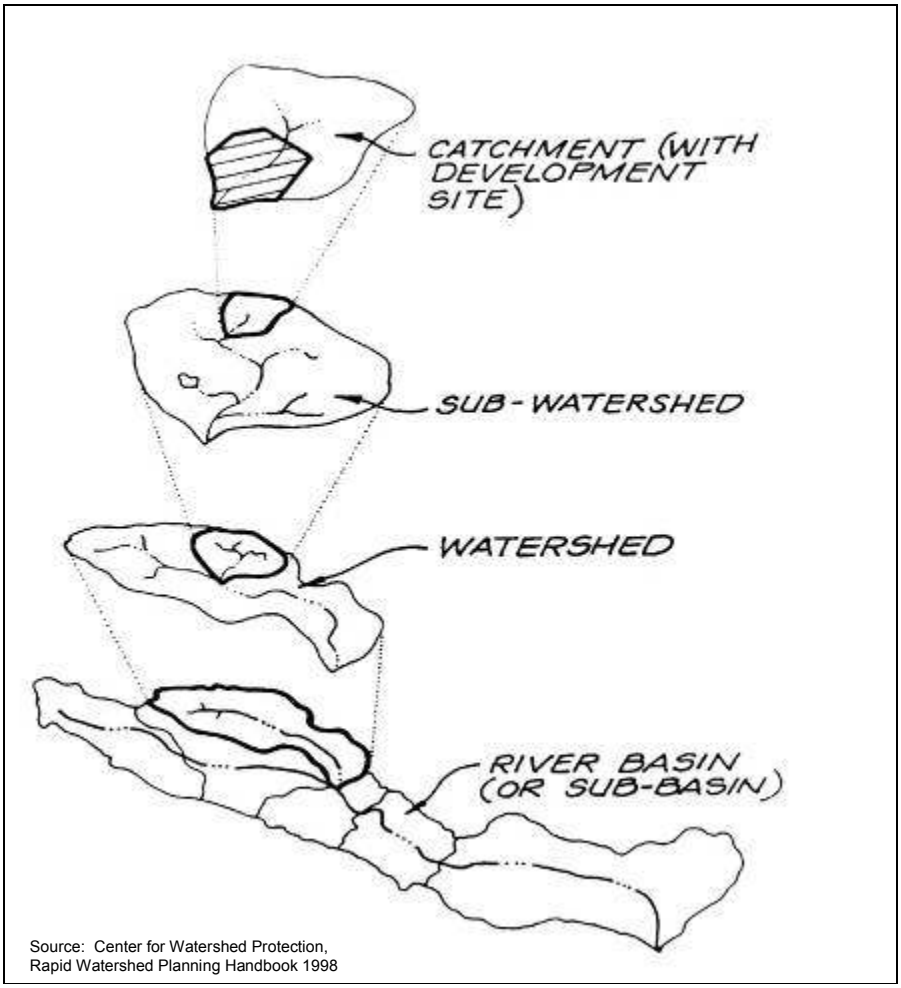
I. Impacts of Development on Water Resources

It is important to understand that each development is part of a drainage system or catchment. In Livingston County, each of the drainage systems is part of a network of streams and drains that make up the headwaters, or sub-watersheds, which, when combined in larger watersheds, make up some of the State's largest river basins. A watershed is simply an area of land that drains to a particular water body. The concept of smaller watersheds, which, when combined, form a larger watershed and, ultimately, a river basin, is referred to as nesting (see figure below). The health of any river system is based on how the land in the sub-watersheds and catchments is utilized.

A watershed is an area of land that drains to a particular waterbody.



Source: Center for Watershed Protection, Rapid Watershed Planning Handbook 1998

Current research indicates that as a catchment or sub-watershed increases with impervious area, there is a direct impact on stream quality. An impervious area is any area that no longer allows rainfall to soak into the ground. Impervious areas include roads, sidewalks, rooftops, and driveways. When a site is developed, it loses its natural storage potential for rainfall (see Water Balance Diagram, page 8). Consequently, rain that previously infiltrated into the ground evaporated, transpired, or was temporarily stored in depressions and tree canopies, now rapidly runs off the site.

An impervious area is any area that no longer allows rainfall to soak into the ground.

