Water Quality in the Knoxville MSA: Inventory, Analysis, and Recommendations

University of Tennessee-Knoxville
Landscape Architecture Program
Work Performed in Design Studio Fall Semester 2011

Presented to the Watershed Symposium
September 18, 2012

Presentation Outline

Introduction
Knoxville MSA Water Resources

Land Use Types: Indicators of potential water quality and quantity concerns

Water Cycle Comparison: Developed Site Conditions, Undeveloped Site Conditions

Low Impact Design Best Management Practices (BMPs)

BMP reccomendations for Land Use Types

Examples of Student Work

KNOXVILLE MSA

(anderson, blount, knox, loudon, union)

Knoxville MSA Total Population - 2010
(698,500)

Knoxville MSA Estimated Population - 2030
(894,700)

= 4,000

WATER RESOURCES

Surface

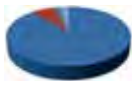
Principal Reservoirs
Norris Lake
Watts Bar Lake
Chilhowee Lake

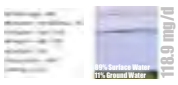
Principal Rivers and Streams
Tennessee River
Holston River
French Broad River
Little River
Little Tennessee River
Clinch River
Beaver Creek
Bullrun Creek

Ground

Principal Aquifers
Pennsylvanian Aquifer (Sandstone)
Valley and Ridge Carbonate Rock Aquifer (Limestone and Carbonate Rock)

