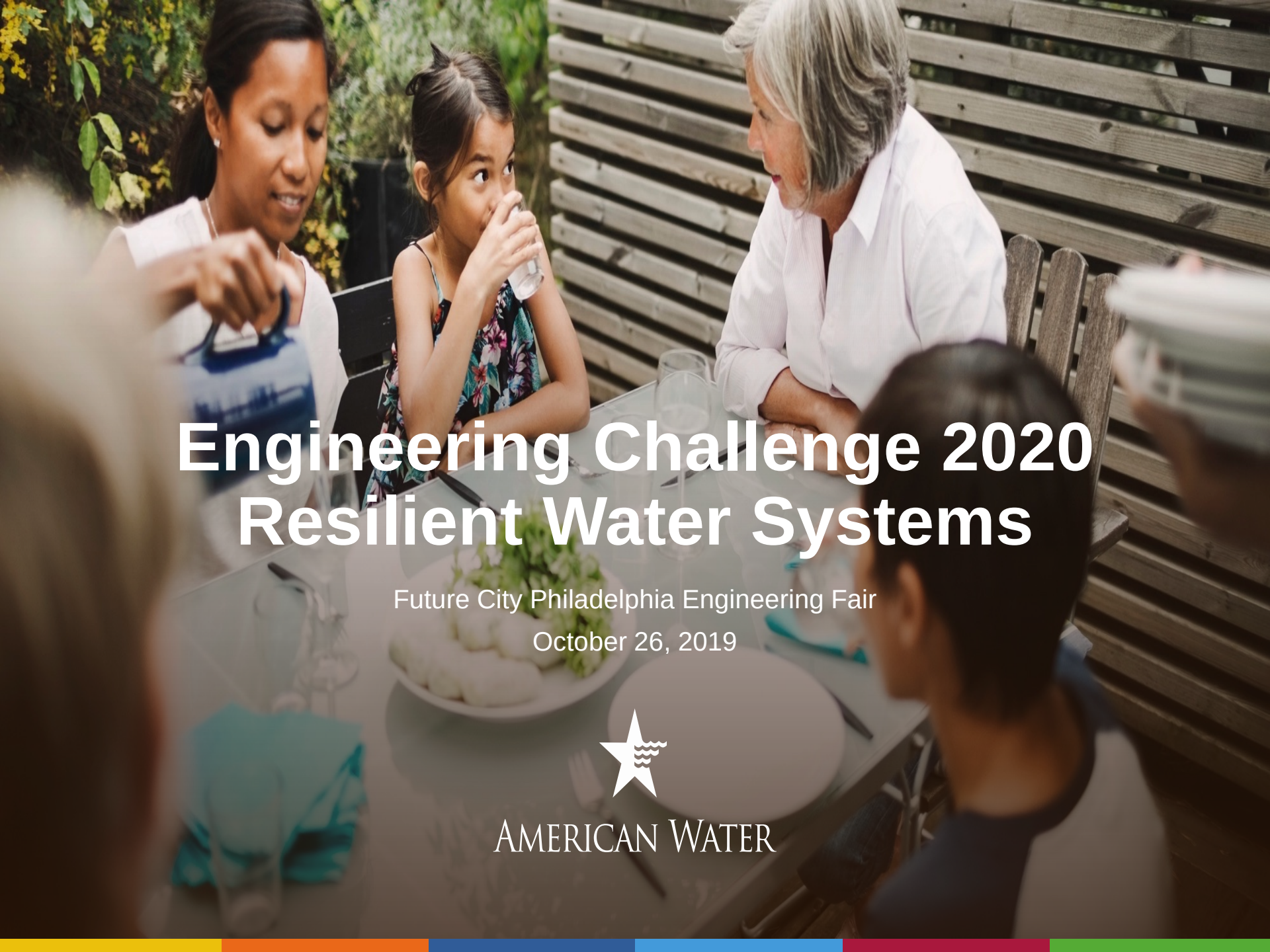


Engineering Challenge 2020
Resilient Water Systems

Future City Philadelphia Engineering Fair

October 26, 2019

AMERICAN WATER

Why is Water Important to You and Your City?

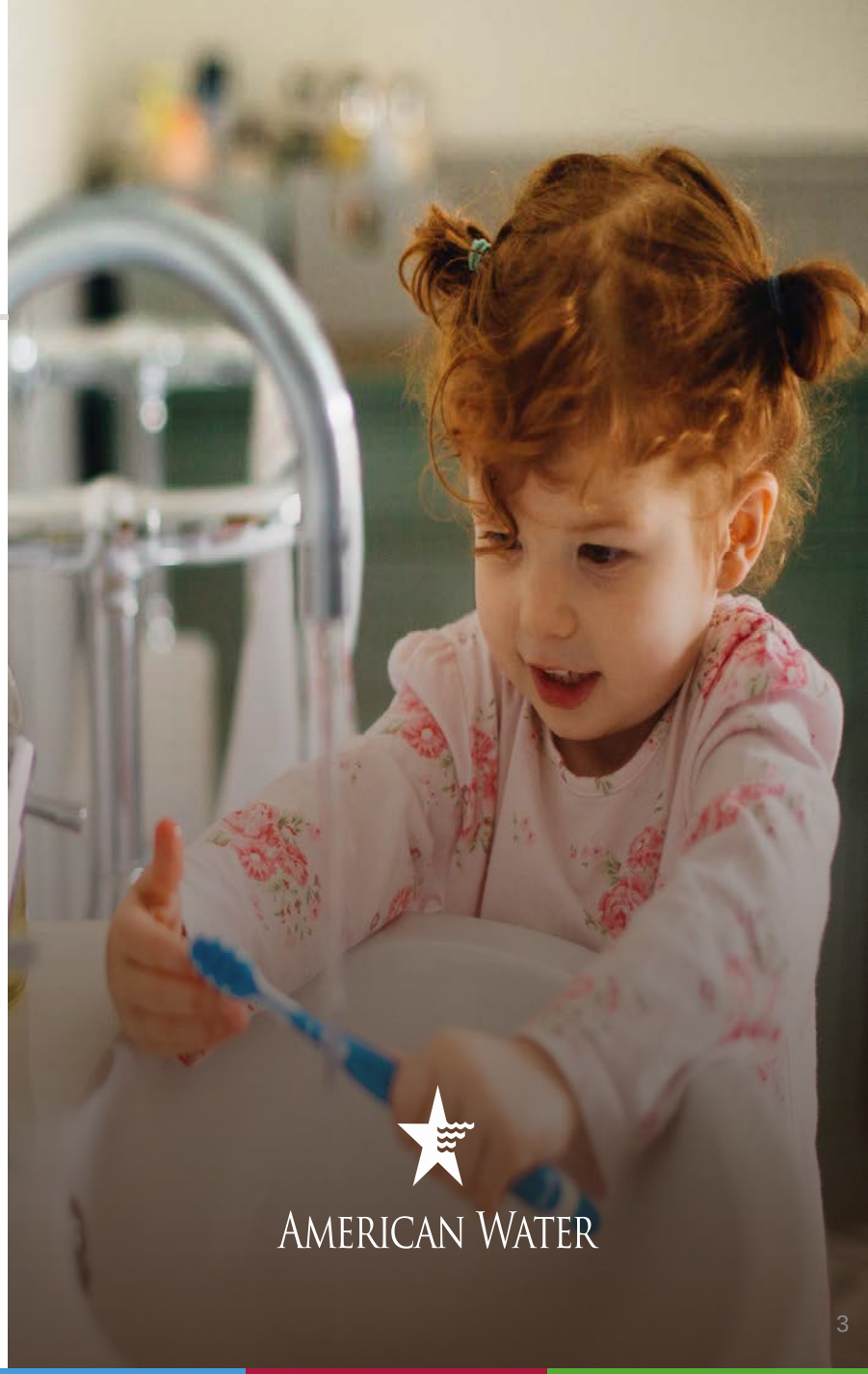
https://youtu.be/tuYB8nMFxQA

Water Keeps Life Flowing

Everyday
- Drinking
- Cooking
- Brushing teeth
- Bathing
- Flushing toilets

Recreation
- Swimming
- Water balloons
- Sprinklers

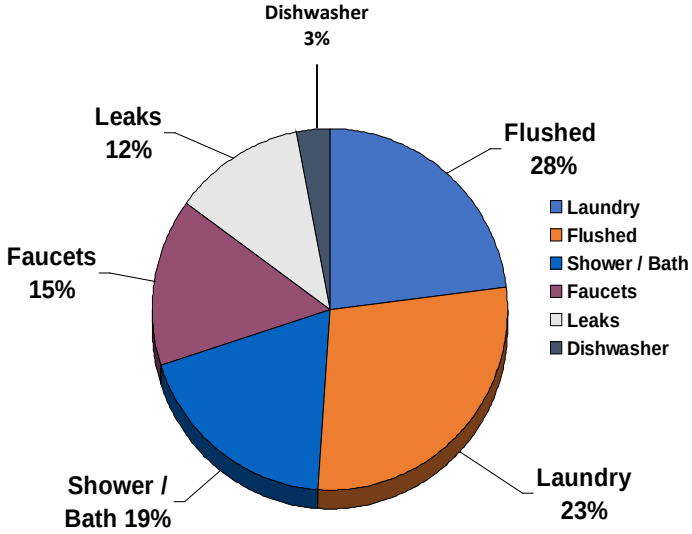
Work
- Doing laundry
- Washing dishes
- Giving the dog a bath



How Much Water Do We Use

Old vs. New Plumbing Fixtures and Indoor Appliances

Type of Use	Pre-Regulatory Flow*	New Standard	Year Effective
Toilets	3.5 gpf 	1.6 gpf 	1994
Clothes washers	41 gpl 14.6 W.F 	26.6 gpl 9.5 W.F 	2011
Dishwashers	14.0 gpc 	4.5 gpc to 6.5 gpc 	2010
Commercial pre-rinse spray valves (PRSVs)	2 gpm to 6 gpm 	1.6 gpm 	2006



ABBREVIATIONS USED
gpf - gallons per flush
gpl - gallons per load
W.F - Water factor or gallons per cycle per cubic feet capacity of the washer
gpc - gallons per cycle

* Average flows for the period 1980-1990 (except for clothes washers), Source: *Handbook of Water Use and Conservation*, Amy Vickers, May 2001

How much water does a person consume daily?

