B. Ambient Monitoring Program

1. Watershed Station Network (AW)

This monitoring module was originally designed (2000) to provide comprehensive monitoring coverage of streams and rivers in each of the 493 local upland Virginia watersheds that had previously been delineated by USDA-NRCS & VA-DCR in 1995 (Chesapeake Bay mainstem excluded). Two of the major data users in the Commonwealth, the Virginia Department of Environmental Quality and the Department of Conservation and Recreation (DCR), indicated that this was an important objective. In addition, both the EPA and the state legislature (Code of Virginia, Article 4.01 - Water Quality Monitoring, Information and Restoration Act [I-0d.pdf] - WQMIRA) require comprehensive geographic coverage of the state's surface waters by DEQ's Ambient Water Quality Monitoring Program.

In the original design, watershed stations were located at the mouth of and within each local watershed, based on the standardized siting scheme described below. Among other considerations, the density of stations in the watershed was determined by the 'NPS Priority Ranking' [II-B-7a.xls] described in **Chapter II. - Virginia's Water Resources, Section C - Classification (Description) of Water Resources**. DEQ water quality monitoring resources were thus focused on known or suspected problem areas, so that higher densities of monitoring stations were established in areas of higher NPS risk potential. Watershed stations were monitored on a 'two out of six years' rotating basis, such that in a six-year rotation cycle all 493 upland watersheds were monitored. Each of these stations was sampled at a bimonthly frequency for a two-year period during each six-year rotation. This rotation schedule and sampling frequency were considered beneficial for several reasons. The sampling frequency provided enough data (12 observations) within a continuous two-year block to perform reliable assessments, and spreading the monitoring over two years reduced the effects of occasional extremely wet or dry years. The rotating stations and basins also provided potential cost savings by concentrating monitoring field runs in consolidated areas, thus minimizing the overall annual mileage required for monitoring runs.

More recently, in 2006, DCR completed the delineation of 315 5th Order (10-digit) watersheds and 1247 6th Order (12-digit) sub-watersheds following new guidelines set forth for developing the National Watershed Boundary Dataset (NWBD – refer to Chapter II.C.4 - The 'National Watershed Boundary Dataset' (NWBD) - 2006). DCR officially adopted the new delineations in July of 2006 and had already begun adapting their land use characterizations and non-point source risk potential assessments to the new hydrological units at that time. They expected to complete the task in 2007, in time for the 2008 305(b)/ 303(d) Integrated Report. At that time, DEQ's guidelines had already been established for station siting within the 1247 6th Order (12-digit) 'sub-watersheds' and are summarized later in this section (§ III.B.1(2) - Siting). DEQ began adapting its watershed station siting protocols to these new sub-watersheds for the two-year rotation that began in 2007 (1 Jan '07 – 31 Dec '08) and planed to complete the process by the end of the following two-year rotation cycle, in December of 2010. The third and final two-year rotation of the second six-year cycle was completed in December of 2012, in time for inclusion in the 2014 305(b)/303(d) Integrated Water Quality Report.

Beginning with the 2008 305(b)/303(d) Integrated Report, DEQ began to employ a six-year assessment window (2001-2006). With proper synchronization, assessing on a six-year window guaranteed statewide coverage by the Watershed Monitoring Network for each biennial 305(b)/303(d) Integrated Report (IR). A summary of timelines for the implementation of the first and subsequent full six-year rotation cycles of watershed stations, illustrating how the station rotation and assessment cycles had been synchronized, is presented in the linked spreadsheet "Watershed Station Rotation Timelines" [III-A-1a-9a.xls]. During the

first full rotation cycle, the first and second sets of rotating stations (July 2001 – June 2003 and July 2003 - June 2005) were monitored for two years each. The third rotation (July 2005 – December 2006) was truncated to 18 months; the first full rotation cycle thus lasted five and a half years, rather than six. This served to synchronize future two- and six-year rotation schedules with calendar years and the newly defined six-year monitoring windows for the biennial Integrated 305(b)/303(d) Assessment Reports. Subsequent six-year assessment windows thus correspond to three complete two-year watershed station rotation cycles. (Beginning in 2007, these six-year rotation cycles also become synchronized with the six-year full revision schedule of DEQ's WQM Strategy: see **Chapter IX – Plan and Schedule for Implementation**.)