Knoxville MSA Total Consumptive Use - 2005





Consumptive Uses by Category - 2005

Public Supply

Industrial & Mining

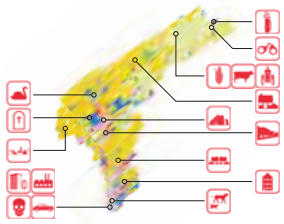
Irrigation - Crop

Irrigation - Golf

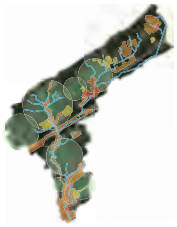
Livestock

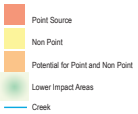
Aquaculture

FIRST CREEK: TYPOLOGIES AND POLLUTANTS



DEVELOPMENT TYPOLOGIES AND POLLUTION SOURCES IN THE FIRST CREEK WATERSHED

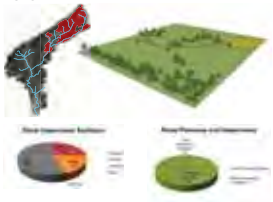




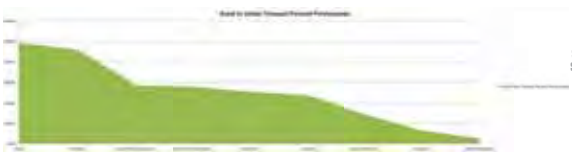
AREAS IMPACTED BY POLLUTION IN THE FIRST CREEK WATERSHED

DEVELOPMENT TYPOLOGIES

Rural



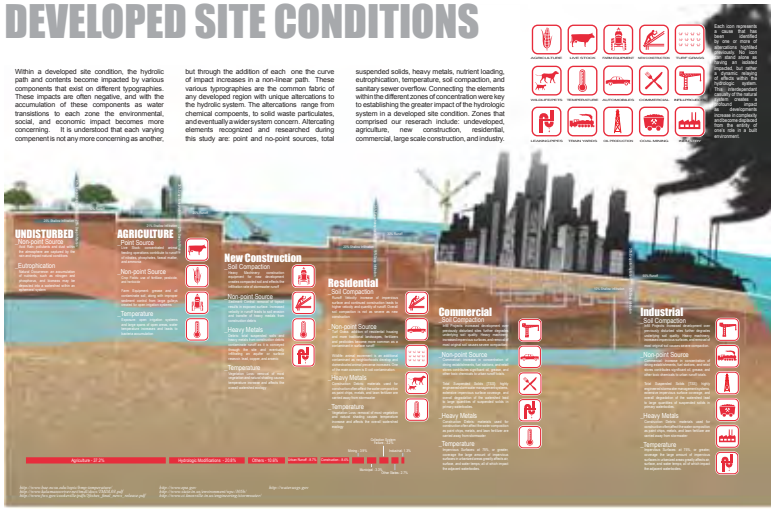
Strip Mall Development



TYPOLOGIES ANALYZED
RURAL
RANCHETTE
SINGLE FAMILY RESIDENTIAL - LOW DENSITY
SINGLE FAMILY RESIDENTIAL - HIGH DENSITY
OFFICE PARK
INDUSTRIAL
GARDEN APARTMENT
DOWNTOWN
STRIP DEVELOPMENT

DEVELOPED SITE CONDITIONS

Within a developed site condition, the hydrolic path and contents become impacted by various components that exist on different typographies. These impacts are often negative, and with the accumulation of these components as water transitions to each zone the environmental, social, and economic impact becomes more concerning. It is understood that each varying component is not any more concerning as another, but through the addition of each one the curve of impact increases in a non-linear path. These various typographies are the common fabric of any developed region with unique altercations to the hydrolic system. The altercations range from chemical components, to solid waste particulates, and eventually a wider system concern. Altercating elements recognized and researched during this study are: point and no-point sources, total suspended solids, heavy metals, nutrient loading, eutrophication, temperature, soil compaction, and sanitary sewer overflow. Connecting the elements within the different zones of concentration were key to establishing the greater impact of the hydrologic system in a developed site condition. Zones that comprised our research include: undeveloped, agriculture, new construction, residential, commercial, large scale construction, and industry.



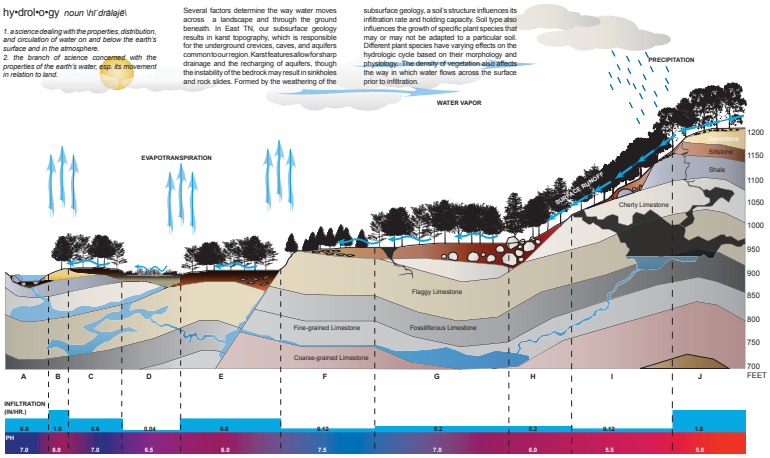
NATIVE SITE CONDITIONS

hy•drol•o•gy *noun \hī'dräləjē*

1. a science dealing with the properties, distribution, and circulation of water on and below the earth's surface and in the atmosphere.

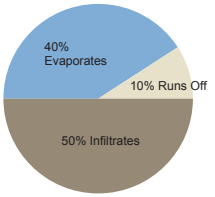
2. the branch of science concerned with the properties of the earth's water, esp. its movement in relation to land.

Several factors determine the way water moves across a landscape and through the ground beneath. In East TN, our subsurface geology results in karst topography, which is responsible for the underground crevices, caves, and aquifers common to our region. Karst features allow for sharp drainage and the recharging of aquifers, though the instability of the bedrock may result in sinkholes and rock slides. Formed by the weathering of the subsurface geology, a soil's structure influences its infiltration rate and holding capacity. Soil type also influences the growth of specific plant species that may or may not be adapted to a particular soil. Different plant species have varying effects on the hydrologic cycle based on their morphology and physiology. The density of vegetation also affects the way in which water flows across the surface prior to infiltration.

