Aquatic Conservation Targets: prioritization of streams in need of restoration and protection and the assessment of stream conditions in 2005 Watershed Restoration Action Strategy (WRAS) watersheds: Deer Creek, Prettyboy Reservoir, Port Tobacco River, Miles River and Assawoman Bay

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Introduction

Maryland’s landscape is changing at a rapid pace. Current and forecasted human population growth, suburban sprawl, and conversion of forested lands will have profound adverse effects on Maryland stream ecosystems and aquatic biodiversity. The pervasive and pressing nature of these threats requires sound conservation planning over a large geographic area. However, limited funding and resources are available for conservation of biodiversity in the State. This necessitates the application of a cost-effective conservation strategy that focuses protection and restoration efforts into priority areas; areas deemed critical for the protection of rare, threatened, or endangered aquatic species in Maryland.

This report describes a watershed prioritization approach that uses best available data on stream biological resources in Maryland to target specific areas for aquatic biodiversity conservation in the 2005 WRAS watersheds: Deer Creek, Prettyboy Reservoir, Port Tobacco, Miles River, and Assawoman Bay. This targeting includes the identification of 12-digit sub-watersheds most in need of both protection and restoration based on the presence of unique stream resources and high biological integrity.

The goal of this report is to provide guidance for targeting resource management initiatives so that they provide the maximum benefit to aquatic biodiversity in these watersheds.

This report also provides biological, chemical, and physical data collected as part of the Maryland Biological Stream Survey (MBSS), conducted by the Maryland Department of Natural Resources. These data describe conditions of non-tidal streams in the WRAS watersheds and can be used to identify problem areas and probable stressors to biota.

This work was completed by the Maryland Department of Natural Resources (MDNR), Resource Assessment Service, Monitoring and Non-Tidal Assessment Division under contract number 1406-1074 CZM 142 as part of the 2005 Watershed Restoration Action Strategy. This report covers the five 2005 WRAS watersheds: Deer Creek, Prettyboy Reservoir, Port Tobacco River, Miles River, and Assawoman Bay. This report, along with the GIS data (shapefiles and layers) used in this analysis, will be provided to each 2005 WRAS Steering Committee.

Methods

Watershed Prioritization: Aquatic Conservation Targets

The significance of every sub-watershed within each of the 2005 WRAS watersheds to aquatic biodiversity cannot be overstressed. These sub-watersheds, and the streams they contain, are a single component of the larger stream network. Water quality, habitat quality, and biological integrity must be maintained or improved in each sub-watershed to ensure overall ecosystem health and to maintain healthy populations of aquatic species at the 8-digit watershed scale. Every sub-watershed is important as habitat, refugia, and
source of recolonization to all aquatic species, including those that are rare, threatened, or endangered. Given limited funding available for conservation in Maryland, complete protection and restoration of every sub-watershed is not realistic. Therefore, it is necessary and cost-effective to prioritize sub-watersheds so that conservation efforts can be focused first into areas deemed most critical to the maintenance of aquatic biodiversity.

A tiered sub-watershed prioritization method was developed for use in the 2005 WRAS watersheds. Fauna included in the prioritization consisted of stream salamanders, freshwater fishes, and freshwater mussels. It is understood that these species do not represent the full array of aquatic biodiversity. However, data on other aquatic fauna and flora are limited or non-existent. Also, this prioritization is focused strictly on freshwater, non-tidal stream biodiversity. Biological data on tidal portions of Port Tobacco River, Miles River, and Assawoman Bay watersheds and on lentic portions of Prettyboy Reservoir watershed were not included in this analysis.

Species identified by MDNR’s Natural Heritage Division as rare, threatened, or endangered (COMAR 08.03.08) and the biological integrity of fish and benthic macroinvertebrate communities were used to prioritize sub-watersheds for protection and restoration. Rare, threatened, and endangered aquatic species data used in this prioritization are provided by the Maryland Biological Stream Survey (Roth et al. 2005), MDNR Natural Heritage Program, and Dr. Richard Raesly at Frostburg State University. Measures of biological integrity used in this prioritization are the Fish Index of Biotic Integrity (FIBI) and Benthic Index of Biotic Integrity (BIBI) developed from MBSS data (1995-2004). FIBI and BIBI scores from MBSS sites and BIBI scores from MDNR Stream Waders sites were used to prioritize 12-digit sub-watersheds (Boward and Bruckler 2004)). BIBI scores from sites sampled by Stream Waders volunteers were used to prioritize sub-watersheds not sampled by the MBSS.

Sub-watersheds are prioritized into tiers, termed Aquatic Conservation Targets, using the following criteria:

**Aquatic Conservation Target 1:** Sub-watershed where an aquatic species considered rare, threatened, or endangered is known to be present. These are species considered critically imperiled in Maryland because of extreme rarity and/or vulnerability to extirpation (MDNR 2003).

