Chapter 7 - Rochester's Storm Water Management System

Rochester's water cycle is no longer natural; it has become "urbanized" by the creation of human habitat with lots of hard, or impervious, surfaces like streets, roof tops, or even construction sites. These impervious surfaces prevent infiltration of precipitation, so when it rains or snow melts, this run-off (or storm water) runs across both natural and constructed surfaces. When the water can't infiltrate, it misses the soil filtration step where microorganisms consume many pollutants. As a result, this change to urban areas causes lost recharge and more runoff that moves across the landscape faster. More and faster moving water can cause erosion and can collect pollutants as it moves and transports them to receiving waters.

An impervious surface does not let water go through it.

Today, storm water pollution is regulated at the federal, state and local levels. The regulations derive from the Federal Clean Water Act (CWA) that was passed by Congress in 1972. (Groundwater is governed under the Safe Drinking Water Act, as is wastewater treatment.) The CWA is the primary law governing the prevention and control of "point source" water pollution. That is pollution that comes out the end of pipes or off a small site. A basic goal of the CWA is to have waters meet water quality standards so surface waters are fishable and swimmable. Initially, the law called for surface water to meet standards for human sports and recreation by 1983 and for the elimination of additional water pollution by 1985. Those goals were not met, so the law has since been updated to create the National Pollutant Discharge Elimination System (NPDES) permit program. Congress then directed the Environmental Protection Agency (EPA) to establish rules for three permit programs that authorize storm water discharges at municipal, industrial and construction sites. EPA can delegate their authority to administer the NPDES permit programs to states that have agencies meeting their requirements. In our state, EPA delegated their authority to the Minnesota Pollution Control Agency (MPCA). So the MPCA wrote three state permits (municipal, industrial and construction) that authorize storm water discharges for specified entities within Minnesota, as long as the permit requirements are met.

Point Source pollution comes from a single identified source. Non-point pollution comes from a diffused sources, not single sources.

This chapter will focus on the Municipal Separate Storm Sewer System (MS4) permits and storm water management in Rochester. (For more information on the industrial and construction storm water permit programs, go to: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/index.html.) The MS4 permit program evolved in two phases, based upon the size of a municipality. The "Large MS4" permit, or Phase 1, started in 1991 for cities with a population greater than 100,000. Phases 2 began in 2003 for cities larger than 10,000 but smaller than 100,000. Rochester was smaller than 100,000 in 2003, so federal rule designated it as a "Small MS4", even though today it is larger than 100,000 people.

The primary goal of Minnesota's MS4 permit is to "restore and maintain the chemical, physical, and biological integrity of waters of the state through management and treatment of urban storm water runoff". To meet its permit requirements, the City must describe and implement Best Management Practices (BMPs) that manage storm water. Together, these BMPs comprise the City's Storm Water Pollution Prevention Program (SWPPP), which is organized according to the federal Minimum Control Measures (MCMs). These fall into six categories:

1. Public Education & Outreach
2. Public Participation & Involvement
3. Illicit Discharge Detection & Elimination
4. Construction Site Storm Water Management
5. Post-Construction Storm Water Management
6. Good Housekeeping and Pollution Prevention

In addition to the MCM requirements, the City must also act in accordance with other rules, like those that pertain to:

- Impaired waters, (tied to Total Maximum Daily Load reports and implementation plans),
- Discharges to waters with restricted discharges, like our calcareous fens, and
- Source water protection, which is managed by Rochester Public Utilities.

Since storm water does not flow to the Rochester Water Reclamation Plant for treatment, there is no single discharge point for storm water to re-enter the Zumbro River. Therefore, it is impossible for storm water permits to have effluent standards the same way a wastewater treatment permit does. Instead, the storm water permit standard says that permit holders must reduce the discharge of storm water pollutants "to the maximum extent practicable" (MEP). Although the Rochester Public Works Department manages the MS4 permit, meeting the permit's MEP standard can only be accomplished if every citizen and business in Rochester works toward reducing storm water pollution individually and together.