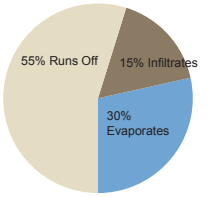


SITE HYDROLOGY COMPARISON

NATIVE SITE CONDITIONS



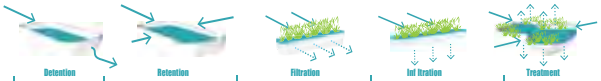
DEVELOPED SITE CONDITIONS



Stormwater Control

Best Management Practices (BMP's) and **Low Impact Development** (LID's) provide an environmentally conscious and alternative approach to managing stormwater runoff than convential engineering mechanisms. These soft engineering applications provide various **economic**, **social**, and **environmental benefits** that include runoff quantity and quality control, pollution mitigation, increased pervious surfaces, and use of native vegetation. The stormwater that enters these systems is controlled in various ways, with each providing a unique impact on the runoff. These systems can be separated into categories of **detention**, **retention**, **filtration**, **Inf Iltration**, and **treatment**. Each BMP is placed into its respective category based on its primary function, however, the matrix below indicates additional secondary functions that the BMP will perform.

Pollution mitigation for enhanced water quality is one of the primary intentions of all BMP's and LID's. The main pollutants within stormwater runoff are **sediment** (suspended solid), **nitrogen**, **phosphorus**, **heavy metals**, **oil**, and **toxins** (bacteria). Filtration of these harmful pollutants is often dictated by duration of time within a BMP, soil types, native vegetation, and velocity reduction. Each BMP is evaluated on its performance of removing the different pollutants and is given a score of 1-3, 3 having the largest impact.



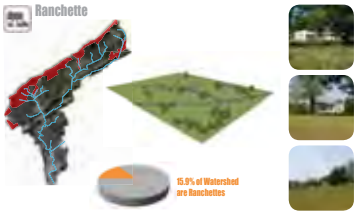
	Rain Gardens	BioDetention Basins	Residential RW Harvesting	Commecial RW Harvesting	BioRetention Basins	Bio-Swale	BioRetention Cell	Filter Strip	Permeable Paving	Parking Design	Tree Canopy	Greenroofs	Constructed Wetlands
Improves Water Quality through Passive Measures	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
Controls Stormwater Runoff Quantity	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
Reduces Stormwater Runoff Velocity	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
Serves as Point-source Pollution Control	✓	✓							✓	✓	✓	✓	✓
Provides Wildlife Habitat	✓	✓							✓	✓	✓	✓	✓
Enhances Spatial and Aesthetic Quality	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
Stores Runoff for Alternative Reuse			✓		✓								
Conveys and Diverts Stormwater Strategically						✓	✓	✓					
Provides Additional Pervious Surfaces	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
Improves Air Quality	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
Erosion and Sediment Control	✓	✓				✓	✓	✓	✓	✓	✓	✓	✓
Recharges Aquifer	✓	✓			✓								
	✓✓✓	✓✓✓			✓✓✓	✓	✓✓✓	✓✓✓	✓	✓✓✓	✓	✓	✓✓✓
	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
	✓✓✓	✓✓✓			✓✓✓	✓	✓✓✓	✓✓✓	✓✓✓	✓✓✓	✓	✓	✓✓✓
	✓	✓			✓	✓	✓	✓	✓	✓	✓	✓	✓
	✓✓✓	✓✓✓			✓✓✓	✓	✓✓✓	✓✓✓	✓	✓✓✓	✓	✓	✓✓✓