Prior to 2012, following several years of sequential reductions in available state and federal resources, it became apparent that it would be necessary to reduce the number of watershed stations. Analytical resources available at that time would only be sufficient to provide for 360 ambient watershed sites to be monitored bimonthly each year, rather than the 400+ monitored annually in previous cycles. Prolonged discussions among monitoring staff between 2010 and 2012 confirmed the high priority for maintaining the watershed network based on 6th order sub-watersheds, and resulted in several recommendations for adapting the Watershed Monitoring Network to maximize the efficiency of resource expenditure and minimize the duplication of effort and overlap among several ambient monitoring programs. These adaptations are described in detail in the final paragraphs of Section - (2) Siting, 2013… below.

(1) Purpose

The Watershed Monitoring Network was established to provide comprehensive statewide coverage of all the Commonwealth's small hydrologic units for ambient surface water quality assessments (see the table "Virginia's DEQ/DCR-Designated 14-Digit Watersheds (1995)" [II-A-3.xls]). In addition, the siting density of watershed stations was adjusted in response to the evaluated potential risk of non-point pollution (see the table of "NPS Risk Potential" [II-B-7a.xls]) in order to provide more inclusive geographical coverage in areas where NPS risk was higher. Working in coordination with surrounding states and various federal agencies, DCR more recently (2006) developed new NWBD 5th and 6th Order Hydrological Unit delineations (10- and 12-digit HUs, respectively). DCR officially adopted them in July of 2006, and reorganized its GIS-based land use and NPS risk assessment database to accommodate the smaller and more numerous 6th Order 'sub-watersheds. A summary of the newly established 5th and 6th Order HUs is provided in the table Virginia's Integrated 5th and 6th Order Watersheds [II-B-5-B.xls]. DEQ subsequently began adapting its Watershed Monitoring Network to the new delineations and completed the process within the same six-year rotation cycle, which was concluded in 2012 (see the discussion below relative to station siting).

Watershed stations initially (2001-2006) consisted of two types, watershed mouth stations and intra-watershed stations. They were hydrologically/geographically targeted to reduce bias in site selection, and effectively provided a census of the state's local watersheds. (Some bias did remain, in that logistical convenience and safety considerations often dictated sampling from bridges or wharves with public access, i.e. near roads!) Watershed stations thus provided data to assess both the quality of ambient water within the targeted watershed and of the water leaving the upstream watershed and contributing to those situated downstream. When resources permitted, the intra-watershed stations also were rotated within the watershed and/or increased in number to eventually provide monitoring data from all significant tributaries within the local sub-watershed.

Adaptation to the NWBD 6th order sub-watersheds, which was begun for the 2007-08 rotation, increased the number of upland hydrologic units to be monitored from 493 (excluding the Chesapeake Bay mainstem) to 1235 (excluding the Chesapeake Bay mainstem and 11 coastal oceanic units). Available

resources at that time limited watershed stations to approximately one per sub-watershed and eliminated the flexibility to adjust station density in response to varying NPS pollution risks.

Adaptations of the Watershed Monitoring Network introduced in 2013 served to improve its geographic representativeness by associating ambient watershed monitoring efforts with the randomly selected sites of the Freshwater Probabilistic Monitoring Program (FP), while providing measures of temporal variation to improve the interpretations of the FP results. Additional Watershed Network resources were targeted at 5th order (10-digit) watersheds that revealed declining water quality trends during Seasonal Kendal and Integrated Water Quality Index trend analyses, or that were otherwise identified as problematic or of special interest.

Watershed stations contribute to the attainment of Objectives I.A (1 - 6) and C (10) of the WQM Strategy. The Watershed Monitoring Network is included among the top three monitoring activity priorities. When required by the reduction of available resources, the parameter coverage and/or the density of watershed stations could be reduced. It was recommended that under no conditions should less than one station be maintained within each watershed, generally at the mouth.

(2) Siting

2001 - 2006 (1995 Delineation - 493 Watersheds): The number of stations in a watershed was based on the watershed's size and its NPS priority ranking (as discussed in the section on the Classification of Virginia's Water Resources - Chapter II). For example, in high priority watersheds, resources permitting, one station, on the average, was located in each 10,000 acres of watershed area. In medium priority watersheds, one station was located in each 20,000 acres of watershed area and in low priority watersheds one station was located in each 30,000 acres of watershed, on the average (e.g. a medium priority watershed of 60,000 acres would have three stations assigned to it.) The priority ranking of the watersheds was completed biennially by DCR, as previously described. The densities of stations suggested here typically resulted in approximately 1200 stations statewide, with a distribution such that approximately 50% of the stations were located in high priority watersheds, which represented approximately 30% of the land area of the state. During the first six-year rotation cycle (actually 5½ years: July 2001 – December 2006) DEQ employed the described densities for the siting of its watershed stations. This concentrated monitoring resources on those watersheds with the highest potential for non-point source (NPS) impairment.

