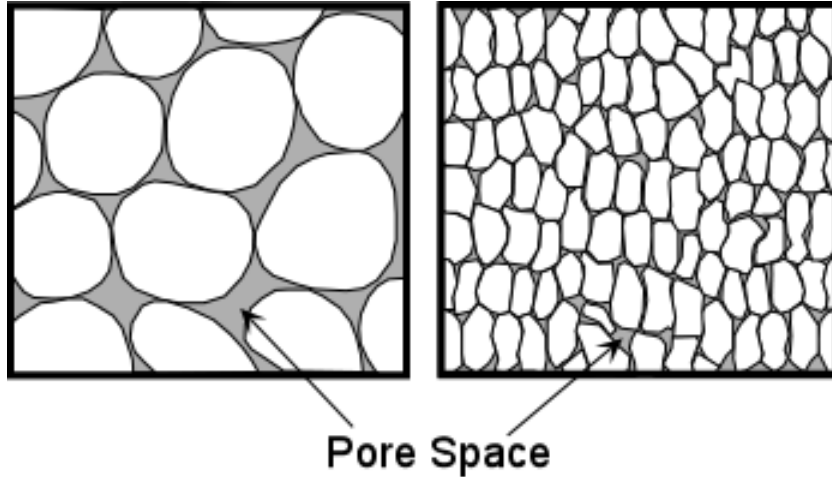


STORMWATER OVERVIEW

THE PROBLEM

Stormwater comes from precipitation events like rain and snow. Some of this water infiltrates the ground and recharges the **groundwater** in **pore spaces** between sediment and fractures in rocks. This stored groundwater gets used by people and soaked up by plants.

