Mirrors of the Landscape

A lake or reservoir ecosystem doesn't stop at the shoreline: it includes all land which drains to it (the *watershed*). The quality of water entering a lake or reservoir from surrounding land has a direct effect on the quality of water in the lake or reservoir. The quality of water coming from a watershed depends on the activities taking place on the land. Lakes reflect the quality of their watersheds, they are mirrors of the landscape.

Many substances enter our waters from watersheds, including sediments which may eventually fill lake or reservoir basin (accelerating "lake succession") and plant nutrients which stimulate an overabundant growth of macrophytes ("weeds") and algae (accelerating "lake eutrophication"). Watersheds also supply our waterways with particulate and dissolved natural organic matter (NOM, photosynthesis happens in the watershed too). Other contaminants are washed from watersheds into our lakes and reservoirs, including heavy metals, salts, pesticides, and pathogenic organisms. Managing the quality of a lake or reservoir resource should include controlling the quality of its source water, water draining from the watershed. Watershed management (AKA "source protection" in the water supply industry) is the intentional and continuous effort to preserve or improve water quality through management of watershed lands.

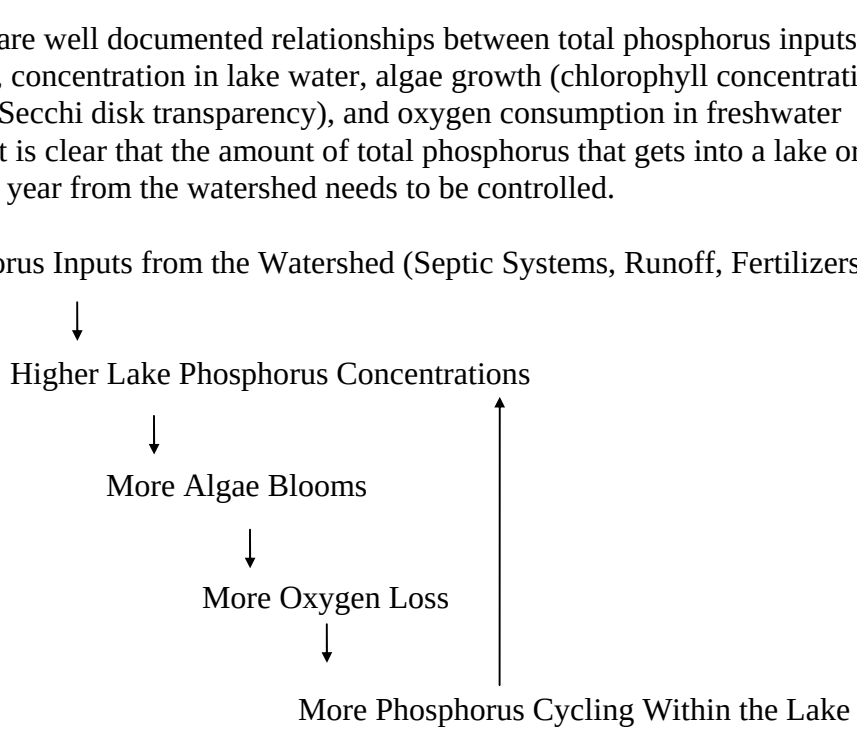
Many lakes have experienced "eutrophication" (a process caused by additional plant nutrients entering from the watershed). Eutrophication results in blooms of algae (turning waters turbid-green in summer) and increased weed growth. Ultimately, eutrophication can cause the loss of important habitat for desirable species, and can reduce biodiversity. It can interfere with recreational uses of the lake. It can decrease the value of the lake resource. What once was a valuable "lake amenity" can become a liability. In water supply reservoirs taste and odor episodes can occur, water treatment can become more difficult and expensive. Eutrophication can result in increased disinfection byproduct production (DBPs), it can shorten filtration runs and the carbon filter longevity, it can increase chlorine and oxidant demand, and increases sludge waste volume. Eutrophication impacts can dramatically increase water supply treatment costs. Effective long-term watershed management is critical to the future quality of our lakes and reservoirs.

"Limiting Nutrients"

Plants will grow until they "run out" of a required component for growth. Among the most important "growth components" are inorganic nutrients (phosphorus, nitrogen, and other compounds), carbon dioxide, light, and water. In terrestrial and estuarine ecosystems additional nitrogen tends to stimulate greater plant productivity. Total phosphorus tends to be the required nutrient that is in the "shortest supply" to algae and macrophytes in most freshwater ecosystems. If more phosphorus enters a lake or reservoir more weeds and algae will grow. If more algae grows, water clarity declines and the lake would frequently look turbid and green during the summer (interfering with recreational and water supply uses, and degrading habitat). If waters became less clear, light does not penetrate as deeply, and oxygen is not be produced by plants in deep water. Oxygen loss results from greater respiration demands and lack of photosynthetic production in deep water. With oxygen loss, more phosphorus is released from bottom sediments into lake waters. Still more algae growth results. The increase in algae and

turbidity accelerates, and water quality declines abruptly. Eutrophication , initiated by nutrients in watershed runoff, becomes an accelerating cycle.

