Cypress Creek Power Plant Modeling: Pollutant Deposition to the Chesapeake Bay and Sensitive Watersheds within the Commonwealth of Virginia

prepared for

Chesapeake Bay Foundation

prepared by

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Old Dominion Electric Cooperative (ODEC) has applied for a permit to install a coal-fired power plant near the town of Dendron in Surry County, Virginia (Burns and McDonnell, 2008). The proposed plant would be constructed adjacent to Cypress Creek where it joins the Blackwater River, about 45 miles southeast of Richmond. The proposed power plant will consist of two 750 MW pulverized-coal boilers, operating continuously, burning primarily bituminous coal (610 tons of coal per hour), which will result in the emissions of many air pollutants, including those shown in Table 1.

Table 1. Proposed Cypress Creek Power Plant Annual Emissions

Pollutant	Emissions
Oxides of Nitrogen (NO_X)	3,070.4 tons
Sulfur Dioxide (SO_2)	3,684.5 tons
Sulfuric Acid Mist (H_2SO_4)	282.2 tons
Particulate Matter (PM_{10})	1,842.2 tons
Mercury (Hg)	210.0 lb

Emissions data were obtained from Appendix C of the permit application (Burns and McDonnell, 2008).* Stack parameters for the two boilers were obtained from Appendix A of the permit application (ibid.). Only one power plant within the entire Commonwealth of Virginia (Chesterfield Power Station) emits more mercury to the atmosphere than the proposed Cypress Creek power plant. The proposed Cypress Creek power plant would be the third largest point source of particulate matter in Virginia. Figure 1 shows the location of the proposed power plant in southeastern Virginia.

During transport through the atmosphere, a portion of the emitted pollutants will be deposited onto the earth's surface either by dry deposition processes or during precipitation. The deposited pollutants have the potential to enter creeks and streams, and cause harm to the region's waterways. Although not all the deposited mercury will become methylated, more mercury delivered to a stream or lake will result in more methylmercury in fish (Lubick, 2009).

High levels of mercury have been observed in streams and rivers throughout the eastern and northeastern United States (U.S. EPA, 1997). The Virginia Department of Health has issued fish consumption advisories for many of the waterways in Virginia based on unhealthful levels of methylmercury found in fish tissue samples (Virginia Department of Health, 2008). As little as 0.3 grams of mercury deposition per year is sufficient in causing methylmercury contamination of a 25-acre lake (Raloff, 1991).

* There is some uncertainty regarding the estimated level of mercury emissions from the proposed power plant. On page 4 of Appendix C of the permit application, total mercury emissions from the two proposed boilers is estimated to be 210 lb/yr, which was obtained by using a best available control technology (BACT) emission factor of 1.71 lb/trillion Btu. However, on page 5 of the same document, the total mercury emissions for the two proposed boilers is estimated to be 118 lb/yr, using an emission factor of 0.96 lb/trillion Btu that was based on a maximum achievable control technology (MACT) analysis. The predicted mercury deposition levels due to the proposed source presented below were prepared using the emissions shown in Table 1. To estimate deposition levels for a differing amount of mercury emissions, one may simply scale the modeled mercury deposition by the emissions ratio. This issue is addressed further in the last section of this report.

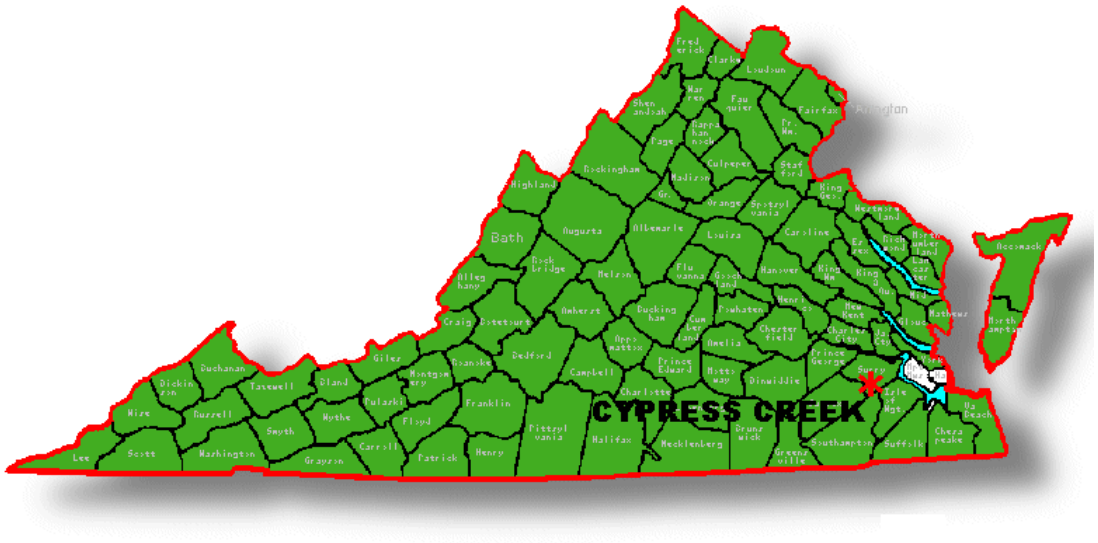

Figure 1. Location of proposed Cypress Creek power plant

A modeling study was undertaken to evaluate the impact that emissions from the proposed power plant would have on a number of sensitive receptor areas, including the Blackwater River and Nottoway River Watersheds, the Roanoke River Watershed, as well as the Chesapeake Bay and its entire watershed. The model, which accounted for the emissions and subsequent atmospheric processes that affect the transport and deposition of pollutants, was used to predict the total amount of each modeled pollutant that would be deposited within each receptor area.

The CALPUFF computer modeling system was used to simulate the injection of pollutants into the atmosphere from the two proposed elevated stacks, followed by the meteorological processes affecting the subsequent transport and dispersion through the atmosphere. CALPUFF is an advanced, non-steady-state Gaussian dispersion model that simulates the effects of time- and space-varying meteorological conditions on pollutant transport, transformation and removal. CALPUFF has been adopted by the United States Environmental Protection Agency (EPA) in its Guideline on Air Quality Models (EPA, 2005) as a preferred model for assessing the long range transport of pollutants.

The model simulated a typical annual cycle of meteorology in order to estimate the long-term effects of emissions from the source. Detailed meteorological data for 1996 were obtained from the Penn State/NCAR Mesoscale Modeling System, Version 5 (MM5), a prognostic model with four dimensional data assimilation. The 36 km MM5 data were augmented by ambient surface meteorological measurements, including wind speed and direction, temperature, and precipitation data.

A more detailed description of the modeling process is included in Appendix A. Appendix B (CD-ROM) consists of a number of the input and output files used in performing the model application.

Model Results

The annual wet and dry deposition rates of sulfur, nitrogen, PM_{10}, and the three emitted mercury species (elemental mercury, reactive gaseous mercury and particulate mercury), as a consequence of the emissions from the proposed Cypress Creek power plant (Table 1), were estimated by the model at each of 8,096 "receptor" locations (spaced every 9 km on a gridded array) within the area modeled, or "modeling domain" shown in Figure 2.

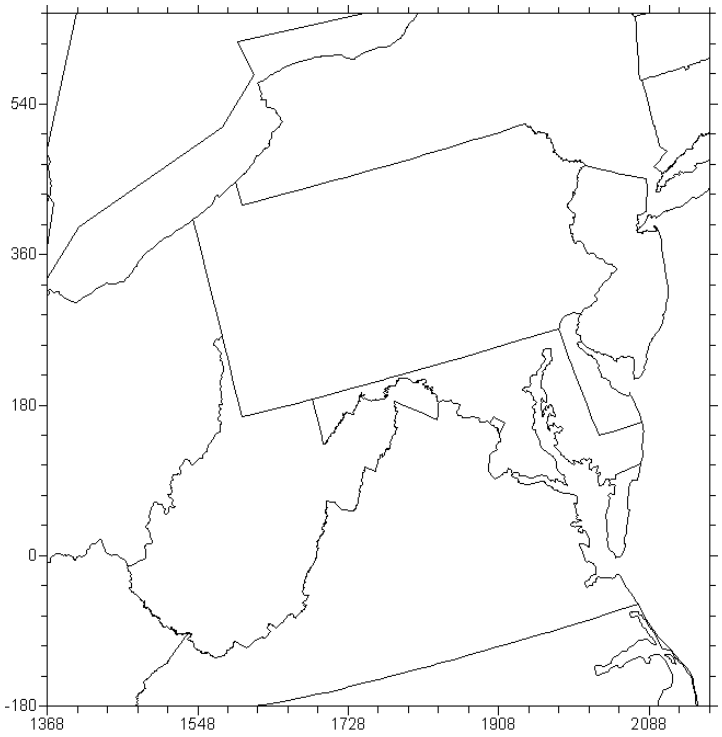

Figure 2. CALPUFF modeling domain

The model predicted that there would be significant (non-negligible) amounts of each of the modeled pollutants deposited in a large area surrounding the proposed source. For example, the annual rate of mercury deposition would exceed 0.1 g/km^2 over a 63,500 km^2 area, an area greater than half of the Commonwealth of Virginia. In addition, elevated levels of mercury deposition, exceeding 0.5 g/km^2 per year, are predicted to occur in a large area (4,300 km^2) surrounding the proposed source (an area equivalent to a circle with a diameter of 74 km). The model estimated that 4.6 percent of the proposed plant's mercury emissions, accounting for more than 9½ lb of mercury each year, would be deposited within this 4,300 km^2 area surrounding the proposed source.

