Chapter 4.1   NONPOINT SOURCE ASSESSMENT, PRIORITIZATION, AND ACTIVITIES

This section of the Virginia Water Quality Assessment 305(b) Report includes an assessment of nonpoint source (NPS) pollution potential at the 6th order hydrologic units level of the National Watershed Boundary Dataset (NWBD) (hereafter referred to as either hydrologic units or just units). It also includes indicators for prioritizing NPS corrective actions at the hydrologic unit level and a summary of NPS reduction activities currently underway. It has been prepared by the Virginia Department of Conservation and Recreation (DCR) to provide a comparative evaluation of the state's waters, on a hydrologic unit basis, for assisting in the targeting of limited resources and funds for NPS pollution protection activities to where they are most needed.

The 2010 NPS Assessment and Prioritization study summarizes information from DCR, the Virginia Department of Environmental Quality (VDEQ), Virginia Department of Forestry (VDOF), U.S. Department of Agriculture - Natural Resources Conservation Service (USDA-NRCS), local Soil and Water Conservation Districts (SWCDs), the Department of Biological Systems Engineering (BSE) at Virginia Tech (VT), the Virginia Department of Health (VDH), the Virginia Department of Game and Inland Fisheries (VDGIF), the Virginia Department of Mines, Minerals, and Energy (VDMME), the Center for Environmental Studies (CES) at Virginia Commonwealth University (VCU), the US Environmental Protection Agency (EPA), the Chesapeake Bay Program (CBP), the U.S. Geological Survey (USGS), the Conservation Technology Information Center (CTIC) and other existing sources of information useful to the determination of nonpoint source pollution impacts to Virginia waters.

There are four major components to the 2010 NPS Assessment and Prioritization study - potential pollutant loadings, water quality impairments, measures of biological health, and NPS reduction activities. The main focus is the determination of potential loadings of nitrogen, phosphorous, and sediment (hereafter referred to as NPS pollutants) by hydrologic unit by general land use classes. The evaluation of hydrologic units by impaired waters and aquatic species health represents water quality measures not necessarily related to the potential NPS pollutant loads. In order to prioritize clean-up and protection activities, hydrologic units of prime importance for the protection of public surface water supplies were also determined. Details on these components follow.

NPS POLLUTION LOADINGS

The NPS Assessment of pollutant loadings is a calculation of the estimated edge of stream (EOS) loadings of nitrogen, phosphorous, and sediment per hydrologic unit using a model whose input data sets had spatial resolutions that were usually much smaller than the hydrologic units themselves.

The calculation of loads of NPS pollutants as a basis for assessing water quality by hydrologic unit is consistent with Virginia's participation as a partner with the EPA's CBP in the calculations of NPS pollutant loads using the Chesapeake Bay Watershed Model (CBWM). Although Virginia uses CBWM results (particularly in CBP related activities), they have only been obtainable for that portion of Virginia that is in the Chesapeake Bay Watershed (James, York, Rappahannock, Potomac, and Bay Coastal basins). There are other state program needs that can benefit from having measures similar to the CBWM loads but for the non-Bay portion of the state. An attempt to have the more current updated phases of the CBWM (beginning with Phase 5) produce statewide NPS pollution values has been underway for several years but has not yet produced approved NPS pollutant loads. Therefore as has been done since 2002, DCR has produced statewide NPS pollutant load results similar to those of the CBWM by using the Generalized Watershed Loading Functions (GWLF) model[1].

The current GWLF model was calibrated for use in Virginia's NPS Assessment by the VT BSE prior to the 2008 assessment runs. Calibration was done to the observed conditions at 133 monitoring sites across Virginia as assembled by the CBP Office primarily from the USGS and the DEQ for the CBWM. Calibration watersheds were created that corresponded to these monitoring station points and were as consistent as

[1] GWLF was chosen because it was configured for continuous simulation and could produce EOS loads based on land-based loadings, fate, and the transport of pollutants as does the CBWM. Both models also simulate seasonal variations, include both surface and subsurface components, and can represent both dissolved and particulate forms of pollutants. The GWLF model used in the 2010 assessment is an update of the model developed for the 2008 assessment.

possible with existing NWBD unit boundaries. There are portions of Virginia that are downstream of these monitoring sites, however, that could not be calibrated in this manner. To calibrate the model for these portions of the state the BSE defined six physiographic regions covering Virginia. Regions consisted of aggregated 6th order NWBD units and were adjusted to coincide with the aforementioned calibration points. Regionally developed parameter values were then modified during the calibration process of the upstream calibration watersheds until GWLF model output (load results) were sufficiently similar to what has been produced by the CBWM for the Chesapeake Bay drainage area of Virginia for this time period. Final parameter values per region were then assigned to the downstream portion of each region.