There are well documented relationships between total phosphorus inputs from the watershed, concentration in lake water, algae growth (chlorophyll concentration), water clarity (Secchi disk transparency), and oxygen consumption in freshwater ecosystems. It is clear that the amount of total phosphorus that gets into a lake or reservoir each year from the watershed needs to be controlled.



Sources of Watershed Phosphorus and Management Strategies

Septic Systems

Dissolved nutrient inputs occur because the capacity of soils to remove phosphorus, and dilute nitrate, is exceeded after a certain age-of-use for septic systems. Dissolved nutrients such as nitrate and phosphorus are not a threat to public health but can stimulate growth of weeds and algae.

Septic System Management Goals

It is important that watershed management 1.) prevents septic system failures and 2.) reduces nutrient loading from functioning systems.

Signs of Septic System Problems:

- Wet or "soggy" ground over the leaching field,
- Occasional odors,
- Very "lush" vegetation over or near the leaching field,
- "sluggish draining" of plumbing fixtures,
- water backing up into the house…

1. Prevent System Failures—Septic system failure occurs when the ground is unable to accept the volume of wastewater generated by a household. Failure results in a breakout of wastewater on the ground surface or a backup into the building. Failure can be caused by poorly drained soils, high groundwater, or clogging of the pipes, leaching field, or soils (often the result of not pumping the septic tank often enough). Septic system failure poses a health risk and causes resource degradation; it must be corrected immediately.

2. Reduce Nutrient Loading from Functioning Septic Systems—The most important component of a septic system for phosphorous removal is the soil. Phosphorous adsorbs ("sticks to") soil particles as wastewater passes through the soil. The amount of soil which treats water is limited, hence phosphorus removal is limited. As a home and its septic system age phosphorus removal capacity of the soil is consumed. Eventually dissolved phosphorus can reach the lake through the ground, even when bacteria and viruses continue to be removed. Hence, although particles in wastewater continue to be removed, eventually dissolved phosphorous may pass through soils to the lake. The length of time that phosphorous is removed depends on soil type (its attenuation capacity), wastewater loading, and soil contact volume (system geometry). Even septic systems that do not "fail" can become a nutrient source to lake waters.

Phosphorus Removal by Septic Systems:

The soil through which wastewater passes is where most dissolved phosphorus is removed. *You can extend phosphorus removal of your septic system by:*

- *Using low phosphorus or phosphate-free detergents,*
- *Not using Septic System Additives,*
- *Designing reconstructed systems for maximum phosphorus removal.*
- *Adequate Pump-out Frequency*
- *Water Conservation*

Preventing Septic System Failures

Individual on-site wastewater treatment systems (septic systems) can be very effective treatment systems, producing very high quality effluent water. However, proper installation in areas of suitable soils, septic system maintenance, reconstruction of failing systems, and design features which go beyond conventional Health Code requirements are needed. The first step to effective septic system management is distribution and use of educational materials (mailings, presentations, school programs,) which describe how septic systems work and how to maintain them.

Septic Tank Pump-Out Frequencies:

The following tables were prepared based on a review of scientific literature. Note that if your home has a kitchen garbage grinder-disposal system that pump out is needed more frequently!

Recommended Septic Tank Pumping Frequency (Years)
Without Kitchen Garbage Disposal

Number of	SEPTIC TANK VOLUME (Gallons)					
Occupants	**500.0**	**1000**	**1500**	**2000**	**2500**	**3000**
1	5.0	10.0	10	10	10	10
2	2.5	5.0	7.5	10.0	10	10
3	1.7	3.3	5.0	6.7	8.3	10.0
4	1.3	2.5	3.8	5.0	6.3	7.5
5	1.0	2.0	3.0	4.0	5.0	6.0
6	0.8	1.7	2.5	3.3	4.2	5.0
7	0.7	1.4	2.1	2.9	3.6	4.3
8	0.6	1.3	1.9	2.5	3.1	3.8
9	0.6	1.1	1.7	2.2	2.8	3.3
10	0.5	1.0	1.5	2.0	2.5	3.0

