Appendix C – Compilation of Measured Stream Data

Contents

This appendix discusses in more detail sources of the data and GIS layers used in the project, and the analyses done with them. It also lists the data files provided in separate directories on the attached disc. Section names in the AppendixC_Data.pdf document are identical to the directory names on the disc.

Disc Contents
Document (PDF file)

- AppendixC_Data.pdf (574 KB)
- Eleven directories containing data files and additional documentation, described below

1. Impoundments

Impoundments in the Potomac River basin were identified in the National Inventory of Dams (NID).[1] They are shown in Figure 1. Impoundments were utilized in several capacities in this project. Firstly, the total NID reported normal storage capacity was calculated for watersheds with observed flow data to understand the effects of impoundments on the hydrologic regime. For more information on this analysis see Chapter 5. Secondly, 12 "significant" impoundments were identified across the basin and added to the 4 already included in the hydrologic model. As impoundments are a potential source of hydrologic alteration, adding the significant ones to the model enables simulation and investigation of the hydrologic effects. For more information on modeling of impoundments, see Appendix E.

Disc Directory Contents
Data file (ArcGIS shapefile)

[1] https://rsgis.crrel.usace.army.mil/apex/f?p=397:12:4227426315264309

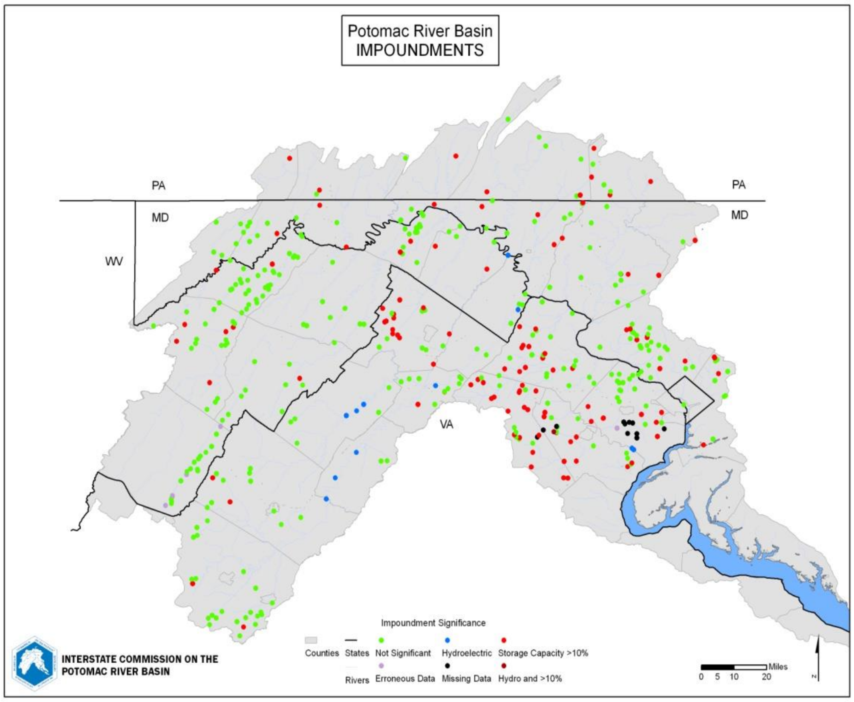

Figure 1. Impoundments in the Potomac River basin.

- 16SigImpnd.shp – This point shapefile contains the locations of the 16 impoundments included in the hydrologic model. The attribute table includes the NID data for each impoundment.

2. Withdrawals

Withdrawal data for Pennsylvania, West Virginia, Virginia, and Maryland for the year 2005 were obtained from the respective basin jurisdictions. The data were formatted and combined into a single comprehensive database and imported into a GIS point shapefile using reported latitude and longitude values. Data quality control procedures were employed by comparing withdrawal attributes to Google Earth imagery. Latitude and longitude values were removed from withdrawal data sets contained in this report, as recommended by the EPA, to protect the location of drinking water supply intakes.

Withdrawal data were summarized for watersheds with observed flow data to understand the impacts of withdrawals on hydrologic alteration (Appendix H) and in model simulations of current and future conditions (Appendix E).

Disc Directory Contents
Data file (MS Access database)

- CurrentScenario\DIV_Data5.mdb – contains the withdrawal time series and river segment identifiers for withdrawal points simulated in the current scenario.
- FutureScenarios\CC_DIV_data4.mdb - contains the withdrawal time series and river segment identifiers for withdrawal points simulated in the climate change future scenario.

- FutureScenarios\DIV_PO2_012412.mdb - contains the withdrawal time series and river segment identifiers for withdrawal points simulated in the power future scenario.
- FutureScenarios\DP1_DIV_Data5.mdb - contains the withdrawal time series and river segment identifiers for withdrawal points simulated in the DP1 scenario.
- FutureScenarios\DP2_DIV_Data_120611.mdb - contains the withdrawal time series and river segment identifiers for withdrawal points simulated in the DP2 scenario.
- FutureScenarios\HotDry_DIV_Data_120611.mdb - contains the withdrawal time series and river segment identifiers for withdrawal points simulated in the hot and dry scenario.

3. Discharges

Point source discharge data were obtained from the Chesapeake Bay Program's point source database by searching for facility information in MD, PA, DC, WV, and VA.[2] The data were used as-is in the current model scenario (Appendix E). Discharges were adjusted in the future scenarios to account for anticipated changes in consumptive use (Appendix B).

Disc Directory Contents

Data file (MS Access database)

- CurrentScenario\CBPP5PS.mdb – Facility information and discharge time series utilized in the current model scenario.
- FutureScenarios\CC_PS.mdb - Facility information and discharge time series utilized in the climate change scenario.
- FutureScenarios\DP1_PS.mdb - Facility information and discharge time series utilized in the DP1 scenario.
- FutureScenarios\DP2.mdb - Facility information and discharge time series utilized in the DP2 scenario.
- FutureScenarios\HotDry_PS.mdb - Facility information and discharge time series utilized in the hot and dry scenario.
- FutureScenarios\PO_PS.mdb - Facility information and discharge time series utilized in the power scenario.

Data file (ArcGIS shapefile)

- CurrentScenario\CBP_pointsource.shp – Shapefile of discharge locations, plotted by latitude and longitude utilizing data from the Chesapeake Bay Program's point source database. The attribute file includes facility information.

4. Land Cover

To couple observed flow data in the model verification efforts, the 30 meter resolution, University of Maryland RESAC 2000 land use raster was utilized to calculate percent urban, percent forest, and percent agricultural areas within each watershed. Forested land uses were a combination of deciduous forests, evergreen forests, and mixed forests for the purposes of this analysis.