Whereas the CBWM uses and produces data in CBWM-specific model segments (36 in Virginia), the assessment runs of GWLF used and produced data at the hydrologic unit level (1236 in Virginia; 11 other units that are all water were not modeled). Assessment runs of GWLF in 2010 differed from the calibration runs in that they used a land use / land cover data set developed by DCR from a number of sources[2] to represent 2007 conditions. It also took into consideration the model-relevant best management practice (BMP) installations and nutrient management planning occurring in Virginia over the previous five year period (2002-2007) by DCR, VDOF, and private plan writers. Table 4.1-1 lists the land use classification system used in the assessment runs of the GWLF model and the equivalent generalized model output land use classes. Spatially attributed BMP and nutrient management plan effects are measured as both land use changes to the aforementioned 2007 land use / land cover data set and as fractional reductions to the loadings by modeled land use. Output from the assessment runs of GWLF are in the form of annual loads (L) of each NPS pollutant (p: nitrogen, phosphorous, and sediment) per modeled land use[3] per unit. From this, two forms of unit area loads are calculated – a per hectare (h) of output land use class (l: agriculture, urban, and forest) per unit (w) load (luUAL) and a per hectare of modeled land (a) per unit load (UAL).

The luUAL value is preferable to the load values themselves when comparing the loading impacts of the individual output land use classes between units. They are normalized in that the size of the unit does not impact this value. It is calculated as:

$$luUAL(plw) = L(plw) / h(lw)$$

While the above calculation does help identify those areas per output land use class that have the greatest loading rates, it does not necessarily identify those *units* in which NPS reduction activities should be focused[4]. Therefore the UAL was used for ranking hydrologic units in this assessment report. The UAL per output land use class per pollutant for each hydrologic unit is calculated as follows:

$$UAL(plw) = L(plw) / h(aw)$$

The output loadings provide a statewide equivalent of the types of results that Virginia has been able to obtain from the CBWM for the Chesapeake Bay drainage area of the Commonwealth over the last twenty one years. Table 4.1-2 compares the final statewide loadings by pollutant by general land use class and the amount of land in Virginia by general land use class. Loading values in this table reflect the loads after the reductions are applied from BMP installations over the previous five years, and reflect a number of improvements to the model, in the input data, and to the calibration process.

There are a number of factors that can account for loading estimation changes between the 2010 and 2008 assessment calculations. Most involve updated and improved data, as the model was not recalibrated and model code remained the same. New and updated data includes more exact soil parameter distribution, a

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[2] The base spatial layer for the 2007 land use / land cover data set was developed by the VDOF. Agricultural uses were modified using the USDA 2007 Census of Agriculture and the 2007 National Crop Residue Management Survey from the CTIC. Barren classes were modified using data from the VDMME. Additional classes were based on processes developed for DCR by The Academy of Natural Sciences of Philadelphia (1997) using data from DCR's confined animal databases.

[3] Not all land uses were modeled (see Table 4.1-1). The area of a particular unit as used in these calculations would not include the hectares of non-modeled land uses occurring in that unit.

[4] For instance, units with high loading rates for agricultural land may have only a small amount of this land use and therefore small total loads of pollutants from agricultural uses. Furthermore, any action (if possible) in any year could encompass all reasonable reduction activities, thus making this unit unworthy of further attention.

new land use dataset from may new components, updated animal types and counts as well as distribution determinations, and new BMP pollutant reductions.

For consistency with other circulating NPS assessment reports and maps and with the manner in which this data is used, the ranking of hydrologic units for the NPS pollutant UAL components for the 2010 NPS Assessment study has maintained the same division of UALs into categories that has been used before - the highest 20% of the values for each component being classified as high, the next 30% being classified as medium, and the remaining 50% classified as low. This ranking methodology applies to the NPS pollutant loads only. These range definitions are not absolute, since units with equal or very similar loading values would not be divided into different classes.

Information regarding the NPS pollutant loadings by general land use and as summations per pollutant is found within the following sections.

Table 4.1-1 Land Use Classification

Original Class	Derived Class	Modeled Class	General Output Class
Pine Forest Hardwood Forest Mixed Forest		Forest	Forest
Forest Harvest		Disturbed Forest	
Crop Bare Soil (portion)	Conventional Tillage Conservation Tillage Hay Unimproved Pasture Pasture Cattle-Grazed Pasture Poultry Litter Manure Acres	Conventional Tillage Conservation Tillage Hay Unimproved Pasture Pasture Cattle-Grazed Pasture Poultry Litter Manure Acres	Agriculture
Pavement Rooftop		Impervious Urban	Urban
Residential/Industrial Grassland Bare Soil (portion)		Pervious Urban	
Natural Barren Extraction		Barren	
Open Water Salt Marsh		not modeled	

Table 4.1-2 Statewide NPS Pollutant Loads – Post BMP Reduction

	Agricultural Class	Urban Class	Forestry Class
Total VA Land Area *#	5,957,955	2,654,341	16,285,678
%of VA Land *	23.6	10.5	64.4
Total Nitrogen **	29.5	10.6	3.0
%of all NPS N	67.7	24.3	6.8
Total Phosphorous **	4.4	0.9	0.4
% of all NPS P	73.2	14.7	6.2
Total Sediment **	2,409.2	167	686
% of all NPS S	60.3	4.2	17.2

* Units are acres.
\# Does not include 399,205 acres of salt marsh and barren land (see Table 4.1-1).
** Units are millions of Kg/year.