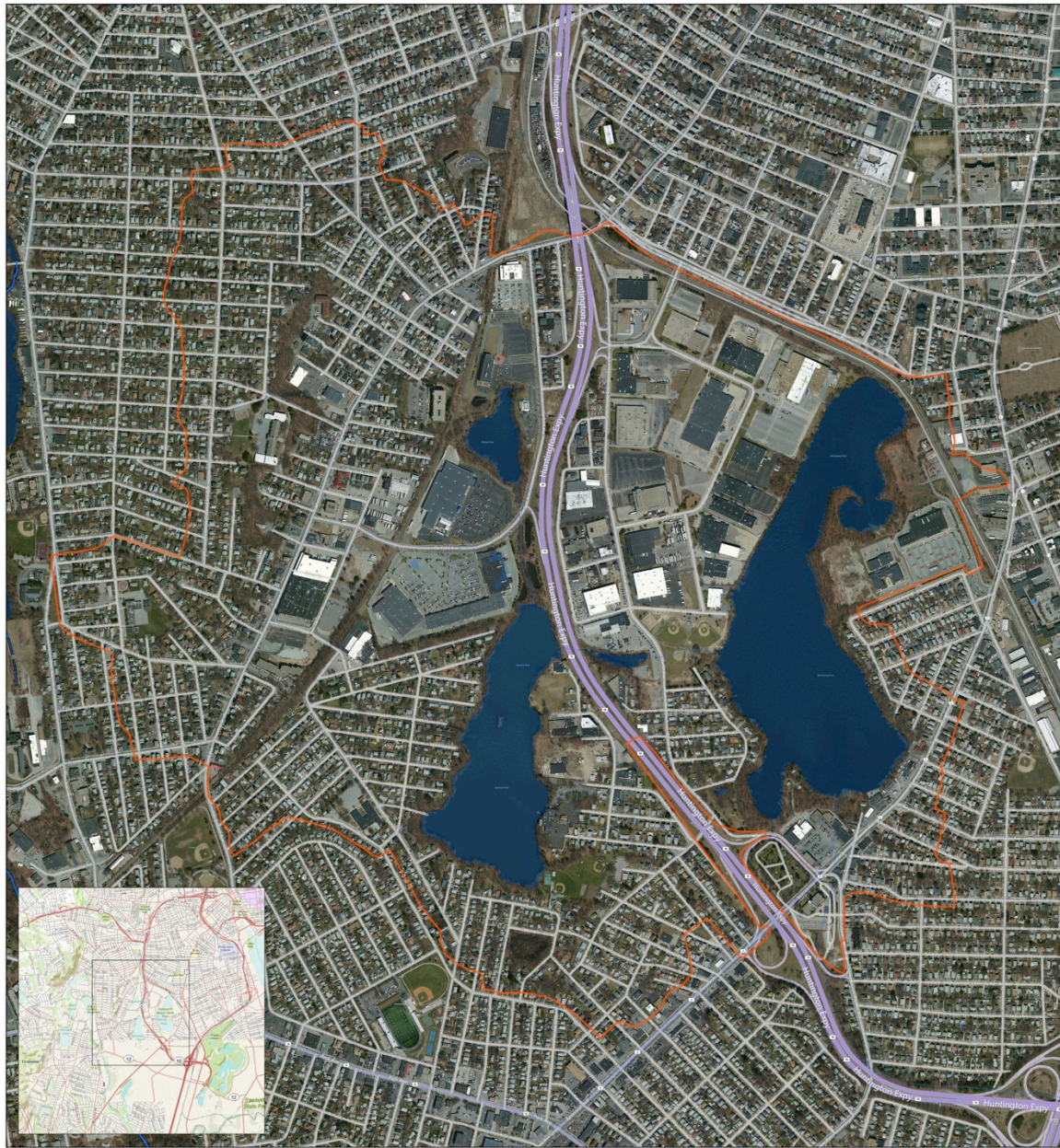


When all the pore space has filled up, or when water falls directly on **impervious or impermeable surfaces**, that water can no longer soak into the ground. Water that cannot infiltrate the ground becomes **runoff**, and flows over land surfaces into water bodies or sewer systems that discharge into water bodies.



Runoff from a nearby business into Mashapaug Pond.

The land area that drains into a given body of water is called a **watershed**. The maps below show the Mashapaud Pond and Narragansett Bay watersheds.



Questions about this map?
Please contact:
RI Dept. of Environmental Management
401-222-1717
dem.pdm@dem.state.ri.gov

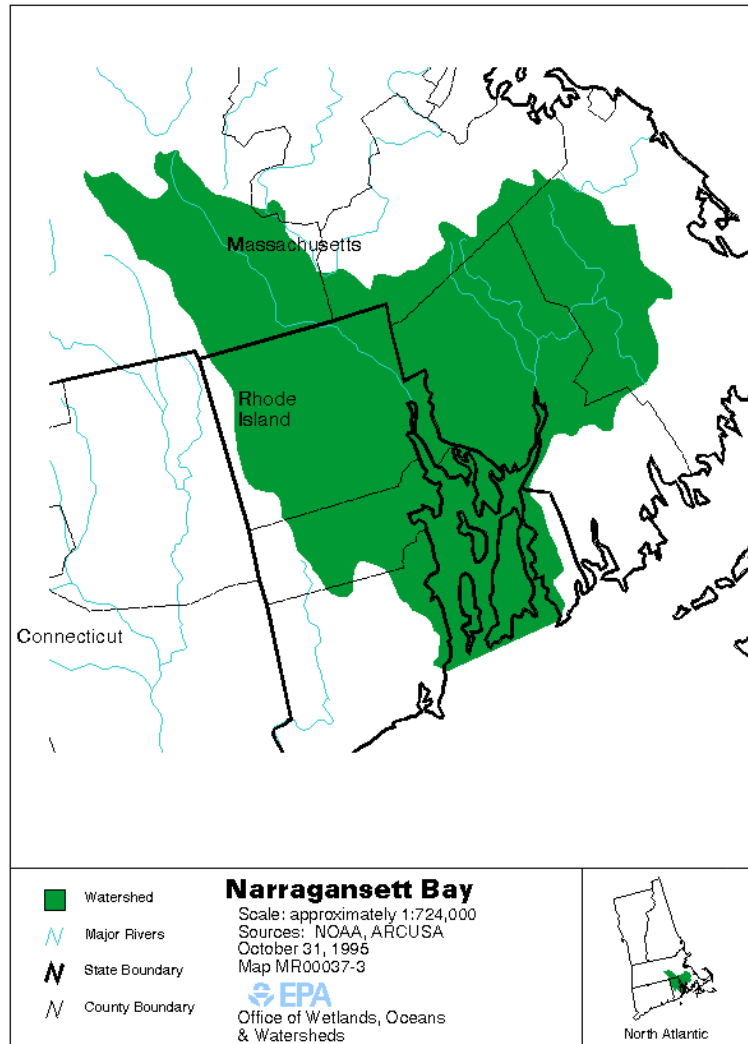
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0 1,000 2,000 Feet

