CUMULATIVE EFFECTS OF LOCKSLEY CONSERVE UPON AQUATIC RESOURCES

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INTRODUCTION

The Locksley Conserve Community Committee retained Community & Environmental Defense Services (CEDS) to evaluate the potential environmental effects of a development proposal known as Locksley Conserve. The project is proposed for a 49-acre site located in the Jacksonville area of Baltimore County, Maryland. Several members of the Committee own property along streams draining the project site and were particularly concerned about possible damage to their stream and property.

The Locksley Conserve proposal consists of 22 single-family dwelling units located on lots ranging from 1.1- to 2.5-acres in area. All 22 homes are proposed for individual septic systems and wells.

I conducted the evaluation presented in this report by:

- Reviewing project files compiled by three units of the Baltimore County Department of Environmental Protection & Resource Management (DEPRM). These units were the Stormwater Management Section, the Groundwater Management Section, and the Environmental Impact Review Division.

- Reviewing a report prepared by Mr. Charles Gougeon, a fishery biologist with the Maryland Department of Natural Resources, documenting the results of fishery surveys he conducted in Sawmill Branch and two unnamed tributaries adjoining the site.

- Reviewing the Development Plan and other plans submitted by the applicant.

- Reviewing environmental protection regulations and policies adopted by DEPRM.

- Reviewing the scientific literature and other published documents for information pertinent to the analysis of the potential effects of the project upon aquatic resources.

- Surveying the streams and other portions of the site on June 16, 1998.

- Measuring the water temperature in the two streams draining the site on July 15, 1998.

ENVIRONMENTAL SETTING

The site of Locksley Conserve adjoins Sawmill Branch, which is a tributary to Little Gunpowder Falls. Two unnamed tributaries to Sawmill Branch are located on the western and eastern sides of the proposed development site. According to the report prepared by Mr. Charles Gougeon, of the Maryland Department of Natural Resources, all three streams support a healthy population of brook trout *(Salvelinus fontinalis)*.

Trout, and brook trout in particular, are among the most sensitive and important fish species occurring in Baltimore County. Of the four classifications of waters found in Baltimore County, natural trout streams benefit from the most stringent water quality protection standards adopted by the Maryland Department of the Environment (COMAR 26.08.02) and DEPRM (§14-341(b)(3)).

The Maryland Department of the Environment cited Little Gunpowder Falls as suffering from *"elevated bacteria and nutrient levels due to agricultural and urban runoff and upstream sources"* (MDE 1995, p. 212).

As will be seen in the next section of this report, land development can have a severe impact upon stream quality. This includes the type of development proposed for the Locksley Conserve site. Fortunately, measures are available for getting the benefits of growth without the loss of important aquatic assets.

OVERVIEW - CUMULATIVE EFFECTS OF LAND DEVELOPMENT UPON AQUATIC RESOURCES

A number of studies have been conducted in Maryland and throughout North America on the effects of land development upon aquatic resources. A summary of these studies is presented in Table 1. What these studies consistently demonstrate is that as the degree of watershed development increases, various indicators of the health of aquatic systems decline. In about a third of the studies the authors carried their analysis to the point of establishing a threshold for "first effect" and "significant adverse effects" upon the aquatic systems. The first effect threshold marks the point where negative effects can be detected. The significant adverse effects threshold marks the point where development causes aquatic systems to decline from a level of good quality to fair or from an unimpaired to impaired level of quality. Crossing the first effects threshold may cause the loss of highly-sensitive aquatic resources. Crossing the significant adverse effects threshold generally results in the loss of benefits associated with aquatic resources, such as fishing and waters which are clear and free of odors.

The thresholds are expressed in terms of *percent impervious area*, which includes all those land development features that prevent rainwater from soaking into the earth. Impervious features include homes and other buildings, sidewalks, streets, parking lots, and any other structure made from asphalt, concrete, or other impermeable materials.

For wetlands adverse effects are first observed when the watershed becomes about 4% impervious, which would equal one home for every six acres (SCS 1986). Significant impact for all other resources begins at an imperviousness of 8%. A watershed with an imperviousness of 8% would have an average of one house for every three acres. Severe degradation occurs when watershed imperviousness exceeds 20%.

The authors of the studies referenced in Table 1, identified a number of specific impacts which accounted for the effects of impervious areas upon aquatic systems. The specific impacts identified through these studies are presented in Table 2. The degradation described in Table 1 is a result of the cumulative effects and interactions of the impacts listed in this second table (Table 2).

Table 1: Summary of Studies Concerning the Effect of Watershed Development upon Aquatic Communities

Geographic Area of Study	Aquatic Systems Studied	Organisms Studied	Nature of Effect of Increasing Watershed Development	Significant Impact Threshold (% impervious)	Reference
Connecticut	wetlands	aquatic insects and other macroinvertebrates	A decline in various indicators of aquatic macroinvertebrate community health was observed in wetlands draining watersheds more than 3% impervious. The degradation became significant in most wetlands at an imperviousness of 8%-9%. This degradation was attributed to physical alterations of the wetlands, sedimentation, nutrients, elevated water temperature, reduced night time dissolved oxygen, elevated pH, and de-icing salts.	8%-9%	Hicks and Larson. 1997
Delaware	streams	aquatic insects and other macroinvertebrates	Dramatic drop in various indices of health of macroinvertebrate community health which are combined into an index of Biologic Integrity	8% - 15%	Shaver et al. 1994
Georgia	streams	aquatic insects and other macroinvertebrates	As watershed development increased the number of macroinvertebrates species declined.		Benke et al. 1981
Maryland	streams rivers	fish, aquatic insects and other macroinvertebrates, and stream baseflow	Fish community Species Diversity Indexand stream baseflow declines as watershed imperviousness increases. Most fish species are eliminated when watershed imperviousness reaches 20%.	10% - 12%	Klein 1979
	streams	aquatic insects and other macroinvertebrates and fish	Combined indexes of macroinvertebrate and fish community health showed declind		Kazyak et al. 1992
	streams	aquatic insects and other macroinvertebrates	As percent urban land use increased indicators of macroinvertebrate community health declined.	15%	Boward and Hurd 1996
	streams	aquatic insects and other macroinvertebrates and fish	Fish and macroinvertebrate diversity declined as watershed imperviousness increased.	10% - 12%	Schueler and Galli, 1992
	tidal creeks	fish	Fish assemblages were less diverse in tidal creeks with watersheds dominated by urban land uses when compared to forest and wetland dominated watersheds; dissolved oxygen was lower in creeks draining urban watersheds when compared to forest-wetland dominated watersheds.		Carmichael et al. 1992
	tidal rivers	fish, macroinvertebrates, and plants	In general, the authors found that tidal tributaries draining more intensely developed watersheds exhibited greater toxicity to fish, benthic macroinvertebrates, and plants. Toxic effects were greatest where developed land uses occupied 25% to 36% of the watershed		Hartwell et al. 1995

Table 1: Summary of Studies Concerning the Effect of Watershed Development upon Aquatic Communities