Agricultural NPS Pollution Loads

Agriculture is a large and diverse industry in Virginia and accounts for almost 24% of Virginia's land use. While this percentage is significantly lower than the national average and continues to decline in Virginia, agricultural activities remain the most significant source of nonpoint source pollution in the state. As shown in Table 4.1-2 and as the current and all past assessment model results suggest, agricultural land in Virginia contributes NPS pollutant loads in greater proportion to the area they comprise than do the other land use classes. Estimated loadings from agriculture in this assessment have declined from the past but are still about 60% to 73% of the total statewide NPS pollutant loads.

Nonpoint source contamination from agriculture originates from several different sources with different associated impacts. Deposition of potential NPS pollutants to agricultural lands in the form of fertilizers and animal manures affect water quality when they reach groundwater reserves, are directly deposited to streams, or are washed into streams, lakes, etc during rain storms in either a dissolved state or with eroding soils. These pollutants include pathogens as well as nutrients. Farming practices can contribute to or retard runoff and can certainly affect the amount of soil lost from fields which can potentially end up in water features.

This assessment measured the nutrient and sediment loads from agricultural areas but not the loading of pathogens. Factors in this assessment which affect the amount of nutrient loads reaching water from agricultural lands include the erodability of the soils, types of agricultural practices, types and numbers of farm animals, land cover, stream density, rainfall, seasonal variations in plant growth and nutrient applications, existence and type of agricultural BMPs, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from agricultural land uses are displayed in Figures 4.1-1, 4.1-2, and 4.1-3 respectively. The rankings are also listed in Table 4.1-3

There are a few factors that are specific to changes in loadings, and thus ranks, of the agricultural NPS pollutants between the current and past assessment products. An updated database on confined animals and a new Census of Agriculture are invaluable in distributing farm animals spatially and allowing for better pollutant load estimations from animal sources. An improved more precise calculation of pasture yield for the distribution of non-confined animals (usually beef) is also employed. There is also a different set of agricultural NPS BMPs installed and operating. Nonetheless, there was not much change in the ranking of hydrologic units for agricultural loads since the previous NPS Assessment.

Urban NPS Pollution Loads

Around 10.5% of the land in Virginia is considered urban. This is a noticeable increase from previous land use analysis and indicative of the urbanization of forest and agricultural land that continued unabated in many parts of the Commonwealth, at least until the recent economic slowdown. Urbanized land produces NPS pollutants as the result of precipitation washing nutrients, sediment, and other toxic substances from the impervious surfaces that make up these areas. The sources of these surface contaminants include: air and rain deposition of atmospheric pollution; littered and dirty streets; traffic by-products such as petroleum residues, exhaust products, heavy metals and tar residuals from the roads; chemicals applied for fertilization, control of ice, rodents and other pests; and sediment from construction sites. Illegal industrial, commercial and domestic hook-ups to storm sewers also contribute a number of specific pollutants to waterways, as do inadequate and/or improperly maintained sewage disposal systems both for municipalities and individual homes.

This assessment measured only the nutrient and sediment loads from urban areas as opposed to all urban NPS pollutants as described. Factors that are specific to changes in loadings, and thus ranks, of the urban NPS pollutants between the current and past assessment products include the updated land use and the removal of natural barren and extraction land use loads from the urban loads. Factors that affect the amount of loads reaching water from urban lands include the degree of imperviousness of the urban land use, impervious area NPS pollutant build-up rates, stream density, rainfall, septic system use, direct discharges, soil saturation, and slope.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from urban land uses (as described in Table 4.1-1) are displayed in Figures 4.1-4, 4.1-5, and 4.1-6 respectively. The rankings are also listed in Table 4.1-3. The highlighted units are reflective of the areas of Virginia that are undergoing significant urban development and redevelopment activity as well as those with significant amounts of marginal septic system use. Urban load measures are based on pollution potential and do not compensate for urban runoff control measures that may be in place in some areas. Such reduction measures are primarily installed by the private sector.

Forestry NPS Pollution Loads

About 64% of the land area of Virginia is forested. Forestland in general produces lower NPS pollutant loads[5] than other land uses. Certain forest disturbing activities such as tree harvesting, site preparation, and reforesting however do make a load contribution. As Table 4.1-2 shows, these activities contribute more to the sediment load than they do to other NPS pollutants.

Forest land can be harvested as part of a land use change such as residential development, clearing for agricultural fields, or surface mining. Due to the similar spectral signatures in classified land cover imagery of these land activities, as well as those of non-temporary land covers such as bare rock and beaches, it can be difficult to discern them from one another without other associated data. Fortunately the VDOF tracks forest harvesting activities so as to facilitate the proper management of Virginia's forest resources relative to water quality and so included this class in their land cover product. This provides a much better distribution of disturbed forest across the state than was possible in previous NPS Assessments.

Whereas agricultural activities operate on a yearly or seasonal cycle on agricultural lands, a single cycle of forest harvesting, site preparation, and reforestation occurs over many years. Where the next cycle begins amongst existing forested lands is undetectable from previous land cover images, making the measure of forest disturbance for these activities more of a snapshot than a trend. As such, the ranking of hydrologic units for forest based loads varies more between NPS Assessments than does the loads of other land use classes.

Factors in this assessment that affect the amount of loads reaching water from forestlands include the erodability of the soils, existence of disturbed forestlands, stream density, rainfall, existence and effectiveness of forest (silviculture) BMPs, soil saturation, and slope.