Development Typologies

Rural

Recommended BMPs

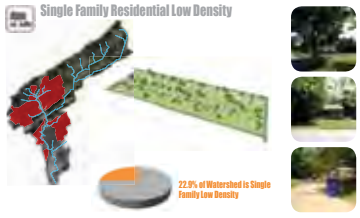
Ranchette



Recommended BMPs

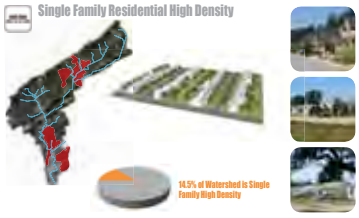
Development Typologies

Single Family Residential Low Density



Recommended BMPs

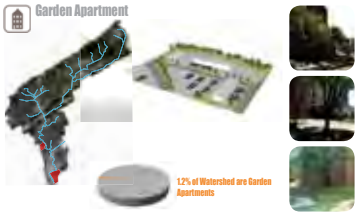
Single Family Residential High Density



Recommended BMPs

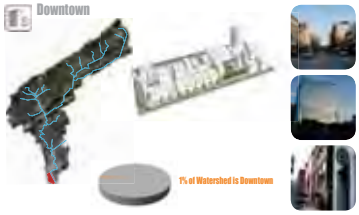
Development Typologies

Garden Apartment



Recommended BMPs

Downtown



Recommended BMPs

Development Typologies

Office Park

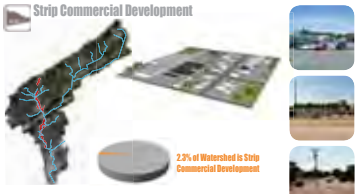
Recommended BMPs

Industrial

Recommended BMPs

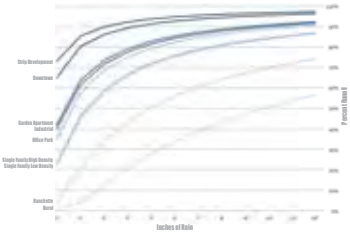
Development Typologies

Strip Commercial Development



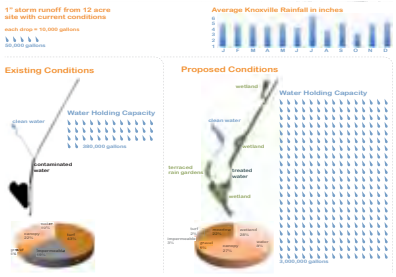
Recommended BMPs

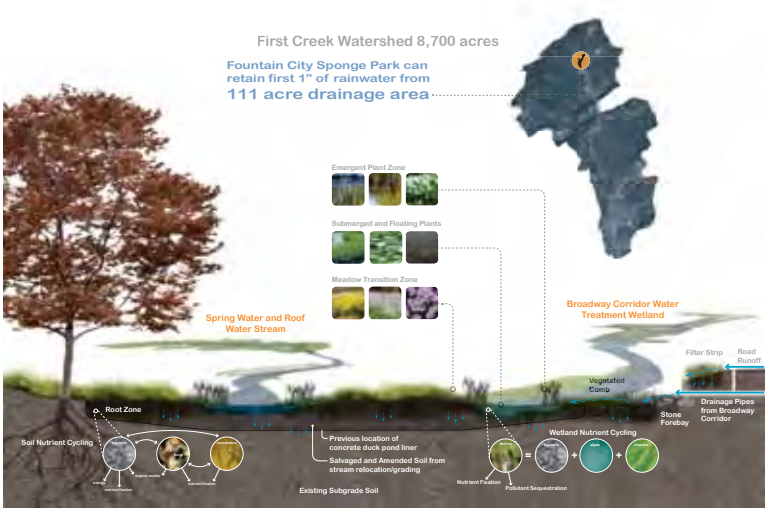
Typology Runoff Rates

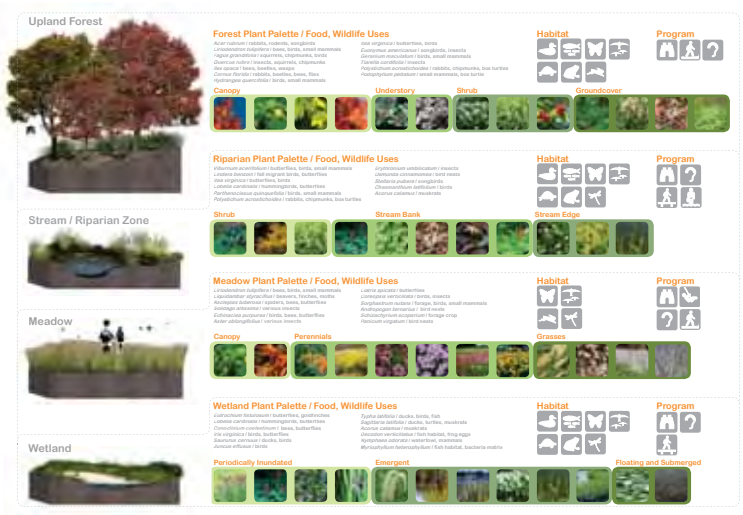


Site Criteria for Hydrologic BMP Design Decisions

- Available Open Space
- Nature of Site Surfaces
- Soil Infiltration Rate
- Proximity to Karst Features / Ground Water Vulnerability, Bedrock Depth
  - Sub-Surface Geology
- Cost Effectiveness
- Nature of Site Pollutants
- Contributing Watershed Size / Volume
- Functional Requirements of a Site



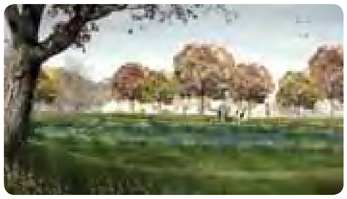




Frog Bowl, Meadow Park, and Wetland Section

Meadow Play Area View

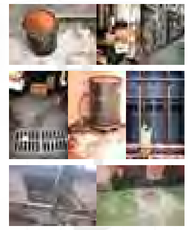
Wetland Boardwalk View



Market Square.tVA PLAZA

A Productive Stormwater Habitat

In the urban environment of Market Square and TVA Plaza, there are limitations and constraints on Best Management Practices and Low Impact Development due to available space and density of development. With these issues, appropriate measures must be considered for the most efficient management of stormwater. Along with these issues of development there is also an increase in concentrated pollutants and accumulation of such within a small area.

