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BALANCING NONPOINT SOURCE WATER QUALITY MANAGEMENT WITH WETLAND AND STREAM PRESERVATION: LESSONS LEARNED

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Abstract. Current and contemporary regulation of development-related activities in pre-regulation pre-existing lands that affect receiving waters, can require complex approaches to nonpoint source pollution - or stormwater management (SWM) - along with wetland resource avoidance including an on-the-ground historical basis for practicable regulatory decision-making. Such experience indicates growth can be accommodated in a manner that not only decreases pre-existing nutrient and loads but also avoids and minimizes stream and wetland impacts - while remaining compatible with effective SWM strategies to the degree of even improving post-construction conditions. In response to increasing regulatory authority over its water resources, the state regulatory agency, the Maryland Department of the Environment (MDE), USA, in cooperation with other local and federal agencies as well as the regional civil engineering industry, has over the years combined various regulatory programs and processes into a "one stop shop" where various issues can be addressed in a consistent manner. This is effective when large-scale multi-phased complex projects are submitted for applicable water resource permits. Experience has shown that successful outcomes can be achieved with a balance of various approaches within this process. Specifically, avoidance and minimization requirements of wetland/stream protection programs may not necessarily be compatible with more traditional SWM strategies that were shown to have room for improvement. Further, MDE's process may necessitate the consideration of SWM and wetland avoidance requirements and practices that can exceed those not historically required by the local municipality. This innovative example project is the first (late 1990s) of several (the last one completed around 2015) development projects in a 405-hectare (1000 acre) watershed of the Potomac River in the greater Washington, DC area and is actually one of the nation's first “Environmental Site Design (ESD)” or “Green Infrastructure” approaches to nonpoint source water quality management before the strategy was formalized in the industry. Regulated water and wetland resource impacts were reduced and mitigated by innovative design revisions along with creative and contemporary approaches to wetland mitigation and SWM strategies. These practices were subsequently utilized and refined for further future development projects in this agricultural watershed – and generated State-wide criteria. The positive outcome of this process is attributable to an effective partnering of engineering and ecology, a water quality/stream biomonitoring plan, and a pro-active "win-win" public involvement process.
Keywords: wetlands, nonpoint, stormwater, stream, watershed, regulation

1.INTRODUCTION

In response to increasing regulatory authority over its water resources in the USA, and specifically in the state of Maryland where the author managed this project over the years, the Maryland Department of the Environment (MDE) in cooperation with the regional civil engineering industry has combined programs and processes into a "one stop shop" where various issues can be addressed in a consistent manner. This can be effective when large-scale complex projects are submitted for applicable water resource compliance approvals. Experience has shown that balancing growth, in predominantly agricultural lands, with resource and water quality protection can involve balancing various approaches within this process. Specifically, physical resource avoidance and minimization requirements of wetland/stream protection programs may not necessarily be effective or compatible with more traditional nonpoint source, or stormwater management (SWM), strategies. Further, MDE's process may necessitate the consideration of requirements and practices that can exceed those not historically required by the local municipality.

