Impacts

Power Plants and Air Quality

Power plants have long been considered one of the more significant contributors to local, regional, and global air quality. In recognition of the potentially significant impacts of power plants on air quality, the U.S. Congress has established numerous provisions to monitor and control the emissions from power plants under the Clean Air Act (CAA). The CAA has been significantly modified twice, first in 1977 and again in 1990.

The State of Maryland, and state and local organizations across the United States, develop air quality regulations to address CAA requirements. Some air regulations target power plants specifically, such as the CAA Acid Rain program and the recently promulgated Clean Air Mercury Rule. Other air regulations address specific pollutants that are emitted by power plants, industrial sources, and mobile sources.

The following section on air quality describes both statewide, and regional emissions from power plants, trends in emissions from power plants over time, and environmental impacts of these emissions. A review of existing and developing air pollution control systems to reduce emissions from power plants is found at the end of the section.

Power Plant Air Emissions

Emissions from power plants are often discussed in terms of three classes of pollutants: criteria pollutants, hazardous (or toxic) pollutants, and greenhouse gases.

Background on "Criteria Pollutants"

The U.S. Environmental Protection Agency (EPA) has established National Ambient Air Quality Standards (NAAQS) for six pollutants, known as criteria pollutants:

- *Nitrogen dioxide (NO_2) – a product of fossil fuel combustion; the nitrogen-based exhaust product from power plants and other combustion sources is termed nitrogen oxides (NO_x) and is composed of several compounds such as NO and NO_2. NO_x emitted by combustion sources is primarily in the form of NO, which is partially converted to NO_2 in the atmosphere. In the presence of sunlight and heat, NO_x reacts with volatile organic compounds (VOCs) to form ground-level ozone (smog).*

- *Sulfur dioxide (SO_2) – also a product of combustion, released when sulfur-containing fuels such as oil and coal are burned.*

- *Particulate matter (PM) – dust, dirt, and liquid droplets that form during combustion of fossil fuels or in the atmosphere by chemical transformation and condensation of liquid droplets. Particulate matter is defined by the size of its particles. PM10, for* *example, contains particles smaller than 10 microns in diameter, and PM2.5 is composed of particles smaller than 2.5 microns in diameter.*

- *Carbon monoxide (CO) – formed by incomplete combustion of carbon-based fuels during the combustion process.*
- *Lead – a metal emitted into ambient air in the form of particulate matter.*
- *Ozone (O_3) – forms in lower levels of the atmosphere as "smog" when NOx and VOCs react in the presence of sunlight and elevated temperatures.*

The U.S. EPA has developed both primary and secondary ambient air quality standards for criteria pollutants, representing the maximum pollutant concentrations that are allowable in ambient air. Primary standards are based on health risk assessments and are designed to protect the health of sensitive populations such as asthmatics, children, and the elderly. Secondary standards are set at lower levels designed to protect the public welfare by increasing visibility and preventing damage to crops, animals, and vegetation. Table 3-1 lists the current NAAQS.

The U.S. EPA and state and local air regulatory agencies, such as the Maryland Department of the Environment (MDE), monitor concentrations of the criteria pollutants near ground level at various locations across the country. The monitoring locations in Maryland are shown in Figure 3-1. If monitoring indicates that the concentration of a pollutant exceeds the NAAQS in any area of the country, that area is labeled a "nonattainment area" for that pollutant, meaning that

Table 3-1 National Ambient Air Quality Standards (NAAQS)

Criteria Pollutant	Averaging Period	Primary NAAQS* $\mu g/m^3$ (ppm)	Secondary NAAQS* $\mu g/m^3$ (ppm)
PM10 (particulate matter	Annual	50	50
<10 microns)	24-hour	150	150
PM2.5 (particulate matter	Annual	15	15
<2.5 microns)	24-hour	65	65
SO_2 (sulfur dioxide)	Annual	80	--
		(0.03)	--
	24-hour	365	
		(0.14)	1,300
	3-hour	--	(0.50)
NO_2 (nitrogen dioxide)	Annual	100	100
		(0.053)	(0.053)
Ozone	1-hour	235	235
		(0.12)	(0.12)
	8-hour	157	157
		(0.08)	(0.08)
CO (carbon monoxide)	8-hour	10,000	10,000
		(9)	(9)
	1-hour	40,000	40,000
		(35)	(35)
Lead	Quarterly	1.5	1.5

*The NAAQS are expressed in terms of micrograms per cubic meter ($\mu g/m^3$) or parts per million (ppm).

Source: 40 CFR Part 50

the area is not attaining the ambient standard. Conversely, any area in which the concentration of a criteria pollutant is below the NAAQS is labeled an "attainment area" indicating that the NAAQS is being met.

The attainment/nonattainment designation is made by states and EPA on a pollutant-by-pollutant basis. The air quality in an area, therefore, may be designated attainment for some pollutants and nonattainment for other pollutants simultaneously.

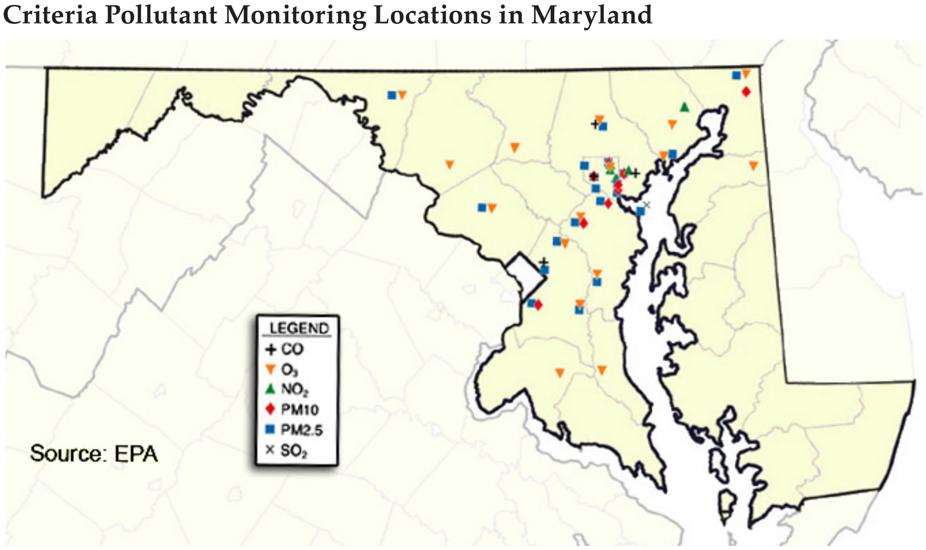
Currently, all of Maryland is in attainment with the NAAQS for most of the criteria pollutants (SO_2, NO_2, PM10, CO, and lead). However, central Maryland counties are not attaining the new PM2.5 standard (see discussion below). In addition, much of the urbanized portion of Maryland is not meeting the NAAQS for ozone. Because ozone is recognized as a regional, rather than local issue, the entire state is treated as an ozone nonattainment area, even though ozone monitoring indicates that many counties are in attainment with the ozone standard.

EPA reviews each of the NAAQS routinely and modifies the standards if new data suggest a change is warranted. For example, in 1997, EPA revised the NAAQS for PM10 and added a standard for a new class of particulate matter known as PM2.5, particulate matter less than 2.5 microns in diameter. PM2.5, or "fine particulates," are of concern because their small size allows them to be inhaled into the lungs. Litigation over the PM2.5 NAAQS delayed the official identification and designation of PM2.5 nonattainment areas until 2004. EPA published its final PM2.5 nonattainment area designations in January 2005.

Power Plant Criteria Pollutant Emissions

Power plants are significant sources of many of the criteria pollutants. For example, power plants contribute nearly 80 percent of the total SO_2 emissions and 30 percent of the total NO_x emissions in Maryland annually. The other significant source of NO_x emissions in Maryland are mobile sources, primarily automobiles.

Figure 3-1
Criteria Pollutant Monitoring Locations in Maryland



PM2.5 Nonattainment Areas

EPA finalized the designation of nonattainment areas for PM2.5 in January 2005. The shaded portions in the figure below represent the nonattainment areas in Maryland for PM2.5.

Source: EPA

Emissions Inventories and Databases

There are a wide range of inventories and databases available that contain air emissions information on power plants in the United States:

- ***eGRID*** *– EPA Office of Atmospheric Programs' Emissions & Generation Resource Integrated Database combines emissions, source, and generation information from several federal agencies into one nationwide power plant database.*
- ***EIA databases*** *– The Department of Energy (DOE) Energy Information Administration (EIA) collects data on a variety of operational and generating factors, including EIA-767 (Annual Steam-Electric Plant Operation and Design Data), EIA-906 (Monthly and Annual Data on Generation and Fuel Consumption at Power Plants), and EIA-860 (Annual Electric Generation Report).*
- ***ETS/CEM*** *– EPA's Clean Air Act Acid Rain database, referred to as the Emission Tracking System/Continuous Emissions Monitoring (ETS/CEM) database, includes limited criteria pollutant and carbon dioxide emissions information on power plants nationwide.*
- ***NEI*** *– The EPA Emission Factor and Inventory Group's National Emissions Inventory (NEI) database is the latest version of nationwide emissions information on point, area, and mobile sources.*
- ***TRI*** *– EPA's Toxic Release Inventory contains information on releases to air, water, and land (landfills and other waste management facilities) of nearly 650 chemicals and chemical categories from industries nationwide, including electric utilities.*

Figure 3-2 presents NO_x emissions from power plants in Maryland during the years 1995 to 2004; Figure 3-3 presents SO_2 emissions over the same time period. NO_x emissions from power plants in Maryland have decreased over time as a result of the increasingly stringent NO_x emission limits to which power plants are subject. SO_2 emissions, on the other hand, remained fairly constant over the years from 1995 to 2004. The CAA Acid Rain Program capped SO_2 emissions from larger power plants in Maryland (and across the country) in two phases that began in 1995 and in 2000. The year-to-year fluctuations since 2000 seen in Figure 3-3 reflect changes in power demand and fuel consumption.

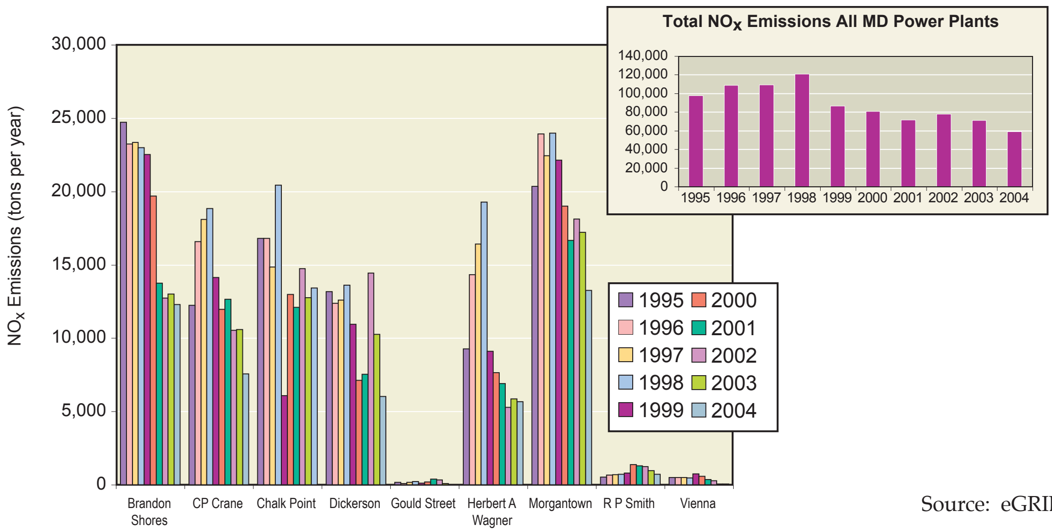
Hazardous Air Pollutant Emissions

In 1990, Congress amended the CAA to regulate a class of pollutants that cause or might cause an adverse impact to the environment. These pollutants are referred to as hazardous air pollutants (HAPs). There are currently 188 pollutants on the HAP list. HAPs occur naturally, but they may be hazardous to humans and the environment when emitted by man-made sources such as mobile or industrial sources (factories, refineries, power plants, etc.).

Although fossil fuel-fired power plants emit HAPs, power plants have not historically been considered among the more significant sources of air toxics nationally. Chemical plants and petroleum refineries use and emit highly toxic compounds and are considered a more significant source than power plants. Prior to the CAA Amendments of 1990, EPA regulations did not apply to HAP emissions from power plants. Many states, including Maryland, have developed toxic air pollutant regulations; however, in Maryland, fuel burning sources are exempt from these regulations.

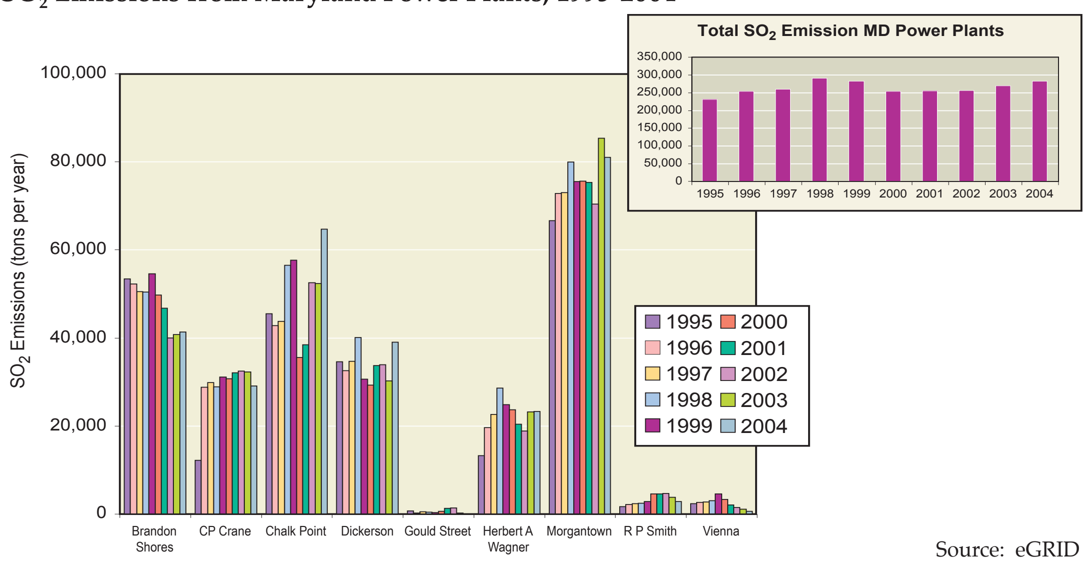
Under the CAA Amendments of 1990, Congress required EPA to evaluate HAP emissions from power plants to determine whether federal regulation of HAPs from power plants was warranted. After a lengthy regulatory process, EPA finalized the Clean Air Mercury Rule (CAMR) in March 2005. CAMR, discussed in more detail

Figure 3-2
NO_x Emissions from Maryland Power Plants, 1995-2004



Source: eGRID

Figure 3-3
SO_2 Emissions from Maryland Power Plants, 1995-2004



Source: eGRID

beginning on page 3-18, will cap and reduce mercury emissions from power plants nationwide.

Among the HAPs emitted by power plants, mercury is a pollutant of primary concern because of its significant negative health effects. Coal-fired power plants account for nearly 30 to 35 percent of the total 115 tons (104 metric tons) of mercury emitted nationally in a given year.

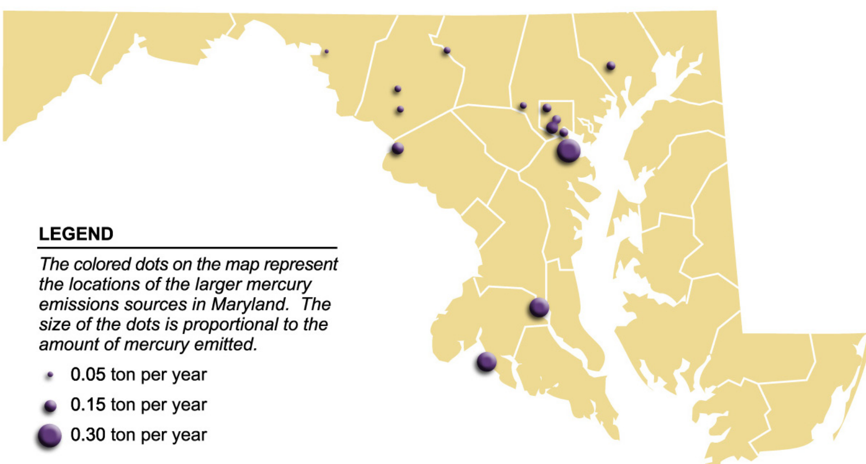
Mercury emissions reported in the National Emissions Inventory (NEI) for 1999 from the largest sources in Maryland are presented in Figure 3-4. Power plants are significant contributors, accounting for more than 50 percent of the total mercury emissions in Maryland. Medical waste incinerators are the other large class of mercury sources in the state and nationally.

Curtis Bay Medical Waste Incinerator

Curtis Bay Energy, formerly known as Phoenix Services, owns and operates a medical waste incinerator in Baltimore that can process about 150 tons (135 metric tons) of medical waste per day. The facility, which receives hospital and medical waste from customers throughout the Mid-Atlantic, is one of the largest medical waste incinerators in the United States. Despite the fact that waste generators are contractually required to remove all mercury before sending waste to the incinerator, some mercury remains in the incoming waste stream, giving rise to varying levels of mercury emissions.

EPA's 1999 emissions inventory reported Phoenix Services as the single largest source of mercury emissions in the eastern United States, with annual reported emissions of 1.3 tons (1.2 metric tons) of mercury, or approximately 40 percent of Maryland's mercury emissions. With such high emissions from a single source, regional-scale mercury modeling showed Baltimore as a mercury "hot spot." However, after investigating the reported mercury emissions further, and reviewing stack tests that Phoenix Services conducted in 2004, PPRP and Phoenix Services discovered that the mercury emissions appeared to be overestimated in the 1999 inventory. The latest round of testing indicates that mercury emissions were on the order of 0.12 ton per year, substantially lower than the previous estimates. This reduction would have a significant impact on the mercury concentration and deposition calculated for Maryland. Curtis Bay is required to conduct stack testing for mercury and other pollutants periodically, and so emissions numbers will continue to be reviewed. Curtis Bay is also subject to a Consent Order issued by MDE that requires the company to evaluate, install, and operate pollution control systems to reduce mercury emissions from the incinerator.

Figure 3-4
Mercury Sources in Maryland



Source: NEI

Greenhouse Gas Emissions

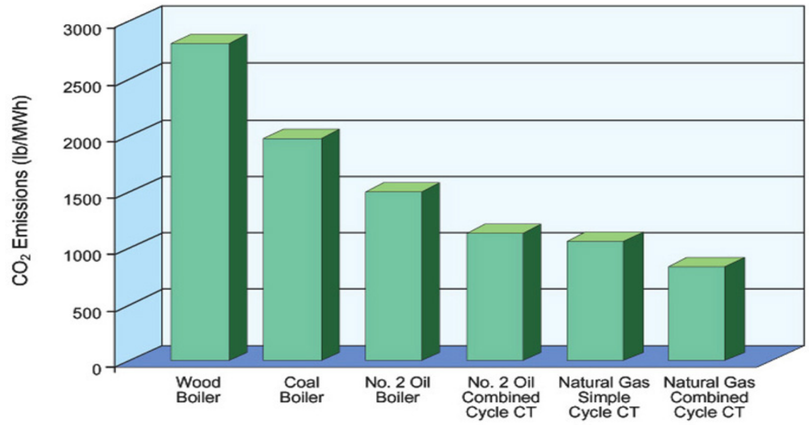
A greenhouse gas (GHG) is defined as any gas that absorbs infrared radiation in the atmosphere. Common GHGs include, but are not limited to: water vapor, carbon dioxide (CO_2), methane, nitrous oxide, ozone, hydrochlorofluorocarbons, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride. GHGs are generated naturally in relatively small quantities as well as anthropogenically (i.e., man-made) from a number of different sources such as agriculture, fuel combustion, gas distribution, mining, oil and gas, transport, landfills, sewage sludge, and other industries. CO_2 is by far the most significant GHG in terms of tons of gas emitted per year, and the most common of anthropogenic gases.

Emissions of CO_2 and other greenhouse gases in the U.S. have increased about 14 percent from 1990 to 2000. This rise can be attributed largely to the expanding use of fossil fuels for energy generation — in electric generating stations, industrial boilers, transportation, residential and commercial heating, etc. In 2001, the electricity generation, transportation, and industrial sectors contributed 33 percent, 27 percent, and 20 percent of the nation's CO_2 emissions, respectively, according to EPA.

Actual emissions of CO_2 from combustion sources vary depending on the type of fuel, type of generating technology, efficiency of the generating unit, and other factors. Figure 3-5 illustrates "typical" CO_2 emission rates that would be expected from common generating technologies burning coal, oil, or natural gas.

MDE reports that electricity generation contributes about 29 percent of Maryland CO_2 emissions (releasing approximately 29 million metric tons of CO_2 annually), which is second only to transportation's contribution of 33 percent. When considering total GHG emissions (including methane, nitrous oxide, sulfur hexafluoride, and others), power generation contributes about 19 percent to Maryland's total GHG emissions while commercial and industrial processes contribute 31 percent, with most of the remainder arising from transportation sources.

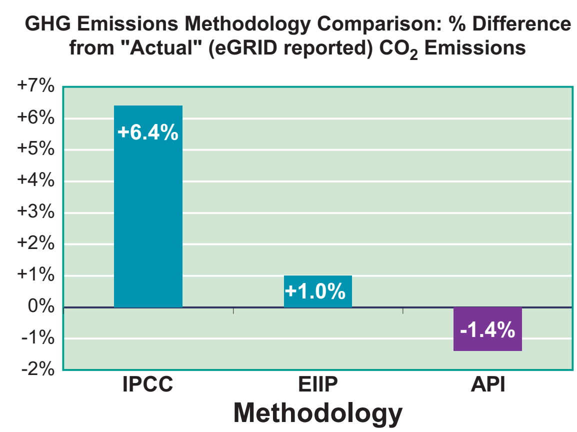
Figure 3-5
CO_2 Emissions from Different Technologies and Fuels
Pounds of CO_2 generated for each MWh of electricity generated



There are numerous ways to estimate GHGs from various types of sources. The Intergovernmental Panel on Climate Change (IPCC) has developed guidelines for conducting national inventories, and these guidelines provide a common basis for expressing the emissions of different GHGs. EPA and trade groups such as the American Petroleum Institute (API) have also been actively developing and publishing guidance for conducting GHG inventories in the U.S.

PPRP recently evaluated the different methods of estimating GHG emissions from power plants. Figure 3-6 presents the results of the comparison of GHG emission calculations for one power plant in Maryland, the Chalk Point plant. "Actual" CO_2 emissions reported by the Chalk Point plant from CO_2 monitoring are compared to CO_2 emissions estimates based on various estimation techniques. This example illustrates the minor differences in estimates arising from the use of different methods.

Figure 3-6
Comparison of Different Methods for Calculating CO_2 Emissions



Greenhouse Gas (GHG) Terminology

Greenhouse Gas – Any gas, occurring naturally or emitted by industrial and mobile sources, that absorbs infrared radiation in the atmosphere.

Global Warming Potential (GWP) – The GWP is a relative (to CO_2) measure of the ability of a particular GHG to absorb radiation (radiative forcing) and thus trap heat in the Earth's atmosphere, integrated over a chosen time period. By definition, CO_2 has a global warming potential of 1; methane has a global warming potential of 21, meaning that one molecule of methane is 21 times more "efficient" at absorbing radiation and influencing global temperatures than one molecule of CO_2. SF_6, which is emitted to the atmosphere in very small quantities, is of concern because it has a GWP of 23,900. (For more information on SF_6, see sidebar on page 3-21.)

Carbon Equivalents – Carbon equivalents are calculated by multiplying emissions by the GWP and by 12/44 (the ratio of the atomic weights of carbon and CO_2). GHG emissions in many inventories and in many discussions of climate change are presented in terms of million metric tons of carbon equivalent (MMTCE). In discussions of national- or global-level GHGs, the unit teragrams of CO_2 equivalent (Tg CO_2 Eq) is often used.

Direct and Indirect Emissions – Direct emissions are emissions of GHGs from sources owned or controlled by the reporting company. Indirect emissions result from operations by a reporting company, but that occur at sources owned or controlled by another company.

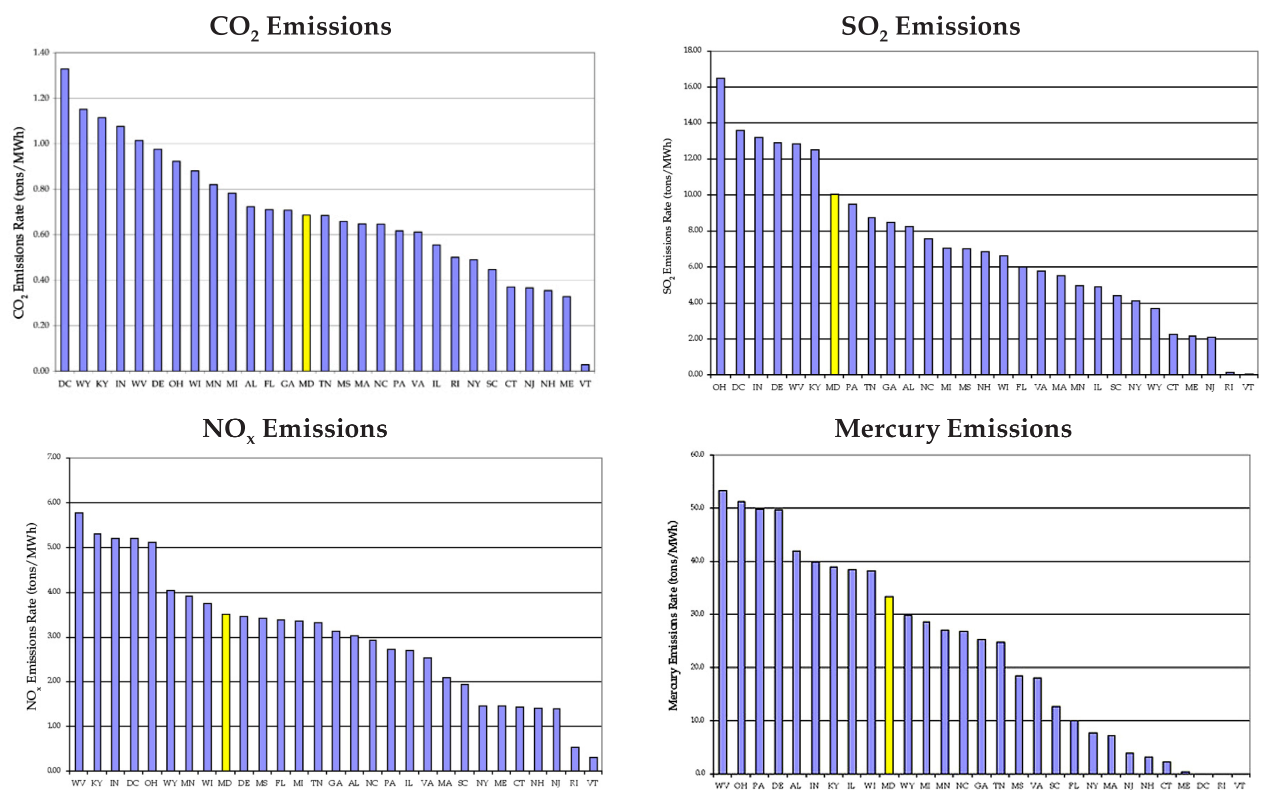
Base Year and Baseline Emissions – As per the Intergovernmental Panel on Climate Change (IPCC), the baseline year for emissions inventory is 1990. Under the Kyoto Protocol, the base year for hydrofluorocarbons, perfluorocarbons, and SF_6 is 1995.

Maryland Power Plant Emissions Relative to Other U.S. Power Plant Emissions

A comparison of Maryland power plants with power plants in other states is presented in Figure 3-7. This figure represents the emissions (in pounds) from all power plants combined, per megawatt-hour of power generated, for the year 2000. Maryland ranks among the top 10 states for SO_2, NO_x, and mercury emissions.

Although Maryland power plants are in compliance with all applicable regulations concerning emission limits, the state still ranks high in power plant emissions relative to other states. One major reason for this is that none of the Maryland plants have post-combustion control devices to reduce NO_x or SO_2 emissions, with the exception of the Brandon Shores and Wagner facilities, which use selective catalytic reduction (SCR) for controlling NO_x emissions. Maryland facilities generally meet the emission limits required by the Acid Rain Program's cap-and-trade system by buying emission allowances, instead of installing add-on control devices to reduce emissions. The higher emission rate for Maryland power plants can also be attributed to the type of fuel used to generate power. Rhode Island power plants, for example, have very low emission rates because that state's plants are powered mainly by natural gas and oil. The majority of Maryland facilities burn coal, which accounts for greater SO_2, NO_x, and mercury releases.

Figure 3-7
Comparison of Power Plant Emissions of CO_2, SO_2, NO_x, and Mercury in Maryland and Other States on a per MWh basis



Source: EPA eGRID database

"Dirty Kilowatts"

The Environmental Integrity Project released "Dirty Kilowatts: America's Most Polluting Power Plants" in May 2005. This report ranks the top 50 power plants in the U.S. for emissions of SO_2, NO_x, mercury, and CO_2. The report presents the emissions information in both an emission rate basis (pounds of pollutant per megawatt hour, lb/MWh) and a total mass emissions (lb/year). The table at right lists the Project's reported rankings of Maryland power plants that made the "Top 50 List" for largest emitters of SO_2, mercury, and NO_x in the country. No Maryland plants were included in the top 50 plants for CO_2 emissions. SO_2, CO_2, and NO_x emissions were based on 2004 data; mercury emissions were based on 2002 data (the most recent data available).

* Report considers Constellation's Brandon Shores and Wagner plants, located immediately adjacent to each other, as a single facility.

"Dirty Kilowatts" Maryland Plant Rankings

Pollutant / Power Plant	Ranking by Total Emissions (lbs released)	Ranking by Emission Rate (lbs released/ MWh produced)
SO_2		
Morgantown	27	19
Dickerson	—	20
Chalk Point	48	47
Mercury		
Dickerson	—	26
Brandon Shores & Wagner*	24	29
Chalk Point	—	36
NO_x		
Chalk Point	13	4

Impacts of Air Emissions from Power Plants

Ozone

Ozone Pollution

The persistent ozone "smog" problem in many areas of the country has been one of the most important drivers for regulation of power plant NO_x emissions over the past decade.

Ozone exists naturally in the upper levels of the atmosphere (from 6 to 30 miles, or 10 to 48 kilometers, above the Earth's surface) and protects the Earth from harmful ultraviolet rays. Although ozone is helpful in the stratosphere, it is harmful when it occurs in the troposphere, or the layer closest to the Earth's surface. Ozone is an invisible gas that is the major component of photochemical smog. It is not emitted directly into the atmosphere in significant amounts but instead forms through chemical reactions in the atmosphere. Ground-level ozone is formed when the precursor compounds — NO_x from both mobile and stationary combustion sources (such as automobiles and power plants respectively), and VOCs from industrial, chemical, and petroleum facilities and from natural sources — react in the presence of sunlight and elevated temperatures. Ozone levels are consequently highest during the summer months when the hours of daylight are greater and the sun's rays are more direct. Weather plays such an important role in the formation of ozone that the U.S. EPA has established an "ozone season" extending from May through September each year (when hot, stagnant conditions are most prevalent), and has developed regulations that require power plants to restrict NO_x emissions during the summer months.

Ground-level ozone is a problem not only because it creates unsightly smog and inhibits visibility, but also because of the adverse human health effects it can cause. Breathing air with high ozone concentrations can cause chest pain, throat irritation, and congestion; it can also worsen pre-existing conditions like emphysema, bronchitis, and asthma. Children and the elderly are especially vulnerable to health problems caused by ground-level ozone.

Ozone Transport

Ozone is a regional problem, and transport of ozone and its precursors across large sections of the U.S. makes control and reduction of ozone smog a particularly difficult issue. As mentioned earlier, while much of Maryland achieves the ambient ozone standards, the entire state is designated as nonattainment for ozone in recognition of the regional aspect of ozone. All of the eastern U.S. states from northern Virginia through Maine are designated ozone nonattainment areas and are collectively referred to as the Northeast Ozone Transport Region.

Ozone Regulation

Because ozone pollution is a regional phenomenon, it cannot be addressed effectively on a state-by-state basis. In September 1998, therefore, EPA finalized a rule based on analysis conducted by representatives from EPA, the Environmental Council of the States, and various industry and environmental groups. The rule requires Maryland and 21 other states, as well as the District of Columbia, to develop regulations (in State Implementation Plans, or SIPs) to reduce regional transport of ozone from stationary sources of NO_x. Because the regulation called for SIPs from this group of states, it is known as the NO_x SIP Call, and it requires NO_x emission reductions from power plants and some other large sources by 70 percent beginning in the ozone season 2004.