[2] http://www.chesapeakebay.net/data_pointsource.aspx

Agricultural land uses included pasture, hay, and croplands. Urban areas included low, medium, high intensity developed, transportation, and urban treed and grassed.

Current scenario modeled land uses were obtained by land-river segment from the CBP Phase 5.2 model for the year 2002, the most recent year. These land uses were adjusted to mimic observed reference watersheds (greater than 78 percent forest and less than 0.35 percent impervious cover) in the baseline scenario utilizing an ICPRB optimization routine developed by J. Palmer. All future model scenarios utilized the CBP Phase 5.1 future land use projections by land-river segment.

Disc Directory Contents

Data file (ArcGIS raster grid)

- 2002RESAC\proj_projcbp – 30x30 meter raster grid of land uses in the Potomac River basin.

Data file (MS Excel spreadsheet)

- Current&Baseline Scenarios\BaselineCurrent_LULC.xlsx – Spreadsheet of the current and calculated baseline land uses for each of the WOOOMM simulated watersheds.

Data file (Comma delimited text)

- Future Scenarios\land_use_p52cal_2030.csv – Spreadsheet of the CBP projected 2030 land uses by land-river segment.

5. Potomac-Susquehanna Flow Gages

This directory contains the Potomac-Susquehanna data set of flow metrics calculated from USGS flow gage data, and the associated watershed characteristics. The data set was used to verify flow metrics calculated from modeled flow time series and examine relationships between flow metrics and watershed geomorphology, size, slope, precipitation, land cover/uses, and water uses. The final Potomac-Susquehanna data set consisted of 40 Susquehanna and 58 Potomac watersheds for a total of 98 watersheds of different sizes and a broad range of land and water uses (Figure 2). Six additional watersheds located wholly or partially in the Coastal Plain were included in various exploratory analyses but were excluded from the final analysis and this data set.

Flow Metrics

Time series of daily mean flows measured at USGS gages in the Middle Potomac assessment area for the water years 1984 – 2005 were downloaded from http://waterdata.usgs.gov/nwis. Thirteen IHA flow metrics were calculated with the Nature Conservancy's Indicators of Hydrologic Alteration version 7.0 software (TNC 2007) using the default settings. Two additional metrics were calculated with the US Geological Survey's HIT program (Henriksen et al. 2006). Gages with greater than five years of missing data during the 1984-2005 period of record were not included in the analysis. Watersheds are nested and cumulative. Flow metrics calculated in the identical manner for streams and rivers in the Susquehanna River basin were obtained from Michele DePhilip and Tara Moberg of The Nature Conservancy (TNC) Pennsylvania chapter and Jennifer Hoffman of the Susquehanna River Basin Commission (SRBC). The selected metrics were intended to capture different portions of the hydrograph and indicate changes caused by hydrologic alteration (Olden and Poff 2003). They are listed in Table 1. Information about the hydrologic and biologic importance of these indicators can be found in Apse et al. (2008).

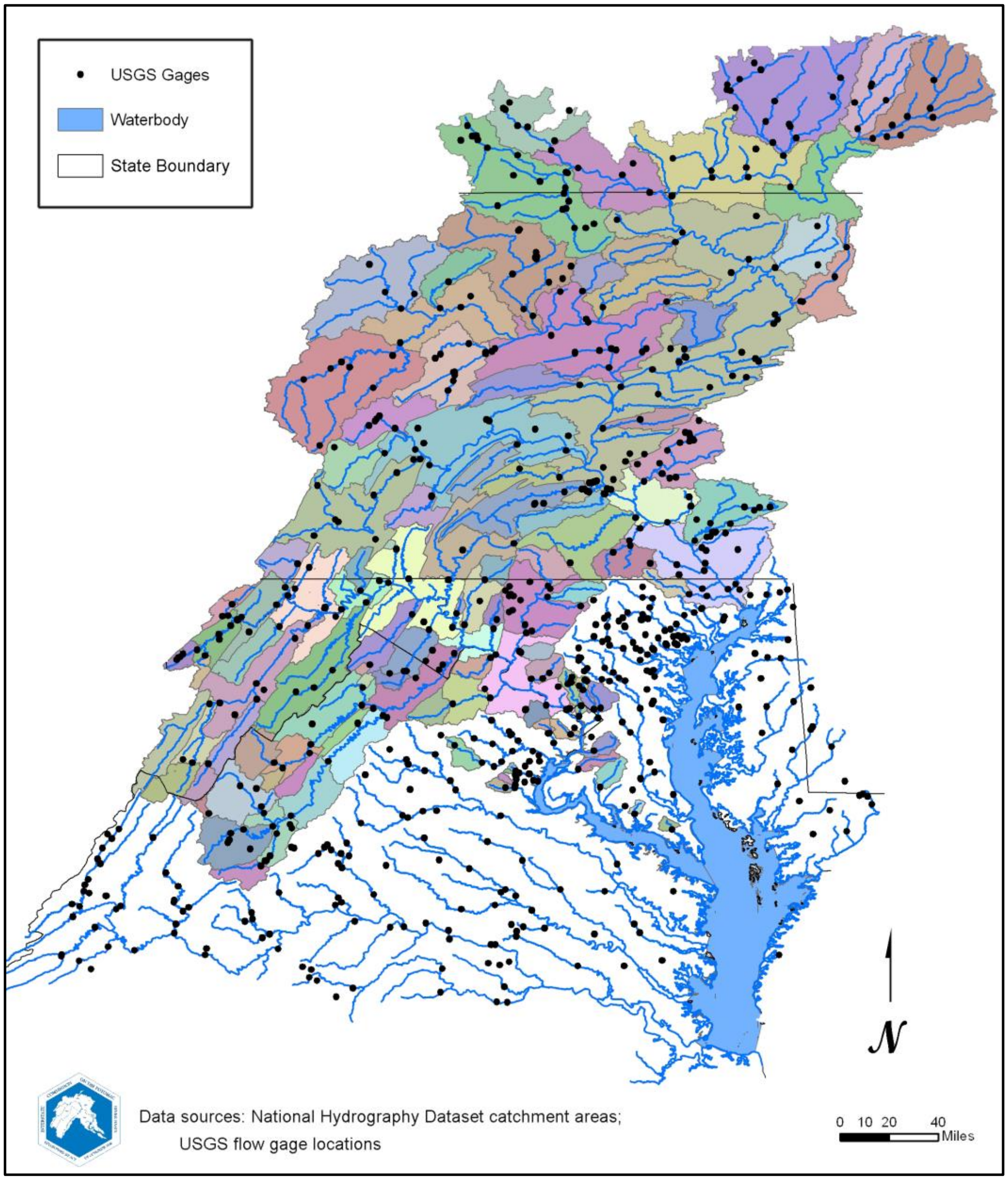

Figure 2. Gaged watersheds in the Potomac and Susquehanna river basins. Black dots indicate USGS gages in the Chesapeake Bay watershed.