Storm Water Pollutants

The reason for storm water management regulations is the need to control pollution from storm water so it is not added to surface water. Storm water pollutants have many forms and sources. Some are artificial and some are natural, but intensified by human actions. People commonly think of trash as being a pollutant, but may forget about pet waste or oil from cars. Sediment, or just plain old dirt, can be a pollutant if there is too much of it suspended in the water. Construction and farming activities disrupt soils so they are more easily eroded to become pollution. Turbidity in streams raises water temperatures and disrupts food chains. Read the following list of common storm water pollutants. Which do you contribute? Can you reduce your impact?

Common Storm Water Pollutant Categories and Sources:

- Sediment
  - Erosion (construction, farming)
- Toxic Chemicals
  - Pesticides and fertilizers
  - Hazardous Wastes (dumping)
  - Fuels, oils, grease (motor vehicles)
  - Salt (winter deicing)
  - Trash
- Nutrients
  - Fertilizers
  - Yard Waste (leaves, grass clippings)
- Bacteria
  - Animal Waste (wildlife, pets)
  - Feedlots (livestock)
  - Failing Septic Systems

Examples of Storm Water Pollutants: Leaves, Dog Poop, Litter and Cigarette Butts

Source: Deb Las (All)

Many people do not realize that their actions on the land affect water quality. All of the materials listed above can be washed off the land into the storm sewers system. In central Rochester (the areas built before 1985), these pollutants can reach our surface waters without any treatment. Therefore, prevention is the best answer to storm water pollution. Remember: no matter where you live in Rochester, you have waterfront property!

Pipes & Connectors

Storm water management programs must accomplish many objectives. In addition to teaching people how to prevent pollution, a system must be built to move, or convey, the water and treat pollution. Engineered structures that intentionally move water are the first part of the storm water management system.

Rochester's conveyance system is a vast network of storm drains (also called catch basins), underground storm sewers, and ground-level drainage ditches whose purpose is to move storm water quickly away from structures (at home, you use gutters to direct water away from your house). The storm water conveyance process starts with graded constructed sites so water will run into streets or ditches. Water collected on streets runs into the catch basin grate, which is attached to an underground pipe, called a storm sewer. Storm sewers range in diameter from 4 to 96 inches. They can serve small or large areas. Ultimately, the water is released from the pipe into a storm water treatment pond or one of Rochester's receiving waters, like Silver Lake or the Zumbro River. That discharge point, or outlet, is known as an outfall. Similarly, water that runs into ditches is often directed into storm sewers. If the ditch is close to a river, it will outlet directly into it.

Catch Basin with Pollutants

Source: Deb Las

Outfall to the River

Source: Deb Las

Groups and individuals mark catch basins around Rochester with "no dumping" decals. These help remind people that storm water flows from the streets into our streams. Only about 11% of catch basins have been labeled, so if your group wants to help, contact Megan at: mmoeller@rochestermn.gov or 328-2440. Or, you can help by "adopting" a catch basin near where you live or work to keep it clear of debris between street sweepings.

Source: Deb Las

In the following map, look at the locations of streams and lakes, storm sewers (pink lines), catch basins (pink squares), and treatment ponds (blue circles, squares and arrows with numbers). Follow the arrows to find the flow of storm water. Can you find which property drains directly to a surface water body without treatment?