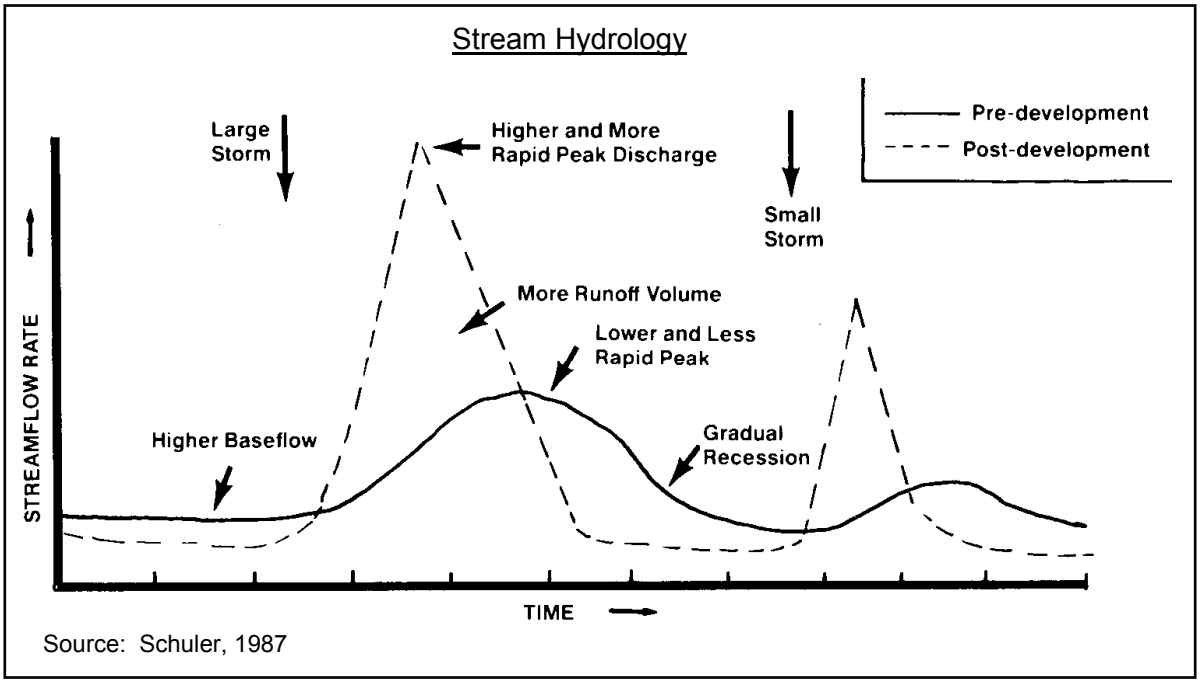
This increased runoff causes a number of changes in stream hydrology (see Stream Hydrology diagram, page 6). The changes in stream hydrology include:

- Increased volume of runoff, which raises the magnitude and frequency of severe flood events.
- Greater frequency of "bankfull" floods - those that fill the stream channel to the top of its banks but do not spill over into the floodplain. Increased bankfull flooding subjects the stream channel to continual disturbance and scour.
- More rapid flow velocities due to the combined effect of greater discharge, rapid time of concentration, and smoother hydraulic surfaces.
- A dramatic increase in stream flow fluctuations as runoff is concentrated into peaks that are sharper, faster, and higher, followed by equally abrupt returns to pre-storm level discharges. Increased flow fluctuations disrupt habitats and reduce the diversity of aquatic species regardless of water quality.
- Reduced infiltration into the underlying water table, which in turn lowers the level of surface water bodies dependent on groundwater to maintain base flows during dry periods.

These changes in stream hydrology cause the following changes in stream morphology:

- Channel widening and downcutting are the primary consequences of increased runoff and flow fluctuations.
- Streambank erosion is accelerated as channels are severely disturbed by undercutting, tree-fall, and slumping.
- Sediment loads increase sharply due to streambank erosion and construction site runoff. These sediments settle out and form shifting bars that often accelerate the erosion process by deflecting runoff into sensitive bank areas.
- Together, increased sedimentation and channel widening modify aquatic habitats in a variety of ways. For example: 1) the pools and riffles that characterize natural streams are eliminated as the gradient of the stream adjusts to accommodate frequent floods, and; 2) the voids between stones on the stream floor are filled with sediment, destroying the habitat of insects at the bottom of the aquatic food chain and fish spawning areas.

As development occurs, changes in land use may contribute new or additional pollutants to storm water runoff. Leaves, litter, animal droppings, exposed soil from construction sites, fertilizer, and pesticides, if not properly managed, can wash off of the land. Vehicles and deteriorating urban surfaces deposit trace metals, oil, and grease onto streets and parking lots. These and other toxic substances are carried by stormwater and conveyed through creeks, ditches, and storm drains into our rivers and lakes. The following table describes sources and impacts of major non-point source pollutants.