Due to the sensitivity of species in Target One watersheds to habitat degradation and their rarity, we recommend that no additional disturbances be allowed in these watersheds. Urban development, stream channel modification, chemical discharges, or other factors that may substantially alter the stream environment should be avoided. In addition to these conservation measures, opportunities for stream improvements should be pursued. These improvements could include, but are not limited to managing runoff from impervious or agricultural land, stabilizing stream banks, removing stream blockages, planting riparian buffers, and any other practices that are likely to result in improved conditions for the sensitive biota residing in these systems.
**Aquatic Conservation Target 2:** Sub-watershed where a “watch list” aquatic species is known to be present. These are rare to uncommon species with relatively restricted distributions in the state that may be susceptible to large scale disturbances (MDNR 2003).

The species in Target Two watersheds are extremely sensitive to habitat disturbances. Human impacts, such as urban development, that are likely to considerably alter the stream environment should be minimized in these watersheds. Wide and continuous riparian buffers should be maintained. Any impervious land cover should be mitigated with the best available storm-water management practices. Stream improvement projects should also be conducted to provide additional protection to these sensitive species.

**Aquatic Conservation Target 3:** Sub-watershed having good biological integrity as measured by the Fish or Benthic Indices of Biotic Integrity (IBI scores > 4.0), and in which no known rare, threatened, or endangered aquatic species are present.

Although rare species do not currently reside in Target Three watersheds, these are places where these species could potentially become re-established if current stream conditions can be improved or at least not allowed to degrade further. The good IBI scores in these watersheds indicate that the streams contain high biological richness and diversity as well as species that are moderately sensitive to stream degradation. To maintain the good biological condition of these watersheds and to enhance the potential for rare and sensitive species to become re-established, protection and restoration strategies as described above for Target Two watersheds should be implemented.

**Aquatic Conservation Target 4:** Sub-watershed having fair or poor biological integrity as measured by the Fish and Benthic Indices of Biotic Integrity (IBI scores < 4.0), and in which no known rare, threatened, or endangered aquatic species are present.

Target Four sub-watersheds are likely to benefit from any restoration. However, restoration work will only be successful if efforts aimed at eliminating stressor sources are also conducted to allow streams to return to an improved stable equilibrium. Historically, these areas most likely supported important components of Maryland’s aquatic biodiversity and even incremental improvements in condition through restoration, along with elimination of stressors, should result in improved biological health of these stream ecosystems.

Stream ecosystems directly reflect conditions within their watersheds. Protection of stream ecosystems requires sound land use planning and responsible land management. Preserving riparian buffers and large tracts of forested land within Aquatic Conservation Target sub-watersheds will help maintain healthy streams and serve to protect unique stream resources and biological integrity. We recommend that protection and restoration efforts be focused in higher priority watersheds first to maintain populations of rare, threatened, or endangered aquatic species and/or good biological integrity. Restoration
initiatives aimed eliminating the sources of stream stressors within these watersheds can improve stream conditions which will also benefit stream biota. Focusing efforts into high priority watersheds is cost-effective, in that it is more expensive to restore degraded watersheds than it is to prevent healthy watersheds from becoming degraded. Also, loss of rare, threatened, or endangered species is often permanent. Reintroduction of these species, if possible at all, is costly.

Limitations to this prioritization approach:

As mentioned above, data on all aquatic biota were not available for this analysis. Only the best available data for the select fauna were used in this approach. Lack of quantitative information on other aquatic fauna and flora (e.g. periphyton, aquatic vegetation) is a major limitation to this aquatic prioritization approach and emphasizes the need for additional biological monitoring and research in Maryland streams. Sub-watersheds with no biological data were not included in this prioritization approach. These watersheds represent major information gaps and are areas in which future biological monitoring and assessment should be focused. Additional conservation priorities are likely to be identified as new information becomes available.

Additionally, this approach focuses only on aquatic biodiversity. Each of the 2005 WRAS watersheds contain terrestrial and wetland biodiversity that is of equal importance. MDNR Natural Heritage Program has identified Ecologically Significant Areas (ESA) in Maryland. These areas contain rare, threatened, or endangered plants and animals and unique, important habitats. Aquatic Conservation Target sub-watersheds, identified in this report, can be used concurrently with the Ecologically Significant Areas to provide guidance for targeting resource management initiatives for the protection of both terrestrial and aquatic biodiversity in each of the WRAS watersheds.