Watershed
Of
Mashapaud Pond



2011 Map of Mashapaud Pond. The watershed is outlined in orange.



Because cities have a lot of impervious surfaces, they experience more runoff than undeveloped areas. Runoff causes several problems, including flooding, erosion, and pollution.

When the volume of runoff overwhelms a city's storm drainage system, flooding occurs. This can cause basement flooding and sewer backups.

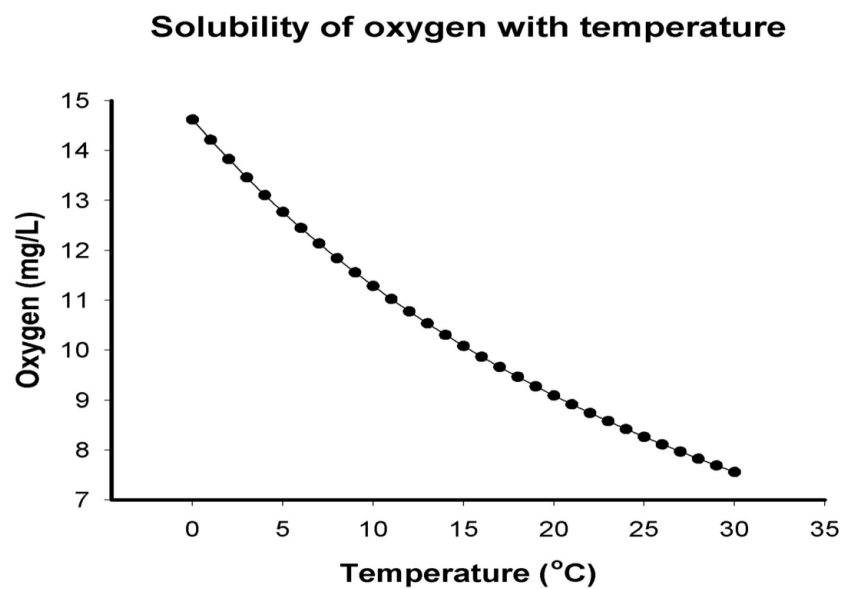
Pollutants and contaminants carried by runoff are called **polluted runoff**. These pollutants might include:

- Oil, grease and toxic chemicals from cars
- Pesticides and fertilizers
- Pet waste
- Road salts
- Heavy metals from cars and roof shingles

As stormwater runoff flows over land, it also removes sediments and carries it into water bodies. This **erosion** can carry contaminants like heavy metals, fertilizers and pesticides; smother the fish and other invertebrates in the water; and prevent light from reaching photosynthesizing aquatic plants.