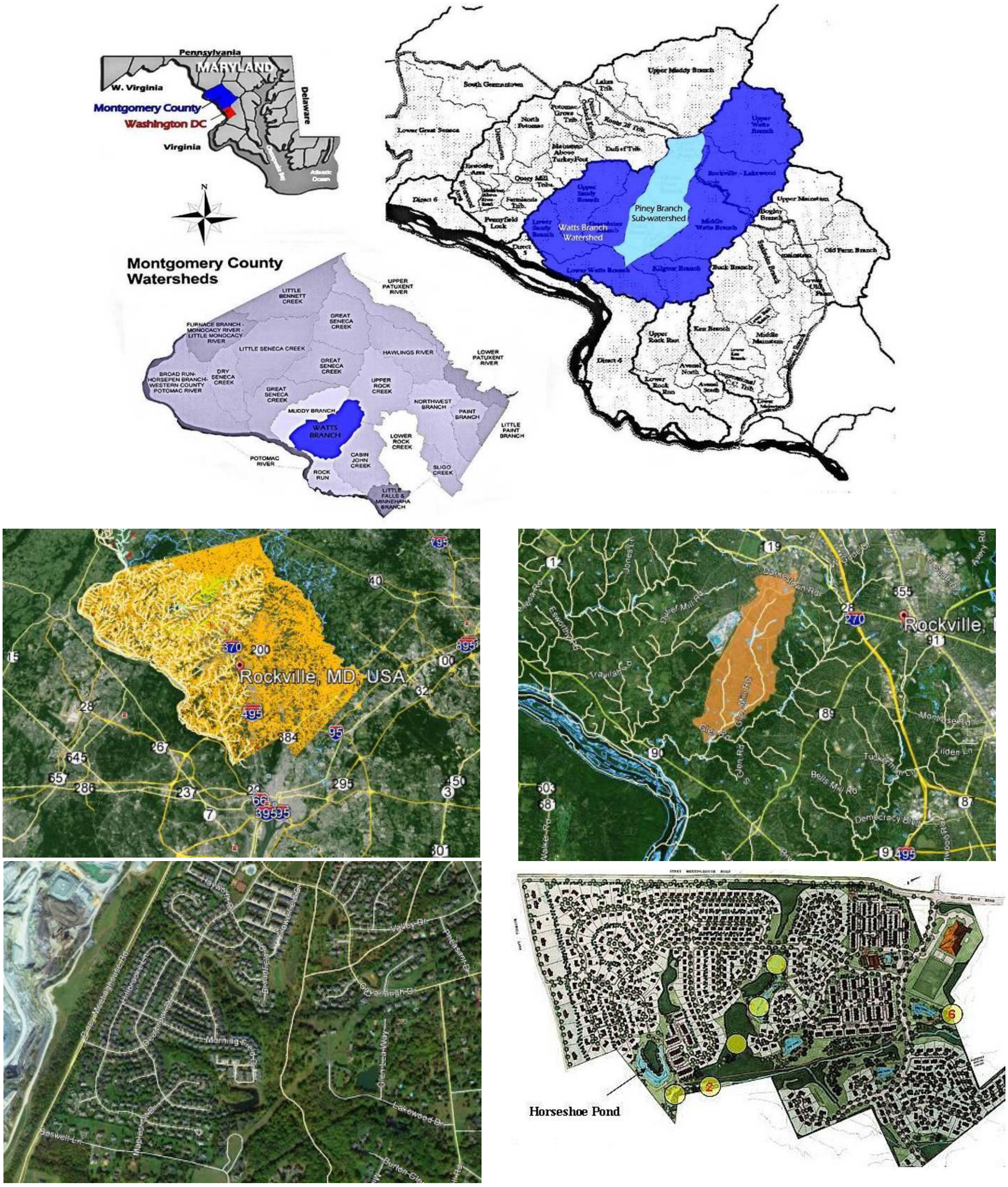

Figure 1. Project location: State, Region, Watershed, County, Property

Presently, MDE regulates the following activities that may affect or impact surface water resources and features under the applicable regulations - which is conceptually similar throughout other states in the USA.

- Nontidal Waters and Wetlands (NTWW): MDE regulates areas that are jurisdictional per the U. S. Army Corps of Engineers' (COE) and their 7.6 meter (25.0 foot) buffer – through joint permit process with COE under the Clean Water Act (CWA) Section 404 process.
- Federally regulated waters of the U.S. (WUS): the COE concurrently regulates similar waters as defined above in a joint process.
- Tidal Wetlands: The MDE regulates tidally influenced open ("navigable") water and their wetlands – no tidal waters are in this region.
- Waterway Construction on Nontidal Waters and Floodplains: MDE regulates activities that can alter flow, current or cross-section of streams and the 100-year floodplain.
- Water Quality Certification: MDE reviews the activities under CWA Section 401 when requiring federal authorization certifying that the COE permit complies with state water quality standards.

Most regulated projects qualify for the COE streamlined Maryland State programmatic general permit that, in effect, allows MDE to authorize many projects on the COE behalf.

The above processes were administered separately when this initial project (of numerous future ones up-drainage in the watershed) started at which time little state-level regulation existed to manage water quality above minimal municipal requirements – and true quality SWM of the nature today did not exist. Most SWM at that time focused of flood control and safe conveyance. This project - as the first example of its kind – facilitated, through the regulatory and public interest process, subsequent regulatory initiatives applying to future projects in this watershed as well as state-wide. Unique first-time water quality and stream monitoring requirements, as part of the authorizations, generated subsequent data to guide future policies and decisions. The project was also a catalyst to support the combination of the different regulatory programs cited above into one coordinated process. Soon after this project was authorized, the more prominent cited Maryland Nontidal Waters and Wetlands Act was passed leading the review and regulation of future projects.

The development project discussed is the first example of several subsequent ones in a 405-hectare (1000 acre) watershed, known as Piney Branch, in Montgomery County, Maryland in the greater Washington D.C. metropolitan area. The area lies in the Potomac River watershed between the Mid-Atlantic Piedmont region and the coastal plain. Some near-pristine areas remain in the lower reaches of the watershed which were avoided. Woodlands are primarily deciduous hardwood forest, some of it being regenerative from previous clearing. The project lies in an actively cropped agricultural field and shrubby intermittently cleared areas. The pre-existing farmed land exhibited severe sediment and chemical runoff from nutrients to the effect some stream channels were overcome with filamentous algae showing eutrophication and poor water quality.