- 2 ½ Quarts

(all sources)

Water is Essential for Communities

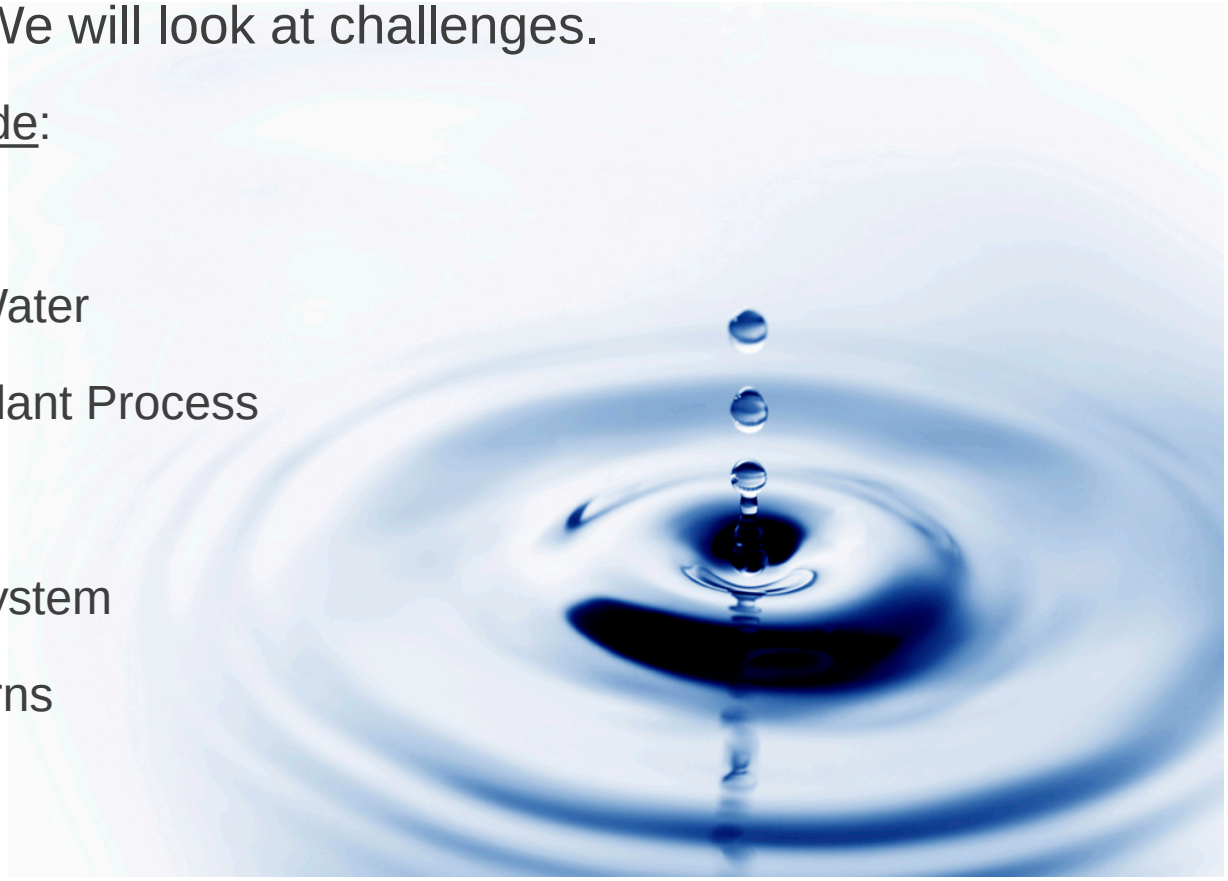
- Fighting fires
- Hospitals and healthcare
- Economic development
- Growing crops

Your Challenge: Resilient Water System

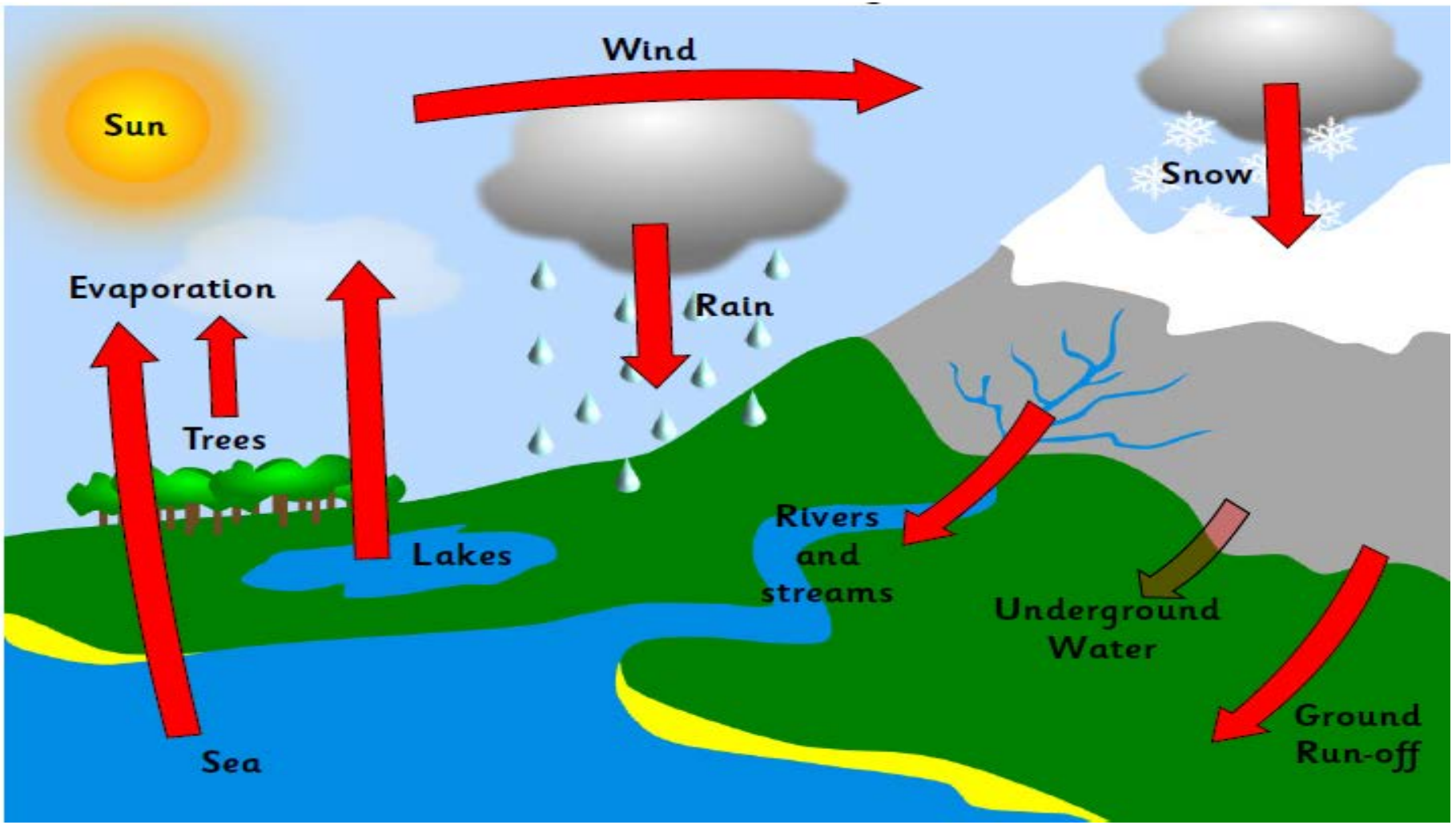
First, understand how a water purveyor obtains, treats and delivers water to customers. We will look at challenges.

