

A Hydrologic Study of Smith College and Impacts on the Mill River Watershed

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Abstract

Environmental practices of Smith College negatively affect the local community, particularly the Mill River watershed. Models of the surface hydrology of Smith College show that runoff originating from the campus flows directly into Paradise Pond and the Mill River. This runoff carries sediment, chemicals, and materials used for lawn and walkway maintenance. Similarly, particulates generated by the numerous sites of construction flow directly into the watershed, increasing turbidity with the increase of suspended and dissolved sediment. Storm water and runoff management practices, such as the use of siltfences and filter cloths, as well as changes in chemical types and applications, can greatly reduce the impact Smith College has on the Mill River and improve the Campus's overall sustainability. Other Five College campuses, particularly Mount Holyoke, currently employ these management practices and can act as models for future Smith College sustainability policies.

Introduction

The Mill River drains a 54 square mile basin that is located within the Connecticut River Valley basin of Massachusetts (USGS 2003). With headwaters originating as far north as Goshen, the Mill River flows through agricultural fields and towns until it

empties into the Connecticut River near Northampton. Smith College is divided by the Mill River and Paradise Pond, which has become an object of attraction and a means of recreation cherished the college and local community. From the Connecticut River, the water travels to the Long Island Sound and is emptied into the ocean. This cycle is repeated as the hydrologic cycle continues, carrying water from the oceans precipitating it over the Smith College campus.

During a precipitation event, runoff does not occur immediately. The initial precipitation wets the surface of the ground. On permeable surfaces, the water begins to infiltrate the soil, filling pore spaces between the particles of sand, silt, and organic material. When the rate at which infiltration can occur is exceeded by the rate of precipitation, water collects on the surface until it begins transport. This moving water is runoff. On impermeable surface, such as parking lots and street, rooftops and even lawns, runoff occurs almost instantly. Often, runoff from permeable surfaces enter impermeable systems like roads and catchbasins (Roesner 1982, Brooks et al. 1997).

The runoff may contain many elements besides water, as the water washes away soil and materials present in the soil and on the ground. From the streets, this material may include sediment, organic matter, and litter. The sediment consists of natural parent material from weathered sediment originating from the local bedrock and sediment bodies. Fill sediment is used to prepare new surfaces for construction. Debris from human activity is also a constituent, most notably sediment from

construction materials. Sediment sizes can range from coarse, such as brick or concrete fragments, to the fine silt and clays of weathered bedrock and fill (Brinkmann et al. 2001). This sediment can collect in water habitats, altering ecosystems and increasing turbidity. The lessening the available light and a blanketing of the river bottom decreases available oxygen and kills fish and plants.

During winter, Smith College applies sand, salt, and other de-icing agents to facilitate travel on snowy and icy roads and walkways. Salt applications typically kill plant material in close proximity to the site of application and increases salinity in water systems. Although much of this matter is collected and sent to the landfill, remains are often left behind and carried away with the spring thaw (Dombkowski 2003). Other constituents of runoff include the chemicals used to maintain the grounds of Smith, notably fertilizers, pesticides, herbicides, and fungicides. Ultimately, all of this material is transported some distance by surface hydrologic processes.

Methods

In order to understand the surface hydrology of the Smith College campus, a model was created utilizing Geographical Information System (GIS) technology. Using a digital elevation model of the area, topographic contours were drawn in 5-meter intervals, the lowest resolution that was accurate without direct mapping. Flow lines were drawn perpendicular to the contours to represent the topographically steepest paths. These paths would most accurately model the path of precipitation and runoff from first contact with the

ground surface to the site of joining with a topographic basin or stream channel.

Large areas of recent and current construction were mapped using a Global Positioning System (GPS) receiver and an enlarged digital photograph of the campus. The data locations collected were then entered into a GIS map and flow lines were inserted to illustrate the path of water draining from those areas. This procedure was repeated for areas of high chemical application, such as the athletic fields and other 'green spaces.' The topographic contours, flow lines, construction site locations, and areas of high chemical application were assembled into maps. The locations of the catchbasins on the campus were also included in the maps.

