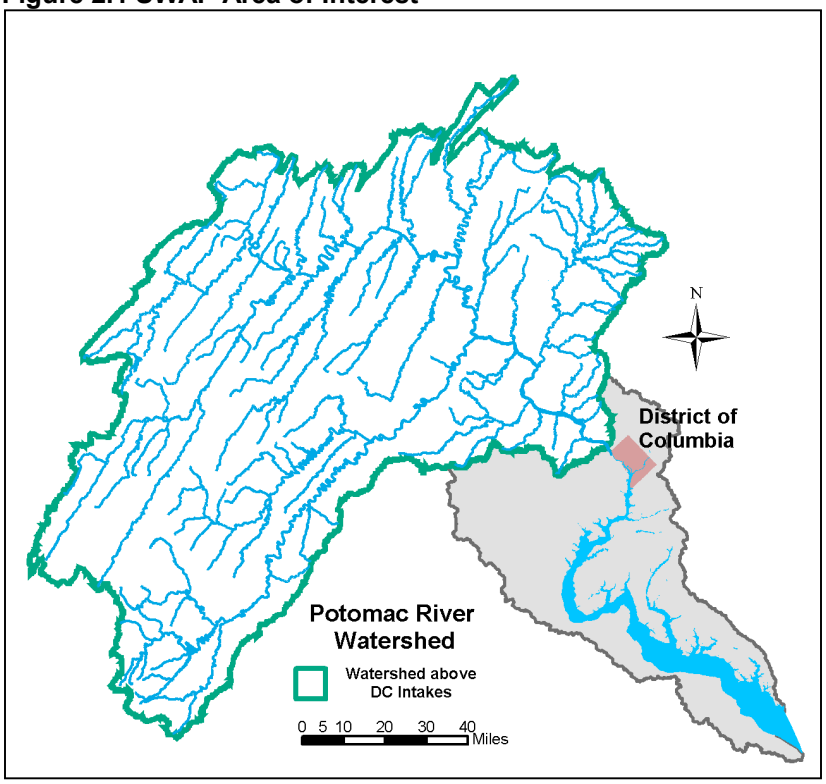
2.1 Source Water Delineation

One of the primary objectives for the DC source water assessment was to delineate the watershed both spatially and temporally and use this information to provide a more accurate picture of activities within the basin that might affect the water quality for the District of Columbia. The spatial boundary analysis combined with the time of travel analysis provided information that identified potential sources of contamination from stationary point sources as well as non-point activities on both a regional and a local level (Chapters 4,5,6). This information will be of value to the District of Columbia for determining potential contaminant sources within the basin as well as predicting arrival times for certain contaminants from activities that could compromise the drinking water quality (Chapter 3). The source waters for the District of Columbia water supply are the Potomac River and its tributaries within the Potomac River Basin above the intake at [REDACTED]. The Potomac River watershed includes portions of Pennsylvania, Maryland, Virginia and West Virginia. The delineations for the source water assessment are based on 11-digit USGS Hydrologic Unit Codes (HUCs). These sub-watersheds and their streams ultimately feed into the Potomac River and provide the water for which DC draws from for its water supply. Figure 2.1 shows the extent of the SWA portion of the basin in relation to the District of Columbia.

Figure 2.1 SWAP Area of Interest



2.2 General Description of Source Water

The Potomac River basin drains the eastern slopes of the Appalachian Highlands and the Coastal Plain in the Mid-Atlantic Region of the United States. The total drainage area of the source waters is approximately 11,500 square miles and extends into four states (Maryland, Pennsylvania, Virginia and West Virginia). The Potomac River extends from its source at Fairfax Stone in W. Virginia to its mouth at the Chesapeake Bay for a total of approximately 383 miles. The total length along the main stem above the intakes is approximately 270 miles.

