Environmental Impacts of Water Use, Water Conservation and Storm Water Management

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Oakland County Stormwater Summit

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Environmental Consulting & Technology, Inc.

Project Partners

Great Lakes Commission des Grands Lacs

ECT Environmental Consulting & Technology, Inc.

Alliance for Water Efficiency

Funded by:

Great Lakes Protection Fund

Project Goals

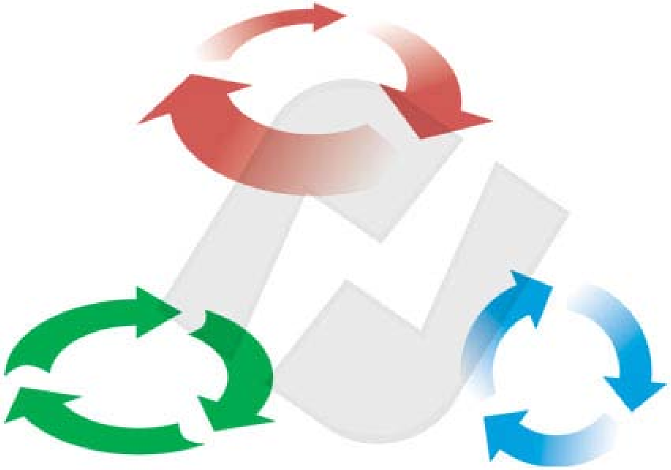
- Better understanding of environmental and financial implications of water conservation and green infrastructure projects for municipalities by testing in 6 municipalities
- Lessons learned shared with other municipalities
- Knowledge-transfer techniques set up to keep sharing occurring after project completion

Project Premises

- Integrated view of water system essential in decision-making that combines:
  - Water supply
  - Water conservation & efficiency
  - Storm water
  - Waste water
  - Green infrastructure
- Need to combine short- and long-term perspectives
- Need to combine environmental and financial perspectives
- One size does not fit all, but valuable lessons still can be learnt from other municipalities' experiences

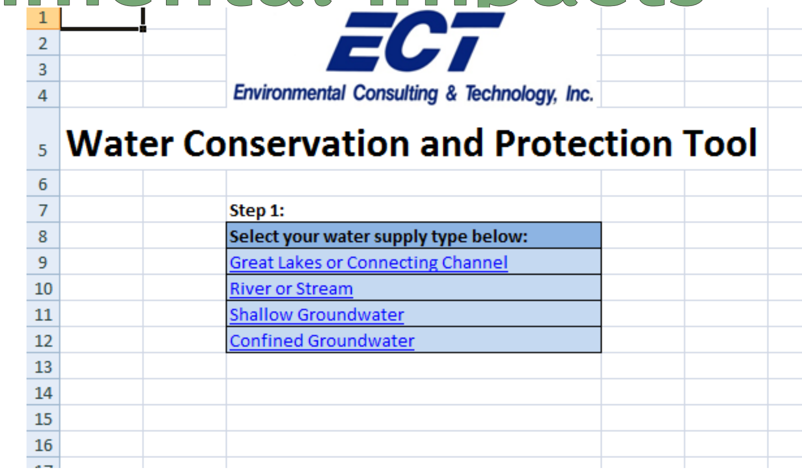
ECT Methodology

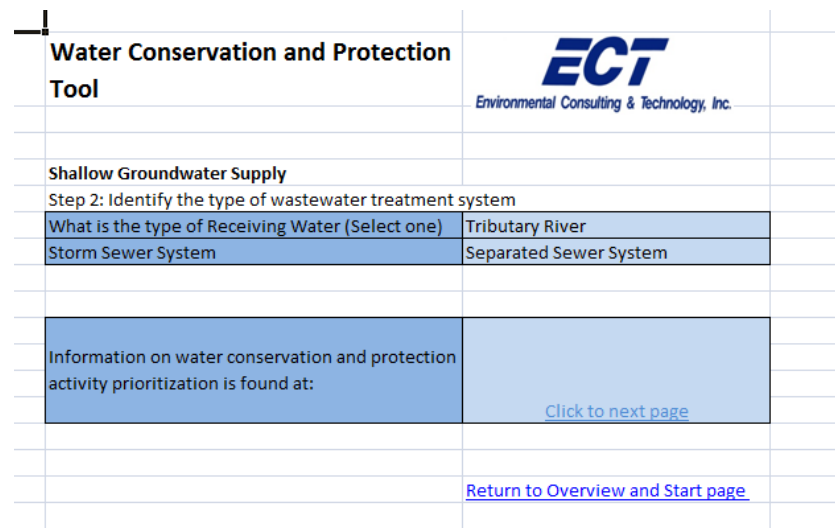
- Effects of withdrawals of same amounts of water have different impacts based on:
  - Source type (Great Lakes, shallow groundwater, confined groundwater, river)
  - Type of storm sewer system (combined or separated)
  - Stormwater management practices
  - Location of discharge for treated wastewater (stream, river, ground)
- Timing of environmental impacts differ based on location and factors listed above



Methodology: Environmental Impacts

- Used a tool developed for a project previously funded by the Great Lakes Protection Fund. Looks at the generalized impacts you could expect to see based on research of communities in the Great Lakes.
- Reviewed water use and wastewater impacts in each community.