Figures 3 and 4 show the model results for mercury deposition over the modeling domain (each small square represents a 9 km by 9 km gridded receptor cell). The area where mercury deposition due to emissions from the proposed source would exceed 0.1 g/km^2 is shown within the light yellow area in the lower right of Figure 3a. This same area (where mercury deposition would exceed 0.1 g/km^2) is shown using the same light yellow color in Figure 3b, which shows results for the southeastern portion of the modeling domain. The 4,300 km^2 area surrounding the proposed source where mercury deposition exceeds 0.5 g/km^2 is shown within the smaller bright yellow area in Figure 3a. Figure 3b shows deposition levels up to 1.0 g/km^2, including higher deposition levels within the inner yellow area of Figure 3a. Figure 4 is a three-dimensional representation of the same information as shown in Figure 3a.

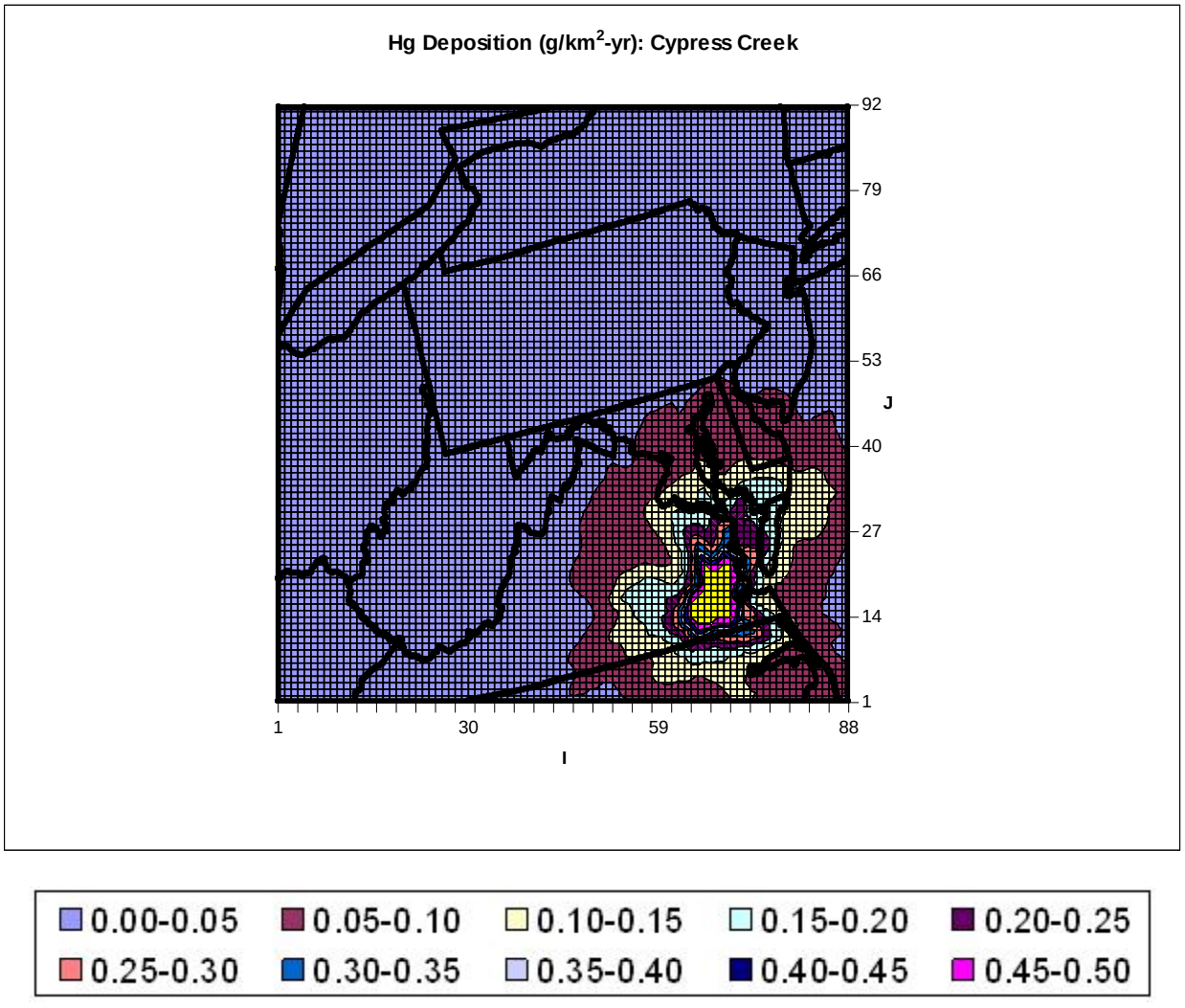

Figure 3a. Annual mercury deposition (g/km^2) due to emissions from the proposed Cypress Creek Power Plant
(The inner bright yellow area corresponds to annual mercury deposition exceeding 0.5 g/km^2.)

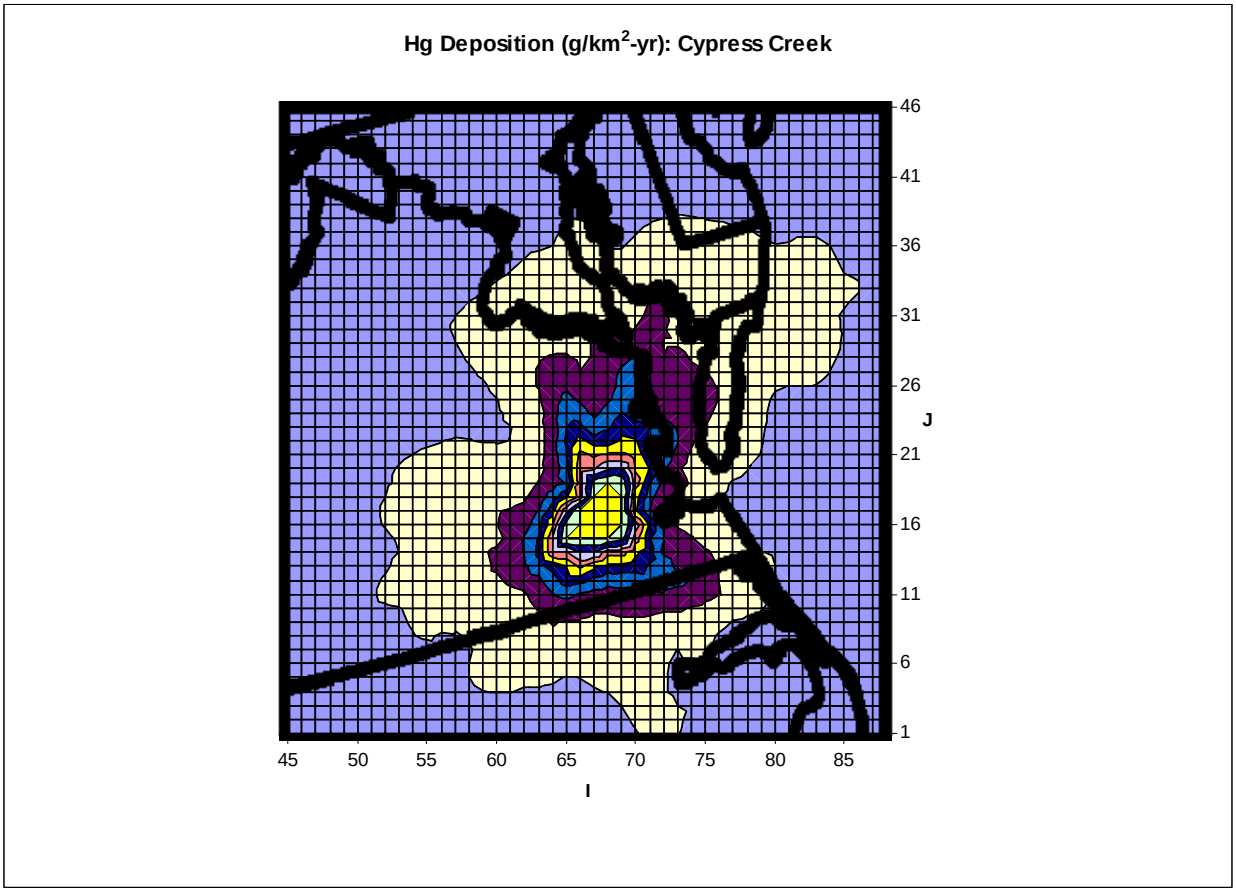

Figure 3b. Annual mercury deposition (g/km^2) due to emissions from the proposed Cypress Creek Power Plant; southeastern portion of modeling domain
(The inner bright yellow area corresponds to annual mercury deposition exceeding 1.0 g/km^2.)