[5] Airborne nutrient pollution is accounted for as part of the load of the land use it falls upon. The majority of the airborne nutrient load falls on forestland in Virginia and is therefore associated more with forestland than with other uses.

The ranked UALs by hydrologic unit of nitrogen, phosphorus, and sediment from forestland uses are displayed in Figures 4.1-7, 4.1-8, and 4.1-9 respectively. The rankings are also listed in Table 4.1-3.

The factors most responsible for the changes in loadings, and thus ranks, of the forest NPS pollutant loads in this assessment include the new land use dataset, particularly the occurrence of a spatial forest harvest land use class since land disturbance is the primary sediment loading activity, and improved silviculture occurrence and effectiveness.

NPS Pollution Loads of Other Land Uses

In previous NPS Assessments the urban class loads included the loads from extraction activities and non-urban barren land uses. This included loads from natural barren lands (beaches, rock outcrops, etc.) and lands made bare for reasons other than urban development (which are part of the urban load) or forest harvesting (which is part of the forest load). Results could be somewhat misleading for urban loads in localized areas of high extraction or natural barren conditions.

Therefore with this NPS Assessment the extraction and non-urban barren lands have not been lumped into the urban land use class with regards to reporting loads or unit area loads (see Table 4.1-2). They also therefore do not influence the ranking of units for the urban load class.

Using spatial data of resource extraction from the VDMME helped isolate true extraction activities from reforesting sites or other land clearing activities. The spatial distribution of extraction land use had to be determined using only county level recordings of extraction activity in past NPS Assessments.

Approximately 14% of the phosphorous, 1% of the nitrogen, and 18% of the sediment load in the 2010 NPS Assessment was associated with these barren and extractive land uses. These loadings were very localized however, having significant potential impacts to water quality in a small percentage of units. The area where these loads were highest was in the Clinch and Powell River basins. Slightly lower barren land loads occurred in the Big Sandy basin and less but noticeable loads coming from barren lands associated with fringe urban development.

Total Loads Per NPS Pollutant

Calculated total nitrogen, total phosphorous, and total sediment unit area loads from all land uses combined, including the other uses noted above, are displayed in Figures 4.1-10, 4.1-11, and 4.1-12 respectively, and listed in Table 4.1-3. Total nitrogen is composed of septic nitrogen, groundwater nitrogen, dissolved nitrogen from various land uses, wash off of nitrogen from impervious surfaces, and sediment-attached nitrogen. Total phosphorous is composed of septic phosphorous, groundwater phosphorous, dissolved phosphorous from various land uses, wash off of phosphorous from impervious surfaces, and sediment attached phosphorous. Total sediment is the sediment yield from all land uses.

The summing of NPS pollutant loads by land use into total NPS pollutant loads in this NPS assessment is simply the addition of values with equivalent units (kg/ha/yr of nitrogen or phosphorous, Mg/ha/yr of sediment). Accordingly, the relative weight of the estimated NPS pollutants coming from one land use versus another is directly comparable. This comparison shows that NPS pollutants from agricultural lands dominate the total NPS pollutant loads although barren lands can be heavy contributors where they occur in some concentration.

IMPAIRED WATERS

In accordance with US EPA guidance and protocol, the DEQ assembled a list of the water quality limited riverine, lacustrine, and estuarine waters of Virginia in 2008 (303d report). That list of water quality limited waters is the basis for the impaired waters portion of the 2010 NPS Assessment study.

Waters listed in the 303(d) do not meet one or more of the EPAs five designated uses for water. Among the many defined attributes in the impaired waters database is the name of the impaired waters, the beginning and ending limits of the impaired portions, impairment causes, and impairment sources. Only waters listed by the DEQ staff as having NPS related sources or those waters not explicitly listed as having an NPS source but which (a) did not explicitly list any other sources, and either (b) listed possible agriculture related impairment causes[6] or (c) correlated with DCR's areas of nonpoint sources, were considered in this analysis.

Waters in the impaired waters layer that are suspected of being impaired due to nonpoint sources were divided by the hydrologic unit boundaries into segments by unit to allow for the summation of impaired water lengths or areas by these units. The same process performed on all waters in the state determined the total available miles of riverine, acres of lacustrine, and square miles of estuarine waters per hydrologic unit that occur for comparison against the impaired portions.

Whereas the NPS pollutant loads of the 2010 NPS Assessment are estimated measures of nutrients and sediment, most of the NPS impaired waters from the 2008 303d report are listed due to the existence of pathogens. Total Maximum Daily Load (TMDL) studies have shown that pet wastes can have a role in high pathogen counts in some urban streams. Concentrations of wildlife can have a similar affect in various land use / land cover settings. Likewise human wastes arising from the existence of straight pipe disposal, failing septic systems, or malfunctioning water treatment plants can all contribute to the impairment of waters due to high levels of pathogens. A significant number of the waters impaired due to the existence of pathogens however are believed to be impaired because of farm animal wastes.

The number of farm animals by type and by unit is part of the nutrient load calculation, since most farm animal wastes are recycled back to the ground by the animals or in a more controlled mode by farmers who want to fertilize fields and/or remove wastes from confined animal sites. The controlled dispersal of wastes is a goal of Nutrient Management planning and a practice that DCR cost-shares with farmers to implement. The fencing off of stream banks and construction of alternative water sources are two such practices, in this case designed to keep cattle out of and away from streams so as to avoid the sediment loading from eroded stream banks and also avoid the high pathogen counts of direct deposition of manure.