	Water Supply Impacts	
	What is your water utility's unaccounted for flow (the amount of leakage from water mains)?	Less than 8%
	Do you have a formal leak detection program?	Yes
	Do you anticipate growth that will require expansion of your water withdrawal and treatment facilities?	Yes
	Are there other communities near yours that draw from the same water supply source?	Yes
	What best describes your outdoor water use restrictions?	No water use during daytime
	What approximate percentage of your community was built since 1994?	Between 51% and 84%
	Is there significant use of curb and gutter and impermeable pavement that directs water into a significant stormwater system?	Yes
	What type of development practices are required (or encouraged) in your community?	Conventional Development
	Have wetlands in the community largely been eliminated through infill for development?	Yes
	Wastewater and CSO Discharges	
2	Do you anticipate growth that will require expansion of your wastewater treatment facilities?	Yes
3	Has your wastewater utility treated 25% more water than the water utility pumped for public supply during any of the the last five years?	No
8	Does the treated wastewater to the receiving water provide additional flow that improves habitat by providing flow, particularly at low flow (for example, increasing levels, allowing for better fish passage)?	Not Sure/Not applicable
9	Are the bulk of nutrients in the stream caused by nonpoint source runoff?	Not Sure/Not applicable

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Water Conservation, Protection and Management Priorities	
Reduce water use demand	LOW-MED
Reduce Summer water use demand	LOW-MED
Sourcewater protection	MEDIUM
Stormwater management	MEDIUM
Replace hardscape with green infrastructure and permeable pavement	MEDIUM
Low Impact development and Conservation Design	MEDIUM
Leak detection program	CONTINUE PROGRA
Aggressive leak detection and repair	HIGH
Inflow and Infiltration reduction program	HIGH

Pumping from shallow groundwater sources can divert groundwater away from streams that previously contributed to base flow. Potential impacts include: some perennial streams (that flow ye round) becoming more intermittent and intermittent streams more ephemeral (flowing only during parts of a year). As stream flow is reduced from decreased water flowing to the stream, water quali could also decrease. Degradation of water quality, stemming from a reduction in base flow contribution, would be especially pronounced in streams that receive wastewater effluent. Wastewater discharges would provide base flow that may improve stream flow, however, if groundwater is drawn from a watershed that is different from the watershed where wastewater is discharged, one watershed would see a decrease in stream flow, while the other would see a decrease. This would alter hydrology that would also impact plants and the types of plants on the ground, wetlands, as well as fish and other aquatic habitat.

Shallow groundwater water sources are also more susceptible to drought as the water table is sensitive to changes in rainfall and snowmelt. In times of drought, the availability of water is decreased, impacting public water supply and forcing it to compete more with ecological resources that also depend upon the groundwater. The impacts can also be increased in areas where rainfall and snowmelt are diverted through piped storm water systems away from the ground and directly into streams. It decreases the amount of water that would otherwise go to recharge groundwater sources that support public water supplies as well as ecological resources.

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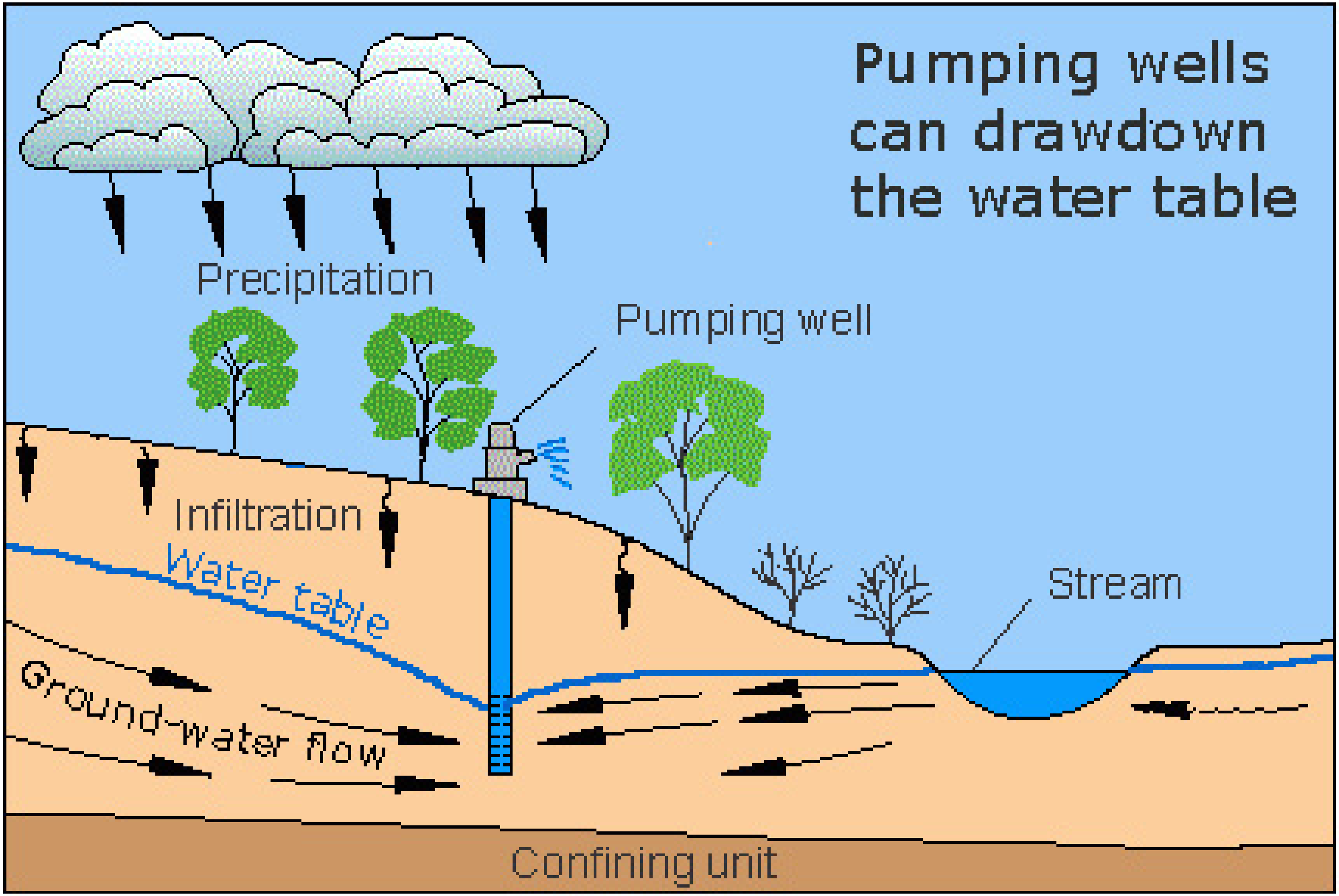
Polluted storm water runoff is commonly transported through Municipal Separate Storm Sewer Systems (MS4s), from which it is often discharged untreated into local water bodies. Storm water runoff is generated when precipitation from rain and snowmelt events flows over land or impervious surfaces and does not percolate into the ground. As the runoff flows over the land or impervious surfaces (paved streets, parking lots, and building rooftops), it accumulates debris, chemicals, sediment or other pollutants that could adversely affect water quality if the runoff is discharged untreated. The primary method to control storm water discharges is the use of best management practices (BMPs). In addition, most storm water discharges are considered point sources and require coverage under an NPDES permit. Diversion of storm water from the ground decreases recharge of