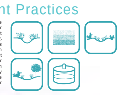


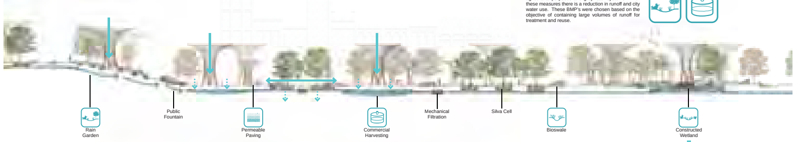
Hydrology

The site location has an extremely shallow slope, averaging .5%, over the length from end to end, with the exception of a 20ft elevation change from the TVA Plaza to Market Square. Stormwater is collected through a series of interventions by their ability to contain and filter runoff for use on the site. The funnels are one of the first devices to collect and filter, which involves a gentle spiral down the perimeter of the top half through a glass pipe. This prolonged circulation allows for the sun's UV rays to begin killing off harmful bacteria that may have came from the storm event. After the stormwater has circulated through the pipe it enters into vegetated planters to allow for natural filtration to remove carbon compounds. Runoff that is not collected from the funnels is directed by the paving to the cisterns underneath the larger funnel. Excess runoff is conveyed through bioswale and eventually into an ephemeral constructed wetland.

Best Management Practices

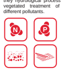
Urban settings contain high density mixed-use development and are limited with open spaces for either parks and recreation or even redevelopment and infill. These constraints become opportunities to use innovative ways of collecting large volumes of runoff and finding alternative uses aside from filtration and conveyance off site. It is important to utilize the stormwater collected and use it for agricultural purposes and greywater systems. With these measures there is a reduction in runoff and city water use. These BMP's were chosen based on the objective of containing large volumes of runoff for treatment and reuse.