Eight of the fifteen flow metrics tested—the annual 1-day minimum, 3-day minimum, August median, median, annual mean, and 3-day maximum, and the average rates of rising and falling flows—are measures of flow volume. Since water volume increases additively as streams merge into rivers, these volume-based metrics were normalized to watershed area to make them water yields, allowing for direct comparisons of values across the range of watershed sizes. The remaining metrics are counts, frequencies, or ratios.

The Potomac and Susquehanna river basins are relatively "rich" in precipitation, but they exhibit a fairly large range in mean annual precipitation, from 32 in. to 55in. per year. To investigate the

Table 1. List of flow metrics calculated for the Potomac-Susquehanna data set. Calculations were performed using the TNC Indicators of Hydrologic Alteration software program (IHA), the USGS Hydrologic Index Tool software program (HIT), and Excel 2007. When a flow metric's unit is cubic feet per second (cfs), it is divided by watershed area expressed as square mile (mi^2) for comparison purposes. "Normalized" flow metrics have been divided by mean annual precipitation calculated for the watershed (see text for details). An., annual mean or median.

Indicator Name	Description	Units	
3-Day Maximum	The average of each year's highest 3-day moving average of daily mean flow (cfs) during the study period (1984-2005) divided by watershed area (mi^2). IHA.	cfs/mi^2	An.
Normalized 3-Day Maximum	The average of each year's highest 3-day moving average of daily flow (cfs) during the study period (1984-2005) divided by watershed area (mi^2) *and normalized to the average annual precipitation.*	ratio (unitless)	An.
Annual Mean Flow	The average of all the annual means of daily mean flows (cfs) during the study period (1984-2005) divided by watershed area (mi^2). The average of each year's mean daily flows is calculated, and then the means of each year are averaged. IHA.	cfs/mi^2	An.
Normalized Annual Mean Flow	The average of all the mean daily flows (cfs) during the study period (1984-2005) divided by watershed area *and normalized to the average annual precipitation*.	ratio (unitless)	An.
Median Flow	The median of all the daily mean flows (cfs) during the study period (1984-2005) divided by watershed area (mi^2).	cfs/mi^2	
Normalized Median Flow	The median of all the mean daily flows (cfs) during the study period (1984-2005) divided by watershed area (mi^2) *and normalized to the average annual precipitation*.	ratio (unitless)	
August Median Flow	The median of the August median flow for each year in the study period (1984-2005) divided by watershed area (mi^2). IHA.	cfs/mi^2	An.
1-Day Minimum	The average of each year's minimum daily mean flow (cfs) during the study period (1984-2005) divided by watershed area (mi^2). IHA.	cfs/mi^2	An.
Normalized 1-Day Minimum	The average of each year's 1-day minimum daily flow (cfs) during the study period (1984-2005) divided by watershed area (mi^2) *and normalized to the average annual precipitation.*	ratio (unitless)	An.
3-Day Minimum	The average of each year's lowest 3-day moving average of daily flow (cfs) during the study period (1984-2005) divided by watershed area (mi^2). IHA.	cfs/mi^2	An.
Normalized 3-Day Minimum	The average of each year's lowest 3-day moving average of daily flow (cfs) during the study period (1984-2005) divided by watershed area (mi^2) *and normalized to the average annual precipitation.*	ratio (unitless)	An.

Indicator Name	Description	Units	
Low Pulse Duration	The median of the annual average number of consecutive days per year that daily flow is below the 10th percentile of the 1984-2005 period of record. IHA.	days	An.
High Pulse Count	The median of the annual average of each year's number of times the daily mean flow is above the 90th percentile of all flows for the study period. IHA.	#	An.
High Pulse Duration	The median of the annual average number of consecutive days that daily flow is above the 90th percentile of the 1984-2005 period of record. IHA.	days	An.
High Flow Index MH21	The average volume of high flow events (above a threshold equal to the median flow of the entire record) divided by the median daily flow for the entire record. HIT.	ratio (unitless)	
High Flow Duration DH17	The average duration of flow events with flows above the median flow for the entire period of record. HIT.	days	
Rise Rate	The average of all positive differences in daily mean flow during "rising periods," or consecutive days for which change in daily flow is positive, in a year. IHA.	cfs/mi^2	An.
Fall Rate	The average of all negative differences in daily mean flow during "falling periods," or consecutive days for which change in daily flow is negative, in a year. IHA.	cfs/mi^2	An.
Number of Reversals	The average number of times in a year that daily mean flow switches from rising to falling and vice versa. IHA.	#	An.
Frequency of Extreme Low Flows	The frequency of extreme low flow events in a year, where daily flow is in the lowest 10th percentile of all the low flows (or below the 2.5th percentile of all flows in the 1984-2005 period of record). IHA.	#	

possible effect of precipitation on the IHAs, five flow-based indicators—mean flow, median flow, 1-day and 3-day minimum flows, and 3-day maximum flow—were normalized to the mean annual precipitation in their watersheds. The 1971-2005 mean annual precipitation data from the NOAA network of Mid-Atlantic weather stations were used to create a spatial layer of mean annual precipitation for the Potomac and Susquehanna basins (Figure 3). Several methods were considered to interpolate the station precipitation data to a spatially explicit grid across the Potomac and Susquehanna Basins, including topo to raster, splining, thiessen polygons, and kriging. A verification data set of 13 precipitation stations was utilized to assess the accuracy of each method. Kriging was selected as it had an average percent error of 2.6%, lower than all three other methods (topo to raster had a 3.5% error, splining had a 4.55% error, and thiesson polygons had a 10.16% error at the validation points).