Areas of focus include:

- The Water Cycle
- Types of Source Water
- Basic Treatment Plant Process
- Water Quality
- The Distribution System
- Big Picture Concerns



Water Cycle... *also referred to as The Hydrologic Cycle*

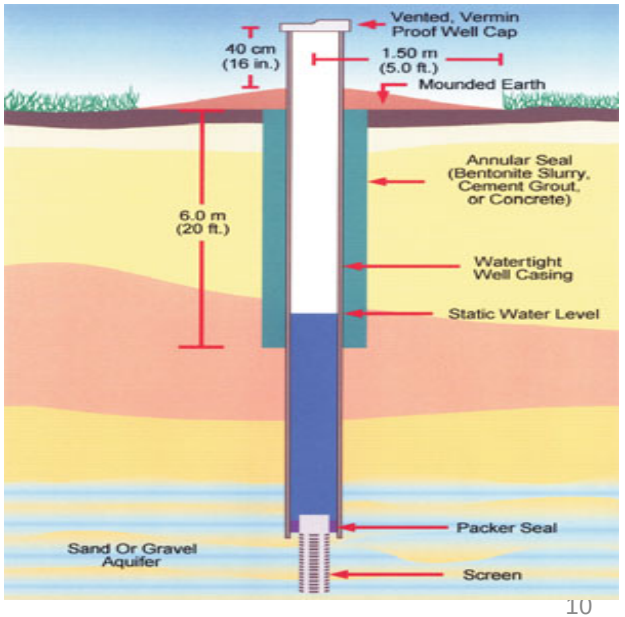


Challenge 1: Water Availability

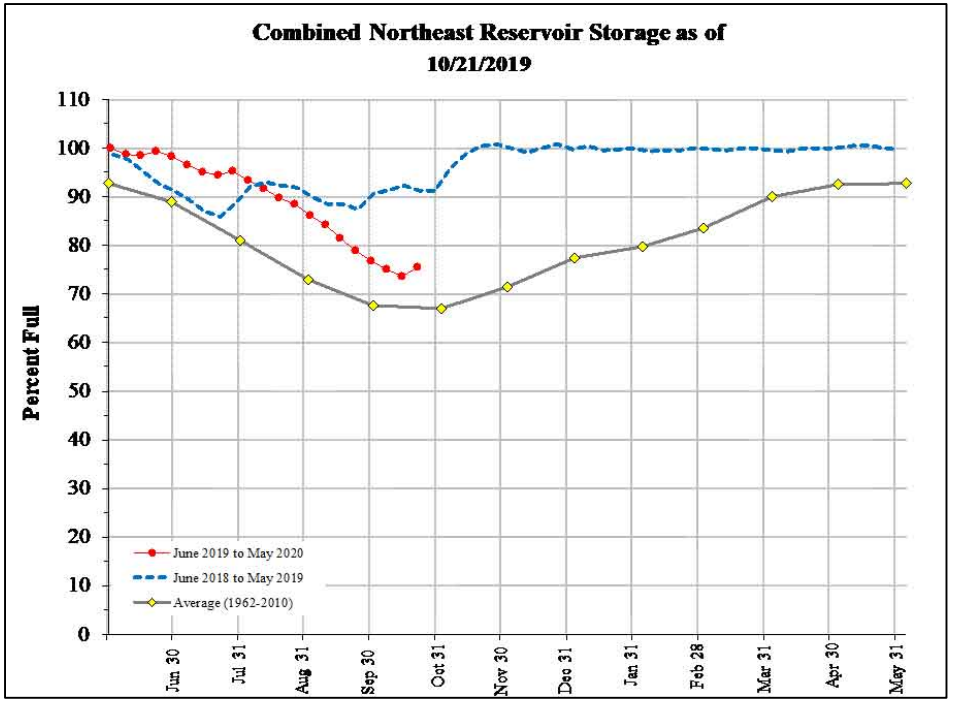
- **About 70% of the earth's surface is covered with water**
- **97% of the earth's water supply is salt water**
- **2% of the water on earth is glacier ice at the North and South Poles.**
  - It is too far away from where people live to be usable.
- **Less than 1% is fresh water!**

Sources of Water

- Surface Water
  - Rivers, Streams, Lakes
  - Reservoirs
- Ground Water
  - Aquifer
  - Artesian Aquifer
- Reclaimed / Reuse Water
  - Non Potable Uses (irrigation, building toilets)
  - Space Station



Drought Monitoring (streamflow and reservoir levels)



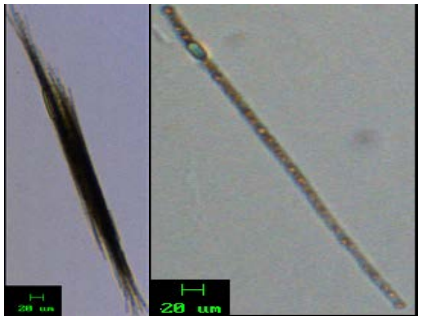
NEW JERSEY
Regional Drinking-Water-Supply Indicators & Declared Water-Supply Status — **October 6, 2019**

Region	Drinking-Water-Supply Indicator: Status	90-day precip-itation	90-day stream-flow	N.J. reser-voirs	Del. R. reser-voirs	Unconf. ground water	Water-Supply Status
North-west	Near or above normal		●	●	●		Normal ●
	Moderately dry	2				2	Watch
	Severely dry						Warning
	Extremely dry						Emergency
Central	Near or above normal		●	●	●	●	Normal ●
	Moderately dry	2					Watch
	Severely dry						Warning
	Extremely dry						Emergency
North-east	Near or above normal	25	●	●	●	●	Normal ●
	Moderately dry						Watch
	Severely dry						Warning
	Extremely dry						Emergency
South-west	Near or above normal		●	●	●	●	Normal ●
	Moderately dry	2					Watch
	Severely dry						Warning
	Extremely dry						Emergency
Coastal North	Near or above normal			●	●	●	Normal ●
	Moderately dry	2	0				Watch
	Severely dry						Warning
	Extremely dry						Emergency

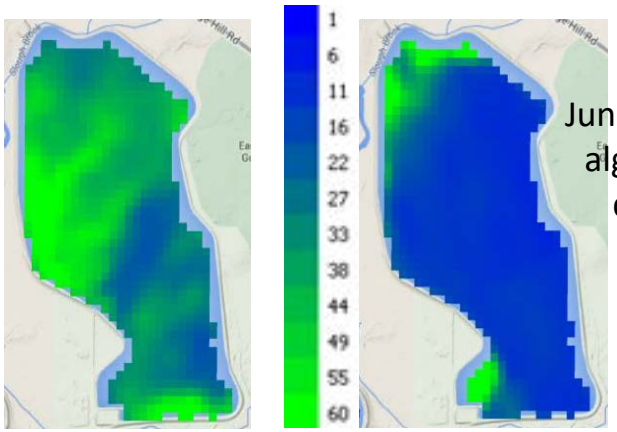
Not a significant region-wide water resource.

Algae & Smarter Reservoir Management

- Solar powered buoys measure algal pigments, dissolved oxygen, pH
- Adjustable ultrasonic frequency to target different algae
- Units can help to prevent algal blooms