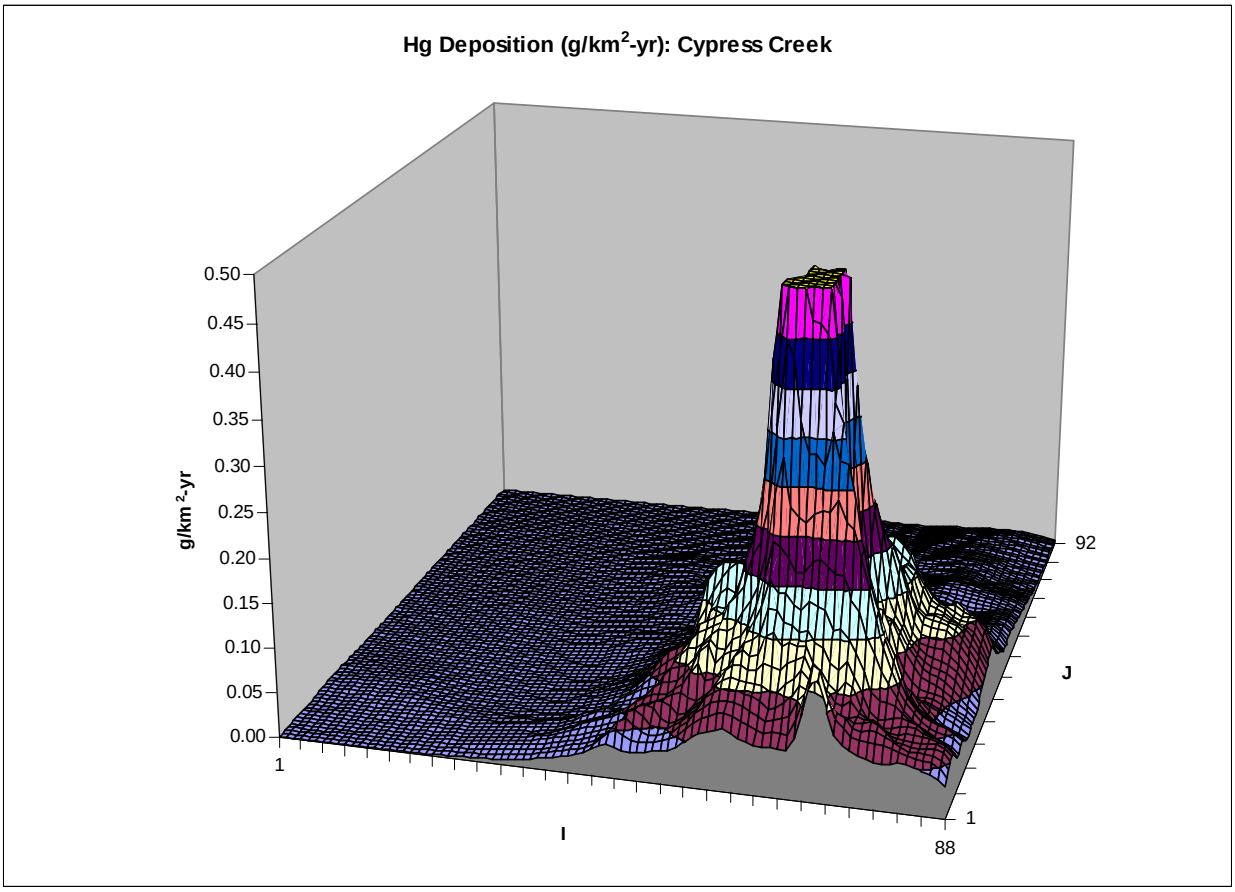

Figure 4. Annual mercury deposition (g/km^2) due to emissions from the proposed Cypress Creek Power Plant.

The model results were aggregated within a number of "sensitive receptor" areas to account for the total amount of annual deposition within each geographical area. Table 2 shows the predicted amounts of sulfur, nitrogen, PM_{10} and mercury that would be deposited annually (1) within the Chesapeake Bay Watershed ("Watershed"), (2) to the water surface of the Chesapeake Bay ("Bay"), and (3) within the Commonwealth of Virginia ("Virginia"). The deposition to each of these three areas is discussed, below.

Table 2. Total Annual Deposition due to Emissions from the Proposed Cypress Creek Power Plant

	WATERSHED	BAY	VIRGINIA
SULFUR, tons	264.4	29.9	279.2
NITROGEN, tons	118.2	10.1	110.9
PM_{10}, tons	286.6	30.5	299.4
MERCURY, lb	26.4	2.9	29.9

Deposition to the Chesapeake Bay Watershed

The Chesapeake Bay Watershed includes all the land surrounding the streams and tributaries that ultimately flow into the bay, and all the waters of the bay. The outline of the Chesapeake Bay Watershed is shown on a composite satellite view in Figure 5. The watershed extends through six states (and D.C.) from Virginia northward into New York, encompassing an area of approximately 170,000 km^2, as shown in Figure 6. The proposed Cypress Creek power plant is located just outside the southern edge of the watershed; however a large portion of the emissions from the proposed plant will be transported and deposited within the watershed. A number of major and secondary rivers empty into the Chesapeake Bay, including the James, York, Rappahannock, Potomac, Patuxent, and Patapsco to the west, the Gunpowder, Bush, Susquehanna, Northeast, Elk, and Sassafras to the north, and the Chester, Choptank, Nanticoke, Wicomico, and Pocomoke to the east.

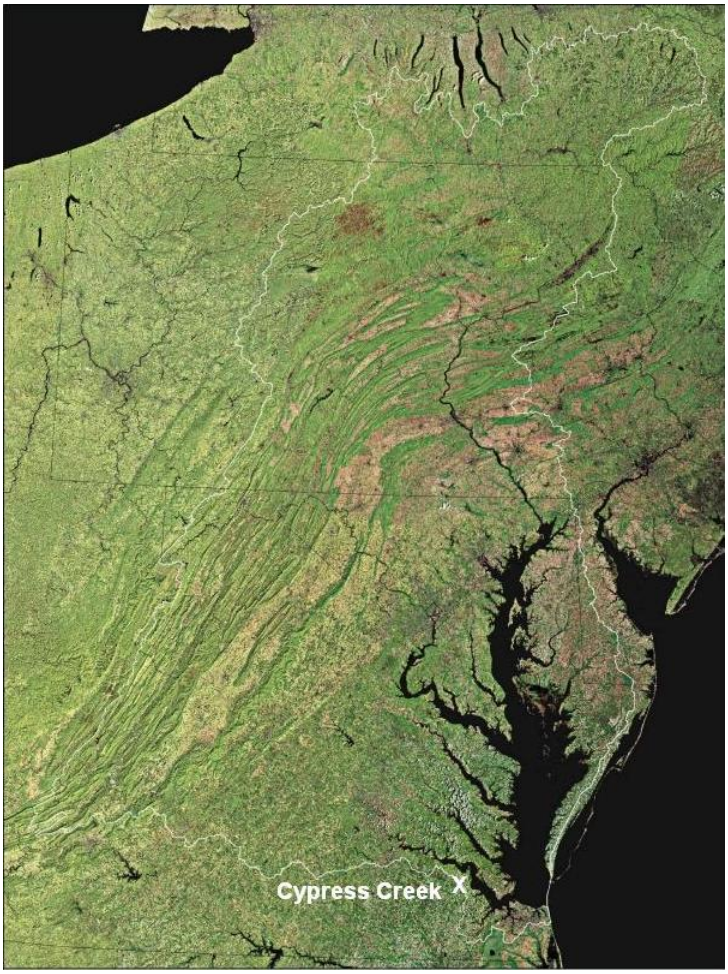

Figure 5. Chesapeake Bay Watershed, showing the location of the proposed Cypress Creek power plant

The model predicted that over 260 tons of sulfur and about 118 tons of nitrogen would be deposited within the Chesapeake Bay Watershed each year due to emissions from the proposed Cypress Creek plant. Between 10 and 15 percent of both the sulfur and nitrogen emissions from the proposed power plant would be deposited within the watershed. The model results also indicate that almost 16 percent of the Cypress Creek's PM_{10} emissions will be deposited within the Chesapeake Bay Watershed, accounting for more than 280 tons per year of fine particulate matter deposition.

The annual deposition of mercury to the Chesapeake Bay Watershed was estimated to be 26 lb (12 kg), which is more than 12 percent of the total mercury emissions from the proposed plant. As expected, the reactive gaseous mercury (RGM) emissions account for the majority of the mercury deposition (24 lb/yr).