Some stream reaches also exhibited accelerated bank erosion and poor invertebrate diversity while other reaches were relatively absent of such indicators and also avoided. Stream bottom substrate is composed of silt, sand and fine gravel with transition to some cobble and rock in lower reaches. While some groundwater contribution was evident, the riparian systems are primarily driven by surface drainage, some from offsite development without stormwater controls. Wetlands were primarily palustrine forested and palustrine scrub-shrub and contiguous to the streams.

The MDE review of this development project began in the late 1990s with the first proposed impacts associated with road construction, minor in-fill, and SWM/wetland basins. The proposed activities required MDE and COE authorization to proceed. Additional portions also requiring MDE/Corps authorization have been reviewed since this project and all of the areas are now constructed and completed around 2015 - the development sequence progressing up-drainage in the below watershed. Presently the entire watershed is now stable.

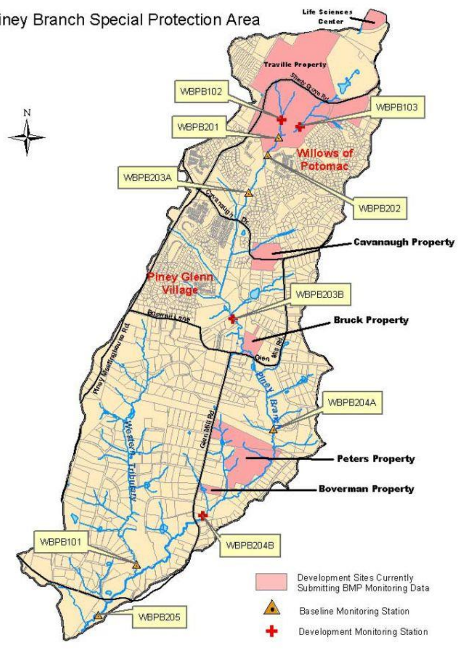

Figure 2 Piney Branch watershed with initial property Piney Glen Village indicated. Numbered label boxes indicate county-wide cumulative stream monitoring stations subsequently installed after project and monitoring completion.

2.METHODS

The initial development proposal was subject to multiple regulatory criteria as described - and the lead agency, MDE, requested that proposed wetland and stream impacts be additionally avoided and subject to further minimization. The remaining impacts associated with road and utility line access were acceptable with some minimization via narrowing of footprint, better crossing approaches and bottomless stream spanning structures. Since the proposed SWM strategies would convert, by ponding, the cooler wooded riparian stream system to warmer open water subject to pollutant loading and eutrophication, the MDE further determined that a larger single in-stream regional management pond might also be incompatible with Maryland's water quality standards.

Maryland's waters are classified by four primary Use designations with certain narrative and numerical criteria for maintaining designated uses (MDE, 2010). P indicates additional use as public water supply.

Use I, I-P : Water contact recreation and protection of aquatic life
Use II : Shellfish Harvesting
Use III, III-P : Natural Trout Waters
Use IV, IV-P : Recreational Trout Waters

In addition, these standards include the U. S. Environmental Protection Agency mandated Anti-Degradation Policy (ADP), administered by the MDE, which is a brief narrative standard stating:

> ..."Certain waters of this State possess an existing quality which is better than the water quality standards established for them...To accomplish the objective of maintaining existing water quality...nonpoint sources shall achieve all cost effective and reasonable best management practices for nonpoint source control"...

It is this standard that MDE applied to the first project requiring true quality SWM when none existed locally. Afterward, the MDE passed a contemporary new SWM law to address nonpoint source pollution management for new construction which is what drove compliance with the future projects, and lessening the need for the ADP – although it is still there but now somewhat redundant.

After some initial revision, the direct wetland and waterway impacts of the construction were sufficiently avoided, minimized, and proposed to be mitigated with extensive onsite wetland creation, but the secondary impacts of accelerated stream flows, flood (quantity) management and nonpoint source pollution associated with inevitable upland development remained a challenge. The county had already approved this project because local SWM ordinances were not necessarily intended for onsite habitat protection at that time, but rather require safe conveyance and flow management at the point drainage departs from the property.