Characterization of stream conditions:

Data on stream conditions in each of the Aquatic Conservation Target watersheds can be useful in determining problem areas and potential stressors to stream biota. Knowledge of stream conditions (e.g. streams with poor water quality, inadequate riparian buffers, poor instream habitat quality, severe stream bank erosion) can assist in focusing restoration efforts that will provide the most benefit to stream habitats and aquatic biodiversity in each Aquatic Conservation Target. Fish, benthic macroinvertebrate, physical habitat, chemical and land use data collected as part of the Maryland Biological Stream Survey conducted in Round 1 (1995-1997), Round 2 (2000-2004) and in 2005, along with Stream Waders Volunteer Monitoring Program data are used in this report to characterize stream conditions in Deer Creek, Prettyboy Reservoir, Port Tobacco, Miles River, and Assawoman Bay watersheds. These data offer useful insights into the health of non-tidal streams in these watersheds and can be used to identify problem areas to focus restoration efforts.

MBSS (Kazyak 2000; Roth et al. 2005) and Stream Waders (MDNR 2001) monitoring and assessment methods are described below:
**Fish:** Fish assemblage data were collected using double-pass electrofishing with direct current backpack units. Each 75 m long site was blocked at each end using 0.25 in. mesh block nets and all available habitats were thoroughly sampled. For each pass, all captured fish were identified to species, counted, and released. Fishes were collected during summer (June - September) to avoid the effects of spring and fall spawning movements on fish assemblages and to maximize electrofishing catch efficiencies. Fish data were analyzed in terms of species richness, composition, relative abundance, and general pollution tolerance. A Fish Index of Biotic Integrity (FIBI) was also calculated. The FIBI is a stream assessment tool that evaluates biological integrity based on characteristics of the fish assemblage at a site (Southerland et al. 2005; http://www.dnr.state.md.us/streams/mbss/mbss_pubs.html#technical).

**Benthic Macroinvertebrates:** Benthic macroinvertebrates were collected by MBSS biologists or Stream Waders volunteers using D-frame sampling nets during spring (March-April). A 100 organism sub-sample of the benthos collected at each site was processed and identified by DNR staff for both programs. MBSS samples were identified to genus taxonomic level. These data were used to calculate a genus level benthic macroinvertebrate index of biotic integrity (BIBI) respectively for each site. Stream Waders samples were identified to family taxonomic level. These data were used to calculate a family level BIBI for each site. The BIBI is a stream assessment tool that evaluates biological integrity based on characteristics of the benthic macroinvertebrate assemblage at a site (Southerland et al. 2005; http://www.dnr.state.md.us/streams/mbss/mbss_pubs.html#technical).

**Water Quality:** MBSS water chemistry sampling occurred during the spring of each sampling year (March - April). Water samples were analyzed for a suite of parameters including closed pH, acid neutralizing capacity, total phosphate and nitrate. Additional sampling of water quality occurred during the summer of each sampling year when in situ measurements were made concurrent with fish sampling. Prior to 2000, parameters measured included dissolved oxygen (DO), pH, and temperature. During 2000, turbidity was added to the suite of summer sampling measurements. All measurements were taken with a Hydrolab™ multiprobe water quality meter, except turbidity, which was measured with a LaMotte™ turbidity meter. Both instruments were calibrated before sampling according to MBSS QA/QC guidelines (Kazyak 2000).

**Physical Habitat:** Physical habitat assessments were conducted to evaluate habitat effects on biota. MBSS habitat assessment procedures were derived from two methods: EPA’s Rapid Bioassessment Protocols (Plafkin et al. 1989), as modified by Barbour and Stripling (1991), and Ohio EPA’s Qualitative Habitat Evaluation Index (Ohio EPA 1987). Instream habitat, epifaunal substrate, and stream bank stability were scored based on visual observations at sites.

**Land Use:** ArcGIS software was used to generate site-specific land use and impervious surface information for the catchment (land area draining to a stream from upstream) of each MBSS site using U.S. EPA Multi-Resolution Land Characteristic Consortium
(MRLC) data. These land use data are based on Landsat™ data acquired between 1986-1993 and, as a result, do not reflect land use changes that have occurred since 1993.

These MBSS data, used in conjunction with MDE’s 2005 Synoptic Stream Survey and Stream Corridor Assessment, can identify potential trouble areas in each WRAS watershed and assist WRAS planners in focusing protection and restoration in Aquatic Conservation Targets.