Figure 6. Chesapeake Bay Watershed

Deposition to the Chesapeake Bay

The Chesapeake Bay is the largest estuary in the United States, with an approximate area of 11,600 km^2. The bay and its shoreline (total shoreline: 18,800 km) are home to a diverse ecosystem of vegetation, fish, and other wildlife. The bay (the dark area in Figure 6) is quite shallow in many places; about one quarter of its area is less than 2 m in depth. Fish consumption advisories have been issued in every state in and around the Chesapeake Bay due to high levels of mercury measured in fish tissue (U.S. EPA, 2007).

The CALPUFF model was used to estimate the airborne sulfur, nitrogen, PM_{10}, and mercury that would be deposited directly onto the water surface of the Chesapeake Bay due to the proposed Cypress Creek power plant's emissions. The results are shown in the column labeled "Bay" in Table 2. The model estimated that 30 tons of sulfur, 10 tons of nitrogen, just over 30 tons of PM_{10} and almost 3 lb (1.3 kg) of mercury would be deposited directly to the surface of the Chesapeake Bay each year as a result of the proposed plant's emissions, accounting for between 1 and 2 percent of the emissions of each of these pollutants.

Deposition within the Commonwealth of Virginia

The model was also used to estimate the deposition of mercury within the borders of the Commonwealth of Virginia (see column labeled "Virginia" in Table 2). The Virginia Department of Health (2008) has issued fish consumption advisories for many of the waterways within the Commonwealth of Virginia due to high levels of mercury and other contaminants measured in fish tissue. The modeled area was 100,861 km^2, accounting for almost the entire state. A significant fraction of the emissions of each of the modeled pollutants would be deposited within the Commonwealth of Virginia. The model predicted that between 12 and 16 percent of the plant's emissions of sulfur, nitrogen, PM_{10} and mercury would be deposited within the Commonwealth of Virginia, accounting for almost 280 tons of deposited sulfur; over 110 tons of nitrogen; almost 300 tons of PM_{10}; and 30 lb (13.6 kg) of deposited mercury annually.

The Virginia Department of Health (2008) has issued fish consumption advisories for many of the waterways within the Commonwealth of Virginia due to high levels of mercury and other contaminants measured in fish tissue.

Deposition to Other Areas Sensitive to Mercury Deposition

Many waterways in the Chesapeake Bay region have been contaminated with mercury and other pollutants. The Commonwealth of Virginia has issued fish consumption advisories due to measured unhealthful levels of mercury for a number of waterways, including the Pamunkey River, Dragon Run Swamp, and the Great Dismal Swamp Canal (Virginia Department of Health, 2008). The locations of these three sensitive receptors are shown on the gridded modeling domain in Figure 7.

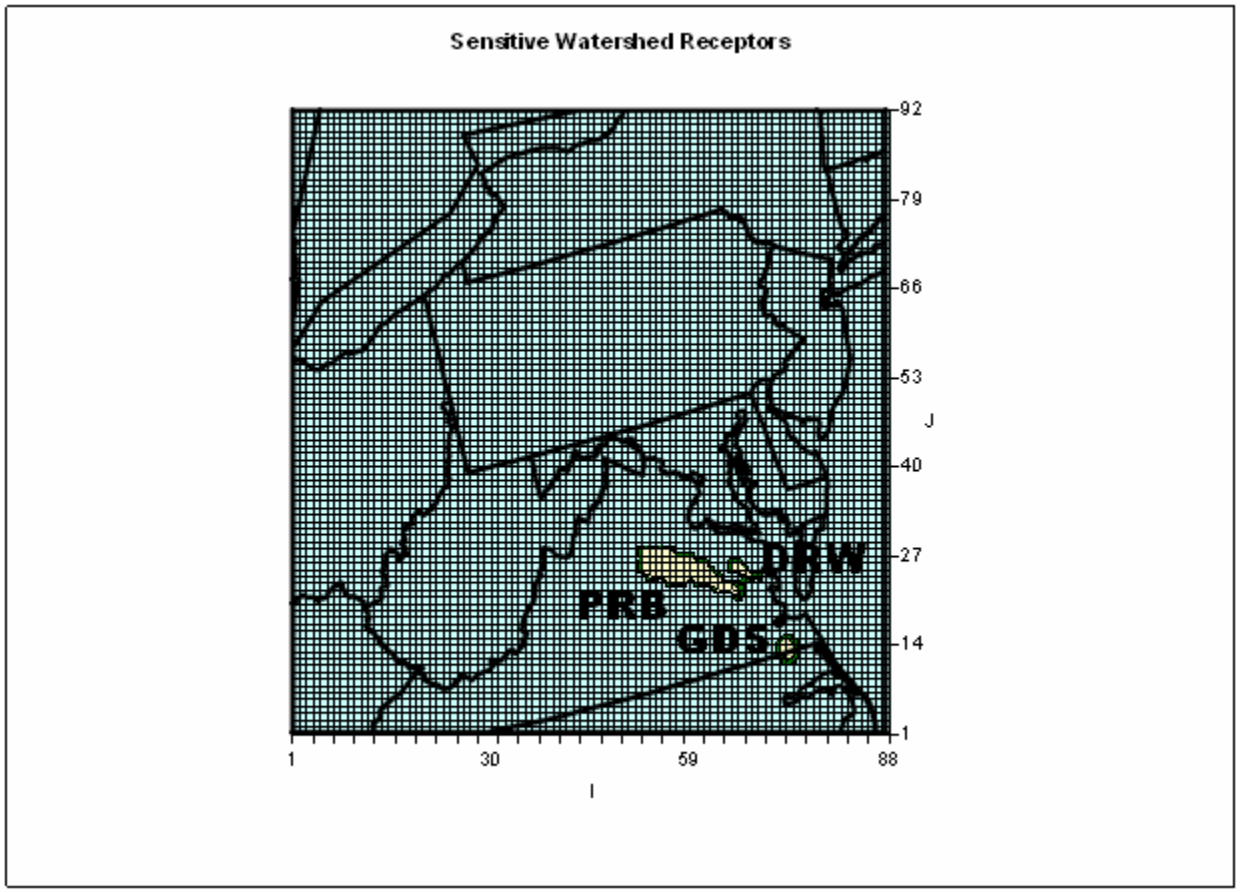

Figure 7. Sensitive Receptors; Pamunkey River Basin (PRB), Dragon Run Watershed (DRW), and Great Dismal Swamp NWR (GDS)

Recently, fish consumption advisories have been added or modified due to mercury contamination at a number of additional water bodies in Virginia, including the Roanoke River which drains into the Kerr Reservoir, and the Blackwater River and Nottoway River Watersheds within the Albemarle-Chowan coastal drainage region, and the James River Basin (Virginia Department of Health, 2008).

Results of the CALPUFF dispersion model were used to estimate the amount of pollutants emitted by the proposed Cypress Creek facility that would be deposited in each of the seven "sensitive receptors" that have been found to be contaminated with mercury. Table 3 shows the estimated annual deposition of Cypress Creek emissions within each of the sensitive receptor areas.

Table 3. Total Annual Deposition to Sensitive Receptors

	PAMUNKEY RIVER	DRAGON RUN	DISMAL SWAMP
SULFUR, tons	10.2	2.2	2.3
NITROGEN, tons	4.6	0.8	0.8
PM_{10}, tons	11.4	2.3	1.5
MERCURY, lb	1.1	0.2	0.3

	ROANOKE	BLACKWATER	NOTTOWAY	JAMES RIVER
SULFUR, tons	20.1	43.6	31.4	67.7
NITROGEN, tons	10.3	13.5	11.5	29.0
PM_{10}, tons	23.2	50.2	28.7	75.8
MERCURY, lb	1.9	5.3	3.4	7.2

Pamunkey River Basin. The Pamunkey River is a tributary of the York River. The Pamunkey River drains the North Anna, South Anna and Little Rivers in Louisa and Hanover Counties, flowing past the Pamunkey Indian Reservation to the town of West Point, where it meets the Mattaponi River to form the York River. The total area of the Pamunkey River Basin is 3,818 km^2, or about 3.4 percent of Virginia. The Pamunkey River Basin (USGS watershed cataloging unit: 02080106), shown in Figure 8, represents about 2 percent of the total Chesapeake Bay Watershed. Fish consumption advisories were established for the Pamunkey and Mattaponi Rivers in 2004 due to high levels of mercury in largemouth bass and blue catfish (Virginia Department of Health, 2008).