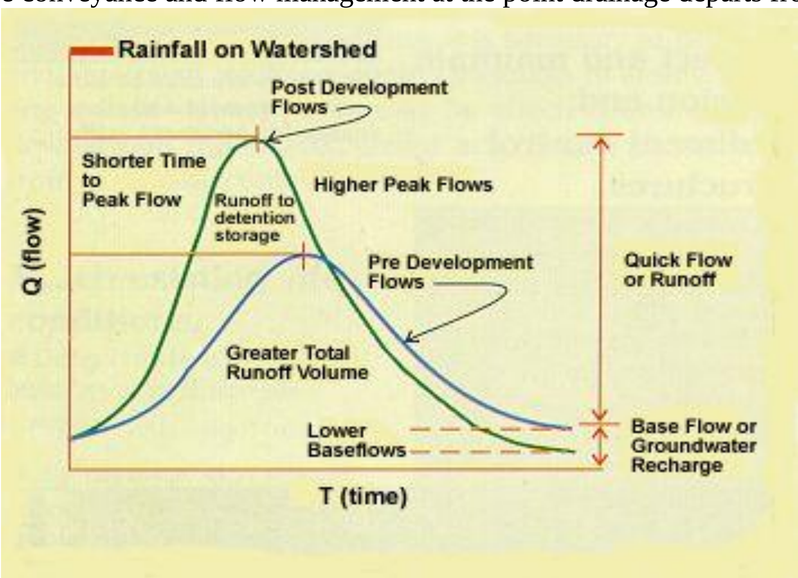

Figure 3. Universal hydrograph of nonpoint source runoff events pre-development (blue) vs. post-development (green)

Therefore, the question remains, in what ways could a continually increasing runoff curve be managed in a manner that will avoid the low-lying stream/wetland areas while allowing for reasonable use of farmed property? The burden to manage for quantity (as opposed to just quality) entirely in uplands can be enormous and require a greater deal of dedicated property for storage. Indeed, this can be, and is, required in more unaltered and pristine watersheds as an alternative to in-stream SWM structures.

In certain situations, a more flexible approach may be warranted on a case-by-case basis where a moderate amount of SWM in wetlands and streams can occur with special mitigative requirements. Such situations typically include:

- Upstream land clearing and development existed before stormwater controls were required, i.e., a retrofit situation, where existing water quality indicators demonstrate ongoing impairment and degradation. Depending on the pre-existing condition, this could yield a net gain.
- Stressed and previously disturbed habitat exists such as accelerated bank erosion and altered species composition with little diversity.
- Completion of extensive local review and design prior to implementation of applicable environmental laws and regulations (this factor is rarely applicable today).
- *Existing land use activities would continue to be detrimental should the area not be developed with mitigative controls.*

Since the above conditions were present in much of the watershed, the MDE determined that to consider site-specific BMP strategies with moderate in-stream impacts desirable to the development effort is appropriate to achieve a net benefit. A hierarchy of ecologically preferred methods for quality SWM control in upland areas were considered where feasible – which are now routine.

Vegetative buffering of impervious surfaces
Infiltration via trenches, basins, or depressions
Bioretention, filtering marsh/wetland, vegetated swales, sand filters, “rain gardens”
Extended detention basin with wetland bottom
Retention pond or lake with wetland habitat

The criteria would require a minimum of the first 1.27 centimeter (half inch) of runoff, which removes 68-90% of pollutants (MDE, 2007), from the impervious surface (sometimes drainage area) to be managed by these practices prior to release into waters, including wetlands, and to control the majority of "first-flush" pollutants such as sediments, nutrients, hydrocarbons and metals.

Today, this is frequently exceeded under current SWM criteria mandating environmental site design (ESD) to the Maximum Extent Practicable (MEP) to the degree it replicates “woods in good condition” to the receiving stream in the post-development condition. Since post-development runoff peaks (quantity) were anticipated to exceed pre-existing conditions by a minimum of 10%, the applicable stormwater ordinance requires quantity management for the 2 and 10-year storm event at a minimum.

Through the analysis of boring logs, infiltration was found to be feasible in only limited portions of the site. The majority of the site was unsuitable due to impermeable soils (must have a minimum infiltration rate of 1.3 centimeters (0.5 inches)/hour and a seasonally high water table within 1.2 meters (4.0 feet) or less of the bottom of a potential facility, steep slopes or rock (MDE, 2007). These were more suitable for conveyance to pretreatment practices such as bioretentention swales, wetlands/marshes, and ponds.

Subsequently, the following mitigative practices and stormwater "best management practices" (BMP) were proposed to the MDE and accepted.

- Total wetland and waters impacts are limited to 1.02 hectares (2.52 acres) out of 8.34 hectares (20.60 acres) for the first 96-hectare (238 acre) property - with impacts limited to road access, pond berms and utilities.
- Any "in-stream" SWM facilities would only occur in areas of marginal quality, i.e., waters of the U. S. that are previous deteriorated agricultural and intermittent channels.
- Minimum stream buffers of 30.5 meter (100 feet) would be observed to augment and reduce reliance on man-made devices - and since vegetative buffers are the most effective. Future projects were subject to a newly locally-implemented requirement for all streams to have 100' buffers for all projects.
- Wetland mitigation will be provided at 2.3:1 replacement ratio along existing cleared riparian areas to reestablish a water quality and riparian buffer.
- The 1.91 to 2.54 centimeters (0.75 to 1.00 inch) of stormwater runoff, which removes 82-99% of pollutants, from the drainage area will be managed entirely in uplands prior to release into waters and wetlands.
- Infiltration and filtration practices will be utilized for pretreatment in those areas that allow.
- Volumes beyond the first flush will be detained in the uplands where feasible and by in-channel embankments with a maximum detention time of 24 hours for the 10-year storm for temporary storage in the naturally occurring contour without excavation and clearing.