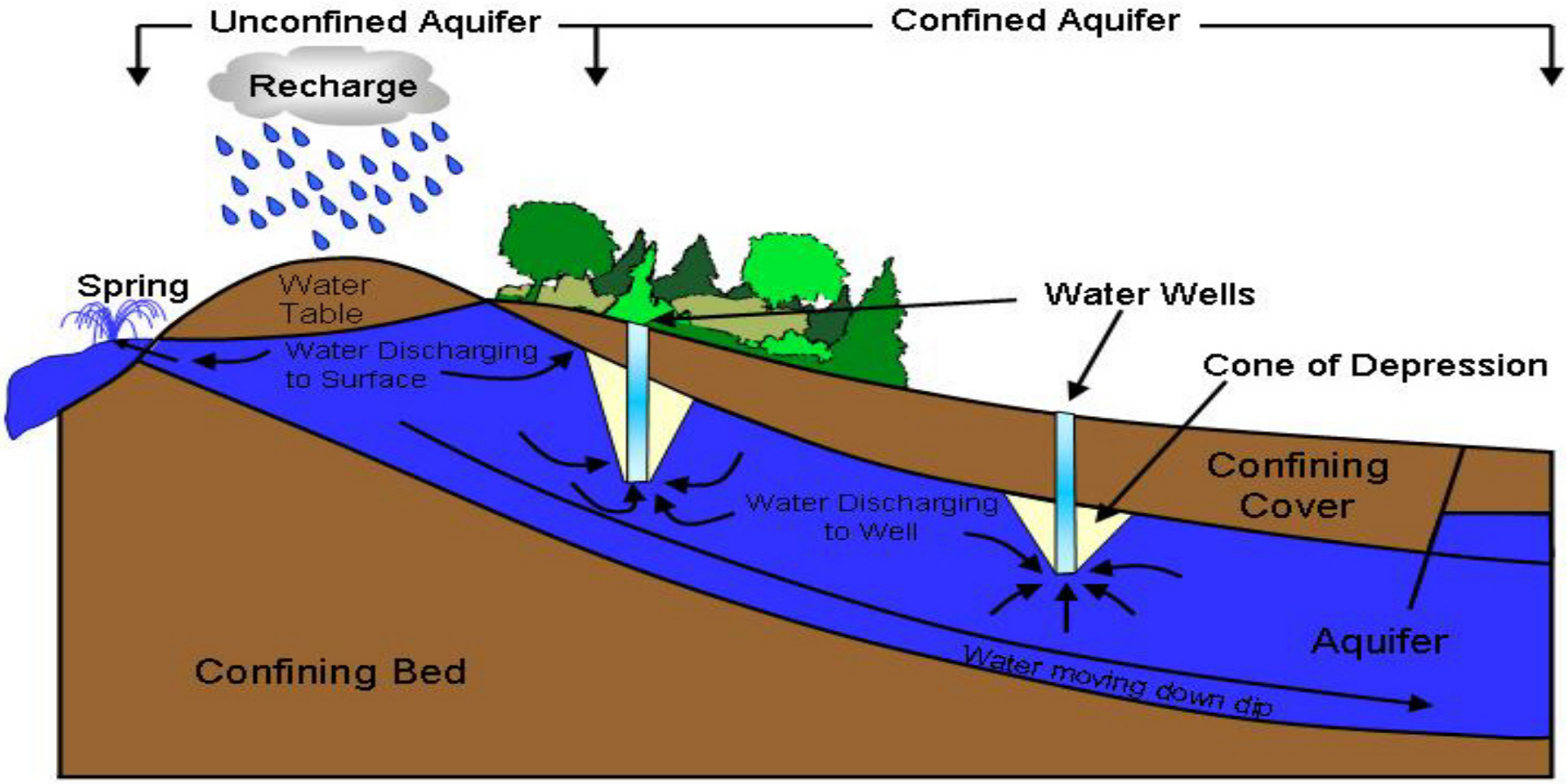
June 2013 before



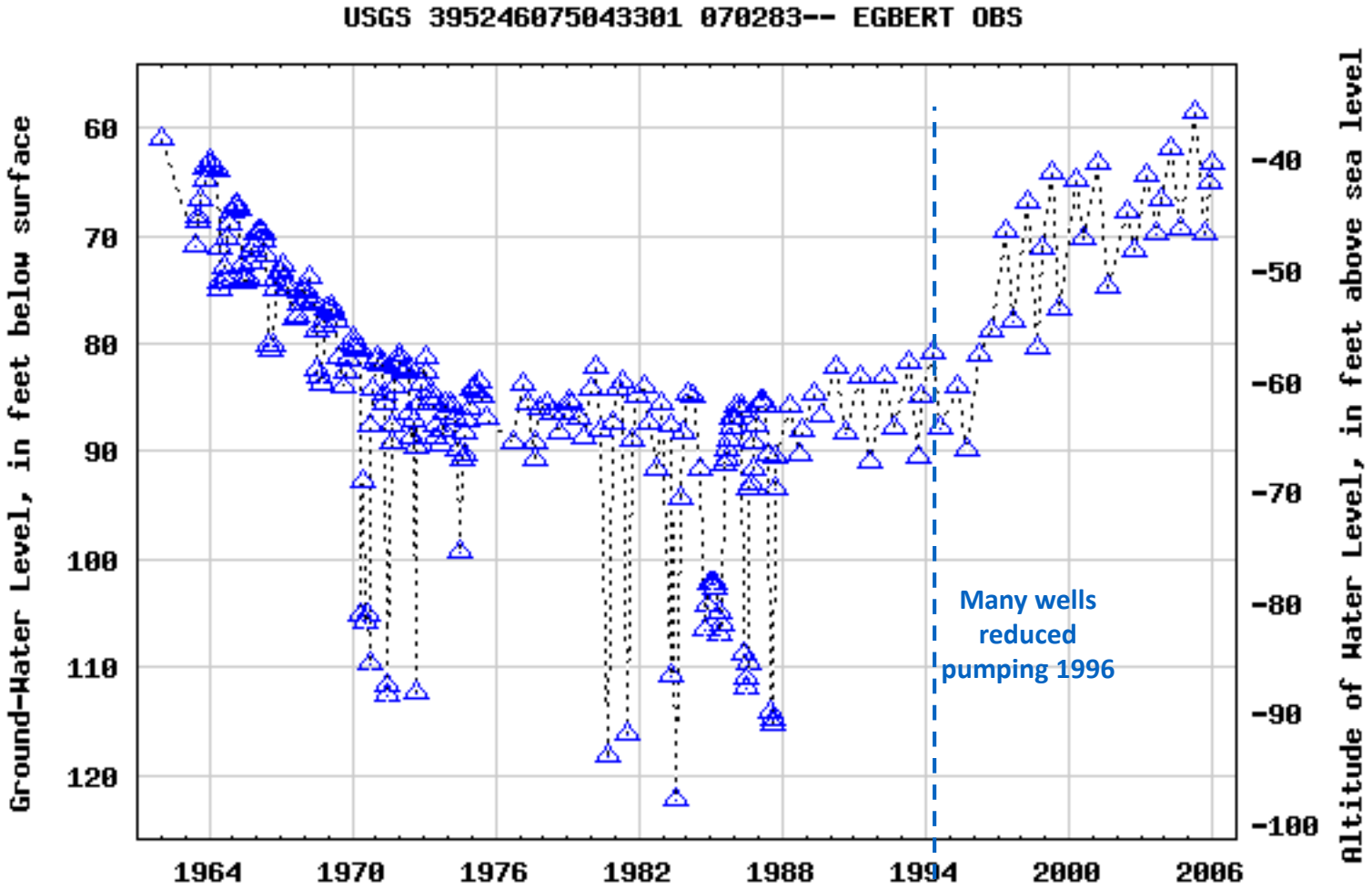
June 2014 after algae control deployed

Ground Water - Aquifer

- A natural underground layer of porous water bearing material capable of yielding water.