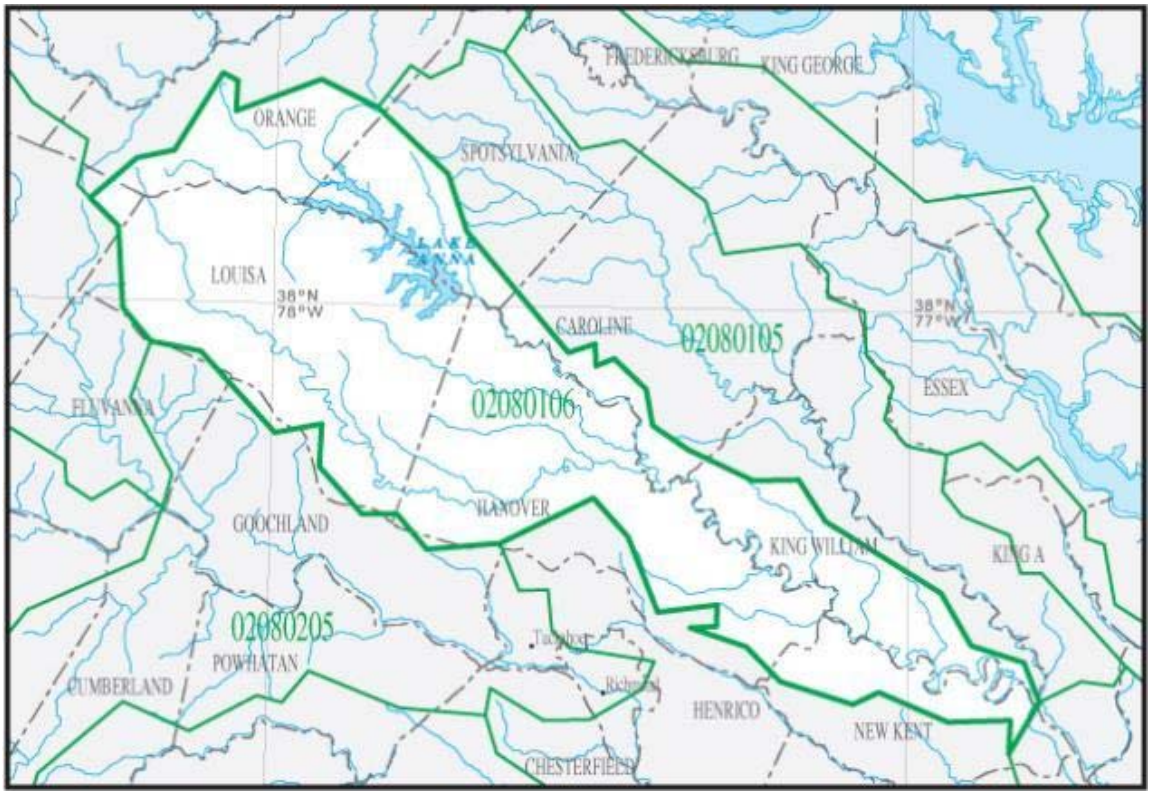

Figure 8. Pamunkey River Watershed (USGS cataloguing unit 02080106)

The model estimated that emissions from the proposed Cypress Creek power plant would contribute significant quantities of each of the modeled pollutants to the Pamunkey River Basin. The proposed source would deposit over 1 lb (0.5 kg) of mercury annually to the Pamunkey River Basin. The proposed source would also deposit over 10 tons of sulfur, 4½ tons of nitrogen, and over 11 tons of PM_{10} to the Pamunkey River Basin each year.

Figure 9. Sweet Hall Marsh, located on the lower Pamunkey River

Dragon Run Watershed. The Dragon Run is a forty-mile brackish water stream, located at the headwaters of the Piankatank River, characterized by extensive non-tidal and tidal cypress swamp. The stream flows through the Virginia Middle Peninsula counties of Essex, King and

Figure 10. Dragon Run Watershed

Queen, Middlesex, and Gloucester. Fed by underground springs, surface runoff and numerous feeder swamps, the Dragon Run twists and turns, meandering through the four-county area, eventually emptying at the headwaters of the Piankatank River, which ultimately flows into the Chesapeake Bay. The Dragon Run is recognized by the Smithsonian Institute as Virginia's most pristine water body to empty into the Chesapeake Bay. The Dragon Run Watershed, shown on the map in Figure 10, consists of 363 km^2, of which 10 percent are wetlands.

The Dragon Run, along with the surrounding Dragon Run Swamp, is almost entirely undeveloped, forming an ecologically unique system with excellent water quality and numerous and diverse species of flora and fauna. The watershed is characterized by dense stands of hardwoods with occasional upland ridges extending to the stream's edge. The Dragon Run supports both recreational fishing and excellent game and non-game wildlife. There is very little evidence of man's presence, essentially maintaining a primitive character throughout the entire watershed (Grymes, 2008). A fish consumption advisory was issued in 2003 for the Dragon Run Swamp due to high levels of mercury in largemouth bass (Virginia Department of Health, 2008).

Figure 11. Dragon Run

The model estimated that the proposed Cypress Creek power plant would be responsible for over 2 tons of sulfur, 0.8 tons of nitrogen, 2 tons of PM_{10}, and 0.24 lb (110 grams) of mercury deposition annually within the Dragon Run Watershed.

Great Dismal Swamp. The Great Dismal Swamp National Wildlife Refuge (NWR) is a largely inaccessible marshy region located in southeastern Virginia and northeastern North Carolina. The refuge consists of 444 km^2 of forested wetlands, including the Dismal Swamp Canal and Lake Drummond, a 13 km^2 lake located in the heart of the swamp (the larger of only two natural freshwater lakes in Virginia). The Great Dismal Swamp NWR is located between two eco-regions, which allows for a wide range of plant and animal species. Cypress, tupelo, maple and pine are the predominant tree species found on the refuge, supporting the vast wildlife including

black bear, bobcat, otter and weasel, along with over 70 species of reptiles and amphibians. More than 200 bird species can be found at the swamp throughout the year, and almost 100 of those are known to nest on the refuge (U.S. Fish and Wildlife Service, 2009).

The waters of Lake Drummond and the Great Dismal Swamp naturally flow southward into North Carolina, emptying into the Pasquotank River and Albemarle Sound. However, the Feeder Ditch and the Dismal Swamp Canal connect the lake (and Albemarle Sound) with the Elizabeth River which empties into the Chesapeake Bay, via the Deep Creek Locks, to the north. A fish consumption advisory was issued for the Great Dismal Swamp Canal in 2003 due to high levels of mercury found in bowfin and chain pickerel (Virginia Department of Health, 2008).

The model predicted that emissions from the proposed Cypress Creek power plant will cause an additional 2 tons of sulfur, 0.8 tons of nitrogen, 1½ tons of PM_{10}, and 0.26 lb (119 grams) of mercury deposition within the Great Dismal Swamp NWR each year.

Figure 12. Lake Drummond, Great Dismal Swamp NWR

Kerr Reservoir/Roanoke River. The Kerr Reservoir is located along the Virginia – North Carolina border, in Mecklenburg County, VA, and Vance, Granville and Warren Counties in NC. The John H. Kerr Dam was constructed in 1952 just upstream of Buggs Island on the Roanoke River (also called the Staunton River) for flood control and for hydropower generation. The resulting 50,000 acre reservoir has over 850 miles of shoreline, where popular recreational activities include boating, camping, swimming, picnicking, hiking, and hunting. The reservoir provides habitat for many game fish species. The Kerr Reservoir is widely known for its large-mouth bass and striped bass fishing. In August 2007, fish consumption advisories were issued

for the Kerr Reservoir, the Dan River and a portion of the Roanoke River due to high levels of mercury found in largemouth bass, white bass, and striped bass (Virginia Department of Health, 2008).

The Roanoke River flows from the foothills of Virginia's Blue Ridge Mountains to North Carolina's northern coast before emptying into the Albemarle Sound. Spanning close to 400 miles, the Roanoke carries more water than any other river in North Carolina, supplying over half of Albemarle Sound's fresh water. As it flows from the Appalachian foothills to the flat coastal plains of North Carolina, the river changes from narrow and lively to broad and slow. In the coastal lands, its swampy floodplains are sometimes five miles wide. With its springtime tendency to overflow, the river nourishes the basin with a rich blanket of organic sediment. The Roanoke River Basin and the John H. Kerr Dam are shown on the map in Figure 13.