- The accelerated peak events will be attenuated without permanent high elevation pooling in the primary storage area to preserve the primary wooded wetland resource upstream of the BMP.
- Specially designed embankments to incorporate offline first flush pretreatment areas in uplands on either side of the short-term in-stream storage area - referred to as “horseshoe pond” because of their plan view and visual depictions.
- Any areas of permanent stormwater pooling will be planted with wetland vegetation for habitat and ecosystem restoration as well as additional water quality enhancement.

During MDE's public interest notice process (a customary requirement), members of the stakeholder community were concerned that the water quality and resource impacts may not be sufficiently avoided and mitigated – despite the pre-existing agricultural condition was already impairing the resources. In addition, the Maryland Department of Natural Resources (DNR) informed MDE that the lower reaches of the property's main stem Use I stream, Piney Branch, possessed characteristics of higher quality Use IV or possibly Use III waters (adult trout and naturally reproducing trout respectively). This is important because the ADP requires that in such a situation the stream be afforded Use III or IV standards – even if it is not designated that way.

With such standards, of particular concern are temperature increases and dissolved oxygen (DO) decreases associated with permanent pool retention of stormwater, which is the primary stressor in colder-water habitats – and may violate the applicable temperature standards of 20 C (68 F) for Use III and 23.9 C (75 F) for Use IV adversely affecting salmonid trout, the regulatory indicator species, should they be present. Further, such habitats are relatively unusual and rare near urban areas. DO standards are 5 milligrams per liter (mg/l) minimum for all waters. Unlike other areas of the country with natural cooler water ground fed glacial lake systems (Maryland has none), streams can suffer from impoundment of flows (Schueler and Galli, 1992). Therefore, wet pond construction is discouraged in Use III and IV waters – thereby potentially affecting the design, or re-design, of the project.

The implications of such a finding could additionally affect the review process by requiring further reduction of development density along with impervious surface while utilizing more of the property for buffers and additional BMP's without any wet pond discharges. Since there was now sufficient reason to determine existing stream quality, the DNR, MDE, and the County implemented their own assessment procedures focusing on EPA's Rapid Bioassessment (RBA) protocol – the only accepted one in place then (EPA, 2002) - which showed that Piney Branch is a higher quality Use I water but not adequate to sustain a Use IV recreational trout resource (DNR, 1991), (MDE, 1991), (MNCPPC, 1991). This was confirmed by the inability of DNR to find one holdover trout (the mandatory indicator) during their sampling a year after stocking.

Due to the higher Use I water quality characteristics now documented in the lower reaches of the watershed, some continued public comment, and the watershed-wide implications of this and forthcoming projects, the following additional water quality management practices were proposed and accepted as conditions of the MDE's approval – and which later became routine.

- A water quality monitoring plan will be developed and implemented throughout the build-out of the watershed and beginning with the first three SWM facilities proposed with this project to monitor effects of the development.
- A stream reach temperature model (Bartholow, 1987) will be implemented to predict potential stream temperature increases, and will be calibrated for improved accuracy as field data become available to estimate likelihood of exceeding Use IV temperature standards.
- A maximum of 20% of stream base flow will be diverted to any offline pretreatment areas of the horseshoe pond or to acceptable in-channel ponds, (i.e. 80% of natural base flow proceeds through or past the facility unaffected) to allow some flow into offline pooling areas during drought conditions promoting wetland conditions and water mixing while not depleting cooler base flow in stream.
- All ponded and pretreatment areas, stormwater conveyance ways and pond outlet structures will be planted with shade-producing species to the extent possible to minimize solar heating during summer.
- Impoundment structures will have "toe drain" pipes under the fill areas to release cooler perched water sources.

In addition, flows were calculated for Piney Branch and the discharge points of all three ponds for the minimum rainfall event that could pool behind the berm (QED), which is 4.45 centimeters (1.75 inches), as well as the 2 and 10 year events to determine percent contribution of potentially warmer water. Results showed a total contribution to base flow of 0.28% for the QED, 0.86% for the 2-year event and 4.57% for the 10-year event, which would be negligible.

Figure 4. Newly created vegetative filtration buffer and habitat for nonpoint source flow management

Figure 5. Constructed “horse shoe” pond for combined water quantity (flood) and quality management with pre-treatment and wetland habitat for additional resource and water quality benefits.

Figure 6. Aerial image and engineered drawing (cross hatch area is preserved forested wetland habitat) of regional horse-shoe pond showing retention areas with pre-treatment cell at pond input and transition habitat –

Figure 7. Numerous innovative quality pretreatment practices – sand filter discharging to a wetland buffer area, parking lot bioretention, stream-side pocket vegetative filtration area, pervious golf green and pathways.