Each watershed had one watershed mouth station [20] sited on the major stream of its drainage, at or near the point where it left the watershed. A watershed mouth station could be either upstream or downstream from the unit boundary, as long as it was outside the mixing zones of any point-source discharges and no major tributaries entered between the site and the watershed boundary. Watersheds with multiple stations had intra-watershed stations sited using the Shreve Stream Order [III-A-1a-2a.doc] concept. Specific details on siting watershed stations using the Shreve Stream Order classification scheme were described in the document "Guidance for Siting Watershed Monitoring Stations" [III-A-1a-3.doc].

2007 – 2012 (2006 Delineation – 1247 Sub-watersheds): During the first full six-year rotation cycle (2001-2006), with 493 14-digit watersheds, sufficient resources were available to establish approximately 1200 watershed stations statewide using the protocol described above. The newly defined 6th Order sub-watershed delineation resulted in 1247 individual hydrological units. If monitoring resource availability were to remain the same, it would only be sufficient to provide a single station per sub-watershed and

[20] There were some exceptions to this rule. In certain circumstances, discussed in the Guidance for Siting Watershed Stations using the Shreve Stream Order concept, a local 'frontal' watershed may have multiple mouth stations or no significant mouth at all!

would not allow the variable density of siting previously described. The agency adapted its siting protocols to incorporate the new delineations. Initial guidance for prioritizing the chronological selection of sub-watersheds for the January 2007 rotation was provided as the Proposed 6th Order Sub-watershed Rotating Criteria [III-A-1a-10.doc].

In summary, the first priority was to include in the following two-year rotation (2007-2008) those units that have not been assessed within the past six years (see Watersheds Assessed by DEQ – 2002-2006 [II-B-7b1.pdf]). Among the 154 units not recently assessed, nine were predominantly near-shore oceanic, along the Atlantic coast. They do not contain any appreciable land area appropriate for inclusion within the Watershed Monitoring Network and will be addressed by other means, most probably with periodic special studies. Many additional sub-watersheds (both assessed and non-assessed) straddled state boundaries, with only a portion of the drainage lying within Virginia. Specific exemptions were provided for those of less than 3200 acres (< 5 mi^2) in area. If such fragments constituted the headwaters of a local watershed and drained out of state, they were be considered as belonging to the neighboring state and would be monitored only if the receiving state has found their portion of the drainage to be impaired. However, Virginia would only have listed the sub-watershed if it violated our own Water Quality Standards. In many cases, these small headwater fragments contain few if any perennial streams. If a minor fragment included the mouth of a sub-watershed and discharged into a downstream sub-watershed within Virginia, it was merged into the downstream unit for assessment purposes.

Among the remaining sub-watersheds without recent monitoring, chronological priority was given to those with 'High' followed by those with 'Medium' NPS rankings. For the 2007-2008 rotation, the most recent NPS ranking (2006 305(b) Report) for the corresponding watershed of the 1995 delineation was used. As a first choice in either case, bimonthly monitoring was conducted for two years using normal watershed (AW) parameters at a station located near the discharge point (mouth) of the unit. If such a watershed was difficult to reach, semiannual (spring and fall) benthic monitoring would be considered as a potential option. Spring and fall benthic monitoring was considered as a first choice for sub-watersheds with 'Low' NPS rankings; it might have been limited to two sampling events in a single year at the discretion of regional biologists. If benthic monitoring was considered to be inappropriate, then bimonthly (AW) monitoring was to be conducted near the mouth.

Regional Office Monitoring Coordinators collaborated with Central Office WQM personnel to identify existing monitoring stations, such as trend stations, long-term special study stations, etc., that would be appropriate to integrate into the Watershed Monitoring Network. If necessary, the parameter suite at such stations was altered to include all normal AW parameters in addition to their original coverage. They could be exempted from the normal watershed rotation schedule if their original purpose (such as trend monitoring) carried a priority equal to or higher than watershed monitoring; refer to Guidance Memorandum No. 03-2004, Managing Water Monitoring Programs While Under Reduced Resources [III-A-0f.pdf], which was in effect at the time, and the sampling 'frequency' descriptions for other monitoring subprograms below. (Memorandum No. 03-2004 was later revoked in June 2009 – see below!)

The exclusion of some sub-watersheds (as described above) from the Watershed Monitoring Network and the integration of stations from other subprograms into the network liberated some monitoring resources. They were redistributed within the network, or provided a potential increase in the total number of watershed stations. Once the availability of resources was defined, additional guidance was developed for further adjusting the intensity of watershed monitoring to specific water quality concerns.