The rankings of hydrologic units by water regime that follow consider only non-shellfish NPS-associated impairments.

Riverine Impairments

Summed lengths of NPS impaired riverine water features in 2008 as miles per hydrologic unit were compared to the total miles of riverine systems available per unit at the same scale[7] to determine the percentage of the available riverine water miles per unit that were NPS impaired. The ranking of this value is based on the value itself and not on a pre-set distribution of the range of calculated percentage values. The rankings of units for impaired riverine waters are displayed in Figure 4.1-13 and listed in Table 4.1-3.

Estuarine Impairments

Most of the impaired main stem estuarine water bodies in Virginia have listed impairment causes that are not considered to be due to (with any significance) practices occurring in the immediate units that the main-stems flow through. There may be, in fact, very little land associated with some of these units. Estuarine waters are also tidal and may show pollution effects from multiple areas, even if they are not main-stem estuarine water bodies. For these reasons the estuarine waters are not being used to rank the

[6] This included all fecal causes of unknown sources since approximately 90% of non-urban fecal problems are surmised to be due to agricultural or natural animal loadings. Similarly, because about 85% of benthic impairments are believed to be sediment related, and because DEQ personnel are more likely to know and document point sources of benthic impairments, all benthic impairments of unknown sources are considered to be NPS related. Impairments with nutrient sources were also included.

[7] The calculation of miles or acres of water within any unit will vary by the scale of the hydrography layer from which it is calculated because of both line generalization and network simplification at lower scales. Therefore the calculation of available miles or acres had to be done using the same scale of hydrography as was used to calculate miles or acres of impaired waters. In 2008 that scale was 1:100,000, augmented by the inclusion of smaller streams designated as impaired. That scale will improve to 1:24,000 with the completion of the high resolution National Hydrography Dataset for Virginia by 2011, at which time these calculations can be redone.

hydrologic units in which they pass in this assessment. Although there are NPS impaired estuarine waters it is difficult to associate them with specific upland NPS pollutant sources.

Lacustrine Impairments

Summed areas of impaired lacustrine waters in 2008 as acres per hydrologic unit were compared to the total acres of lacustrine waters available per unit to determine the percentage of lake waters in a unit that were impaired. Although the land area of these units can be a source of the NPS pollutants, so too can the incoming streams.

The ranking of this value is based on the value itself and not on a pre-set distribution of the range of calculated percentage values. The vast majority of the hydrologic units in Virginia contained no impaired lake or reservoir waters in 2008. The majority of the rest however had very high percentages of impaired lacustrine waters. This distribution is in part due to the decreased unit sizes of the 6^{th} order NWBD units but also due to the call regarding their impairment source. The rankings of hydrologic units for impaired lacustrine waters are displayed in Figure 4.1-14 and listed in Table 4.1-3.

BIOLOGICAL HEALTH

Also included in the 2010 NPS Assessment and Prioritization study is information from VDH on public surface water sources and their protection zones, and an evaluation of the health of aquatic species in the state's waters by the CES at VCU. These components provide an additional means to prioritize water quality protection - the protection of the sources of public drinking water and of natural aquatic communities respectively.

Public Source Water Protection

As part of their Source Water Area Protection (SWAP) Program, the VDH determined the area upstream of public surface water intakes that must be investigated for threats to water quality. The most immediate area of their concern is referred to as the Zone 1 for each intake. Zone 1 areas extend out to a 5 mile radius upstream from a water supply intake or 5 miles around a lake containing an intake, without crossing watershed boundaries except those upstream. The population served by an intake, provided by VDH, and the portion of a hydrologic unit that is within a Zone 1 area has been used by DCR to calculate the concentration of persons served per unit by these public surface water supplies. The concentration values serve as a measure of the importance of high water quality by hydrologic unit for public drinking water supply protection.

Concentration values are the summation by hydrologic unit of all Zone 1 areas or combinations of Zone 1 areas in that unit times one one-thousandth of the effective population each serves. In cases where a municipality owned several intakes, the single recording of population served was divided amongst each intake to create an effective population served. In cases of overlapping intake reaches the effective population of each reach was summed for the portion of overlap.

The categorized values and rankings for indicating concentration by unit are displayed in Figure 4.1-15 and listed in Table 4.1-3. Unlike the NPS loading variables in this assessment, where units that are ranked high represent units of concern, the high ranking public source water units are just units with a high need for water quality protection. A significant amount of their area lies immediately upstream from surface water intakes that are used extensively for public drinking use by many people.

The vast majority of hydrologic units contained no Zone 1 protection zones or portions of Zone 1 protection zones. Of those with some Zone 1 content, the majority had low levels (< 10) of the calculated measure for concentrations of people served within a watershed. Of the remaining units, a few had significantly higher value measures (> 100) and were therefore classified as having a "Very High" need for source water protection. The rest were divided amongst a moderate category (10-30) and a high category (30-100).