Geographic Area of Study	Aquatic Systems Studied	Organisms Studied	Nature of Effect of Increasing Watershed Development	Significant Impact Threshold (% impervious)	Reference
Maryland and Virginia	tidal rivers	benthic macroinvertebrates and water quality	As watershed urbanization increased the health of benthic communities declined; as the proportion of the watershed in forest increased, so did the condition of benthic communities.		Ranasinghe et al. 1994
Minnesota	streams	aquatic insects and other macroinvertebrates	As watershed development increased, macroinvertebrate community diversity decreased.		Richards and Host 1994
New York	nontidal and tidal streams	fish	Alewife herring egg and larval densities decreased as the extent of watershed development increased; dissolved oxygen was more variable in streams draining urbanized vs. undeveloped watersheds.		Limburg and Schmidt 1990
New Jersey	wetlands	plants	As watershed development increased indigenous plant species declined due to water quality changes and invasion by upland and exotic species.		Ehrenfeld and Schneider 1991
	wetlands	plants	Runoff from developed land killed sphagnum moss is two wetlands.		Vedagiri and Ehrenfeld 1991
	stream	aquatic insects and other macroinvertebrates	Diversity and abundance declined dramatically as a stream flowed through a heavily developed area.		Garie and McIntosh 1986
Ontario, Canada	streams	fish	Index of macroinvertebrate community health declined as the degree of watershed development increased.	7% - 10%	Steedman 1988
Virginia	streams	aquatic insects and other macroinvertebrates	As watershed development increased pollution sensitive macroinvertebrates became less abundant.	14%	Jones and Clark 1987
		fish	Comparisons of fish communities in a stream over a 32-year period showed that watershed development resulted in a significant decline in species diversity.		Weaver and Garman 1994
		aquatic insects and other macroinvertebrates and algae	Macroinvertebrate diversity s and algal species decrease as watershed development increased.		Mangun 1988-89
Washington (state)	streams	fish habitat	Quality of fish habitat declines with increasing watershed development.	8% - 10%	Booth and Jackson 1994
	streams	aquatic insects and other macroinvertebrates	Macroinvertebrate community in a rural stream was twice as diverse when compared to a stream draining an urbanized watershed.		Pederson and Perkins 1986

Table 1: Summary of Studies Concerning the Effect of Watershed Development upon Aquatic Communities

Geographic Area of Study	Aquatic Systems Studied	Organisms Studied	Nature of Effect of Increasing Watershed Development	Significant Impact Threshold (% impervious)	Reference
	wetlands	amphibians, water-level fluctuations, and water quality	Significant decline in the number of amphibian species as the degree of watershed development increased; significant increase in water-level fluctuations; conductivity, suspended solids, and fecal coliform bacteria were higher in wetlands draining most developed watersheds.	4% - 14%	Reinelt and Horner 1991

Table 2: Specific Land Development Impacts Associated with Degradation of Aquatic Communities

Specific Factor Causing Significant Degradation	References
Sediment released from construction sites and road surfaces	5, 12, 13, 14, 23, 24, 25, 26, 27
Hydrologic and habitat modifications	1, 5, 8, 12, 14, 26, 27
Diminished groundwater inflow	5, 13, 25, 27
High fluctuations in water level	6, 15, 25, 27
Erosion/scour due to increased flood flows	1, 2, 5, 9, 10, 13, 14, 23, 27
Elevated water temperature due to reduced riparian shading	5, 8, 27
Thermal impact of runoff from heated impervious areas	5, 17, 26
Organic pollution (sewage, other oxygen demand)	5, 8, 11, 12, 25, 26
Dissolved oxygen deficiency	3, 6, 11, 12, 26
Elevated nutrient inputs	5, 6, 11, 15, 26
Toxicity of an undefined nature.	22
Metals	5, 10, 12, 13, 19, 20, 21, 28
pH changes	10, 12, 26
Road salt	5, 13, 15, 16, 18, 19
Oil	5, 20, 28
Reduced inputs of food materials due to loss of riparian forest	5, 13, 21, 23
No specific factor identified as causing degradation	4, 7

References

1. Booth and Jackson 1994
2. Boward et al. 1995
3. Carmichael et al. 1992
4. Kayzak 1992
5. Klein 1979
6. Reinelt and Horner 1991
7. Shaver et al. 1994
8. Steedman 1988
9. Booth and Reinelt 1993
10. Vedagiri 1989
11. Ranasinghe et al. 1994
12. Limburg and Scmidt 1990.
13. Jones and Clark 1987
14. Mangun 1988-89

15. Ehrenfeld and Schneider 1991
16. Crowther and Hynes 1977
17. Yetman 1991
18. Wilcox 1986
19. Kszos et al. 1990
20. Roper et al. 1988
21. Garie and McIntosh 1986
22. Hartwell et al. 1995
23. Pedersen and Perkins 1986
24. Richards and Host 1994
25. Weaver and Garman 1994
26. Hicks and Larson, 1997
27. Pitt and Bissonnette, 1984
38. Cooke et al. 1994 Table 2

The specific impacts shown in Table 2, do not affect all aquatic resources equally. For example, the thermal impacts of streamside shade loss and runoff from heated impervious surfaces has more of an impact upon trout ecosystems when compared to fish inhabiting warmwater streams, such as the Patapsco River. However, there are fish species which may inhabit even warmwater streams that are temperature sensitive (Galli 1990). Figure 1 lists six types of aquatic resources and shows the relative effect of each specific impact upon each resource type.

A number of measures have been developed for mitigating the specific impacts presented in Table 2. These measures, or Best Management Practices (BMPs), are also shown in Figure 1. The relative effectiveness of each BMP in mitigating each specific impact is also provided in Figure 1.

Figure 1, shows that the right combination of BMPs can be highly effective in addressing most of the specific impacts of development. This combination would include the following BMPs: buffers, trapping devices plus temporary stabilization measures applied to soils disturbed through construction activity, and using infiltration measures combined with carefully designed ponds for the final developed land use.

Several recent studies have shown that ponds, which are the most widely used BMPs on proposed development sites, are not effective in protecting sensitive aquatic resources (Jones et al. 1996; Maxted and Shaver 1996). In these studies the aquatic communities inhabiting streams draining two types of developed watersheds were compared: 1) watersheds where the development drained to ponds, and 2) watersheds where ponds and other measures were absent below the developed areas. Both studies found that sensitive aquatic organisms dissappeared regardless of the presence or absence of ponds. Thus ponds alone are not sufficient to protect sensitive species of aquatic life. But when combined with infiltration measures it is conceivable that development could occur with little adverse effect upon sensitive aquatic communities.

LOCKSLEY CONSERVE PROJECT: IMPACTS OF PROPOSED IMPERVIOUS AREAS & BMPS

As previously stated, the Locksley Conserve project would consist of 22 single-family homes on lots ranging from 1.1- to 2.5-acres in area. The site is drained by three streams - Sawmill Branch and two first-order, unnamed tributaries to Sawmill Branch. All three streams are designated Class III natural trout waters by the Maryland Department of the Environment (COMAR 26.08.02.08J(3)(c)).

Table 3 and Figures 2 and 3, provides a comparison of the impervious area in the watershed of the Western and Eastern Tributaries to Sawmill Branch. The data presented in Table 3 shows that the existing watershed imperviousness for the Western Tributary is 7%, which is slightly below the threshold of significant impact.

Figure 1: Effectiveness of Best Management Practices in Mitigating Specific Land Development Impacts

TYPE OF AQUATIC RESOURCE AFFECTED [1]

- **Ž Beneficial uses associated with these waters usually adversely affected due to this specific impact**
- **™ Beneficial uses occassionally adversely affected**
- **• Seldom adversely affected**

EFFECTIVENESS OF BEST MANAGEMENT PRACTICES [2]

- **Ž Highly Effective**
- **™ Partially Effective**
- **• Ineffective**
- **W Ineffective and May Increase Impact**