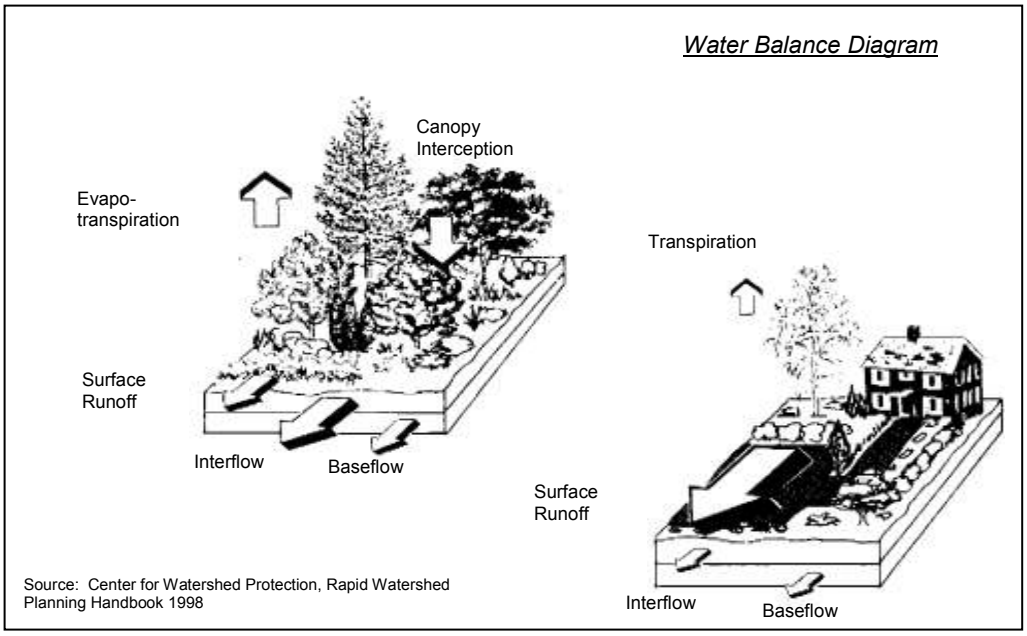
Source: Schuler, 1987

MAJOR CATEGORIES OF NONPOINT SOURCE POLLUTANTS AND THEIR ASSOCIATED IMPACTS

Pollutants	**Source**	**Impacts**
Sediments	Construction sites, agricultural lands, and other disturbed and/or non-vegetated lands, including eroding streambanks.	Once deposited, sediment can decrease the storage capacity of a water body, as well as smother organisms that dwell on the bottom and destroy their habitat. Suspended sediment can lower the transmission of light through water and interfere with animal respiration and digestion. Contaminated sediments act as a reservoir for particulate forms of pollutants such as organic matter, phosphorus, or metals that can be released later.
Nutrients (e.g. Phosphorus and Nitrogen)	Septic systems, fertilizers, animal waste, detergents, and plant debris.	Slow-moving waters become choked with nutrient-induced algae and weeds that take up dissolved oxygen in the water needed by fish and other aquatic life. This reduction in dissolved oxygen can also cause pollutants trapped within sediments to be released back into the water column.
Temperature Enhancement	Impervious surfaces collect heat and warm the stormwater as it passes over them and into receiving waterways. The creation of storage ponds and impoundments and the removal of trees and other vegetation that shade stream banks increase the surface area of water exposed to solar heating.	Temperature enhancement severely interferes with cold-water organisms such as trout and stoneflies and may cause their extinction in intensively developed areas.
Toxic Compounds	Pesticides, road de-icing materials, motor vehicles, industrial activities, atmospheric deposition, and illicit dumping and sewage connections.	Toxic substances can degrade the appearance of water surfaces, lower dissolved oxygen, stress sensitive flora and fauna, and enter into the aquatic food chain.
Bacteria	Animal waste (including pets and birds), failing septic systems, and illicit sewer connections.	Increased bacteria levels can pose health risks and close or restrict the use of recreational areas.
Litter and Debris (Organic and Non-organic)	Urban and suburban landscapes contribute grass clippings and leaves. Non-organic debris is generated by careless disposal practices (e.g., street litter).	Litter, leaves, and trash wash through the storm drain system, clogging pond outlets and creating large debris jams within streams and floodplains. In addition, organic materials require oxygen to decompose and so lower the level of dissolved oxygen available to aquatic life.