Aquatic Species Measures

The presence or absence of certain aquatic species can serve as an indication of the overall quality of a particular waterway. They can also indicate where the most biological damage can occur from water quality degradation. Accordingly, the NPS Assessment and Prioritization study provides a ranking of hydrologic units for stream-dependent living resources (including fish, mollusks, and crayfish) using a multi-metric index calculated by the CES at VCU as part of their Interactive Stream Assessment Resource (INSTAR).

These indexes (referred to as the mIBI - a modified version of the Index of Biological Integrity) are calculated by the CES using databases originally developed by DCR, the VDGIF, and VCU[8]. More than 162,000 database records have been gathered since INSTAR's conception. As a result it was possible to calculate a mIBI value for more than 92% of the 6th order units of the NWBD. An equally beneficial result from having more records available for any unit is the decreased likelihood of a false prioritization indication based on minimal information.

By associating a hydrologic unit code to each of the stream segments for which aquatic species information was available in the various databases, metric scores by unit were developed for each of 6 metrics. These metrics are as follows:

Metric 1 – Number of Intolerant Species: refers to the total number of unique water quality intolerant species found in a unit.
Metric 2 - Native Species Richness: refers to the number of indigenous (local) species present in a unit.
Metric 3 - Number of Rare, Threatened and Endangered Species: refers to the number of species that are considered rare, threatened or endangered due to their low population levels that are present in a unit.
Metric 4 - Number of Non-indigenous Species: refers to the number of non-native species present in a unit. These are introduced species that would not normally be found in this particular location.
Metric 5 - Number of Critical Species: refers to the number of species found in a unit that are considered critical because of some important role that they play, such as being a food source or major recreational fishery.
Metric 6 - Number of Tolerant Species: refers to the number of species found in a unit that are tolerant to degraded stream conditions and can survive even in these sub-optimal conditions.

A score of 0 – 5 was assigned by the CES for each metric based on the metric's values. In general high metric values were assigned high metric scores - indicative of high stream health. A score of zero was given if insufficient data was available. Of the 1247 hydrologic units, 97 (8%) were assigned a zero for this reason. Metrics 4 and 6 were reversed in the scoring, since a low value for either of these metrics would indicate high stream health. Therefore a high metric score was given for low metric values for these two metrics. Lower values are more desirable in metrics 4 and 6 because a high number of non-native species and/or a high number of species that are tolerant to stream degradation are less desirable characteristics for a stream.

Scores for each metric for each unit were totaled to give an overall total mIBI score per hydrologic unit. These summed scores per hydrologic unit were then tiered relative to the summed scores of the other units in the same basin by assigning a category value of High (score of 5), Medium (score of 3), or Low (score of 1) on a per metric per basin basis. The resulting total mIBI scores are used to place each hydrologic unit into ranked categories reflecting biotic integrity and resource importance.

Since there were 6 metrics and a maximum score of 5 could be obtained for each metric, the overall maximum score a unit could receive was 30 (6 x 5). Just under 8% of the units (97) are considered to have very high biodiversity, with total mIBI scores of 20 or more. Another 193 units have total mIBI scores of at least 18. At the other end of the spectrum, 6.3% of the units (78) with sufficient data have total metric scores of 10 or less – indicative of low biodiversity. These units most probably contain waters with some degree of degradation.

Figure 4.1-16 displays, and Table 4.1-3 lists, the categorization of the mIBI scores by hydrologic unit. In this figure and table, high mIBI scores equate to areas of high biotic integrity. Whereas low mIBI ranked

[8] More information about the mIBI and the other components of INSTAR can be found at http://instar.vcu.edu.

represent units of concern in regards to low water quality based on aquatic species measures, high ranked units represent areas of importance for the protection of the state's streams of exceptional biodiversity. The majority of the changes in total mIBI scores occurred in the southwest portion of the state and may be due to increased data collection in that area rather than an increase in water quality degradation.

While the maintenance or enhancement of water quality for the protection of all native aquatic life is the preferred goal, these aquatic species priorities should help direct NPS pollution mitigation efforts and other water quality improvement projects toward hydrologic units with the most important aquatic resources.

COLLECTIVE USE OF RANKINGS

The 12 rankings assigned to hydrologic units for NPS pollutants by land use class, the 2 rankings of units for impaired waters, and the 2 rankings of units for biological health can be used in various combinations to evaluate statewide conditions and prioritize NPS reduction activities. Which measures are included in each prioritization process, and how one weighs in comparison to another, is dependant on the activity to be prioritized. For instance, DCR uses the agricultural NPS pollution rankings as variables in the targeting of agricultural best management practices (see Agricultural Cost Share Program below) and rankings of NPS pollutant loads and biological health were part of the TMDL implementation prioritization (see Total Maximum Daily Loads below).

There are a number of considerations to keep in mind when constructing prioritization processes using these rankings. Perhaps the most important is that some factors are measures potentially being produced at the hydrologic unit of interest, such as the NPS pollutant loadings. Other measures reflect existing conditions at the unit of interest, such as the impaired waters and aquatic species health, and may in part be due to activities occurring in upstream units. The source water concentration values directly account for the upstream affect by virtue of their being based on a designated upstream zone.