SPECIFIC IMPACTS	TYPE OF AQUATIC RESOURCE AFFECTED						EFFECTIVENESS OF BEST MANAGEMENT PRACTICES							
								Constructi on Phase		Post-Construction Stormwater Management Measures				
	Groundwater	Wetland	Warmwater Stream	Salmonid Stream	Pond or Lake	Tidal Waters	Buffers	Trapping Devices	Temporary	Water Quality	Ponds	Filter - Non-	Infiltration	Swales with Check
Construction phase sediment	•	Ž	Ž	Ž	Ž	Ž	•	™	Ž					
Hydrologic/habitat alterations	™	Ž	Ž	Ž	Ž	Ž	Ž							
Diminished groundwater inflow	Ž	Ž	Ž	Ž	Ž	Ž	•			•	•	•	Ž	™
High fluctuations in water level	•	Ž	Ž	Ž	Ž	Ž	™			•	™	™	™	™
Erosion/scour	™	Ž	Ž	Ž	Ž	Ž	™			•	W	™	™	™
Shade loss & thermal impact	•	•	™	Ž	•	•	Ž			•	•	Ž	Ž	•
Thermal impact of runoff	•	•	™	Ž	•	•	™			•	W	™	Ž	™
Organic pollution	™	Ž	Ž	™	Ž	Ž	™			™	™	Ž	Ž	™
Dissolved oxygen deficiency	•	Ž	Ž	™	Ž	Ž	™			™	™	Ž	Ž	™
Nutrients	™	Ž	Ž	™	Ž	Ž	™			™	™	Ž	Ž	™
Metals	™	Ž	Ž	Ž	Ž	Ž	™			™	™	Ž	Ž	™
pH changes	•	™	™	™	™	™	™			•	•	™	™	™
Road salt	™	™	™	™	™	™	•			•	•	•	•	•
Oil	Ž	Ž	Ž	Ž	Ž	Ž	™			™	™	Ž	Ž	™
Reduced food inputs	•	•	™	™	•	•	Ž			•	•	•	•	•

1. Based upon the studies referenced in Table 1 and Table 2.
2. Based upon *Performance of current sediment control measures at Maryland construction sites* (Schueler and Lugbill 1990), *Controlling urban runoff, A current assessment of urban best management practices* (Schueler et

al. 1992), *Site Planning for Urban Stream Protection* (Schueler 1995), and *Design of stormwater filtering systems* (Claytor and Schueler 1996).

Table 3: Land Use & Impervious Area

LAND USE	Western Tributary	Eastern Tributary
Drainage Area (acres)	67	49
Number of Houses		
Existing	29	14
With Locksley Conserve	35	30
Impervious Area		
Existing	7%	4%
With Locksley Conserve	8%	9%

Drainage area was determined from the Baltimore County Photogrametric Maps of the area. The number of existing homes was determined from 1986 aerial photos with ground truthing to account for homes built since 1986. Impervious area was measured from the aerial photos and from the Locksley Conserve Development Plan.

Once Locksley Conserve is developed the watershed of the Western Tributary will become 8% impervious. The Eastern Tributary watershed is presently 4% impervious which will increase to 9% if Locksley Conserve is developed as proposed.

As previously stated, Maryland Department of Natural Resources fishery biologists sampled fish populations in all three streams. The State biologists found brook trout in each stream. Trout streams constitute the most sensitive aquatic community present in Baltimore County with brook trout be the most sensitive of the three trout species.

The Locksley Conserve project would expose the trout communities to a number of the specific impacts presented in Table 2 and Figure 1. Of these, three are of particular concern: a decline in stream baseflow, thermal impacts, and increased loadings of toxic metals. The project will also increase nutrient loadings to Little Gunpowder Falls, which can only perpetuate the elevated nutrient levels cited as a problem by the Maryland Department of the Environment (MDE 1995).

In a letter dated June 9, 1998, from Mr. Mark Richmond, of KCI Technologies, to Mr. Lee Dregier, of DEPRM's stormwater section, the following stormwater management measures were proposed for the Locksley Conserve project.

- A pond would be constructed in the stormwater management reservation area shown on the Development Plan along the eastern perimeter of the site. All public roadways would drain to the pond. The drainag e plan submitt ed by the applicant shows that 9.5 houses would also drain to the pond. The most likely type of pond constructed in this area would be that known as an extended-detention pond designed for a maximum drawdown time of 12 hours. What this means is that runoff from impervious areas draining to the pond would be stored then released over a 12-hour period.

- The applicant's June 9th letter also proposed that runoff from the 12.5 houses (and driveways, patios, etc.) not draining to the pond would receive "water quality" treatment by "sheet flow through grass and wood areas."

Figure 2: Impervious Area

Western Tributary

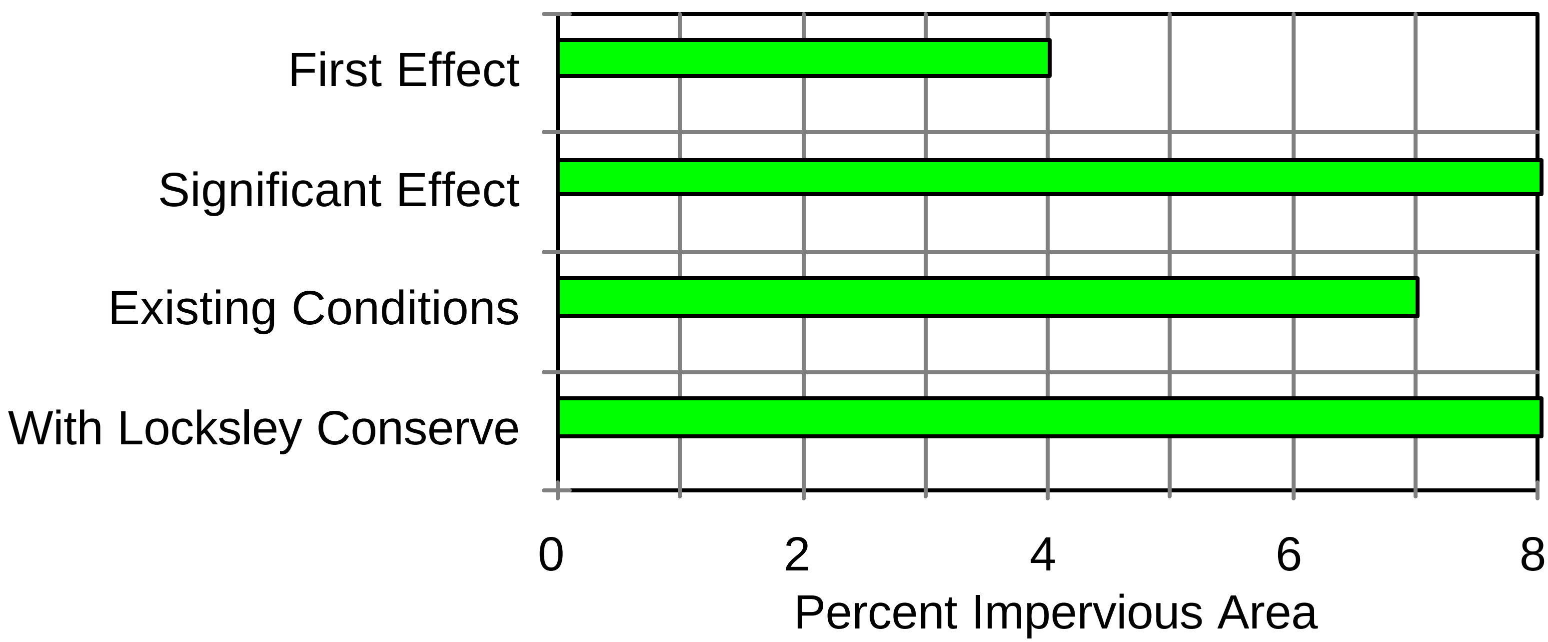
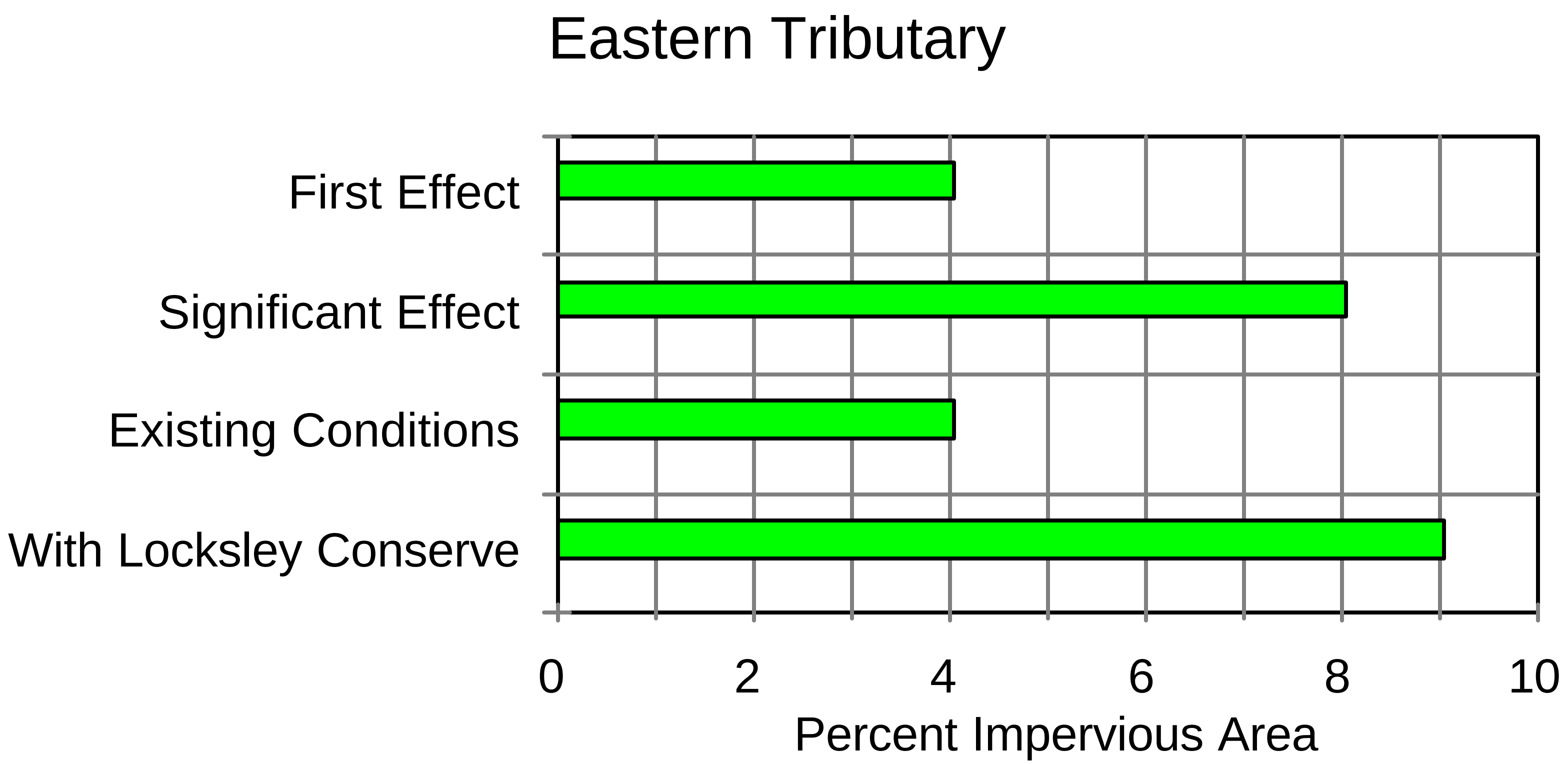


