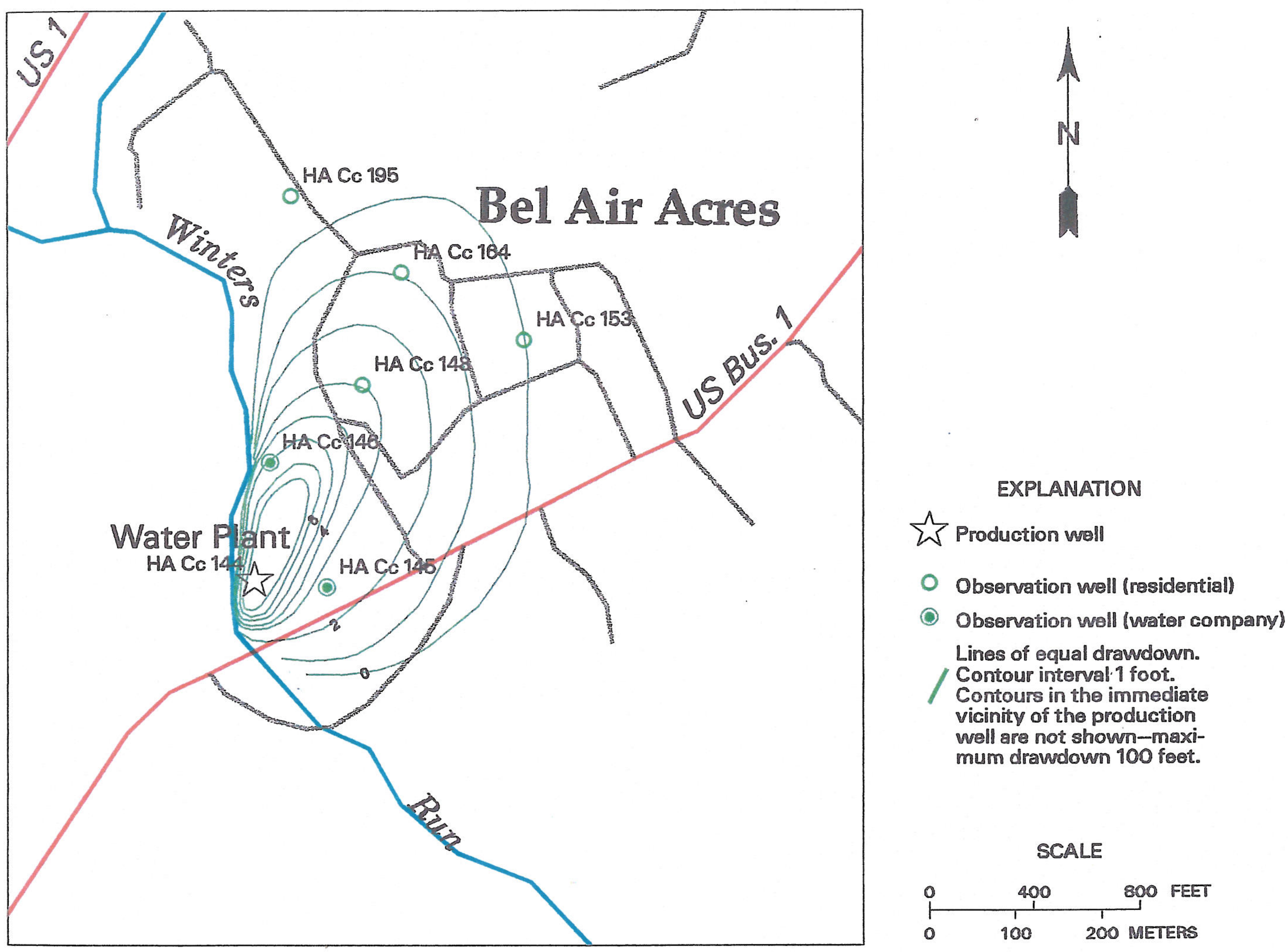