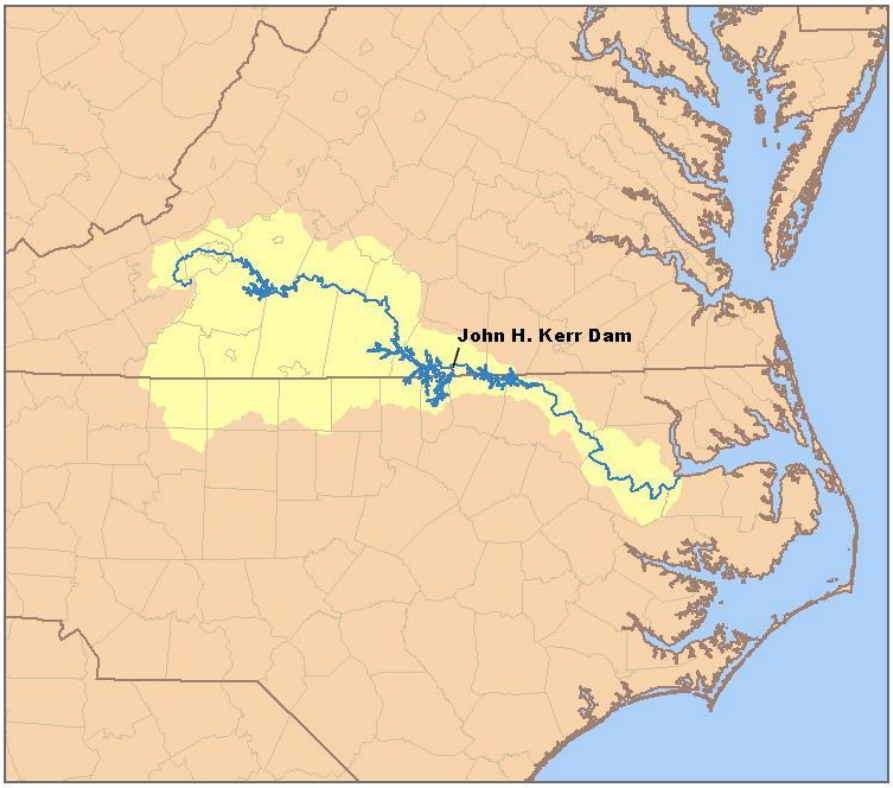

Figure 13. Roanoke River Basin

The dam, at about 300 ft elevation, is the terminus point for the Middle Roanoke River Watershed, which is downstream of four other tributary watersheds. These five watersheds make up the upper portion of the Roanoke River Basin (USGS watershed accounting unit: 030101), as shown in Figure 14. A combined watershed was defined for this analysis, consisting of the Kerr Reservoir and all its tributaries. The Middle Roanoke Watershed (03010102) is fed by the Upper Roanoke (03010101), Upper Dan River (03010103), Lower Dan River (03010104), and the Bannister River (03010105).

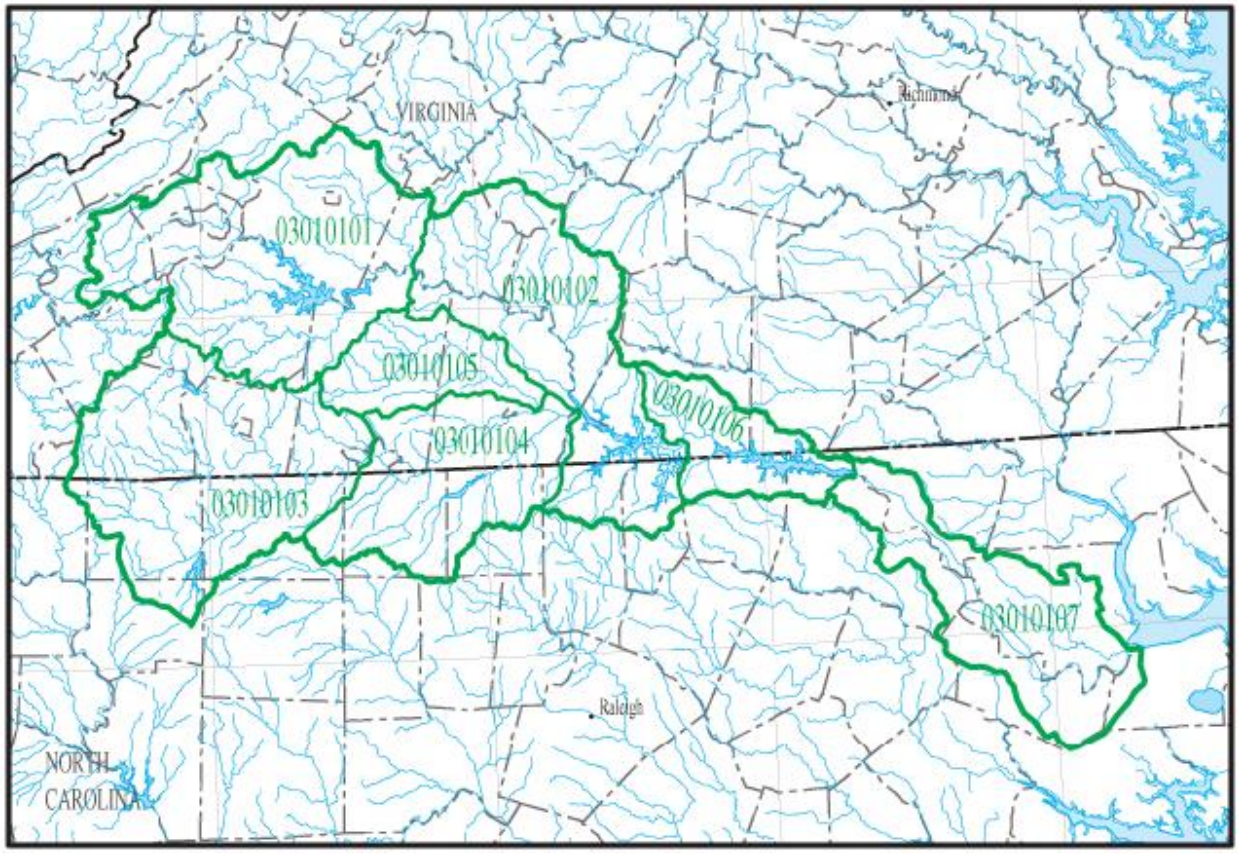

Figure 14. Roanoke River Basin (with USGS cataloging units)

The amount of pollutant deposition within the combined five-watershed receptor area (the Kerr Reservoir and all its tributaries; area: 20,202 km^2) due to emissions from the proposed Cypress Creek power plant was estimated by the CALPUFF model. The model estimated that the proposed power plant would deposit more than 20 tons of sulfur, over 10 tons of nitrogen, and 23 tons of PM_{10} onto the Kerr Reservoir and its tributaries each year. The proposed power plant would also cause the deposition of 1.9 lb (880 grams) of mercury annually to the combined watershed. (Note: Less than 4 percent of the combined watershed area is outside the modeling domain; the estimated deposition totals are for deposition within the modeling domain only; the modeled area is 19,467 km^2.)

Figure 15. John H. Kerr Dam and Reservoir

Blackwater and Nottoway River Watersheds. The Chowan River flows into the Albemarle Sound in North Carolina. Major tributaries of the Chowan include the Blackwater and the Nottoway, which join to form the Chowan at the Virginia – North Carolina state line (see Figure 16). Fish advisories have been established for both the Blackwater and Nottoway Rivers due to high levels of mercury found in many fish species, including largemouth and smallmouth bass, sunfish, bowfin, and chain pickerel.

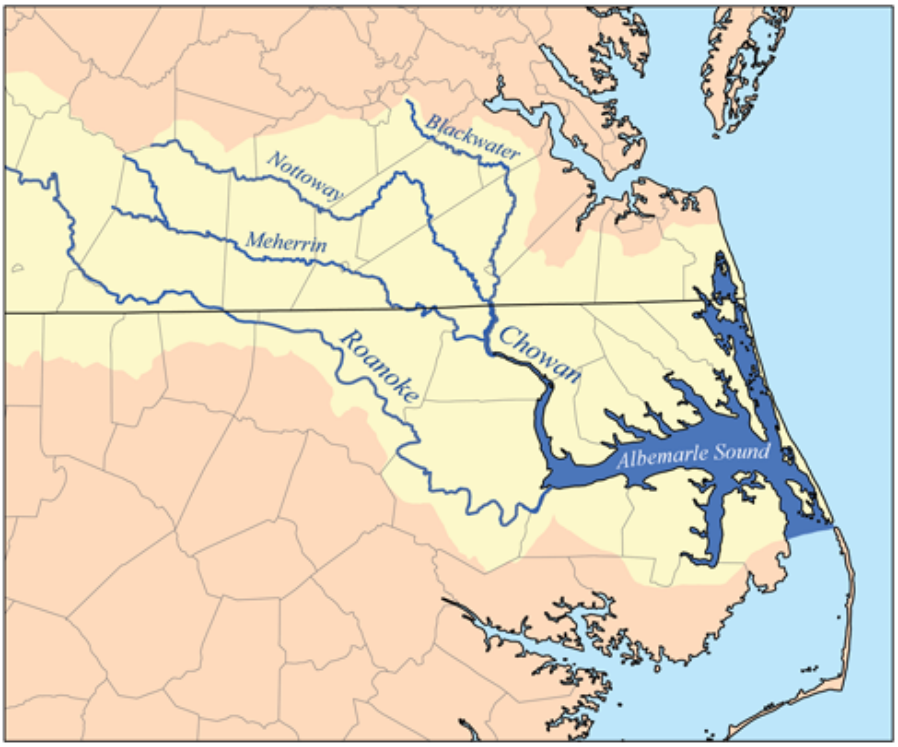

Figure 16. Chowan River Basin

The Blackwater originates as a coastal plain swamp in Prince George County. It flows east through braided channels of bald cypress and tupelo in Surry County. The river then turns south along the Southampton County line where several boat ramps are accessible for anglers, hunters and boaters. The Nottoway is a scenic river, with a minimum of development that also maintains a diverse fishery. It begins in Nottoway County, turns northeast in Sussex County, then heads southward through Southampton County until it forms the Chowan River in North Carolina at its confluence with the Blackwater River. The Blackwater River Watershed (USGS watershed 03010202; area: 1,927 km^2) and the adjacent (to the west) Nottoway River Watershed (03010201; area: 4,403 km^2) are shown in Figure 17. The proposed Cypress Creek power plant would be located less than one mile north of the Blackwater River, as shown in Figure 17.