Kriging "assumes that the distance or direction between sample points reflects a spatial correlation that can be used to explain variation in the surface. This method fits a mathematical function to a

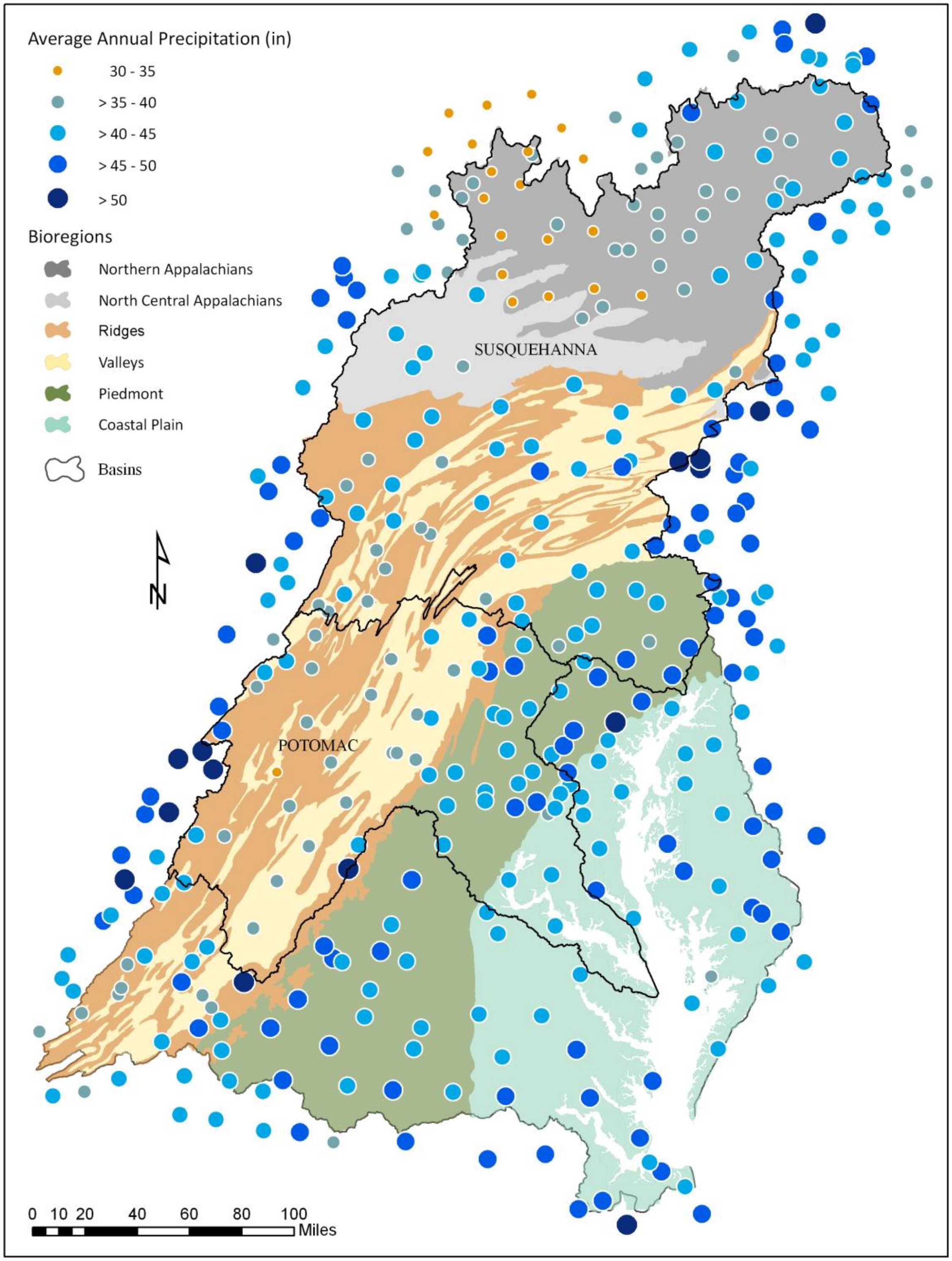

Figure 3. Average annual precipitation (inches) at NOAA Mid-Atlantic weather stations located in and near the Chesapeake Bay watershed, superimposed on bioregion. The Potomac and Susquehanna river basins are outlined.

specified number of points, or all points within a specified radius, to determine the output value for each location" (ESRI, 2009). ArcMap 9.4 uses the following formula for kriging:

$$\hat{Z}(s_0) = \sum_{i=1}^{N} \lambda_i Z(s_i)$$

where:

$Z(s_i)$ = the measured value at the i^{th} location.

λ_i = an unknown weight for the measured value at the i^{th} location.

s_0 = the prediction location.

N = the number of measured values.

The annual mean volume of water falling on each of the watersheds in the study was estimated from the spatial precipitation layer. The four IHAs with flow rate components (cfs) were divided by mean annual rainfall after converting all values to the same units.[3] The resulting ratio (unitless) is thus weighting, or normalizing, the IHA relative to the precipitation falling on the watershed. Values of these normalized indicators are noted as such.

Watershed Characteristics

The watersheds above each of the USGS gaging stations in the Potomac-Susquehanna data set were delineated in a graphical information system (GIS) using the NHDPlus stream network layer (USEPA 2005). The purpose of delineating the watersheds was to extract information about each watershed from GIS layers for size, slope, geology, and land cover.

<u>Area</u> Watershed area was determined from the GIS layer using the Calculate Area tool in ArcGIS and incorporated into the data set if it agreed with the area published by the USGS with the flow time series. If it did not agree exactly, the USGS area was used. Selected watersheds in the Susquehanna basin tend to be larger than those in the Potomac (Table 2).

<u>Watershed Mean Slope</u> The National Elevation Dataset (NED) 30m resolution raster elevation grid was obtained and used to calculate the mean slope of each watershed. ArcGIS 9.2 Spatial Analyst's Calculate Slope tool converted the Digital Elevation Model (DEM) to slope in degrees. The slope of each 30m grid cell was calculated by identifying the maximum rate of elevation change between that cell and its 8 neighbors. Slope statistics for each watershed were then calculated using Spatial Analyst's Zonal Statistics tool. The tool provides a statistical summary of all 30m cells within a watershed. For the purposes of this analysis, minimum, maximum, mean, standard deviation, and range of slope values for each watershed were obtained.

<u>Karst Geology</u> The percentage of karst geology in each Potomac and Susquehanna watersheds was calculated using the US EPA's Mid-Atlantic ecoregions polygon shapefile in ArcGIS 9.2 (Figure 4). Three Level 4 ecoregions were identified; namely, Northern Limestone/Dolomite Valleys, Piedmont Limestone/Dolomite Lowlands, and Limestone Valleys and Coves. The 'tabulate area' tool was

[3] Cubic feet per second of flow multiplied by 31,557,600 seconds per year multiplied by watershed area equals annualized mean flow per unit area (cfy/mi^2). Long-term annual inches of precipitation multiplied by watershed area equals long-term annual mean volume of precipitation per unit area (cfy/mi^2).

Table 2. Counts of gaged watersheds in the Potomac-Susquehanna data set, grouped by the Northeastern Aquatic Habitat Classification System (NEAHCS).