The NO_x SIP Call program is an attempt to address the regional nature of ozone, and is designed to alleviate urban ozone levels. Power plants are also now subject to additional NO_x control requirements (see the discussion of the Clean Air Interstate Rule, CAIR, beginning on page 3-17).

PM2.5

PM2.5, or fine particulate matter, consists of particles (such as dust, soot, and liquid droplets) measuring less than 2.5 microns in diameter. The particles are about 1/30th the width of a human hair. PM2.5 is created and emitted by many sources. It can either be emitted as fine particulate matter (such as dust, ash from burning activities, etc.) or can be created when gases (such as SO_x and NO_x) form particles during transport. Fine particulate matter is different from many other air pollutants in that it is not a chemical compound itself, but is comprised of various compounds in particle form. Common sources include:

- *smoke and soot from forest fires,*
- *wind-blown dust,*
- *fly ash from coal burning,*
- *particles emitted from motor vehicles,*
- *hydrocarbons associated with vehicles, power plants, and natural vegetation emissions, and*
- *SO_2 and NO_x emitted from fossil fuel combustion.*

Fine particles pose a great health risk because of their ability to cause asthma attacks, aggravate respiratory and cardiovascular disease, and decrease lung function. Several studies have linked particulate matter exposure to premature death due to heart attacks, arrhythmia, lung disease, and other ailments. Children, senior citizens, and those with heart or lung disease are especially susceptible to health problems associated with fine particulate matter. In addition to adverse health effects, PM2.5 also contributes to haze and smog.

EPA issued fine particle standards in 1997 and monitoring began across the U.S. to identify nonattainment areas. In January 2005, EPA finalized PM2.5 nonattainment areas in the United States. Ten counties in Maryland as well as the City of Baltimore were designated as nonattainment areas. Maryland, along with other states containing nonattainment areas, will be required to develop a SIP designed to achieve attainment status in these affected areas. EPA is developing an implementation rule (a guideline for states to use in their plans) that it expects to finalize in early 2006; state implementation plans will be due two years later.

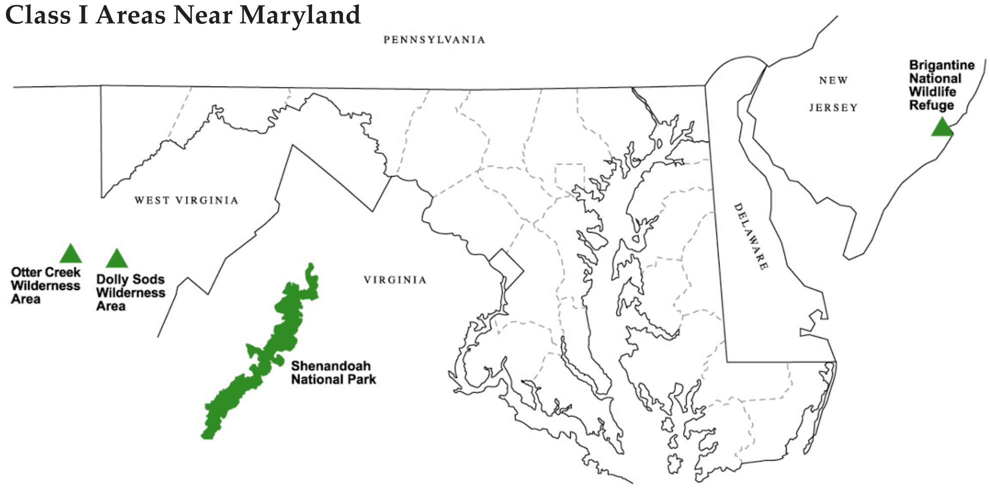
Fortunately, since monitoring began in 1999, EPA has reported that PM2.5 levels have already decreased significantly. It announced that PM2.5 levels in 2003 have declined by 10 percent from 1999 levels, and that levels are 30 almost percent lower than estimates of levels 25 years ago. EPA credits its other initiatives, such as the Acid Rain Program, for contributing to the decrease.

Visibility and Regional Haze

PM2.5 is not the only contributor to decreased visibility and regional haze. Certain gases and larger particles can also interfere with the ability of an observer to view an object. Visibility is defined as the "greatest distance up to which a black object can be seen against the horizon." In general, it refers to the conditions which can facilitate the appreciation of natural landscapes. The national visibility goal, which was established as a part of the CAA Amendment of 1977, requires improving the visibility in federally managed "Class I areas." These areas include more than 150 parks and wilderness areas across the U.S. considered pristine air quality areas. Since 1998, EPA and other agencies have been monitoring visibility in these areas.

In 1999, EPA finalized the Regional Haze Rule, which required states to set up periodic goals for improving visibility in natural areas. EPA has now amended the Regional Haze rule to require large, older coal-fired power plants, such as the Morgantown, Chalk Point, and Brandon Shores plants in Maryland, to implement pollution controls called Best Available

Figure 3-8
Class I Areas Near Maryland



MANE-VU

The Mid-Atlantic/Northeast Visibility Union (MANE-VU) is one of five regional planning organizations across the country established to address visibility issues. MANE-VU is a multi-jurisdictional organization that includes Mid-Atlantic and Northeastern states, Native American tribes, and federal regulatory agencies. The goal of MANE-VU is to improve pollution problems in federal pristine parks and wilderness areas known as "Class I areas" and prevent future air quality degradation in these environments. Class I areas are locales that have been designated as having special national or regional natural, scenic, recreational, or historic value, such as Dolly Sods and Otter Creek Wilderness Areas in West Virginia, the Shenandoah National Park in Virginia, and the Brigantine National Wildlife Refuge in New Jersey.

Retrofit Technology (BART). The implications of the BART rule on power plants in Maryland are currently being evaluated by PPRP.

PPRP has been involved with evaluating the impacts of industrial and utility sources in Maryland on federally managed Class I areas in the vicinity of Maryland (see Figure 3-8). In 2004, PPRP participated in a coordinated effort with Northeast States for Coordinated Air Use Management (NESCAUM) and the State of Vermont to evaluate impacts of visibility-impairing sources in the Eastern U.S. The study evaluated the tools and techniques currently available for identifying contributions to regional haze in the Northeast and Mid-Atlantic regions. PPRP was involved with the application of a dispersion model, CALPUFF, for estimating visibility degradation in Class I areas. The model identified the contributions of sources in different states in the Eastern U.S. to visibility impairment in various Class I areas in the region. PPRP continues to support and contribute to this ongoing work.

The Mid-Atlantic Northeast Visibility Union (MANE-VU) is conducting several projects to provide states with the information needed to increase air quality within their states and region. Ongoing projects include quantifying air pollution impacts on visibility, identifying and analyzing potential strategies to improve visibility, and building a regional consensus for action. By 2008, MANE-VU member states will develop plans to improve visibility in their state and throughout the region and submit these plans to EPA.

Acid Rain

Acid rain occurs when precursor pollutants NO_x and SO_2 react with water and oxidants in the atmosphere to form acidic compounds. These acidic compounds, when deposited with precipitation ("acid rain") or deposited with dry particles ("dry deposition"), acidify lakes and streams and damage forest and coastal ecosystems, as well as man-made structures.

The Acid Rain Program was established under the CAA Amendments of 1990 with the goal of reducing acid rain by limiting NO_x and SO_2 emissions. The program capped total SO_2 emissions from power plants at 8.95 million tons nationally by 2000. SO_2 emissions are controlled with an allowance trading system, under which affected power plants are allocated a certain number of tons of SO_2 annually. These plants must then either reduce emissions to stay under the allowance cap or purchase SO_2 "allowances" from power plants that have overcontrolled and banked excess SO_2 credits. NO_x emissions are controlled with rate-based limits (in units such as pounds per million Btu, lb/MMBtu) applied to certain coal-fired electric facilities.

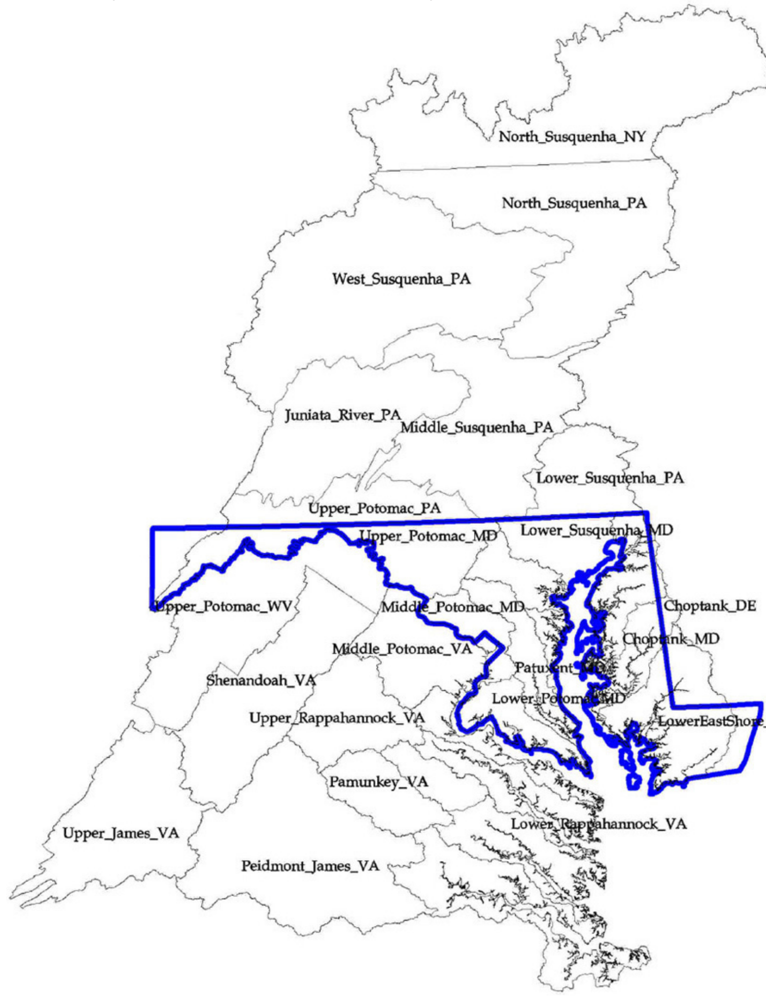
Efforts to reduce acid rain have been highly successful. For 31 states and Washington, D.C., SO_2 emissions in 2000-2003 were lower than annual emissions in 1990. In 2003, total NO_x emissions from all power sources were 37 percent below 1990 emissions levels. These reductions have been achieved even as the inputs used to generate power have increased 30 percent since 1990.

Nitrogen Deposition

The Chesapeake Bay is the largest estuary in the United States. Protection and restoration of living resources in the Bay has been the goal of the Chesapeake Bay Program since its inception in 1983. The Chesapeake Bay Program is a regional partnership which comprises the States of Maryland, Pennsylvania, and Virginia, the Chesapeake Bay Commission, EPA, and other participating advisory groups.

Reducing nitrogen input from controllable sources is a high priority because excess nitrogen is one of the major sources of eutrophication in the Chesapeake Bay. The 1987 Chesapeake Bay Agreement established a goal of reducing controllable nitrogen by 40 percent compared to 1985 levels, and program participants reaffirmed that goal in their 2000 agreement. The Chesapeake Bay Program estimates that approximately 30 percent of the nitrogen load to the Bay comes from atmospheric deposition and subsequent transport of nitrogen through the watershed. Much of this loading comes from NO_x emissions from power plants, industrial sources, and mobile sources. Increased efforts have been devoted recently to the role of ammonia in deposition processes.

Figure 3-9
Tributary Areas in Chesapeake Bay Watershed



For more than a decade, PPRP has evaluated the regional sources of NO_x emissions and their impacts on the Chesapeake Bay.* PPRP is working with the Chesapeake Bay Program and the individual tributary teams to plan mitigation strategies. (A map of the individual tributary areas in the Chesapeake Bay watershed is shown in Figure 3-9.) As a part of this effort, advanced computer modeling systems are used to simulate the transport and subsequent deposition of emissions from these regional sources to the Chesapeake Bay. The actual loading to the Bay is calculated using a similar methodology that the U.S. Geological Survey uses with its land-to-bay models. The total nitrogen deposited in the watershed annually is estimated to be approximately 38 million pounds (17 million kilograms), based on emissions of NO_x in 1996.

The model allows PPRP to evaluate the relative contribution of Maryland sources and other regional sources to deposition totals, since sources located farther from Maryland have a relatively smaller impact on the Bay than sources located closer

* Regional sources of NO_x include power plants, industrial sources, area sources, and mobile sources east of the Mississippi River, extending south to northern Georgia and north to Vermont.

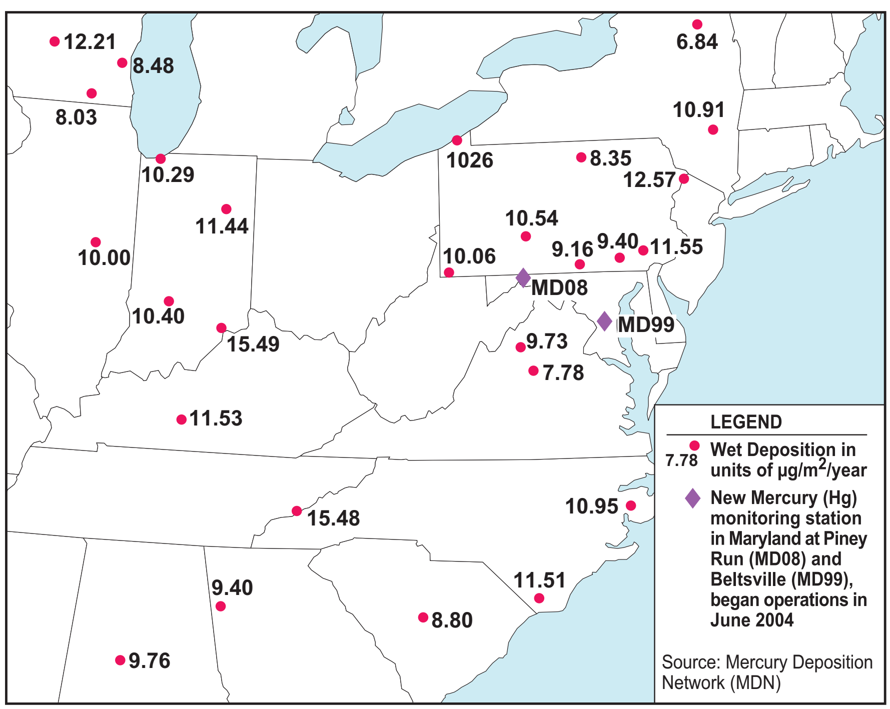
to the Bay. As a part of this study, an "emissions credit and benefit" scheme is developed to evaluate the impacts of emission reductions for sources located in different states. The credit refers to the source for which the emissions are reduced and the benefit refers to the tributary and state that derive the benefit from the emission reductions. Using this scheme, regional and local planning agencies can better plan for emission reduction strategies.

Mercury

With the passage of the Clean Air Mercury Rule in March 2005, EPA has established limits on emissions of mercury from power plants in the U.S. under the Clean Air Act. The primary stationary sources of mercury are coal-fired power plants, medical waste incinerators, cement plants, paper mills, and municipal waste combustors. Mercury in the atmosphere occurs in three forms: elemental, reactive, and particulate.

Since power plants contribute between 65 and 70 percent of the total mercury emissions in Maryland, PPRP plays a significant role in supporting scientific research. PPRP has been actively involved in the study of regional sources of mercury emissions and their impacts on the Chesapeake Bay. In cooperation with the University of Maryland, PPRP has sponsored several deposition monitoring programs and continues to evaluate the impacts of toxic emissions from power plants in Maryland. A mercury monitor has been in operation in Beltsville since June 2004. In June 2005, PPRP initiated a project to measure ambient air mercury concentrations at the Piney Dam monitoring site in Garrett County using a

Figure 3-10
Wet Deposition of Mercury in Eastern United States



Source: National Atmospheric Deposition Program continuous mercury monitoring instrument. This state-of-the-art monitoring effort will provide valuable data to the mercury research community.

PPRP has also been involved in conducting a complex modeling study to estimate the quantity of mercury from Maryland and other regional sources that is deposited in the Bay. The study estimates the ambient concentrations of dry and wet mercury deposition contributed by Maryland and regional mercury sources. The pattern of mercury deposition in the eastern United States, based on regional deposition monitoring data, is shown in Figure 3-10.

Mercury Testing at MD Power Plants

In 2003, PPRP was involved in a coordinated effort with MDE and Constellation Power to estimate stack gas mercury emissions at three Maryland power plants — Brandon Shores, H.A. Wagner, and C.P. Crane. The goal of the program was to gain a better understanding of mercury emissions from various types of coal-fired boilers, providing a basis for better control of mercury emissions from power plants in the future. In this state-of-the-art study, mercury testing was conducted using three methods — sorbent trap method, Ontario-Hydro method, and a new semi-continuous emissions monitoring (SCEM) method. In addition to the stack gas sampling, mercury in ash and coal were analyzed so that a mass balance of mercury could be completed. The separation of mercury into elemental, reactive, and particulate forms was estimated for different types of units and control devices. The study found that mercury emissions are significantly influenced by the type of combustion unit as well as the control device installed. The study also presented options for retrofit technology that could be installed for additional mercury control.

Climate Change

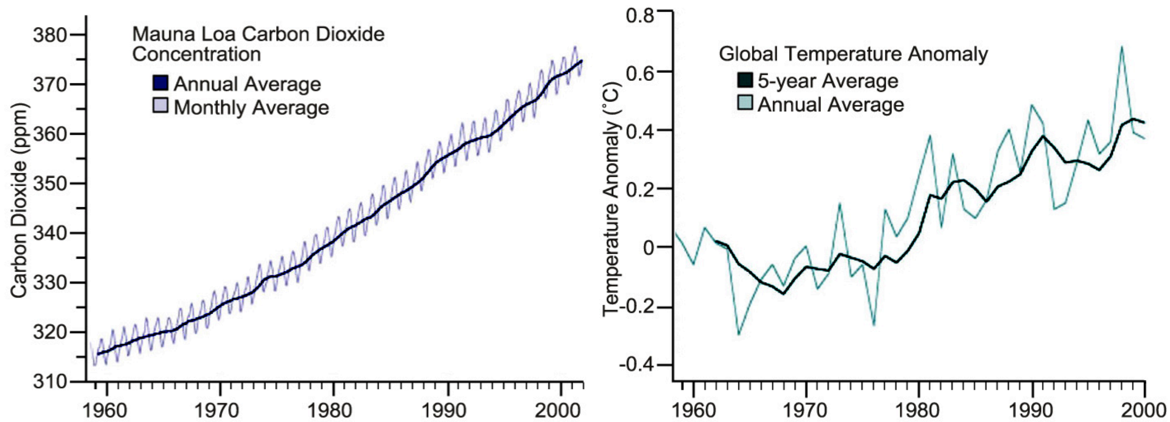
By absorbing heat energy radiated by the Earth back into space, GHGs trap energy in the atmosphere. Known as the greenhouse effect, this naturally occurring phenomenon ensures that the average temperature on Earth is about 60°F warmer than it would be without it, and sustains life on Earth. However, the greenhouse effect is enhanced due to increased levels of GHGs in the atmosphere, leading to increased temperatures on Earth. Although plants and other biomass remove CO_2 from the atmosphere as part of the natural carbon cycle, this is insufficient to offset current high levels of anthropogenic CO_2 emissions, resulting in CO_2 build-up in the atmosphere.

Increased temperatures can lead to significant changes in weather patterns around the world (climate change). Specifically, this would lead to changes in rainfall patterns, resulting in droughts and floods, and a rise in sea level, with varying impacts on plants, wildlife, and humans. These impacts include health problems, ecological disturbances such as droughts and flooding, enhanced air pollution, changes in food and water supplies, threats to coastal areas, and altered habitats and ecosystems.

Many scientific models suggest that increased concentrations of GHG in the atmosphere are correlated with increases of average temperatures on Earth (global warming), although the extent and rate at which this is taking place is uncertain. The international scientific community agrees that the levels of GHGs in the atmosphere are rapidly rising. According to EPA, atmospheric concentrations of carbon dioxide have increased nearly 30 percent, methane concentrations have more than doubled, and nitrous oxide concentrations have increased by about 15 percent over the last few hundred years. However, there is less consensus about the extent to which anthropogenic GHG emissions are responsible for this global warming trend, given that other factors such as natural climatic variations, changes in the sun's energy, and the cooling effects of pollutant aerosols also affect the planet's temperature.

Established in 1988 by the World Meteorological Organization and the United Nations Environment Programme, the Intergovernmental Panel on Climate Change provides an authoritative international consensus on the science of climate change. Reflecting the views of leading international scientists, the IPCC stated that there was a "discernible" human influence on climate, and that the

CO_2 Concentrations and Temperature Rise



Carbon dioxide concentration in the atmosphere has been increasing since measurements began in 1958 on Mauna Loa in Hawaii. Simultaneously, global temperatures have been rising. The graphs above compare carbon dioxide concentration to temperature anomaly (the difference between annual temperatures and a long-term average temperature). Note the decrease of carbon dioxide during each Northern Hemisphere summer, which is caused by plant respiration.
Graphs based on data from the NOAA Climate Monitoring & Diagnostics Laboratory (left) and the Goddard Institute for Space Studies (right).

observed warming trend is "unlikely to be entirely natural in origin." In 2001, the IPCC stated in its third assessment report that "there is new and stronger evidence that most of the warming observed over the last 50 years is attributable to human activities." Indeed, since the late 19th century, combustion of fossil fuels and other human activities such as agriculture, deforestation, landfills, industrial production, and mining that release carbon dioxide, methane, and nitrous oxide have increased while global mean surface temperatures have also increased by about 0.5-1.0°F (0.3-0.6°C). As GHG levels in the atmosphere continue to rise, average global temperatures are also expected to continue to rise as a result. The IPCC expected average global surface temperatures to rise by 1-4.5°F (0.6-2.5°C) over the next fifty years, and by 2.2-10°F (1.2-5.6°C) by the year 2100.

Control of Power Plant Emissions

Emissions from power plants have been, and continue to be, the focus of intense air pollution control programs and initiatives both locally and nationally. Historically, industry has developed and implemented control technologies in incremental steps to separately mitigate emissions of SO_2, NO_x, PM, and other pollutants, as driven by air pollution requirements. Efforts to control power plant emissions to address one specific pollutant (or impact) often reduce emissions of other pollutants as well.

For example, the mandated reductions in SO_2 and NO_x emissions from power plants under the Acid Rain Program also helped to alleviate ozone impacts (since NO_x is a precursor compound to ozone formation). Further, those same reductions in SO_2 and NO_x also reduced the formation and deposition of fine particulate matter in the form of sulfates and nitrates, and, therefore, assisted in reducing nitrogen deposition to the Bay and improving visibility and regional haze.

Some programs, however, primarily affect the targeted pollutant or condition. Seasonal programs such as the NO_x Budget Program (established by states participating in the Ozone Transport Commission, OTC) and the regional haze pro-

Control Requirements for New Power Plants

New power plants and other large industrial sources are subject to the most stringent levels of pollution control. For each class of pollutant emitted by new facilities above defined "major source" thresholds, new power plants are subject to one or more of the following levels of pollution control:

- ***Best Available Control Technology (BACT)*** *— Applies to criteria pollutants (NO_x, SO_x, PM, CO, and VOCs) from power plants in areas of the country meeting the National Ambient Air Quality standards, known as "attainment" areas. BACT is an emission limit based on the "maximum degree of reduction" of a pollutant, taking into account energy, environmental, and economic impacts. BACT is determined on a case-by-case basis.*
- ***Lowest Achievable Emission Rate (LAER)*** *— Applies to criteria pollutants in non-attainment areas (where the new power plant is not meeting the ambient standards), LAER represents the lowest emission rate that any similar type of power plant anywhere in the world has or has been permitted to emit. LAER, therefore, is a "technology-forcing" program. Each time there is an advance in the technology for controlling NO_x, the next power plant must apply that control technology, or better, to achieve the lowest emission rates possible.*
- ***Maximum Achievable Control Technology (MACT)*** *— Applies to hazardous air pollutants (HAPs) from certain larger combustion turbines and industrial boilers.*
- ***Best Available Retrofit Technology (BART)*** *— Applies to particulate matter, NO_x, and SO_x emissions from large, older power plants that are affecting visibility and contributing to regional haze.*

gram were developed to reduce NO_x emissions region-wide to attain the ozone NAAQS. These programs required that power plants reduce NO_x emissions only during the ozone season (May through September). While these seasonal control programs improve urban smog, they may not adequately address deposition or visibility issues.

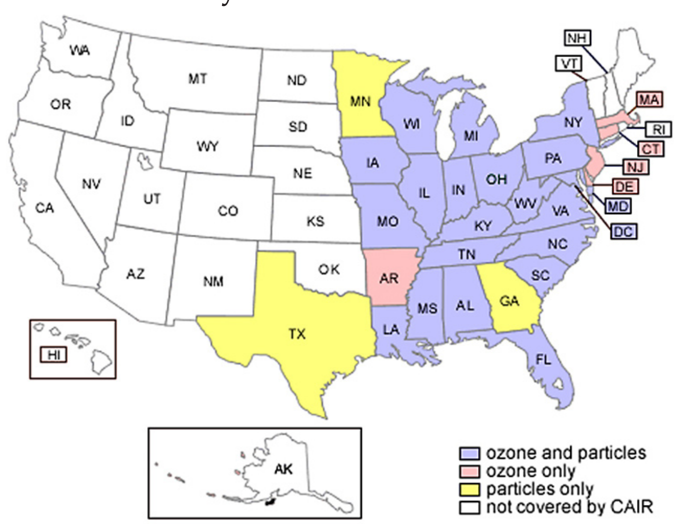
Regulatory Drivers for Emission Control

Power plant emissions continue to be of great concern for public health and welfare. EPA has given significant attention in recent years to the continuing issues of ozone nonattainment, visibility, particle deposition, and mercury control. As a result, NO_x, SO_2, and mercury (Hg) have been the focus of new federal regulatory actions affecting power plants, including the Clean Air Interstate Rule (CAIR) and the Clean Air Mercury Rule (CAMR). Evolving multi-pollutant regulatory requirements such as these will lead many new and existing power plants to install state-of-the-art controls either voluntarily (because of economic incentives) or by regulatory requirement. Coal-fired power plants, including the eight in Maryland, will be particularly affected by these new regulatory drivers.

Clean Air Interstate Rule (CAIR)

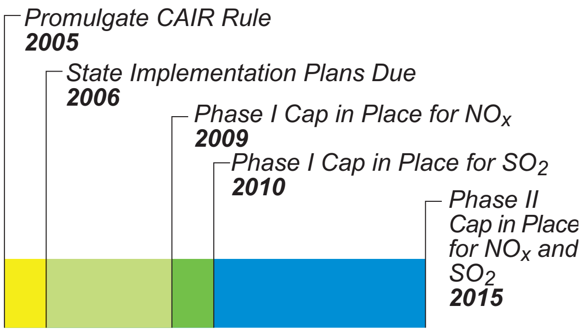
On March 10, 2005, the EPA finalized the Clean Air Interstate Rule (CAIR) affecting 28 eastern states and Washington, D.C. This initiative is designed to reduce SO_2 and NO_x emissions, which are precursor pollutants contributing to the formation and downwind transport of fine particulate matter (PM2.5) and ozone. Like the Acid Rain Program, CAIR will cap SO_2 and NO_x emissions, allowing states to comply by either

Figure 3-11
States Affected by CAIR



Source: EPA

Figure 3-12
Timeline of CAIR Milestones



participating in an EPA-administered cap-and-trade system or by implementing measures of the state's choosing (such as state-defined and EPA-approved emission limits).

Under the cap-and-trade program, EPA has set emissions "budgets" — tons of pollutants per year — for SO_2 and NO_x for each state affected by the rule (shown in Figure 3-11). Each state will then distribute the available emissions to affected power plants. The plants can then reduce emissions to meet the cap, or purchase emissions credits, or "allowances" from power plants that have over-controlled and banked excess emissions reductions for sale. Banking and trading CAIR allowances are similar to the allowance cap-and-trade program established under the Acid Rain Program (see page 3-12).

CAIR will be implemented in phases (see Figure 3-12). The first phase of NO_x reductions starts in 2009, covering the period from 2009-2014, and the first phase of SO_2 reductions starts in 2010, covering 2010-2014. The second phase of reductions for both NO_x and SO_2 starts in 2015, covering 2015 and thereafter. By 2015, CAIR is projected to result in reductions of about 70 percent in power plant SO_2 emissions and about 60 percent in power plant NO_x emissions in the CAIR states, compared to 2003 levels.

Clean Air Mercury Rule (CAMR)

EPA finalized the new Clean Air Mercury Rule (CAMR) on March 15, 2005, establishing standards of performance that limit mercury emissions from new and existing coal-fired electric generating units. This represents the first federal action ever designed to regulate mercury from electric generating units.

Like CAIR, the new mercury rule creates a market-based cap-and-trade program designed to reduce nationwide utility emissions of mercury in two distinct phases. The first phase will cap nationwide mercury emissions at 38 tons per year

Table 3-2 Mercury Performance Based Emission Limits for New Coal-Fired Electric Utility Steam Generating Units

Unit Type	Mercury Emission Limit[1] (10^{-6} lb/MWh)
Bituminous-Fired[2]	21
Sub bituminous Wet FGD	42
Sub bituminous Dry FGD	78
Lignite	145
IGCC	20
Coal Refuse	1.4

Source: EPA, CAMR Final Rule, March 2005
[1] 12-month rolling average; all standards based on gross energy output
[2] Anthracite units are included with bituminous units
FGD - Flue gas desulfurization
IGCC - Integrated gasification combined cycle

(34 metric tons per year) and will become effective in 2010. The second phase will cap emissions at 15 tons per year (14 metric tons per year) and will become effective in 2018. Again like CAIR, EPA has established mercury budgets for each state for both phases. States will have to submit a revised State Implementation Plan to EPA detailing how they will meet the prescribed budgets.

Coal-fired plants starting construction after January 2004 will have to meet stringent mercury performance standards, in addition to being subject to the caps. The performance limits (shown in Table 3-2) vary according to the type of coal unit being regulated, reflecting the fact that different raw materials and energy conversion processes yield different mercury emission rates. All coal-fired plants in Maryland are the bituminous-fired type (first line in Table 3-2); a new plant of this type would be subject to the mercury limit of 21×10^{-6} pounds per MWh.

Multi-Pollutant Regulation and Control

There have been many initiatives recently in state legislatures to address power plant emissions with a new regulatory approach, often referred to as "multi-pollutant" legislation. This approach aims to reduce emissions of NO_x, SO_2, CO_2, and/or mercury. There are several advantages to addressing power plant emissions with a multi-pollutant approach, one of which is the reduction in overall cost of control.

The U.S. EPA's recent Clean Air Interstate Rule sets a precedent for the federal government in tackling power plant emissions with a multi-pollutant approach. Many of the state initiatives to pass multi-pollutant legislation have arisen out of the federal government's previous inaction in passing such regulations. A patchwork of state actions has resulted. The lack of uniformity among state regulations has created some degree of regulatory complexity for both regulators and power plant operators. Connecticut, Massachusetts, New Hampshire, New Jersey, and North Carolina, for example, have all adopted multi-pollutant rules. Late in 2005, Governor Robert L. Ehrlich, Jr., proposed the Clean Power Rule, calling for substantial reductions in NO_x, SO_2, and mercury emissions from Maryland's coal-fired power plants. The reductions under the Clean Power Rule would be larger than those required under EPA's CAIR regulations and would require in-state reductions of the target pollutants starting in 2010.

Emerging Air Pollution Control Technologies

Power plants employ a number of techniques and pollution control technologies to reduce regulated pollutants. Table 3-3 describes the more common pollution controls in place at power plants regionally. This section reviews some of the new and emerging control technologies that power plants may be using more widely in the future to reduce emissions.

Recent and Emerging Multi-Pollutant (NO_x, SO_2, and Mercury) Controls

There are a number of emerging control technologies that will offer multi-pollutant controls, also known as co-controls. Co-control opportunities are characterized by EPA as processes that control SO_2 and mercury, SO_2 and NO_x, or all three pollutants. EPA reviewed some of these options in a 2005 report entitled "Multi-pollutant Emission Control Technology Options for Coal-Fired Power Plants."