Frequencies > 10 Years are not Recommended

Recommended Septic Tank Pumping Frequency (Years)
With Kitchen Garbage Disposal

Number of	SEPTIC TANK VOLUME (Gallons)					
Occupants	500.0	1000	1500	2000	2500	3000
1	3.3	6.7	10.0	10	10	10
2	1.7	3.3	5.0	6.7	8.3	10.0
3	1.1	2.2	3.3	4.4	5.6	6.7
4	0.8	1.7	2.5	3.3	4.2	5.0
5	0.7	1.3	2.0	2.7	3.3	4.0
6	0.6	1.1	1.7	2.2	2.8	3.3
7	0.5	1.0	1.4	1.9	2.4	2.9
8	0.4	0.8	1.3	1.7	2.1	2.5
9	0.4	0.7	1.1	1.5	1.9	2.2
10	0.3	0.7	1.0	1.3	1.7	2.0

Frequencies > 10 Years are not Recommended

- **Septic System Pump-Out Reporting Ordinance.**

The purpose of the Reporting Ordinance is to acquire data on pump-out frequencies and to identify further wastewater management needs (for example, whether a Septic System Licensing Ordinance is needed).

- **Septic System Licensing Ordinance.**

A Licensing Ordinance treats a septic system as an "individual wastewater treatment system" which is operated by a property owner with requirements for pump out, maintenance, monitoring, etc.

- **Septic Tank Effluent Filters:**

Tank effluent filters prevent solids from flowing out of the septic tank and into the leaching field where costly repairs would be needed. If a system "fails" it would likely be the result of a clogged effluent filter (easily cleaned) rather than a clogged leach field (expensive reconstruction). Applicability and cost will vary due to the specific design of a particular system.

Reducing Phosphorus Loads from Non-Failing Systems

- **Performance Standard for Soil P Attenuation:**

A performance standard for P-attenuation capacity of fill could increase the effective life of a septic system for phosphorous removal. Methods to enhance the attenuation capacity of sand fill include selecting material with a high natural capacity and/or adding iron oxide or other soil conditioning additive as a soil amendment.

- **Septic System Geometry**

Maximizing setback from a potential groundwater exfiltration site (stream, wetland, lake), selecting an area with maximum depth to groundwater, and placing the long axis of a leaching field parallel to topographic contours can maximize the volume of soil that wastewater will pass through enroute to a water resource, increasing the effective lifespan for phosphorus removal.

- **Ban on Septic System Additives**

Although some products may reduce the rate of solids accumulation in septic tanks, the resultant "liquefied effluents" may create problems. Septic system additives currently available can cause additional contamination and pollution and should be avoided.

- **Innovative Septic System Designs**

Innovative designs incorporating such features as iron-enriched filter media, alum-enriched sand, up-flow sand filters, and other phosphorus removal techniques could be considered in addition to other Health Code requirements.

Development Effects and Management Options

Land disturbance activities in the watershed increase the amount of nutrients, sediments, and other contaminants which enter a lake or reservoir. There are short-term (during disturbance) effects as well as long-term water quality and quantity changes.

- **Control of Short-term Construction Phase Impacts**

Erosion and sedimentation is a major concern during land clearing, grading, excavation, filling, and construction. It is critical that well planned and implemented controls are used during all watershed disturbances, and that control systems are maintained throughout the period of disturbance.

- Erosion and sedimentation controls should be clearly defined on plans and specifications, with detailed installation, timing, maintenance, and monitoring requirements.
- "Erosion source controls," such as heavy mulch covering of exposed soils, should be emphasized. "Recovery methods," which are intended to remove sediment from flowing water after it has been mobilized by erosion, should also be used, but not as a sole method.
- Whenever it is feasible, erosion control systems should be fully and properly installed prior to disturbance of soils. When not feasible (e.g. for mulch coverage of a soil stockpile), all materials should be on-site and ready for *immediate* installation prior to the first storm following disturbance.
- When a significantly large area is to be disturbed a detailed plan should be required, including monitoring and reporting conditions.
- A "Contractor's Compliance Statement" and "Notice of Intent to Begin site work" should be required as a standard condition for all permits involving land disturbance in the watershed. For large projects an Environmental Site Monitor should be required with a specified reporting responsibilities.

Control of Long-term Land-Use Impacts

Even after a disturbed site has again been stabilized, water quality and quantity impacts continue. Impervious surfaces (roads, parking lots, driveways, rooftops) and semi-pervious surfaces (e.g. lawns) result in higher runoff volumes and increased contaminant loading.