Storm Sewer Network

Source: Rochester Public Works

The South Fork of the Zumbro River is the primary river that flows through Rochester. About 9 miles of its course is in the City and another 103 miles of its tributary creeks pass through the City, too. As of 2012, Rochester's constructed storm water conveyance system had the following public and private components:

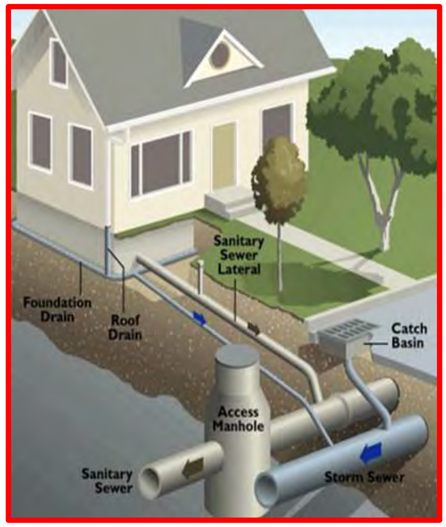
- 422 miles of storm sewer pipe,
- 1,755 outfalls to receiving waters,
- 15,699 storm sewer catch basins,
- 7,986 storm sewer manholes,
- 61 bridges and box culverts,
- 834 lane miles of City streets, plus
- 330 lane miles of open road ditches and thousands of road culverts.

Waterway Conveys Snow Melt

Source: Deb Las

Storm sewer pipes that direct storm water to the river are a separate system from sanitary sewer pipes that take wastewater to Rochester's Water Reclamation Plant. A big difference between the two systems is that storm water is not treated for pollutants prior to release, while wastewater is treated.

Two Different Piping Systems



Source: http://www.vil.spencerport.ny.us/departments/public-works-sanitary-

Storm Water Ponds

Another part of storm water management is treating storm water pollutants in ponds. The ponds collect and hold water so pollutant removal processes can take place. Pond environments are designed to operate a lot like mini-wastewater treatment plants; many processes are at work to remove pollution. A primary pollutant-removal step is the settling of sediment. Because many pollutants adhere to the sediment, cleaner water stays at the top where it is then discharged.

Natural Pollutant Treatment Processes in Ponds:

- Nutrient uptake by plants
- Consumption by micro-organisms
- Chemical reactions by sunlight & oxygen
- Settlement of sediment & other solids

In general, these ponds are located downstream of new or expanding development and upstream of receiving waters. In addition to providing water quality treatment, wet ponds also provide rate control to help with flood protection. A few ponds are now being constructed that allow infiltration to help recharge groundwater. Ponds may be owned by a governmental agency, a commercial development, or residents of a homeowners' association. In 2013, there are 361 storm water ponds within Rochester and 145 of them are public ponds maintained by the City.

Storm Water Pond After a Rain Storm

Source: Rochester Public Works

The location, structure, and maintenance of storm water ponds are carefully planned. Under dry weather conditions, the normal water level of water quality treatment ponds must be maintained between three and ten feet deep below the discharge pipe. Of course, after storm events, the water level will rise, so ponds are designed with enough capacity to hold water from a 100-year storm event. Regulations specify that the size of the pond must allow for an inflow of 1,800 cubic feet per second per acre and the outflow must be less than 5.66 cubic feet per second. (See the Chapter 4 Case Study to learn more about sizing storm water ponds.) Native plants are often planted around a pond for added pollutant removal.

Because ponds are designed to collect sediment before it reaches the river, they can lose their water quality treatment function if they accumulate too much sediment. When the amount of sediment fills a pond half full, the sediment must be removed. Depending on the pond location and the amount of sediment, a dredging permit and coordination with several agencies may be needed.

Ponds are intended to capture pollutants from storm water and should not be used for recreational activities such as swimming or fishing. (See Chapter 4 to learn about recreational water bodies.)

To Adopt-A-Storm Water Pond, go to: www.rochesterstormwater.com/adoptapond.asp.