NEAHCS Size Class (mi^2)	Description (Class Designation)	Potomac (n=65)	Susquehanna (n=40)	Totals (n=105)
<3.86	Headwaters (1a)	1	-	1
3.86 – <38.6	Creeks (1b)	9	-	9
38.6 – <200	Small Rivers (2)	28	3	31
200 – <1,000	Medium Tributary Rivers (3a)	17	24	41
1,000 – <3,861	Medium Mainstem Rivers (3b)	6	6	12
3,861 - <9,653	Large Rivers (4)	2	2	4
≥9,653	Great Rivers (5)	2	5	7

utilized to calculate the karst area of each watershed. The calculated karst areas were divided by the total area of each respective watershed to obtain percentages.

Bioregion Level 4 "ecoregions" have been characterized and delineated by the US EPA (http://www.epa.gov/wed/pages/ecoregions/reg3_eco.htm). Ecoregions are physiographic regions "of relative homogeneity in ecological systems … soils, vegetation, climate, geology, and physiography" (Wood et al. 1999). Aggregation of these Level 4 ecoregions into "bioregions" has proven an effective method of classifying macroinvertebrate communities in the Potomac River basin and the larger Chesapeake Bay basin (Astin 2006, Buchanan et al. 2011). Four bioregions are found in the Potomac River Basin (Figure 3). The mountainous Ridges bioregion is characterized by high gradient, cool, trellised streams with many riffles and active down-cutting. The Valleys bioregion, interspersed between mountain ridges, has warmer, low gradient streams. Portions of this bioregion are underlain by karst geology and have a low density of streams. The Piedmont bioregion has low to moderate gradient streams with falls, islands, and rapids. The Coastal Plain bioregion—a little of which is located in the study area—has very low gradient streams on poorly drained, alluvial sediments and streams are often poorly incised and lack a defined channel. To calculate the predominant bioregion in each Potomac and

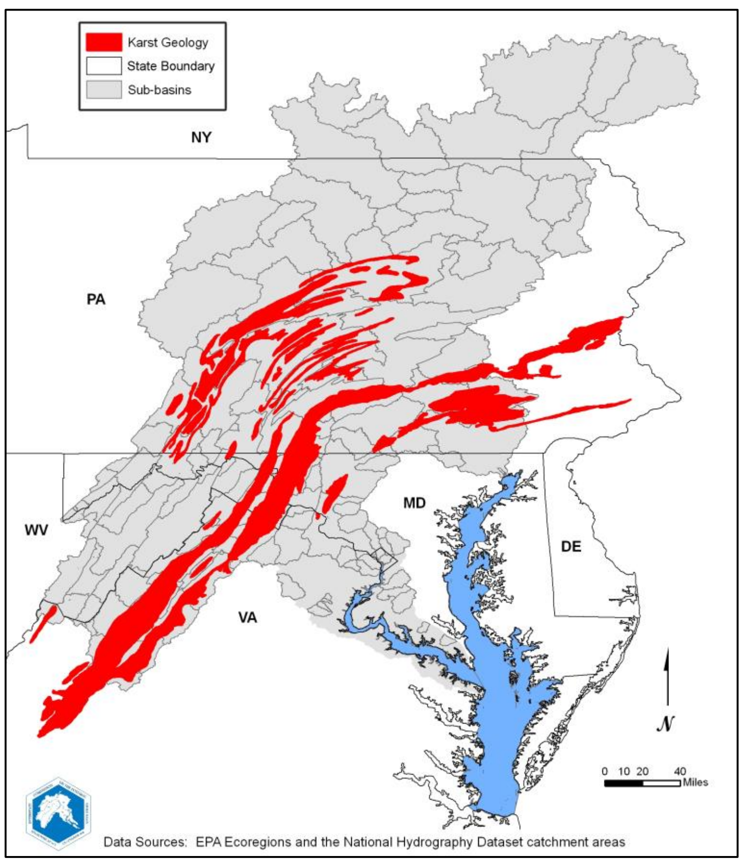

Figure 4. Areas with karst geology in the Potomac and Susquehanna river basins.

Susquehanna watershed, the percentages of each Level 4 ecoregion overlapping the watershed were determined from the US EPA Mid-Atlantic ecoregion polygon shapefile in ArcGIS 9.2 and then summed to the corresponding bioregion. The Level 4 ecoregions assigned to each bioregion are listed in Table 3.

Land Cover, Withdrawals, Impoundments
Methods identical to those described above were used to determine land cover, withdrawals, and impoundments in the Potomac River basin. The equivalent information for the Susquehanna watersheds was provided by the Nature Conservancy Pennsylvania office. The Nature Conservancy utilized SRBC permitted withdrawal data to calculate withdrawal and consumptive use risk factors in the Susquehanna Basin. Due to potential over-estimation of permitted withdrawals in the Susquehanna permitted data set (when compared to actual withdrawals in the Potomac Basin) only Potomac data was utilized to investigate the effects of withdrawals.

Consumptive Use USGS Aggregate Water Use Data System (AWUDS)[4] county data from 1995 were obtained for all counties in the Potomac Basin. A consumptive use coefficient for each reported water use was estimated by dividing consumptive use by withdrawals. The average consumptive use coefficients by water use in the Potomac Basin are shown in Table 4. The consumptive use coefficients were multiplied by the 2005 total withdrawals (MG/year) for that water use type to estimate total consumptive use (MG/year) for each watershed. Consumptive uses for each watershed are shown in Appendix B. Consumptive use values were calculated for the Susquehanna Basin based on permitted withdrawals and sector appropriate factors published in USGS 2005. Since permitted withdrawals may over-estimate actual use, Susquehanna consumptive use data were removed from the CART analysis.

Disc Directory Contents
Data file (MS Excel 2007 spreadsheet)

- Potomac-Susquehanna.xlsx

6. Stream Macroinvertebrates

This directory contains the comma-delimited, related data files of the family-level metrics and Chessie BIBI calculated from the stream macroinvertebrate data (taxonomic identifications and enumerations) contributed by 23 monitoring programs in the Chesapeake Bay basin. The directory also contains metadata for the individual monitoring programs and information about the relational database structure which houses the primary and aggregated data at CBP. A subset of these data from sampling locations in the Middle Potomac assessment area was used to develop the flow alteration-ecology response curves. The primary data sets from which family-level macroinvertebrate metrics and the Chessie BIBI are calculated can be requested from the individual data providers (see metadata) or from the Living Resources Data Manager/Analyst (see contact information later in section).