The most feasible and effective mercury controls to date involve existing commercially available SO_2 control technologies, some of which also appear to remove mercury. Research and testing is underway to enhance existing traditional SO_2 flue gas desulfurization (FGD) technologies to improve mercury removal.

Newer systems, such as electro-catalytic oxidation (ECO) or SCR/wet FGD combine a series of conventional controls into a system that will treat NO_x, SO_2, particulates, and mercury.

Update on Maryland Power Plant Control Strategies

All fossil fuel-fired power plants in Maryland and regionally have been subject to various new air pollution regulations in recent years; however, most of the more recent regulations mandating emissions reductions — and thus addition of pollution control systems — have targeted coal-fired power plants. Maryland's eight coal-fired power plants have implemented some new pollution control systems, and like those across the country, are developing strategies to comply with upcoming additional NO_x, SO_2, and mercury control requirements.

- **SO_2 –** Unlike in most other states in the Northeast and Midwest, no power plants in Maryland have installed high efficiency scrubbers to reduce SO_2 emissions to comply with the Acid Rain regulations that have been in place since the mid-1990s. Instead, affected power plants in Maryland have elected to purchase SO_2 pollutant allowances to comply with SO_2 limits. However, in anticipation of even more stringent SO_2 limits under CAIR, two power companies in Maryland — Mirant and Constellation — are planning to switch to lower sulfur coals to reduce SO_2 emissions. Currently, both Mirant at its Morgantown plant, and Constellation at its C.P. Crane plant, bring in coal by rail. Mirant recently received a CPCN from the Maryland PSC to install new coal barge unloading facilities to enable the company to import low sulfur coal from South America and elsewhere. Constellation is in the process of obtaining permission from the PSC for a similar project at C.P. Crane.

Table 3-3 Available Pollution Control Technologies for Power Plant Emissions

Pollutant	Type of Control	Feasible for	Expected Reduction Rates	Co-Control Opportunity	Capital Costs*	Annual Costs*
PM	Cyclones	Boilers	70 - 90%	--	\$2.20 - \$3.50	\$1.30 - \$13.50
	Clean fuels (e.g., natural gas)	Boilers, CTs	0 - 80%	Reduces NO_x, SO_x	N/A	N/A
	Wet scrubbers	Boilers	90 - 99%	Reduces SO_x	\$2 - \$55	\$2 - \$193
	Fabric filters ("baghouse")	Boilers	99%+	Hg by 0 - 89%	\$6 - \$85	\$5 - \$50
	Electrostatic precipitator (ESP)	Boilers	90-99%	Hg by 0 - 35%	\$20 - \$200	\$4 - \$47
NO_x	Clean fuels (e.g., natural gas)	Boilers, CTs	80%	Reduces PM, SO_x	N/A	N/A
	Combustion Controls					
	- Water/steam injection	Boilers, CTs	40 - 70%	—	N/A	N/A
	- Staged combustion	Boilers, CTs	30 - 60%	—	N/A	N/A
	- Flue gas recirculation (FGR)	Boilers	50%	—	N/A	N/A
	- Gas reburning	Boilers	30 - 60%	—	N/A	N/A
	- Low NOx burners	Boilers	25 - 50%	—	N/A	N/A
	Add-on Controls					
	- Selective Non-catalytic Reduction (SNCR)	Boilers	35 - 50%	—	\$9,000 - \$25,000	\$3,000 - \$10,000
	- Selective Catalytic Reduction (SCR)	Boilers, CTs	70 - 90%	—	\$400 - \$3,500	\$70 - \$850
SO_2	Clean fuels (natural gas, low sulfur fuels)	Boilers, CTs	95%+	Reduces PM, NO_x	N/A	N/A
	Flue gas desulfurization (FGD)	Boilers	50 - 98%	Reduces Hg	\$40,000 - \$1,500,000	\$20,000 - \$500,000
CO	Clean fuels (e.g., natural gas)	Boilers, CTs	0 - 80%	Reduces PM, NO_x, SO_x	N/A	N/A
	Catalytic Oxidation	Boilers, CTs	90%+	Reduces VOC, organic HAPs	\$35 - \$140	\$8 - \$42

Source: EPA, Air Pollution Technology Fact Sheets, http://www.epa.gov/ttn/catc/products.html
* PM and CO control costs are \$/scfm; NO_x and SO_2 control costs are \$/MW. Costs are in year 2002 dollars, except SNCR and SCR, which are in 1999 dollars.
N/A – Cost information for these technologies not available

The AES Warrior Run coal-fired plant near Cumberland utilizes fluidized bed combustion (FBC) to control sulfur emissions. Rather than removing sulfur from the flue gas after combustion, FBC uses limestone sorbent within the combustion chamber itself to capture sulfur and minimize SO_2 emissions. Because FBC operates at lower combustion temperatures compared to conventional pulverized coal boilers, NO_x formation is also lower.

- **NO_x –** There has been much more progress in Maryland in NO_x reductions in the past several years, because the regulatory drivers for NO_x have been significant. Constellation has installed state-of-the-art SCR control systems at the two coal-fired units at Brandon Shores and at one unit at Wagner, and Mirant recently announced that it plans to install SCR on the coal units at Morgantown. Mirant is also installing a NO_x combustion control technology known as separated overfire air (SOFA) on its coal units at Dickerson, which will achieve substantial NO_x reductions from these units. These systems will result in reductions of thousands of tons of NO_x in the state when implemented.
- **Mercury –** None of the power plants in Maryland has installed controls specifically designed to reduce mercury; however, in planning compliance strategies for the new BART and CAIR programs, power plants are considering "co-control" opportunities to address mercury emissions from coal-fired units.

Table 3-4, on the next page, summarizes air pollution controls that are now in place at Maryland power plants (gas- and oil-fired as well as coal-fired plants).

Control and Mitigation of Power Plant CO_2 Emissions

Engineering Controls

In 1994, the United States and 188 other governments ratified the United Nations Framework Convention on Climate Change treaty to stabilize concentrations of CO_2 in the atmosphere to "prevent dangerous anthropogenic interference with the global climate." The treaty has called for governments and industry around the world to work towards implementing a number of strategies, including:

- *Efficient energy conservation,*
- *Adoption of advanced fossil fuel processes and lower- and non-emitting energy sources such as renewable energy (e.g., biomass, solar, wind), and*
- *Capturing and sequestering (storing) CO_2 in underground formations or in soils and vegetation.*

President George W. Bush consequently called for stabilizing greenhouse gas concentrations in the atmosphere with two policy initiatives — the National Climate Change Technology Initiative, announced in June 2001, and the Global Climate Change Initiative in February 2002. As part of these initiatives, the Integrated Sequestration and Hydrogen Research Initiative was created, consisting of a $1 billion government/industry partnership to design, build and operate a nearly emission-free, coal-fired electric and hydrogen production plant. The

SF_6

Sulfur hexafluoride (SF_6) is a compound most commonly used as an electrical insulator in high-voltage equipment that distributes electricity. Approximately 80 percent of all SF_6 produced worldwide is purchased and used by the utility sector. Unfortunately, some SF_6 is released into the atmosphere during everyday equipment installation, operation, and maintenance.

SF_6 is a greenhouse gas of special concern because its global warming potential is 23,900 times that of carbon dioxide, and it persists in the atmosphere for 3,200 years. This means that one pound of SF_6 has the same global warming potential of 11 tons of CO_2. EPA created the SF_6 Emission Reduction Partnership for Electric Power Systems in 1999 as a way to collaborate with the power industry to identify and implement cost-effective ways to reduce emissions of SF_6. Sixty power companies have voluntarily joined the program, which accounts for roughly 45 percent of the electric power generated nationwide. Through employee education and training, leak reduction and repair, and recycling of SF_6, emissions are reduced and electric companies benefit from cost savings and positive company recognition.

Table 3-4 Maryland Power Plant Air Emissions Reduction Systems

Plant	No. of Steam Units and Fuel Types	No. of Combustion Turbines and Fuel Types	NO_x Pollution Reduction Systems on the Boilers*	SO_2 Pollution Reduction Systems on the Boilers*	PM Pollution Reduction Systems on the Boilers*	Hg Pollution Reduction Systems on the Boilers*
Brandon Shores	2 Coal	--	LNB with OFA; SCR during ozone season (May-Oct)	--	ESPs	Some co-control of Hg by ESPs
C.P. Crane	2 Coal	1 Fuel oil	Coal units: overfire air during ozone season	--	Fabric filters	Some co-control of Hg by fabric filters
Chalk Point (Mirant)	2 Coal 2 Fuel oil	2 Fuel oil 5 Natural gas	Coal units: LNB with OFA; one unit being retrofitted with SACR for ozone season 2006	--	ESPs	Some co-control of Hg by ESPs
Chalk Point (SMECO)	--	4 Natural gas	--	Use of natural gas	Use of natural gas	--
Dickerson	3 Coal	2 Natural gas/ fuel oil	Coal units: LNB with OFA	--	ESPs and fabric filters	Some co-control of Hg by ESPs and fabric filters
Easton	--	7 Fuel oil; 5 natural gas/fuel oil; 4 Residential oil engines	--	--	--	--
H.A. Wagner	2 Coal 2 Fuel oil	1 Fuel oil	Coal units: LNB or LNB with OFA on all units; Unit 3 SCR during ozone season	--	ESPs	Some co-control of Hg by ESPs
Meadwestvaco Luke	2 Coal	--	Cyclone unit: SNCR; Pulverized coal unit: OFA	--	ESPs	Some co-control of Hg by ESPs
Morgantown	2 Coal	6 Fuel oil	Coal units: LNB with OFA; planning installation of SACR for ozone season '09	--	ESPs	Some co-control of Hg by ESPs
Notch Cliff	--	8 Natural gas	--	Use of natural gas	Use of natural gas	--
Panda Brandywine	--	2 Natural gas/ fuel oil	--	Use of natural gas and low sulfur fuel oil	Use of natural gas and low sulfur fuel oil	--
Perryman	--	4 Natural gas/ fuel oil	One unit: water injection, DLN	Use of natural gas and low sulfur fuel oil	Use of natural gas and low sulfur fuel oil	--
Philadelphia Road	--	4 Fuel oil	--	--	--	--
R. Paul Smith	2 Coal	--	LNB	--	ESPs	Some co-control of Hg by ESPs
Riverside	1 Natural gas	2 Fuel oil 1 Kerosene	--	Use of natural gas	Use of natural gas	--
Rock Springs	--	4 Natural gas	DLN	Use of natural gas	Use of natural gas	--
Vienna	1 Fuel oil	1 Fuel oil	LNB	--	--	--
Warrior Run	1 Coal	--	SNCR	FBC technology with lime injection	Fabric filters	Some co-control of Hg by fabric filters

* Table lists controls in place at the steam generating units and not the combustion turbines, with the exception of Chalk Point (SMECO), Notch Cliff, Panda Brandywine, Perryman, and Rock Springs. For these plants, the control technology information applies to combustion turbines.

Abbreviations:

Controls				Pollutants	
SNCR	Selective non-catalytic reduction	FBC	Fluidized bed combustion	NO_x	Nitrogen Oxides
LNB	Low-NO_x burners	OFA	Overfire air	SO_2	Sulfur Dioxide
DLN	Dry low-NO_x combustors	SCR	Selective catalytic reduction	PM	Particulate Matter
ESPs	Electrostatic precipitators	SACR	Selective auto-catalytic reduction	Hg	Mercury

275-megawatt prototype plant, FutureGen, will serve as a large scale engineering laboratory for testing new clean power, carbon capture, and coal-to-hydrogen technologies.

Aside from design, construction, and operation of the prototype plant, the goals of the initiative will include the capability to sequester at least 90 percent (and potentially 100 percent) of the CO_2 emissions from the plant. The initiative will also strive to prove the effectiveness, safety and permanence of CO_2 sequestration; to establish standardized technologies and protocols for CO_2 measurement, monitoring, and verification; and, finally, to validate the engineering, economic, and environmental viability of advanced coal-based, near-zero emission technologies by 2020. These technologies will produce electricity with less than 10 percent increase in cost, compared to traditional systems, and will produce hydrogen at $4.00 per million BTUs.

On a parallel track to these initiatives, the U.S. Department of Energy (DOE) has funded the Midwest Regional Carbon Sequestration Partnership (MRCSP), which will assess the technical, economic, and social feasibility of carbon sequestration in the Midwest. Maryland recently became a member of the MRCSP; active participants include Constellation Energy and the University of Maryland as well as PPRP and other State agencies.

ENERGY POLICY ACT OF 2005:

Greenhouse Gas Emissions

Although the Act does not impose limits on greenhouse gas emissions, it does establish a federal panel to develop a national policy to address climate change and to promote research and development of technologies that reduce greenhouse gas emissions.

CO_2 Capture and Transport

CO_2 capture from an industrial source, such as a flue gas stream from a coal-fired electricity generation facility, presents the first challenge in controlling CO_2 emissions. Once collected, CO_2-bearing gas may require treatment to remove other products of combustion. Treatment can also serve to stabilize gas pressure and temperature prior to transport to the intended geological storage site. A number of commercial technologies to capture CO_2 have been developed, such as chemical absorption with liquid amine solution, oxygen-fired combustion, and pre-combustion decarbonization (e.g., through gasification). These technologies, however, are energy-intensive and reduce the power plant net output while increasing cost and contributing to atmospheric emissions. The cost of current technology to capture CO_2, for example, is approximately $150 per ton of carbon. With Maryland power plants emitting roughly 30 million tons of CO_2 annually, capture of all that CO_2 could cost $6 billion in this state alone. Furthermore, DOE reports that the installation of such capture technology at a power plant may reduce the plant's net output by as much as 14 to 40 percent, depending on the type of combustion technology used.

To reach the disposal site, CO_2 is transported to the location where it is injected into the selected geological formation. CO_2 can be transported by truck, rail, pipeline or ship. Given the relatively large quantities involved in typical commercial CO_2 capture and storage projects, transportation by dedicated pipeline is currently the only practical option over land.

CO_2 Disposal – Geologic Carbon Sequestration Opportunities in Maryland

The MRCSP is working to identify greenhouse gas sources in its region and determine the technical and economic feasibility of capturing and sequestering these emissions in deep geologic formations, agricultural forests, and degraded land systems. Existing member states include Pennsylvania, Ohio, Indiana, West Virginia, and Kentucky; Michigan is joining Maryland as another new member. In support of Maryland's participation in the MRCSP, PPRP is working together with the Maryland Geological Survey (MGS) and the Maryland Energy Administration (MEA) to initiate geologic studies that will support potential carbon sequestration in geologic formations.

Geologic sequestration involves more than simply pumping captured CO_2 into the ground. The CO_2 must be injected into a formation that is permeable enough to allow the gas to flow. The formation must also contain some form of cap or structural trap to prevent the gas from leaking out. In Maryland, three types of geologic formations have been identified as potential reservoirs for CO_2 sequestration:

- ***Deep saline aquifers*** – *These aquifers consist of sandstone or limestone formations and have high porosity values (3 to 30 percent). The Waste Gate formation, situated in the coastal plain of Maryland is an example of this type of formation.*
- ***Depleted natural gas fields*** – *Like deep saline aquifers, natural gas fields consist of rock formations of relatively high porosity. The pore spaces remaining after the natural gas is extracted could be used to store CO_2. The Oriskany sandstone, a portion of which is situated in Western Maryland, is an example of this type of formation.*
- ***Coal bed methane deposits*** – *Coal deposits often contain methane (CH_4) gas, which is chemically bonded to the solid coal. CO_2 injected into these deposits can displace the CH_4. This has the double benefit of sequestering CO_2 and mobilizing CH_4, which can then be recovered for commercial use. The Pittsburgh and Upper Freeport coal seams in Western Maryland represent two formations of this type.*

PPRP and its partner organizations are working to collect and evaluate data to further characterize the Waste Gate formation, the Oriskany sandstone, and the Pittsburgh and Upper Freeport coal seams. Figures 3-13 and 3-14 show the locations of natural gas wells and coal corehole locations that penetrate the Oriskany sandstone and Pittsburgh and Upper Freeport coal seams respectively. (Coreholes are borings within coal beds that are drilled for the purpose of determining thickness and extent of the seam.) Data such as depth, elevation, and formation thickness have been determined using these wells and borings. This information has been organized into a database, which will be expanded to include additional information on these formations as well as the Waste Gate formation as it becomes available. It is anticipated that this data will be used to create maps of these potential CO_2 storage formations, including their areal extent, depth, thickness, and structural features. Once the collection and analysis of the data are complete, the data and maps will be provided to MRSCP and uploaded to the MGS website, where they can be accessed by federal, state, and county agencies, as well as private industry and the general public.

Greenhouse Gas Emission Reporting Under the 1605(b) Program

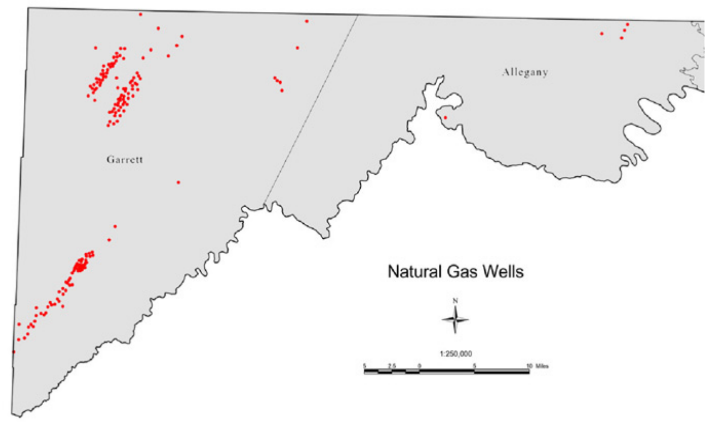
The Voluntary Reporting of Greenhouse Gases Program, established by Section 1605(b) of the Energy Policy Act of 1992, provides the opportunity for businesses, organizations and individuals who have reduced their greenhouse gas emissions to record their accomplishments and share their ideas for action. The information collected through the Voluntary Reporting of Greenhouse Gases Program is made available through a public database. The program accepts reporting information on carbon dioxide, methane, halogenated substances (such as chlorofluorocarbons), nitrogen oxides, non-methane volatile organic compounds, and carbon monoxide. Access to the database encourages public awareness of initiatives to reduce greenhouse gas emissions, supports educational programs and public policy development.

The Voluntary Reporting of Greenhouse Gases web site can be accessed at http://www.eia.doe.gov/oiaf/1605/frntvrgg.html.

Biological Controls

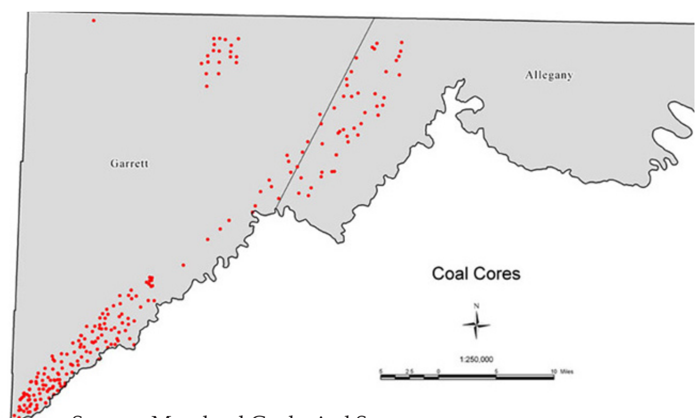
The power industry is actively developing carbon sequestration projects to help meet the goals of President Bush's Global Climate Change Initiative. The near-term goal is, by 2012, to reduce the amount of carbon dioxide released per unit of power produced by 18 percent. This is an ambitious task, since it will require Maryland's power producers to reduce and/or sequester roughly 1.25 tons of carbon dioxide emissions annually for each person living in Maryland. Because carbon sequestration rates vary by type of project, local growth conditions, and even the weather, carbon storage must be monitored to know how well the project is working.

Figure 3-13
Natural Gas Wells in Garrett and Allegany Counties



PPRP has initiated research to develop field methods and data that can be used to determine carbon storage amounts and potentials, measure sequestration rates, and certify carbon accumulations. Data are being collected at recently reforested sites to mitigate power plant emissions, and at nearby mature forests. When completed, these studies will provide a clearer picture of what biological carbon sequestration projects can accomplish in Maryland, and what tools are needed to implement them.

Figure 3-14
Coal Corehole Locations in Garrett and Allegany Counties



Source: Maryland Geological Survey

Trees and plants consume carbon dioxide during photosynthesis and use it to build cells and store energy. Many common trees are quite efficient at storing carbon-rich photosynthetic byproducts in their stems, branches, and roots; wood is about 40 percent carbon by weight. By some estimates, a modestly managed acre of forest can remove almost 3 tons of carbon dioxide from the atmosphere each year. Hence, forests and other vegetation have considerable potential to help reduce our net carbon dioxide input to the atmosphere.

PPRP has been studying how the carbon sequestration potential of natural biological processes might be tapped to offset power plant carbon dioxide emissions while simultaneously providing other environmental or economic benefits. In addition to investigating the possible contributions from forests, other options for increasing carbon sequestration in agricultural areas, wetlands, and ecologically degraded zones are being developed. There are three general management approaches that may be applied in any of these environments: conservation, restoration, and production.

When the existing vegetation and soils in an area are already acting as an efficient carbon absorber, it is often best to preserve the area as it is and protect those elements that store carbon (conservation approach). Where the land or ecosystem has been disturbed by human activity, however, it may be better to intervene and recover the natural productivity of the system — for instance, by reintroducing native species or by removing man-made landscape features (restoration approach). The third type of management approach, production, makes sense when the vegetation can be harvested regularly and turned into long-lived products, such as construction materials or wood furniture, that store carbon usefully in our homes and businesses.

The rate at which carbon dioxide is removed from the atmosphere differs among the three approaches. Conservation areas that have been continuously forested for several tree generations ("old growth" forests) harbor large stocks of carbon, but the amounts of carbon dioxide that they capture and release are nearly balanced. Consequently, these areas can be expected to have a net sequestration of only about 1 ton of atmospheric carbon dioxide per acre per year.

When a cleared area is reforested, on the other hand, there is a period of time during which there is little dead wood to decay and trees are growing rapidly. For two or three decades, the carbon dioxide removal rate can be as much as 5.5 tons of carbon dioxide per acre per year. A rate close to this maximum can be maintained if the trees are harvested frequently for wood products; otherwise it will begin to decline toward the lower rate of a mature forest. Harvesting less often or selectively removing mature trees and replanting can achieve more modest rates of about 3 tons per acre per year with less environmental impact than frequent clear cutting.

PPRP is currently evaluating specific types of conservation, restoration, and production projects that could be undertaken in Maryland. Models of vegetation growth and decay for forests, agricultural areas, and wetlands estimate the carbon sequestration rate for each type of project. The results of this evaluation will be a portfolio of potential carbon sequestration projects that can be considered by power companies, or other interested groups, as ways to reduce the amount of carbon dioxide they add to the atmosphere.

The best approach for any given area, of course, will depend on ecological and economic factors as well as the amount of carbon potentially sequestered. A well-established forest that protects water quality and provides hunting and camping opportunities is a candidate for conservation, while an abandoned farm is likely to contribute most through production of biofuel crops or restoration to forest. Restoring wetlands is particularly attractive, because wetlands can have relatively high sequestration rates as well as significant ecological and water quality benefits.

Biogas Recovery

Biogas recovery is another biological approach that can be used for reducing dependence on fossil fuels and managing the amount of carbon-based greenhouse gases in the atmosphere. Biogas is a mixture of methane and carbon dioxide that is released from decaying organic matter in the absence of oxygen. It can be used in any energy application that would normally use natural gas. Because the carbon in the organic matter comes from atmospheric carbon dioxide, burning the biogas as fuel simply returns an equivalent amount of carbon dioxide, without causing any net increase in the amount of greenhouse gases.

Almost any organic matter can be used as raw material for generating biogas. Concentrated source materials are readily available at landfills, wastewater treatment plants, and livestock farms, feedlots, and dairies. Using animal manure to generate biogas is particularly beneficial, since the manure is also a primary source of water pollutants in agricultural watersheds.

The primary process used for generating biogas is anaerobic digestion of organic matter. In the absence of oxygen, some bacteria extract energy and nutrients from organic material while producing methane instead of carbon dioxide. Important factors that govern this process include temperature, moisture, and acidity. Methane generation occurs spontaneously in landfills, wetlands, and other low oxygen environments. A number of technological approaches have also been developed to try to maximize the amount or rate of gas production from specific source material.

Maryland has substantial amounts of raw material for generating biogas. Estimates are that landfills in the state produce tens of millions of cubic feet of biogas per day. Several million cubic feet could also potentially be recovered from the hundreds of thousands of cows in the state. This resource is harder to tap, because cows are widely distributed throughout the state. In some counties, however, there are large dairy farms or concentrations of such farms for which collection and processing of animal waste could be profitable.

The current and potential applications of biogas recovery in Maryland are suggested by the following examples:

Heating. Landfill gas from the Sandy Hill landfill (in Prince George's County) is transported to NASA's Goddard Space Flight Center through a 5-mile pipeline. Burning the landfill gas provides all of the heating needs 95 percent of the time for the 31 office and laboratory buildings on the Goddard campus. Estimated savings are at least $350,000 per year in fuel costs over buying natural gas and fuel oil.

Power Generation. Existing landfill gas power generating facilities at Gude Landfill (Montgomery County) and Brown Station Road Landfill (Prince George's County) have generating capacities of 3 MW and 6 MW, respectively. On a smaller scale, a recent study of an out-of-state dairy farm found that it produced 33.3 kWh of electrical energy per 1000 cubic feet of biogas generated from cow manure, and could generate up to 49.9 kWh per 1000 cubic feet under optimum conditions. (It takes between 10 and 20 cows to produce 1000 cf of biogas per day.) The system provides all electricity for the farm and operates at a net profit by selling excess electricity back to power suppliers. (More information on landfill gas fired projects in Maryland is available on page 4-13.)

Transportation. In several areas around the country, fleets of buses or trucks are being run on natural gas. Diesel engines are readily modified to run on a diesel/natural gas mixture of 15/85 percent and achieve significant reductions in emissions of particulates, nitrogen oxides, and non-methane hydrocarbons. At least one landfill processes its biogas to natural gas quality and uses it to fuel its refuse collection trucks.

Water Impacts

Aquatic resources can be significantly affected by the generation of electricity. The withdrawal of water for cooling and other uses at steam generating power plants, and the operation of hydroelectric facilities alter the natural conditions of surface and ground water resources. Such changes may impact aquatic life as well as other users of the water. The following sections discuss the volume of water used in Maryland for power plant operation, the potential resource impacts resulting from that use, and methods for minimizing any adverse impacts.

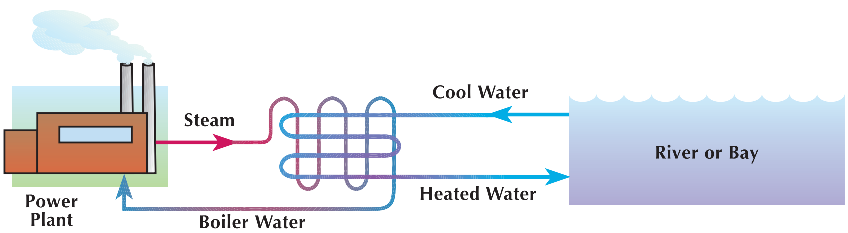
Cooling Water Withdrawal and Consumption

Most electricity is produced in Maryland by four broad types of generating technologies: steam-driven turbines, combustion turbines, combined cycle facilities (a hybrid of steam and combustion turbine units), and hydroelectric facilities. Power plants with steam cycles have the largest water withdrawals because of the need to cool and condense the recirculating steam. This cooling water is generally supplied from surface water, while the other water needs of the power plant (typically much smaller in quantity) are met by on-site ground water wells or municipal water systems. (See discussion of ground water impacts starting on page 3-33.)

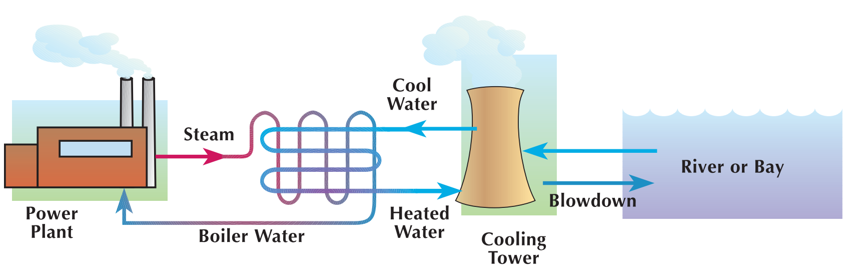
Table 3-4 lists all major steam generating power plants in Maryland (excluding self-generators) and quantifies their water withdrawals and consumption for 2004. Most steam plants in Maryland use once-through cooling, in which cooling water is continuously drawn from a water source, used, and then continuously returned to (usually) the same source. While water losses within the cooling system are negligible, the release of heated water results in elevated evaporative losses in the receiving waters. According to work conducted by the Interstate Commission on the Potomac River Basin (ICPRB), the in-stream evaporative loss

Once-Through vs. Closed-Cycle Cooling

In **once-through cooling**, water is drawn continuously from a bay or river to cool the power plant's condensers (that portion of the plant where steam is condensed to water and recycled to the boiler). Power plants with once-through cooling withdraw very large amounts of water, then return water to the bay or river at elevated temperatures. About 0.5 percent of the water is consumed because the warmer water evaporates more quickly.



In **closed-cycle cooling**, a much smaller amount of water is withdrawn, compared to once-through cooling, and the water is recirculated several times within a cooling tower. But closed-cycle cooling systems consume more water resources than once-through systems by evaporating the water. As much as half of the water withdrawn for cooling tower use is consumed by evaporation. The remainder is discharged back to the surface water source as blowdown.



The primary types of closed-cycle cooling towers include the natural draft design — large hyperbolic structures like those at the Chalk Point power plant (see photo at left) — and smaller mechanical draft systems like the cooling towers at Panda Brandywine (right).

caused by heated discharges varies from 0 to 2.5 percent of the discharge volume, with an average of about 0.6 percent during the summer and 0.5 percent during the winter. PPRP used ICPRB's calculation methods, applying them to facilities' 2004 water use data, to estimate the amount of water lost to evaporation as a result of thermal discharges from Maryland power plants. The calculations indicate that an estimated 28 mgd of water is lost to evaporation.

While most of this evaporation occurs in tidal waters, with negligible impacts to other water users, approximately 2 mgd of that loss represents freshwater losses in the Potomac River as a result of heated discharges from Mirant's Dickerson plant and Allegheny Energy's R. Paul Smith facility.

Four steam power plants in Maryland — AES Warrior Run, Brandon Shores, Panda Brandywine, and Vienna — use closed-cycle cooling (cooling towers) exclusively instead of once-through cooling. (Chalk Point has multiple steam boilers, two of which use once-through and two of which use closed-cycle cooling.) Closed-cycle systems recycle cooling water and use less than one-tenth of the water required for once-through cooling; however, 50 to 75 percent of the water evaporates from the tower and, therefore, does not return to the source.

Table 3-5 Surface Water Appropriations and Use at Maryland Power Plants with Steam Cycles

Power Plant	Surface Water Appropriation (average, mgd)	2004 Actual Surface Withdrawal (average, mgd)	Estimated Consumption (mgd)[1]	Water Source
Once-through Cooling				
BRESCO	62.2	27	0.12	Patapsco River
Calvert Cliffs	3,500	3,317	18	Chesapeake Bay
Chalk Point[2]	720	705	N/A	Patuxent River
C.P. Crane	475	344	2.4	Seneca Creek
Dickerson	400	372	1.5	Potomac R. *(non-tidal)*
Morgantown	1,500	1,094	2.3	Potomac River
Riverside	40	1	0.01	Patapsco River
R.P. Smith	70	30	0.4	Potomac R. *(non-tidal)*
H.A. Wagner	940	554	3.2	Patapsco River
Closed-cycle Cooling				
AES Warrior Run	3.0	1.9	1.75	City of Cumberland
Brandon Shores	35	6.5	3.3	Patapsco River
Panda Brandywine	3.0	0.36	0.24	Mattawoman WWTP
Montgomery Co. Resource Recovery Facility	3.0	0.90	0.6	Potomac R. *(Dickerson Station's discharge canal)*
Vienna	2.4	0.095	0.06	Nanticoke River
TOTAL	7,753.6	6,454	33.9	

Sources: U.S. Geological Survey, MDE

1 Derived from ICPRB's 1986 report, *Evaporative Loss from Receiving Waters Due to Heated Effluent Discharges.*

2 Chalk Point has two units on once-through cooling and two on closed-cycle cooling. The appropriation of 720 mgd covers all four steam units; data on each cooling system individually are not available.