2013 – 2018? (2006 Delineation – 1247 Sub-watersheds): The second of two statewide six-year rotation cycles of watershed monitoring terminated in December of 2012, and the second complete six-year

assessment window, from January 2007 through December 2012, will be included in the 2014 305(b)/ 303(d) Integrated Water Quality Report. Because of a precipitous decline in available resources between 2006 and 2012, it became apparent that the previous design of the statewide watershed network could no longer be maintained.

A proposal to collect additional water quality monitoring data in association with freshwater probabilistic monitoring sites [III-A-1a-8.doc] had been put forth in 2011. The primary objective was to better characterize temporal variability at ProbMon sites and spatial variability statewide. This proposal was discussed and evaluated at length, slightly modified, and was finally accepted in 2012. A portion of the resources previously dedicated to the Watershed Monitoring Network was subsequently transferred to provide monthly monitoring of physical and chemical parameters at carefully selected freshwater ProbMon sites, now identified as Probabilistic Ambient (PA) sites. Monitoring sites established for this new monitoring sub-program (PA) were selected and sampled using the transferred resources as follows. Sites from the annual selection of 50 – 60 locations for the Freshwater Probabilistic Monitoring Program (FP) were evaluated for accessibility and representativeness: (1) if public access [21] (*e.g.*, a highway bridge) was available within two kilometers up- or downstream from the nominal coordinates of the ProbMon site, (2) if no major change in land use practices or (3) change in Strahler stream order occurred between the two locations, and (4) if no point source discharges occurred within that segment, the public site was designated for monthly ambient monitoring of conventional field parameters and, at a minimum, normal watershed chemical parameters (AW-Freshwater, AW-Estuarine) [III-A-0b.xls] for a period of one year under Program Code PA - Monthly FP monitoring for physical and chemical parameters.[22] The Summary of Monitoring Stations [III-A-0ab.xls] in the 2013 MonPlan indicated that 42 PA sites met these criteria and were included for monitoring during the 2013 calendar year. Since these sites are monitored monthly for one year, the resource expenditure is equivalent to 84 normal watershed stations (monitored bimonthly) or 23.3% of the previously available annual watershed network resources. Monitoring was consequently suspended at previously established watershed stations within the same sub-watersheds.

Monitoring of previously established watershed stations was also suspended in those sub-watersheds where representative trend stations also existed, or where year-round monitoring of TMDL stations or special study stations was being carried out, with the caveat that at least one trend, TMDL, or special study station within the watershed include all AW parameters within its suite of analytes. The siting, frequency of sampling, and schedule of rotation of the remaining watershed stations were significantly modified.

Regional Monitoring Coordinators were given the option of focusing watershed monitoring on watersheds or sub-watersheds in their region that were considered problematic. Two proposed options [III-A-1a-10c.doc] for selecting such watersheds were to focus on the clusters of 6th order sub-watersheds that composed the 5th order watersheds identified as having declining water quality trends by the IWQ regression analyses [III-A-1a-10a] or that contained the long-term trend stations at which the Seasonal Kendall trend analyses [III-A-1a-10b] identified declining water quality reported in Virginia's 2012 305(b)/303(d) Integrated Water Quality Report. The 2013 MonPlan identified 145 (AW) watershed stations in this category. These sites are also monitored monthly for one year; the resource expenditure is therefore

[21] While authorization is generally freely given for access to probabilistic sites on private property, landowners are generally more reluctant to allow repeated access for additional monitoring during a prolonged period. In addition, reaching isolated sites is often arduous and time consuming, especially when monitoring equipment must be carried by hand. Sampling at a point of public access is more dependable and conserves time as well as human and logistical resources.

[22] Several studies have shown that collecting additional [benthic] data within two kilometers downstream of the nominal probabilistic site are representative of the reach conditions in which the probabilistic station is located (USEPA 2006, Southerland 2007, and Miller 2008)..

equivalent to 190 normal watershed stations or 52.8% of the previously available watershed network annual resources.

(3) Parameters

At a minimum, watershed stations are sampled for all parameters listed under the Watershed Monitoring Program (Program Code = AW) in the current "Matrix of Parametric Coverage" [III-A-0b.xls] summary, or that are otherwise required to determine local water quality conditions.