Details of the drainage systems, sand and salt applications, and grounds chemicals were obtained through interviews with Bob Dombkowski, the supervisor of grounds at Smith College. Evidence for poor stormwater runoff management practices were documented with a digital camera.

Results

Surface Modeling

The surface hydrologic model clearly shows that the majority of runoff from Smith College directly enters the Mill River and Paradise Pond (Fig. 1). Flow lines from the residential Quadrangle, Science Quadrangle, Center Campus, Upper Elm Street, and the athletic fields are some of the areas with flow lines that end in the river channel. Flow lines from Green Street show water transport ending downstream of Paradise pond,

while runoff originating in the Lower Elm Street area of campus moves toward downtown Northampton.

Active flow channels of variable discharge were directly observed emptying into Paradise Pond, incising the dirt path that follows is proximal to the river (Fig. 2). One of these channels, located in a gully behind the President's House, contains water year-round (Fig. 3 and 4). Tests performed by the College have suggested the source of the water, which exits a pipe near the back of the gully, is a system that collects under the King/Scales houses and flows to the pipe (Dombkowski 2003). Other episodic channels result from storm runoff and tree watering.

Construction and Sediment Runoff

Construction sites around campus showed sediment transport due to runoff. No efforts were present to contain the sediment or decrease the velocity of the runoff, allowing suspended sediment to settle (Fig. 5 and 6). The result is active erosion, which can be substantial on steep exposed slopes similar to the Fitness Center construction area. Trash, building materials, and unidentified chemical precipitates were observed in puddles and channels, escaping from the construction site and entering roads (Fig. 7).

A major source of sediments collected along the roadside and in drains comes from the spreading of sand, salt and other products along roads and pathways across campus. Although sand and salt is still utilize by Smith College, the amounts have

decreased in recent years due to the introduction of the liquid de-icing agent Ice B'Gone. The amount of sand used has decreased from 250 yards in previous years to 10 yards during the winter of 2002-2003, and is applied only to walkways. Salt application increased this year, due to the long and unusually cold winter, but was also decreasing the year prior. Ice B'Gone, a byproduct of the fermenting process that is less corrosive than salt and non-toxic, has replaced both sand and salt on the roads and is used on many of the walkways.

Much of this runoff enters catchbasins, the grates located in streets, walkways, and some fields and lawns. The catchbasins are attached to concrete pipes that channel the runoff and its constituents. Most of the catchbasins on campus connect to three major pipes that drain directly into the Mill River. Those catchbasins connected to the Northampton City system most likely drain into the Mill River as well, as most of Northampton's pipes are older and do not lead to the city treatment facility. Many of the catchbasins are located near sites of construction and are clogged by sediment, organic material, and trash (Fig. 8, 9, and 10).

Chemical Application

Chemical types, amounts, and application schedule vary year by year and depend on the type of chemical and the nutrient levels present in the soil. As an example, Smith applied 56,375 pounds of the fertilizer Poly-Plus to the entire Smith campus, with 14% of the amount applied to the athletic fields in 2001. In 2002, Smith switched to Morse

& Son, Inc. Polymer Coated Sulfur Coated Urea (PCSCU) and applied only 37,925 pounds, with 16% applied to the athletic fields (Dombkowski 2003).

Side effects of fertilizer application include leaching, nitrification, and eutrophication in ponds and streams. Algal blooms, a result of fertilizer in water habitats, have been witnessed in Paradise Pond. Herbicides are water soluble and are toxic to fish and native plant species. In lab animals, herbicides can cause liver, kidney, thyroid, and adrenal damage. They are persistent in soils, lasting as long as 14 months, and can persist in mulch and compost. Pesticides are extremely toxic to fish, aquatic invertebrates, and bees. The pesticides used by Smith College are not mobile in soil because the molecules attach to the soil particles. Fungicides, applied exclusively to the athletic fields, are extremely toxic to fish and aquatic invertebrates.