Figure 8. Biosensitive road crossing preserving stream channel stability and riparian habitat as a component of a mitigation plan – a major and keystone component of all present watershed improvement strategies.

The water quality monitoring requirement had two goals: 1) compare baseline and post-construction data to determine BMP effectiveness for future regulatory use and 2) begin a local/State cooperative effort to determine appropriate and effective development and BMP criteria for future projects - as well as initiate a cooperative interagency review and water quality assessment process. Quarterly reports were generated and provided directly to MDE and the county to aid in their local planning and decision-making process. Historic data is shown for three stations (#2, #6, #10) and monitoring for ultimately six stations was done on an ongoing basis subject to a separate reporting timetable. But for simpler initial indicators, Stations #2 and #6 began three months prior to initial grading activities and is the primary focus. Initially, Station #2 began as lowest point in watershed. All monitoring and data generation has ceased and findings completed.

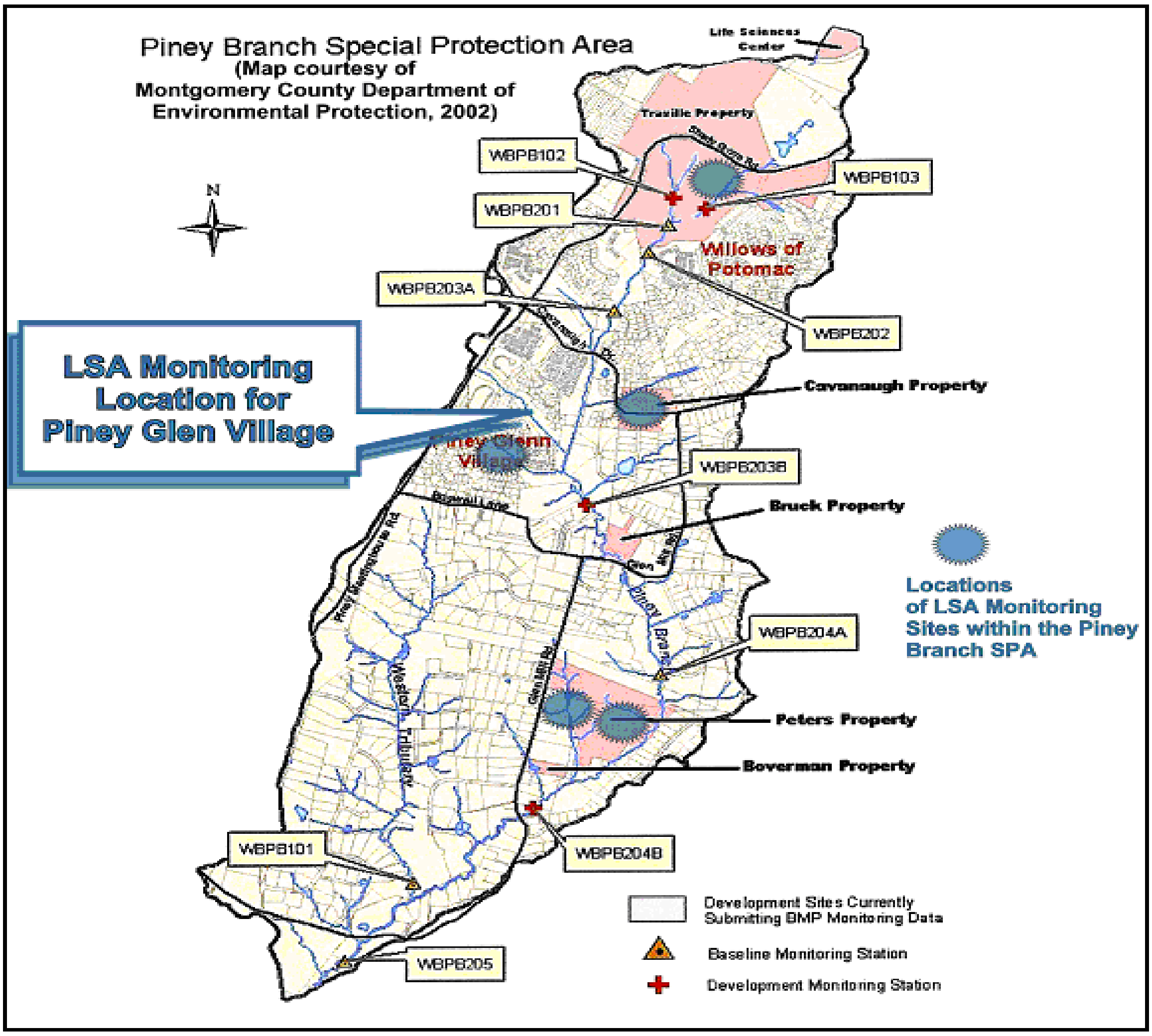

Figure 9. Piney Branch Watershed with the first template project identified by initials of engineering consultant. Blue circles represent additional developer-provided stations for site-specific and BMP-specific data. Subsequent county monitoring stations – beige rectangles - currently used these efforts for future criteria after build-out complete.