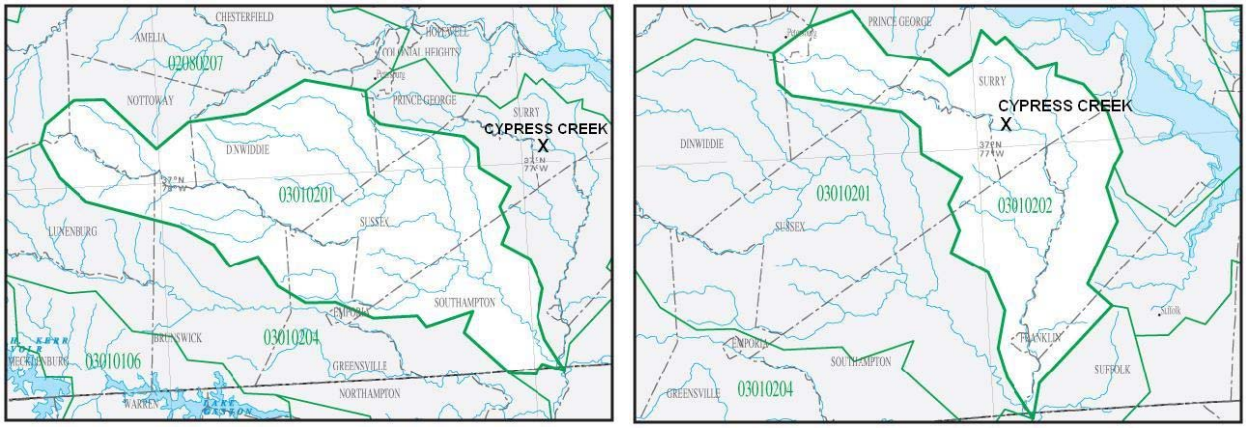

Figure 17. Nottoway River Watershed (03010201), left, and Blackwater River Watershed (03010202), right

Results of the CALPUFF modeling application were used to estimate the impact of the proposed Cypress Creek power plant's emissions on pollutant deposition rates within the Blackwater River and Nottoway River Watersheds. The model estimated that the proposed power plant would add over 43 tons of sulfur, 13½ tons of nitrogen, and 50 tons of PM_{10} to the Blackwater River Watershed each year. Emissions from the proposed power plant would also increase the annual deposition in the Nottoway River Watershed by 31 tons of sulfur, 11½ tons of nitrogen, and almost 29 tons of PM_{10}. According to these model results, between 2 and 3 percent of the sulfur and PM_{10} emitted from the proposed power plant, and about 1½ percent of the emitted nitrogen, would be ultimately deposited within the Blackwater River Watershed that surrounds the source. Between 1 and 2 percent of the emitted sulfur, nitrogen and PM_{10} would also be deposited into the nearby Nottoway River Watershed.

The model estimated that the proposed power plant would increase the level of mercury deposition in the Blackwater River Watershed by 5.3 lb (2.4 kg) per year, and would result in the deposition of 3.4 lb (1.5 kg) of mercury each year within the neighboring Nottoway River Watershed. The model predicted that 2½ percent of the total mercury that is emitted from the

proposed power plant would eventually be deposited within the Blackwater River Watershed, and 1.6 percent of the emitted mercury would be deposited within the Nottoway River Watershed.

The proposed Cypress Creek power plant would be located within the Blackwater River Watershed. As a consequence, a larger relative amount of the power plant's emissions would be deposited in a given area of this watershed than the other sensitive receptors (see Table 4, below). The average annual rate of mercury deposition across the Blackwater River Watershed was estimated to be 1.24 g/km^2.

Figure 18. Nottoway River

James River Basin Watershed. The James River Basin (Figure 19) consists of the region in which precipitation will ultimately drain into the Chesapeake Bay via the James River. The James River Basin Watershed is Virginia's largest river basin; it accounts for almost one fourth the area of the Commonwealth of Virginia. The watershed includes about 4 percent open water and includes a population of about 2.5 million people. Over 65 percent of the watershed is forested, with 19 percent in cropland and pasture. The remaining 12 percent is considered urban. The James River Basin (USGS accounting unit 020802; area = 26,418 km^2) is made up of eight smaller watersheds: Upper James (USGS cataloging unit 02080201), Maury (02080202), Middle James-Buffalo (02080203), Rivanna (02080204), Middle James-Willis (02080205), Lower James (02080206), Appomattox (02080207), and Hampton Roads (02080208), as shown in Figure 20.

Figure 19. James River Basin

Including its Jackson River source, the James River is over 400 miles long. It is the twelfth longest river in the United States that remains entirely within one state. The James River forms in the Allegheny Mountains, near Iron Gate on the border between Alleghany and Botetourt counties from the confluence of the Cowpasture and Jackson Rivers, and flows into the Chesapeake Bay at Hampton Roads. Tidal waters extend west to Richmond at its fall line (the head of navigation). Larger tributaries draining to the tidal portion include the Appomattox River, Chickahominy River, Warwick River, Pagan River, and the Nansemond River. The James contributes about 12 percent of the streamflow from the non-tidal part of Chesapeake Bay Basin, making it the third largest streamflow source after the Susquehanna and the Potomac Rivers.

The James River and its tributaries contain numerous parks and other recreational attractions. Canoeing, fishing, kayaking, hiking, and swimming are some of the activities that people enjoy along the river during the summer months. From the river's start in the Blue Ridge Mountains to Richmond, numerous rapids and pools offer fishing and whitewater rafting. The most intense whitewater stretch is a two mile segment that ends in downtown Richmond where the river goes over the fall line. This is the only place in the country where extensive class III (class IV with above average river levels) whitewater conditions exist within sight of skyscrapers. Below the fall line (east of Richmond), the river is better suited for water skiing and other large boat recreation. Here the river is known for its blue catfish, reaching average sizes of 20 to 30 pounds, with frequent catches exceeding 50 pounds. Within the Chesapeake Bay Watershed, the James River is the last confirmed holdout for the nearly extirpated Atlantic sturgeon. A May 2007 survey identified 175 sturgeon remaining in the entire river, with 15 specimens exceeding five feet. Fishing is also popular along the Chickahominy, both above and below Walker's Dam. Among the most populated are blue catfish, largemouth bass, river herring, striped bass, shad, river herring, and yellow perch.

Fish consumption advisories have been issued due to mercury (July 2006) in two locations in the lower James River Watershed (Harrison Lake and the Chickahominy Lake portion of the Chickahominy River, above Walker's Dam). In addition, public health advisories were issued in September 2006, due to elevated levels of mercury, which recommend that ingestion of largemouth bass from Lake Trashmore (Virginia Beach City) be limited, and that carp not be eaten at all from Lake Whitehurst (Norfolk City).