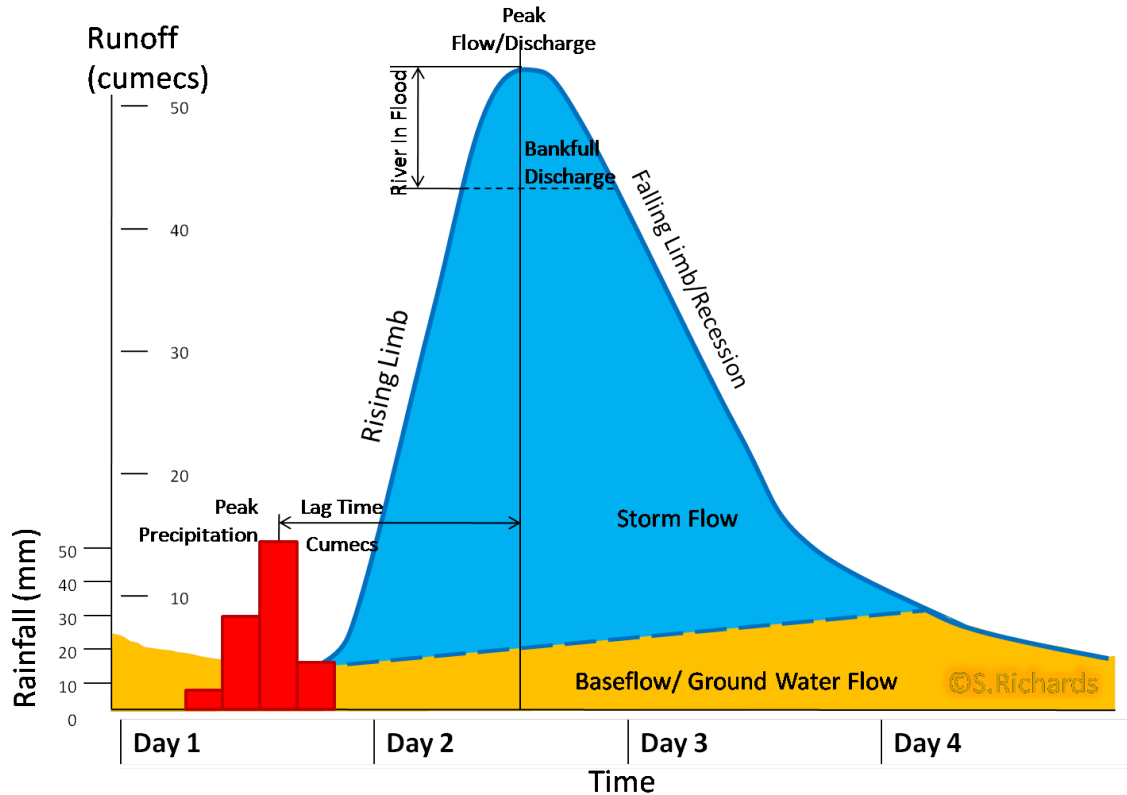
During warm weather, as stormwater passes over hot parking lots, roads, and sidewalks, runoff can raise the temperature of the water bodies it enters. This **thermal pollution** can decrease oxygen supply (since cold water holds more dissolved oxygen) and shock the organisms living in the water that are used to a different temperature range.

Temperature vs. Dissolved Oxygen



HYDROGRAPHS

Hydrographs help us understand how runoff occurs following a storm.