2.2.1 Physiography

The three major tributaries are the North Branch, with a drainage area of 1,328 square miles, the South Branch, draining 1,493 square miles and the Shenandoah River Basin, with a drainage area of 3,054 square miles. In addition to these principal branches, three other large tributaries enter the main stem below Cumberland, MD; The Cacapon River, Conococheague Creek, and the Monocacy River, with a combined drainage are of 2,216 miles.
The North Branch drains the northwestern portion of the Potomac River basin in Maryland, West Virginia, and Pennsylvania. The South Branch Potomac River and Cacapon River drain the mountainous West Virginia part of the basin. The Shenandoah River drains the broad, relatively flat Shenandoah Valley in Virginia. Conococheague Creek and the Monocacy River drain the northern and northeastern parts of the basin in Maryland and Pennsylvania (Basin Facts, ICPRB). Table 2.1 and 2.2 detail the drainage characteristics for the main stem of the Potomac above the intakes as well as the larger tributaries.

Table 2.1. Major Potomac River Drainage Areas and Hydrography

Reach	Drainage Area (sq. mi.)	Length (mi.)	Average Fall (ft. / mi.)
Confluence North and South Branches of Potomac River	2,821		
Confluence North and South Braches of Potomac River to Hancock, MD	4,073	46	2.9
Hancock, MD to Harpers Ferry, WV	9,371	66	1.7
Harpers Ferry, WV to Brunswick, MD	9,420	7	7.9
Brunswick, MD to C&O Canal Feeder Dam # 2	11,390	32	1.2
C&O Canal Feeder Dam # 2 to Washington DC	11,580	18	9.8

Table 2.2. Principal Tributaries and Hydrography

Stream	Drainage Area (sq. mi.)	Length (mi.)	Average Fall (ft. / mi.)
North Branch	1,328	97	21.3
South Branch	1,493	133	11
Cacapon River	683	113.5	11.8
Conococheague Creek	563	80	18.1
Shenandoah River	3,054	181	6.4
Monocacy River	970	53	3.2

2.2.2Topography

The Potomac River basin lies in three distinct physiographic provinces. The Appalachian Province, the Piedmont Province and the Coastal Plains Province. These major provinces are sub-divided into districts; the Appalachian Province contains the Allegheny Plateau, Valley and Ridge, the Great Valley and the Blue Ridge, the Piedmont contains the Western division and Eastern Division and the Coastal Plain Province contains the Western shore and Eastern shore.

Ridges range in elevation from 1200 to over 4000 feet along the northwest and southeast boundaries. The rolling terrain west and north of the Washington Metro area, range in elevation from 200 to 1000 feet. The remainder of the basin below the fall line ranges in elevation 250 feet to sea level (Basin Facts, ICPRB).

2.3 Basin Geology

Each of the physiographic regions in the Potomac River basin presents its own geologic characteristics (figure 2.2).

The Allegheny Plateau is a high, deeply dissected plateau formed in gently warped rocks of Upper Devonian and Mississippian age. Its high escarpment facing eastward, is known as the Allegheny Front or Allegheny Mountain. Nearly horizontally bedded shales and sandstones and shallow surface soils predominate this region.