(4) Frequency

Watershed stations were formerly sampled bimonthly during a two-year period for conventional water column parameters. Resources permitting, they also could be sampled once during the two-year period (once each six-year rotational cycle) for metals and toxic organic compounds (e.g., pesticides, PCBs, etc.) in the sediment. Following the restructuring of the program described above, stations are sampled monthly for one year, and may then be rotated into other watersheds of interest.

(5) Duration

Originally watershed mouth stations were considered permanent, fixed sites of the monitoring program, and would have been monitored for at least two years during each six-year rotation cycle. Intra-watershed monitoring stations, however, were considered to be semi-permanent, since they could be redistributed within the watershed in response to changing NPS risk potential evaluations or in response to changes in the availability of monitoring resources.

The two-out-of-six-year rotational monitoring schedule has now been modified for many watersheds and/or watershed stations, depending upon the number of monitoring events available for assessment within a specific 'assessment window' and the results of the subsequent water quality assessment. The normal biennial assessment of water quality at watershed monitoring stations was predicated upon data from 12 sampling events. Because the initial two-year rotation schedule for watershed stations was not synchronized with the assessment cycle, and the fact that some water samples are later lost prior to or during analysis, stations may vary considerably in the number of data points available for assessment. The specific criteria used in the subsequent assessment process are summarized in the biennial Water Quality Assessment Guidance Manual. The classification of water 'Categories' described in the 'Background' section of the manual and the associated 'Assessment Rules' of 'Part I' guide the decision of whether a watershed station should be rotated or if monitoring should be continued at the site.

Under the new guidance for siting and monitoring described in Section (2) above, watershed stations (AW) and probabilistic ambient stations (PA) will be monitored monthly for a single year, and then the decision will be made as to whether they should be rotated or not.

(6) Plan and Schedule

The concept for locating these stations was relatively new to DEQ when it was initiated, and resulted in a statewide uniformity in the siting of monitoring stations. The systematic selection of watershed station sites was initiated during 2000. Many of the 493 watersheds defined by the 1995 delineation already had a station located at or near their mouths, and many of the watersheds also had numerous stations within their stream reaches. Many previously established monitoring sites were thus incorporated into the watershed network when the full implementation of this module began on 1 July 2001. The Watershed Monitoring Network, as initially designed, could accommodate variations in resource appropriations by adjusting the density of watershed stations relative to the NPS risk potentials of individual watersheds. The total number of stations, and the number to be sited in each watershed, could easily be adjusted to available analytical

resources using the Excel spreadsheet illustrated in DEQ's 2001 "Watershed Station Density Protocol" [III-A-1a-6.xls].

Because the original siting of intra-watershed stations among watersheds of the 1995 delineation was reasonably symmetrical, based on the Shreve orders of contributing tributaries, many of the 1247 new sub-watersheds defined by the 2006 delineation of the National Watershed Boundary Dataset already contained watershed stations. The number of upland 6th order sub-watersheds in the new delineation (1235, plus the Chesapeake Bay mainstem and 11 oceanic sub-watersheds) was almost equivalent to the total number of watershed stations previously defined (~1200). Most sub-watersheds consequently contained a single station, and limited resources restricted (or eliminated) the flexibility of varying the density of sites within 6th order sub-watersheds in response to NPS risk factors. Additional mechanisms for adjusting station siting within the new NWBD delineations to NPS and other risk potentials, and especially to varying resource availability, had to be developed for the next monitoring biennium (2013-2014). The focusing of watershed monitoring in 2013 within those 5th order watersheds identified to have the greatest preponderance of declining water quality trends (Seasonal Kendall and/or IWQ trend analyses in the 2012 305(b)/303(d) IR) has provided a first step in this process. For the foreseeable future, 2013 – 2018, the rotation of watershed (AW) and probabilistic ambient (PA) stations will be evaluated on an annual basis.

Funding of the watershed-based approach is dependent on the Virginia General Assembly's appropriations of funds for water quality monitoring, which becomes effective on 1 July of each even-numbered biennium (*i.e.*, appropriated during the 2013 Session to be implemented for State Fiscal Year 2014, beginning on July 1, 2013).

The Watershed Monitoring Network is still considered to be a permanent, high priority element of the WQM Program, even though it was previously classified as a Priority 2 monitoring activity, relative to its source of funding (state general funds) and its flexibility of design. Although watershed monitoring cannot be arbitrarily discontinued, consensus among central and regional office managers has resulted in a reduction of its (2013) monitoring intensity to provide additional resources for other monitoring activities.

Contact: For further information contact:

Donald H. Smith, Ph.D.
629 East Main Street
Richmond, Virginia 23219
(804) 698-4429
Donald.Smith@deq.virginia.gov