Probable Stressors to Fishes:

Probable stressors to the fishes within each of the WRAS watersheds are diagnosed at each MBSS site based on relationships between stressor variables and fish species presence and absence (Stranko et al. 2005). Diagnosing probable stressors to fish species that were expected to occur, but were absent was determined based on the tolerance thresholds of fish species to 14 stressor variables in the MBSS data set. The tolerance thresholds for each species were considered the minimum and maximum value for each variable where the species was collected in the development data set. If the value for one of these stressor variables exceeded the tolerance thresholds for a species that was absent but was expected to occur at a site then that variable was considered to be a stressor to the species. Sets of these variables were combined into seven stressors for ease of reporting. Stressors that were reported (along with the variables that were combined for that stressor) included: Acidic pH (pH and Acid Neutralizing Capacity), habitat (instream habitat, epifaunal substrate, embeddedness, average thalweg depth, pool quality, and riffle quality), stream bank erosion (bank stability), nitrate (nitrate-nitrogen), agriculture (percent agriculture land use in catchments draining to MBSS sites), urban (percent urban land use in catchments draining to MBSS sites, percent impervious land cover in MBSS site catchments), introduced species (large numbers of brown trout associated with absence of brook trout where brook trout were expected to occur).

Knowledge of the stressors to a given stream system can be used to focus restoration efforts on parameters that should provide the greatest benefit to biological communities and aquatic biodiversity.

All possible physical and chemical conditions could not be measured at MBSS sites and many that were measured were only measured one time and may not reflect the most severe conditions for biota. Therefore, the identification of land-use stressors is directly related to sensitivity of fishes to physical and chemical conditions that are likely to be more severe than reflected by other variables as a result of the conversion of land to impervious parking lots and roads or agricultural crops and pastures. Although sampling by the MBSS includes a large number of probable stream stressors, many variables not measured by the MBSS may have influenced stream fishes and were not detected. Discrete, one-time sampling by the MBSS may also miss important measurements that may be acting as stressors to stream biota.
Deer Creek:

Watershed Prioritization: Aquatic Conservation Targets:

<table>
<thead>
<tr>
<th>Aquatic Conservation Target</th>
<th>12-digit Watershed</th>
<th>Streams in Aquatic Conservation Target Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 021202020327</td>
<td>Deer Creek mainstem/ Rock Hollow Branch/ Wet Stone Branch</td>
<td></td>
</tr>
<tr>
<td>1 021202020328</td>
<td>Little Deer Creek</td>
<td></td>
</tr>
<tr>
<td>1 021202020324</td>
<td>Deer Creek mainstem/ Saint Omer Branch</td>
<td></td>
</tr>
<tr>
<td>1 021202020321</td>
<td>Deer Creek mainstem at Susquehanna River confluence</td>
<td></td>
</tr>
<tr>
<td>2 021202020329</td>
<td>Falling Branch/ Deer Creek mainstem</td>
<td></td>
</tr>
<tr>
<td>2 021202020332</td>
<td>Deer Creek mainstem in Baltimore County</td>
<td></td>
</tr>
<tr>
<td>2 021202020322</td>
<td>Coolbranch Run/ Mill Brook/ Hopkins Branch/ Hollands Branch/ Deer Creek mainstem</td>
<td></td>
</tr>
<tr>
<td>2 021202020326</td>
<td>North Stirrup Run/ South Stirrup Run</td>
<td></td>
</tr>
<tr>
<td>3 021202020331</td>
<td>Big Branch</td>
<td></td>
</tr>
<tr>
<td>3 021202020330</td>
<td>Island Branch/ Jackson Branch/ Deer Creek mainstem</td>
<td></td>
</tr>
<tr>
<td>3 021202020325</td>
<td>Cabbage Run/ Stout Bottle Branch</td>
<td></td>
</tr>
<tr>
<td>3 021202020323</td>
<td>Thomas Run</td>
<td></td>
</tr>
</tbody>
</table>

Deer Creek 12-digit sub-watersheds 021202020327, 021202020328, 021202020324, and 021202020321 are designated as Aquatic Conservation Target One watersheds (Figure 1). It is recommended that protection and restoration be focused in these watersheds first to maintain populations of rare, threatened, or endangered aquatic species and/or good biological integrity. MDNR Natural Heritage Program’s Ecologically Significant Areas depict lands within the Deer Creek watershed having important terrestrial biodiversity. ESAs should be used in conjunction with Aquatic Conservation Targets to focus protection and restoration to benefit terrestrial and aquatic biodiversity in Deer Creek (Figure 2).

Characterization of stream conditions:

A total of 75 MBSS sites were sampled in the Deer Creek watershed from 1994 to 2005 (Figure 3). An additional 171 Stream Waders sites were sampled in the Deer Creek watershed from 2000 to 2005. Select water quality, physical habitat, and land use variables that are useful indicators of anthropogenic influence at each MBSS site in Deer Creek are mapped (Figures 4 - 17). Measures of biological integrity (FIBI and BIBI) are also useful indicators of biological conditions as it relates to human disturbance. Biological integrity measured at MBSS and Stream Waders sites in Deer Creek are also mapped (Figures18-20). These maps depict site-specific data overlying the Aquatic Conservation Target sub-watersheds and should be useful in identifying problem areas and potential stressors to stream biota in these areas. The thresholds that were used for classifying values as good, fair, or poor on these figures are listed in Appendix A.
Probable Stressors to Fishes:

The most prevalent stressors to fishes based on species absence where they were expected to occur in the Deer Creek watershed were high urban land use, high agriculture land use, and high nitrate concentrations. Stream bank erosion, acidic pH, introduced species, and low physical habitat scores were also identified as stressors to fishes in some streams (Figures 22-28).