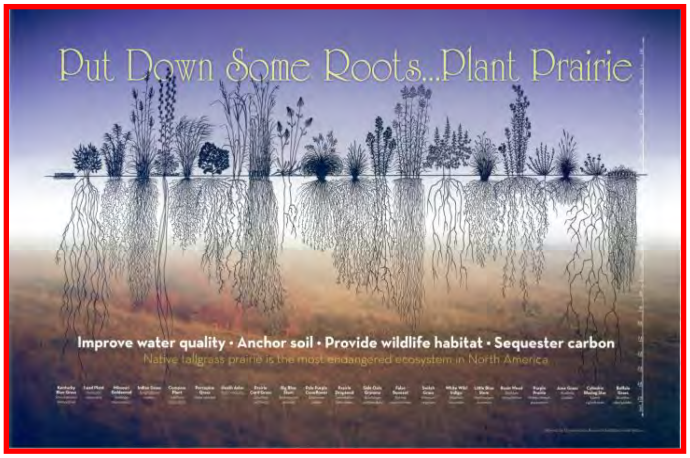
In addition to ponds, there are many other types of engineering designs are used to control the rate of storm water discharge, treat it, or infiltrate it into subsurface, like those shown on the following table.

Storm Water BMPs in Rochester (2013)	#
Storm water Pond: Retention – Wet Basin	280
Storm water Pond: Detention – Dry Rate Control Basin	73
Storm water Pond: Detention – Filtration Basin	3
Storm water Pond: Detention – Infiltration Basin	4
Biofiltration: Biowales	8
Biofiltration: Constructed Wetlands	3
Biofiltration: Filtration Trench	3
Biolfiltration: Infiltration Trench	31
Biofiltration: Raingardens	53
Catch Basin Sump	8
Grit Chamber	8
Internal Energy Dissipater	3
Pervious Pavement: Permeable Pavers	2
Pervious Pavement: Porous Pavement	6
Rock Check	4
Small Basin	40
Underground Detention	4
Construction Basin (Temporary)	19

State and federal agencies are recommending a shift from using storm water treatment ponds to emphasizing the installation of "Green Infrastructure" BMPs that retain storm water as close to where it falls as possible. Storm water ponds will still be prevalent, though, because they provide flood protection in addition to storm water management. For more information about each BMP type, look at the MN Stormwater Manual: http://www.pca.state.mn.us/index.php/water/water-types-and-programs/stormwater/stormwater-management/minnesotas-stormwater-manual.html.

Green Infrastructure

A raingarden is one type of Green Infrastructure that is becoming more common. They are desirable because the help capture and infiltrate storm water close to where the precipitation falls on the ground, so the opportunity for the storm water to collect pollutants is reduced. Of course, the intensity and duration of a rain event can affect how much rain soaks into the ground, as can the type of soil below it. Water that soaks into the ground can be used by plants or travel deeper to recharge groundwater. Native plants are ideal for raingardens because they take up a lot of water and they promote deeper infiltration.



Source: Minnesota DNR

Grant

Source: Rochester Public Works

Raingardens can be beautiful additions to any yard. Rochester has a cost-share grant program to help promote the installation of residential raingardens. Locally, grants are available to help establish new raingardens. Go to: www.rochesterstormwater.com/r_r_r.asp for more information on how to apply

Benefits of Raingardens:

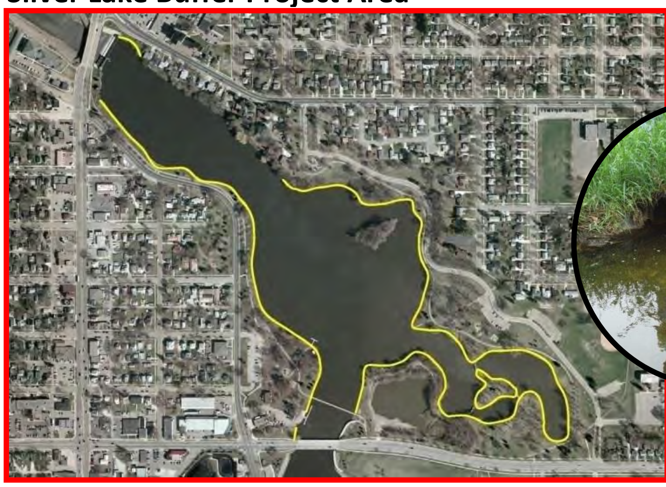
- Soak up 30% more runoff than lawn
- Filter polluted runoff
- Recharge groundwater
- Help prevent flooding
- Habitat for wildlife
- Beautify your yard
- Less maintenance than turf grass