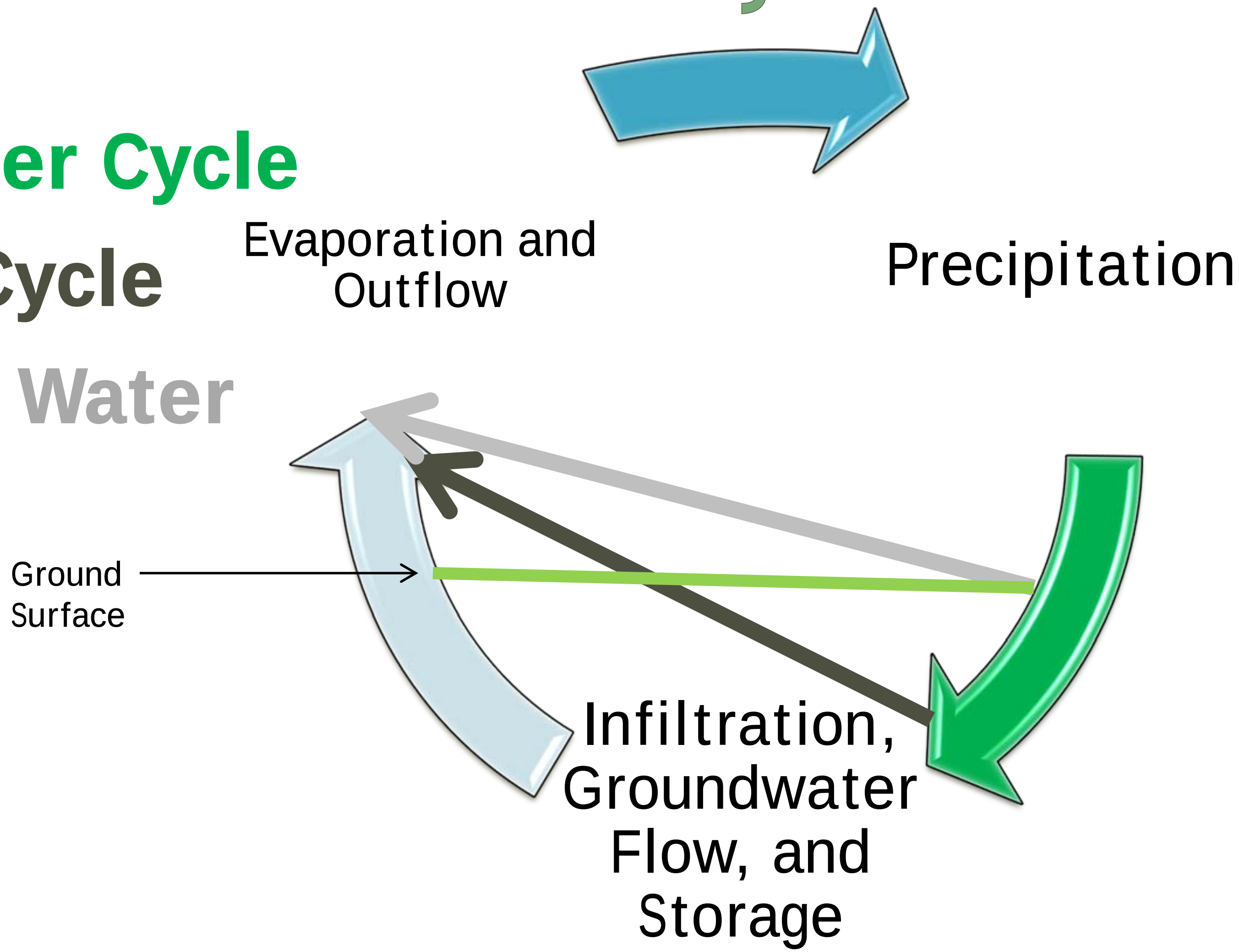

Pumping wells
can drawdown
the water table
Precipitation
Pumping well
Infiltration
Water table
Stream
Ground-water flow
Confining unit

The Three Water Cycles

Natural Water Cycle

Water Use Cycle

Interrupted Water Cycle



The Three Water Cycles

Natural Water Cycle

The natural continuous movement of water on, above, or below the surface of the earth.

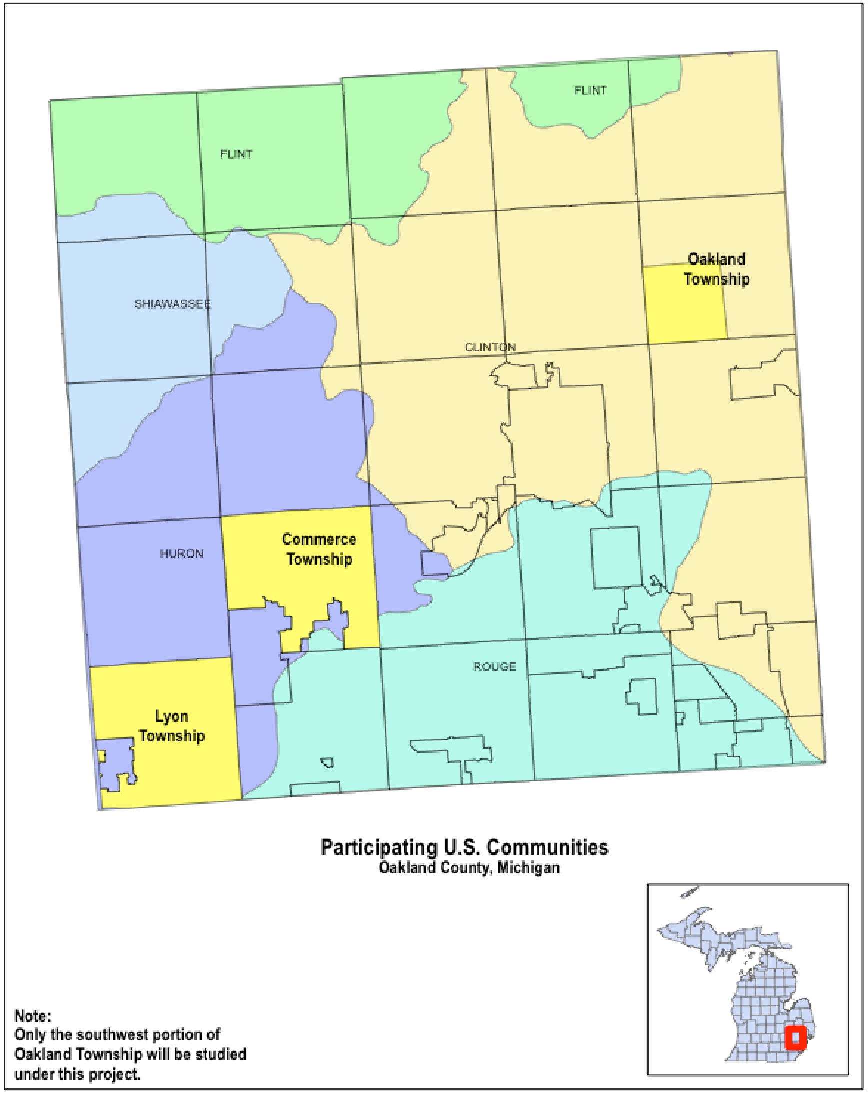
Water Use Cycle

The flow of water drawn for human use, undergoing pipe flow, treatment and distribution.

Interrupted Water Cycle

Precipitation and snow melt is directed to storm sewer systems via impervious surfaces.

The Michigan Municipalities



The Water Use Cycle

- Protect Water Recharge
- Protect Sourcewater
- Reduce Impacts of Water Use Withdrawal