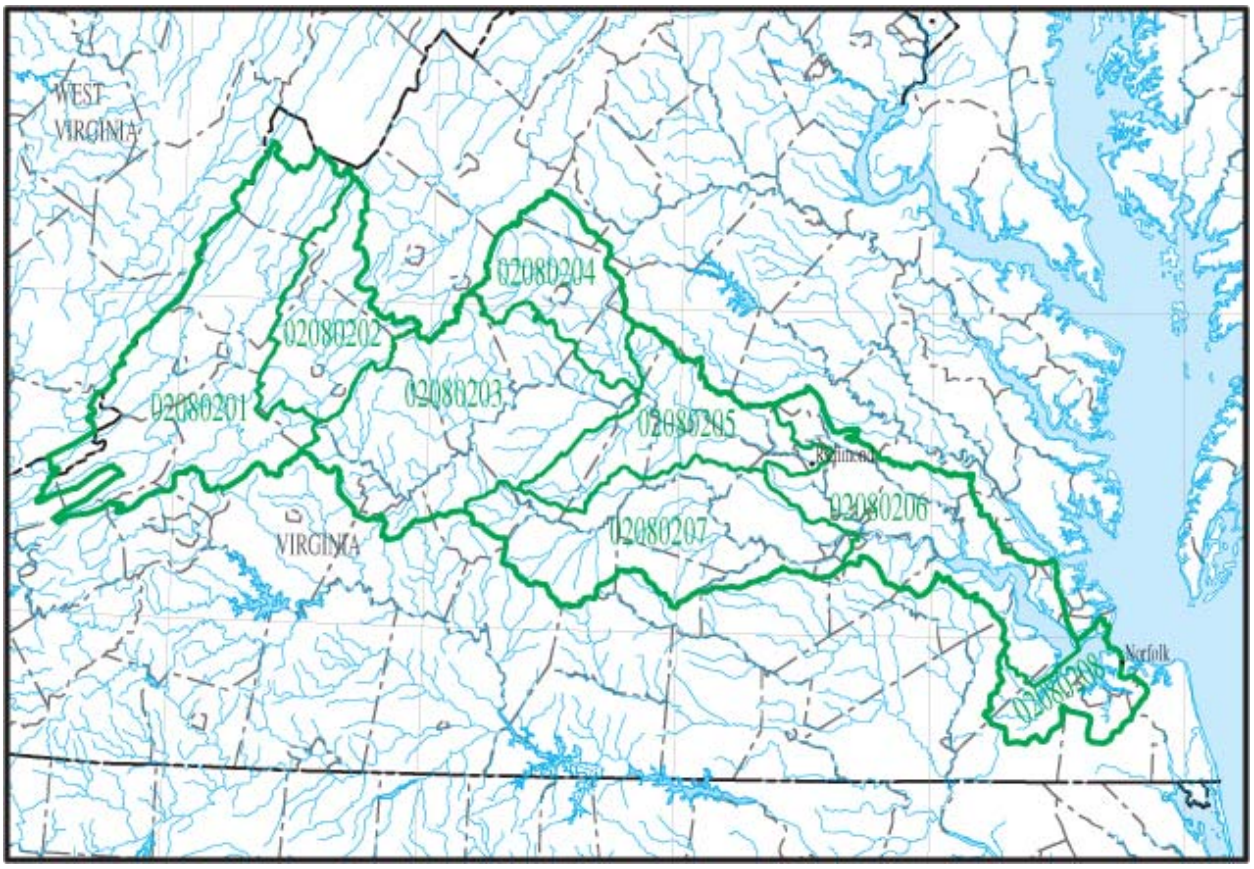

Figure 20. James River Basin (with USGS cataloging units)

The CALPUFF model results were used to estimate the levels of pollutant deposition within the James River Basin due to emissions from the proposed Cypress Creek power plant. The model estimated that the proposed power plant would be responsible for almost 68 tons of additional sulfur deposition, 29 tons of nitrogen deposition, and over 75 tons of PM_{10} deposition within the James River Basin each year. In addition, more than 7 lb (3.3 kg) of mercury would be deposited annually within the James River Basin due to emissions from the proposed power plant. More than 3 percent of the total mercury emitted by the proposed power plant would be deposited within the James River Basin.

Figure 21. Huntington Park Beach on the James River

Average Rate of Mercury Deposition within Each Sensitive Receptor

Dividing the total mass of mercury that would be deposited within each receptor by the total area of the receptor provides a comparison of the relative deposition rates between receptors. Not surprisingly, the Blackwater River Watershed, which includes the proposed source location, exhibits a much higher relative rate of deposition (1.24 g/km^2) than all other receptor areas. The sensitive receptor areas that are close to the proposed source (Dragon Run and Nottoway River) also had relatively higher rates of mercury deposition (greater than 0.3 g/km^2). The spatial average rates of mercury deposition due to the proposed Cypress Creek power plant are shown in Table 4 for each of the modeled receptor areas.

Table 4. Average Spatial Rates of Mercury Deposition

RECEPTOR	ANNUAL MERCURY DEPOSITION (grams)	AREA (km^2)	AVERAGE MERCURY DEPOSITION RATE (g/km^2)
Chesapeake Bay Watershed	11,966	170,000	0.07
Chesapeake Bay	1,299	11,600	0.11
Virginia	13,560	100,861	0.13
Pamunkey River Basin	512	3,818	0.13
Dragon Run Watershed	110	363	0.30
Great Dismal Swamp	119	444	0.27
Kerr/Roanoke River	880	19,467	0.05
Blackwater River Watershed	2,384	1,927	**1.24**
Nottoway River Watershed	1,543	4,403	0.35
James River Basin	3,263	26,418	0.12

Long-term Deposition Rates

The model results can be used to estimate the long-term impacts at each of the sensitive receptor areas due to the proposed Cypress Creek power plant. The lifetime of a coal-fired power plant is typically greater than 20 years, so one can safely assume that the proposed power plant would operate for at least twenty years. Table 5 shows the total amount of mercury that would be deposited in each of the receptor areas over a 20 year period.

The model estimates that, over a 20 year period, emissions from the proposed power plant would deposit 528 lb of mercury into the Chesapeake Bay Watershed. During the same 20 year period, about 600 lb of mercury would be deposited within the Commonwealth of Virginia, almost one quarter of which (144 lb) would be deposited within the James River Basin. The surface within the Blackwater River Watershed would receive over 100 lb of mercury as a result of this plant's emissions. Both the Nottoway River Watershed (68 lb) and the Kerr Reservoir and its tributary watersheds (39 lb) would also have substantial amounts of mercury deposited over the lifetime of the proposed power plant.

Table 5. Lifetime Mercury Deposition Rates Due to Proposed Cypress Creek Power Plant

RECEPTOR	LIFETIME (20-yr) MERCURY DEPOSITION RATE (lb)
Chesapeake Bay Watershed	528
Chesapeake Bay	57
Virginia	598
Pamunkey River Basin	23
Dragon Run Watershed	5
Great Dismal Swamp	5
Kerr/Roanoke River	39
Blackwater River Watershed	105
Nottoway River Watershed	68
James River Basin	144

Alternative Mercury Emission Levels

As discussed in the footnote on page 1, there is some ambiguity regarding the estimated mercury emissions for the proposed power plant. The CALPUFF modeling was performed assuming that the total mercury emissions for the two proposed boilers would be 210 lb/yr. If, in fact, the MACT level is achieved, resulting in a lower level of mercury emissions, then the model results may be linearly scaled in order to estimate the quantity of mercury deposition due to the proposed power plant's emissions. For example, if the actual mercury emissions from the proposed power plant are 118 lb/yr, then each of the mercury deposition estimates presented above should be scaled by 118/210 (= 0.56) in order to estimate the deposition impacts corresponding to the MACT emissions level (the percentage of total mercury emissions that are deposited within each receptor area remains the same). Table 6 shows the estimated mercury

deposition impact at each modeled receptor for both stated mercury emission levels (the results in the "210 lb/yr" column are identical to the results presented in Tables 2 and 3, above). Similarly, Table 7 shows the average spatial rates of mercury deposition at each receptor area (see Table 4) for both levels of total mercury emissions, and Table 8 shows the lifetime (20-yr) mercury deposition rates due to the proposed power plant (see Table 5).

Table 6. Total Annual Mercury Deposition (lb) due to Variable Levels of Emissions from the Proposed Cypress Creek Power Plant

	Mercury Emissions	
RECEPTOR	**210 lb/yr**	**118 lb/yr**
Chesapeake Bay Watershed	26.4	14.8
Chesapeake Bay	2.9	1.6
Virginia	29.9	16.8
Pamunkey River Basin	1.1	0.6
Dragon Run Watershed	0.2	0.1
Great Dismal Swamp	0.3	0.1
Kerr/Roanoke River	1.9	1.1
Blackwater River Watershed	5.3	3.0
Nottoway River Watershed	3.4	1.9
James River Basin	7.2	4.0

Table 7. Average Spatial Rates of Mercury Deposition (g/km^2) due to Variable Levels of Emissions from the Proposed Cypress Creek Power Plant

	Mercury Emissions	
RECEPTOR	**210 lb/yr**	**118 lb/yr**
Chesapeake Bay Watershed	0.07	0.04
Chesapeake Bay	0.11	0.06
Virginia	0.13	0.08
Pamunkey River Basin	0.13	0.08
Dragon Run Watershed	0.30	0.17
Great Dismal Swamp	0.27	0.15
Kerr/Roanoke River	0.05	0.03
Blackwater River Watershed	1.24	0.69
Nottoway River Watershed	0.35	0.20
James River Basin	0.12	0.07

Table 8. Lifetime Mercury Deposition Rates (lb) due to Variable Levels of Emissions from the Proposed Cypress Creek Power Plant

	Mercury Emissions	
RECEPTOR	**210 lb/yr**	**118 lb/yr**
Chesapeake Bay Watershed	528	296
Chesapeake Bay	57	32
Virginia	598	336
Pamunkey River Basin	23	13
Dragon Run Watershed	5	3
Great Dismal Swamp	5	3
Kerr/Roanoke River	39	22
Blackwater River Watershed	105	59
Nottoway River Watershed	68	38
James River Basin	144	81

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