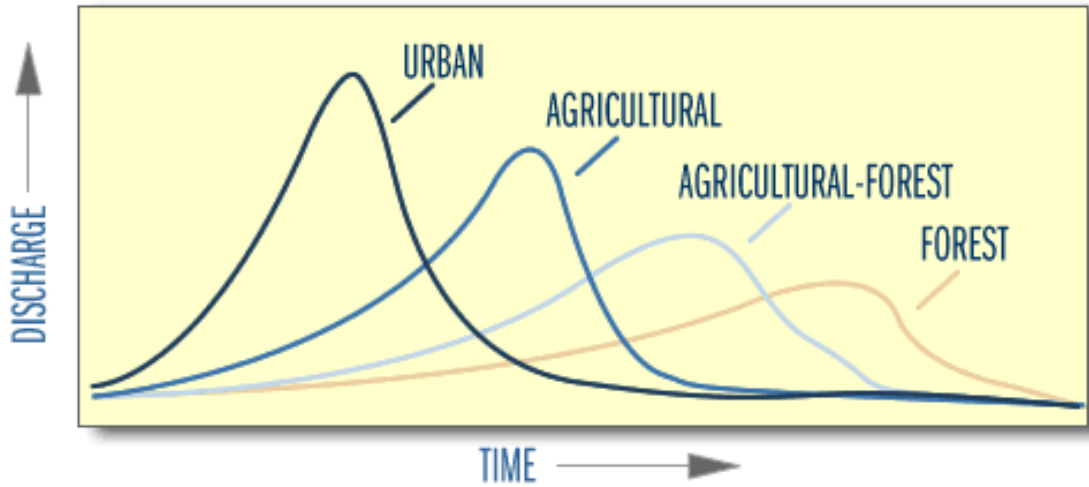
In this graph, the precipitation event is shown in red. The x-axis is time and the y-axis is runoff into a hypothetical river in units of cubic meters per second. The yellow part of the graph shows the normal discharge of water into the river in the absence of precipitation. The blue part of the graph is runoff into the river caused by the storm.

The **rising limb** shows the normal flow of the river rising as runoff and groundwater reaches the river following the storm. The **lag time** is the time between peak precipitation and peak flow, and indicates the time it takes for water to reach the river. **Peak flow** is when discharge into the river reaches a maximum rate and the river reaches its highest flow. The **falling or recession limb** shows water still reaching the river a few days after the storm, but at decreasing rates.

A larger drainage area receives more precipitation than a small drainage area and therefore has larger runoff. It also has a longer lag time, since water has to travel a longer distance to reach the river. Steeply sloping land causes a steeper rising limb and shorter lag time. The more water infiltrates the ground, the shallower the rising limb and longer the lag time. Pervious surfaces allow for rapid infiltration and low

storm flow, causing a shallow rising limb. Vegetation also intercepts the precipitation, causing a shallow rising limb and long lag time. Impervious surfaces cause a steep rising limb and short lag time.

STORMWATER DISCHARGES FROM VARIOUS LAND COVERS



COMBINED SEWER SYSTEMS

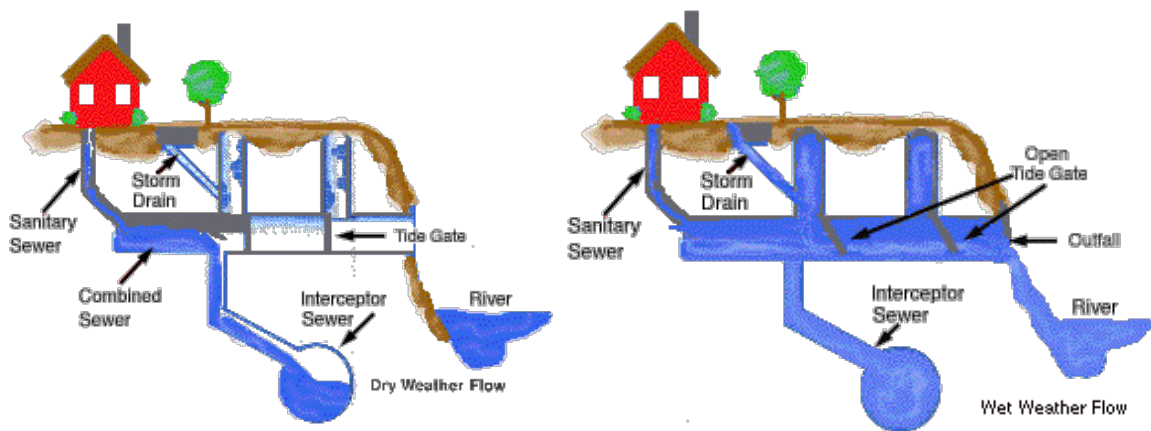
Storm drains or sewers drain excess stormwater from impervious surfaces into waterways. As water carries debris and trash into these storm drains, they can get clogged.