Figure 10. Aerial rendering of proposed completed first project with primary pond and two water quality monitoring stations, #2 at low point and #6 upstream, indicated (Station #10 up-drainage is not shown)

Water quality parameters monitored in the field were dissolved oxygen, pH, turbidity, stream conditions and base flow, monthly throughout March to October. Water temperature was continuously recorded. Samples requiring collection and laboratory analysis were done for oil and grease and between November and February, inclusive for chlorides. The RBA Protocol II was used three times/year to assess benthic macroinvertebrates – which are a key cumulative indicator unlike chemical measurements. Temperature and dissolved oxygen, the pertinent State numerical standards, along with the RBA were required by MDE and later the county. Additional parameters were included at the request of the county.

3.RESULTS

The re-calibrated stream temperature modeling yielded the following data based on climatological records to date. Existing conditions showed a mean of 22.8 C (73.1 F) and maximum of 24.6 C (76.3 F). Build out conditions showed a mean of 23.2 C (73.8 F) and maximum of 24.9 C (76.9 F) which is acceptable. Final design and mitigation plans were provided and the permit was issued with all aforementioned special BMP and mitigation conditions.

The very first required water quality monitoring report submissions began in 1992 (Loiederman and Associates, 1992 - 1996). While this study had generated a plethora of "keystone" regulatory data, the most pertinent are temperature, DO and the RBA, as well as the success of stream restoration strategies. The historical RBA studies for stations #2, #6, and #10 are summarized in Table 1 – and temperature and DO results are summarized in Tables 2 and 3.

Table 1. One year, the site suffered severe adverse effects from a ten-year storm resulting in out-of-bank flooding, alteration of channel morphology and breaching of a beaver dam. In addition, severely polluted runoff from an offsite upstream mulch and debris disposal area (not part of the property) using water spray to cool potential spontaneous combustion had been discharging to the study area and was corrected shortly thereafter. Other anomalies occurring within the data period was a drought. The results showed that, despite these activities, stream and wetland restoration practices were successful and DO concentrations were unexpectedly elevated during periods of higher temperature, and water quality standards had not been violated at the downstream locations – tables 2 and 3.

Rapid Bioassessment Metric Comparisons to Pre-Construction Scores			
Year	**ST2**	**ST6**	**ST10**
1993	Non Impaired **	Non Impaired **	
1994	Non to Mod. Impaired	Non Impaired	Non Impaired **
1995	Non to Mod. Impaired	Non to Mod. Impaired	Non Impaired
1996	Non to Mod. Impaired	Moderately Impaired	Non to Mod. Impaired
1997	Non to Mod. Impaired	Non to Mod. Impaired	Moderately Impaired
1998		Moderately Impaired	Non to Mod. Impaired
1999	Moderately Impaired	Moderately Impaired	Moderately Impaired
2000	Moderately Impaired	Non to Mod. Impaired	
2001	Non to Severely Impaired	Moderately Impaired	Non Impaired
2002	Non to Mod. Impaired	Mod. to Severely Impaired	

** Non Impaired value is given to the first (reference) date for comparison purposes;
the streams on those dates are not necessarily truly non-impaired.