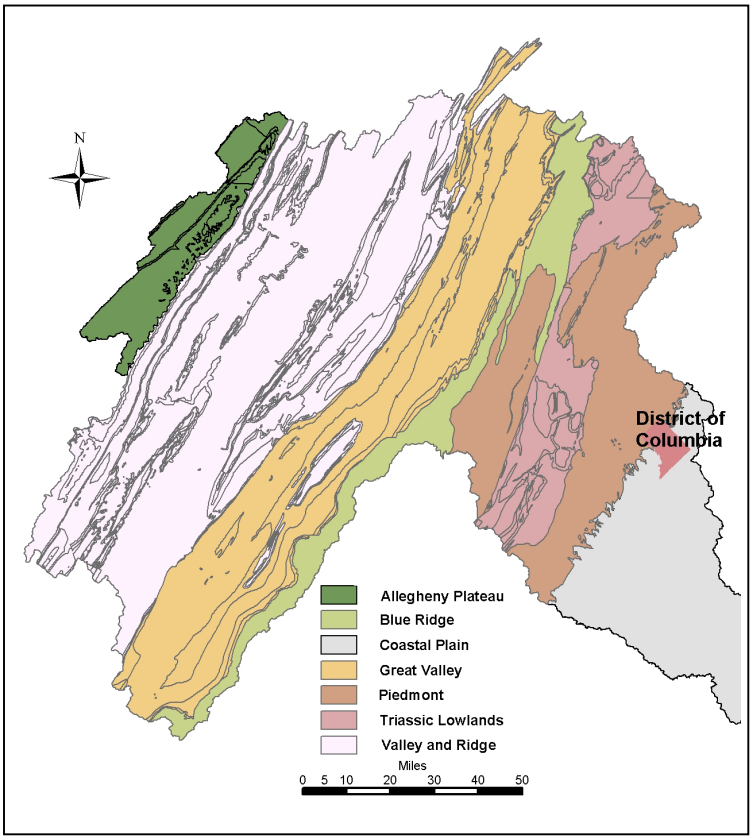
The Ridge and Valley Province includes much more of the basin than any of the other provinces. It extends eastward from the Allegheny Front to the Blue Ridge Mountains. The ridges and valleys are roughly parallel, oriented in a northeasterly-southwesterly direction. This province is composed of intensely folded and faulted

sedimentary rocks that range in age from Cambrian to Devonian. The eastern one-third or more of this province is a broad limestone valley, the Great Valley, drained by the Shenandoah River and Conococheague Creek. This valley is an area of well-developed subsurface drainage and widespread solution cavities. The western two-thirds of the Ridge and Valley Province is characterized by comparatively narrow parallel ridges and valleys with shales predominating in the valleys and the more resistant sandstones generally forming the ridges. Limestones belonging to the Helderberg formation are also present in many of the ridges and valleys.

The Blue Ridge Province is a narrow mountainous belt separating the Ridge and Valley Province from the Piedmont Plateau. This province is characterized by sharply folded quartzites, slates, phyllites and greenstones. In general, it is a single ridge composed of steeply dipping quartzites and slates of Cambrian age on the west and pre-Cambrian greenstones, schist, and granite on the east.

The Piedmont Plateau is a mature, dissected, eastward-sloping belt, within the Piedmont Province. With the exception of Catoctin Mountain and the broad Triassic Lowland immediately to the east, this Piedmont area is characterized by rounded hills an V-shaped valleys cut in pre-Cambrian schists an gneisses which have been intruded in may places by younger igneous rocks. Deep zones of soil and weathered rock are common in the valley walls and beneath the uplands (Basin Facts, ICPRB).

Figure 2.2 Basin Provinces



2.4 Land Use/Land Cover

Much of the Potomac basin outside the greater Metro area is composed of small farms and undeveloped forest. Landuse activities would include; agriculture, small-scale animal operations, surface coal mining, some light industry and timber harvesting. The numbers listed in table 2.3 represent a static look at the landuse within the basin as of 1990(CPB Model).

Table 2.3. Land usages by activity and area (sq. mi.)

Forest	High till	Low till	Pasture	Hay	PervUrb	ImpUrb	Water	Total
6163.54	370.52	642.10	1813.23	843.61	1419.50	221.62	64.92	**11539.04**

A more general analysis of the data shows that the basin is composed of roughly 53.5% forest, 32% farmland, 14% urban and the remaining 0.5% covered by water. These numbers have changed annually in the last 12 years as development continues on the periphery of the Metro boundaries within the basin. The primary change in landuse can be attributed to a growth in the regional population. As the population increases, farmland is replaced to accommodate the development activities such as housing construction and creation of suburban communities and accompanying services.

2.5 Population

Over 2 million people live upstream of the intakes (Table 2.4). Roughly half of this population lives in the greater DC Metro area of Virginia and Maryland. The remainder is scattered around the basin in rural townships and communities many located on or near the mainstem of the Potomac River or its major tributaries.