Cooling water withdrawals at steam electric facilities represent the majority of surface water usage in Maryland. In 2004, combined water withdrawal for all steam generating power plants in Maryland is estimated at 6.4 billion gallons per day (see Table 3-5). All other non-power plant users in the state have a combined appropriation of 3.4 billion gallons per day. By comparison, the Potomac River has an average discharge of roughly 7 billion gallons per day, while the Susquehanna River discharges an average of about 23 billion gallons per day (actual daily flows in both the Susquehanna and the Potomac fluctuate greatly, both seasonally and from year to year).

Nuclear power plants fall within the steam generating category; however, they use nuclear reactions instead of fossil fuel combustion to create the thermal energy. Nuclear facilities generate more waste heat than fossil fuel-fired plants of the same capacity, and require 10 to 30 percent more cooling water to produce the same energy, according to data from the U.S. Nuclear Regulatory Commission. Maryland has one nuclear power plant operating on the western shore of the Chesapeake Bay, Calvert Cliffs, which withdraws an average of 3.3 billion gallons per day from the Bay. This is the largest single appropriation of water in the State of Maryland, 13 times more than the municipal supply for the Baltimore City metropolitan area of 250 million gallons per day. However, use of the once-through cooling technology at Calvert Cliffs allows for the majority of the cooling water to be discharged back into the Bay.

Low-Flow Issues

In the nontidal portion of the Potomac River, new consumptive users of water (such as power plants with large cooling water needs) must comply with Maryland's consumptive use regulations for the Potomac River Basin (COMAR 26.17.07). Consumptive water use refers to that portion of a water withdrawal that, as a result of evaporation, interbasin diversions, or other means, is not returned to the source to be available for subsequent use. The main focus of this regulation is to ensure that upstream users do not withdraw too much water during low-flow periods, and that sufficient water is present downstream to supply municipal water to the Washington, D.C., metropolitan area.

The consumptive use regulations require users consuming more than 1 mgd of water from the Potomac River to maintain low-flow augmentation storage, and to release water from storage to offset their consumption during low-flow periods. Alternatively, users can comply with the rules by reducing consumptive use to less than 1 mgd during low-flow periods. Users can provide low-flow augmentation storage, if necessary, by developing new water storage facilities or by purchasing storage space in existing water storage facilities, or both. The regulations specify the amount of augmentation storage that must be secured to avoid the potential for curtailment of water withdrawals during low-flow periods.

Recent Cases

The recently completed Catoctin Power licensing proceeding provides an example of how compliance with the Potomac River consumptive use regulations affected the developer's proposed project. Catoctin Power received a CPCN to build a combined cycle power plant in Frederick County in April 2005. The developer proposed to meet their cooling water needs either from reclaimed water obtained from a Frederick County wastewater treatment plant, or from direct withdrawal from the Potomac River. The CPCN requires the developer to meet the consumptive use regulations regardless of which source is selected because both water sources are derived from the Potomac River Basin.

Catoctin Power proposed to comply with the regulations by providing augmentation storage upstream of the power plant to maintain a minimum flow during low-flow conditions. Low-flow augmentation of this magnitude has not been previously implemented in Maryland. The consumptive use regulations require the power plant developer to maintain almost 470 million gallons of water in storage.

To provide sufficient augmentation storage volume, Catoctin Power has identified two potential sites; both are quarries located along the Shenandoah River near Millville in Jefferson County, West Virginia. These quarries lie less than five miles from the confluence of the Potomac River.

- ***Millville Quarry.*** *The Millville Quarry property encompasses approximately 1,700 acres, and includes several active and inactive workings. The active workings have been allowed to partially or fully flood, including the main pit, which is the area proposed for low-flow augmentation storage. The main pit covers a surface area of approximately 53 acres and is up to 280 feet deep at its lowermost working level. At the current maintained pool elevation of 255 feet above mean sea level (msl), and a corresponding pool area of 49 acres, an estimated 936 million gallons of water are contained in the quarry.*
- ***Old Standard Quarry.*** *The Old Standard Quarry property encompasses approximately 418 acres. The current pool elevation is 320 feet msl, compared to the mean river stage elevation of 295 feet msl at the USGS Millville gauging station. The quarry is estimated to be up to 80 feet deep. At a pool elevation of 320 feet msl, and a corresponding pool area of 35 acres, an estimated 851 million gallons of water are contained in the quarry.*

Catoctin Power will chose one of the two quarries for low-flow augmentation storage after further discussion with the quarry owners and technical analyses, to ensure the cost and technical feasibility of releasing water from the quarries to the Shenandoah River.

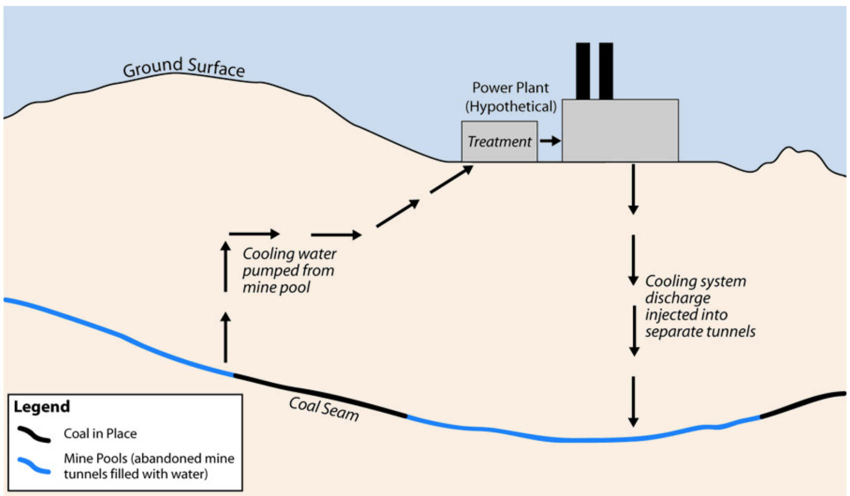
In another recent licensing case, Mirant agreed to incorporate on-site water storage to meet low-flow requirements as part of its expansion at the Dickerson plant on the Potomac River. Mirant received a CPCN in 2004 to add more than 700 MW of new generating capacity at this site in Montgomery County. PPRP's licensing review determined that 20 million gallons of on-site storage would ensure that the plant would be available at full capacity to meet peak electrical demands, based on historic maximums. Furthermore, if the plant ever becomes unavailable because the stored water is used up during an extended low-flow event, under the terms of its CPCN Mirant must install additional storage volume.

Cooling System Alternatives and Advances

With increasing pressures to minimize water withdrawals, power plant developers are finding more efficient means of cooling. Once-through cooling — once standard for power plants — is not a viable option for new power plants, particularly in light of EPA's newly promulgated regulations under the Clean Water Act Section 316(b), which target ecological effects of cooling water withdrawals (see sidebar on page 3-38). Closed-cycle cooling towers have become standard on

Mine Pools

Ponded mine water is another potential source of water that has been identified, particularly for any future generating facility in Western Maryland. Abandoned underground coal mines in the Appalachian region contain billions of gallons of water, much of which is acidic because of the geologic nature of the coal beds that supported the mines. Pumping that water to the surface and treating it to prevent cooling system corrosion could provide a cost-effective and environmentally preferable alternative to tapping the upper reaches of the Potomac River. Use of mine water would prevent any aquatic impacts associated with a direct withdrawal of cooling water, and it would reduce the amount of acidic water that drains into the Potomac and its tributaries from abandoned underground mines.



new steam generating power plants, which reduce water withdrawals substantially compared to once-through cooling systems, although their consumptive use is somewhat higher.

The reuse of treated wastewater treatment plant (WWTP) effluent is also becoming more acceptable and viable for power plants. The Panda Brandywine combined cycle facility, located in Prince George's County, currently utilizes about 1.5 million gallons per day of treated effluent from the Mattawoman WWTP. As mentioned earlier, Catoctin Power included WWTP effluent as an alternative in its facility plans, and another recently proposed plant, Free State-Kelson Ridge, also proposed WWTP effluent reuse. Effluent reuse has been established as an alternative that can be economically attractive and technically viable for sites located near large WWTPs. With respect to environmental impacts, effluent reuse still represents a consumptive loss of freshwater resources, since the treated effluent that is used and evaporated in the cooling towers would otherwise be discharged to surface water. However, aquatic impacts are reduced because effluent reuse does not involve direct withdrawals from a surface water body.

Dry cooling systems are also making significant inroads to the power industry. Once thought infeasible due to their large size (aesthetics, parasitic power use, required land, capital outlay), dry cooling towers are now being seriously evaluated as potential alternatives to wet cooling systems. Although currently there are no facilities in Maryland using dry cooling systems, this option has been proposed at the Kelson Ridge and Dynegy sites. As appropriations for cooling water become more restricted, dry cooling becomes more attractive.

Recently proposed power plants that include steam cycles have all incorporated on-site water storage as a contingency against low flow restrictions. A developer can build ponds or tanks to store cooling water, which could carry the facility through a short-term drought. However, based on current conditions, it is prohibitively expensive for plant developers to construct on-site storage that could supply enough water to support operations through a prolonged period of withdrawal restrictions. Plants that propose to withdraw cooling water from nontidal waters of the Potomac therefore accept the risk that, occasionally, severe drought conditions will require them to curtail their operations. PPRP has addressed this issue in recent licensing cases by recommending that developers incorporate significant on-site water storage to ensure that generating capacity remains available to Maryland customers under most drought conditions. It is recognized that severe drought conditions correlate quite well with conditions of heavy electricity consumption.

PPRP recognizes the increasingly sensitive issue of water appropriation for power plant use, and supports research and development in the areas of alternative cooling methods and environmentally beneficial water use. New power plant proposals in Maryland will continue to be subject to strict CPCN conditions regarding water use, given the increasing water demands across the state.

Ground Water Withdrawals

Some of Maryland's power plants are also significant users of ground water. Ground water is used for boiler feedwater in coal-fired power plants, inlet air cooling and emissions control in gas- and oil-fired combustion turbines, and potable water throughout the power plants. Use of ground water for process cooling is severely restricted in Maryland. High-volume ground water withdrawals from aquifers have the potential to lower the water level of an aquifer, reduce the amount of water available for other users, lower the water table of an area, or, in the case of Coastal Plain aquifers, cause intrusion of salt water into the aquifer. The impact of these withdrawals is a key issue in southern Maryland, where there is a significant reliance on ground water for public water supply. Although large volumes of ground water are available in the Coastal Plain aquifers, withdrawals must be managed over the long-term to ensure adequate ground water supplies are available in the future.

Currently seven power plants in Maryland withdraw ground water from Coastal Plain aquifers for plant operations. These plants include: Constellation's Calvert Cliffs Nuclear Power Plant and Perryman combustion turbine facility, Mirant's Chalk Point and Morgantown power plants, NRG's Vienna power plant, SMECO's combustion turbine facility (located at the Chalk Point plant), and Panda-Brandywine's combined cycle power plant. All of these plants are located in the Coastal Plain of Maryland, and with the exception of the Perryman and Vienna facilities, all are located in southern Maryland. Perryman, located in Harford County northeast of Baltimore, withdraws ground water from the Talbot Aquifer; Vienna, located in Dorchester County on the Eastern Shore, withdraws ground water from the Columbia Group Aquifer. An eighth power plant, the Rock Springs combustion turbine facility in Cecil County, is now operating and has been authorized to withdraw ground water under certain conditions.

Five power plants located in southern Maryland (Calvert Cliffs, Chalk Point, Morgantown, SMECO, and Panda) withdraw ground water from three aquifers: the Aquia, the Magothy, and the Patapsco. Figure 3-15 shows the ground water withdrawal rates expressed as daily averages from 1975 to 2004 of each of these five power plants, in addition to the Perryman and Vienna facilities; the rates are also listed in Table 3-6. The power plants typically withdraw amounts of water well below their appropriation permit limits. The average withdrawal for all seven power plants in 2004 was 1.98 mgd compared to a combined daily appropriations limit of 2.66 mgd. The amount of ground water withdrawal in 2004 was nearly identical to amounts withdrawn in previous years.

Three government agencies — the Maryland Geological Survey, the U.S. Geological Survey, and PPRP — jointly operate a ground water monitoring program to measure the water levels in these aquifers to ensure the long-term availability

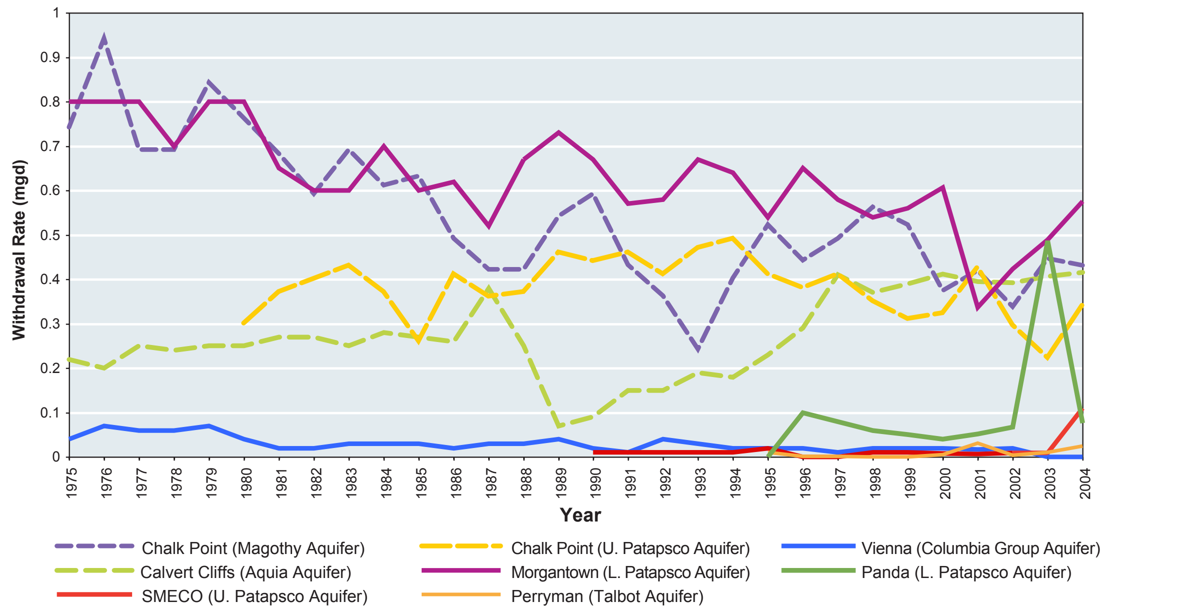
Table 3-6 Average Daily Ground Water Withdrawal Rates at Maryland Power Plants (in mgd)

	Chalk Point (Magothy Aquifer)	Chalk Point (U. Patapsco Group Aquifer)	Vienna (Columbia Aquifer)	Panda (L. Patapsco Aquifer)	Morgantown (L. Patapsco Aquifer)	Calvert Cliffs (Aquia Aquifer)	SMECO (U. Patapsco Aquifer)	Perryman (Talbot Aquifer)	Total Average Daily Withdrawal
Current Appropria-tions Limit:	**0.66**	**0.66**	**0.05**	**0.064 ***	**0.82**	**0.45**	**0.02**	**0.1**	**2.66**
1975	0.75		0.04		0.8	0.22			1.81
1976	0.95		0.07		0.8	0.2			2.02
1977	0.7		0.06		0.8	0.25			1.81
1978	0.7		0.06		0.7	0.24			1.70
1979	0.85		0.07		0.8	0.25			1.97
1980	0.77	0.3	0.04		0.8	0.25			2.16
1981	0.69	0.37	0.02		0.65	0.27			2.00
1982	0.6	0.4	0.02		0.6	0.27			1.89
1983	0.7	0.43	0.03		0.6	0.25			2.01
1984	0.62	0.37	0.03		0.7	0.28			2.00
1985	0.64	0.26	0.03		0.6	0.27			1.80
1986	0.5	0.41	0.02		0.62	0.26			1.81
1987	0.43	0.36	0.03		0.52	0.38			1.72
1988	0.43	0.37	0.03		0.67	0.25			1.75
1989	0.55	0.46	0.04		0.73	0.07			1.85
1990	0.6	0.44	0.02		0.67	0.09	0.01		1.83
1991	0.44	0.46	0.01		0.57	0.15	0.01		1.64
1992	0.37	0.41	0.04		0.58	0.15	0.01		1.56
1993	0.25	0.47	0.03		0.67	0.19	0.01		1.62
1994	0.41	0.49	0.02		0.64	0.18	0.01		1.75
1995	0.53	0.41	0.02	0	0.54	0.23	0.02	0.01	1.76
1996	0.45	0.38	0.02	0.1	0.65	0.29	0	0.001	1.89
1997	0.5	0.41	0.01	Not Available	0.58	0.41	0	0.001	1.91
1998	0.57	0.35	0.02	0.06	0.54	0.37	0.01	0	1.92
1999	0.53	0.31	0.02	0.05	0.56	0.39	0.01	0	1.87
2000	0.382	0.322	0.019	0.04	0.606	0.412	0.008	0.005	1.79
2001	0.427	0.426	0.017	0.051	0.337	0.395	0.007	0.031	1.69
2002	0.346	0.296	0.020	0.067	0.423	0.392	0.009	0.004	1.56
2003	0.454	0.222	0.022**	0.486	0.489	0.407	0.009	0.010	2.08
2004	0.439	0.341	0.008***	0.076	0.575	0.415	0.11	0.025	1.98

Source: U.S. Geological Survey

* Panda was granted a higher appropriation during construction of its pipeline for conveying treated effluent.
** No report was submitted to MDE for the period July-December 2003. The amount shown was estimated using the total volume withdrawn of 4,131,683 gallons reported for the period January-June 2003.
*** No report was submitted to MDE for the period January-June 2004. The amount shown was estimated using the total volume withdrawn of 1,505,770 gallons reported for the period July-December 2004.

Figure 3-15
Average Daily Ground Water Withdrawal Rates at Maryland Power Plants



Note: Panda's increased ground water withdrawal in 2003 resulted from an extended outage at the Mattawoman wastewater treatment plant, which is Panda's primary source of cooling water, coincident with a period of high electricity demand.

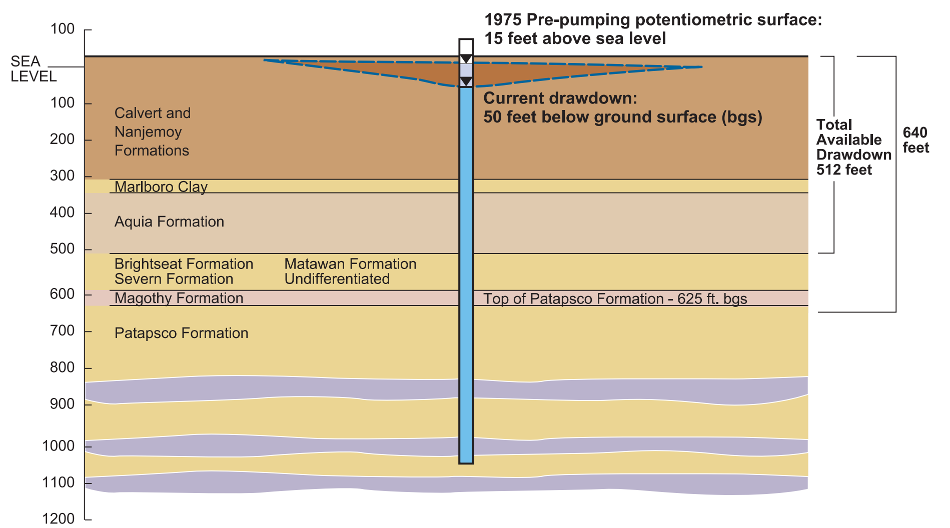
of ground water. MDE WMA, which has permitting authority over all ground water appropriations, uses the data from the joint monitoring program to assess the significance of impacts to these aquifers when reviewing additional appropriations requests.

Long-term monitoring indicates a steady decline in water levels in the Aquia, Magothy, and Patapsco aquifers. However, these declines are not solely due to withdrawal from power plants, and are considered acceptable by MDE when compared to the amount of water available in the aquifers. The amount of water available is expressed as the aquifer's "available drawdown," which is defined in MDE regulations as 80 percent of the historic pre-pumping level in the aquifer.

Evaluating Drawdown Impacts

Long-term monitoring data show how pumping from a ground water aquifer affects the water level over time. MDE regulations define "available drawdown" in an aquifer as 80 percent of its historic pre-pumping level. The significance of the current drawdown can then be estimated by comparing current drawdown to the total available drawdown (see drawing at right for an illustrated example).

Upper Patapsco Aquifer at Chalk Point



Also, although power plants have contributed to the decline in the water levels in these aquifers, increased withdrawals from municipal well fields in southern Maryland have caused most of the recent declines. Water quantity impacts to each of the three aquifers are summarized below.

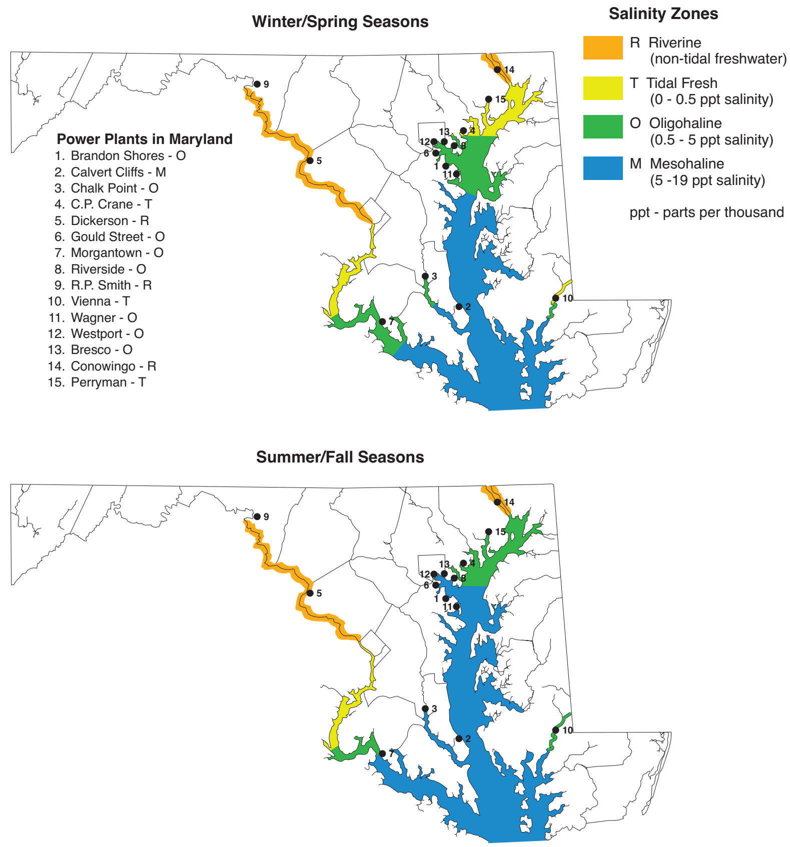
- ***Aquia Aquifer at Calvert Cliffs*** *– Water levels in the Aquia Aquifer at Calvert Cliffs have declined 60 feet over the period 1982 to 2003, with most of the decline occurring since 1990. This acceleration in water level declines is due to the withdrawal from municipal well fields at Lexington Park in St. Mary's County and Solomons Island in Calvert County. The water levels at Lexington Park and Solomons Island have declined nearly 18 feet since 1997 and approximately 108 feet since 1982. The impacts from the water level declines are considered acceptable given the 315 feet of available drawdown currently estimated in the Aquia Aquifer at Calvert Cliffs.*
- ***Magothy Aquifer at Chalk Point*** *– MDE has required industrial users of the Magothy Aquifer to use deeper aquifers like the Patapsco to allay concerns over water level declines in the Magothy. As a result, the Chalk Point power plant reduced its ground water withdrawal from the Magothy during the time period 1990 to 2003 by about 40 percent compared to the period before 1980. This reduction has resulted in a commensurate reduction in the rate of water level decline at the facility during this same period; however, water levels continue to decline in the aquifer due to the extensive continued use in Annapolis and Waldorf. The drawdown at Chalk Point between 1975 and 2003 has been approximately 35 feet, and a total of about 65 feet since pumping at Chalk Point began in 1964. Prior to pumping in 1962, the elevation of the potentiometric head in the Magothy Formation was 28 feet above msl; thus the available drawdown is 80 percent of 600 feet plus 28 feet, approximately equivalent to 500 feet. Consequently, the total drawdown of 65 feet is small compared to the estimated total available drawdown of approximately 500 feet for the Magothy Formation in the vicinity of Chalk Point.*
- ***Upper Patapsco Aquifer at Chalk Point*** *– The water level surface in the Upper Patapsco Aquifer declined up to 20 feet at Chalk Point between 1990 and 2003. Recent measurements indicate a total drawdown of nearly 67 feet between 1975 and 2003 at Chalk Point. These declines will not impact the approximately 512 feet of available drawdown in the Upper Patapsco Aquifer at Chalk Point.*
- ***Lower Patapsco Aquifer at Morgantown*** *– The water level surface of the Lower Patapsco Aquifer in the vicinity of the Morgantown power plant has declined up to 30 feet between 1990 and 2003. Since 1997, water levels in the vicinity of the Morgantown power plant have remained constant.*

Impacts to Water Quality and Aquatic Biota

Other than a small segment of western Maryland that is in the Youghiogheny River watershed (Ohio-Mississippi drainage) and small estuarine water bodies of Atlantic Shore (the Chincoteague watershed), the bulk of Maryland's drainage system feeds the Chesapeake Bay. All of Maryland's primary rivers drain into the Chesapeake Bay: Potomac, Patuxent, Patapsco, Susquehanna, Chester, Choptank, Nanticoke, Blackwater, and Pocomoke Rivers. Together, these rivers and the Bay extend over a large geographic area and encompass a broad range of aquatic habitat types, including marine, estuarine, and freshwater rivers and lakes.

All steam electric power plants in Maryland are located in the Chesapeake Bay watershed. As depicted in Figure 3-16, the power plants occupy various physiographic and habitat types, including upland, riverine, and estuarine.

Figure 3-16
Salinity Zones of the Maryland Chesapeake Bay



Potential impacts from steam-electric power plants on rivers and estuaries may include a reduction in river flow volumes due to evaporative water loss in the plant's cooling system, mortality of aquatic organisms as a result of entrainment in the cooling system, impingement of larger organisms on cooling system screens, and elevated temperatures of receiving waters after power plant discharge.

Water usage and the resulting environmental impacts have been monitored by various agencies and organizations; these issues have been a major responsibility of PPRP since it was established in 1972. In systems where multiple sources of potential impacts can affect water quality and aquatic habitats, the combined effects may compound or intensify the effects of the individual sources, and accumulate in downstream areas. Although permit requirements and regulations may not require an assessment of cumulative effects, the health of the contiguous system is determined by the impact of multiple influences. PPRP has conducted aquatic impact assessment studies at all of Maryland's existing plants and has identified no measurable cumulative adverse impacts. MDE issues discharge permits, in accordance with the Clean Water Act, and uses aquatic impact assessment data to monitor continued performance of power plants in minimizing these impacts.

In addition to minimizing impacts, several power plants have instituted cooperative aquatic enhancement measures at their facilities, such as constructing and operating gamefish hatcheries where fish are released under the direction of Maryland DNR. Power plants have also established funds to remove fish migration obstructions caused by low-head dams no longer in use. The types of impacts identified by PPRP, along with the steps that have been taken to minimize and mitigate these impacts, are discussed in greater detail below. The impacts associated with cooling water withdrawals in the state are currently being reevaluated for regulatory compliance because of the new U.S. EPA Section 316(b) regulations for new and existing power plants (see sidebar on next page).

Direct Withdrawal Impacts: Entrainment, Impingement, and Entrapment of Organisms

Cooling water withdrawals can cause adverse ecological impact in three ways:

- *entrainment – drawing in of plankton and larval or juvenile fish through plant cooling systems;*
- *impingement – trapping larger organisms on barriers such as intake screens or nets; and*
- *entrapment – accumulation of fish and crabs (brought in with cooling water) in the intake region.*

In the 1970s and early 1980s, PPRP evaluated aquatic organism impacts at 12 major power plants. The studies were used to evaluate the relative impacts of power plant operations on the aquatic environment, with special emphasis on the Chesapeake Bay. Results of the studies showed that while power plant operations affect ecosystem elements, the cumulative impacts have no significant consequence to Maryland's aquatic resources.

Although entrainment losses for aquatic organisms have been measured, they do not reveal consistent depletions of populations. Even though power plant activities are not substantially decreasing populations, the plants are still modifying their operating procedures and have constructed on-site hatchery facilities for fish stocking operations. They have also provided funding to remove blockages to migratory fish and developed improved intake technologies and other modifications to reduce entrainment or impingement.

New EPA Regulations for Power Plant Cooling Water Withdrawals (Clean Water Act Section 316(b))

Phase 1: Applies to **new** facilities with a cooling water intake, constructed after January 17, 2002.

Phase 2: Applies to **existing** power-producing facilities, effective September 7, 2004, with a cooling water intake design greater than 50 million gallons per day (mgd). The rule applies to each facility as its NPDES permit is renewed.

Phase 3 (proposed): Applies to **manufacturing** facilities with a cooling water intake design flow greater than 50 mgd.

The regulations establish specific performance standards for reduction of impingement and entrainment. There are five compliance alternatives for utilizing best technology available to minimize adverse environmental impact at the facility:

(1) *The performance standard is met for impingement and entrainment if the facility water intake flow is similar to that used for closed-cycle cooling. The impingement standard is also met if the intake system has a velocity of less than half a foot per second.*

(2) *Existing operational and/or restoration measures meet performance standards.*

(3) *Existing and new design and construction technology or, existing and new operational and/or restoration measures meet performance standards.*

(4) *The compliance standard is met if a submerged cylindrical wedge-wire screen is installed and maintained under certain specified conditions, or approval of another technology can be requested if it is shown that it meets the performance standards.*

(5) *A site-specific determination of the best technology available to minimize adverse environmental impacts can be requested if reliable, scientifically valid cost and performance data are submitted showing that the costs of compliance are greater than those considered by EPA in establishing the performance standards for a similar facility.*

PPRP is assisting MDE in implementing the new regulations for new and existing facilities in Maryland. Maryland has eleven existing steam electric power plants with an NPDES permit and a cooling water intake and discharge. Of these, two plants are below the 50 mgd design threshold for Phase 2 facilities (Warrior Run and Vienna), one may be classified as a Phase 3 facility (BRESCO), and the remaining eight (Calvert Cliffs, Chalk Point, C.P. Crane, Dickerson, Morgantown, Riverside, R.P. Smith, and Wagner-Brandon Shores) will require a Phase 2 evaluation.

Because of PPRP's review of intake technologies, the design of facility intake structures must now incorporate some or all of the following characteristics:

- ***Installing physical barriers*** *– Screens or nets are most successful and economical for reducing both entrainment and impingement; wedge-wire screens keep entrainment low and almost eliminate impingement.*
- ***Collecting and releasing organisms after impingement*** *– This activity can reduce impingement losses. If organisms are returned to the receiving water body near the intake structure, they may be susceptible to re-impingement. Morgantown power plant, therefore, redesigned its system to return fish to the side of the intake structure flowing away from the plant (depending on the direction of the tide). Similarly, the fish return system installed at the Wagner power plant places impinged fish into a channel leading away from the intake screens.*
- ***Modifying intake screen wash cycles*** *– Intake screens are rotated at various intervals which does not alter the rate of impingement but does reduce the time organisms are exposed to scavengers and anoxic conditions.*
- ***Discontinuing the use of auxiliary tempering pumps*** *– Auxiliary pumping causes additional entrainment and impingement of aquatic organisms, because it withdraws surface water to mix with the plant's discharge water to lower the temperature of the discharge water. Mirant's Chalk Point plant was the only Maryland station to use this approach, but has discontinued it because studies showed that in the absence of such mixing, the water discharge temperature difference did not significantly increase downstream mortalities.*

Because there have been no major modifications in the intake systems of power plant facilities since PPRP conducted its detailed entrainment and impingement studies in the 1970s and 1980s, no additional studies have been performed. As the new Section 316(b) rules for new and existing facilities are implemented starting in 2005, additional entrainment and impingement studies and measures are being conducted at most of the existing facilities.

Stream Flow Volume Reductions

In response to multiple power plant proposals in 2001 with potential impacts on the Potomac River, PPRP developed worst-case scenarios in which proposed new power plants were added to the set of plants already withdrawing water from the non-tidal region of the Potomac River. These scenarios assessed the effects that the multiple withdrawals would have on the river stage (i.e., depth of water at a particular location) and habitat in the Potomac River. PPRP considered the potential cumulative effects of the Dickerson expansion in western Montgomery County, as well as up to two new facilities withdrawing Potomac River water, based on the level of interest that power plant developers have shown in that area of Maryland.