Prettyboy Reservoir:

Watershed Prioritization: Aquatic Conservation Targets:

<table>
<thead>
<tr>
<th>Aquatic Conservation Target</th>
<th>12-digit Watershed</th>
<th>Streams in Aquatic Conservation Target Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>021308060313</td>
<td>Compass Run/ PrettyBoy Reservoir/ Frog Hollow Cove</td>
</tr>
<tr>
<td>2</td>
<td>021308060316</td>
<td>Gunpowder Falls/ Muddy Run/ Walker run</td>
</tr>
<tr>
<td>2</td>
<td>021308060315</td>
<td>Grave Run/ Indian Run</td>
</tr>
<tr>
<td>3</td>
<td>021308060317</td>
<td>South Branch Gunpowder Falls</td>
</tr>
<tr>
<td>3</td>
<td>021308060314</td>
<td>Compass Run/ Georges Run/ Murphy Run/ Peggys Run</td>
</tr>
</tbody>
</table>

The Prettyboy Reservoir 12-digit sub-watershed 021308060313 is designated as an Aquatic Conservation Target One watershed (Figure 29). It is recommended that protection and restoration be focused in this watershed first to maintain populations of rare, threatened, or endangered aquatic species and/or good biological integrity. MDNR Natural Heritage Program’s Ecologically Significant Areas depict lands within the Prettyboy Reservoir watershed having important terrestrial biodiversity. ESAs should be used in conjunction with Aquatic Conservation Targets to focus protection and restoration to benefit terrestrial and aquatic biodiversity in the Prettyboy Reservoir watershed (Figure 30).

Characterization of stream conditions:

A total of 40 MBSS sites were sampled in the Prettyboy Reservoir watershed from 1996 to 2005 (Figure 31). An additional 16 Stream Waders sites were sampled in the watershed from 2000 to 2005. Select water quality, physical habitat, and land use variables that are useful indicators of anthropogenic influence at each MBSS site in Prettyboy Reservoir are mapped (Figures 32-46). Measures of biological integrity (FIBI and BIBI) are also useful indicators of biological conditions as it relates to human disturbance. Biological integrity measured at MBSS and Stream Waders sites in Prettyboy Reservoir are also mapped (Figures 47-49). These maps depict site-specific data overlying the Aquatic Conservation Target sub-watersheds and should be useful in identifying problem areas and potential stressors to stream biota in these areas. The thresholds that were used for classifying values as good, fair, or poor on these figures are listed in Appendix A.
Probable Stressors to Fishes:

The most prevalent stressors to fishes based on species absence where they were expected to occur in the Prettyboy Reservoir watershed were high urban land use, high agriculture land use, high nitrate concentrations, low physical habitat quality, and stream bank erosion (Figures 50-54).

Miles River:

Watershed Prioritization: Aquatic Conservation Targets:

<table>
<thead>
<tr>
<th>Aquatic Conservation Target</th>
<th>12-digit Watershed</th>
<th>Streams in Aquatic Conservation Target Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>3</td>
<td>021305020443</td>
<td>Potts Mill Creek</td>
</tr>
<tr>
<td>3</td>
<td>021305020442</td>
<td>Potts Mill Creek</td>
</tr>
<tr>
<td>3</td>
<td>021305020441</td>
<td>Goldsborough Creek</td>
</tr>
<tr>
<td>4</td>
<td>021305020444</td>
<td>Black Duck Cove/ Gully Cove/ Miles River/ Potts Mill Creek</td>
</tr>
<tr>
<td>4</td>
<td>021305020439</td>
<td>Hunting Creek/ Leeds Creek/ Miles River/ Woodland Creek</td>
</tr>
<tr>
<td>4</td>
<td>021305020438</td>
<td>Groceleys Cove/ Hayward Cove/ Long Haul Creek/ Miles River/ Spencer Creek/ Oak Creek</td>
</tr>
<tr>
<td>4</td>
<td>021305020440</td>
<td>Glebe Creek</td>
</tr>
</tbody>
</table>

There are no Target One or Target Two watersheds in Miles River. Miles River 12-digit sub-watersheds 021305020443 and 021305020442 are designated as Aquatic Conservation Target Three watersheds (Figure 55). It is recommended that protection and restoration be focused in these Target Three watersheds first to maintain good biological integrity. MDNR Natural Heritage Program’s Ecologically Significant Areas depict lands within the Miles River watershed having important terrestrial biodiversity. ESAs should be used in conjunction with Aquatic Conservation Targets to focus protection and restoration to benefit terrestrial and aquatic biodiversity in Miles River (Figure 56).