Table 2.4 Basin state demographics

State	Population (Approx)	Area (sq. mi.)
Maryland	860,000	2,430
Pennsylvania	179,000	1,585
Virginia	795,000	4,090
W. Virginia	212,500	3,500
Total	2,046,500	11,605

Pop. Estimated from Census 2000 data

2.6 General Hydrology

Average annual precipitation is least at the foothills of the Allegheny Mountains, ranging from 30 to 35 inches, but increase rapidly to 50 inches on the western divide and to 45 inches along the crest of the Blue Ridge. Monthly precipitation is generally greatest from May to August, and the smallest monthly total is likely to occur in February or November. The annual average runoff varies from 13 inches in the lower reaches of the Potomac River to about 23 inches in the North Branch. The months of greatest runoff are generally March and April while the month of least flow is usually August or September. About 43% of the annual runoff of the

basin occurs during the three-month period from March through May while only 12% occurs during the three-month period from July through September. The greatest runoff occurs in the Appalachian Plateau and westernmost parts of the Valley and ridge Province. The least runoff occurs in the Shenandoah River portion of the Great Valley.

2.6.1 Streamflow Regulation

Streamflow regulation in the Potomac River Basin is minimal. The three largest impoundments in the Potomac River Basin above the intakes are the Savage River reservoir, William Jennings Randolph Lake on the North Branch Potomac River, and the Mt. Storm Lake on Stony River. William Jennings Randolph Lake and Savage River Reservoir combine to provide flood control on the North Branch and water quality control in an area affected by acid mine drainage, as well as low flow augmentation on the North Branch (USGS Report 95-4221).

2.6.2 Flow Characteristics

Maximum daily flow at Chain Bridge was 309,700 mgd and minimum daily flow was 388mgd. Flow characteristics of the basin streams are definitely related to sub-basin location and topography. The flow in small mountain tributaries varies from zero to large flood flows of short duration, and runoff in these areas is translated rapidly downstream. As a result of topographic differences and the distribution of average annual rainfall, more sustained flows are observed in the streams which enter the Potomac River from the north side, such as the Conococheague Creek, Antietam Creek and Monocacy River than those from the south. The arrangement of sub-basins within the Potomac River basin is such that tributary flood peaks often tend to synchronize and accentuate downstream flood flows. This is also characteristic of the effect of the Shenandoah River on the mainstem Potomac River states under heavy general rainfall over the entire basin.

