Fate and Transport Mechanisms

Understanding the potential for fate and transport of potential contaminants will help superintendents to minimize the risk of off-site movement of nutrients and chemical pesticides applied to golf courses. Research indicates that using BMPs minimizes the chances for movement of potential water quality contaminants into ground or surface water. When BMPs are not properly implemented, however, water quality is at greater risk. These risks are primarily the result of runoff and leaching:

- Runoff is the movement of water across the turf and soil surface, typically following a storm event or heavy irrigation.
- Leaching is the downward movement of water through the soil and potentially into groundwater.

Additional fate and transport mechanisms for nutrients and pesticides include drift and spills. Drift occurs when pesticides become airborne as dry particles, liquid spray droplets, or vapor. Spills are the unintended releases of chemicals, such as fertilizers, pesticides, hazardous materials, or petroleum products released during transportation, storage, and routine maintenance and facility operations. These releases can be a point source of contamination.

Runoff

Surface runoff is a water flow along the surface of the ground that occurs when the soil is saturated, compacted, high in clay particles, or has lost soil structure (large pores). When runoff flows along the ground, it can pick up contaminants (including but not limited to, fertilizers, and petroleum) that then become discharge or nonpoint source pollution. The potential for runoff is greater on steep slopes. Research on golf courses has shown that in areas with minimal slopes, runoff on fairways is less than 5% of rainfall (Easton et al. 2005).

Surface water is the focus of watershed protection because recent research on the environmental impact of nutrients and pesticides applied to golf courses has indicated that for the majority of the acreage under turf management, surface runoff is a much greater concern than leaching. While leaching of certain materials does occur at low levels and under specific environmental and climatic conditions, more materials are transported in surface runoff than through leaching (Baris, R.D. et al. 2010). However, certain areas of New York have a history of groundwater contamination problems.

For more information on runoff, see: “Loss of Nitrogen and Pesticides from Turf Via Leaching and Runoff”, http://usga.org/course_care/articles/environment/pesticides/Loss-of-Nitrogen-and-Pesticides-from-Turf-via-Leaching-and-Runoff/.

Leaching

Leaching refers to the loss of water-soluble plant nutrients or chemicals from the soil as water moves through the soil profile and into the vadose zone (saturated zone). Solute leaching becomes an environmental concern if it contributes these contaminants to groundwater or to surface waters where contaminated groundwater replenishes surface water bodies. Several variables influence the

probability and rate of leaching, such as soil type and structure, vegetation, chemical properties, rate of precipitation, and depth to groundwater. When deciding on the rate and timing of fertilizer and pesticide application, it is critical to assess soil moisture status and potential for high infiltration in order to minimize potential losses. In addition, soil texture is a major influence on nutrient and pesticide leaching. For example, three to four times more nitrates have been shown to leach from a bentgrass sand fairway turf than from a sandy loam or silt loam soil (Petrovic 2004).

For more information on leaching see:

- "Loss of Nitrogen and Pesticides from Turf Via Leaching and Runoff http://usga.org/course_care/articles/environment/pesticides/Loss-of-Nitrogen-and-Pesticides-from-Turf-via-Leaching-and-Runoff/
- Appendix B, Groundwater Quality of Eastern Long Island, NY Golf Courses

Drift and Volatilization

Pesticides can move from the sites where they are applied into the surrounding environment through drift and volatilization. EPA defines pesticide spray or dust drift as "the physical movement of pesticide droplets or particles through the air at the time of pesticide application or soon thereafter from the target site to any non- or off-target site."

Volatilization occurs when pesticide surface residues change from a solid or liquid to a gas or vapor after a pesticide application. Once airborne, volatile pesticides can come into contact with applicators or move long distances off site. Not all pesticides are volatile, and the higher the vapor pressure of a given chemical, the higher its volatility will be. Appendix C lists all the pesticides registered for use in New York State with the corresponding vapor pressures. Generally, any pesticide with a vapor pressure greater than 1 millipascal (mPa) is deemed to be volatile. For more information on drift and volatilization, see:

- EPA Pesticide Issues: pesticide volatilization: http://www.epa.gov/pesticides/about/intheworks/volatilization.htm
- Croplife Foundation, "Minimizing Pesticide Spray Drift": http://croplifefoundation.files.wordpress.com/2012/05/spray_drift.pdf
- Cornell University Pesticide Application, Turf Spraying web page: http://web.entomology.cornell.edu/landers/pestapp/turf.htm

Sedimentation

A primary benefit of turfgrass or any perennial vegetation is the reduction in sediment and particulate movement, or reduced soil erosion. Precipitation and irrigation can carry soil particles (sediment) in runoff and deposit them into surface waters. Too much sediment can cloud the water, reducing the amount of sunlight that reaches aquatic plants and harming aquatic species. In addition, sediments can carry fertilizers, pesticides, and other chemicals that are attached to the soil particles into the water bodies, causing algal blooms and depleted oxygen. Sedimentation is controlled through BMPs that

control the volume and flow rate of runoff water, keeping adequate turf density, and reducing soil transport.

Point Sources

The legal definition of "point source" is provided in 6 NYCRR Part 050-1.2(65) as follows:

> The term "point source" means any discernible, confined and discrete conveyance, including but not limited to any pipe, ditch, channel, tunnel, conduit, well, discrete fissure, container, rolling stock, concentrated animal feeding operation, or vessel or other floating craft, or landfill leachate collection system from which pollutants are or may be discharged. This term does not include agricultural storm water discharges and return flows from irrigated agriculture.

On golf courses, point sources of pollution can originate from:

- storage and maintenance facilities
- the unintended release of chemicals, such as pesticides, fertilizers, or fuel, during transportation, storage, or handling
- drainage discharge outlets (for example, the end of a drainage pipe)

Containment measures can easily prevent chemicals from becoming point sources of pollution during storage and handling. To prevent discharges from contaminating surface waters, the discharges must be diverted away from surface water and onto turf areas or other appropriate areas instead.