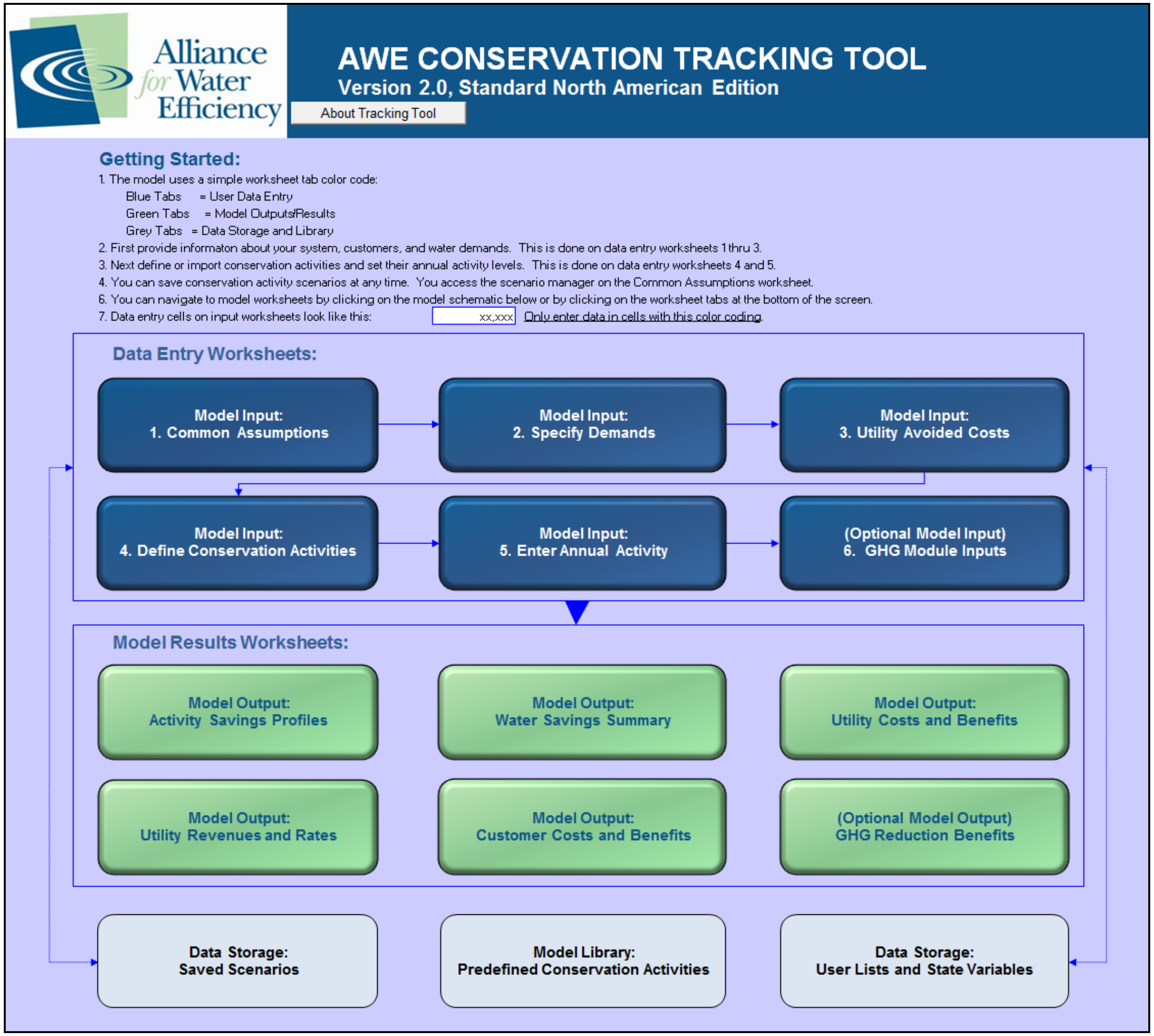
Factors that dictate water use impacts

- Type of water supply used
- Local hydrology
- Development patterns
- Upstream water use
- Storm water management design
- Wastewater discharge location

Different Water Sources Cause Different Impacts

- What are the impacts if 1 MGD of water is withdrawn from…
  - A Great Lake?
  - A groundwater aquifer?
  - A river source?