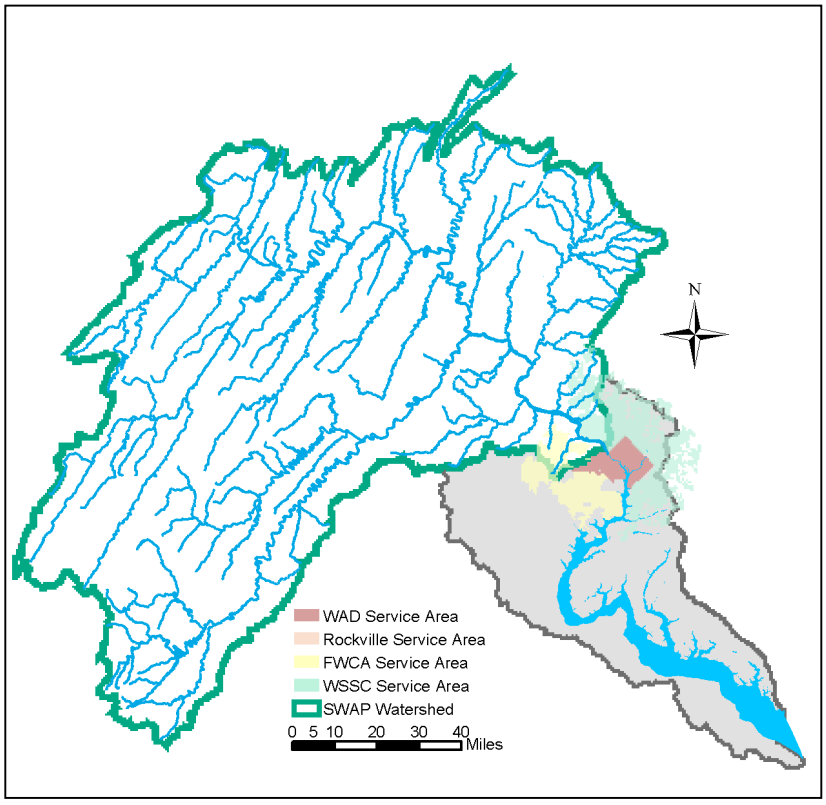
2.7 The Drinking Water System

The Washington Aqueduct is a water supplier that is owned and operated by the U.S. Army Corps of Engineers. It wholesales finished water to its three customers: the District of Columbia Water and Sewer Authority, Arlington County, and the City of Falls Church, Virginia. Washington Aqueduct through its wholesale customers serves approximately one million consumers (USACE).
The Washington Aqueduct is comprised of two water treatment plants: McMillan and Dalecarlia. Washington Aqueduct is governed by the Environmental Protection Agency (EPA) to provide safe drinking water under the Safe Drinking Water Act.

2.7.1 Other Greater Metro Water Systems

The Washington Aqueduct is not the only water supplier in the Washington metropolitan area drawing water from the Potomac River. Figure 2.3 shows the service areas of the major water utilities in the Washington metropolitan area. The Potomac River is a primary source, but not a sole source, of drinking water for the Washington Suburban Sanitary Commission (WSSC) and the Fairfax County Water Authority (FCWA). WSSC serves 1.6 million customers in Montgomery and Prince George's Counties. Their Potomac intake is located [REDACTED]. FCWA serves 1.2 million customers in northern Virginia. Their Potomac intake is located [REDACTED]. The City of Rockville also has an intake on the Potomac [REDACTED]. Their system provides water to approximately 11,000 accounts. For more information on WSSC's and FCWA's systems, see their respective SWAs (WSSC, 2002; FCWA, 2002).

Figure 2.3 Greater Washington Metro Water Service Areas



2.7.2 System Operations

The Washington Aqueduct draws water from the Potomac River as its only source water supply. The Aqueduct produces an average of 180 million gallons of water a day to a population that is generally residential and commercial. There are no major industrial customers.

On an annual basis the majority of the water is drawn from the Potomac at [REDACTED]. That water is transported to the Dalecarlia Reservoir by gravity flow in large conduits. A pumping station at [REDACTED] may be operated during high demand periods to augment the gravity flow [REDACTED]. That water also goes to the Dalecarlia Reservoir. The Dalecarlia Reservoir serves as a pre-sedimentation basin for water that is routed to either the Dalecarlia or McMillan plants for further treatment. The Washington Aqueduct utilizes conventional treatment processes consisting of coagulation, flocculation, sedimentation, filtration and disinfection (Table 2.5). The current treatment process uses alum as the coagulant. Polymers are added to enhance the coagulation and filtration processes. Fluoride is also added for the prevention of tooth decay. Occasionally carbon is added in the sedimentation basins to reduce tastes and odors caused by algae in the raw water. Both treatment plants use dual media filters for particle removal and chlorine as a primary disinfectant and chloramine as a secondary disinfectant.

Table 2.5. Filter media and site capacities for treatment facilities

Treatment Facility	Backwash frequency	No. of Filters	Filter Media Composition	Stored Water
Dalecarlia *	96	36	West filters (10)	
			Wheeler Bottom Underdrains 10" Support Gravel 12" Sand 18" Anthracite	15 mg clearwell (7mg -10mg) 30 mg clearwell (23mg - 30mg)
			East filters (26)	
			Plastic block underdrains Media retention cap 12" Sand	
			18” Anthracite	
McMillan	96	12	Block underdrains 9" Support Gravel 3" Garnet 10" Sand 20" Anthracite	North clearwell (9.5mg -14.6mg) South clearwell (16.2mg - 20.3mg)
Water Processed : 170 MGD (avg.) **Plant Capacity : 280 - 320 MGD**				

- Number and type of filter media after Filter rehabilitation (June 2002)