Close-up of trash in a storm drain near Reservoir Elementary School in Providence, RI.

Many cities use a **combined sewer** system, which collects stormwater runoff and sewage in a single pipe system. During heavy precipitation, some of the combined stormwater and sewage gets discharged untreated to our water bodies. This **combined sewer overflow** poses environmental and public health risks, since it carries things like oil, grease, bacteria, and untreated sewage.

Traditionally in Rhode Island, water that couldn't get treated in time during rainstorms would get released untreated into Narragansett Bay. This is why certain areas of Narragansett Bay are closed for swimming and fishing during heavy rains. In recent years, however, Providence has reduced the amount of contaminated water entering adjacent waters by revamping the city's combined sewer system to capture contaminated stormwater during rainstorms and hold it for treatment until after the rain has subsided.



SOLUTIONS

We can start addressing stormwater runoff through changes in **infrastructure**. **Gray infrastructure** carries stormwater out of cities through sewers and pipes. **Green infrastructure** uses vegetation, soils, and natural processes to soak up and store stormwater.

Common examples of green infrastructure include:

Planter boxes that intercept, store, and filter stormwater runoff from downspouts that are flow into pervious, instead of impervious, ground. These are called **disconnected downspouts**. Runoff is retained and stored in the soil and intercepted by plants, which **evapotranspire** moisture. Planter boxes are commonly used in urban areas next to buildings and along sidewalks.



Green roofs are vegetated roof covers. The vegetation helps absorb and evapotranspire stormwater runoff, as well as delay and filter runoff flows that exceed the roof's runoff storage capacity. Green roofs also provide natural thermal insulation, meaning they are cooler in summer and warmer in winter. As a result, they help reduce building energy use.



Native plants are species that were growing naturally in an area before humans introduced plants from distant places. They evolved to survive the soil, moisture, and weather conditions of a particular location, with a higher ability to survive winter cold and summer heat. They are also resistant to more pests and diseases in a given area. Once established, they require no irrigation or fertilization, thereby increasing water conservation and protecting water quality. They increase biodiversity by providing food and shelter for wildlife like birds and butterflies.

Phytoremediation refers to the use of plants to contain, degrade, or eliminate contaminants such as metals, pesticides, solvents, explosives, crude oil and its derivatives from contaminated soils, water, or air.

Rain gardens are gardens filled with native plants. The plants and soil in the garden remove contaminants and sediment from stormwater runoff through **bioretention**. Native plants provide wildlife habitat, and have lower irrigation and maintenance costs than traditional forms of landscaping.



Rain barrels and **cisterns** collect stormwater through a disconnected downspout. They help protect water quality by keeping runoff out of sewers, and conserve water by eliminating the need to use potable water for irrigation.



Bioswales are gently sloped ditches vegetated with native plants that reduce runoff through infiltration and evapotranspiration. They are often located in parking lots or next to roads in lieu of curbs and gutters. They improve water quality by infiltrating and filtering stormwater runoff.



Permeable pavement systems allow liquids to infiltrate through void spaces in hard materials while maintaining the functionality of an impervious surface. These might include porous asphalt, porous concrete, gravel, and pavers, which are concrete surfaces installed with gaps to allow water to pass through.



VOCABULARY LIST

Stormwater
Groundwater
Pore Space
Impervious / Impermeable Surface
Runoff
Watershed
Polluted Runoff
Erosion
Thermal Pollution
Hydrographs
Rising Limb
Lag Time
Peak Flow
Falling Limb
Combined Sewer System
Combined Sewer Overflow
Infrastructure
Gray Infrastructure
Green Infrastructure
Planter Boxes
Disconnected Downspouts
Evapotranspiration
Green Roofs
Native Plants
Phytoremediation
Rain Gardens
Bioretention
Rain Barrels/ Cisterns
Bioswales
Permeable Pavement