AWE Analyzed the Costs and Benefits of Efficiency Programs for Six Communities



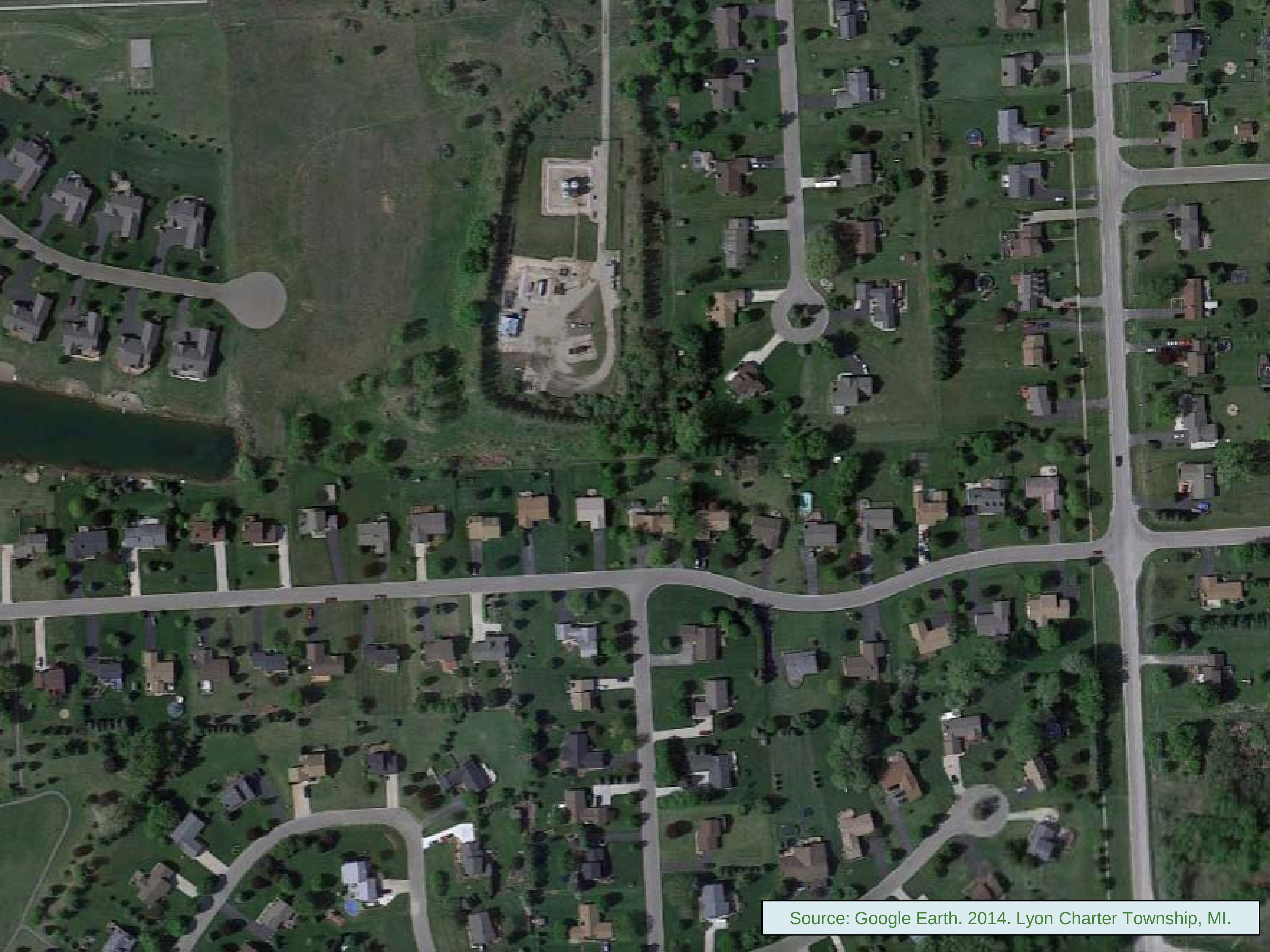
Components of AWE Tracking Tool Analysis

Inputs

- Demographic data
- Weather data
- Customer rates
- Water demand
- Avoided costs
- Efficiency programs
- Energy use