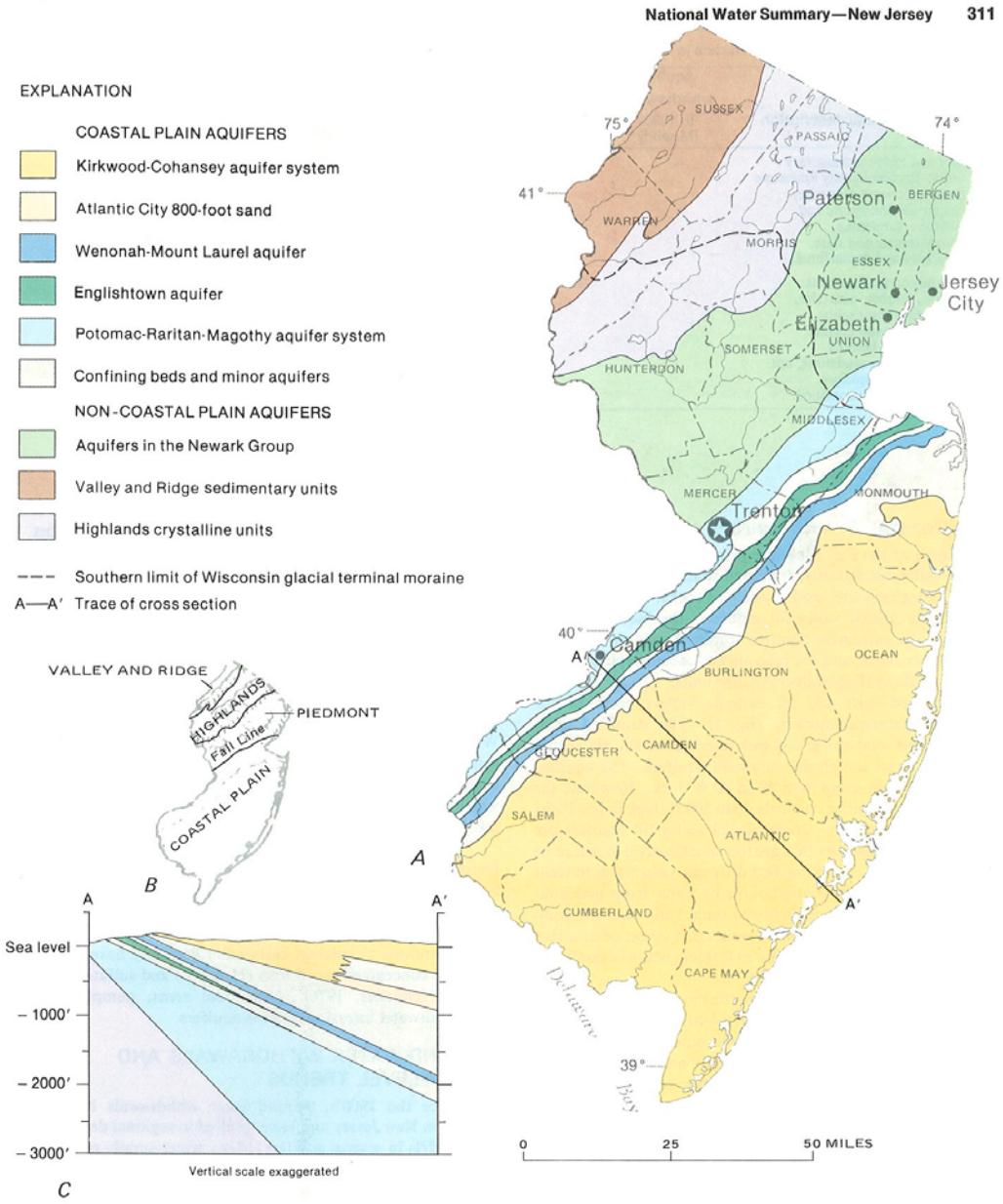


Aquifer Water Levels Decline if Pumping > Recharge from Streams and Rainfall



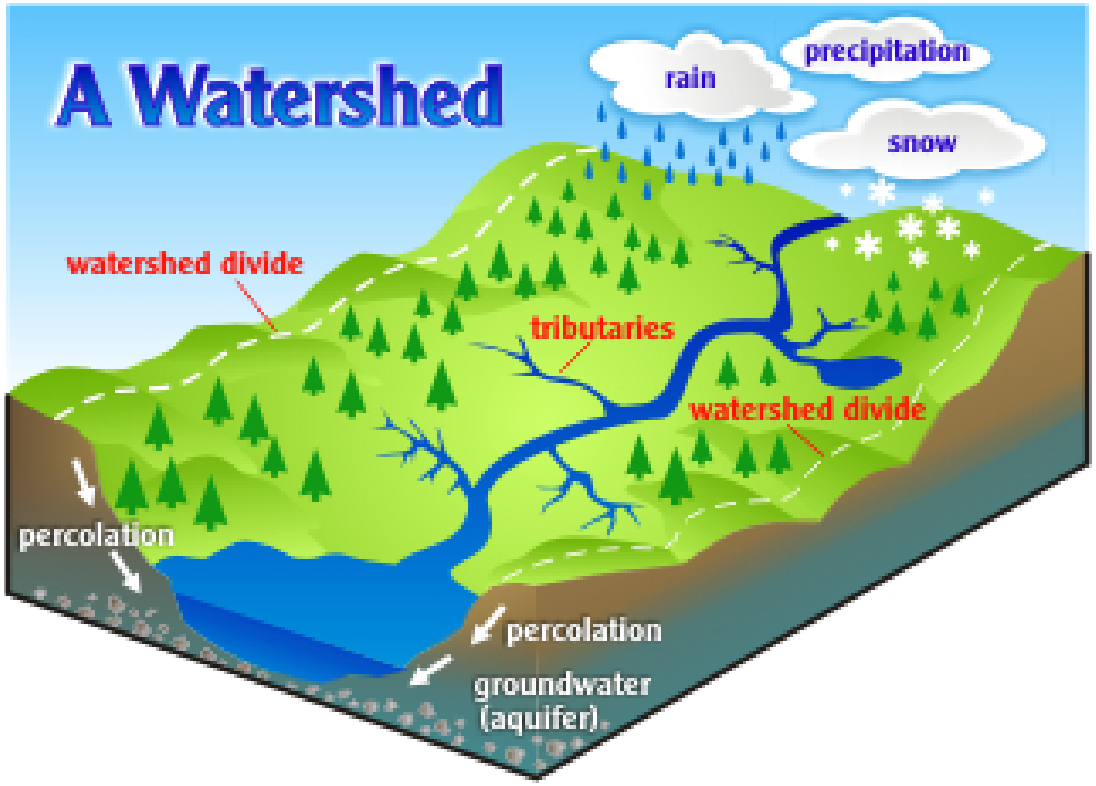
Example of Mapping of Aquifers

(USGS.com)



Challenge 2: Protect Water Quality in Watershed

Definition: an area of land that drains water



Source Water Quality & Monitoring

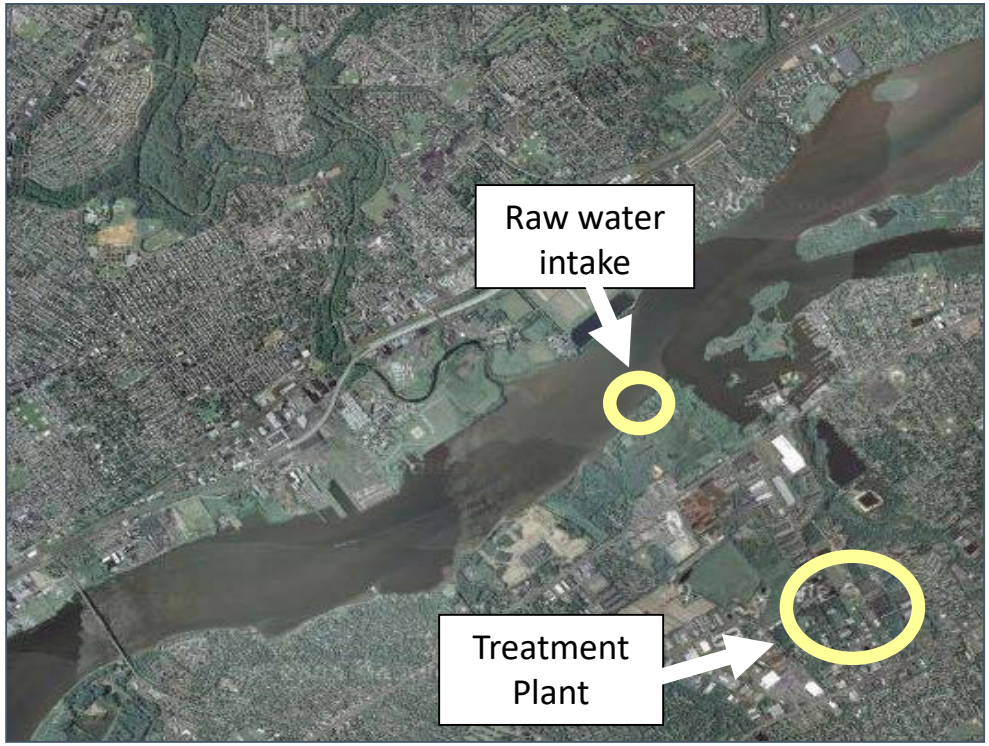
- Naturally Occurring
  - Biological (pathogens)
    - Microbes
    - Viruses
    - Bacteria
  - Chemical
    - Metals such as Iron, Manganese
    - Arsenic
- Man Made
  - Inorganic / Organic
  - Agricultural (nitrates, fertilizers)
  - Petroleum products
  - Pharmaceuticals
  - Personal care products
  - River spills from vessels
  - PFAS chemicals
  - MTBE chemical
  - Road salt

Challenge 3: Meet Treatment Objectives

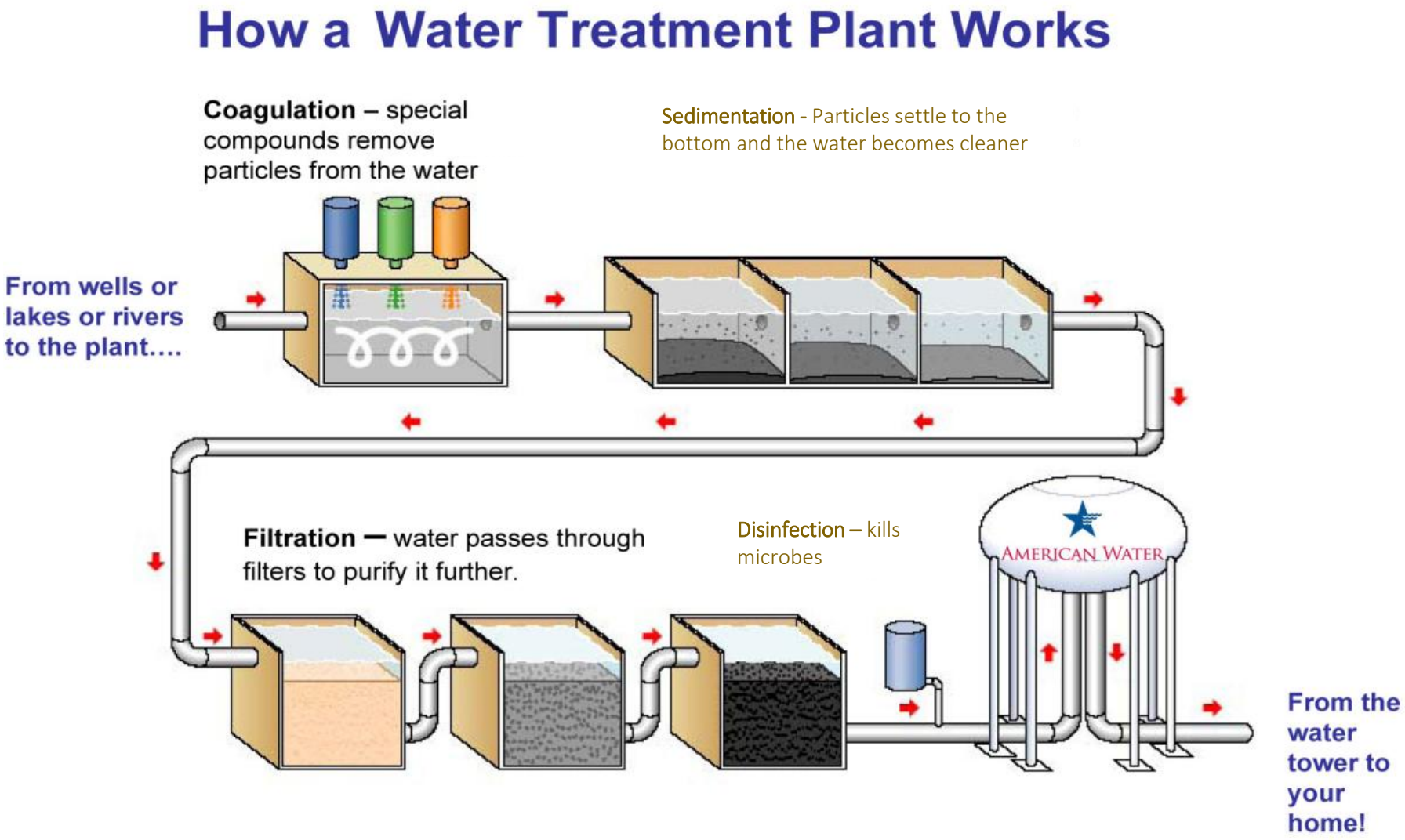
- To provide safe drinking water
  - **Water Must be:**
    - Free of disease causing organisms (pathogens, viruses)
    - Free of toxic substances (organic, inorganic & radiologic)
    - Should have a pleasing taste, odor and appearance