Another consideration is the possible incorrect inference of cause and effect. Waters in a hydrologic unit may be impaired due to nonpoint sources, and subsequently ranked high, but the cause of these waters being listed as impaired is often not related to the nitrogen, phosphorous, and sediment that is potentially being loaded to these waters in either the unit of concern or upstream of it. Likewise point source loadings can be the reason for the streams in a unit to collectively produce a low mIBI score and aquatic species rank.

In the 2010 NPS Assessment and Prioritization some units have been flagged for a number of conditions that can be determined by comparing the rankings for all measures in this report. The flags have been entered into Table 4.1-3. The conditions are:

Exceptional aquatic biodiversity.
1> Units (9) with mIBI scores of 24 or greater.

High aquatic biodiversity with potentially high NPS pollutant loads.
2> Units (7) with mIBI scores of 18 or greater and all high ranked total NPS pollutant loads.

High public water supply protection need with potentially high NPS pollutant loads.
3> Units (6) with source water concentration values greater than 30 and any high ranked total NPS pollutant load.

NPS impaired waters within high public water supply protection need zones.
4> Units (10) with source water concentration values greater than 30 with NPS impaired riverine or lacustrine waters within the source water protection zone and upstream of the intake.

Excessive agricultural loadings.
5> Units (7) with agricultural nutrient loads greater than 3 times the standard deviation from the mean agricultural nutrient load.
6> Units (18) with agricultural sediment loads greater than 3 times the standard deviation from the mean agricultural sediment load.

NPS REDUCTION ACTIVITIES

Efforts to reduce NPS pollution in Virginia have been undertaken by a full range of government agencies - federal, state, regional, and local, as well as by citizen action. In many cases the activities are cooperatively performed and funded. The 2004 Virginia Nonpoint Source Pollution Program Report, found at http://www.dcr.virginia.gov/stormwater_management/documents/npsrep04.pdf, contains descriptions of the cooperative NPS reduction activities. Most of these efforts target particular watersheds. Among them, and elaborated on here, are the TMDL studies and implementation, Tributary Strategies, Agricultural Cost Share incentive programs for BMP installations, and incentives for the set aside of agricultural land.

Total Maximum Daily Loads

TMDLs, described elsewhere in this 305(b) report, are performed for waters that have been determined to be impaired and are so listed in the State's 303(d) report. Streams are not listed as impaired however due to high concentrations of nitrogen, phosphorous, or sediment, but rather because they cannot support, or can only partially support, one or more of the five designated uses. This is because water quality standards do not exist for concentrations of these NPS pollutants for free-flowing waters. Nevertheless, certain impairment causes are primarily due to nonpoint source pollutants (see Impaired Waters in this chapter) and DEQ staff has often determined that there are nonpoint sources for these impairments.

Using the logic of the impaired waters rankings of the NPS Assessment study, all impairments for which one or more of the stages of a TMDL have begun were divided between those with and those without a nonpoint source. Most of the waters declared impaired in Virginia are, or are believed to be, impaired due to, or partially due to, nonpoint source pollution. Consequently, most of the TMDLs that are being undertaken have a nonpoint source component. These studies are focusing on identifying the sources of the impairment causes, quantifying the loadings of these sources to the water, and determining the reduction in loads needed in order to meet the use criteria. The development of an implementation plan is expected following the completion of a TMDL study for a particular watershed. Implementation of the plan's course of action then follows.

The number of TMDLs underway or completed is continually increasing. Table 4.1-4a lists the NPS TMDL Study Reports (excluding shellfish) and Table 4.1-4b lists the NPS TMDL Implementations Plans as of Feb 2010 by their status, which is a temporal condition. There are now 45 completed NPS dominated TMDL Implementation Plans covering 113 impaired waters with another 11 underway covering 40 impaired waters. In addition there are 165 NPS dominated TMDL Studies covering 374 impaired waters that have been approved by the EPA, with another 35 studies under development covering 103 impaired waters. The number of TMDL Study Reports completed cannot be directly compared to Implementation Plans completed as the geographic area and impaired waters included may vary; that is, an Implementation Plan may be developed for only a portion of a TMDL Study.

Whereas it is streams or water bodies that are listed as impaired, it is the watershed of those impaired stream segments and water bodies that are the focus of nonpoint source pollutant reduction activities. The hydrologic units listed in Tables 4.1-4a and 4.1-4b are those in which some portion of the unit contains the listed impaired stream segment. Sometimes the entire area of the listed hydrologic unit is the watershed of the impaired stream segment, but often only a portion of that unit must be studied for a TMDL. Figure 4.1-17a shows the true TMDL study areas and thus gives a better indication of the geographic extent of where the work is being performed. One difficulty in geographically representing the extent of multiple TMDL areas is that they often overlap – the watershed of a TMDL for a headwaters stream becomes part of the watershed of a TMDL for a larger water feature downstream. In Figure 4.1-17a the EPA approval status of the latest TMDL work is assigned visual priority. Figure 4.1-17b likewise shows the true TMDL Implementation Plan areas which include no geographic overlap.

Agricultural Cost Share Program

The Virginia Agricultural Cost Share Program (VACS) offers incentives to farmers and agricultural land- owners to encourage the installation and use of a number of approved techniques (BMPs) for reducing agricultural related nonpoint source runoff. While the program aims to address nonpoint source pollutants statewide, specific hydrologic units are targeted based on the agricultural loads estimated from the NPS

Assessment study (see Agricultural NPS Pollution Loads) and other factors. Soil and Water Conservation Districts further target the practices to individual needs within their district within these load priority areas.