Characterization of stream conditions:

A total of 12 MBSS sites were sampled in the Miles River watershed from 2003 to 2005 (Figure 57). An additional 15 Stream Waders sites were sampled in the watershed in 2005. Select water quality, physical habitat, and land use variables that are useful indicators of anthropogenic influence at each MBSS site in Miles River are mapped (Figures 58-72). Measures of biological integrity (FIBI and BIBI) are also useful indicators of biological conditions as it relates to human disturbance. Biological integrity measured at MBSS and Stream Waders sites in Miles River are also mapped (Figures 73-
75). These maps depict site-specific data overlying the Aquatic Conservation Target sub-watersheds and should be useful in identifying problem areas and potential stressors to stream biota in these areas. The thresholds that were used for classifying values as good, fair, or poor on these figures are listed in Appendix A.

**Probable Stressors to Fishes:**

The most prevalent stressors to fishes based on species absence where they were expected to occur in the Miles River watershed were high urban land use, acidic pH, and stream bank erosion (Figures 76-78).

**Port Tobacco River:**

**Watershed Prioritization: Aquatic Conservation Targets:**

<table>
<thead>
<tr>
<th>Aquatic Conservation Target</th>
<th>12-digit Watershed</th>
<th>Streams in Aquatic Conservation Target Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>021401090773</td>
<td>Hoghole Run/ Port Tobacco Creek</td>
</tr>
<tr>
<td>1</td>
<td>021401090770</td>
<td>Port Tobacco River</td>
</tr>
<tr>
<td>3</td>
<td>021401090774</td>
<td>Jennie Run/ Port Tobacco Run/ Pages Swamp</td>
</tr>
<tr>
<td>3</td>
<td>021401090771</td>
<td>Wills Branch</td>
</tr>
<tr>
<td>3</td>
<td>021401090772</td>
<td>Wills Branch</td>
</tr>
</tbody>
</table>

Port Tobacco River 12-digit sub-watersheds 021401090773 and 021401090770 are designated as Aquatic Conservation Target One watersheds (Figure 79). It is recommended that protection and restoration be focused in these watersheds first to maintain populations of rare, threatened, or endangered aquatic species and/or good biological integrity. MDNR Natural Heritage Program’s Ecologically Significant Areas depict lands within the Port Tobacco River watershed having important terrestrial biodiversity. ESAs should be used in conjunction with Aquatic Conservation Targets to focus protection and restoration to benefit terrestrial and aquatic biodiversity in Port Tobacco River (Figure 80).

**Characterization of stream conditions:**

A total of 32 MBSS sites were sampled in the Port Tobacco River watershed from 2003 to 2005 (Figure 81). An additional 65 Stream Waders sites were sampled in the watershed from 2003 to 2005. Select water quality, physical habitat, and land use variables that are useful indicators of anthropogenic influence at each MBSS site in Port Tobacco River are mapped (Figures 82-96). Measures of biological integrity (FIBI and BIBI) are also useful indicators of biological conditions as it relates to human disturbance. Biological integrity measured at MBSS and Stream Waders sites in Port Tobacco River are also mapped (Figures 97-99). These maps depict site-specific data overlying the Aquatic Conservation Target sub-watersheds and should be useful in identifying problem areas and potential stressors to stream biota in these areas. The
thresholds that were used for classifying values as good, fair, or poor on these figures are listed in Appendix A.

Probable Stressors to Fishes:

The most prevalent stressors to fishes based on species absence where they were expected to occur in the Port Tobacco River watershed were acidic pH, high urban land use, low physical habitat quality, and stream bank erosion (Figures 100-103).