The three potential hypothetical facilities were estimated to withdraw an additional 30 mgd from the river, of which 24 mgd would be consumed. The volume loss of water was estimated based on the maximum consumptive use from three additional closed-cycle power plants and the potential impact evaluated for a point in the river where the river stage is monitored.

Table 3-7 Change in River Stage from Three Hypothetical Additional Power Plants Upstream of Point of Rocks

	Gaging Station					
	Point of Rocks (USGS 01638500) Rating Table No. 24			Little Falls Dam (USGS 01646500) Rating Table No. 8		
Parameter	Before Withdrawal	After Withdrawal	Reduction	Before Withdrawal	After Withdrawal	Reduction
Flow, cfs	842	805	37	458	421	37
Stage, feet	0.49	0.47	0.024	2.40	2.38	0.02
Stage, in.	5.88	5.59	0.29	28.80	28.58	0.22

Changes in river stage due to increased water loss are based on the stage-discharge relationships established by the U.S. Geological Survey (USGS) for the gauging stations at Point of Rocks (upper end of the affected reach) and at Little Falls Dam (lower end of the non-tidal Potomac River). Table 3-7 shows the change in stage that would result from a 24 mgd (37 cfs) decrease in flow at each of these gauging stations. These changes were calculated for the lower end of the rating curve where the decrease in flow would represent the greatest percentage drop in flow.

The results show that even under this drought scenario, the change in river stage would be less than one-third inch at Point of Rocks and less than one-quarter of an inch at Little Falls Dam. Under higher flow conditions, when the river is wider, the change in stage would be less than during these worst-case, low-flow conditions. This is a conservative analysis because it assumes withdrawals are not curtailed during low flow conditions. In reality, the combined withdrawals of the three hypothetical plants would be only 3 mgd during low flow events (1 mgd for each facility), due to regulatory constraints.

In addition to changes in river stage, PPRP evaluated the potential reduction in aquatic habitat that could occur if multiple new power plants began withdrawing water from the Potomac. Reduction in habitat would be greatest in the Great Falls reach of the river, due to the large water supply withdrawals which already occur in that area. The only available flow-related habitat information from that area was collected by Maryland DNR in the late 1970s. In that study, several transects were measured for depth and velocity at several flows, and model simulations were made to estimate habitat area at various flow levels. The best habitat in the Great Falls to Little Falls reach was determined to be in the Carderock area. In the recent evaluation of potential new plants withdrawing from the Potomac, therefore, PPRP used estimated habitat from the Carderock area to calculate the change in habitat for the entire reach. This is an environmentally conservative estimate and assumes that a river length of 10 miles is represented by this reach. The results of the calculations indicate that even at very low (drought) flow, the wetted area would be reduced by only 0.8 percent. This estimate assumes that ideal habitat occurs for the entire length of the reach, and that flow reduction measures would not be imposed during drought conditions, so it provides a very conservative estimate of the reduction in the river's wetland perimeter.

Potomac River Flow-by Evaluation

A 1981 Maryland DNR study served as the basis for a multi-agency agreement that established a Potomac River minimum flow-by requirement at Little Falls of 100 million gallons per day (mgd) and a recommendation of 300 mgd at Great Falls. While these low flow criteria have been in place for more than 20 years, the severe drought conditions that occurred in the Potomac River watershed in 1999 raised concerns about the adequacy of these flow-by requirements for protecting the river ecosystem and its resources. At issue was the technical basis for the designation of those flow targets in 1981 and the methods used to develop them.

Maryland DNR agreed to evaluate if the current requirement adequately protects natural resources. PPRP served as lead agency for this effort, based on its previous experience with stream flow issues at Deep Creek, Jennings Randolph reservoir, and Conowingo Dam, and its evaluation of potential power plants with new water intakes on the Potomac River in Frederick and Montgomery counties.

PPRP produced a report that provides background information describing the history of current low flow requirements, a review of the studies conducted to support those requirements, and a habitat assessment conducted during low flow conditions in 2002. In April 2003, a workshop was convened with a panel of nationally recognized experts to review the habitat assessment issues and to develop recommendations for consideration by decision makers. A methods update workshop was convened in November 2004. The summary report and recommendations of the two workshops can be viewed on the PPRP web site, www.dnr.state.md.us/bay/pprp.

Cooling Water Discharge Impacts

Impacts to aquatic biota from power plant cooling water system discharges include elevated temperatures, discharge of chemicals used for biofouling treatment (e.g., chlorine), discharge of metals eroded from internal plant structures (e.g., copper), and, in the case of Maryland's only nuclear power plant, discharge of radiological materials. Each of these impacts is discussed below.

Thermal Changes

Biological impacts from heated effluents depend upon the magnitude and duration of the temperature difference between discharge water and river water. Small organisms that pass through a plant's cooling system experience the greatest temperature stress, both in magnitude and duration. Exposed organisms in the receiving waters are more likely to experience smaller increases in temperature of shorter duration due to dispersion of the thermal plume and mobility of most of the exposed aquatic biota (e.g., fish, blue crabs). PPRP conducted studies to determine the effects of thermal discharges at each existing power plant in the state. Because different aquatic biota occupy different habitat types in Maryland waters, study results are presented here according to the habitats where power plants are located. The following pages present a brief summary of the findings in those studies.

Mesohaline Habitat – The largest power plants (in megawatts) in the state discharge into mesohaline habitat during all or part of the year. PPRP studied thermal discharges from Chalk Point, Morgantown, Calvert Cliffs, and H.A. Wagner power plants as part of extensive fieldwork in the 1970s and 1980s. Thermal plume dimensions for these power plants varied with season, tidal stage, wind velocity and direction, and plant operating levels.

The effects of thermal discharges from the power plants located in the mesohaline habitats of the Chesapeake Bay have been localized and are not considered significant. PPRP found no cumulative adverse impacts to the habitats of the Chesapeake Bay ecosystem. PPRP will continue to evaluate the habitats, however, if additional power plant discharges are proposed, and new technology would then be considered to reduce thermal discharges.

Tidal Fresh and Oligohaline Habitat – Two plants, Vienna and C.P. Crane, discharge into tidal fresh and oligohaline waters. PPRP studies showed that the thermal plume at Vienna was small and its discharge effects were negligible. The thermal plume at C.P. Crane affected about 40 percent of the volume of the receiving water embayment. C.P. Crane effluents also resulted in a slight increase in nearfield salinity due to plant-induced changes in the nearby bay circulation pattern, but these factors did not affect nearfield dissolved oxygen.

Findings at the plants in these tidal fresh and oligohaline habitats were consistent with those at facilities in mesohaline areas. Thermal discharge effects were small and localized. PPRP studies found no evidence that fish movements were blocked by thermal plumes in the plants' receiving waters in these particular habitats.

Nontidal Freshwater Habitat – Only R.P. Smith and Dickerson power plants are located in nontidal riverine habitat in Maryland. The thermal impact of their discharges on the Potomac River ecosystem were assessed in a long-term freshwater benthic study conducted by PPRP over an 8-year period. While this long-term study documented that the thermal discharges from these two plants had an adverse impact on benthic communities in the immediate area of the discharges, these effects were localized. The affected percentage of the total river bottom is very small. To assess whether these localized impacts on benthic communities may be affecting fish populations within the river, the NPDES permit for the Dickerson facility included a requirement for a multi-year study of growth and condition of several fish species in the vicinity of the plant. Based on data on fish condition collected over a 21-year period near the plant and at reference locations, there was no indication that fish near the plant were affected by the localized discharge effects on benthic communities.

Chemical Discharges

Concerns regarding the impacts of copper and chlorine discharged into sensitive waters of the Chesapeake Bay watershed in the late 1970s and early 1980s led to extensive studies by PPRP as well as others.

Copper – In the late 1970s and early 1980s, oysters in the vicinity of the Chalk Point, Calvert Cliffs, and Morgantown power plant discharges were found to be bioaccumulating copper that was present in the effluent discharge. The copper resulted from erosion of the copper condenser tubes within the plants' cooling systems. While PPRP studies showed that oyster growth and survival were not adversely affected, the elevated levels of copper concentrations in oysters posed a potential risk to the health of individuals who might consume them. While no immediate health threat existed, PPRP recommended that the power plants replace the copper condenser tubes with titanium tubes at power plants where this problem was most significant, primarily in estuarine waters. The titanium tubes eliminated the metals erosion, which also resulted in less maintenance on the condenser tubes. Currently, NPDES permitting for all power plant discharges includes an evaluation of maximum discharge levels for copper (as well as other metals) to protect human health and the environment.

Chlorine – This substance is used by power plants to control bio-fouling of condenser tubes in cooling water systems. While it may be an effective means of controlling biological organisms within the cooling system, it can also cause mortality in the aquatic biota of the receiving water body. Presently, the NPDES permits for all power plants in Maryland require that chlorine not be discharged into the state's waters for more than two hours in any one day from any one unit, and no more than one unit may discharge at any one time. An exception may be granted if a facility demonstrates that more chlorination is needed to control macroinvertebrates. Chlorinated discharge impacts are now considered resolved and no further action is needed.

Effects of Combustion Product Storage

Coal-fired power plants produce significant amounts of coal combustion products (CCPs — see discussion on page 3-77). Approximately 49 percent of the CCPs produced in Maryland are placed in landfills where they have the potential to leach chemical constituents into ground water. Certain beneficial use applications, such as structural fill and mine reclamation, also involve the placement of CCPs in locations where they could come into contact with ground water. In order to address concerns about CCP impacts to ground water quality, PPRP is conducting several studies on the interactions between ground water and CCPs in both disposal and beneficial use projects.

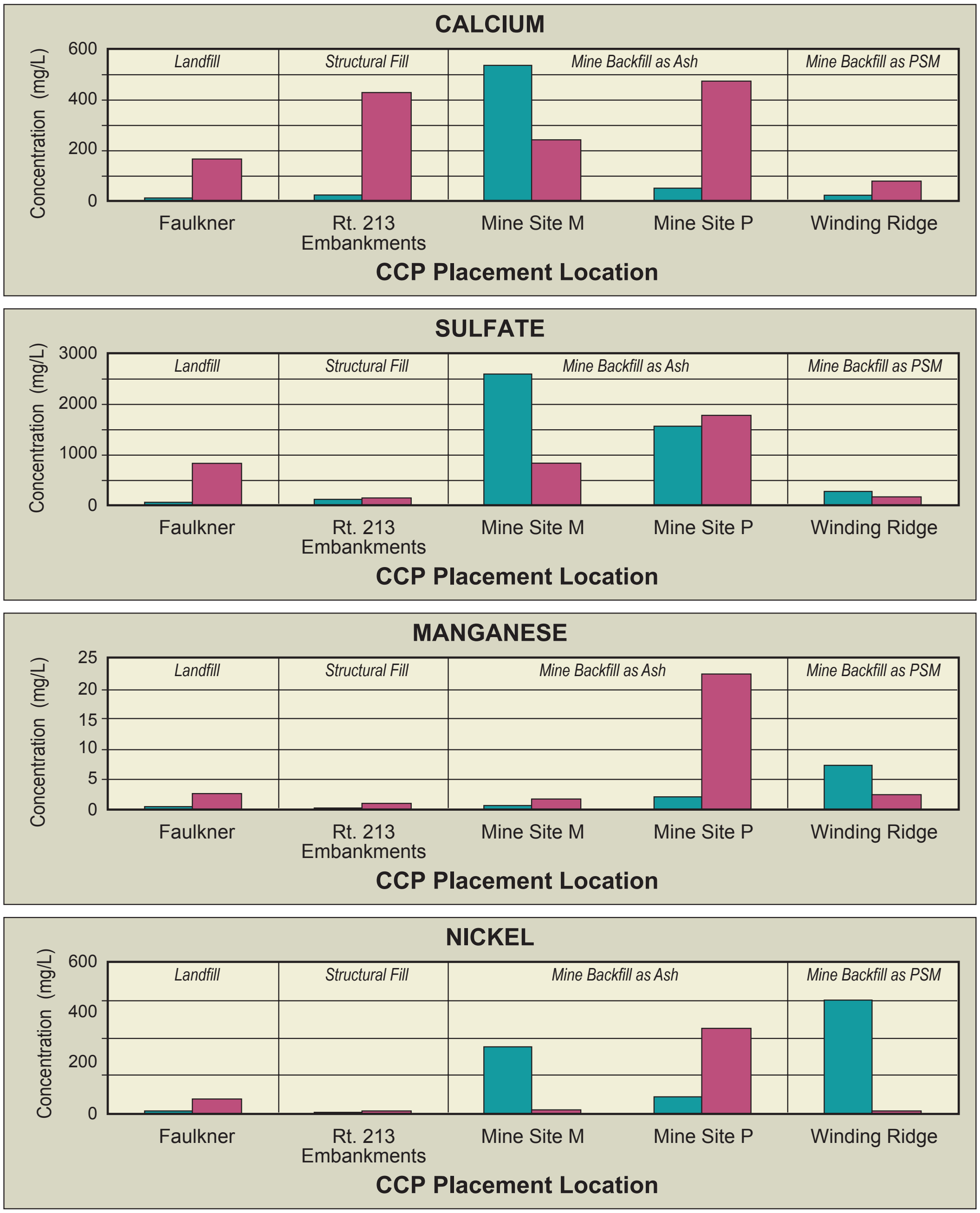
In general, CCPs can be placed, stored, or beneficially used as ash or as pozzolan stabilized material (PSM). Placement as ash is the most common placement form for CCP landfills and many beneficial use applications where CCPs are used as aggregate, structural fill, or surface mine backfill. However, due to their chemical nature, CCPs can be mixed in such a way as to harden into a concrete-like solid monolith (referred to generically as PSM). Of these two placement forms, placement as ash has a much higher risk of leaching constituents into ground water due to the high surface area of the material. This is demonstrated by a number of studies at different types of sites:

- *CCPs stored at the Faulkner Fly Ash Storage Facility have generated leachate characterized by low pH and high concentrations of sulfate and metals. This leachate has negatively impacted shallow ground water and streams in the area. PPRP is currently sponsoring a study of passive treatment systems to address this leachate problem.*
- *PPRP's study of CCPs used as structural fill in two highway embankment projects along Route 213 and Interstate 695 in Maryland showed that leachate containing calcium, sulfate, and certain trace metals formed in pore water infiltrating into the CCP materials. In these instances, however, the dissolved constituents were attenuated in the native soils and/or diluted in ground water to the point that no downgradient impacts were detected.*
- *In a study conducted by the West Virginia Water Research Institute, the water quality was monitored at two mine sites where CCPs were placed as ash in order to provide alkalinity that would mitigate acid mine drainage (AMD) discharge from the mines. The study found that the CCPs were effective in increasing the pH of the mine discharge. The CCPs also appeared to reduce the concentrations of some chemical constituents in the discharge due to lower solubility of these metals at high pH. However, the CCPs appeared to increase the concentrations of other chemical constituents due to either their higher solubility at high pH or their presence within the CCPs themselves.*

Figure 3-17 summarizes selected ground water and mine discharge water quality data from the above-mentioned studies. Although there have been fewer studies on the potential for PSMs made from CCPs to produce leachate, these materials should pose far lower risk to water quality because of their much lower surface area and monolithic structure when allowed to harden in place. Notably, water quality data generated at the Winding Ridge site, where CCPs were used to create a PSM grout that was injected into an abandoned coal mine, support this statement (for more information on the Winding Ridge project, see page 3-81). The Winding Ridge data show that, while certain relatively benign major ions (such as calcium, potassium, sodium, and chloride) have dissolved from the grout surface, the grout itself remains cohesive and intact. Furthermore, the overall water quality which, prior to injection was typical of AMD, has improved as evidenced by lower concentrations of iron, aluminum, and various trace metals in the mine discharge.

In order to further address the informational gap on the potential for CCP-based PSMs to form leachate, PPRP is working together with partner organizations to conduct a series of bench-scale laboratory tests on the physical and chemical weathering of grouts made from CCPs.

Figure 3-17
Leaching of CCPs in Various Types of Fill Applications



Notes:

Faulkner data are from monitoring wells upgradient and downgradient of the landfill area.

Rt. 213 Embankments data are for background ground water and pore water within the CCP fill material.

Mine Site P and Mine Site M data West Virginia Water Research Institute study.

Winding Ridge data are for pre-injection mine seep water and post-injection (2004) mine seep water.

LEGEND

Before interaction with CCPs

After interaction with CCPs

Deep Creek Hydroelectric Project: Balancing Multiple Resource Uses

The 3,900-acre Deep Creek Lake was formed in 1925 by the construction of a rockwall dam across Deep Creek, a tributary of the Youghiogheny River. The Deep Creek Hydroelectric Project includes two turbines with a combined generating capacity of about 20 MW. Operation of the facility affects recreational users of the lake and the river. The Youghiogheny River is Maryland's only designated "wild" river. It supports a trout fishery and is one of the most challenging whitewater runs in the country.

In 1994, the owner of Deep Creek Station agreed to develop the conditions required under a water appropriations permit administered by MDE. Working with PPRP and MDE, conditions were designed to achieve two objectives: 1) to provide a reliable and economical source of electricity; and 2) to enhance Deep Creek Lake's and the Youghiogheny River's natural and recreational resources. Because the interests of lake and river users often conflict, it was a complex task to develop an operational plan for the station that balanced environmental and recreational issues with economical operation.

Lake Water Levels - Recreational lake users typically want minimal and consistent drawdown of the lake during summer, with a higher than historic level in the autumn to extend the boating season. Historically, the power company lowered the water level in the fall and winter to prevent ice damage to the spillway. To help evaluate possible alternative operating strategies, a computer model of historical lake inflow, storage, and electricity generation was developed. The model was used to create monthly operating rules for the Deep Creek Hydroelectric Project that balanced electricity generation with the maintenance of desirable lake water levels.

Downstream Fisheries - Naturally high water temperatures in the Youghiogheny River and low dissolved oxygen (DO) levels in the hydroelectric station's discharge historically limited trout habitat. The discharge from the hydroelectric station tends to be cooler than the river because it draws cooler water from the bottom of the lake. PPRP developed a protocol for station operators that regulates the timing and volume of water discharges during periods of peak temperatures in the Youghiogheny River, such that downstream trout habitat is enhanced. The protocol uses river flow and temperature changes, and available predictions of maximum air temperature and cloud cover for the region. The goal is to maintain the river temperature below 25°C. The plant owner also installed structures to aerate discharge water to alleviate the low DO problem.

Whitewater Recreation - The Youghiogheny River is an exceptional whitewater recreation resource that depends on releases from the Deep Creek Project for adequate flow volume in most summer months. Whitewater boaters rely on timed and dependable releases from the hydroelectric facility to plan trips in advance. Operation of the facility is scheduled around providing: 1) suitable flow for boating at fixed times on all Fridays and Mondays during the whitewater recreation season (April 15 through October 15), except when lake levels are too low; and 2) suitable boating flow on at least one Saturday per month and during other special events on a prearranged basis.

Deep Creek Station's water appropriations permit expires in 2006. MDE, with assistance from PPRP, will review the permit conditions with the goal of continuing to promote optimal use of Deep Creek Lake and other affected natural resources.

Impacts of Hydroelectric Facilities

While only two large-scale hydroelectric projects (greater than 10 MW capacity) are present in Maryland, seven additional small-scale facilities also generate electricity within the state. Maryland's hydroelectric plants are listed in Table 3-8 with locations shown in Figure 3-18. All of Maryland's hydroelectric facilities have been in existence for many years and therefore have been subject to detailed environmental review. This review is the result of procedures required for licensing by the Federal Energy Regulatory Commission (FERC) and for obtaining water use permits from the State of Maryland.

Hydroelectric facilities may present special environmental concerns that are not encountered at the steam electric power plants. Development and operation of hydroelectric facilities can cause three main types of impacts:

- ***Changes in water quality** – Impoundments created for hydroelectric dams significantly alter river flow from free-flowing streams to deep water flow. This alteration causes changes in natural water clarity, thermal stratification, and lower dissolved oxygen concentrations upstream of the dam, which, in turn, may result in low dissolved oxygen levels in the water discharged from the dam. To mitigate these impacts, a procedure known as turbine venting was implemented at Conowingo Dam on the*

Table 3-8 Hydroelectric Projects in Maryland

Project Name	Project Capacity (kW)	River / Location	FERC Project No.	Owner	FERC License Type	FERC License Issued	FERC License Expires	Year Operational
Brighton	400	Patuxent River / Clarksville, Montgomery County	3633	Alternative Energy Associated Limited Partnership	Minor License	1984	2024	1986
Conowingo	549,500	Susquehanna / Conowingo, Harford County	405	Susquehanna Power Co. and PECO Energy Power Co.	Major license	1980	2014	1928
Deep Creek	20,000*	Deep Creek / Oakland, Garrett County		Brascan Power	None**			1928
Gilpin Falls	396	Northeast Creek / Pleasant Hill, Cecil County	3705	American Hydropower Company	License Exemption	1982	--	1984
Gores Mill	10	Little Falls / Baltimore County	--	C. Lintz	None	--	--	1950s
Parker Pond	40	Beaver Dam Creek / Wicomico County	--	W.H. Hinman	None	--	--	1950s
Potomac Dam 4	1,900	Potomac River / Shepherdstown, WV	2516	Allegheny Energy Supply	Major License	2004	2033	1909
Potomac Dam 5	1,210	Potomac River / Clear Spring, Washington County	2517	Allegheny Energy Supply	Major License	2004	2033	1919
Wilson Mill	23	Deer Creek / Darlington, Harford County		H. Holloway	None	--	--	1983

* Nameplate capacity listed in EIA-860 database.

** Deep Creek Hydroelectric Project is administered under a Maryland water appropriations permit from MDE, which expires January 1, 2006.

Susquehanna River. This venting allows air to be entrained into the water passing through the turbines and increases the oxygen content of the water. Similarly, an aeration weir was constructed in the Deep Creek Station tailrace to increase oxygen in water from the dam's discharge.

- ***Changes in water quantity*** *– Operating hydroelectric facilities in a peaking mode (in response to peak electrical demand) produces unnatural, and frequently extreme water level fluctuations in impoundments as well as downstream from the dams. Additional small-scale projects may also divert some flow away from the natural streambed. Fluctuations in water level and flow may reduce fish abundance as well as food sources important to fish growth and survival. Several studies, initiated in the early 1990's and completed in 1998 were conducted at Conowingo Dam to determine the minimum flow necessary to protect and enhance aquatic biota as well as whether a continuous flow is needed.*

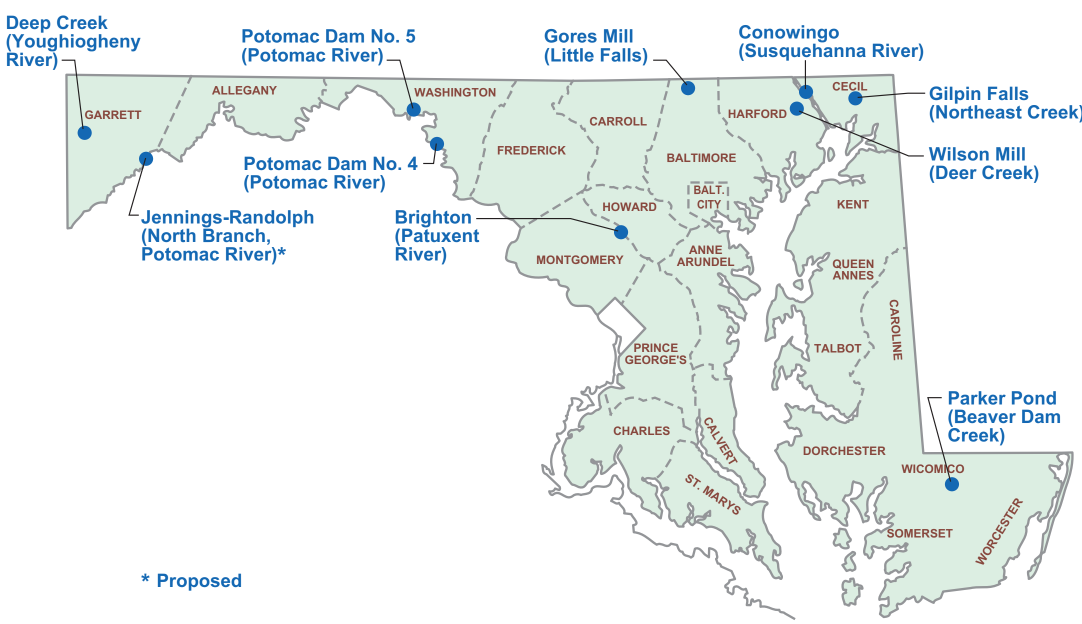
- ***Direct adverse effects on fish populations** – Dams prevent the natural upstream and downstream movement of both resident and anadromous fish species. Entrainment of fish attempting to move downstream past the dam may cause mortality due to the turbines. Factors that affect fish mortality include the type of turbine, the proportion of flow diverted through the turbine, and the size of fish. Restoration activities at Conowingo, such as fish lifts, have proven effective in enhancing fish populations and reducing fish mortality.*

Historically, the Susquehanna River supported large spawning runs of anadromous species such as American shad, river herring, and striped bass. The massive anadromous fish runs that generated migrations extending as far upstream as Cooperstown, New York, however, were eliminated with the construction of four major hydroelectric facilities on the lower Susquehanna in the early 1900s (Maryland's Conowingo Dam, and Holtwood, Safe Harbor, and York Haven dams in Pennsylvania).

When the FERC licenses for the four Susquehanna River hydroelectric facilities were being considered for renewal in the early 1970s, a major issue that arose was restoration of anadromous fish to the Susquehanna. Participants in the FERC license proceedings included PPRP, on behalf of the state of Maryland; the state of Pennsylvania; the state of New York; the U.S. Fish and Wildlife Service; and several non-governmental organizations (NGOs). The ultimate goal of the resource agencies and NGOs was to restore migratory fish runs throughout the Susquehanna River basin. This goal was pursued through an active restoration program (e.g., trapping and trucking adult fish to areas above the dams, hatchery rearing of larval and juvenile shad for stocking in the river) and the installation of fish passage devices at all four dams.

By the year 2000, restoration programs had been operating for nearly thirty years, and fish passage devices had been installed at all four hydroelectric facilities. For

Figure 3-18
Location of Hydroelectric Facilities in Maryland



Conowingo Pool Water Use Plan

Effective management of the pool formed by the Conowingo Hydroelectric Project during low flow conditions is critical to economic, environmental, and human welfare. Besides providing streamflow to generate electricity at two projects, the Conowingo hydroelectric facility and the 880 MW Muddy Run pumped storage facility, the pool also provides cooling water for the Peach Bottom nuclear plant in Pennsylvania and back-up municipal water supply for the Baltimore metropolitan area. Increasing demands on the Susquehanna River flow could potentially result in decreased inflow into the Conowingo Pool during severe droughts. The Susquehanna River Basin Commission (SRBC) is currently developing a framework to facilitate dialogue and policy development necessary to support ensuing economic and environmental decisions that affect the Conowingo Pool.

To assess the situation, SRBC undertook a study of the Conowingo Pool. This study included several tasks:

- *developing a workgroup dedicated to the comprehensive management of water resources in the vicinity of the pool;*
- *gaining an understanding of the factors, both natural and man-made, that affect water resources of the Conowingo Pool;*
- *conducting a study to assess the ability of the available water resources to meet present and future demands;*
- *identifying existing constraints and potential conflicts, evaluating alternative solutions through the use of the detailed Conowingo Pool model, and developing a procedure for the resolution of future conflicts;*
- *educating the stakeholders and the public regarding the Conowingo Pool's demands, constraints, water availability and management opportunities;*
- *and preparing and implementing a long-term management plan.*

SRBC convened a workgroup of interested parties (including PPRP) to discuss issues surrounding operations of the Conowingo Pool during low flow conditions, and to recommend alternatives to resolve conflicts. The workgroup provided input for a management plan that would satisfy the needs of interested parties. The management plan identifies operational parameters, roles, and responsibilities for better managing the Conowingo Pool during low flow conditions, and specifies actions that SRBC should incorporate into its regulatory and water resource management programs. The draft Conowingo Pool Management Plan is expected to be submitted to SRBC in early 2006.

the first time since the dams had been constructed, the entire Susquehanna River had been re-opened to migratory fish. This has created the potential for shad and other species to move as far upstream as New York State, representing well over 400 miles of new habitat.

Growth of the Susquehanna River shad stock in response to the restoration efforts and installation of fish passage devices has been dramatic. This growth peaked in 2001, when nearly 200,000 American shad passed over Conowingo Dam (see Figure 3-19). Ongoing monitoring of restoration progress, however, revealed some issues that need to be addressed. The primary concern at the present time is the low percentage of shad that are able to move past the Holtwood Dam once they have successfully moved past the Conowingo Dam. In 2004, only 3.1 percent of the shad passing over Conowingo Dam succeeded in moving beyond Holtwood Dam. Concerns also exist regarding the percentage of shad that move past York Haven Dam. A more thorough assessment of that issue may not be possible until a higher passage efficiency is achieved at Holtwood Dam. PPRP, working with dam owners and other state and federal agencies, is continuing efforts to enhance upstream migratory fish passage as well as downstream passage of juveniles through operational and/or engineering modifications. The FERC licenses for three of the four lower Susquehanna facilities expire at the end of 2014, and agency consultation on relicensing is already underway. Fish passage and flow issues (see sidebar on the Conowingo Dam water use plan) will be further addressed as part of this process.

Figure 3-19a
Number of American Shad Passed at Conowingo Dam (Susquehanna River), 1985 - 2005

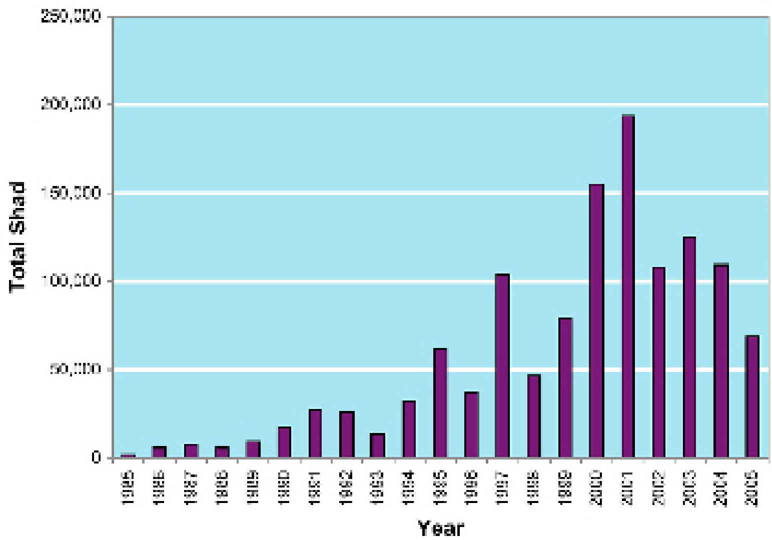


Figure 3-19b
Number of American Shad Passed at All Susquehanna River Dams Since 1995

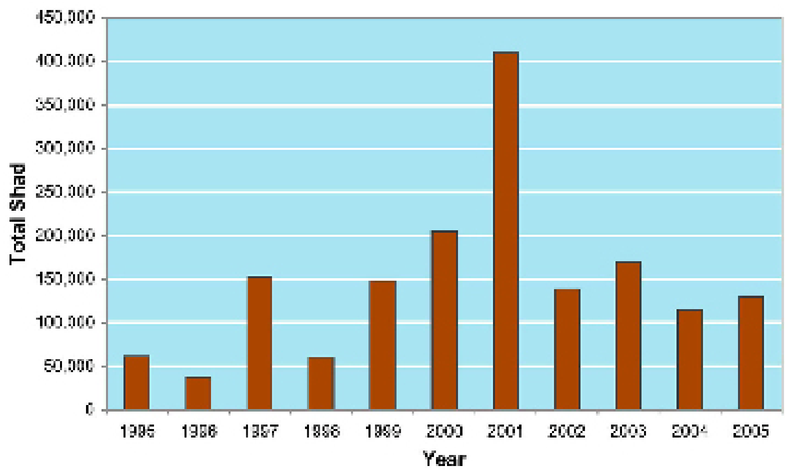
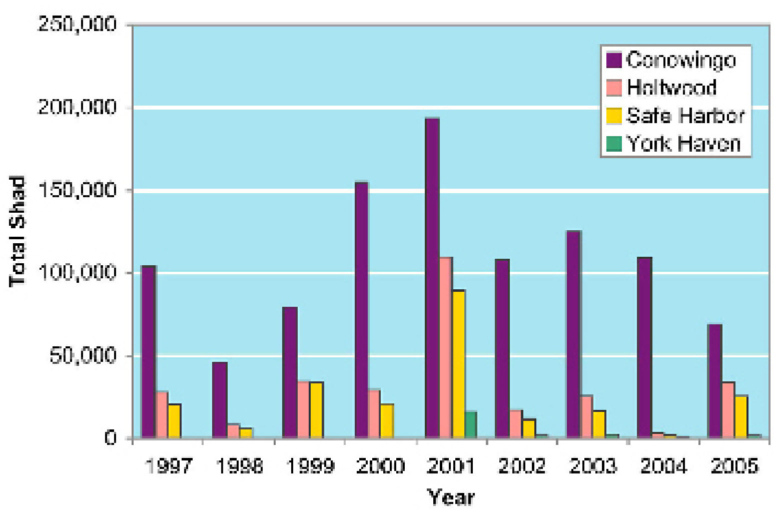


Figure 3-19c
Number of American Shad Passed at Each Dam on Susquehanna River, 1997 - 2005



Terrestrial Impacts

Construction and operation of power generation and transmission facilities (i.e., power plants; pipelines for water, natural gas, and oil; electric transmission lines; roadways and railways) can have significant effects on terrestrial environments and wetlands. Specifically, these facilities can:

- *Physically change or eliminate existing habitats;*
- *Disturb or displace wildlife;*
- *Emit particulate matter or gases to the atmosphere that later deposit on the landscape; and*
- *Release toxic material through permits or inadvertent spills.*

For a relatively small state, Maryland contains a surprising number of natural habitats, which vary with physiographic region, geology, and other factors. From east to west, different habitats make up the coastal marshes and forests along the Atlantic Ocean and Chesapeake Bay, the mixed-agricultural areas and wetlands over much of the Eastern Shore, the deciduous forests and riparian ecosystems in the agricultural and urbanizing matrix of the Piedmont, and the mostly contiguous mixed-deciduous forest in the Highlands of western Maryland. Habitats in each of these environments possess a suite of flora and fauna that is definitive (but not necessarily unique). Flora and fauna typical of common Maryland habitats are presented in Table 3-9.