Funding for the implementation of these practices has been borne by the state and the federal government since the program's inception in 1985. The number of installations per year has varied widely over the years, correlating with the variation of funds available to the program. At this time the primary funding source is the Water Quality Improvement Fund (WQIF) of the Commonwealth's Water Quality Improvement Act (WQIA). Other state and federal funds may be used however, such as Chesapeake Bay Implementation Grants.

Table 4.1-5 contains the estimated NPS reductions by basin for program years 2008 and 2009, as well as the state's costs to attain these reductions, from the VACS Program. The $27,179,824 of total VACS costs for this program in this table is almost 5 times the amount of expenditures from the 24-month period in 2005-2006 as reported in the 2008 305(b) Report. As might be expected therefore, there is a significant increase in the reported estimated loads of NPS pollutants that are being reduced.

Additional information on agricultural best management practices and the cost-share program can be found at http://www.dcr.virginia.gov/stormwater_management/costshar.shtml. Other efforts to reduce NPS pollutants include local and state stormwater controls, BMP installations by the USDA, and silviculture BMP installations by the VDOF. These and other pro-active efforts increase the reductions reported and negate estimated loads as calculated in the NPS pollution loadings of this assessment.

Table 4.1-5 NPS BMP Pollutant Reductions and Costs, Program Years 2008 & 2009
1 July 2007 through 30 June 2009

	Ag Cost Share Totals				CREP Totals			
BASIN	Tons SL Reduced	Lbs N Reduced	Lbs P Reduced	State Cost ($)	Tons SL Reduced	Lbs N Reduced	Lbs P Reduced	State Cost ($)
POTOMAC	60406	328606	51854	1,835,019	8427	45841	6303	317,457
SHENANDOAH	125808	684397	158460	3,805,286	3108	16906	3787	1,150,467
RAPPAHANNOCK	185738	1010417	194128	2,531,353	7688	41824	6319	1,081,919
YORK	291020	1583148	306785	1,873,622	903	4915	754	205,100
JAMES	164866	896873	189588	4,765,609	10088	54881	9772	1,450,466
BAY COASTAL	21843	118828	27949	1,359,931	586	3190	780	59,581
OCEAN COASTAL	9913	53926	13608	489,429	104	565	137	14,158
ALBEMARLE SOUND	5820	31661	5827	284,952	441	2400	632	77,090
CHOWAN	71684	389959	104969	1,662,017	4521	24594	6691	691,869
ROANOKE	158928	864568	173727	4,485,764	7393	40219	8943	677,980
YADKIN	2191	11920	2191	50,025	14	78	14	4,200
NEW	119219	648553	114370	1,542,568	2618	14240	2564	470,074
CLINCH/POWELL	45643	248298	48861	1,118,155	3596	19562	3740	532,223
HOLSTON	68704	373752	76085	1,277,897	8550	46510	9129	918,546
BIG SANDY	1265	6882	1265	98,197	0	0	0	400

Conservation Reserve Enhancement Program

The USDA's Conservation Reserve Program (CRP) provides incentives for the removal of agricultural land from production to protect environmentally sensitive land alongside rivers and streams. The Virginia Conservation Reserve Enhancement Program (CREP) augments CRP by providing for state enhanced cost-share and rental payments for conservation practices focused on the restoration of riparian buffers and wetlands. The Virginia CREP also funds the purchase of conservation easements on the restored riparian buffers.

Most areas of the state qualify for CREP assistance. Table 4.1-5 contains the estimated reduction of nonpoint source pollutants by basin for program years 2008 and 2009 from the Virginia CREP, as well as the state's costs to attain these reductions. The $7,651,530 of total state costs for this program in this table is more than 7 times the amount of expenditures from the 24-month period in 2005-2006 as reported in the 2008 305(b) Report. As with the VACS funding reductions, there is a significant increase in the reported estimated loads of NPS pollutants that are being reduced from CREP installations.

The USDA's CRP increases the reported reductions. Information about CRP can be found at http://www.nrcs.usda.gov/programs/crp/. Additional information on the Conservation Reserve Enhancement Program can be found at http://www.dcr.virginia.gov/stormwater_management/crep.shtml.

Tributary Strategies

Tributary Strategies are basin wide water quality plans designed to meet the pollution reduction goals of the Chesapeake Bay Program. They are part of the State's CBP commitment, and thus are described in that chapter of this 305(b) report. The goals of these plans directly specify both nonpoint source nutrient load reductions needed for water quality attainment and attainment measures that will require nonpoint source pollutant reductions. Significant amounts of nonpoint source pollutants must be reduced to achieve these plans, at considerable cost.

In Virginia implementation Plans have been written for the Eastern Shore, York River, Potomac-Shenandoah Rivers, James River, and the Rappahannock River. A priority of these plans is the addressing of agricultural sources through cost-share and other programs. In addition, water quality initiatives that achieve measurable reductions will be funded in the urban and suburban arenas and competitive grants are being offered to local governments and nonprofits through Cooperative Nonpoint Source Local Programs for local water quality implementation projects that meet tributary strategy goals.