Figure 3: Impervious Area



As will be shown in the following sections of this report, the applicant's proposed stormwater management scenario will not protect the brook trout inhabiting the three streams associated with the site.

Stream Baseflow

Baseflow is the water carried by a stream during dry-weather. It originates as rainfall which soaks into the soil and travels through the earth to enter a stream channel through the banks, the stream bed, or from nearby springs and seeps.

Three of the studies referenced in Table 2 cited a decline in stream baseflow as contributing to the degradation caused by increasing watershed development and imperviousness. One of those studies, which was conducted by the author of this report (Klein 1979), included data collected on streams in Baltimore County similar to Sawmill Branch and the two unnamed tributaries.

Watershed development decreases baseflow by covering the soil surface with impervious materials - asphalt, concrete, and buildings. These impervious materials prevent rainwater from soaking into the earth. Instead, rainwater flows along the land surface and quickly enters the nearest waterway. While the same volume of rainfall may enter the stream, it enters in a matter of minutes or hours. Prior to development it would have taken days or weeks for infiltrated rainwater to enter the nearest stream as baseflow.

When watershed development causes a decline in recharge and baseflow, then:

- the depth of the stream decreases which lowers the quality of the habitat for fish and other organisms,
- the reduced depth increases the difficulty fish have in negotiating riffles, waterfalls, and other barriers,
- the reduced depth also increases the vulnerability of fish to predators, and
- causes the stream to become more vulnerable to the heating effects of the sun and atmosphere.

The 22-lot subdivision will create 2.5-acres of impervious area. According to the Maryland Geological Survey report *Solid Waste Disposal in the Geohydrologic Environment of Maryland* (Otton 1972, Table 4), groundwater recharge in the Littler Gunpowder Falls watershed averages 306,822 gallons per acre per year. As shown in Table 4 and Figure 4, the 2.5 acres of impervious area would reduce recharge by 0.8-million gallons per year. About 75% of the proposed impervious area would be created in the watershed of the Eastern Tributary and the remainder in the watershed of the Western Tributary. Thus the decline in recharge and baseflow

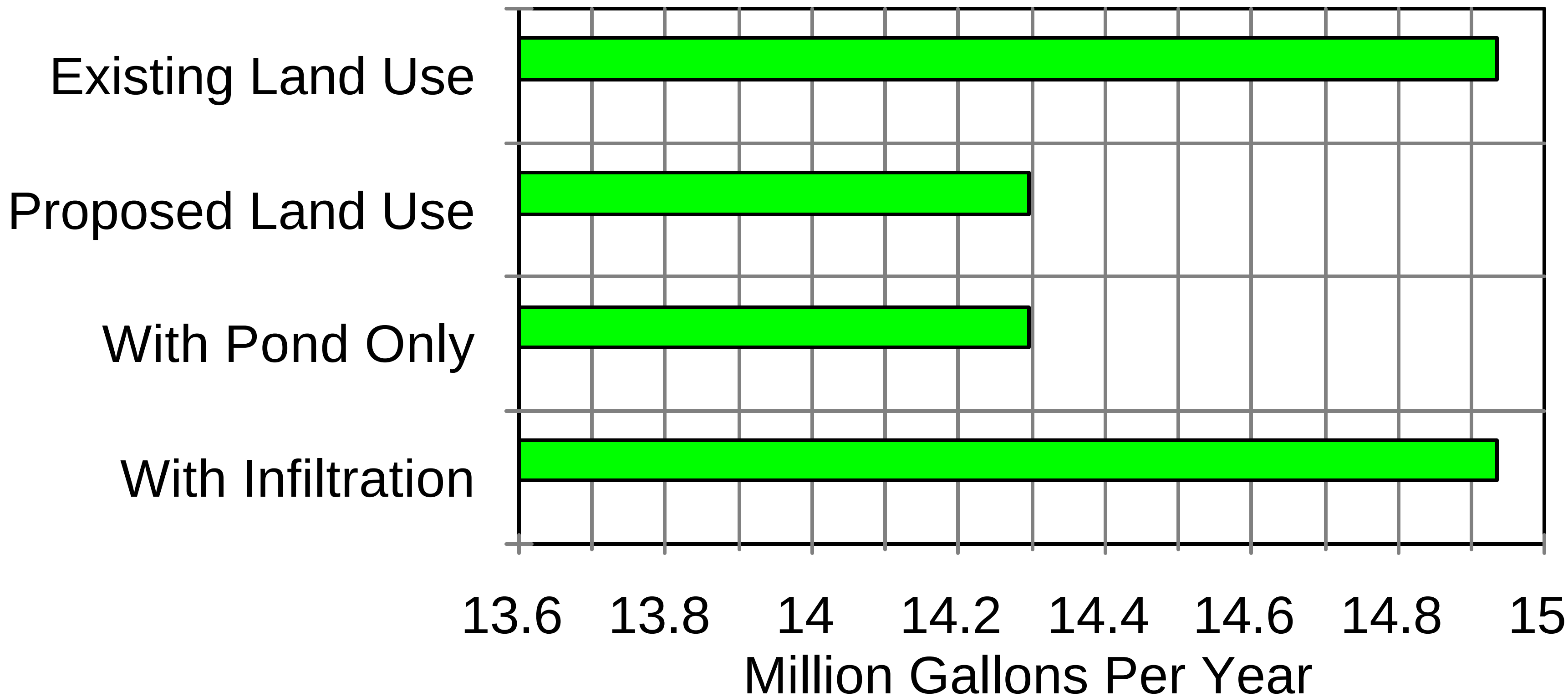
Table 4: Comparison of the Environmental Effects of Locksley Conserve