Example of a Surface Water Treatment Plant

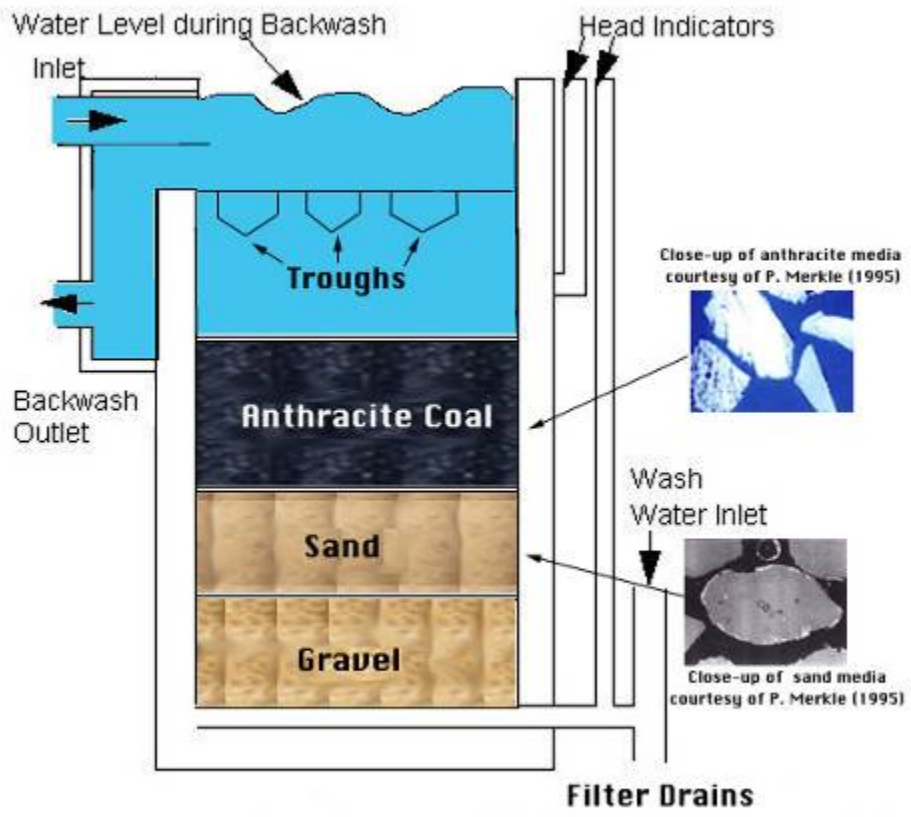
- 40 Million Gallons per Day Capacity
- A person uses 50-100 gpd
- Business may use 100-1000+ gpd
- Manufacturing facilities may recycle water but can use tens of thousands of gallons per day



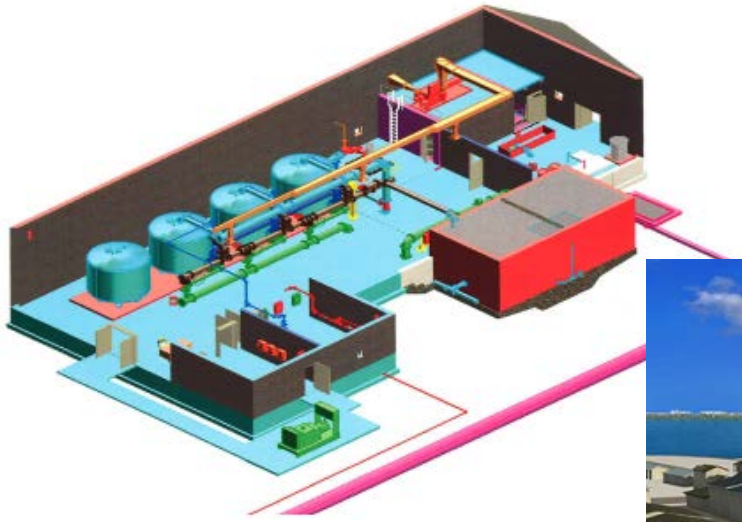
Surface Water Treatment



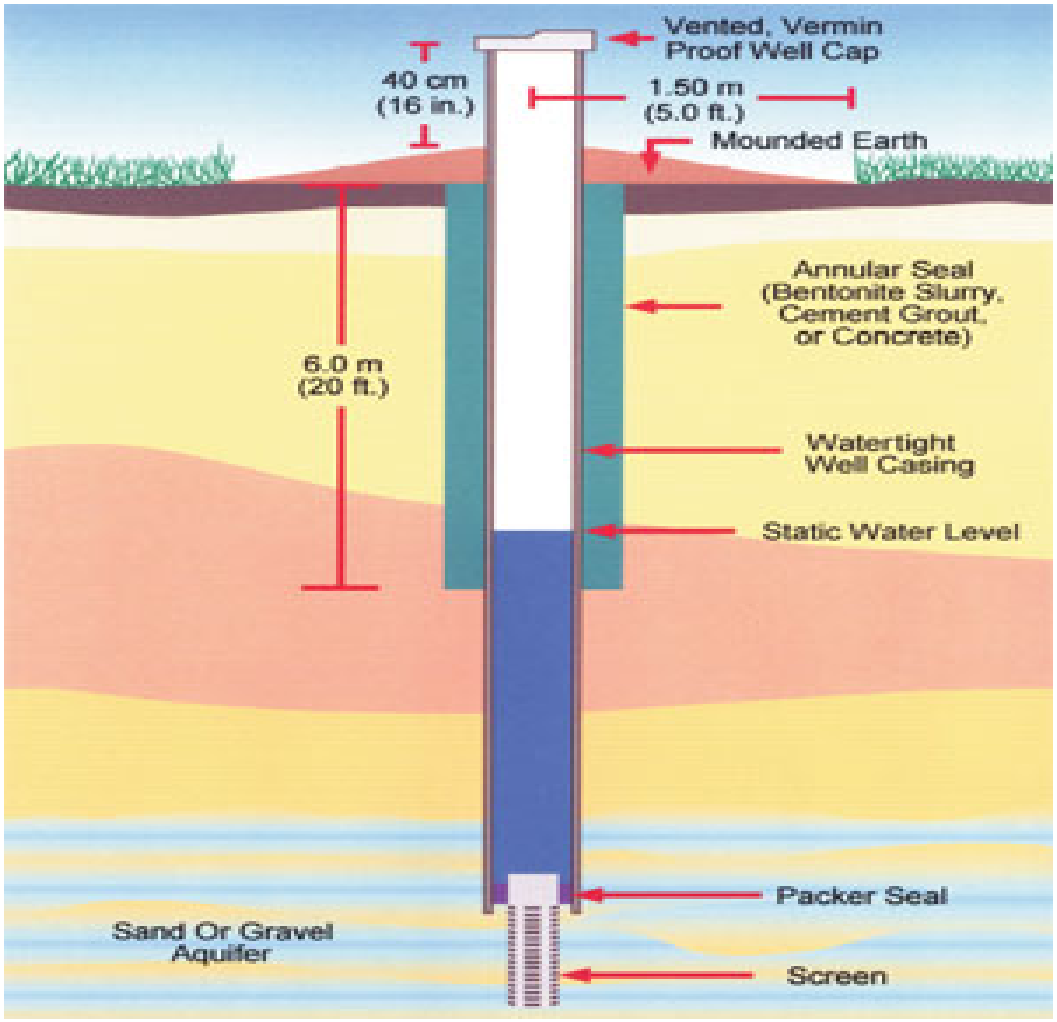
Filtration (fine carbon granules, sand and gravel)



Example of a Ground Water Treatment Plant (exterior designed to blend into a neighborhood)



Ground Water Wells (50 - 1,000+ feet deep)



Water exists in sand or sand/gravel layers below ground. (see blue layers in diagram)

Water is pumped to the surface piping. Water enters the well through screens. The screens keep the sand in place so it is not pumped out of the ground with the water.

Water Quality Standards

- Protect Public Health and Safety
- Federal and State Standards (EPA)
  - Safe Drinking Water Act (SDWA)
  - Maximum Contaminants Level (MCL)
  - Secondary Maximum Contaminant Level (SMCL)
  - Thousands of water quality test per year

- Water quality is measured at the source (before treatment), stages during treatment, point of entry (after treatment, but before distribution), within the distribution system and at representative customer taps.

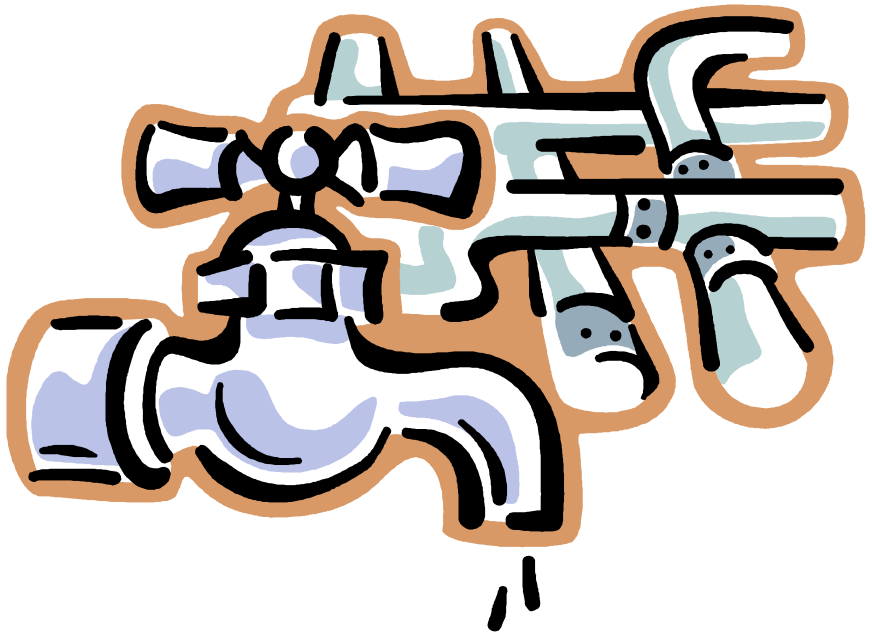
Water Quality Measured in the Lab. Some are as trace as Parts per Trillion