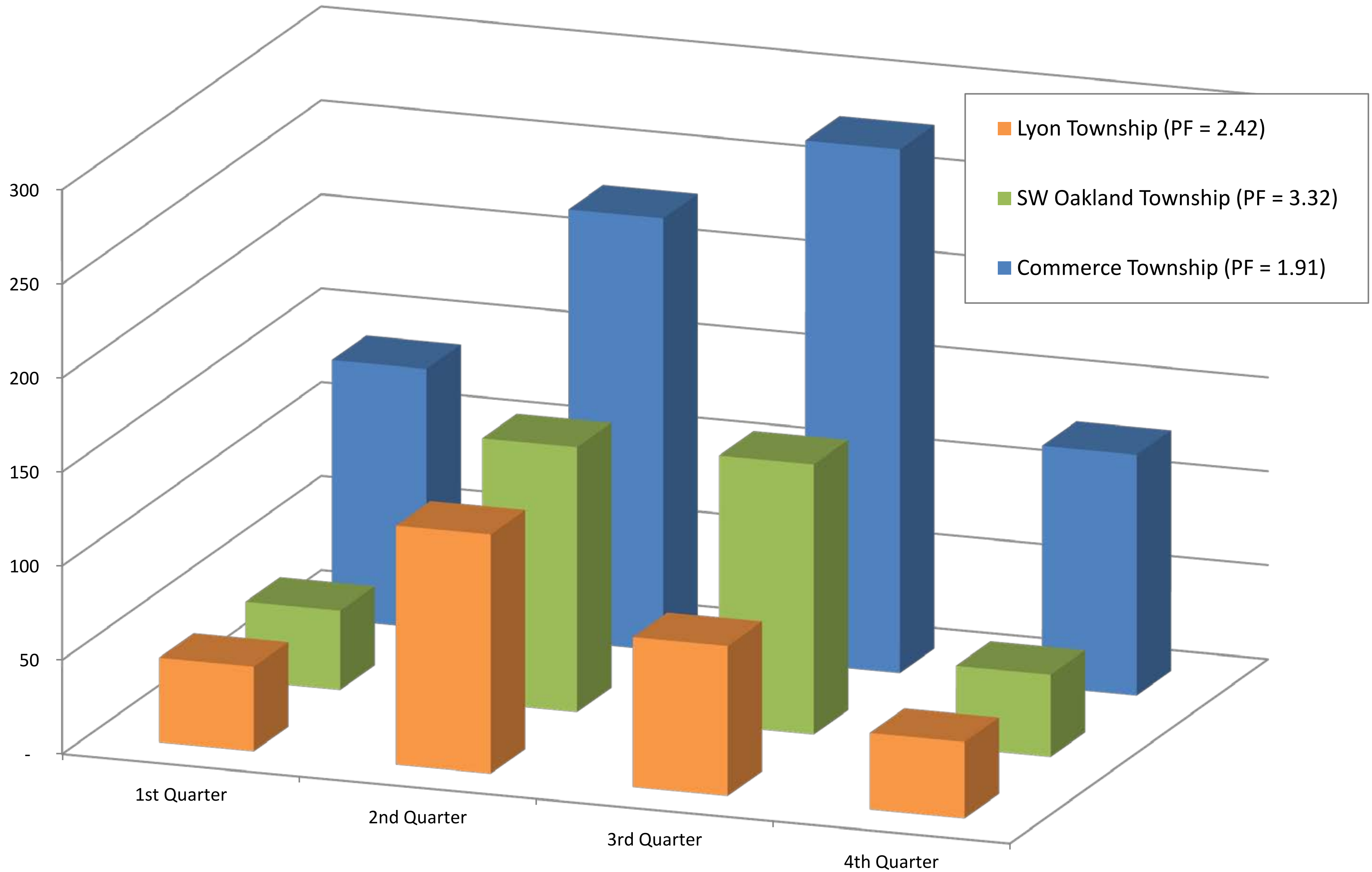
Outputs

- Water savings
- Costs and benefits
- Impact to revenue and rates
- Energy and emission reductions



Source: Google Earth. 2014. Lyon Charter Township, MI.

2010 Total Water Consumption by Quarter (MG)



Why is Commerce Township's Peaking Factor the Lowest?

Possible reasons:

- Smaller lot sizes
- Older housing stock may = less automatic irrigation systems
- Higher water rates
- Commerce has outdoor water use restrictions
  - Odd/Even alternate days + time of day restrictions

Commerce Charter Township, (Oakland Co.), Michigan, Code of Ordinances Sec. 40-169. - Outdoor water use restrictions.

Water Efficiency Programs Evaluated

Toilet replacements

- Replace 3.5 gpf toilets with WaterSense labeled toilets.
- Require the replacement of all 3.5 gpf toilets in participating homes.

Residential Clothes Washers

Residential Efficient Irrigation Nozzles

Residential Irrigation ET Controllers

Residential Soil Moisture Sensors

Large Landscape Surveys

Large Landscape Irrigation Controllers

Cost-Benefit Analysis

	Commerce		Lyon		SW Oakland	
Activity Name	**NPV ($)**	**B/C Ratio**	**NPV ($)**	**B/C Ratio**	**NPV ($)**	**B/C Ratio**
Residential HE Toilets	$ 2,580,634	13.57	$ 28,304	1.42	$ 90,117	2.29
Residential HE Washer	$ 132,070	2.84	$ (10,400)	0.45	$ (5,642)	0.71
Residential Efficient Irrigation Nozzles	$ (2,205)	0.51	$ (3,996)	0.09	$ (4,100)	0.09
Residential Irrigation ET Controller	$ 7,781	1.22	$ (27,862)	0.20	$ (28,419)	0.21
Residential Soil Moisture Sensor	$ 74,341	3.08	$ (10,624)	0.69	$ (6,126)	0.83
Large Landscape Surveys	$ 138,919	4.27	$ (10,539)	0.74	$ (9,602)	0.77
Large Land. Irrigation Controller	$ 424,741	3.94	$ (50,457)	0.64	$ (48,320)	0.66
Total	**$ 3,356,282**	**7.22**	**$ (85,575)**	**0.75**	**$ (12,091)**	**0.97**

Components of Successful Landscape Water Efficiency Programs

- Target high irrigation users
- Educate contractors and customers
- Follow-up to assess water savings
- Follow-up to ensure equipment is programmed and functioning properly
- For turf that is not replaced with native plants or other options, maintain turf quality

Strategies Beyond Water Conservation Programs

- Rate design
- More frequent billing
- Education
- Ordinances and codes
- Requirements for new development