LAND USE & BEST MANAGEMENT PRACTICE SCENARIOS [1]	Acres	Percent Impervious [2]	Ground Water Recharge (million gal/year) [3]	POLLUTANT LOADINGS (Pounds per Year)					
				NUTRIENTS [4]		METALS [5]			
				Nitrogen	Phosphorus	Copper	Lead	Zinc	Total Metals
Existing Land Use									
Forest	23.30	0.0	7.15	72.00	1.51	0.23	0.47	2.56	
Meadow	25.36	0.0	7.78	78.36	1.65	0.25	0.51	2.79	
Existing Building & Road	0.34	100.0	0.00	2.86	0.41	0.13	0.51	0.50	
Subtotal	49.00		14.93	153.22	3.58	0.62	1.48	5.85	7.95
Proposed Land Use									
Parcel B (Forest)	8.31	0.0	2.55	25.68	0.54	0.08	0.17	0.91	
Residential (22 lots)	40.69	6.0	11.74	399.17	28.87	1.74	6.68	6.53	
Subtotal	49.00		14.29	424.85	29.41	1.83	6.85	7.45	16.12
With Proposed Stormwater Pond [6]			14.29	384.93	25.08	1.52	5.41	6.37	13.30
With Infiltration of First Inch [6]			14.93	159.00	14.34	0.43	1.56	2.21	4.20

1. Existing and proposed land use is based upon the applicant's Forest Conservation Worksheet and Development Plan.
2. Percent impervious area is based upon Table 2-2a, in *Urban hydrology for small watersheds.* U.S. Soil Conservation Service, Post Office Box 2890, Washington, D.C. 20013. Available from the National Technical Information Service, Springfield, VA 22161. Order No. PB87-101580.
3. Groundwater recharge is the amount of precipitation which soaks sufficiently deep into the earth to become available to well users and to enter surface waters. A recharge rate of 309,537 gallons per acre per year is based data for the Little Gunpowder River basin presented in Table 4, *Solid Waste Disposal in the Geohydrologic Environment of Maryland*, Report of Investigations No. 18, Maryland Geological Survey, 2300 Saint Paul Street, Baltimore, MD 21218.
4. Nutrient loadings are based upon *Chesapeake Bay Program Watershed Model Application To Calculate Bay Nutrient Loadings*, U.S. Environmental Protection Agency, 410 Severn Avenue, Annapolis, MD 21403..
5. Metal loadings from undeveloped land uses are based upon *Environmental data summary for the Rhode River ecosystem (1970-1978)*, Chesapeake Bay Center for Environmental Studies, Post Office Box 28, Edgewater, MD 21037. Metal loads from developed land uses are based upon Equation 1.1, in *Controlling Urban Runoff: A Practical Manual for Planning & Designing Urban BMPs*, Metropolitan Washington Council of Governments, 777 N. Capitol St., N.E., Washington, D.C. 20002.
6. The Drainage Area Plan for the site indicates that about half of the impervious area will drain to the proposed stormwater pond. With the infiltration option it is assumed all impervious area runoff is treated. The effectiveness of stormwater ponds and infiltration is based upon *National Pollutant Removal Performance Database for Stormwater Best Management Practices*, by Brown and Schueler, 1997, Center for Watershed Protection, 8391 Main Street, Ellicott City, MD 21043. (410) 461-8323.

Figure 4: Groundwater Recharge

Locksley Conserve



in the Eastern Tributary would be about 0.6 million gallons per year and 0.2 million gallons per year for the Western Tributary.

The small size and shallow depth of both unnamed tributaries causes each to be particularly vulnerable to the effects of increased impervious area, reduced groundwater recharge, and diminished base flow. As will be shown in the next section of this report, the recharge reduction will cause a significant decline in the dry-weather (base) flow of the Eastern Tributary and will contribute to a water temperature increase lethal to brook trout.

Thermal Impacts

Trout are extremely sensitive to thermal pollution and temperature stress (Galli 1990). The water quality standards established by the Maryland Department of the Environment call for a temperature of no more than 68°F in a natural trout stream (COMAR 26.08.02.03-3D(3)(a)). In *Thermal impacts associated with urbanization and stormwater management best practices,* Galli (1990, Appendix p. 91) states that brook trout begin dying at a water temperature of 75°F.

As previously stated, the Locksley Conserve project would create 2.5 acres of additional impervious area within the watershed of the three trout streams. Summer runoff from impervious surfaces attains a temperature of 82.4°F (Yetman 1991), which is well in excess of the preferred and lethal temperature for brook trout. During a typical summer thunderstorm the volume of runoff generated by 2.5 acres of impervious area would easily overwhelm the capacity of the three streams to neutralize heated runoff through mixing with cooler stream water, particularly if baseflow has also been diminished by the same impervious areas..

Additionally, the development plan for the Locksley Conserve project shows a stormwater management reservation area near the Eastern Tributary. According to a letter dated June 9, 1998, from Mr. Mark Richmond, of KCI Technologies, to Mr. Lee Dregier, of DEPRM's stormwater section, a pond will be constructed in this reservation. The most likely type of pond would be that known as an extended-detention pond designed for a maximum drawdown time of 12 hours. While the heated impervious surface runoff sits in the pond it will be susceptible to further heating by the sun. In fact, a Montgomery County, Maryland study of extended-detention ponds found that runoff will heat to a temperature of 80°F to 83°F (Galli 1990, Table 16).