A report about the family-level metrics and development of the Chessie BIBI as of 5/9/2011 is available online at http://www.potomacriver.org/cms/publicationspdf/ICPRB11-01.pdf. The full

[4] AWUDS data available at http://water.usgs.gov/watuse/wuawuds.html.

Table 3. Correspondence between the US EPA Level III and IV ecoregion classifications and the Chesapeake Bay watershed bioregions. * Level IV ecoregions with limestone geology.

Bioregion	EPA Level III Ecoregion	EPA Level IV Ecoregion
Northern Appalachian Plateau and Uplands	60 Northern Appalachian Plateau and Uplands	60a Glaciated Low Plateau
		60b Northeastern Uplands
		60d Finger Lakes Uplands and Gorges
		60e Glaciated Allegheny Hills
	83 Eastern Great Lakes and Hudson Lowlands	83f Mohawk Valley
North Central Appalachians	62 North Central Appalachians	62a Pocono High Plateau
		62b Low Poconos
		62c Glaciated Allegheney High Plateau
		62d Unglaciated Allegheney High Plateau
Middle Atlantic Coastal Plain	63 Middle Atlantic Coastal Plain	63b Chesapeake-Pamlico Lowlands and Tidal Marshes
		63c Swamps and Peatlands
		63d Virginian Barrier Islands and Coastal Marshes
		63e Mid-Atlantic Flatwoods
		63f Delmarva Uplands
Southeastern Plains	65 Southeastern Plains	65n Chesapeake Rolling Coastal Plain
		65m Rolling Coastal Plain
Ridges	66 Blue Ridge	66a Northern Igneous Ridges
		66b Northern Sedimentary and Metasedimentary Ridges
	67 Ridge and Valley	67d Northern Dissected Ridges and Knobs
		67c Northern Sandstone Ridges
		67i Southern Dissected Ridges and Knobs
		67h Southern Sandstone Ridges
	69 Central Appalachians	69a Forested Hills and Mountains
		69b Uplands and Valleys of Mixed Land Use
	70 Western Allegheny Plateau	70c Pittsburgh Low Plateau
Piedmont	45 Piedmont	45c Carolina Slate Belt
		45e Northern Inner Piedmont
		45f Northern Outer Piedmont
		45g Triassic Basins
	58 Northeastern Highlands	58h Reading Prong
	64 Northern Piedmont	64d Piedmont Limestone/Dolomite Lowlands*
		64c Piedmont Uplands
		64b Trap Rock and Conglomerate Uplands
		64a Triassic Lowlands
Valleys	67 Ridge and Valley	67e Anthracite Subregion
		67a Northern Limestone/Dolomite Valleys*
		67b Northern Shale Valleys
		67f Southern Limestone/Dolomite Valleys & Low Rolling Hills*
		67g Southern Shale Valleys

Table 4. Average consumptive use coefficients.

Water Use	Consumptive Use Coefficient
Domestic	21.4%
Industrial	24.8%
Thermoelectric	2.5%
Mining	17.4%
Livestock	75.2%
Irrigation	84.2%
Average	15.2%

citation is: Buchanan, C., K. Foreman, J. Johnson, and A. Griggs. 2011. Development of a Basin-wide Benthic Index of Biotic Integrity for Non-Tidal Streams and Wadeable Rivers in the Chesapeake Bay Watershed: Final Report to the Chesapeake Bay Program Non-Tidal Water Quality Workgroup. ICPRB Report 11-1. Report prepared for the US Environmental Protection Agency, Chesapeake Bay Program.

Biological metric definitions

Table 5 provides a complete list of biological metrics currently generated by CBP indicator programs and their definitions. An asterisk (*) indicates those metrics that are either minimally affected or not affected by the level of taxonomic identification (i.e., genus- versus family-level).

Two forms of each metrics are available:

- Those calculated from the samples as reported by the data generators, with total counts per sample ranging widely
- Those calculated from samples that have been randomly standardized to a total count of 100 organisms

The two forms of the metrics are calculated identically. Metrics calculated from the randomly standardized ("rarefacted") data are denoted with a "_R" suffix attached to the metric name. In this project, only metrics calculated from standardized samples were used.

Table 5. Macroinvertebrate metric codes and descriptions.

Metric Name	Metric Description
ASPT_MOD	Average of each individual's family-level tolerance score
BECK	Becks Index based on family-level taxonomy
DIPTERA_TAXA_CNT	Count of Diptera families
EPHEMEROPTERA_ TAXA_CNT	Count of Ephemeroptera families
EPT_TAXA_ABUND *	Abundance of EPT individuals (this is equivalent to percent EPT in samples standardized to 100 count)
EPT_TAXA_COUNT	Count of EPT families
EPT_TAXA_COUNT_NO_	Count of EPT families excluding tolerants (EPT families with

Metric Name	Metric Description
TOL	tolerance values ≥ 7)
FBI *	Hilsenhoff Family-level Biotic Index
GOLD *	Index equal to 1 minus proportional abundance of gastropods, oligochaetes and Diptera individuals
MARGALEFS	Margalef's Index based on family-level taxonomy
NCO_TAXA_CNT	Count of families in sample minus Chironomidae and oligochaete families
NON_INSECT_TAXA_CNT	Count of non-insect families
PCT_BURROWER *	Percent of individuals that are adapted for burrowing
PCT_CHIRONOMIDAE *	Percent of individuals that are chironomids
PCT_CLIMB *	Percent of individuals that are adapted for climbing
PCT_CLING *	Percent of individuals that are adapted for clinging
PCT_CLINGER_TAXA	Count of clinger families expressed as a percent of the total number of families present in sample
PCT_COLLECT *	Percent of individuals that are collectors (filterers + gatherers)
PCT_DIPTERA *	Percent of individuals that are Diptera
PCT_DOM1	Percent of individuals in the most common families
PCT_DOM2	Percent of individuals in the two most common families
PCT_DOM3	Percent of individuals in the three most common families
PCT_EPHEMEROPTERA *	Percent of individuals that are Ephemeroptera
PCT_EPT *	Percent of individuals that are Ephemeroptera, Plecoptera and Trichoptera (EPT)
PCT_EPT_TAXA_RICH	Count of EPT families expressed as a percent of the total number of families present in sample
PCT_FILTERERS *	Percent of individuals that are adapted for filtering fine particles
PCT_GATHER *	Percent of individuals that are adapted for gathering
PCT_LIMESTONE *	Percent of individuals that are isopods, amphipods, and Ephemeralla
PCT_NET_CADDISFLY *	Percent of individuals that are net-spinning caddisflies
PCT_NON_INSECT *	Percent of individuals that are not insects
PCT_PLECOPTERA *	Percent of individuals that are Plecoptera
PCT_PREDATOR *	Percent of individuals that are predatory
PCT_SCRAPER *	Percent of individuals that are adapted for scraping periphyton from hard surfaces
PCT_SENSITIVE	Percent of individuals with family level tolerance values ≤ 3
PCT_SHREDDER *	Percent of individuals that are adapted for shredding coarse organic material
PCT_SIMULIIDAE *	Percent of individuals that are Simuliidae
PCT_SWIMMER *	Percent of individuals that are adapted for swimming
PCT_TOLERANT	Percent of individuals with family-level tolerance values ≥ 7
PCT_TRICHOPTERA *	Percent of individuals that are Trichoptera
PCT_TRICHOPTERA_ NO_TOL *	Percent of individuals that are Trichoptera excluding Hydropsychidae