- Watering restrictions
- Irrigation professional certification

The Interrupted Water Cycle

- Impacts of groundwater recharge
- Impacts of pushing water into streams
  - During rain events
    - Downstream flooding
    - Greater volumes and velocities of water going through streams
  - On times when there are droughts
    - Less baseflow going to streams from groundwater because had been pushed into streams
    - Lower stream flows and volumes
    - Greater likelihood of contaminants being pulled off of roadways

Broad vs. Concentrated Impacts of Stormwater

- Rain falls over a broad, large scale surface area.
- Water is pumped from wells – impact is concentrated in that specific area.
- When water falls on pavement, water is moved from a wider area and discharged to specific concentrated locations in a stream.

Groundwater Withdrawals

- Divert groundwater away from streams that previously contributed to base flow
- Decrease water quality as stream flow is reduced
- Decrease water available to surface ecology
- Lead to increased impacts during times of drought
- Pull water from surface water sources to recharge aquifers

Great Lakes Surface Water Withdrawals

- No measureable impacts on lakes
- Impacts associated with urbanization, not withdrawal
- Water that would flow into terrestrial habitats or wetlands now flows into storm sewers
- Upstream urban and Agricultural runoff
- Water use increases in summer. Water has to move approximately 90 miles from Lake Huron to Commerce Township to water lawns

Urbanization Impacts

- More impervious surfaces
- More debris in runoff
- Less natural infiltration
- Increasing storm sewer and POTW flows
- Blacktop temperatures
- More CSO's
- In already heavily developed areas of Oakland County, stream flow altered
  - Higher high flows and lower low flows
  - Need to take into account in developing areas

Runoff Gallons per Road Mile

Cover Type	Soil Type	Area (sf)	Area (ac)	Runoff Volume, V (ft^3)	Runoff Volume (gallons)	Yearly Average Volume (gal)
Assuming D Type Soils						
Roadway	D	126,720	2.9091	8,352	62,473	1,360,946

- 1-inch Rain
- 24 Foot Wide Road
- 1 mile long
- Does not include parking lots or runoff from land adjacent to roads

How much water runs off of a 1 mile road, 24 feet wide?