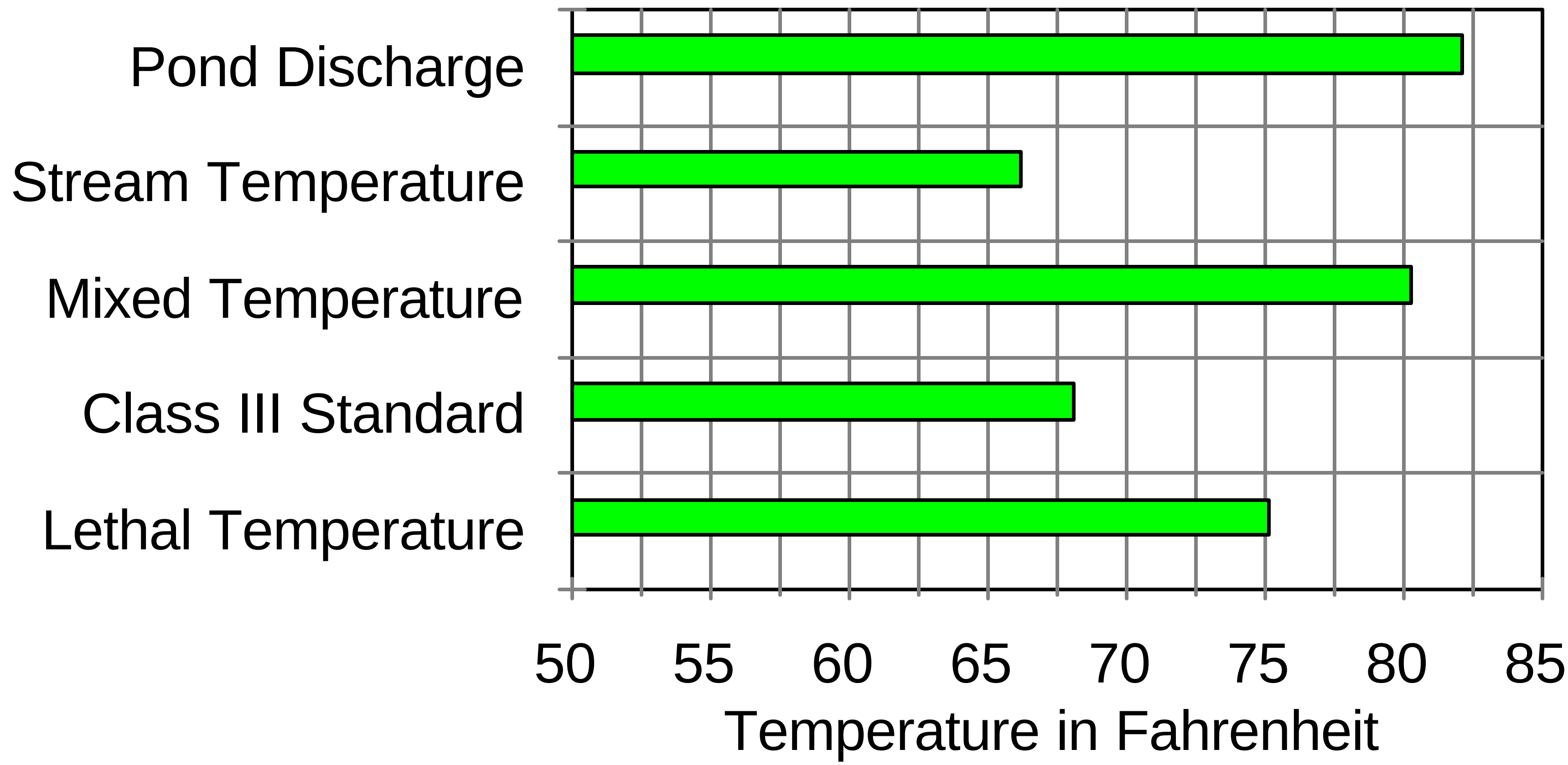
In Table 5, an analysis is presented of the effects of Locksley Conserve upon the temperature of the Eastern Tributary. The analysis examines conditions likely to occur at least once every summer. The analysis begins with the storm that would produce maximum runoff from impervious surfaces, but no runoff from lawns, forests, croplands, or other land uses within the watershed of the Eastern Tributary. This storm would release slightly more than 1.20 inches of rainfall in a 24-hour period (Tables 2-1 and 2-2a in SCS 1986). Given the Elioak, Manor, and Glenelg soils which dominate the site, it would take more than 1.20 inches of rain to produce runoff from lawns, cropfields, and forests. However, just 0.20 inches of rain is required before impervious surfaces begin producing runoff. Thus during a 1.20-inch rainstorm, all the surface runoff entering the Eastern Tributary would be from impervious surfaces. When this rainfall

Table 5: Effects of Locksley Conserve on the Temperature Regime of the Eastern Tributary

Temperature Factor	Value
Volume of Impervious Surface Runoff to Pond & Volume of Pond Discharge to Eastern Tributary	
A. Impervious Area Draining to Pond *(9.5 houses (40'x65') @ 2,600 ft^2 each; 10 driveways @ 700 ft^2 each; 33,840 ft^2 = 65,540 ft^2 = 1.50 acres)*	1.50 acres
B. Rainfall Depth Producing Maximum Runoff from Impervious Areas, But No Runoff from Other Surfaces *(Table 2-1 and 2-2a in SCS 1986)*	1.20 inches
C. Runoff Depth from Impervious Area Draining to Pond During 1.20 Inch Rainfall *(Table 2-1 and 2-2a in SCS 1986)*	0.99 inches
D. Gallons of Runoff from Impervious Area Draining to Pond During 1.20-Inch Rainfall *(A x C converted to feet then to gallons)*	40,321
Volume of Flow in Eastern Tributary Available to Dilute Pond Discharge	
E. Average Stream Base Flow (ft^3/sec/sq mile) in Little Gunpowder Watershed *(Based upon 2-year, 30-day average low-flow presented in Carpenter 1983 for Little Gunpowder Falls)*	0.50
F. Average Stream Base Flow Converted to Gallons/sec/sq mile *(E x 7.48)*	3.74
G. Drainage Area of Eastern Tributary in Acres *(see Table 3)*	49
H. Drainage Area of Eastern Tributary Converted to Square Miles *(G ÷ 640)*	0.08
I. Average Flow of Eastern Tributary in Gallons/Second *(H x F)*	0.29
J. Gallons of Flow in Eastern Tributary During Six-Hour Period Pond is Discharging *(0.29 gallons/second x 60 seconds/minute x 60 minutes/hour x 6 hours)*	6,185
...volume of flow in Eastern Tributary less recharge reduction due to impervious surfaces	
K. Average Recharge in the Little Gunpowder Basin in Gallons/Acre/Year *(Otton 1972)*	306,822
L. Acres of Existing & Proposed Impervious Area in Eastern Tributary Watershed *(see Table 3)*	4.46
M. Recharge Loss (gallons/year) Due to Impervious Area *(K x L)*	1,368,426
N. Recharge Loss Converted to Gallons/Six Hour Period *(M ÷ 365 days/yr ÷ 4)*	937
O. Gallons of Stream Flow in the Eastern Tributary During the Six-Hour Pond Discharge Period After Subtracting Recharge Loss *(J - N)*	5,248
P. Total Flow in Eastern Tributary (Impervious Surface Runoff Plus Stream Flow) During Six-Hour Pond Discharge Period *(D + O)*	45,569
Temperature in Eastern Tributary After Mixing of Pond Discharge with Stream Flow	
Q. Temperature (°F) of Extended-Detention Pond Discharge *(Table 1, in Galli 1990)*	81.9
R. Eastern Tributary Water Temperature (°F) *(Based upon measurement made on July 15, 1998)*	66.0
S. Predicted Stream Temperature (°F) After Complete Mixing of Pond Discharge with Flow in Eastern Tributary *(Based upon volume-temperature of the discharge and stream flow volume-temperature given above)*	80.1
T. Class III Stream Temperature (°F) Standard *(from COMAR 26.08.02.03-3D(3)(a))*	68.0
U. Lethal Temperature (°F) for Brook Trout *(Appendix p. 91 in Galli 1990)*	75.0

Figure 5: Temperature Effects

Locksley Conserve



eventoccurs in July or August the runoff from sun-baked asphalt surfaces and rooftops would be very hot - on the order of 82°F (Yetman 1991).

As shown in Table 5, 1.5-acres of impervious area will drain to the proposed stormwater reservation area. This estimate is based upon the applicant's drainage area plan and development plan. The 1.5-acres of impervious area would generate 40,321 gallons of runoff to the stormwater reservation area. Again, the most likely measure to be built in the reservation area is an extended-detention pond with a maximum drawdown time of 12-hours. Since the 12-hour drawdown is geared to the two-year storm, which releases 3.2 inches of rain, it is assumed the runoff from a 1.20-inch rain would be released in about six hours.