The State of Maryland has enacted the following regulations that afford protection of habitats and species in terrestrial and wetland environments:

Waterway Construction – COMAR 26.17.01 applies to activities in State waterways.

Water Quality and Water Pollution Control – COMAR 26.08.01 through COMAR 26.08.04 applies to discharges to surface water and maintenance of surface water quality.

Erosion and Sediment Control – COMAR 26.17.01 applies to the preparation, submittal, review, approval, and enforcement of erosion and sediment control plans.

Nontidal Wetlands – COMAR 26.23 applies to activities conducted in nontidal wetlands.

Tidal Wetlands – COMAR 26.24 applies to activities conducted in tidal wetlands.

Forest Conservation – COMAR 08.19.01 through COMAR 08.19.06 apply to the development of local forest conservation programs, and the preparation of forest conservation plans.

Threatened and Endangered Species – COMAR 08.03.08 and COMAR 08.02.12 apply to protections for State-listed threatened and endangered flora and fauna.

Table 3-9 Typical Flora and Fauna of Common Habitat Types in Maryland

Habitat Type	Flora	Fauna
Tidal (salt) Marsh	cordgrasses salt hay black rush glasswort cattail (narrow-leaved) high tide bush	fiddler crab blue crab killifish great blue heron willet osprey
Freshwater Marsh	common reed jewelweed cattail (broad-leaved) woolgrass sedges swamp rose mallow lizard's tail buttonbush	muskrat marsh rice rat star-nosed mole beaver prothonotary warbler water snake leopard frog pickerel frog
Wetland Deciduous Forest	red maple green ash sweetbay greenbrier spicebush highbush blueberry false nettle cinnamon fern	white-tailed deer gray squirrel raccoon woodcock wild turkey wood duck Acadian flycatcher slimy salamander
Coastal Forest	American holly greenbrier red maple sweetgum willow oak scrub oak cottonwood sweet pepperbush pinxter flower	white-tailed deer gray squirrel opossum raccoon mockingbird yellow-breasted chat bald eagle red shouldered hawk American toad
Upland Deciduous Forest	red maple white ash oaks hickories tuliptree American beech black cherry southern arrowwood poison ivy	white-tailed deer gray fox woodchuck white-footed mouse ovenbird pileated woodpecker box turtle red-backed salamander Fowler's toad
Mixed Deciduous Forest	Virginia, pitch, and loblolly pine oaks American beech hickories sugar and striped maple black huckleberry hackberry black birch quaking aspen	white-tailed deer fox squirrel gray squirrel black bear striped skunk raccoon gray fox golden-crowned kinglet Carolina chickadee
Oldfield	Joe-pye-weed Canada goldenrod broomsedge yarrow wild carrot broomsedge evening primrose blackberries raspberries	red fox white-tailed deer groundhog white-footed mouse meadow vole white-eyed vireo prairie warbler garter snake black racer snake

Table 3-10 Types of State-Listed Rare, Threatened, and Endangered Species

Group	Number of listed species
Plants	841
Planarians	5
Mollusks	22
Crustaceans	27
Spiders	3
Insects/Collembola	1
Insects/Coleoptera	23
Insects/Diptera	1
Insects/Ephemeroptera	1
Insects/Homoptera	2
Insects/Lepidoptera-Butterflies	39
Insects/Lepidoptera-Moths	23
Insects/Odonata	109
Insects/Trichoptera	1
Fishes	27
Amphibians	11
Reptiles	15
Birds	78
Mammals	31

PPRP's role in the CPCN process is to facilitate compliance with these regulations and natural resource objectives, even when the CPCN supersedes individual statutes. The Waterways Construction, Water Quality and Water Pollution Control, and Erosion and Sediment Control laws require best management practices (BMPs) to eliminate or minimize disturbance in and discharges to Maryland waters. These BMPs are uniformly included as conditions in CPCNs. The other laws specifically address the loss of valuable habitats, including wetlands, forests, and species habitats.

In the 1780s, Maryland had about 1,650,000 acres of wetlands (24.4 percent of the surface area); two hundred years later, in 1989, Maryland had only about 440,000 acres of wetlands (6.5 percent of its surface area), a reduction of 73 percent. To address such losses the State developed regulations under Maryland's 1991 Nontidal Wetlands Protection Act, with the goal of no net loss of nontidal wetlands. Similarly, the 1994 Tidal Wetlands Regulations were developed to regulate activities in tidal wetlands. Under Maryland's nontidal wetlands regulations, permanent impacts to nontidal wetlands must be mitigated at various ratios depending on the type of wetlands affected. For example, a ratio of 3:1 is applied to scrub/shrub and forested wetlands of special State concern; a ratio of 2:1 is applied to other scrub/shrub and forested wetlands, and to herbaceous wetlands of special State concern; and a ratio of 1:1 is applied for emergent wetlands. Mitigation ratio requirements are similar for State tidal wetlands. Temporary impacts and impacts to wetlands buffers do not usually have replacement mitigation requirements but may require compensatory or enhancement measures. Assessing potential wetlands impacts and developing appropriate mitigations are an essential part of the CPCN process.

Similar to the wetland concerns, losses of Maryland's forest resources prompted the 1991 Forest Conservation Act (FCA). With the exception of heavily forested Allegany and Garrett Counties, all construction developments of greater than 40,000 square feet must comply with the FCA. Under the FCA, existing forest condition and character became an integral part of the development planning process across the State. Prior to issuance of grading permits or erosion and sediment control plans by county agencies, applicants must provide information on the condition of the existing forest and provide a strategy for conserving the most ecologically valuable areas of the forest. The FCA requires submittal of both a Forest Stand Delineation (defining the nature of the existing forest) and a Forest Conservation Plan (for protecting the most ecologically valuable areas of forest). Under the FCA, tree conservation, replanting, and other environmental parameters must be considered before any development disturbs forest resources. An exemption from FCA requirements for rights-of-way and land for construction of electric generating facilities can be granted if a CPCN is issued by the Public Service Commission. A project may lose its exemption status if the developer of a site or its linear facilities cannot demonstrate that cutting or clearing of forest will be minimized. As a matter of policy, however, PPRP has been successful in having power companies comply with the FCA on proposed projects through CPCN conditions.

Irrespective of the kind of habitat involved, areas that support State-listed threatened and endangered flora and fauna are protected under the Maryland Threatened and Endangered Species regulations. Table 3-10 lists the number of protected species by taxonomic group that the CPCN process considers when evaluating potential adverse effects and developing protective conditions.

Wind Power Terrestrial Issues

Wind power development poses new types of potential risks for biological resources. At present, wind power development in Maryland has been proposed only in the western part of the state, specifically along Appalachian Mountain ridges (see discussion starting on page 4-15). The kinds of habitat potentially affected by wind power development are those found in high elevation environments, which are among the least common in the state. Forested habitat in the region is considered to be a southern extension of the northern hardwood forests that range much more broadly to the north, and historically included pure stands of white pine, eastern hemlock, and red spruce. At present, however, much of the forest has been fragmented by logging, coal mining, and home-building in the area. Where contiguous forest exists, wind power development could potentially exacerbate fragmentation. During facility construction, it is generally necessary to disturb a greater area than that which will constitute the footprint of the project in order to install the wind power turbines. Clipper Windpower projected a maximum area of disturbance of 250 acres for the installation of 41 turbines at its Allegheny Heights project, while the permanent footprint consisting of turbine pads and access roads would only be about 40 acres. In most cases, the balance of the disturbed area is allowed to revegetate to a natural community.

Bird and Bat Impacts from Proposed Wind Power Plants

The biological impacts of wind power facilities on birds have been studied since the late 1980s in the United States, and earlier in Europe. Wind power effects on birds came to light in California where a high incidence of raptor fatalities, including golden eagles, was reported from the Altamont Pass Wind Resource Area. Subsequent research on wildlife interactions with wind power facilities remained focused on birds although occasional fatalities of bats were also reported. Only in the past few years, as wind power development interests have grown in the eastern United States, has concern for bats surpassed that of birds. With recently granted licenses for wind power development in western Maryland and additional projects being planned, the State is becoming increasingly involved in this contentious issue.

Wind power development imposes two types of potential adverse effects on birds and bats. The first effect includes the direct loss of habitat from the construction of facility infrastructure, such as wind turbines and service roads. Although the footprint of a turbine is relatively small, the cumulative area disturbed for the more commonly proposed multiple turbine arrays and associated access roads can be significant. In addition, a greater area is usually affected during project construction, as the large components of turbines typically require broad staging areas. In forested habitats, like the facilities proposed for development in western Maryland, habitat fragmentation can occur. Fragmentation affects birds and bats as well as other terrestrial species through direct loss of forested habitat, the encroachment of species that can have direct (e.g., brown-headed cowbird as a nest parasite) or indirect (e.g., raccoons that can be disease vectors) detrimental effects, the potential disruption of corridors for daily movement or seasonal migration, and the failure of the resident species to adapt to the wind power facility.

The second type of impact is collision with turbines that results in bird and bat fatalities. After more than a decade of study at a number of wind power facilities in the U.S. and abroad, there is evidence that the numbers of bird fatalities are small. Per turbine, two to three birds are killed annually on average. Recent studies at new facilities constructed on eastern Appalachian ridges in West Virginia and Pennsylvania report similar rates of bird fatality. In contrast, the numbers of bats killed at these regional facilities are among the highest ever reported for birds or bats, and annual estimates range into the thousands for each project. It is currently regarded that most of the bat fatalities occur during the late summer to fall migration period as bats move to their over-wintering habitat.

The cumulative impact of bird fatalities, at present, is not considered great for any one species, as no single species appears to be disproportionately affected. In addition, operational (e.g., lighting that can attract birds) and design (e.g., guyed structures) circumstances that can contribute to higher fatalities are better understood so that new facilities are constructed and managed in a way to minimize impacts. Birds considered most at risk are songbirds that migrate nocturnally. High fatality events for these species often coincide with nights that have a low cloud cover resulting in birds flying closer to ground level. Although the Migratory Bird Treaty Act prohibits the “take” of any birds, the U.S. Fish and Wildlife Service, in practice, only requires that good faith efforts be employed to avoid fatalities.

The cumulative impact to bat species is more of a concern. The high level of fatalities has been distributed among only a few species, predominantly red and hoary bats. These two species undertake long distance seasonal migrations and typically roost in trees, whereas most other species have shorter seasonal movements to and from caves in which they will over winter. At present the population characteristics of these species is uncertain. They are known to be relatively long-lived and produce few offspring annually, which are characteristics of species that may not be able to sustain a high level of fatalities. Recent studies of bat activity in Western Maryland have recorded high numbers of these two species during spring monitoring.

Wind turbines have killed several other species of bats, but so far none have been identified as a threatened or endangered species. Western Maryland provides year-round habitat to the federally endangered Indiana bat, and the state listed as In Need of Conservation small-footed bat. Most records of these two species come from winter cave surveys when the bats are hibernating. Much less is known of their habits during the flying season as they disperse throughout the landscape. A recent study that used radio-tracking methods to follow female Indiana bats migrating from caves tracked one from a Pennsylvania cave to Carroll County, Maryland. The seasonal and daily activity patterns of these two species must be investigated further before concerns about the risks posed by wind turbines can be dismissed.

To further our understanding of the migratory movements of birds and bats in relation to the mountain ridges of Western Maryland, PPRP is conducting several studies. At present they are developing protocols for using a mobile, marine-grade radar system to track migratory movements during spring and fall and to obtain information on the height of passing migrants. Microphones have been deployed to monitor the calls of night passing migrants. Remote acoustic bat detectors have been deployed at several locations throughout Allegany and Garrett Counties. Results from these research efforts, coupled with pre- and post-construction studies at wind power facilities, will allow better assessment of risks posed by projects proposed in the future.

Sensitive Rocky Habitats and Associated Species

The high elevation ridges of the Appalachian Mountains also possess rocky habitats that can provide habitat for many rare, threatened, and endangered species. A number of small mammals – including the State endangered Allegheny woodrat and southern rock vole, and the State listed as In Need of Conservation long-tailed shrew, smoky shrew, and porcupine – rely on rocky habitat and live within the crevices, fissures, and caves that are present along mountain ridge top. Similarly, amphibians and reptiles inhabiting rocky areas include the State listed as In Need of Conservation Wehrle's salamander and the globally rare timber rattlesnake. Aside from sharing habitat preferences, most of these species can be difficult to observe because of their rarity, their nocturnal habits, or by virtue of the inaccessibility of the rocky habitats.

The development of wind power in areas with rocky habitat must consider these species when siting wind turbines and access roads. During the final siting of turbines for the Clipper Windpower project, a State Natural Heritage biologist worked with the developer to micro-site the turbine locations to avoid sensitive rocky habitat that could support several of the small mammal species believed to occur along Backbone Mountain.

Transmission Line and Pipeline Rights-of-Way

More than 2000 miles of electric power transmission line and natural gas pipeline rights-of-way are located throughout Maryland. Constructing and maintaining these rights-of-way creates long, mostly linear, corridors that are often quite different from the surrounding environment. These corridors can affect nearby areas, including terrestrial habitats and wetlands, in a variety of ways, either temporarily during construction or over the long term. To provide public review and to ensure that environmental and other concerns are addressed, CPCN applications are required for new corridor construction and for modifications in existing corridors. PPRP reviews these applications and recommends conditions that will address any concerns.

The CPCN recently granted for the Catoctin Power project in Frederick County illustrates the result of the review, recommendation, and public hearing process. The project included several right-of-way features, including transmission lines, a natural gas pipeline, and cooling water supply and wastewater discharge pipelines. Twelve conditions were included in the CPCN to minimize impacts to forest

ENERGY POLICY ACT OF 2005:

Facilitating Transmission Rights-of-Way

The Act allows the Federal Energy Regulatory Commission to order the construction of electric transmission facilities under certain circumstances and directs the Department of Energy (DOE) to designate National Interest Transmission Corridors (NITC). When exercised, the "FERC backstop" authority supersedes the permitting authority of states, providing FERC the legal authority to order construction of transmission facilities in a designated NITC. The FERC may begin a proceeding to issue a construction permit for transmission facilities in an NITC if the FERC finds that the state does not have authority to approve the siting of such facilities; where a state has considered an application for construction but has withheld approval for more than a year after the application filing; or if the state has conditioned the approval such that it would not significantly reduce transmission congestion. The west-to-east transmission corridors running through Maryland could be designated as National Interest Transmission Corridors.

In Maryland, the Act would supersede the Certificate of Public Convenience and Necessity (CPCN) authority of the Maryland PSC. However, the standards that FERC must consider do not relieve transmission facility developers from first filing an application as required by state law. In the event that FERC applies its backstop authority and initiates an application process for a permit to construct within a FERC proceeding, states are afforded an opportunity to comment prior to any final determination. A state may circumvent the FERC backstop authority through creation of a regional transmission siting authority, consisting of at least three states. States that belong to a regional transmission siting authority may challenge the FERC backstop authority if all of the member states are in agreement.

areas, wetlands, wildlife habitat, soils, parks, road and railroad crossings, and archeological sites. In addition, Catoctin Power is required to plant trees on state land as mitigation for forest losses associated with the construction of the water intake and discharge pipelines.

Utilities request permission to change or build transmission line corridors for a variety of reasons. Older transmission lines that have insufficient capacity to supply growing areas may need to be upgraded or replaced. New lines may be required to connect new power facilities to the transmission network or to ensure that the regional power supply grid is stable and reliable. Recently proposed projects include a second, independent line from the Brandon Shores Power Plant to the Riverside Substation to increase the reliability of power flow into Baltimore City; upgrades of the transmission lines between Boonsboro, Maryland, and Marlowe, West Virginia, and between Doubs and Lime Kiln to reinforce power delivery and network stability in Central Maryland; and a new, high-voltage line into the Urbana substation to meet demand from rapid growth in southeastern Frederick County.

Transmission line corridors may affect specific environmental features, alter the landscape over long distances, or change the way people use nearby residential, commercial, or agricultural land. For each right-of-way modification or construction proposal, PPRP reviews the potential impacts of the proposed project on streams, floodplains, wetlands, forests, rare species, historical and archeological sites, and surrounding land use. Quantitative comparisons of alternate routes are derived from digital maps, aerial photographs, and other data sets, and supplemented by field inspections. The purpose of these comparisons is to identify the types of impacts that may occur along each possible corridor and to find the route with the lowest overall impact. Where undesirable impacts cannot be avoided, recommendations may include compensating for the damage and/or maintaining certain conditions in the corridor after construction. The upgrade of the Boonsboro-Marlowe transmission line, for example, required special attention to the portion of the right-of-way that crosses the C&O Canal National Historical Park (see sidebar).

The bulk of the environmental impact from transmission lines and pipelines is caused by the construction and maintenance of the right-of-way. Construction impacts normally involve short-term environmental damage that can be minimized with good planning and mitigated by post-construction restoration. If there is unavoidable permanent damage, the transmission company is usually required to provide environmental compensation by creating an equal or larger amount of equivalent habitat elsewhere.

Beneficial Right-of-Way Management

Illustration of low-growing vegetation and gradual transition into the adjacent forest that can be maintained at transmission line rights-of-way to benefit wildlife and provide ecological services.

Transmission Line Licensing: Coordination With NPS, C&O Canal

The Chesapeake & Ohio Canal (C & O Canal) National Historical Park follows the route of the Potomac River for 184.5 miles from Washington, D.C. to Cumberland, MD. The National Park Service (NPS) is responsible for preservation and maintenance of the park. Due to the length of the park, it is inevitable that electric transmission rights-of-way (ROW) will cross the park. These crossings require ROW maintenance activities.

As part of the recommended licensing conditions for a recently proposed transmission line upgrade, PPRP facilitated an agreement between the utility (Allegheny Power) and the NPS to prepare and execute a Memorandum of Agreement (MOA). The MOA established a framework to ensure that adverse impacts caused by construction, operation, and maintenance of all transmission ROW used by that utility within the C&O Canal National Historical Park would be avoided or mitigated. The MOA also noted the utility's willingness to establish and document a funding mechanism to provide monetary reimbursement for NPS restoration activities related to transmission line crossings within the Park, as the need arises.

Construction impacts can often be avoided by careful placement of the transmission line towers. PPRP worked with Potomac Edison during field reviews of the proposed New Market project to protect wooded areas containing large native trees by re-aligning several tower locations. The PPRP input assisted Potomac Edison to plan the project with only minor adjustments in alignment of two transmission towers, but avoided impacts to the large trees and several other areas of forest. PPRP also worked with Potomac Edison to develop effective mitigation plans for unavoidable tree losses at other places along the right-of-way, including an estimated 69 trees in wetlands.

Right-of-way maintenance, on the other hand, is a regular activity that may have a long-term environmental impact. The primary goals of right-of-way maintenance are to retard the growth of woody vegetation and to assure emergency access. Trees or branches that grow too close to power lines can fall on the lines, especially during adverse weather conditions, causing power interruptions and safety hazards. Deep-rooted trees also jeopardize the integrity of underground pipelines. Herbicides used to remove vegetation typically pose little danger to the terrestrial environment if properly applied. For example, herbicides with glyphosate as the active ingredient persist in the environment for less than two months and are generally not toxic to wildlife when applied appropriately. Improper use of chemical herbicides, however, can result in excessive amounts being carried by water runoff or wind into areas outside the right-of-way, and may damage untargeted vegetation and wildlife.

Mechanically cutting vegetation in rights-of-way is not necessarily a benign alternative; it can disturb and kill wildlife, and has the potential for encouraging erosion and polluting surface waters, depending on the type of equipment used. Right-of-way management, whether it is accomplished by mowing or by herbicides, often affects wildlife by altering the original habitats and vegetation. To encourage the implementation of environmentally friendly management in rights-of-way, PPRP has compiled information on innovative practices that reduce adverse effects on local wildlife and plant communities. Most Maryland utilities indicate that they now use a combination of selective herbicide application and mechanical cutting rather than exclusively one or the other. Several of Maryland's utilities also have maintenance programs to improve wildlife habitats in rights-of-way. Results provided by the utilities indicate that such programs have created better, more stable habitats for wildlife, and have saved thousands of dollars in annual maintenance costs.

By considering landscape context, transmission line siting and right-of-way maintenance can sometimes be designed to have a positive environmental presence, as well as to complement

Stakeholder Engagement for the Urbana Loop Transmission Line

In August 2004, Allegheny Power applied to the Maryland PSC for a CPCN to construct the Urbana Loop double-circuit 230 kV transmission line from the Lime Kiln-Montgomery transmission line to the Urbana substation. The applicant's preferred alternative was met with widespread opposition from the residents in the area. Much of the opposition arose from a general sentiment that there had been no opportunity for local residents to have any voice in the routing process. To address these concerns, PPRP undertook a stakeholder engagement process to bring together local citizens interested in commenting on the proposal.

The ultimate objective of the process was to identify a route for the Urbana Loop transmission line that has the support of all, or at least most, of the potentially affected stakeholders. Key features of the process were to:

- *assess public reaction to the proposed route and alternatives;*
- *allow interested parties to identify decision criteria of importance; and*
- *identify additional alternatives that satisfy the decision criteria.*

The stakeholder engagement process included a series of three meetings held in Urbana. During the meetings the stakeholders were divided into work groups and were asked to provide specific alternatives that they found to be potentially acceptable, to identify a list of decision criteria, and finally to arrive at consensus measurement methodologies and weighting factors by which the alternatives could be measured. From this process, the stakeholders identified 10 decision criteria and agreed that the most important criteria (visual impacts, property values and select routes that use nonresidential areas or existing ROWs) were given equal weight (20% each) representing 60 percent of the total score. The remaining decision criteria, while important, were given lesser weights and when combined represented 40 percent of the score.

After the conclusion of the meetings, the decision criteria and consensus measurement methodologies were applied by PPRP to each of the proposed alternatives using readily available information. The results of this analysis indicated that all of the stakeholder alternatives scored better than the applicant's preferred alternative.

Consequently, the stakeholder engagement process allowed interested parties to identify decision criteria of importance, allowed an assessment of public reaction to the proposed route and alternatives, allowed public input to identify additional alternatives that satisfy decision criteria, allowed meaningful stakeholder input on both process and substance that might help guide the selection of a mutually acceptable route and identified for consideration by the PSC Hearing Examiner alternatives that may be acceptable to the applicant and other parties.

land uses in neighboring communities. For example, proposed routes can be changed to avoid fragmenting ecologically important contiguous parcels of forest into smaller patches. Fragmentation often reduces the biodiversity of forested habitats by opening them to colonization by invasive edge-dwelling species that compete with or prey upon forest-interior dwelling species, such as migratory songbirds. The impact of fragmentation of a forest area is one of the issues currently being evaluated for a proposed new transmission line near Urbana.

In more open areas, on the other hand, rights-of-way can be maintained or enhanced to act as corridors that connect isolated patches of ecologically valuable forest or other habitats. The introduction of desirable species into the right-of-way through "right tree/right place" planning projects or wildlife habitat enhancement projects is often possible. Such integrated planning for ecologically sound management of the natural resources on utility rights-of-way has the potential for benefiting the public interest while also resulting in cost savings or compensating for other damage elsewhere.

Another potential area of impact that the power industry has addressed involves bird collisions with power lines. The U.S. Fish and Wildlife Service and the Avian Power Line Interaction Committee (APLIC), which includes a significant degree of involvement from Edison Electric Institute, have cooperatively developed guidelines to help prevent injuries to birds as a result of contacting power lines. The voluntary guidelines, which were released in 2005, are designed to help utilities develop Avian Protection Plans that meet the specific needs of their facilities, protecting birds from electrocution and collisions as well as reducing the likelihood of power outages caused by bird collisions. Maryland utilities that own and operate distribution and transmission lines have been working on the avian impact issue for many years and are implementing the principles contained in the APLIC guidelines.

Maryland's increasing population and its location along the power transmission routes into the large urban areas of the Mid-Atlantic region will require future transmission line expansion. Transmission bottlenecks have been identified in Western Maryland and on the Delmarva Peninsula. An underwater cable across Chesapeake Bay has been proposed as one method of dealing with the latter problem. In Central Maryland, Potomac Edison has sketched out a multi-year series of upgrades and additions to reinforce the existing system to adapt to increasing demand from growing suburban areas. Reliability issues requiring at least one new transmission line have been identified in the Baltimore area. Each of these potential projects raises unique environmental or other issues, e.g. fragmenting forests in Western Maryland, protecting the views and vulnerable stream habitats of suburban Central Maryland, perturbing the sensitive bottom habitats of the Chesapeake Bay, or insuring the security of power delivery to populations and facilities in urban areas. Addressing these issues and finding ways to minimize or mitigate adverse impacts will be essential to the continuing development of Maryland's power network.

Socioeconomic and Land Use Issues

Cultural and Archaeological Resources

State and federal jurisdictions overlap in power plant assessments, most commonly in the consideration of air quality and wetlands impacts. Less frequently, power plant construction and operation proposals need to be scrutinized by both state and federal agencies for their effects on cultural resources. State involvement is codified under Maryland State law (Article 83B, 5-617 & 5-618 of the Annotated Code of Maryland), which requires State agencies to consider the effects of their undertakings on properties included on or eligible for the National Register of Historic Places and the Maryland Register of Historic Properties, prior to final action by any State agency on a request for a permit or license. The law further requires State agencies to consult with the Maryland Historical Trust (MHT) in evaluating such impacts. MHT is the principal operating unit within the Division of Historical and Cultural Programs of the Maryland Department of Housing and Community Development, and is responsible for identifying, studying, evaluating, preserving, protecting, and interpreting the state's significant prehistoric and historic districts, sites, structures, cultural landscapes, heritage areas, cultural objects, and artifacts, as well as less tangible human and community traditions. Maryland's State Historic Preservation Officer (SHPO), appointed by the Governor pursuant to the National Historic Preservation Act of 1966, is a member of the Trust staff.

Federal involvement is governed by Section 106 of the National Historic Preservation Act, which requires federal agencies to take into account the effects of their undertakings on historic properties. Since "undertaking" includes not only projects funded by a federal agency, but also those requiring a federal permit, license or approval, power plants that traverse or otherwise occupy federal land can be subject to "Section 106" review.

This is the scenario that evolved during PPRP's environmental review of the recently licensed Catoctin Power Plant in Frederick County. Although wastewater from the county's water and sewage system was (and still remains) the preferred cooling water supply alternative, Catoctin Power needed to identify an alternative source in the event that negotiations with the county were unsuccessful. As a result, Catoctin Power identified several alternative pipeline routes to the Potomac River. The Maryland side of the Potomac River is occupied by the C&O Canal National Historical Park, a 184.5-mile trail and historic towpath that extends from Washington, D.C., to Cumberland. As a result, all potential routes traverse the park, an entity under the jurisdiction of the National Park Service (NPS). The identification of pipeline corridors to the Potomac River therefore triggered the involvement of the NPS into the assessment of effects on cultural resources of an undertaking that was previously only the State's concern. Construction and operation of a water supply and discharge pipeline is expected to require a permit from the NPS, which is currently reviewing the application. The NPS will likely require Catoctin Power to conduct an Environmental Assessment or furnish an Environmental Impact Statement assessing the impacts on the C&O Canal National Historical Park.

Section 106 review is not an autonomous federal action. Although it requires federal agencies to assess the effects of undertakings on historic properties and affords the Advisory Council on Historic Preservation an opportunity to comment, the State Historic Preservation Officer, among others, has a consultative role in the process (36 CFR 800.3).

The Maryland Public Service Commission proceeding on the application by Catoctin Power concluded on April 25, 2005, with Commission Order No. 79923, which granted a CPCN to construct and operate a 600 megawatt generating station in Frederick County. Because Catoctin Power has not specified which water supply option will be used, the agreement of stipulation and settlement with PPRP contains conditions for both, with the Potomac River water supply option requiring MHT involvement in archeological surveys in corridors outside the C&O Canal National Historical Park and NPS involvement, should Catoctin Power require an easement or right-of-way. With SHPO consultation provisions in the Section 106 review process, impacts on significant cultural resources in Maryland will be comprehensively examined, and adverse effects will be mitigated through the combined efforts of State and federal agencies.

Nuisance Items

Light

Light pollution is the inadvertent illumination of adjacent areas and is a frequent consequence of development. It is of concern to PPRP because most recently licensed power plants in Maryland have been located in naturally dark rural areas. In these cases, the addition of power plants causes unnatural lighting in a dark background, and affects surrounding property owners. Minimum lighting standards for satisfying regulatory requirements result in some degree of unavoidable light spillover. Lighting at power plants is a necessary adjunct to safety. It is used to illuminate areas that would otherwise be hazardous to workers. In addition, strobe lights on tall structures, such as stacks and wind turbines, are required for aviation safety.

Controlling light pollution has started to become a matter of public policy in Maryland, not necessarily because of power plant development, but because of increasing residential and commercial sprawl. House Joint Resolution 14 sponsored a task force to study lighting efficiency and light pollution in Maryland. The report was published in March 2002 and issued a number of guidelines for achieving efficient/cost effective lighting.

- *Choose luminaries that distribute light only where it is needed, minimizing light pollution and unnecessary energy consumption.*
- *Choose appropriate lamp source color.*
- *Choose lamp types to maximize visibility per lumen output, as well as maximizing lumen output per input watt of energy.*
- *Choose lamps with longer life ratings.*
- *Choose appropriate efficient ballasts.*
- *Design to appropriate lighting levels based on Illuminating Engineering Society of North America (IESNA) recommendations and to avoid over lighting.*

- *Lay out lights to avoid spillover onto adjacent property, and choose appropriate pole heights.*

The report also recommended that State departments and agencies, and the University System of Maryland analyze their outdoor lighting systems and practices, and develop a plan for bringing all State-owned or State-maintained outdoor lighting into compliance with applicable outdoor lighting standards. These plans are intended to bring existing lighting systems and fixtures into compliance within the next six years, when economically feasible. Additionally, all new lighting systems and fixtures should comply with applicable outdoor lighting standards.