- Assuming a 1 inch rain event, approximately 400 Million Gallons of water runs off from impervious surfaces alone.
- All roads in Oakland County generate well over 10 billion gallons of runoff per year – just the roads
- Does not include parking lots, water flowing to roads
- Does not address all of the multilane highways

Rooftop Capture

- What size of cistern would capture rooftop runoff? (A 1250 square foot roof generates over 600 gallons of water in a one inch rain)
- Can the water be reused?
- Can it be released at later times to enter the system?

Volume of Water Falling on a Roof

Cover Type	Area (sf)	Area (ac)	Runoff Volume, V (ft^3)	Runoff Volume (gallons)	Yearly Average Volume (gal)
Assuming D Type Soils					
Pavement and Rooftop	1,250	0.0287	82	616	13,425

- 1 inch rain
- 25 x 50 foot roof (1250 sq. ft.)

Recharge and Projecting Water Use Reductions

- Main recharge occurs primarily in winter snow melt and spring rains
- Summer rainfall more likely to evaporate off the surface
- Need to look at spring rainfall and impact on groundwater levels
  - Anticipate lower groundwater levels during main outdoor watering season
  - Provide public education on potential need for outdoor watering reductions

The Cost and Value of Green Infrastructure

Management Practice	Proposed Area (ac)	Area (sf)	Volume Captured (cf)	Volume Captured (gal)	Cost: Volunteer	Cost: Contractor
Urban Reforestation	1.00	43,560	33	246	$ 62,495	$ 110,637
Forest Retention**	1.00	43,560	6,394	48,474	$ 54,784	$ 111,998
Wet Meadow	10.00	435,600	435,600	3,258,724	$ 796,413	$ 796,413
Native Prairie	10.00	435,600	294	2,197	$ 274,616	$ 291,101
Agriculture	10.00	435,600	294	2,197	$ 264,473	$ 280,968
Raingarden	1.00	43,560	24,684	184,661	$ 301,220	$ 772,900
Bioswales**	5,000.00	<----- Enter desired linear feet				
	2.41	105,000	105,000	785,505	$ 216,058	$ 216,058
Totals	**35.41**	**1,542,480**	**572,298**	**4,282,003**	**$ 1,970,059**	**$ 2,580,076**

** Contractor Only

*** Assume 1" storm, D class soil

Capital costs to build a 4,282,003.10 gallon conventional retention facility:

Cost per gallon	**$ 3.22**	**Total cost**	**$ 13,795,385**
Maintenance Costs per gallon over 20 years	**$ 2.15**	**Total cost**	**9,196,923**
		Total cost	**22,992,308**

Treatment Cost Savings Analysis

Total Projected Treatment and Chemical Savings	**$ 3,583**

Estimated Power Savings

Cost of Energy (per KWH)	$ 0.074
Total kWh Saved	**146,864**
Total Projected Power Savings	**$ 10,868**

Summary of Lessons Learned for Decision-Making

- Need to take integrated water system approach to planning
- Need to combine both water supply and water management in planning
- Central part of solution is a combination of water conservation/efficiency and green infrastructure programs

Knowledge Transfer Tools

- Great Lakes Commission Knowledge Transfer Site
  - http://glc.org/projects/water-resources/water-mgmt/
- The AWE Water Pricing Tool
  - http://www.allianceforwaterefficiency.org/tracking-tool.aspx
- The ECT Water Resource Planning Tool
  - Identify starting points for developing water effective conservation plans and strategies
- Municipality Guidance

Tools

- Alliance for Water Efficiency Water Use Tracking Tool (Available for AWE members)
- Alliance for Water Efficiency Rate Scenarios Tool (Free online)
- Water Conservation Planning Tool (ECT developing for this project)
- Green Infrastructure impacts estimating and costs tools (ECT)

Water Conservation

- Water Conservation Options
  - Outdoor water use education
    - How often do lawns need to be watered
    - When are the best times of day for the lawn and overall water management
  - Outdoor water use ordinances
    - Time of day
    - Number of times per week
- Taking residential rainwater harvesting beyond the rain barrel
- Explore integrated decentralized rainwater harvesting and runoff control system model project

Stormwater

- Stormwater Management Plans
  - Encouraging more green infrastructure
  - Target broader implementation in specific areas
- Wellhead protection in areas that do not have it
- Green infrastructure model design for participating communities
  - Small rain gardens of about 30 square feet can capture about 150 gallons in a one inch rain
  - 50 in an area captures a total of 7500 gallons of runoff
  - Keeps more water off the streets
- Rain barrels and cisterns
  - Managed systems that can automatically empty before a rain
  - How much water can you hold in a rain?

Thank You

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