Metric Name	Metric Description
PLECOPTERA_TAXA_CNT	Count of Plecoptera families
RATIO_SC_TO_CF *	Ratio of scrapers to collector-filterers
RATIO_SC_TO_SH *	Ratio of scrapers to shredders
RATIO_SH_TO_CG *	Ratio of shredders to collector-gatherers
SCRAPER_TAXA_CNT	Count of scraper families
SENSITIVE_TAXA_COUNT	Count of families that have family-level tolerance values $\leq$ 3
SIMPSON_DIVERSITY	Simpson Diversity index based on family-level taxonomy
SW	Shannon Wiener Index based on family-level taxonomy
TAXA_RICH	Count of families in sample
TOLERANT_TAXA_ COUNT	Count of families that have family-level tolerance values $\geq$ 7
TOTAL_ABUNDANCE *	Total number of individuals in sample
TRICHOPTERA_TAXA_ CNT	Count of Trichoptera families
TRICHOPTERA_TAXA_ COUNT _NO_HYDR	Count of Trichoptera families excluding Hydropsychidae

* metrics that are either minimally affected or not affected by the level of taxonomic identification (i.e., genus- versus family-level)

Acknowledgements

In publications, reports or presentations generated from this database of biological metrics, please acknowledge the monitoring programs and the CBP for their work in compiling the data. Suggested acknowledgement:

> "The author(s) <u>credit / thank / acknowledge</u> the monitoring programs of federal, state, interstate, and local agencies and academic institutions in Delaware, Maryland, New York, Pennsylvania, Virginia, and West Virginia for collecting and processing the stream data used in this <u>publication / report</u>, and the Chesapeake Bay Program (CBP) for incorporating the data into a uniform database and making the database available."

CBP would also like copies of any such documents so they can track who is using the data for future program planning. Questions, comments, and documentation can be sent to:

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Disc Directory Contents

Data files (comma delimited text)

- EVENTS.txt: contains sampling event information including site locations

- HABITAT.txt: habitat assessment data
- WQ.txt: water quality data
- BIBI.txt: the multi-metric **B**enthic **I**ndex of **B**iotic **I**ntegrity for Chesapeake Bay basin streams - please note that Chessie BIBI results are derived using a CBP protocol and will differ from jurisdictional assessments
- WAREHOUSE.txt: the full suite of family-level macroinvertebrate metrics currently calculated by CBP

Documentation on CBP non-tidal benthic macroinvertebrate relational database structure

- SQL_NT_BENTHOS.pdf : Non-Tidal Benthic Monitoring Database: Version 3.0; Database Design Documentation and Data Dictionary

Metadata for the original data sources

- DE_DENREC_2009.xml: FGDC Compliant Metadata for all Delaware Department of Natural Resources and Environmental Control Monitoring Data
- EPA_2009.xml- FGDC Compliant Metadata for all USEPA-EMAP and MAIA Programs Monitoring Data
- EPA_remap_maia.xml: FGDC Compliant Metadata for all USEPA-Wadeable Streams Assessment Program Monitoring Data
- Fairfax_CO_VA_2009.xml: FGDC Compliant Metadata for all Fairfax County Virginia Monitoring Data
- Fredrick_CO_2009.xml: FGDC Compliant Metadata for all Fredrick County Maryland Monitoring Data
- Howard_CO_2009.xml: FGDC Compliant Metadata for all Howard County Maryland Monitoring Data
- Loudoun_CO_VA_2009.xml: FGDC Compliant Metadata for all Loudoun County Maryland Monitoring Data
- MD_MBSS_2009.xml: FGDC Compliant Metadata for all Maryland Biological Stream Survey Monitoring Data
- MD_WADERS_2009.xml: FGDC Compliant Metadata for all Maryland Stream-waders Monitoring Data
- Montgomery_CO_2009.xml: FGDC Compliant Metadata for all Montgomery County Maryland Monitoring Data
- NYDEC_2009.xml: FGDC Compliant Metadata for all New York Department Of Environmental Conservation Stream Monitoring Data
- PADEP_2009.xml: FGDC Compliant Metadata for all Pennsylvania Department of the Environment Stream Monitoring Data
- Prince_Georges_CO_2009.xml: FGDC Compliant Metadata for all Prince Georges County Maryland Monitoring Data
- SRBC_2009.xml: FGDC Compliant Metadata for all Susquehanna River Basin Commission Monitoring Data
- USFS_2009.xml: FGDC Compliant Metadata for all United States Forest Service Monitoring Data
- USGS_NAWQA.xml: FGDC Compliant Metadata for all United States Geological Survey National Water-Quality Assessment Program monitoring program data
- VADEQ_2009.xml: FGDC Compliant Metadata for all Virginia Department of Environmental Quality Monitoring Data

- VA_INSTAR_2009.xml: Virginia Commonwealth University **IN***teractive* **ST***ream* **A***ssessment* **R***esource Program Data*
- WVADEP_2009.xml: FGDC Compliant Metadata for all West Virginia Department of Environmental Protection Monitoring Data

7. Model Input-Output

The CBP HSPF model and associated inputs can be downloaded online[5]. Adaptations to the standard CBP model included re-segmentation at impoundments and implementation of a non-linear groundwater recession (Appendix E).

Additional WOOOMM input data files, including withdrawals, discharges, impoundments, and land cover are described in previous sections of this document. The methodologies utilized to generate the WOOOMM inputs are also described in Appendix E.

Each of the seven model runs (baseline, current, DP1, DP2, power, hot and dry, and climate change) resulted in a daily flow time series for each watershed. Current and baseline scenarios were modeled for 747 watersheds utilizing the WOOOMM and for 153 river segments utilizing the HSPF model. The five future scenarios were run for the 153 river segments in the HSPF model.