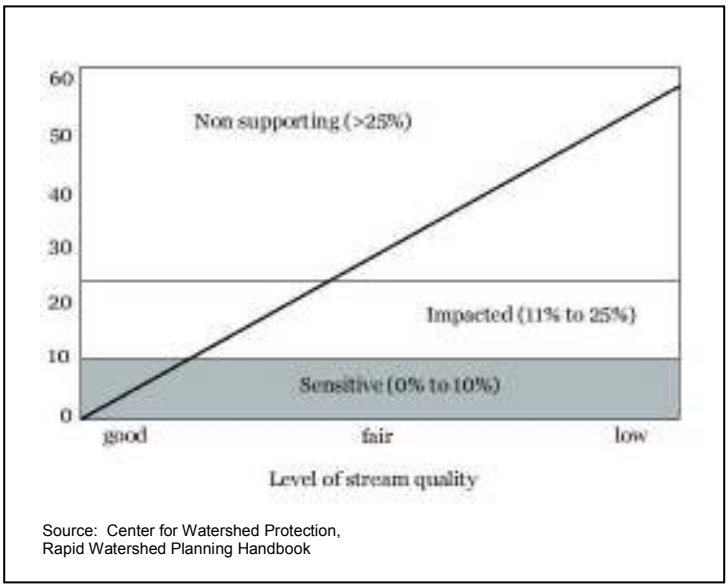
Source: Washtenaw County Drain Commissioner, 1998

There is research which now identifies zones of stream quality that can be described based on the amount of impervious cover (see figure below). At 10% impervious cover, sensitive stream elements such as stable channels, excellent habitat structure, diversity of fish and aquatic insects, and excellent water quality are lost. At 25-30% impervious



Source: Center for Watershed Protection, Rapid Watershed Planning Handbook 1998

cover, most indicators of good stream quality are lost. Above 30% impervious cover, streams are often unable to recover their health and do not support diverse fish communities. In essence, at above 25% impervious cover, streams are generally limited to conveying storm water (Center for Watershed Protection, 1999(b)). In addition to stream degradation, an increase in impervious area can lead to flooding, impact the recharge of water supplying aquifers, and alter the microclimate of an area by increasing summer heat.



Source: Center for Watershed Protection, Rapid Watershed Planning Handbook

These impervious thresholds form the basis for the Livingston County Drain Commissioner Rules. They are not absolute: rather they are targets to help us sustain those amenities which make Livingston County such a great place to live, work, and play.

The Livingston County Drain Commissioner Procedures and Design Criteria for Stormwater Management Systems apply only to stormwater management systems within new development projects. The following discussion applies to all aspects of managing land and stormwater.

II. Framework for the Design of Stormwater Management Systems

Thoughtful site planning can reduce or eliminate the negative impacts associated with development. Toward this end, communities, regulatory agencies, and designers must begin to evaluate the impact of each individual development project over the long term and on a watershed scale. Such an approach requires the consideration of Best Management Practices (BMPs) that function together as a system to ensure that the volume, rate, timing, and pollutant load of runoff remains similar to that which occurred under natural conditions. This can be achieved through a coordinated network of structural and nonstructural methods, designed to provide both source and site control. In such a system, each BMP by itself may not provide major benefits, but when combined with others becomes very effective.

Source Controls

Source controls reduce the volume of runoff generated on-site and eliminate initial opportunities for pollutants to enter the drainage system. By working to prevent problems, source controls are the best option for controlling stormwater and include the following key practices:

- Preservation of existing natural features that perform stormwater management functions, such as depressions, wetlands and vegetation along stream banks.
- The minimization of impervious surface area through site planning that makes efficient use of paved, developed areas and maximizes open space. Impervious surfaces are also reduced by encouraging flexible street and parking standards while conforming to Livingston County Road Commission requirements and the use of permeable ground cover materials.
- Direction of stormwater discharges to open, grassed areas such as swales rather than allowing stormwater to run off from impervious areas directly into the stormwater conveyance system. Careful design and installation of erosion control mechanisms and rigorous maintenance throughout the construction period. Effective erosion control measures include minimizing the area and length of time that a site is cleared and graded and the immediate vegetative stabilization of disturbed areas.

Site Controls

Site controls are the subject of this document. After the implementation of source controls, site controls are then required to convey, pre-treat, and treat (e.g., detain, retain, or infiltrate) the stormwater runoff generated by development. The range of