Assawoman Bay:

Watershed Prioritization: Aquatic Conservation Targets:

<table>
<thead>
<tr>
<th>Aquatic Conservation Target</th>
<th>12-digit Watershed</th>
<th>Streams in Aquatic Conservation Target Watershed</th>
</tr>
</thead>
<tbody>
<tr>
<td>4</td>
<td>021301020688</td>
<td>Montego Bay/ Caine Keys/ Bayside Keys</td>
</tr>
<tr>
<td>4</td>
<td>021301020689</td>
<td>Back Creek/ Greys Creek/ Goose Creek/ Peeks Creek</td>
</tr>
</tbody>
</table>

There are no Target One, Target Two, or Target Three watersheds in the Assawoman Bay watershed. Assawoman Bay 12-digit sub-watersheds 021301020688 and 021301020689 are designated as Aquatic Conservation Target Four watersheds (Figure 104). Target Four watersheds are likely to benefit from any restoration effort. Historically, these areas most likely supported important components of Maryland’s aquatic biodiversity and even incremental improvements in condition through restoration should result in improved biological health of these stream ecosystems. MDNR Natural Heritage Program’s Ecologically Significant Areas depict lands within Assawoman Bay watershed having important terrestrial biodiversity. ESAs should be used in conjunction with Aquatic Conservation Targets to focus protection and restoration to benefit terrestrial and aquatic biodiversity in Assawoman Bay (Figure 105).

Characterization of stream conditions:

A total of four MBSS sites were sampled in the Assawoman Bay watershed in 2005 (Figure 106). There are no Stream Waders sites in this watershed. Select water quality, physical habitat, and land use variables that are useful indicators of anthropogenic influence at each MBSS site in Assawoman Bay are mapped (Figures 107-120). Measures of biological integrity (FIBI and BIBI) are also useful indicators of biological conditions as it relates to human disturbance. Biological integrity measured at MBSS sites in Assawoman Bay are also mapped (Figures 121-122). These maps depict site-specific data overlying the Aquatic Conservation Target sub-watersheds and should be useful in identifying problem areas and potential stressors to stream biota in these areas.
The thresholds that were used for classifying values as good, fair, or poor on these figures are listed in Appendix A.

**Probable Stressors to Fishes:**

No specific stressors to fishes were identified in the Assawoman Bay watershed.
Literature Cited


Kazyak, P.F. 2000. *Maryland Biological Stream Survey Sampling Manual.* Prepared by the Monitoring and Non-Tidal Assessment Division, Maryland Department of Natural Resources. Annapolis, MD.

MDNR. 2003. Rare, Threatened, and Endangered Animals of Maryland. Prepared by Wildlife and Heritage Service, Natural Heritage Program, Maryland Department of Natural Resources. Annapolis, MD.


Appendix A: Thresholds for classifying physical habitat, chemical, biological, and land use values as indicative of degradation or good quality.

**Biological Parameters**

**Fish IBI Score:** Fish Index of Biotic Integrity, scored on the following scale:

<table>
<thead>
<tr>
<th>Good</th>
<th>IBI Score 4.0-4.9</th>
<th>Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td>IBI Score 3.0-3.9</td>
<td>Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally impacted streams. Fall within the lower portion of the range of reference sites (10&lt;sup&gt;th&lt;/sup&gt; to 50&lt;sup&gt;th&lt;/sup&gt; percentile).</td>
</tr>
<tr>
<td>Poor/ Very Poor</td>
<td>IBI Score 1.0-2.9</td>
<td>Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating severe degradation.</td>
</tr>
</tbody>
</table>

Site is shaded red if FIBI score is <3.0.
Site is shaded yellow if FIBI score is 3.0-4.0.
Site is shaded green if FIBI score is >4.0.

**Benthic IBI Score:** Benthic Index of Biotic Integrity, scored on the following scale:

<table>
<thead>
<tr>
<th>Good</th>
<th>IBI Score 4.0-4.9</th>
<th>Comparable to reference streams considered to be minimally impacted. Fall within the upper 50% of reference site conditions.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fair</td>
<td>IBI Score 3.0-3.9</td>
<td>Comparable to reference conditions, but some aspects of biological integrity may not resemble the qualities of these minimally impacted streams. Fall within the lower portion of the range of reference sites (10&lt;sup&gt;th&lt;/sup&gt; to 50&lt;sup&gt;th&lt;/sup&gt; percentile).</td>
</tr>
<tr>
<td>Poor/ Very Poor</td>
<td>IBI Score 1.0-2.9</td>
<td>Significant deviation from reference conditions, with many aspects of biological integrity not resembling the qualities of these minimally impacted streams, indicating severe degradation.</td>
</tr>
</tbody>
</table>

Site is shaded red if BIBI score is <3.0.
Site is shaded yellow if FIBI score is 3.0-4.0.
Site is shaded green if BIBI score is >4.0.
**Water Quality Parameters**

**NO₃ Nitrate Nitrogen (mg/L):** Site is shaded red (excessive) if value is >5, orange (high) if value is between 3 and 5, yellow (moderate) if value is between 1 and 3, and green (baseline) if value is <1.

**Total Phosphorus (mg/L):** Site is shaded red (high) if value is >0.07, yellow (moderate) if value is between 0.025 and 0.07, and green (low) if value is <0.025.