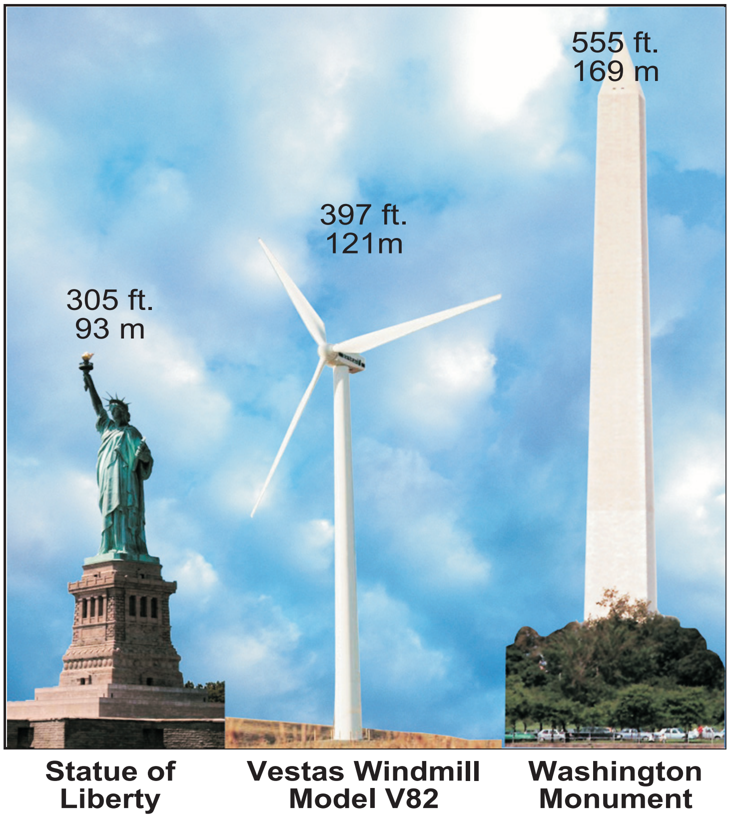
Few Maryland jurisdictions address lighting standards through zoning ordinances, although many require an outdoor lighting plan as part of the site plan review process. Some counties, such as Garrett, impose certain lighting conditions on a case-by-case basis. As public awareness of outdoor lighting issues is increasing, Maryland counties are beginning to recognize light pollution as a planning issue.

Although there is no statewide regulatory framework, PPRP recently began adressing light pollution in its environmental reviews of proposed generation facilities, including the recently licensed Catoctin facility in Frederick County. In that case, a licensing condition requires Catoctin Power to develop, in coordination with the Frederick County Division of Planning, a lighting distribution plan to mitigate intrusive night lighting and avoid undue glare onto adjoining properties.

Light pollution was also identified as an issue in the environmental review of the proposed Mirant coal barge unloading facility at Morganton in Charles County, where structures as high as 40 feet will extend about 1,000 feet into the Potomac River. In addition to nighttime navigational lights required by the U.S. Coast Guard, the facility will require nighttime operational lighting, creating additional nighttime light intrusion. PPRP's recommended conditions would require Mirant to develop a lighting distribution plan. The company will be expected to follow best practice light and glare reduction standards for industrial facilities, such as shielding exterior lighting and directing it away from adjacent residential areas.

PPRP has also recommended conditions for wind power projects in Western Maryland that require developers to minimize lighting to reduce the potential for avian and visual impacts. PPRP has proposed illuminating the fewest number of turbines feasible and installing red strobes with frequency cycles of 24 per minute, the minimum lighting that is consistent with Federal Aviation Administration (FAA) lighting requirements. Currently, all structures more than 200 feet in height must have aircraft warning lights under FAA rules, meaning that all wind turbines being planned for Western Maryland would be illuminated. However, the American Wind Energy Association (AWEA) recently sponsored several meetings between wind industry and FAA representatives to explore reducing wind turbine lighting requirements while maintaining aviation safety. AWEA has also provided funding to study the issue and to develop design guidelines. Experiments at several wind facilities undertaken by visual guidance experts suggest that perimeter lighting positioned at the top of the nacelle, and spaced no more than one-half mile apart, should be sufficient to indicate wind energy facilities to pilots without creating light pollution for surrounding communities. A final report, anticipated before the end of 2005, is expected to result in revised FAA guidelines and reduced lighting requirements for Western Maryland wind facilities.

Figure 3-20
Comparative Height of Typical Large Wind Turbine



Visual

Adverse effects from power plants include a visual component that varies by technology. One of the more recognizable features of some power plants is the natural draft cooling tower, a sight often incorrectly associated with nuclear power plants. But coal-fired power plants usually have tall stacks, and buildings that house the boilers and turbines for generating electricity can be highly visible under certain conditions. High voltage transmission lines add towers and wires to both rural and urban views. Technologies such as combustion turbines have a lower profile than coal and nuclear power plants. This reduces their visual intrusion into the surrounding environment, but facilities such as these are often located closer to communities because of their smaller "footprint." Visual impacts from the Rock Springs combustion turbine facility on nearby properties and historic structures was a major issue during licensing proceedings, for example.

Adverse visual effects from power plants are usually mitigated by land buffers and vegetative screening. A land buffer provides a setback from adjoining properties to allow terrain and natural vegetation to block or diffuse views of a power plant. Vegetative screening is often used around the perimeter of a power plant site to intercept views in the direction of the facility components.

Of new energy technologies, adverse visual effects from wind turbines are the most problematic because the turbines are usually deployed in an array of 20 to 50 turbines along prominent ridgelines. Because of their height (see Figure 3-20), land buffers and vegetative screening are not effective. Furthermore, as discussed in Chapter 4, the best land-based wind resources in Maryland are located in the western part of the state. With wind projects clustered within a relatively small area of Western Maryland, cumulative visual effects from wind energy projects have become a concern to PPRP.

Without land buffering and vegetative screening, a key determinant of visibility of wind projects is distance, from which the visual thresholds of detection, recognition, and visual impact are defined. It is also important to recognize that natural vegetation, particularly trees that may be located anywhere between a viewer and landscape alteration, contracts a visibility zone by blocking the view of a visual intrusion such as a wind turbine. Depending on the local topography, the close-in visual impact of a given project is frequently less intrusive than the longer views.

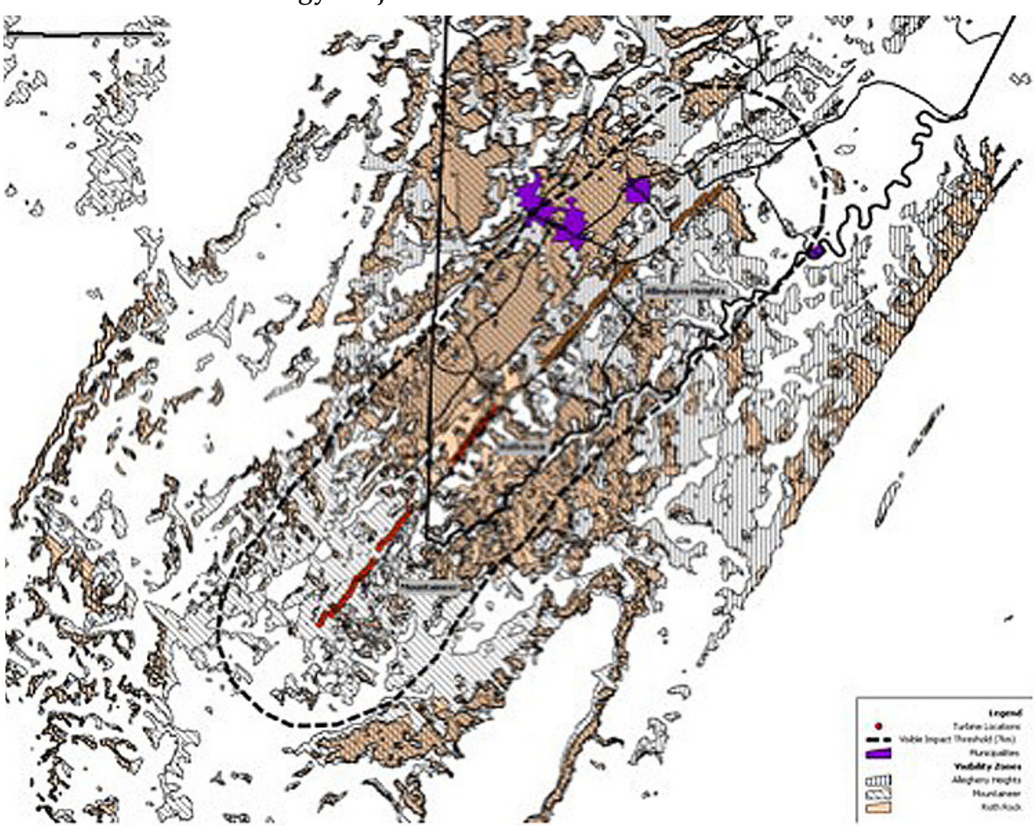
Controlled perception studies suggest the following distance thresholds associated with wind energy facilities:

- *Object detection or recognition will occur in the absence of atmospheric reduction in contrast from 30 km (19 miles) for about 5 percent, and from 20 km (13 miles) for about 10 percent of the population.*
- *Most of the drop in object detection rates occurs between 8 and 12 km (5 and 7.5 miles) in clear conditions, and between 7 and 9 km (4 and 6 miles) in light haze.*
- *The percentage of population visually impacted, in clear air, drops rapidly at 4 km (2.5 miles) and is below 10 percent at 6 km (4 miles).*

In general, distance thresholds are significantly reduced by atmospheric scattering from haze, and increased by special conditions of high contrast, such as an approaching storm. There is considerably more uncertainty regarding visual impact thresholds than those associated with detection and recognition because the adverse effect is also dependent on landscape content and the attitudinal composition of potential viewers. However, the research suggests that visual impact from wind turbines could potentially be minimal beyond 5 to 7 km (3 to 4 miles) even in clear air.

The assessment of cumulative socioeconomic effects of wind energy development is primarily concerned with cumulative landscape and visual impacts and,

Figure 3-21
Cumulative Visibility Zone of Roth Rock, Allegheny Heights, and Mountaineer Wind Energy Projects



through associations, with effects on tourism and general amenity. Cumulative landscape and visual effects occur when two or more projects are simultaneously visible, or when they are seen sequentially when a viewer passes through a landscape. In other words, it is not necessary for two or more energy projects to be simultaneously visible for cumulative effects to be experienced. Guidelines for assessing landscape and visual effects of wind energy facilities have been described by Landscape Design Associates in a study that supports the principle of assessing the effects on the visual quality and effects on landscape separately.

Cumulative visual quality effects concern the degree to which wind energy development predominates in particular views or sequences of views, and the effect this has on the viewer. Cumulative effects on the landscape relate to the degree to which wind energy development becomes a significant or defining characteristic of the landscape, and the degree to which it affects the values and experiences that are associated with the landscape.

In its Environmental Review of the proposed Roth Rock wind energy facility, PPRP assessed three operational or proposed wind energy developments arrayed along Backbone Mountain — Allegheny Heights (Clipper) and Roth Rock in southern Garrett County, and Mountaineer in West Virginia. Cumulative visual and landscape effects from wind energy developments along Backbone Mountain were estimated by first characterizing a preliminary area of potential effect (APE) from overlays of visibility zones for the three projects.

Within the potential visibility zones of the individual projects, PPRP found several areas where the visibility model predicted that views of the three projects would intersect, including parts of the Youghiogheny River valley south of Oakland and some segments of the Potomac River valley (see Figure 3-21). However, trees and other features block views of the Mountaineer project and the Backbone Mountain ridge line from many perspectives in southern Garrett County. Furthermore, views of Backbone Mountain in southern Garrett County have already been degraded by existing communications towers, strip mining, clear cutting, and other human activities, even though the ridgeline south of U.S. 50 is primarily forested. PPRP concluded that wind project development would not be the predominant view because visibility is constrained by natural buffers in the line of sight from most viewpoints, and mountain views from some perspectives are influenced by other man-made activities. Nevertheless, constructing more than 90 wind turbines on the Backbone Mountain ridgeline could change the character of the southern Garrett County landscape from a mostly natural setting to one where wind energy development is a significant defining characteristic.

The implications of this are unclear. Wind energy development is not a thematic element of land use planning at either the State or local level. The Garrett County Heritage Plan, for example, emphasizes the county's connection to the west and seeks to communicate its heritage as a frontier region and its Appalachian mountain culture. However, Western Maryland's coal mining heritage, another defining characteristic of this part of the state, has been recognized and promoted both by the county, through its Heritage Plan, and by the State, in its Scenic Byways Program. It remains to be seen whether wind energy can be incorporated into the cultural fabric of the western part of the state.

Traffic

Traffic impacts from power plants involve both automobiles and trucks. Automobile traffic due to commuting workers at recently licensed power plants has been minor because the operation of new facilities has required fewer workers to operate them. However, impacts from truck traffic are becoming an increasingly more important issue and are addressed in CPCN proceedings. Truck traffic is associated with the transportation of materials used to construct and operate a power plant. Mitigation for truck traffic impacts can take many forms and involve cooperation and coordination between local and State departments.

During the review of Catoctin Power's application to construct a 600 MW gas-fired facility in Frederick County, PPRP assessed aqueous ammonia transport needed to support air pollution control equipment. Once the Catoctin Power facility is in operation, tanker trucks delivering 5,000-gallon loads of 19 percent aqueous ammonia solution to the facility will travel over public roads once or twice a week. Aqueous ammonia in a 19 percent solution is liquid at ambient temperature and pressure, and is classified as a corrosive hazardous material by the U.S. Department of Transportation.

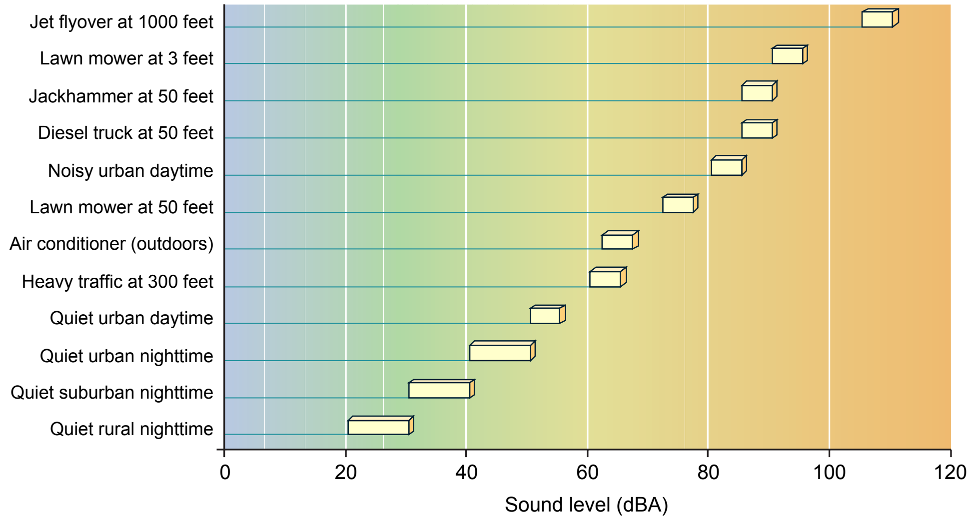
Less than five percent of trucks carrying hazardous materials are involved in fatal and nonfatal traffic crashes each year. In 2003, there were 72 tanker truck accidents in Maryland, half occurring on state or county roads. Because there are no prescribed truck routes in Frederick County, PPRP was concerned about the possibility of a catastrophic ammonia spill near homes, schools or other sensitive receptors. PPRP conducted an off-site consequence analysis of a catastrophic release of 5,000 gallons of aqueous ammonia from a tanker truck. Using established modeling techniques, spill distances ranging from 0.3 to 0.6 miles to the toxic endpoint were calculated. Based on this, PPRP included in Catoctin's CPCN a designated truck route that experiences low traffic and ensures that sensitive receptors such as schools and housing developments are beyond the toxic endpoint of an accidental spill.

Construction of wind power facilities in Western Maryland may involve transport of wind turbine components on trailers up to 90 feet in length. Maximum sizes and loads for motor carriers for commercial travel on Maryland highways are specified in the Maryland Motor Carrier Handbook published by the Maryland Department of Transportation State Highway Administration (SHA), and are the same standards used by County roads departments. SHA requires transporters of oversize loads to obtain permits to travel on interstate, federal and state highways and on county roads to the construction site. State and county highway departments also require developers to obtain permits before improving road sections or connecting facility access driveways to public roads. PPRP incorporates these requirements into recommended licensing conditions for proposed power plants.

Noise

Noise consists of vibrations in the air that gradually decrease, or attenuate, the farther they travel. For people who live or work near a power plant, the noise impacts, along with visual and traffic impacts can be the most significant type of effect caused by the facility.

Figure 3-22
Ranking of Comparative Noise Levels



Noise is made up of many components of different frequency (pitch) and loudness. The decibel (dB) is a measure of sound energy; one decibel is approximately the smallest change in sound intensity that can be detected by the human ear. An additional 10 units on the decibel scale is perceived subjectively as a doubling of the loudness. Ranges of typical A-weighted sound levels for various common sounds are shown in Figure 3-22.

The sensitivity of the human ear varies according to the frequency of sound; consequently, a weighted noise scale is used when discussing noise impacts. This A-weighted decibel (dBA) scale weights the various components of noise based on the response of the human ear. For example, the ear perceives middle frequencies better than low or high frequencies; therefore, noise composed predominantly of the middle frequencies is assigned a higher loudness value on the dBA scale.

The State of Maryland has adopted noise pollution standards, found in COMAR 26.02.03, which are adopted from the draft federal standards on noise. The maximum allowable noise levels specified in the regulations vary with zoning designation and time of day, as indicated in Table 3-11.

The State regulations provide certain exemptions for specified noise sources and noise generating activities. For example, the regulations also allow for construction activity to generate noise levels up to 90 dBA during daytime hours, but the nighttime standard may not be exceeded during construction.

Table 3-11 Maximum Allowable Noise Levels (dBA) for Receiving Land Use Categories

	Zoning Designation		
	Industrial	**Commercial**	**Residential**
Day	75	67	65
Night	75	62	55

Source: COMAR 26.02.03

Note: Day refers to the hours between 7 AM and 10 PM; night refers to the hours between 10 PM and 7 AM.

Structures such as berms and walls may be constructed solely to provide noise control, and have been used in transportation applications for many years. Vegetative buffers may be used in conjunction with these structures for additional noise abatement. Sound waves decrease in strength as they travel, and each doubling of distance from a noise source results in a decrease of 6 dBA in the measured sound level.

In cases where developers propose new generating units on small sites — where the nearest residents may be less than a half-mile away — noise impacts to surrounding communities can be a serious concern. Modeling noise sources and nearest receptors is part of the review of impacts that both the applicant and PPRP conduct in order to assess the noise impacts of proposed facilities. When modeling shows that the threshold levels cannot be achieved, measures to meet the allowable levels are recommended and incorporated into the CPCN. For instance, in the licensing evaluation for the Rock Springs combustion turbine facility, a detailed noise mitigation evaluation was conducted because of the proximity of residential and commercial receptors and the generally low background noise levels. PPRP examined the mitigation measures, such as barriers, acoustical enclosures, vent fan mufflers, and silencers for the exhaust stacks, that ODEC was proposing to install. After negotiations with PPRP, local residents, and elected officials, ODEC agreed to enhance the noise reduction features, including upgraded silencers, improved vent muffling, and additional soundproofing material for the turbine enclosures. Ultimately, the plant was designed to meet the State nighttime noise limit of 55 dBA but additionally will meet that standard even during daytime operation.

With the recent increase in licensing activity for landfill gas projects, such as those recently proposed in Baltimore County and Wicomico County, and of wind power projects in Western Maryland, PPRP is conducting monitoring to obtain more specific information about the noise characteristics of these types of units.

Economic Development

Property Value Impacts

The adverse effect of power plants on residential property values is an issue that has been increasingly raised in power plant permitting cases in Maryland. Although a considerable amount of research has been done to examine hazardous facilities, very little has been done in associating conventional generating facilities and new technologies, such as wind farms, to property values. As a result, residential property value impact estimates have lacked the credibility needed to influence public policy decisions related to the siting of energy facilities.

Residential property value depends on many factors including the size and amenities of the property itself, improvements made to the property, and the attributes of the surrounding neighborhood. Previous research has suggested that distance to “environmental disamenities” is a contributing factor in adversely affecting property value. It should be noted, however, that declines in property values have been more consistently observed in residential properties that are near higher-risk disamenities (e.g., hazardous waste facilities) or facilities that lack adequate land or vegetation buffers. Because risk is not strongly associated with most types of power plants, their influence on residential property values has been largely ignored.

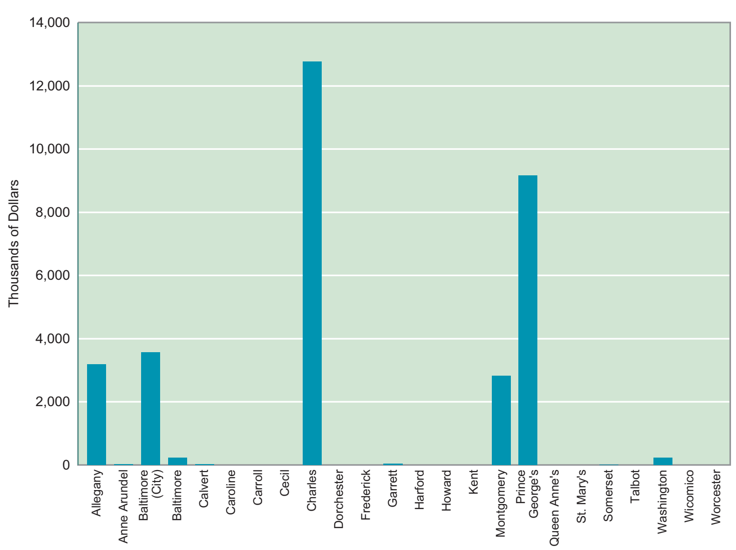
PPRP recently sponsored a study to estimate property value impacts from power plants and comparable large industrial facilities in Maryland. Using disamenity distance — the distance from a property to a disamenity — as one of the explanatory variables, hedonic property value models were estimated to examine how property values have been affected by three major industrial facilities in Maryland — Alcoa Eastalco Works in Frederick County, Calvert Cliffs Nuclear Power Plant in Calvert County, and the Dickerson Generating Plant in Montgomery County.

Of the three, only residential property values near the Alcoa Eastalco Works in Frederick County appear to be adversely affected by their proximity to the facility. This is true despite the fact that all of the disamenities evaluated are large industrial facilities, and Calvert Cliffs in particular is associated with heightened risk.

In its Environmental Review of the Roth Rock Wind Energy Facility, PPRP undertook a similar approach to assessing potential adverse effects on property values from the proposed Roth Rock wind energy facility in Garrett County. A hedonic model was estimated on properties around the planned Allegheny Heights wind energy project, located just north of the Roth Rock project. This project was announced in 2002 and permitted in March 2003. Although results initially revealed a positive and significant relationship between assessed property values and distance from a wind turbine, further analysis showed that distance of the property to Deep Creek Lake was the important factor in property valuation in the area. The study found no evidence that wind farm development in Garrett County has had an adverse effect on residential property values. However, because some of the properties included in the study sample were likely assessed before the Allegheny Heights wind project was announced, this analysis may not have captured the full effect of wind turbines on property values. Future studies may be more definitive.

Adverse effects on property values from electric generation facilities is a legitimate concern of host communities. To date, property value effects have not been observed around power plants in Maryland, which can be partly credited to impact mitigation from PPRP conditions stipulated in CPCNs. The changing mix of electric generation technologies in Maryland will continue to influence the debate on this issue, however.

Figure 3-23
FY04 Property Tax Revenues from Power Plants, by County



Local Taxes

Power plants pay property taxes like other businesses in Maryland. Utility generators are subject to two tax rates for: county utility property (covering both real and personal property), and state utility property. Non-utility generators are subject to three tax rates: county real property, county personal property, and state real property. The real property tax component is the tax on land and buildings; personal property refers to equipment and components used at the site.

Table 3-12 Property Tax Rates by Maryland County and State, Fiscal Year 2004 (Rates shown per $100 valuation)

County	Real Property Tax Rate (%)	Personal Property Tax Rate (%)	Utility Property Tax Rate (%)	Effective Rate* (%)
Allegany	1.0007	2.5018	2.5018	3.5025
Anne Arundel	0.9410	2.3520	2.3520	3.2930
Baltimore (City)	2.2380	5.8200	5.8200	8.0580
Baltimore	1.1150	2.7875	2.8550	3.9025
Calvert	0.8920	2.2300	2.2300	3.1220
Caroline	0.9520	2.3800	2.3800	3.3320
Carroll	1.0480	2.6200	2.6200	3.6680
Cecil	0.9800	2.4500	2.4500	3.4300
Charles	1.0260	2.5650	2.5650	3.5910
Dorchester	0.9300	2.3300	2.3300	3.2600
Frederick	1.0000	0.0000	2.5000	1.0000
Garrett	1.0360	0.0000	2.5900	3.6260**
Harford	1.0920	2.7300	2.7300	3.8220
Howard	1.0440	2.6100	2.6100	3.6540
Kent	1.0120	0.0000	2.5300	1.0120
Montgomery	0.7340	1.8350	1.8350	2.5660
Prince George's	0.9600	2.4000	2.4000	3.3600
Queen Anne's	0.9260	0.0000	2.3150	0.9260
St. Mary's	0.8780	2.1950	2.1950	3.0730
Somerset	1.0100	2.5250	2.5250	3.5350
Talbot	0.5400	0.0000	1.3500	0.5400
Washington	0.9480	2.3700	2.3700	3.3180
Wicomico	1.0250	2.5630	2.5630	3.5880
Worcester	0.7300	1.8250	1.8250	2.5550
State	**0.1320**	**0.0000**	**0.3300**	

Property tax rates in effect on July 1, 2004.

* Effective rate is the combination of real and personal property tax rates, applicable to non-utility generators.

** Non-utility generators are taxed at utility property rate.

Source: MD SDAT, 2004-2005 County Tax Rates, www.dat.state.md.us/sdatweb/taxrate.html

Assessments are allocated to Maryland jurisdictions hosting generation property using a cost-based estimate of value, to which county tax rates are applied (shown in Table 3-12). Generators receive a 50 percent exemption for personal property that is machinery or equipment used to generate electricity for sale. Most personal property associated with electric generation is classified under Category G assets, which have an allowable depreciation rate of 5 percent per year. All personal property is subject to a minimum assessment of 25 percent of the original cost.

In Fiscal Year 2004 (FY04), the assessed value of business personal property of Maryland's utilities and independent power producers totaled more than $1.2 billion of a total of $11 billion (the assessed value of all business and personal

Table 3-13 Contribution of Power Plants to County Property Tax Base and Payments (FY04)

County	Assessed Base ($ Thousand)	Generator Assessment ($ Thousand)	Percent of Assessed Base (%)	Actual Yield (all businesses) ($ Thousand)	Generator Payments (see note) ($ Thousand)	Percent of Yield (%)
Allegany	361,703	127,058	35.13	9,271	3,179	34.29
Anne Arundel	2,320,976	892	0.04	49,924	21	0.04
Baltimore (City)	1,961,828	61,234	3.12	101,048	3,564	3.53
Baltimore	2,810,527	8,172	0.29	79,178	228	0.29
Calvert	878,086	1,522	0.17	19,454	34	0.17
Caroline	77,539	0	0.00	1,988	0	0.00
Carroll	487,128	27	0.01	12,614	1	0.01
Cecil	262,967	0	0.00	6,132	0	0.00
Charles	800,128	497,703	62.20	18,917	12,766	67.48
Dorchester	138,443	0	0.00	3,383	0	0.00
Frederick	334,892	0	0.00	0	0	0.00
Garrett	125,152	1,404	1.12	3,014	36	1.19
Harford	875,366	0	0.00	22,814	0	0.00
Howard	1,276,375	103	0.01	34,109	3	0.01
Kent	36,386	0	0.00	0	0	0.00
Montgomery	3,945,325	153,697	3.90	42,206	2,820	6.68
Prince George's	2,850,781	381,815	13.39	67,982	9,164	13.48
Queen Anne's	59,669	0	0.00	1,393	0	0.00
St. Mary's	224,565	0	0.00	5,088	0	0.00
Somerset	71,127	570	0.80	1,886	14	0.74
Talbot	53,789	0	0.00	704	0	0.00
Washington	498,790	10,185	2.04	11,738	241	2.05
Wicomico	445,526	0	0.00	8,458	0	0.00
Worcester	285,895	0	0.00	5,357	0	0.00
TOTALS	**$21,182,963**	**$1,244,382**		**$506,658**	**$32,071**	

Note: Estimated personal property taxes paid by utility and non-utility power plant owners.

Source: MD SDAT, 2004-2005 County Tax Rates

property in the state). Combined, utilities and independent power producers paid more than $32 million in personal property taxes in FY04 (Table 3-13). Maryland counties that collected the most property tax revenues from power plants in FY04 were those with a non-zero personal property tax rate hosting significant generating capacity, such as Allegany, Charles, Montgomery, and Prince George's Counties, as well as Baltimore City (see Figure 3-23). Mirant Corporation, which operates power plants in three of these counties, is one of the largest property tax payers in the state. More than 50 percent of Charles County's personal property tax revenues arises from power plants.

One of the more recently licensed power plants is a natural gas-fired, combined-cycle power plant under development by Catoctin Power in Frederick County, and is valued at nearly $40 million. However, Frederick is one of only four Maryland counties that do not tax business personal property. As a result, property tax revenues from the facility are not expected to exceed $400,000 per year — still a significant amount, but not as large as it might be if the plant were located in a county with a different tax structure.

This difference in property tax rates among Maryland counties tends to suggest that property taxes might be a factor in determining the location of new generating capacity. However, important location determinants for facilities are access to a reliable fuel supply, cooling water, and the electric distribution system. Given the predominance of gas-fired power plants in recent CPCN applications, location has been driven by proximity to natural gas pipelines that are also near a cooling water source and transmission lines. Licensed and proposed wind energy projects have to date been located along mountain ridges in western Maryland where the required wind characteristics exist. Therefore, property tax differentials do not appear to influence the location of these facilities.

Radiological Issues

Production of nuclear power in the United States is licensed, monitored, and regulated by the U.S. Nuclear Regulatory Commission (NRC). Provisions in the operating licenses of each plant allow utilities to discharge low levels of radioactive material to the environment. The kind and quantity of releases are strictly regulated and must fall within limits defined in federal law as protective of human health and the environment. The NRC regulates releases from power plants according to the principle that the exposure of the environment and humans to radiation be kept "as low as reasonably achievable."

Pathways of exposure to radioactive material in the environment are similar to those for other pollutants. An aqueous (water) pathway dose can be received internally or externally by ingesting contaminated water and seafood, or by exposure to contaminated sediments and water. An atmospheric pathway dose can result from exposure to or inhalation of radioactive gas or airborne particles, or ingestion of radionuclides deposited on or assimilated by terrestrial vegetation and animals.

Nuclear power plants are minor contributors to radiation exposure in the United States. As Figure 3-24 illustrates, natural radiation sources account for more than 80 percent of the average radiation dose to human beings. Of the approximately 18 percent of the radiation dose to human beings arising from man-made sources, only 1 percent is attributed to commercial nuclear power production.

Figure 3-25 shows the locations of nuclear power plants in and near Maryland. Calvert Cliffs Nuclear Power Plant, in Calvert County, is the only nuclear power station in the state. The next closest plant, Peach Bottom Atomic Power Station, is on the Susquehanna River just north of the Pennsylvania/Maryland border. Both these facilities release radionuclides into Maryland's environment. PPRP, MDE, and the utility operators conduct environmental monitoring programs near both plants.