- **Drinking Water Standards**
  - **Primary**
    - **Inorganics, (metals and minerals),**
    - **Nitrate & Nitrite**
    - **Lead and copper**
    - **Volatile Organic Compounds (VOC's)**
    - **Disinfection By- Products (THM, HAA)**
    - **Total Coliform Rule (microbiological analysis) - measure chlorine residual**
    - **Turbidity**
  - **Secondary**
    - **Hardness, pH, Taste & Odor, Color**
    - **Iron and manganese**

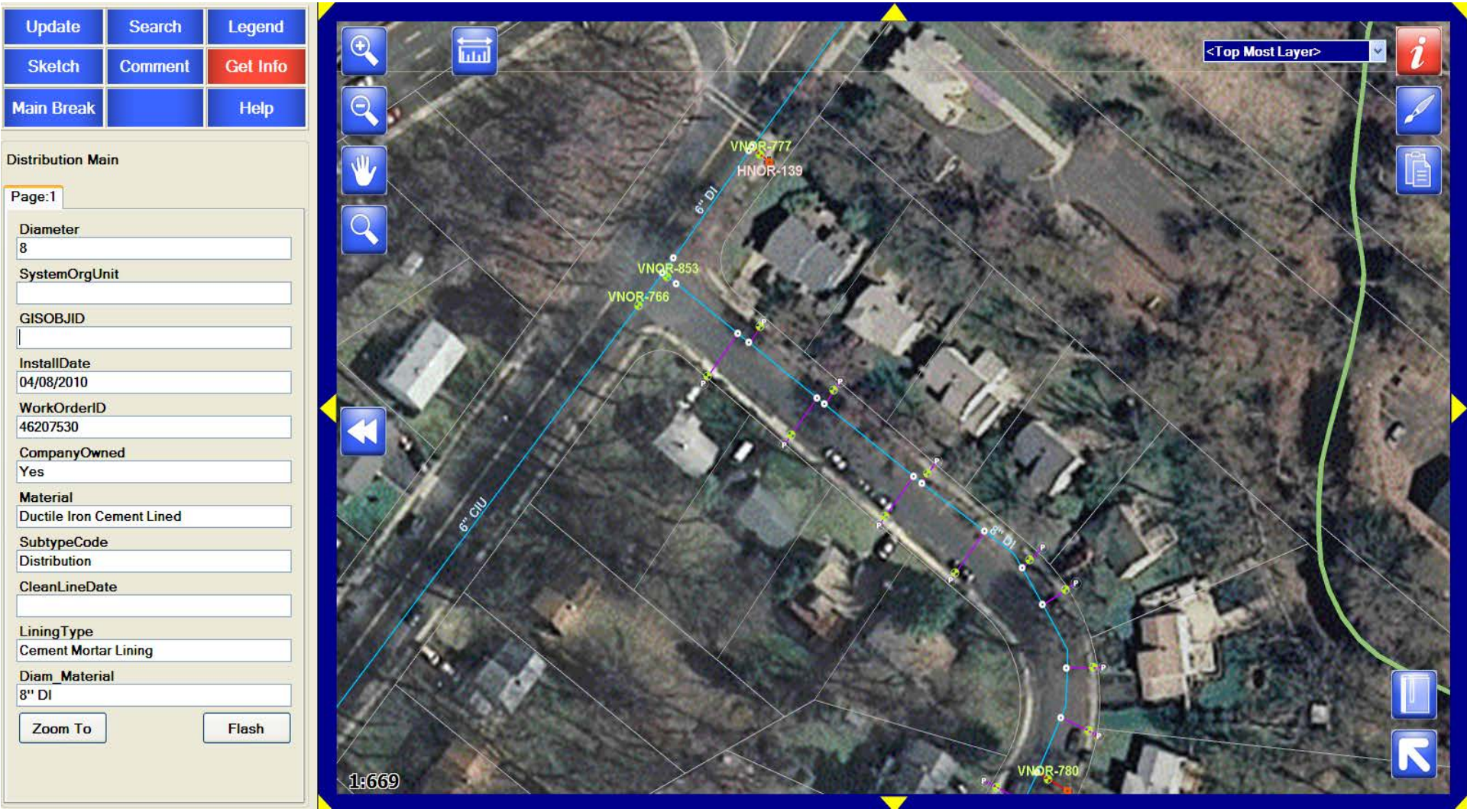
Challenge 4: Deliver Water to Customer & Maintain Quality through Distribution System Pipes

Purpose is to deliver adequate quantities of water at sufficient pressures while protecting water quality.

- Storage Facilities
- Water Mains
- Valves
- Fire Hydrants
- Services
- Meters
- Pumping Stations



Water Mains Deliver Water and Sewer Mains Collect Wastewater



Tunnels and Transmission Mains- Large Diameter Mains are 16 to 100+ inches in diameter

- **Major trunklines that deliver water from the water treatment plant to the distribution system.**

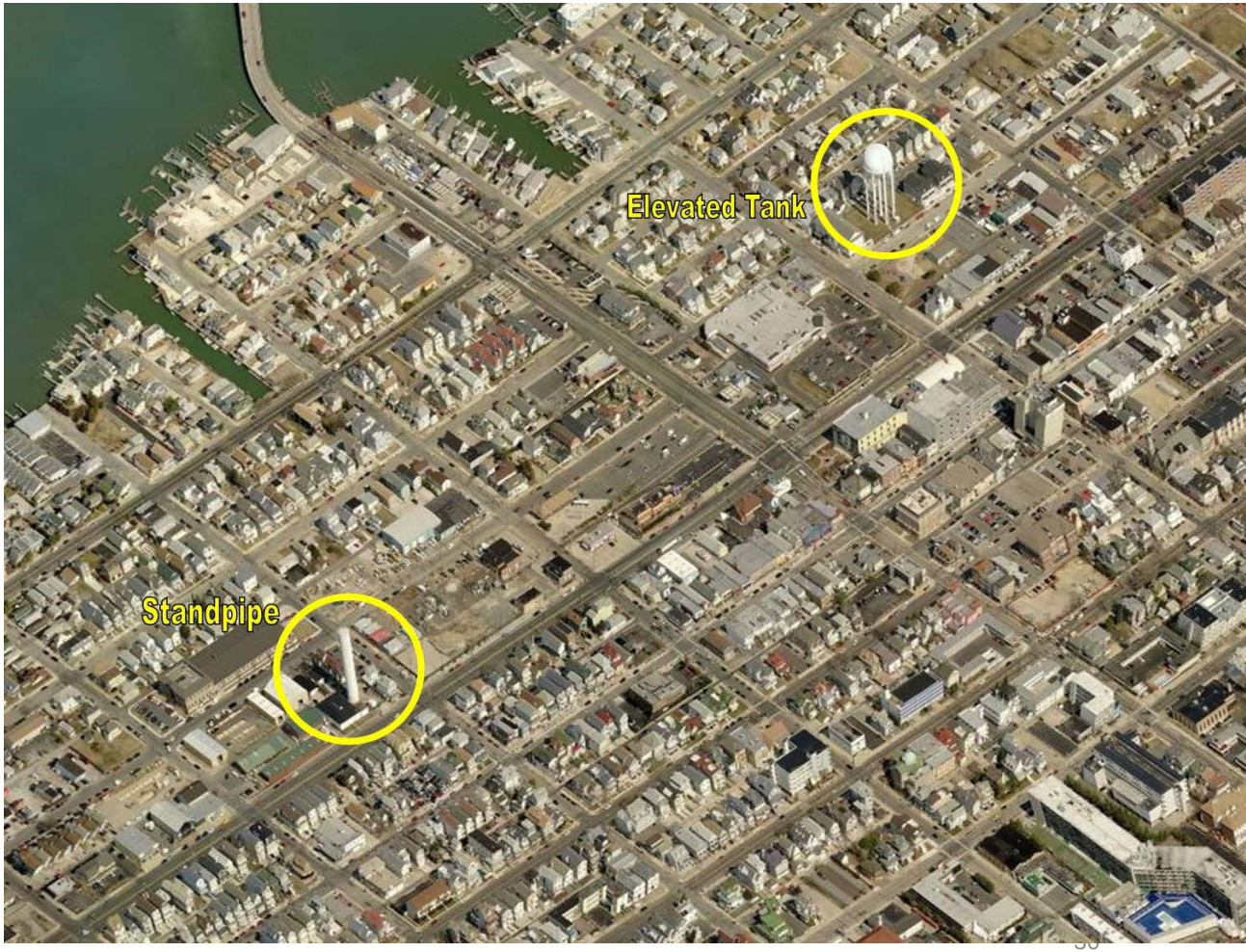
Distribution Mains in Neighborhoods - Smaller Diameter Mains of 4 to 16 inches in diameter

- **Grid, looped or branched system that delivers water from the transmission mains to customers.**
- **Installed at a depth below the frost line**

Water Storage Facilities

Tank Types

- Elevated Storage
- Stand Pipe
- Ground Storage



Storage – Basic Tank Types

- Elevated tanks

- Standpipes

- Ground Storage

Pumping Stations

Pumps help distribute water within the distribution system.

Locations used:

- Elevation change in system
- Large system

Pipe Material Types

Wood pipe (log and stave) was used from the 1700s to the late 1800s. These are not in use today.