**D.O. Dissolved Oxygen (mg/L):** Site is shaded red if value is ≤ 5 mg/L water criterion (COMAR 26.08.02).

**pH (units):** Site is shaded red if value is < 5.0. pH less than 5.0 is considered harmful to stream biota, especially fish (COMAR 26.08.02).

**Acid Neutralizing Capacity (µeq/L):** Site is shaded red (highly sensitive to acidification) if value is <50, yellow (sensitive to acidification) if value is between 51 and 200, and green (not sensitive to acidification) if value is >200.

**Turbidity (NTU):** Measurement of suspended solids. Site is shaded red (high) if value is ≥10, and green (low) if value is <10.

**Physical Habitat Parameters:**

**Instream Habitat Quality:** Measurement of habitat quality as it relates to stream fishes. Site is shaded red if value is < 6, yellow if value is between 6 and 15, and green if value is >15.

**Epifaunal Substrate Quality:** Measurement of habitat quality as it relates to benthic macroinvertebrates. Site is shaded red if value is < 6, yellow if value is between 6 and 15, and green if value is >15.

**Stream Bank Stability:** Measurement of severity of erosion and potential for erosion on both stream banks. Site is shaded red if value is < 6, yellow if value is between 6 and 15, and green if value is >15.

**Substrate Embeddedness (%):** Measurement of percentage of stream substrate surrounded by fine sediments (sands and silts). Site is shaded red (high) if value is 100.

**Stream Temperature (°C):**

- **Use Class I (Water Contact Recreation) Waters:** Site is shaded red if value is >32°C (COMAR 26.08.02).
- **Use Class III (Natural Trout) Waters:** Site is shaded red if value is > 20.0 °C (COMAR 26.08.02).
- **Use Class IV (Recreational Trout) Waters:** Site is shaded red if value is > 23.9°C
Land Use Parameters

**Riparian Buffer Width (meters):** Site is shaded red if buffer width is <10 meters, yellow if buffer width is between 10 and 49 meters, and green if width is ≥50 meters.

**Impervious Land Cover (%):** Percent impervious land cover in the upstream catchment of site. Site is shaded red (excessive) if value is > 10, yellow (moderate) if value is between 2 and 9, and green (low) if value is < 2.

**Urban Land use (%):** Percent urban land cover in the upstream catchment of site. Site is shaded red if value is > 50, yellow if value is between 21 and 49, and green if value is ≤ 20.

**Agriculture Land Use (%):** Percent agriculture land cover in the upstream catchment of site. Site is shaded red if value is > 75.

**Stressors to Stream Fishes:**

Fish species tolerances to MBSS variables as used in this report can be found in Stranko et al. (2005). These thresholds, in some cases, exceed thresholds used for water quality criteria. For example, pH values recorded at a site may be above the water quality criterion of 5.0, but may exceed threshold tolerances for a fish species.
Aquatic Conservation Targets: sub-watersheds in Prettyboy Reservoir prioritized for protection and restoration.
Figure 3. MBSS and Stream Waders sites sampled in Prettyboy Reservoir watershed.
Figure 33. Dissolved Oxygen concentrations at MBSS sites in Prettyboy Reservoir watershed.
Figure 36: Nitrate concentrations at MBSS sites sampled in Prettyboy Reservoir watershed.
Figure 38. Turbidity at MBSS sites sampled in Prettyboy Reservoir watershed.
Figure 39: Instream habitat quality at MBSS sites sampled in Prettyboy Reservoir watershed.

Aquatic Conservation Targets

Instream Habitat Quality

- 0 - 5 (Poor)
- 6 - 15 (Fair)
- 16 - 20 (Good)
Figure 42. Substrate embeddedness at MBSS sites in Prettyboy Reservoir watershed.
Figure 44. Percent of urban land use at MBSS sites in Prettyboy Reservoir watershed.
Figure 46. Percent of impervious surface at MBSS sites in Prettyboy Reservoir watershed.
Figure 47. Fish index of biotic integrity (FIBI) scores for MBSS sites in Prettyboy Reservoir watershed.
Figure 48. Benthic index of biotic integrity (BIBI) scores for MBSS sites in Prettyboy Reservoir watershed.
Figure 50. MBSS sites in Prettyboy Reservoir watershed where stream bank erosion was identified as a stressor to stream fishes.
Figure 51. MBSS sites in Prettyboy Reservoir watershed where inadequate physical habitat was identified as a stressor to stream fishes.
Figure 5. Moss sites in Prettyboy Reservoir watershed where high nitrate concentrations were identified as stressors to stream fishes.
Figure 53. MBSS sites in Prettyboy Reservoir watershed where urban land use was identified as a stressor to stream fishes.
Figure 54: MBSS sites in Prettyboy Reservoir watershed where high agricultural land use was identified as a stressor to stream fishes.