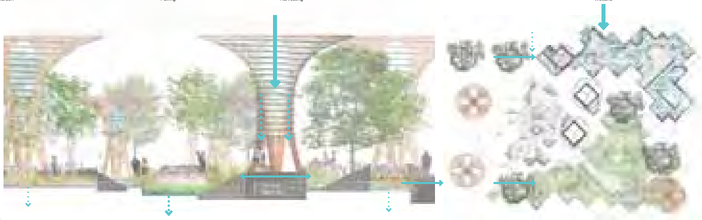




Treatment

Within our studies of Market Square and TVA it was discovered that the movement of stormwater makes contact with various pollutants from different types of typologies and surface types. It was important to intercept this runoff quickly to prevent the accumulation of different toxins. These detail illustrations of the ephemeral wetland breakdown they hydrological process and vegetated treatment of the different pollutants.





Vegetation

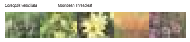
Native vegetation was selected based on two criteria. It's tolerance to inundation over an extensive period of time. Higher tolerance plants were placed within the lower marshes of the wetland, and less tolerant were placed in the high marsh locations. The other criteria was the plants ability to remove harmful pollutants from stormwater runoff.

Trees

Scientific name	Common Name
Carpinus caroliniana	Ironwood
Acer Rubrum	Red Maple
Betula Nigra	River Birch

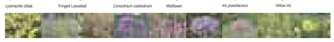
High Marsh Vegetation

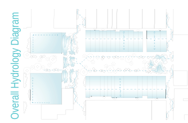
Scientific name	Common Name	Scientific name	Common Name
Elymus hystrix	Bottlebrush Grass	*Sporobolus heterolepis*	Prairie Dropseed
Solidago rugosa 'Fireworks'	Fireworks Goldenrod	*Echinacea tennesseensis*	Tennessee Coneflower
Coreopsis verticillata	Moonbean Threadleaf		

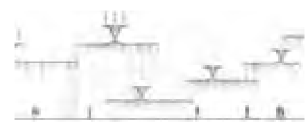


Low Marsh Vegetation

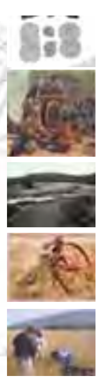
Scientific name	Common Name	Scientific name	Common Name	Scientific name	Common Name
Helenium autumnale	Autumn Sneezeweed	*Vernonia altissima*	Ironweed	*Monarda x media*	Purple Bergamot
Baptisia australis	Blue Wild Indigo	*Liatris spicata*	Blazing Star	*Carex spp.*	Sedges
Lysimachia ciliata	Fringed Looseleaf	*Conoclinium coelestinum*	Mistflower	*Iris pseudacorus*	Yellow Iris



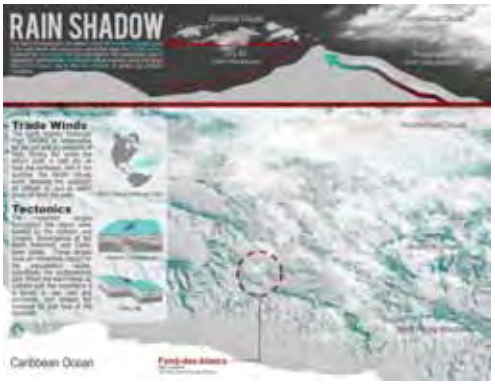


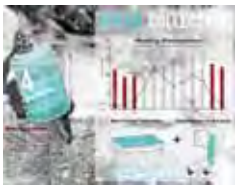


program and space dynamics

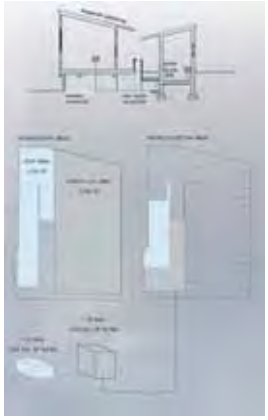



Agriculture Heritage Park: Hydrology


RAIN SHADOW
Trade Winds
Tectonics
Caribbean Ocean




CO-HABIT



Stormwater / rainwater Management