Other types of Green Infrastructure include “green pavements” like porous concrete or porous bituminous surfaces and permeable pavers. These hard surfaces are engineered to allow infiltration instead of causing runoff like traditional pavements. Biowales, constructed wetlands, filtration trenches, infiltration trenches and water storage devices like rain barrels or underground detention chambers are other practices that help mimic pre-settlement hydrology. Visit the Cascade Meadow & Environmental Science Center (2900 19th St NW) or the Rochester Public Works Operation and Transit Center (4300 East River Rd NE) to view many of these BMPs at work.

Buffers

Buffers are vegetated borders of native plants that help treat pollutants in runoff. They can be planted around a storm water pond, along a stream or river, or around a wetland or lake. The City received a grant to help pay for the installation of an upland prairie and wetland buffer around Silver Lake. Its purpose is to reduce storm water contaminants, including: fecal coliform bacteria, suspended solids, Kjeldahl nitrogen, and phosphorous. The section of the Zumbro River flowing through Silver Lake is listed as impaired for fecal coliform bacteria because bacteria levels exceed water quality standards. By helping to reduce the bacteria load in the Lake, the buffer is helping the City reverse this impairment. Silver Lake was an important place to target fecal coliform bacteria reduction because the concentration of Canada geese and their poop in Silver Lake was a likely source of the impairment. It took 4 years to create the buffer and now it is maintained by the City Park and Recreation Department. They combine mowing, spot weed removal and prescribed burning to keep the native plants healthy.

Silver Lake Buffer Project Area



Source: Rochester Public Works

Total Kjeldahl nitrogen or TKN is the sum of organic nitrogen, ammonia (NH_3), and ammonium (NH_4^+) in the chemical analysis of water.

The project converted about 8,700 feet of shoreline into storm water buffer. The plans for the buffer project consisted of three vegetative zones: upland, transition, and aquatic. The upland zone included a prairie area planted with native seed, several created wetlands, and tree groves. To prepare for the transition zone planting, the old pillow concrete rip rap had to be punched with holes and covered with compost before it was seeded with prairie and wetland species and covered with erosion and sediment control netting. Thirty, 50-foot long areas were selected for planting aquatic plants in the lake edge. To protect these areas from wave action and ice damage, concrete barriers were placed in the lake. Then coir fabric (a biodegradable fabric made of coconut fiber) containing emergent

Emergent plants grow in the water, but extend up through the water surface.

plant plugs grown at a nursery was installed. Physical barriers were installed to protect the new plantings from geese and fish predation. The barriers were removed once the plant communities were established, a period of about three years. Unfortunately, the transition and aquatic plantings suffered substantial damage when seeds and plants were washed away in the August 2007 flood. Those areas are slowly recovering as new plants grow into those areas.

Before

Source: Rochester Public Works

During

Source: Rochester Public Works

After

Source: Deb Las

Funding

Rochester operates its storm water management program as a utility, just like wastewater and water supply. The monthly fees paid by land owners in Rochester pay for all the storm water management services required by the permit. Since there is no way to turn on or turn off precipitation, the storm water system must be fully operable at all times for everyone. The "meter" for the fee is the amount of impervious surface on a parcel of property, because the higher the amount of impervious, the more storm water management is needed. The storm water management fee appears on the monthly RPU bill. Go to: www.rochesterstormwater.com/fundraising_projects/fundingprojects_utilityfee.asp to learn more about the utility fee.

Additionally, developers pay a "storm water management area charge" at the time of new development to connect to the storm water system and to contribute to the construction of required water quality treatment practices.