Best Management Practices (BMPs)

A variety of methods are available to reduce the impact of land disturbance and use. BMPs are available for controling the quantity and timing of runoff, and water quality. Some of these methods include:

1.) *Retain more undisturbed woodland.*

One of the best ways to reduce nutrient and contaminant loading related to development is to minimize areas of semi- and impervious surfaces. The more land area

that remains as undisturbed woodland the better. "Undisturbed Woodland" means just that, *undisturbed,* with its closed canopy, shrub, ground cover, and forest floor soils *intact*. Such a woodland is a very valuable watershed asset.

2.) *Creation of Simulated Woodlands, vegetative filter strips. Setback buffers.*

Conversion of lawns and other semi-pervious areas to a "simulated woodland" can significantly reduce TP export. Converting areas to a landscape that imitates an undisturbed woodland can reduce nutrient and contaminant loading of a water resource. Careful design and layout can retain view corridors and not impact the "lake-front" features of property. For example, conversion of a lawn to a "simulated woodland" involves:

- Spreading of Peat Moss and then Rototiling the entire area to at least 6" deep,
- Covering the rototilled area with woodchip/bark mulch,
- Planting evergreen and/or deciduous tree saplingswith 20-30 foot on-center spacing,
- Planting lower growing shrubs (5-15 ft tall when mature) for about 50% coverage (when fully grown),
- Planting ground covers (<5 feet tall) over 50% coverage (when fully grown).

3.) *First-Flush Infiltration and other Stormwater Management Techniques*

This BMP involves collecting runoff from impervious surfaces (roads, driveways, rooftops) and directing the first ½ to 1 inch of rainfall runoff to "management system" such as an infiltration chamber, created wetland, or vegetated basin or swale. A number of stormwater management methods have been developed over the past twenty years.

4.) *Runoff Detention and Created Wetlands*

These BMPs can be usefull in certain circumstances, such as to treat runoff from several lots in a development.

Fertilizers

The phosphorus content of lawn fertilizers should be low. Lawns generally need more nitrogen than phosphorus. Low (or no) phosphorus fertilizer will help keep the lawn green, and the lake clean. Soil testing is the best way to determine fertilization needs.

Reduce the total amount of fertilizer used in the spring. Apply the total dose of necessary fertilizer in two parts, several weeks apart; and only apply the second half if the turf needs it (for example if it hasn't "greened up" adequately).

Apply lawn fertilizer after significant rainstorms, when no further storms are forecast for the next several days. "Water in" the fertilizer after application. These measures will help keep your fertilizer investment on your lawn where it is needed, and out of a waterway (where it is not needed).

If necessary, apply higher phosphorus content lawn fertilizer between Labor Day and Columbus Day. This is when the phosphorus requirement of lawns is higher for root development and to help grasses "over-winter". Again be careful with amounts applied and timing of applications.

Vehicles

Contaminants which are carried in road runoff can be very damaging to a lake or reservoir, including nutrients, hydrocarbons, ethylene glycol (antifreeze), heavy metals, sediment, road sand and deicing compounds. Loads tend to increase with increasing area of coverage and axle-miles traveled on watershed roads.

Watershed Management Plans: Principles

1. A Watershed Management Plan should be based on sound technical information about the water resource and anticipated impacts of land-use and water-use activities. A Watershed Management Plan should be based on specific water quality goals, which will differ for various water supply, recreation, and habitat uses.

2. When possible, voluntary approaches and educational/public awareness approaches, should be attempted first--before Regulations and Ordinances. If voluntary efforts are not adequately successful, several Regulations and Ordinances may be needed.

3. No "Undue" or "Unnecessary" burden should be placed on the Community or Individuals. The Plan needs to be specific to actual needs for protecting the resource. "Regulatory Approaches" must be well defined and specific. A "Quantitative Watershed Management Plan" which defines goals and protection needs will be most successful.

4. Management measures which are recommended, promoted, or required should be simple, low-maintenance, effective at controlling phosphorus (and other pollutants), and relatively low cost.

5. The Watershed Management Plan should be "dynamic", and amendments should be based on continued annual water quality monitoring and effectiveness of various Plan components. Regular progress reviews should be performed.

New Tools; The future of watershed management

Allocation Models, GIS, Databases…..

Allocation of Phosphorus Loading

If a development is projected to export more phosphorus than its annual allocation, a set of "Best Management Practices" (BMPs) can be employed to ensure

compliance. BMPs are relatively simple, inexpensive, low maintenance approaches, including:

- stormwater collection/infiltration
- creation of “simulated woodlands”
- runoff landscaping techniques

By using a nutrient allocation assessment model a landowner can select a set of BMPs appropriate for their property and use, and thereby come into compliance with the allocation of his or her parcel.