Figure 3-24
Estimated Effective Radiation Dose from Natural and Man-made Sources

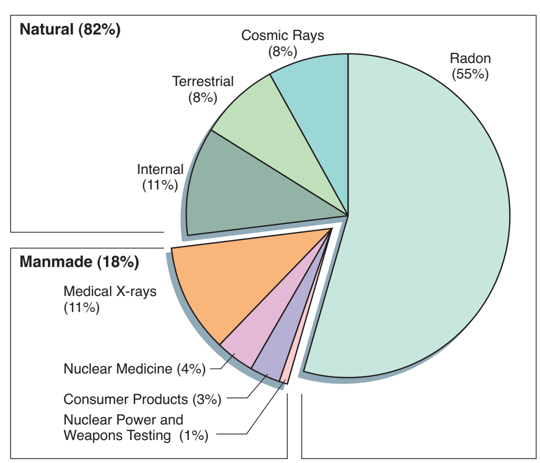


Figure 3-25
Nuclear Power Plants In and Around Maryland

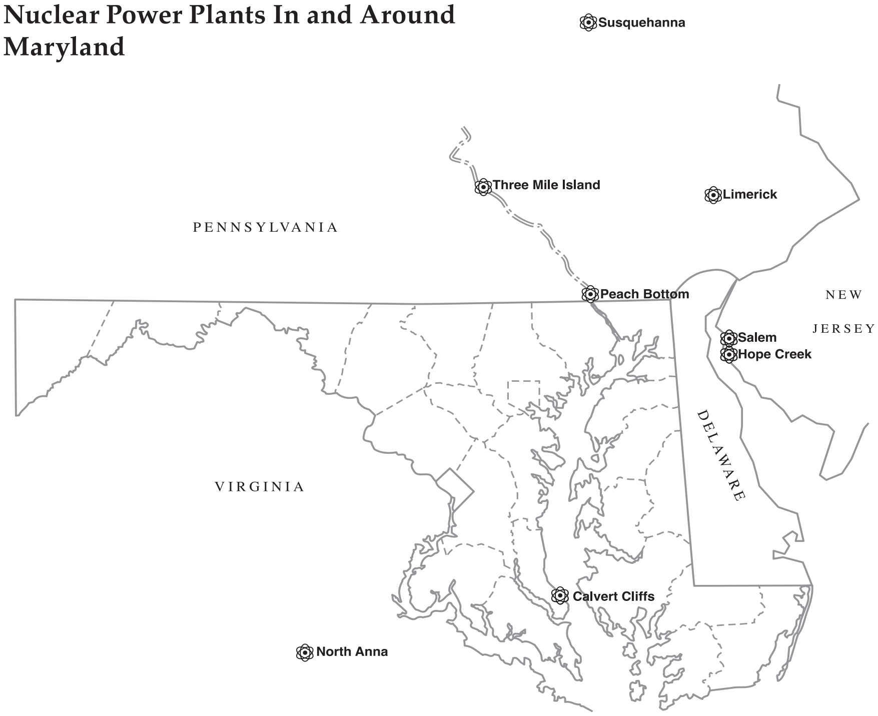
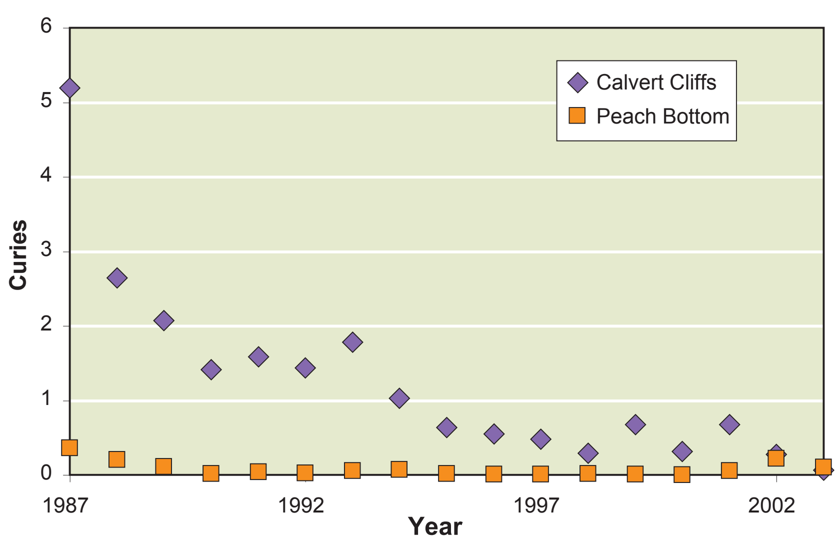


Figure 3-26
"Environmentally Significant"* Annual Aqueous Releases, 1987 - 2003 (Curies)



* Environmentally significant refers to certain radionuclides that are known to be assimilated by biological organisms and are discharged in detectable amounts. Noble gases, tritium, or very short-lived radionuclides are not environmentally significant.

These monitoring programs are used to assess the radiological effects on the environment attributable to each of the power plants.

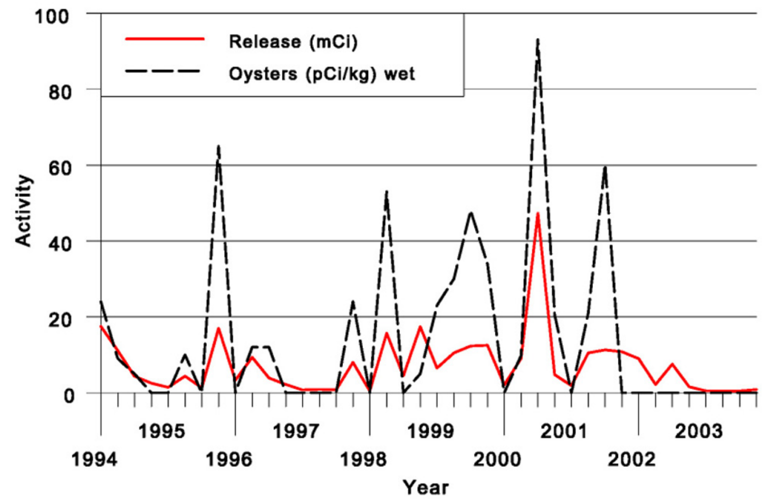
Calvert Cliffs Nuclear Power Plant

Constellation Generation Group owns and operates the Calvert Cliffs facility, on the western shoreline of the Chesapeake Bay. Each of its two units is a pressurized water reactor with a generating capacity of approximately 915 MW. The units began service in May 1975 and April 1977.

Calvert Cliffs routinely releases low-level gaseous, particulate, and liquid radioactive material into the atmosphere and the Chesapeake Bay. PPRP has monitored radionuclide levels in the Chesapeake Bay and environment surrounding Calvert Cliffs since 1975. The level of radioactivity of these materials at any given time depends on many factors, such as plant operating conditions and conditions of the nuclear fuel. Releases of radioactivity to the environment from Calvert Cliffs have been well within the regulatory limits since the beginning of its operation.

Radioactive noble gases, primarily isotopes of xenon and krypton, constitute most of the radioactive material released to the atmosphere from Calvert Cliffs. Noble gases are chemically inert, are not readily incorporated into biological tissues, and are not bioconcentrated. They are readily dispersed in the atmosphere, and most have short half-lives, thus, decaying rapidly to stable forms. For these reasons, the noble gases do not represent a significant threat to human or ecological health. The most recently

Figure 3-27
Concentration of ^{110m}Ag in CCNPP Aqueous Effluent and 3-month Tray Oysters, 1994 - 2003



compiled results from PPRP's environmental assessments (for the years 2002 and 2003) indicate that releases of radioactivity to the atmosphere by the Calvert Cliffs plant were not detectable in air, precipitation, or vegetation.

Although atmospheric releases consist mainly of radioactive noble gases, which have little environmental significance, aqueous discharges contain radionuclides that can be accumulated by biota and can become trapped in sediments at the bottom of the Bay. Over time, these radionuclides may potentially contribute to a radiation dose to humans by being transported through the food chain. For CCNPP, the environmentally significant radionuclides (see Figure 3-26) are primarily forms of radioactive iron, cobalt, antimony, niobium, and silver. However, the quantities of environmentally significant radionuclides released from Calvert Cliffs and subsequently detected in shellfish and Bay sediments were quite small (approximately 0.3 percent of all radioactivity detected in sediments, which includes historic nuclear weapons testing fallout and naturally occurring radionuclides).

Bay oysters are ideal indicators of environmental radionuclide concentrations because they do not move and they readily ingest and concentrate metals. Oysters are commercially harvested near Calvert Cliffs, and they have the greatest potential for contributing to a human radiation dose through seafood consumption. PPRP routinely monitors the uptake of radionuclides in test oysters placed on platforms on the Bay floor in the vicinity of the Calvert Cliffs discharge. The oysters are collected at scheduled time intervals and analyzed for radionuclide content in their tissues. Radiosilver (^{110m}Ag) has historically been the principal plant-related radionuclide accumulated by test oysters as well as oysters on natural beds. The lack of ^{110m}Ag detection reflects a recent downward trend in ^{110m}Ag releases from CCNPP (see Figure 3-27).

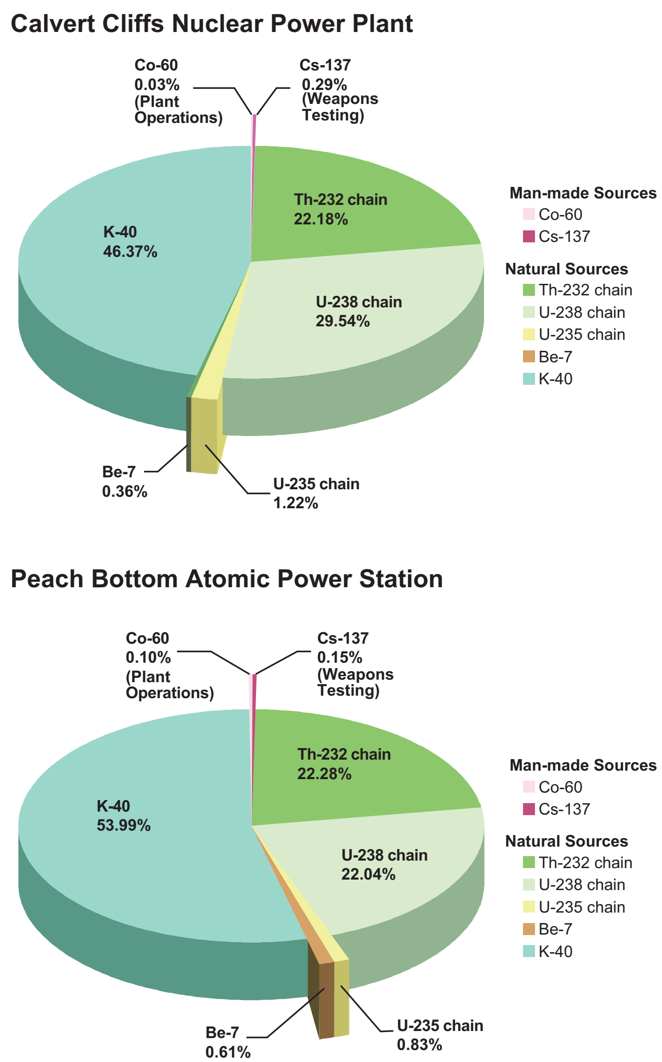
As part of its assessment program, PPRP estimates doses of radiation to individuals consuming seafood. The doses are calculated based on maximum or worst-case estimates of the amount of plant-related radioactive material potentially available. Results indicate that radiation doses attributable to operations at Calvert Cliffs are well below federally mandated limits.

Chesapeake Bay sediments are also useful indicators of environmental radionuclide concentrations because they serve as natural sinks for both stable and radioactive metals. PPRP collects sediment samples seasonally from eight transects extending bayward north and south of the Calvert Cliffs plant. Cobalt-60 was the plant-related radionuclide detected almost exclusively in Bay sediments during the 2002-2003 reporting period (see Figure 3-28).

A comparison of radionuclide concentrations in environmental samples collected in 2002 and 2003 with levels detected since 1978 shows the following:

- *The levels of plant-related radionuclides detected during 2002 and 2003 are slightly less than the range of concentrations detected over the previous decade.*
- *Although radionuclide concentrations fluctuate seasonally and annually, no long-term accumulation of plant-related radioactivity in Bay aquatic life and sediments is evident.*
- *The radioactivity introduced into the environment by Calvert Cliffs is very small compared with background radioactivity from natural sources and weapons test fallout.*
- *Radiation doses to humans due to atmospheric and aqueous releases are well within regulatory limits (see Table 3-14).*
- *Environmental, biological, and human health effects of releases of radioactivity from Calvert Cliffs are insignificant.*

Figure 3-28
Proportion of Natural vs. Man-made Radionuclides in Sediment Samples Near CCNPP and PBAPS



Peach Bottom Atomic Power Station

Exelon Generation Company, a subsidiary of Exelon Corporation, operates Peach Bottom Atomic Power Station (PBAPS), which began operations in 1974. Peach Bottom is located on Conowingo Reservoir just north of the Pennsylvania-Maryland border. The plant's two operating units are boiling water reactors, each with a currently licensed capacity of approximately 1,150 MW. PPRP has monitored radionuclide levels from the plant since 1975.

Like Calvert Cliffs, Peach Bottom routinely releases low-level gaseous, particulate, and liquid radioactive material into the atmosphere and the Susquehanna River. All liquid and atmospheric releases of radioactivity from the plant have been well within regulatory limits since the beginning of its operation.

Information from Exelon's monitoring programs shows that in recent years, noble gases accounted for nearly all of identifiable radioactivity released to the atmosphere by the plant. The most recently compiled results from PPRP's environmental assessments (for the years 2002 and 2003) indicate that releases of radioactivity to the atmosphere by the Peach Bottom plant were not detectable in air, precipitation, or vegetation.

Of the radionuclides released by Peach Bottom to the Susquehanna River in 2002 and 2003, 99 percent was tritium, which is not bioaccumulated and is not environmentally significant. Very small quantities of radioactive cobalt, zinc, and manganese accounted

Table 3-14 Comparison of Radiation Doses to Humans and Applicable Regulatory Limits

Exposure Route			EPA Regulatory Limit (40CFR190 Subpart B)	NRC Regulatory Limit (10CFR50 Appendix I)
Dose by ingestion (mrem)				
Oyster ingestion, whole body dose (from CCNPP)	0.00003 (adult)[a]		25	3
Oyster ingestion, other organ dose (from CCNPP)	0.023 maximum (adult GI tract)[a]		25	10
Finfish ingestion, whole body dose (from PBAPS)	0.005 maximum (adult)[b]		25	3
Finfish ingestion, other organ dose (from PBAPS)	0.008 maximum (teen liver)[b]		25	10
Dose by inhalation (milliRoentgen)[a]				
	2002	2003		
Whole body dose (gaseous, from CCNPP)	0.0003	0.002	25	3
Other organ dose (gaseous, from CCNPP)	0.0009	0.003	25	10

[a] Source: Annual Radiological Environmental Operating Reports for 2002 and 2003, Constellation Generation Group
[b] Source: PPRP

Note: Data are not available regarding Peach Bottom atmospheric (inhalation) doses.

for most of the remaining liquid radioactive material released. These particular radionuclides are environmentally significant (see Figure 3-26) because they can be readily accumulated by aquatic life such as mussels and finfish.

Finfish collected by PPRP from the Conowingo Reservoir area contained only historical, fallout-related radionuclides. Radioactivity related to Peach Bottom plant was detected in sediments collected down-river of the plant (see Figure 3-28). It is estimated that historically, less than 20 percent of the radioactivity released in Peach Bottom water discharge is found in sediments of the Conowingo Reservoir. The remaining radioactivity is transported downstream to the Chesapeake Bay.

PPRP has estimated radiation doses to individuals consuming fish using the maximum plant-related radionuclide concentrations, similar to the studies at Calvert Cliffs. However, because the Susquehanna River is a source of drinking water, its ingestion, in addition to fish consumption, may potentially contribute to a human radiation dose. The annual total body doses associated with the consumption of finfish and drinking water are well below federal limits.

Comparing PPRP's radiological monitoring of Peach Bottom-related radioactivity of aquatic life and sediments collected from 2002 and 2003 with monitoring results since 1978 shows the following:

- *The low levels of plant-related radioactive material detected in aquatic life and sediments represent a small portion of the radioactive material in the Susquehanna River-Chesapeake Bay system compared with that from natural sources and weapons test fallout.*
- *No long-term accumulation of plant-related radioactive material in river biota is evident.*
- *Long-term operation of Peach Bottom Atomic Power Station has not caused significant accumulation of radioactive material within the Conowingo Reservoir.*

- *Radiation doses to humans due to atmospheric and aqueous releases are well within regulatory limits (see Table 3-14).*
- *Environmental, biological, and human health effects of releases of radioactivity from Peach Bottom are insignificant.*

Radioactive Waste

In addition to the production of atmospheric and liquid effluent releases as a byproduct of normal power generation operations, both Calvert Cliffs and Peach Bottom generate radioactive waste products which require disposal:

Low-Level Radioactive Waste (LLRW)

This type of waste consists of materials such as contaminated gowns, toweling, glassware, resin, equipment, and reactor control rods that are used in the normal daily operation and maintenance of the power plant. Much of the waste is safety and testing equipment that have become contaminated through normal use. Resin is used to remove radioactivity from wastewater through an ion-exchange process. Depending on the waste type and radioactivity level, waste is dried, compressed, and sealed into high-integrity containers, metal boxes, or 55-gallon drums. These containers may in turn be sealed into shipping casks. Low-level radioactive waste from Calvert Cliffs is transported by truck to licensed radioactive waste processing firms located in South Carolina, Tennessee, and Utah, depending on the type of waste. Some of the waste's final destination is a burial site located in Barnwell, South Carolina (after June 30, 2008, only waste from South Carolina, Connecticut, and New Jersey will be accepted at the Barnwell facility). Other LLRW from Calvert Cliffs is incinerated or chemically reduced, depending on the waste processing vendor and type of waste.

Irradiated Fuel

Spent nuclear fuel from both Calvert Cliffs and Peach Bottom are presently stored onsite within spent fuel pools for the recently discharged fuel or, in the case of older, "decayed" fuel generated in earlier years of plant operation, at dry storage independent facilities located within the protected plant area. These Independent Spent Fuel Storage Installations (ISFSIs) are licensed by the NRC for 20 years. ISFSI design and construction must conform to strict NRC specifications that protect against unauthorized entry, earthquake, and other natural phenomena such as floods and hurricanes. The U.S. government expects to move irradiated fuel stored in ISFSIs at commercial power plants throughout the country to a central location beginning in 2010. The Yucca Mountain, Nevada, repository is currently the sole site under consideration as the central long-term storage facility. The U.S. Department of Energy is currently in the process of submitting a license application to the NRC to open the facility for waste shipments.

As of October 1, 2005, Calvert Cliffs had 48 casks loaded with spent fuel in the ISFSI, each of which holds 24 spent fuel assemblies, for a total of 1,152 assemblies in dry cask storage. Constellation Energy has acquired a license amendment for its ISFSI with the NRC to utilize a similar cask design by the same manufacturer that would accommodate 32 assemblies per cask rather than 24. Given that approval, Constellation Energy will utilize only the 32-assembly casks and anticipates loading about 3 casks per year through the current licensed ISFSI lifetime (2014).

Exelon's dry cask storage facility at Peach Bottom currently has 28 casks loaded with 68 fuel assemblies each for a total of 1,904. No more casks will be loaded in 2005. Like Constellation Energy, Exelon expects to obtain NRC approval in 2006 for a modified cask design to accommodate a greater number of fuel assemblies.

Power Plant Combustion Products

Coal, like all fuels, produces gaseous and solid "by-products" during combustion. The solid by-products result from components of coal not consumed during combustion. This section of the report focuses on the solid coal combustion products (CCPs) produced by coal-fired power plants in Maryland. Specifically, the amounts of CCPs produced in 2004 are reported and more importantly, ways in which CCPs were disposed of are discussed. Much of the discussion focuses on beneficial industrial uses of CCPs and ongoing research efforts to identify additional uses for CCPs with the ultimate goal that all CCPs produced in Maryland, to include those currently stockpiled, will be used in beneficial ways.

Generation and Current Disposition

CCPs are produced during the combustion process necessary for the production of electrical energy at modern coal-burning power stations. In 2004, coal-fired power plants in Maryland generated an estimated 1.9 million tons of CCPs. These CCPs are the non-combustible mineral matter present in coal and any unburned carbon remaining as a result of incomplete combustion.

The two primary types of CCPs produced by Maryland's coal-burning power stations, fly ash and bottom ash, are differentiated by their physical characteristics. Fly ash is the finely divided residue or ash that is transported from the furnace along with emission gases. Fly ash is composed of very fine, and generally spherical, glassy particles. Conversely, bottom ash is collected from the bottom of the furnace and is composed of coarser, angular, porous, or glassy particles. There is little difference in the chemical makeup of fly ash and bottom ash. The principal difference is that the particles of bottom ash are much larger than particles of fly ash.

The chemical nature of CCPs depends upon the nature of the coal burned and the combustion process used. For the most part, power plants in Maryland burn bituminous coal from the eastern United States, which produces predominantly Class F fly ash. Class F fly ash is distinguished from Class C fly ash by having less than 10 percent free lime (CaO) by weight. The ash is typically composed of more than 85 percent silicon, aluminum, and iron oxides. Class F fly ash may also contain trace metals such as titanium, nickel, manganese, cobalt, arsenic,

Reported TRI Releases Associated with CCPs

In 1986, the Toxics Release Inventory (TRI) was established under the Emergency Planning and Right to Know Act. The TRI is a database maintained by the U.S. EPA listing the quantities of toxic chemicals released to the environment annually by facilities in certain industries. Electric utilities became subject to TRI reporting requirements in 1997.

The TRI reporting for CCPs is based on the mass of the regulated chemical that was disposed, rather than the total mass of CCPs. There are currently 594 chemicals that require TRI reporting. Of these 594 chemicals, only 14 have been reported in the Electric Utility land-based waste disposals during the last six years (1998 to 2003). The table below lists these chemicals along with the quantities disposed by Maryland electric utilities in 2003. The table shows that barium and manganese compounds constitute the largest portion of TRI reportable chemicals disposed in CCPs in 2003. Overall, the mass of TRI reportable chemicals represents less than 1 percent of the total mass of CCPs produced annually in Maryland.

Chemical	Quantity Disposed in 2003 (pounds)
Arsenic Compounds	47,160
Barium Compounds	1,131,618
Beryllium Compounds	6,900
Chromium Compounds	181,227
Cobalt Compounds	48,800
Copper Compounds	253,344
Lead Compounds	75,875
Manganese Compounds	1,616,224
Mercury Compounds	418
Molybdenum Trioxide	28
Nickel Compounds	179,181
Selenium Compounds	84
Vanadium Compounds	368,154
Zinc Compounds	154,785
Total Reported to TRI in 2003	**4,063,798**

and mercury. Electric utilities are required to include all applicable constituents of their CCPs when reporting chemical releases through EPA's Toxics Release Inventory (TRI) program (see sidebar).

Two relatively new clean coal technologies are fluidized bed combustion (FBC) and flue gas desulfurization (FGD). Both of these technologies include the use of sorbents, such as limestone, during or after combustion to reduce air pollution by removing sulfur compounds from power plant emissions. While the use of sorbents improves air quality, the noncombustible sorbents significantly increase the volume of CCPs produced.

FBC by-products and FGD sludges resulting from these clean coal technologies contain many of the same chemical components as ordinary coal ash, but they tend to contain much larger proportions of calcium sulfate and sulfite miner due to reactions between the limestone sorbent and sulfur emissions. They may also also contain lime (unreacted sorbent), causing the ash to behave like cement when it is mixed with water. The AES-Warrior Run power plant in Cumberland is currently the only Maryland power plant that uses FBC technology. No FGD scrubbers are used today at Maryland's coal-fired power plants.

Figure 3-29 highlights the quantity of CCPs generated and disposed by Maryland's coal-fired power plants annually. Of the approximately 1.9 million tons of CCPs produced by these plants in 2004, about 49 percent are placed in disposal sites (see locations in Figure 3-30). Like all landfills, CCP disposal sites have the potential to adversely impact Maryland's terrestrial and aquatic resources if

Figure 3-29
CCP Generation and Disposal

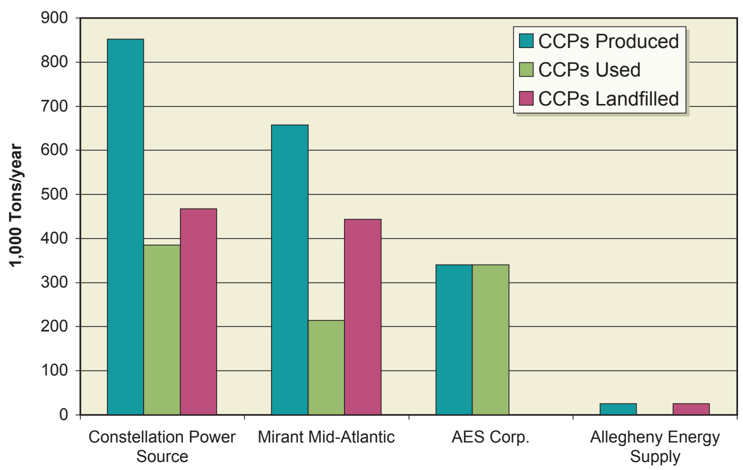
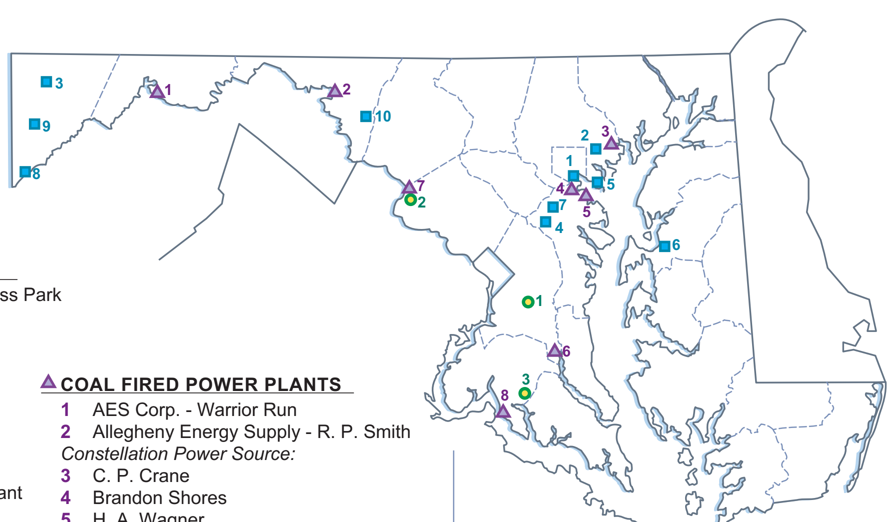


Figure 3-30
Distribution of Beneficial Use CCP Projects in Maryland



KEY

BENEFICIAL USE PROJECTS
1 Brandon Woods Energy Business Park
2 Rossville Industrial Park
3 The Winding Ridge Project
4 BBSS, Inc.
5 I-695 Highway Embankment
6 Route 213/301 Overpass
7 Millersville
8 Kempton Mine Complex
9 Hoyes Run
10 Boonsboro Water Treatment Plant

DISPOSAL SITES
1 Brandywine
2 Westland
3 Faulkner

COAL FIRED POWER PLANTS
1 AES Corp. - Warrior Run
2 Allegheny Energy Supply - R. P. Smith
Constellation Power Source:
3 C. P. Crane
4 Brandon Shores
5 H. A. Wagner
Mirant Mid Atlantic:
6 Chalk Point
7 Dickerson
8 Morgantown

not designed and managed properly. The remainder of the CCPs is used beneficially in a variety of applications:

- *Highway embankment structural fill (360,000 tons of CCPs used between 1993 and 1998);*
- *Regrading structural fill (approximately 5 million tons of CCPs used since 1982);*
- *Surface coal mine reclamation (approximately 340,000 tons of CCPs used in 2004);*
- *Concrete and cement manufacturing (approximately 300,000 tons of CCPs used in 2004);*
- *Flowable fill manufacturing (approximately 19,000 tons of CCPs used in 2004); and*
- *Blasting grit (approximately 67,000 tons of CCPs used in 2004).*

Beneficial Use Demonstration Projects

While the 51 percent beneficial usage of CCPs in Maryland is above the national average of 35 percent, as reported by the American Coal Ash Association in 2003, PPRP believes that this percentage can be increased even further. For this reason, PPRP has supported research on both traditional and innovative beneficial uses of CCPs. Of particular interest are applications which use massive quantities of CCPs and can be adapted and adopted by both private and public enterprises to suit their particular needs.

Building upon the success of the Winding Ridge Demonstration Project, PPRP is working on projects to address AMD and the protection of ground water at the much larger Kempton Mine Complex. The Kempton Complex covers approxi-

Weathering Studies of CCP-based Pozzolan Stabilized Materials

In spite of the extensive water quality data generated as part of demonstration projects like the Winding Ridge project, uncertainty still remains concerning the physical and chemical stability of CCP-based grouts in underground mine environments. To address these uncertainties, PPRP is working with partner organizations to conduct bench-scale controlled weathering experiments using blocks of CCP-based grout. The blocks will be exposed to running water at controlled pH values ranging from pH 3 to 7. This exposure is designed to simulate interactions between the grout and typical mine water. Physical weathering of the blocks will be monitored by careful observation and measurements of flow grooves in the blocks. Chemical weathering of the blocks will be monitored by analysis of the water after it has been allowed to pass over the blocks repeatedly. The data collected during this study will be used to design future deep mine reclamation projects, such as the Siege of Acre project, and may provide insight useful for the development of generalized leaching test methods for stabilized CCP materials.

Experimental setup for CCP-grout weathering tests

mately twelve square miles and is mostly situated in West Virginia, although portions of the mine extend into Maryland. Among the Maryland portions of the mine is a point at which AMD exits the mine and discharges into Laurel Run. PPRP currently has two projects that are underway or in the planning stages at Kempton investigating the beneficial use of CCPs to reduce acid formation: the Kempton Man Shaft Project, and the Siege of Acre Project.

The Kempton Man Shaft Project was designed to demonstrate the replacement of concrete with CCPs in seepage barrier applications. The Kempton Man Shaft is a 420 foot deep vertical shaft located within the Kempton Complex. The Man Shaft acts as a conduit conveying good quality shallow ground water into the deeper mine pool. Grout injection at the Man Shaft was conducted from September to November 2003. Post injection monitoring, including water level measurements and a dye tracer study, have been conducted since that time to determine whether the barrier is slowing or preventing movement of water into the Man Shaft.

The Winding Ridge Demonstration Project

PPRP and the MDE Bureau of Mines initiated the Western Maryland CCP/AMD Initiative in 1995 with the Winding Ridge Demonstration Project. In 1996, 5600 cubic yards of 100% CCP grout were injected into the Frazee Mine, a small abandoned coal mine in Garrett County, Maryland. The grout cured within the mine to a PSM and core samples retrieved from the mine one year after injection had compressive strengths above 1,000 pounds per square inch (psi). Additional core samples retrieved seven years later showed that the PSM had retained its integrity over this time. Post-injection monitoring results show that the concentration of AMD-related parameters, including iron, aluminum, sulfate, total acidity and trace metals in the mine discharge have decreased to well below pre-injection conditions. The pH of the mine discharge has also increased slightly, although it remains in the acidic range. While certain major ions (namely calcium, sodium, potassium, and chloride) do appear to have dissolved from the PSM surface into the mine discharge, their concentrations are decreasing with time and the PSM does not appear to have leached trace metals into the mine discharge water. In summary, the Winding Ridge Demonstration Project shows that CCPs can be used beneficially to form a PSM that can be injected into an abandoned, underground coal mine to reduce acid formation.

Aerial view of the Winding Ridge project location

In addition, ground water samples are being collected to determine what, if any, ground water quality impacts have resulted from the grout injection. The water level measurements and dye tracer study indicate that water is still flowing from the shallow aquifer into the Man Shaft. This is believed to be due to the highly fractured nature of the aquifer rock (which was more fractured than anticipated at the initiation of the project). The project has, however, demonstrated that CCPs, along with traditional mixing and pumping equipment can be used in place of traditional concrete for this type of application.

The Siege of Acre Project represents a unique mine injection project that is currently in the planning and pre-injection monitoring stages. This project focuses on an isolated section of the Kempton Complex, identified as Siege of Acre. This section, located at the extreme northern end of the Complex, is comprised of three isolated tunnels. The water seeping into this section of the mine drains from the lowest of the three tunnels and has been found to have a pH of 2.3 and chemistry consistent with AMD. The project objective is to inject a CCP grout with appropriate flowability to minimize injection drilling, yet cover most of the mine pavement and entomb the majority of mine debris on the mine floor. Once hardened, the grout would act as a barrier by preventing contact between pyrite, oxygen, and water seeping into the mine, thereby reducing or preventing acid formation within the tunnel. This section of the Kempton Complex is representative of several hundred acres of exposed mine pavement on the west side of the Kempton Mine Pool, where it is suspected that most of the acid discharging from the Complex is formed.

In addition to demonstration projects, PPRP also supports research that may lead to future projects or provide data that can be used by others in adapting CCP use technologies. The PSM weathering study in the sidebar on page 3-80 is one such research project. Other projects include:

- ***Cost Optimization Study*** *– PPRP is working with the AES Warrior Run power plant to study the means, methods, and associated costs to use the CCPs generated at this plant for deep mine restoration in the Georges Creek Basin. This deep mine restoration could reduce the risks of subsidence, mine out-gassing, mine fires and further disturbances of hydrogeology in this area. This area is of particular interest for CCP utilization because it is located within the same distance that AES currently transports the CCPs for surface mine reclamation. Thus, deep mine restoration in this area would not only provide benefits over and above those currently realized during surface mine restoration but it would not incur increased transportation costs for AES.*

- ***Frostburg Deep Mine Reclamation*** *– The City of Frostburg is situated on top of a complex network of abandoned underground coal mines. Mine tunnel collapse in this area has resulted in significant subsidence problems for the city. Research is currently being conducted on the feasibility of injecting CCP-based grout into subsurface mines that underlie the City of Frostburg to provide additional support to the mine tunnels and mitigate or prevent future subsidence problems.*