Evidence of storm water management activities can be seen throughout the City. Whenever you see these kinds of features, they are clues that storm water management is happening.

Scour Stop

Spring Street Sweeping

Construction Site Erosion Control

Stream Bank Stabilization

Outfall

Source: Rochester Public Works

What You Can Do

Pollution in the Zumbro River

Source: Deb Las

Improving the quality of storm water will improve water quality in our lakes, rivers, and wetlands. Each individual's actions on the land determine how clean our water will be. Storm water management is everyone's responsibility. Are you willing to help end pollution like this? Read the list below and pick one new thing that you will do to help.

With Your Car and Other Vehicles:

- Repair fluid leaks
- Attend to your car while fueling so gas doesn't spill on pavement
- Keep a trash bag in your car for waste
- Cover loads
- Use a commercial car wash

At Home:

- Keep hard surfaces free of litter, yard waste, and chemicals
- Pick up after your pet
- Minimize salt use in winter
- Bag and tie your trash bag before putting it in your trash bin to prevent litter

In the Yard:

- Minimize and correctly apply chemicals
- Plant a tree
- Plant more long-rooted, native plants
- Direct downspouts to vegetated areas
- Use a rain barrel
- De-chlorinate your pool before emptying it
- Plant a raingarden

Be Proactive:

- Report water polluting activities by calling 328-2440
- Learn more at: www.rochesterstormwater.com

Case Study: Quarry Hill Park's Water Story

Take a step back in time by taking a self-guided hike through Quarry Hill Park and discover the interesting ways humans, land, and water have converged there. What was done in the past, affects us now. What we do now, will affect us in the future. Read the following information before you begin.

Geology: Local geology governs how surface water and groundwater flow in Quarry Hill Park. Storm water becomes groundwater when it soaks into the upper Galena limestone formation (the burgundy layer in the diagram below). Gravity pulls the water downward until it reaches the highly impermeable Platteville-Glenwood-Decorah shale unit (the gold layer). Once there, groundwater flows outward and over hillside edges until it reaches the porous St. Peter sandstone bedrock (the green layer). There it infiltrates and recharges our water supply. Elevation changes in the landscape control surface water flow, descending from the highlands and through the lowlands. After you have taken your hike, look at this map again and see if you can find the: wet pond, infiltration basin, riffle/pool section of Quarry Hill Creek, filtration basin, and fen terrace.

Vegetation: Long-rooted native prairie and wetland plants that are adapted to our climate are highly desirable for controlling erosion and treating storm water. Most of the original vegetation in the Park was lost to agriculture in the late 1800's. The absence of prairie-sustaining wildfires and the abundance of competitive, invasive plants (like reed canary grass, buckthorn and crown vetch), makes restoration of desirable native plants in the Park very challenging. Once established, ongoing management is needed to support reintroduced plant habitats.

Humans and the Environment

Humans have been affecting water movement in Quarry Hill Park since the late 1800's. In 1879, Minnesota's second hospital for the insane opened on the land that became Quarry Hill Park in 1966. Many patients worked on the 500-acre farm, which later became known as the Rochester State Hospital, tending crops and animals and taking limestone from the quarry.

Quarry Hill Creek is an intermittent stream (the blue line on the map) that flows from the uplands into the valley between the east and west hills of the Park. The first significant change affecting water flow happened in 1934, when the Civilian Conservation Corps (CCC) moved the creek from the west to the east side of the Park, perhaps to protect the quarry road from flooding and to create larger crop fields. The second major change started when Rochester grew north of the Park, adding hard surfaces and more storm water discharges. Both changes eventually led to the major repair and treatment projects that are described below and that can be seen in the Park. Just follow the Water Drop Trail in the Park (the yellow dots on the map; the water drop signs in the Park.)