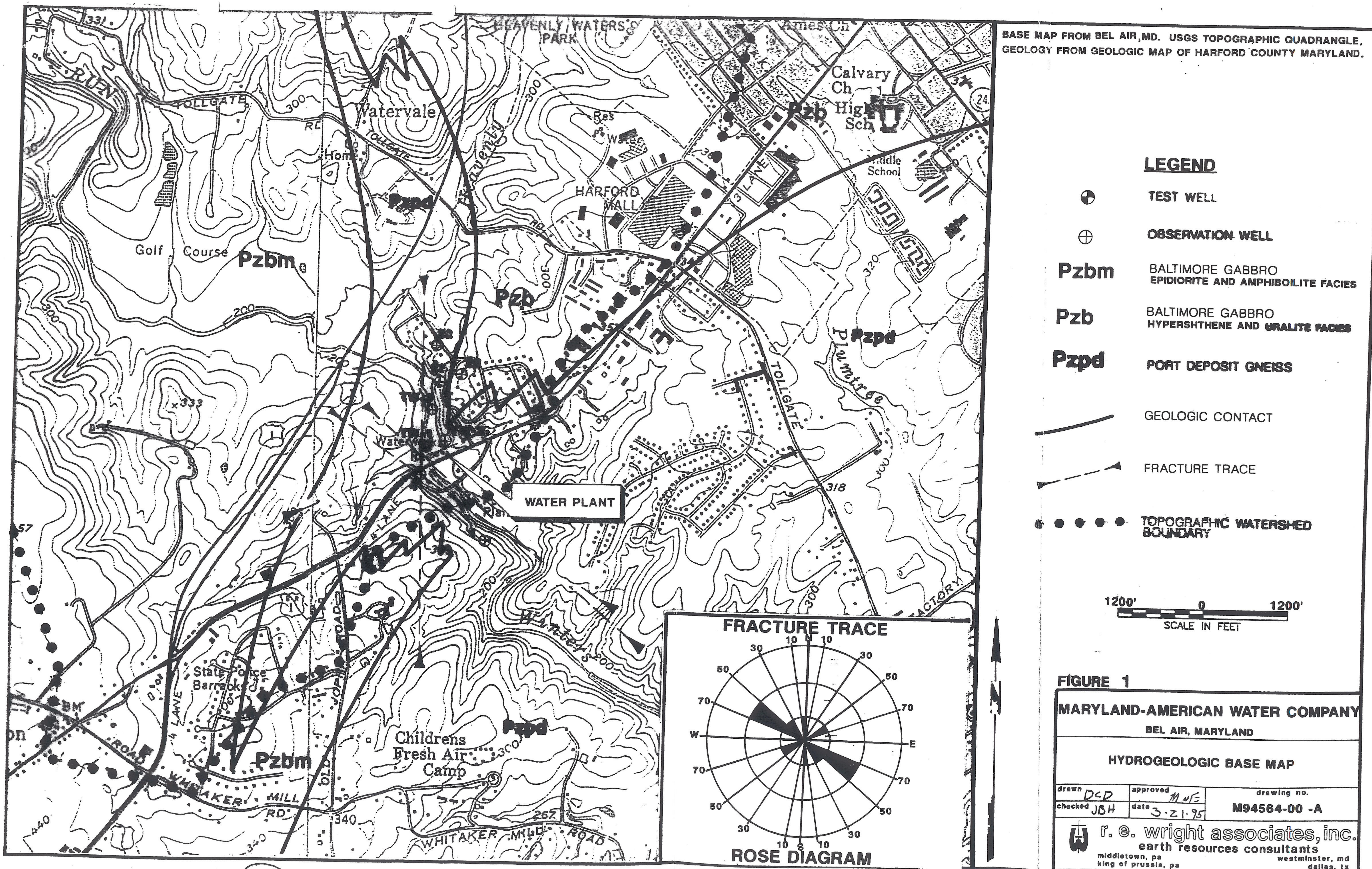