Disc Directory Contents

Data files (comma delimited text)

- HSPF_Scenarios\Baseline*.txt – Baseline daily flow time series for each of the simulated 153 HSPF river segments.
- HSPF_Scenarios\ClimateChange*.txt – Daily flow time series for the climate change scenario for each of the simulated 153 HSPF river segments.
- HSPF_Scenarios\Current*.txt – Daily flow time series for the current scenario for each of the simulated 153 HSPF river segments.
- HSPF_Scenarios\DP1*.txt – Daily flow time series for the DP1 for each of the simulated 153 HSPF river segments.
- HSPF_Scenarios\DP2*.txt – Daily flow time series for the DP2 scenario for each of the simulated 153 HSPF river segments.
- HSPF_Scenarios\HotDry*.txt – Daily flow time series for the hot and dry scenario for each of the simulated 153 HSPF river segments.
- HSPF_Scenarios\Power*.txt – Daily flow time series for the power scenario for each of the simulated 153 HSPF river segments.
- WOOOMM_Current&Baseline*.csv – Daily flow time series for each of the WOOOMM components, including the 747 ELOHA watersheds.
- WOOOMM_Current&Baseline\readme.txt – File explaining the format of the WOOOMM output files.

[5] http://ches.communitymodeling.org/models.php

8. Flow Metrics

A total of 256 flow metrics were originally calculated on each of the simulated flow time series described in Hydrologic Alteration Assessment section of the report. The complete list of metrics was then screened to select a sub-set of metrics for use in development of the flow alteration – ecological response relationships. The screening process is described in the Hydrologic Modeling section of the report.

Disc Directory Contents
Data files (MS Excel spreadsheets)

- FutureScenario_Metrics.xls – Spreadsheet containing select flow metrics for the 153 HSPF river segments for all 5 future scenarios as the corresponding HSPF current and baseline scenario runs.
- All_IHA_Results_013012.xlsx – Spreadsheet containing the full suite of IHA metrics for the 841 WOOOMM components, including the 747 ELOHA watersheds.
- HITMetrics_121711.xls – Spreadsheet containing all calculated HIT metrics for the 747 ELOHA watersheds.

9. Future Scenarios

This directory contains the information and data used to develop the future scenarios described in "Water Withdrawals, Consumptive Use, and Resource Analysis in the Potomac River Basin," a report prepared by ICPRB for the US Army Corps of Engineers and The Nature Conservancy as part of this project and available in Appendix B. Readme files included on the disc explain the contents of each data file.

Disc Directory Contents
Data files (MS Excel spreadsheets, text files, MS Word files)

- ResultsData/README_AltFutScenario.docx – Document describing information contained in AltFutScenario.xlsx. It includes a description of the spreadsheet's field names.
- ResultsData/AltFutScenario.xlsx – Spreadsheet containing results for the six potential future water withdrawal and consumptive use scenarios.
- SourceData/README_AnimalNumbers.docx – Document explaining the data and fields in SourceData/AnimalNumbers_Prebmplanduse.xls.
- SourceData/README_ChesapeakeBay_Population.docx – Document explaining the data and fields in SourceData/ChesapeakeBay_Population_1790_2007.txt.
- SourceData/README_FRIS.docx – Document explaining the data and fields in SourceData/fris03.zip and SourceData/fris08.zip.
- SourceData/README_USGS_WaterUse.docx – Document explaining the data and fields in USGS_WaterUse85to05.xlsx.
- SourceData/README_Withdrawal6.docx – Document explaining the data and fields in
- SourceData/AnimalNumbers_Prebmplanduse.xls – These data are the animal numbers used in the Chesapeake Bay Program's Watershed Model – HSPF. The alternative future scenarios used this source data. See README_AnimalNumbers.docx for more information.

- SourceData/ChesapeakeBay_Population_1790_2007.txt – Population data from the Chesapeake Bay Program. These data were used to project the population growth in each county. This was in turn used to predict the water withdrawals in the Potomac River basin for the alternative future scenarios.
- SourceData/fris03.zip – Data downloaded from the USDA NASS website: http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Farm_and_Ranch_Irrigation/index.asp. These data were used to estimate the amount of water withdrawn for irrigation in the alternative future scenarios.
- SourceData/fris08.zip – Data downloaded from the USDA NASS website: http://www.nass.usda.gov/Surveys/Guide_to_NASS_Surveys/Farm_and_Ranch_Irrigation/index.asp. These data were used to estimate the amount of water withdrawn for irrigation in the alternative future scenarios.
- SourceData/USGS_WaterUse85to05.xlsx – Water withdrawal data downloaded from the USGS website: http://water.usgs.gov/watuse/data/ . These data were used to project the water withdrawals in the Potomac River basin for the alternative future scenarios.
- SourceData/withdrawal6.xlsx – These data are the actual withdrawals reported by the Potomac River jurisdictions for the year 2005. The alternative future scenarios used this as source data.

10. GIS Files

Disc Directory Contents
Data files (ArcGIS shapefiles)

- Model Geometries\ICPRB_Reseg_RiverSegments_HSPF.shp – This shapefile shows the HSPF river segments utilized in this project, after re-segmentation at 12 additional impoundments. The attribute table of this shapefile contains the name of the river segment (CATCODE) and the area of the river segment. Note this area does not include the upstream drainage area for each river segment, only the area contained within the river segment boundary. In the Master Spreadsheet (see data files for section 8 of this document), watersheds are either identified by a 15 or a 13 character identifier. Watersheds with 13 character identifiers are included in this shapefile.
- Model Geometries\P5_LandSegs_July-7_clip2_HSPF – This shapefile depicts the land segments utilized in Phase 5.2 of the CBP HSPF model. The shapefile has been clipped to the Potomac River basin. The attributes table includes entries originally distributed by the CBP.
- Model Geometries\All_Class_Sheds_031011_CH_FixedJD2.shp – Shapefile of the ELOHA watersheds along with some additional model components. In the Master Spreadsheet (see data files for section 8 of this document), watersheds are either identified by a 15 or a 13 character identifier. Watersheds with 15 character identifiers are included in this shapefile.
- sw_withdrawal_123011.dbf – Database of withdrawals.

11. Master Data Set

The Master data set merges key data elements needed to derive flow alteration-ecology response curves from the ELOHA data set of delineated watersheds, and to evaluate some of the possible non-flow factors that can confound the responses. The first two tabs in the worksheet ("metadata1" and "metadata2") document the contents of the subsequent data tabs.

Disc Directory Contents

Data file (Excel 2007 spreadsheet)

- Master_020612_v1a.xlsx – Master spreadsheet containing select flow metrics, biological metrics, and watershed characteristics for each of the ELOHA watersheds.