The Water Drop Trail at Quarry Hill

Source: Rochester Public Works

Drop Structure Built by CCC Workers

Source: Deb Las

Drop A—The CCC Was Here

Look at the craftsmanship in this old limestone structure. It was built in 1934 by the CCC to stabilize the new junction of Quarry Hill Creek with Silver Creek. This change created a steeper and shorter creek, triggering a cycle of soil erosion and deposition that disconnected the creek from its floodplain, led to flooding near the nature center, and was a contributing factor to Silver Creek's inability to meet state water quality standards.

Drop B—A New, Old Confluence

The location where one stream enters another is called a confluence. The City of Rochester returned Quarry Hill Creek to its former channel to halt and correct erosion that started over 70 years ago. This new confluence near its original location was engineered to withstand rainfall events of at least 6.1 inches in 24 hours. This special reinforcement was needed because the area that drains to Quarry Hill Creek today has many more impervious surfaces like roofs, sidewalks, driveways, and streets. As the impervious cover increases, the speed and amount of storm water increases, so a small, natural creek channel can no longer withstand the erosive effects of big storm events in an urban setting. The reinforced banks also protect a buried sanitary sewer line from future erosion.

Drop C—Sinuosity And Stability

Do you see the S-shaped path the stream takes? A meandering channel was chosen to help keep the new creek stable over time. This design mimics how streams naturally evolve in areas with very gentle slopes.

Stabilizing a new creek takes some clever engineering. In the short term, erosion control mats and slope control structures keep the channel bottom in place. Can you see glimpses of the biodegradable coconut fiber blankets that keep the soil on the banks? As native grasses and shrubs take root, they add long-term stability.

Drop D—Older And Wiser

Until the 1980's, managing storm water focused on quickly moving it away from buildings and roads to protect structures and people from flooding. Discharging storm water into natural drainage ways was a common practice when the Parkwood Hills neighborhood was built on top of the hill. We've learned that when loose soils overlie wet Decorah shale conditions, the slopes can be too weak to transport the focused discharges from the bluff tops, leading to significant soil erosion.

To repair the eroded ravine, it was necessary to bury a limestone rock channel in this hillside to carry groundwater while also holding the steep, fragile slope. Look for the native grasses and trees that will increase slope stability as they mature.

Drop E—All Aboard the Treatment Train

Four engineered systems are linked together here to minimize storm water impacts. First, a vegetated drainage swale helps slow runoff and absorb excess lawn chemicals from backyard drainage. Underneath the swale is a pipe that collects storm water from front yards and roads in Parkwood Hills. Next, a wet pond receives and holds runoff from the swale and the storm sewer for more cleansing. Many natural processes are working to help treat the water: settlement of sediments, uptake of chemicals by plants, addition of oxygen by wind and plants, and UV radiation from sunlight. Finally, the treated storm water enters an infiltration basin where it can recharge our groundwater supply and sustain the base flow of Quarry Hill Creek.

Drop F—Basins, Riffles & Pools, Oh My!

This filtration basin acts like a wet pond *and* an infiltration basin in one! The site soils here were not permeable enough for a dry infiltration basin, so this design allows water to slowly filter through underlying soils. Then it seeps into drain tiles which release water to recharge the downstream riffle/pool stream channel.

Severe erosion in this stream channel also needed correction. Without room for a meandering channel here, a sequence of rock riffles separated by shallow pools was designed to slow and retain water to halt and prevent erosion. Instead of meandering side to side, the channel meanders up and down!

Drop G—Hillsides as Headwaters

When groundwater flows out of the upper limestone bedrock and across broad Decorah shale terraces, groundwater-fed wetlands, known as fens, can form high in the landscape. These small, rare hillside fens are scattered throughout Rochester. They may not look impressive, but these unique habitats are *very* important; they help remove nitrate pollution and they are the headwaters of our streams.

A deep erosion channel was draining this fen, so it was filled with soil and rock “dams”. By stopping this water loss, wetland vegetation restored itself and the two, split wetlands were reunited into one healthy wetland.

Source: Rochester Public Works