Figure 8.—Drawdown on August 21, 1998, after approximately 5 days of pumping at 123 gallons per minute. The elongate shape of the cone of depression indicates aquifer anisotropy. Contours for drawdowns greater than 6 ft (nearest the pumping well) are not shown: maximum drawdown was nearly 100 ft.

FROM MGS INTERIM TECHNICAL REPORT BY MARK DUIGON AND BARBARA COOPER, 1999



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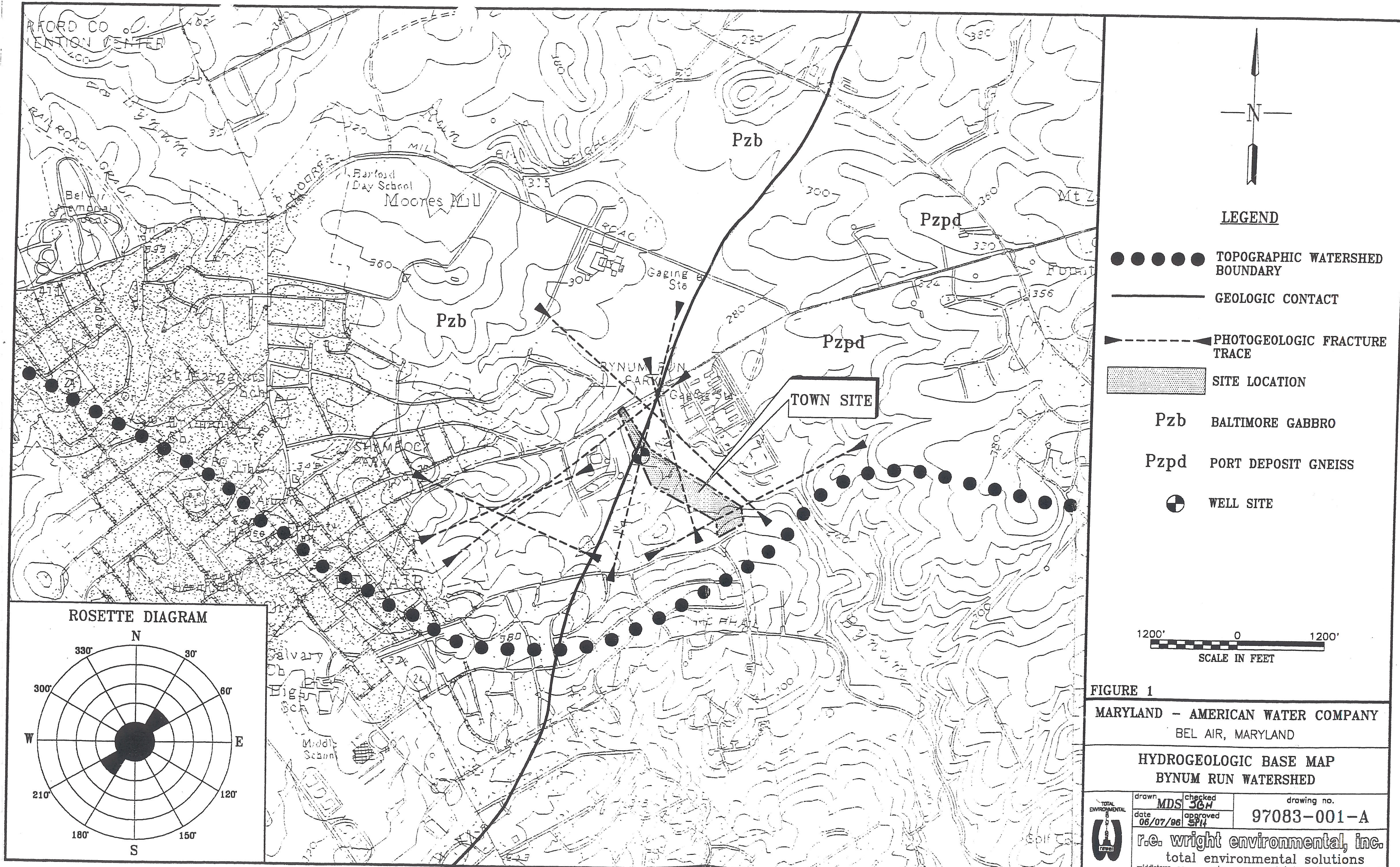
From REWEI Hydrogeologic Evaluation and Ground Water Development at the Winters Run Water Treatment Plant, 1995



NOTE: BASE MAP FROM THE BEL AIR, MD; USGS 7.5 MIN TOPOGRAPHIC QUADRANGLE; GEOLOGY FROM STATE OF MARYLAND GEOLOGIC SURVEY, GEOLOGIC MAP OF HARFORD COUNTY.

From REWEI Hydrogeologic Evaluation and Ground Water Development at the Winters Run Water Treatment Plant, 1997