As also shown in Table 5 and Figure 5, the Eastern Tributary would carry 6,185 gallons of flow during the six-hour period that the pond is releasing heated runoff into this stream. Actually, the stream flow would be just 5,248 gallons due to the loss of recharge caused by existing impervious areas and increased imperviousness created during the development of the Locksley Conserve site. Thus during the six-hour pond discharge period the Eastern Tributary would carry a total of 45,569 gallons of flow (40,321 gallons from the pond and 5,248 from groundwater inflow). In other words, 88% of the water carried by the Eastern Tributary will be heated pond discharge.

The temperature in the Eastern Tributary will be a function of the temperature of the stream flow above the point where the pond discharge enters and the temperature of the pond discharge water. Above the discharge the stream will likely have a temperature of 66°F, which was the actual temperature measured in the Eastern Tributary on July 15, 1998.. The pond discharge would by 81.9°F based upon the results of studies presented above. After complete mixing the temperature of the Eastern Tributary would be 80.1°F. As previously mentioned, State water quality regulations call for no more than 68°F in a Class III trout stream and the temperature lethal to brook trout is 75°F. Thus the project would create a water temperature in the Eastern Tributary lethal to brook trout.

The Eastern Tributary flows through a heavily wooded - and shaded - area. One might assume that the heated pond discharge would cool once it begins flowing along the well-shaded channel. Unfortunately research into the effects of shading upon streams heated by pond discharges shows little cooling, even after a distance of 1,900 feet (Galli 1990, p. 47). Thus the construction of a pond in the area reserved for stormwater management would eliminate the brook trout population in the Eastern Tributary.

The Western Tributary is also threatened by the impact of heated runoff from impervious surfaces. Runoff from six houses and driveways will flow to the Western Tributary. As previously stated, the applicant proposes to provide water quality treatment for this runoff via *"sheet flow through grass and wood areas."* While sheet flow through grass and wooded areas may be an effective method for treating runoff from some agricultural areas, it is not effective when used as the sole method for managing runoff from impervious surfaces (Schueler and Herson-Jones, 1995). The problem is that for effective pollutant removal to occur, runoff must be flowing over grass or wooded areas in a shallow sheet. This allows for infiltration of runoff into the soil as well as filtration of particles from runoff by grass and other objects. But runoff from impervious surfaces is in *channel* flow, not *sheet* flow. This runoff moves too swiftly over the soil for infiltration to occur and the depth of channel flow precludes substantial, quantifiable pollutant removal via filtration. Attempts to convert channel flow into sheet flow with measures such as level spreaders have proven unsuccessful.

Sheet flow is particularly ineffective in managing the thermal impact of impervious surface runoff. The scenario presented above was for a 1.20-inch rainfall event. Again, this rainfall event is just shy of that needed to produce runoff from grass and wooded areas. Thus the soil surface in grass and wooded areas will be saturated by the time rainfall accumulates to 1.20 inches. Therefore little opportunity remains for runoff to infiltrate into the soil.

An option is available which would eliminate the impact of heated runoff from all impervious surfaces as well as the heating which would occur while runoff is detained in the pond. This option is to infiltrate the first 1.20-inches of runoff from all rooftops, roads, driveways, and other impervious surfaces. As will be explained later in this report, infiltration is not only feasible on the site but is also required by Baltimore County policy and by State law.

Toxic Effects of Metals Entrained in Stormwater Runoff

The U.S. Environmental Protection Agency funded a study of stormwater runoff quality in 27 areas throughout the United States (EPA 1983). This study, known as the Nationwide Urban Runoff Program or NURP, included sampling sites in Baltimore County (Fisher and Katz 1988). The NURP study showed that three metals (copper, lead, and zinc) are ubiquitous in runoff from developed lands. Of these three, copper most frequently exceeds standards for the protection of aquatic life.

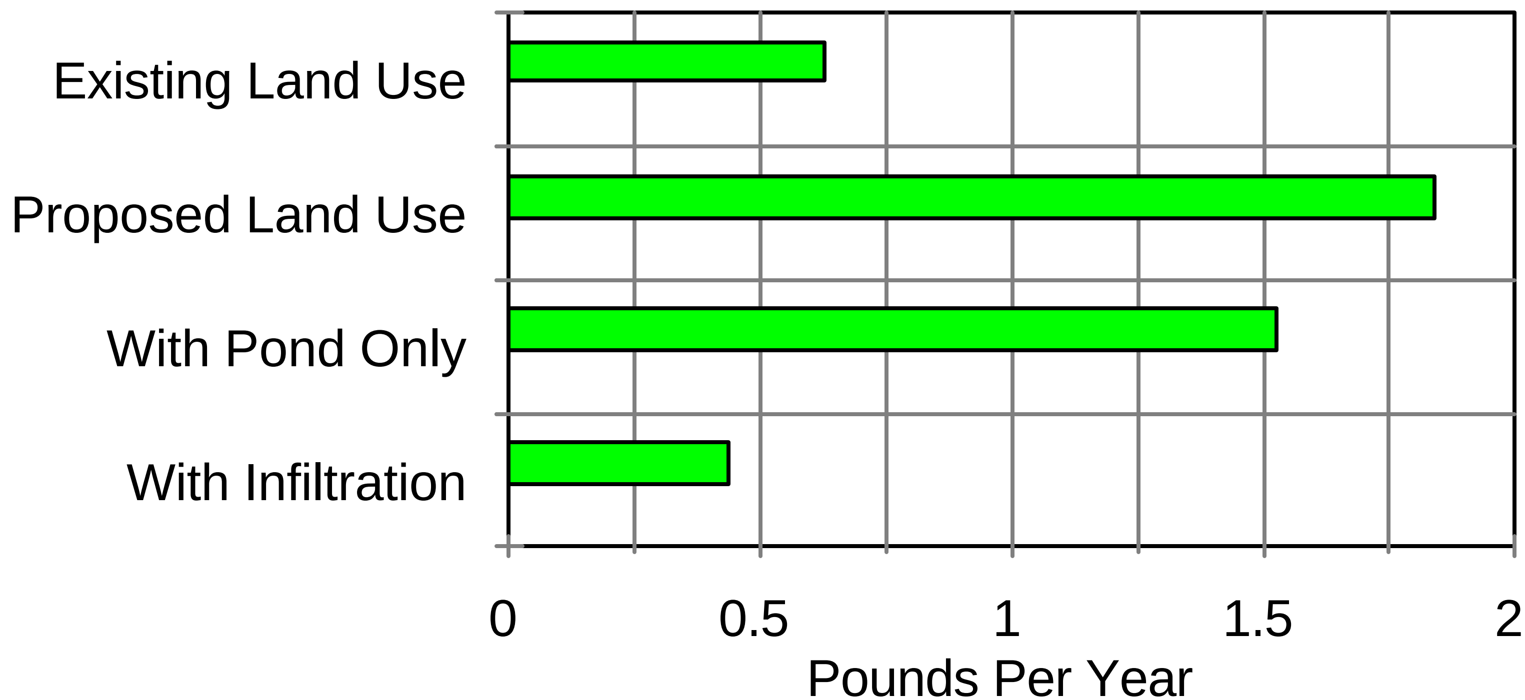
Table 4 and Figure 6, shows that the Locksley Conserve project would cause the amount of copper released to the three trout streams to increase by 2.5-times. As will be explained in the next few paragraphs, this will expose the brook trout and other organisms inhabiting the streams to toxic conditions.

The average concentration of copper in runoff from developed areas is 47 micrograms per liter (µg/l) or parts per billion (Schueler 1987, Table 1.1). But the criteria established by the U.S. Environmental Protection Agency (EPA 1985) and the Maryland Department of the Environment (COMAR .26.08.02) to protect aquatic life is not based upon an *average* concentration, but the *maximum* anticipated in a typical three-year period (EPA 1985). If an aquatic community is exposed to an excessive copper concentration more frequently than once every three years, then it may have difficulty rebuilding and maintaining itself.