The surface hydrologic model shows that all runoff from all areas of chemical application flow either directly into the Mill River and Paradise Pond or indirectly through the series of catchbasins and underground pipes (See Figure 10).

Discussion

In no location observed by the author were storm water or soil retention practices being used. It is possible, therefore, to assume that all material susceptible to runoff entered the Mill River Watershed. While some chemicals applied to the athletic fields and lawns are not soluble, the soil particles containing these chemicals may still be washed into the river and accumulate in the river bottom or pond sediments to reach

toxic levels for susceptible organisms. Algal blooms, already a problem for the Mount Holyoke College campus, can become problematic for Smith College if fertilizer use is not kept at the lowest levels possible. Sediment accumulation produces the need for dredging the pond periodically. In order to reduce the impact Smith College has on the Mill River Watershed, runoff management practices must be introduced to the college's ground management policies.

Mount Holyoke College (MHC) has already begun stormwater runoff management (Houlihan 1998). In the case of construction, MHC uses siltfences to direct runoff from construction sites and slow the velocity of the water, allowing suspended sediment to settle (Fig. 11). Areas of loose sediment are covered by hay and plastic tarps (Fig. 12 and 13). In order to prevent sediment from entering catchbasins, filter cloths are placed around the catchbasins to trap sediment but allow water to permeate through (Fig. 14). All of these solutions successfully reduce the amount of sediment entering the waterways.

Storm runoff can be reduced on the campus in many ways. Storage of rooftop runoff will reduce the amount of water reaching the ground during a storm event and provide non-potable water to water lawns and lessen demand on public water resources. Porous or punctured asphalt, vegetated retention basins around parking lots, and grassy strips on parking lots will increase the permeability of the area, allowing more water to infiltrate into the ground (Delleur 1982). By reducing the amount of

runoff, or slowing its course, less material will enter the watershed.

Conclusion

Smith College greatly impacts the surrounding environment. Reducing our impact by becoming a more sustainable campus positively affects the watershed, the surrounding community, and Smith College itself. By polluting less, Smith College will ultimately reduce the costs to 'clean up', whether the cleaning is dredging the pond or making the aquatic habitats healthy again. Introducing runoff management practices would bring the college to the standards already being set by Mount Holyoke College, as well as encourage the other colleges within The Five College community to implement policy of their own. Ultimately, the Five College community will have a clean and healthy environment to be proud of.

Figure 2: The author inspects a channel created by runoff from the watering of trees. Note how the water has eroded the trail.

Figure 3: This pipe behind the President's House contains water year-round and frequently floods the path along the water, carrying water and sediment into Paradise Pond.

Figure 4: Water from the pipe behind the President's House is blocked by organic material, forming a stagnant pond that floods the nearby path and flows into Paradise Pond.

Figure 5: Sediment from the construction of the new Campus Center flows along the road and under the fence.

Figure 6: Renovation of Lilly Hall resulted in areas of loose sediment that was carried away during storm events.

Figure 7: Trash, building debris, and an unidentified white precipitate cover the construction area of the Campus Center.

Figure 9: Sediment, organic debris, and trash enter and clog this catchbasin in the Science quad.

Figure 10: Paved channels direct stormwater from Paradise Road into a catchbasin, which flows into the Mill River.

Figure 12: Siltfences border construction at Mount Holyoke College to prevent the transport of sediment. (Houlihan 1998)

Figure 13: Hay covers areas of exposed and unvegetated soil (Houlihan 1998).

Figure 14: Plastic tarps cover piles of sediment and building materials to decrease sediment loss (Houlihan 1998).

Figure 15: Filter cloths prevent sediment from entering and clogging catchbasins (Houlihan, 1998)

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- For a more detailed analysis of the use of chemicals on the grounds of Smith College, see class paper by Moir, Ilana (2003) *The "Greening" of Smith College Campus: Fertilizers, Herbicides, Insecticides, and Fungicides Used to Maintain the Grounds*. Unpublished Report.

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