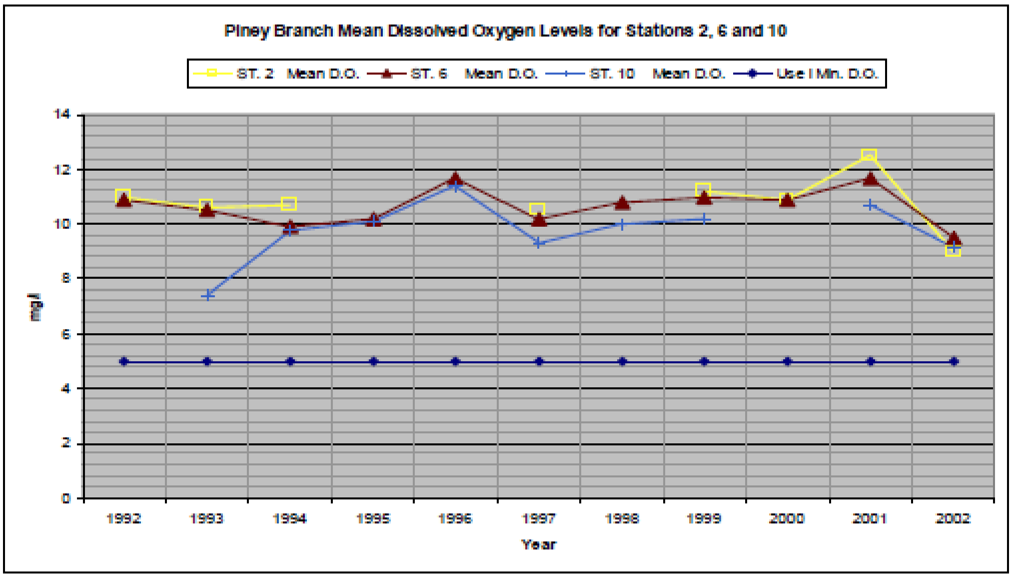

Table 2

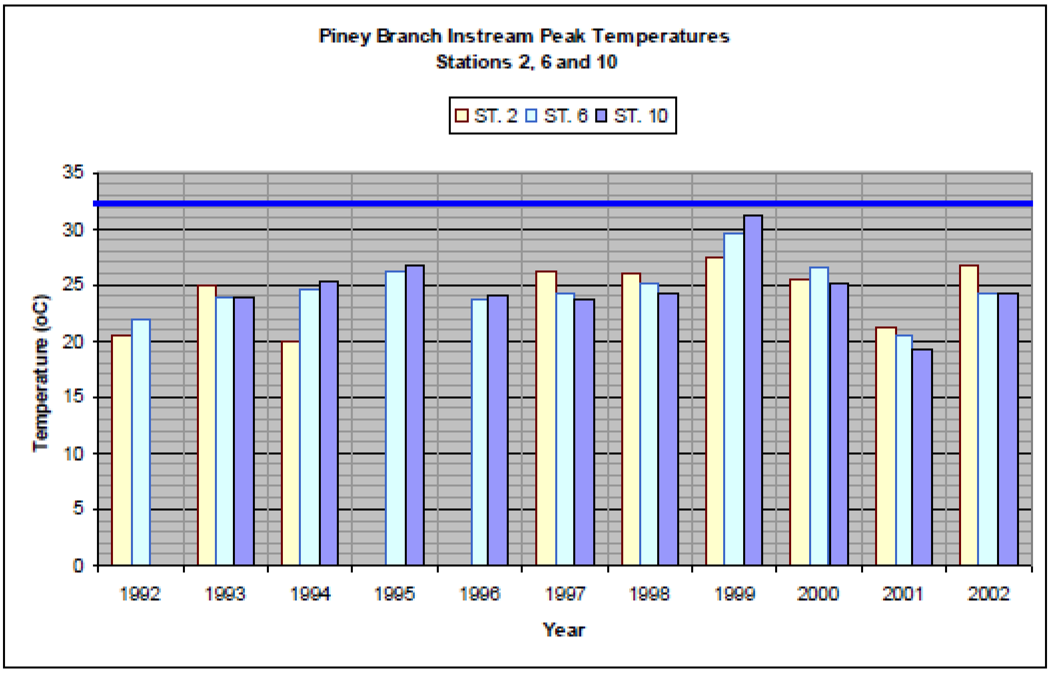

Table 3

The moderate stream impairment and the noncompliant spike of the 1996 T indicated items that needed more scrutiny in subsequent measurement and was determined to be an anomaly related to the 10 year storm and mulch pile runoff. More significant data since then has shown similar results as cumulative indicators established themselves. Monitoring results from this initial project not only provided data on specific BMP performance, but the vital long-term picture for the watershed as well, since the property is at a lower point. Other future regulated projects up-drainage also provided similar on-site monitoring and results.

4.CONCLUSIONS

The monitoring results and evaluation of onsite conditions indicate that the lower stream reaches of the property have sensitive water resources and can potentially be developed in a manner that complies with regulatory requirements for wetland and stream protection – and in light of the pre-existing agricultural use, even a net gain. While this particular project required lengthy analysis and redesign, the lessons learned here made subsequent projects proceed more efficiently – and now the lessons and practices learned are routine and customary today.

More important, this project along with the development review of the subsequent properties up-stream fueled state/county efforts to refine and establish more progressive ecologically-based stream and wetland restoration practices, stormwater management regulations, improved and strengthened local involvement in the permitting process, and removed sometimes incompatible regulatory conflicts encumbering the regulated public.

This effort also laid historical groundwork for the creation of numerous interagency processes including the following initiatives.

- A basis for "how we do it now"
- A basis for groundbreaking county Special Protection Area legislation
- A basis for local, state, federal coordinating committees and public processes
- A basis for initial findings for new U.S. EPA required ("MS4") watershed-wide nonpoint source monitoring and compliance requirements
- A basis for more biosensitive stream crossing initiatives
- A basis for formalizing increased local/state biological monitoring teaming efforts
- More efficient and equitable review of future critical projects

ACKNOWLEDGMENTS

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