Data is provided in *Controlling urban runoff: A practical manual for planning and designing urban BMP's* (Schueler 1987) to compute the maximum copper concentration one

Figure 6: Copper Loading

Locksley Conserve



should anticipate in a typical three-year period. On average about 40 rainfall events will occur in a typical year that release sufficient precipitation to cause runoff from impervious surfaces (Schueler 1987, Figure A-4). Thus about 120 runoff producing events will occur in a typical three year period. Table 1.3, in *Controlling urban runoff*, shows that one out of every 100 storms will produce a copper concentration of 114 µg/l.

Both EPA and MDE (Table 1 in COMAR 26.08.02.03-2G) state that the copper concentration should not exceed 18 µg/l in a freshwater stream. Actually this standard is based upon the dissolved or biologically available fraction of copper. Copper that is not dissolved may have little adverse effect upon aquatic organisms. Approximately half of the copper entrained in runoff from developed areas is dissolved (EPA 1983). It is this dissolved fraction which is most difficult to remove from runoff. Ponds, such as that proposed for the Locksley Conserve site, can remove up to 50% of the copper entrained in runoff (Brown and Schueler 1997, Table III.1). This is mostly the copper which is attached to particulate matter - not the dissolved fraction.

Infiltrating runoff into the soil can remove 95% to 99% of the copper load (Schueler 1987). To achieve the 18 µg/l standard the three-year maximum copper concentration (114 µg/l) must be reduced by 84%. Only infiltration measures can achieve this goal. Therefore without greater use of infiltration measures the trout and other sensitive organisms inhabiting the three streams associated with Locksley Conserve will be exposed to copper at a concentration above the level deemed safe by the Environmental Protection Agency and the Maryland Department of the Environment.

As previously stated, Table 4 shows that the Locksley Conserve project will increase copper loadings to the three streams by 2.5 times. This will greatly increase the extent of stream exposed to the toxic effects of the elevated copper concentrations from impervious surfaces. Infiltrating the first 1.20-inches of runoff from impervious would eliminate this impact.

Nutrients

Little Gunpowder Falls is located one mile downstream of the Locksley Conserve site. The Maryland Department of the Environment cited Little Gunpowder Falls as suffering from *"elevated bacteria and nutrient levels due to agricultural and urban runoff and upstream sources"* (MDE 1995, p. 212).

Table 4 shows that the project will result in a two- to seven-fold increase in nutrient loadings to Little Gunpowder Falls. If runoff from all lots and roads flowed to infiltration measures then nitrogen loads would remain at the current rate while phosphorus loads would still increase by four-fold. Therefore, infiltration would be far more effective in preserving water quality in Little Gunpowder Falls.

AN ALTERNATIVE STORMWATER MANAGEMENT SCENARIO

While the applicant's proposed stormwater management measures will not be sufficient to protect the brook trout populations in the three streams, the following alternative scenario could achieve this goal. The key to success is maintaining the current infiltration rates on the site. As previously stated, runoff does not occur on the site until rainfall exceeds 1.20-inches. Therefore the goal should be to infiltrate the first 1.20-inches of runoff from all impervious surfaces (rooftops, driveways, patios, roadways, etc.)

Baltimore County policy[1], as well as State regulations[2], require that infiltration be the first stormwater management measure considered for a proposed development site. If soil conditions preclude the use of infiltration, then the applicant may propose a pond. Soil conditions which preclude the use of infiltration are:

- soil permeability of 0.52-inches per hour or less, or
- the depth to bedrock or the water table is less.four feet.

The 22 homes proposed for Locksley Conserve will be served by on-lot septic systems. The soil conditions required for the use of septic systems are *more* stringent than those required for infiltration. Soil permeability must be a minimum of 2.0-inches per hour for septic systems versus 0.52 inches per hour minimum for infiltration measures. The passed perc test symbols shown on the Development Plan for Locksley Conserve shows that much of the soils on the site are suitable for septic systems and, therefore, infiltration measures.

Section 26-203(d)(10) of the *Baltimore County Development Regulations* requires that the applicant show proposed stormwater management areas on the Development Plan. The only area shown on the plan is the Storm Water Management Reservation located on the eastern perimeter of the site below Lot 12. Three of the five perc tests conducted in this area showed suitable soils. The other two failed to meet minimum requirements. Thus it is questionable whether this area is suitable for infiltration. Further testing would be required.

The Storm Water Management Reservation only drain 9.5 of the 22 houses proposed for the site. The Development Plan does not show a stormwater management area that would receive runoff from the other 16.5 houses. Therefore the Development Plan fails to comply with the requirements of §26-203(d)(10).

The applicant should be directed to identify areas on the site where soil conditions are suited to the use of infiltration measures. It will then be necessary to check all well, house, and septic system locations to ensure that the setbacks contained in §3.2 of the *Baltimore County Stormwater Code & Policy Manual* are met. These requirement call for a 100-foot separationbetween an infiltration measure and wells and septic systems along with a 50-foot separation from any house with a basement.

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[1] Section 1.2.1, Stormwater Management Code & Policy Manual, published by the Baltimore County Department of Environmental Protection & Resources Management.

[2] COMAR 26.09.0208A(1)(a).

If the applicant resubmits a Development Plan showing that all impervious surfaces will drain to infiltration measures and these measures are designed to infiltrate the first 1.2-inches of runoff from impervious surfaces, then:

- stream baseflow will be maintained at current levels;
- thermal impacts will be avoided by maintaining baseflow and by infiltrating heated runoff into the soil where it will cool to a natural temperature before entering the streams;
- copper toxicity will be prevented by diverting virtually all of road and rooftop runoff into the soil where 95% to 99% of the metal will be removed, which is far in excess of the 85% reduction needed to meet EPA and Maryland water quality standards;
- nutrient load increases to Little Gunpowder Falls will be minimized; and
- the brook trout population in the three streams should continue to thrive.

Before closing this portion of the report, it is important to add one very important caveat regarding infiltration. Historically, infiltration measures, particularly infiltration ponds, have exhibited a high rate of failure (Galli 1992; Lindsey et al. 1992).. Recent design innovations have resulted in infiltration measures which *should* have a lower rate of failure. However, without frequent inspections for maintenance requirements failure becomes far more likely. Therefore, provisions must be made to ensure that infiltration measures installed at Locksley Conserve will be inspected on a regular basis. Several guidance documents point to the need for quarterly inspections of infiltration measures (Claytor and Schueler 1996; Galli 1992).

A more reliable approach would be to limit the number of houses that may be built at Locksley Conserve. The limit should be designed to prevent watershed imperviousness from exceeding 8%. The Western Tributary is already at 9% impervious area. Thus no more homes could be erected in this watershed. Five more homes could be built in the watershed of the Eastern Tributary without exceeding an imperviousness of 8%.

WELL-SEPTIC SYSTEM ISSUES

In addition to the concerns presented above there also appears to be several conflicts with the proposed layout of septic systems and State regulations.

1. COMAR 26.04.02.05C states that sewage disposal systems shall be located ***downgrade*** from private water supplies. The development plan for Locksley Conserve shows that septic systems will be ***upgrade*** of proposed well locations on the following lots: 1, 2, 3, 4, 5, 6, 7, and 22.

2. COMAR 26.04.02.04J(1) requires that a sewage disposal area (SDA) be at least 25 feet from a slope greater than 25%. The development plan for Locksley Conserve shows that the SDA for lot 16 abuts a 33% slope.

3. COMAR 26.04.02.04J(3) requires that a sewage disposal area (SDA) be at least 25 feet from a drainageway. A drainageway bisects the SDA for lot 15.

The applicant should be directed to correct these conflicts and submit a revised development plan.

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