Pipe Material Types (Commonly Used)

Concrete

Ductile Iron

Pipe Material Types (Specialty Uses)

HDPE

Steel

Distribution System – Valves

- Allows interruption of flow for repairs or maintenance
- Separates other pressure systems or areas
- Allows extension and expansion of the existing system
- Reduces Pressure
- Drain Water
- Regulate Flow

Distribution System - Hydrants

Hydrants are required for:

- Fire Fighting
- System Flushing
- Sampling

Distribution System – Services & Meters

Service

- Connection from water main in street to customer.
- Meters measure water use.

Types of Services:

- **Domestic:** Delivers potable water to commercial and residential customers.

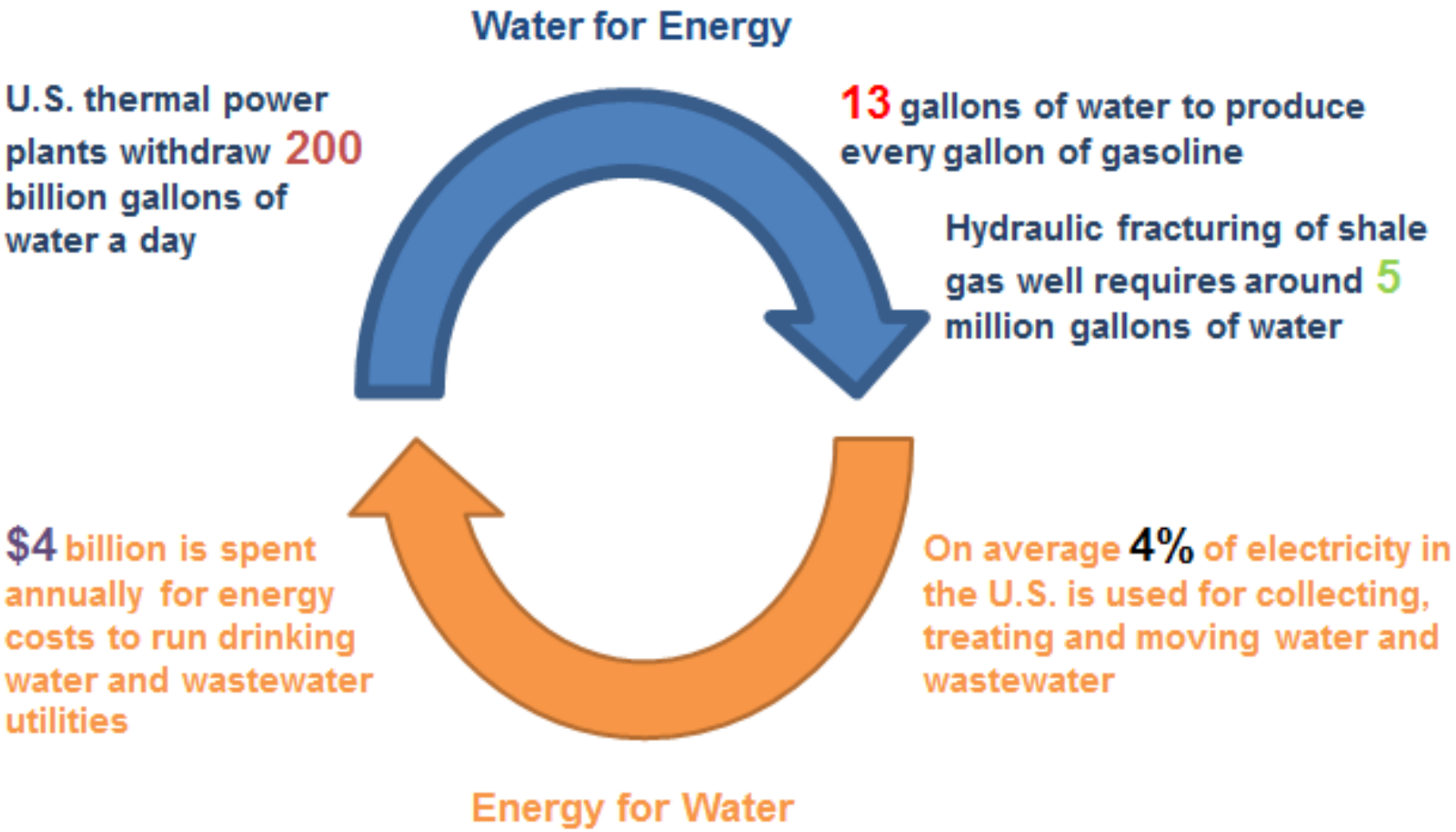
- **Fire :** Delivers water to commercial building fire protection systems.

Challenge 5: Water and Energy

1 gallon = 8.35 pounds

Water is heavy! Pumping millions of gallons each day requires significant energy, Energy sources could be electricity, natural gas, solar, and wind. Some small water plants may use propane. Some wastewater treatment plants turn the methane from the sewage process into energy.

Water – Energy Nexus



Pumping and Energy Management

Pumping ~ 80% - 90% of total water system energy use

Floating Solar Array on Reservoir in New Jersey

NJ Solar Powered Mixers in Reservoirs

www.solarbee.com

Improve raw WQ:

- **Reduce B-G algae**
- **Improve T&O**
- **Improve aesthetics**
- **Increase Dissolved Oxygen levels**
- **Reduce turbidity**

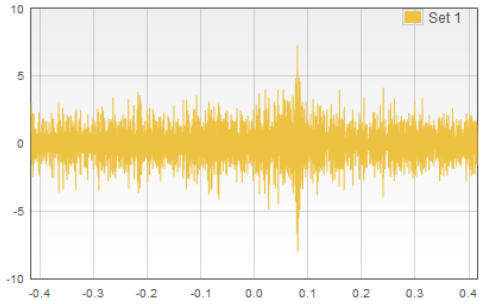
Solar Powered Mixers in Water Storage Tanks

Other Solar Applications

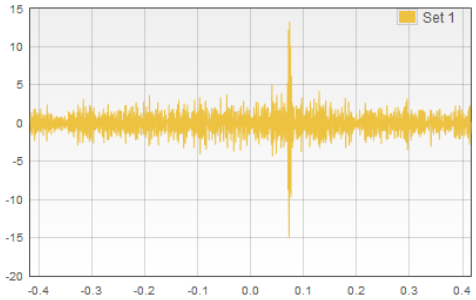
Small Applications For Solar

Solar gate operator

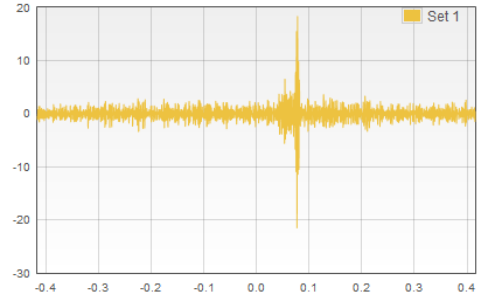
Smart Pipe and Advanced Instruments Help Maintain Water System Integrity and Save Energy



Origin



+2 weeks



+4 weeks

Echologics EchoShore – found 2.3 mgd of leaks in the first 5 months

- Turns valves and hydrants into smart devices
- Reduces leakage, extends pipe life

Challenge 6: Natural Hazard Threats

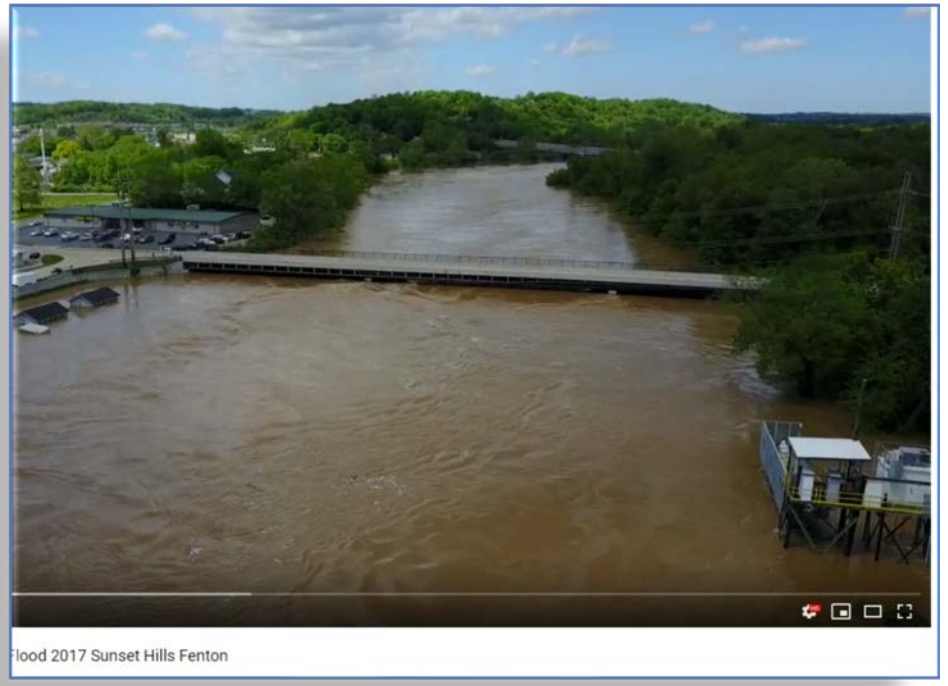
Floods & Storm Surge

Earthquake

Heat Waves & Drought, Wildfires

Wind, Tornado, Hurricane

Stream Flow Can Vary Seasonally
(example shows 40-ft difference in depth of river)



https://www.youtube.com/watch?v=_cMs4ZNCmH8

Some Water Treatment Plants are protected by Floodwalls due to Flooding from Storms

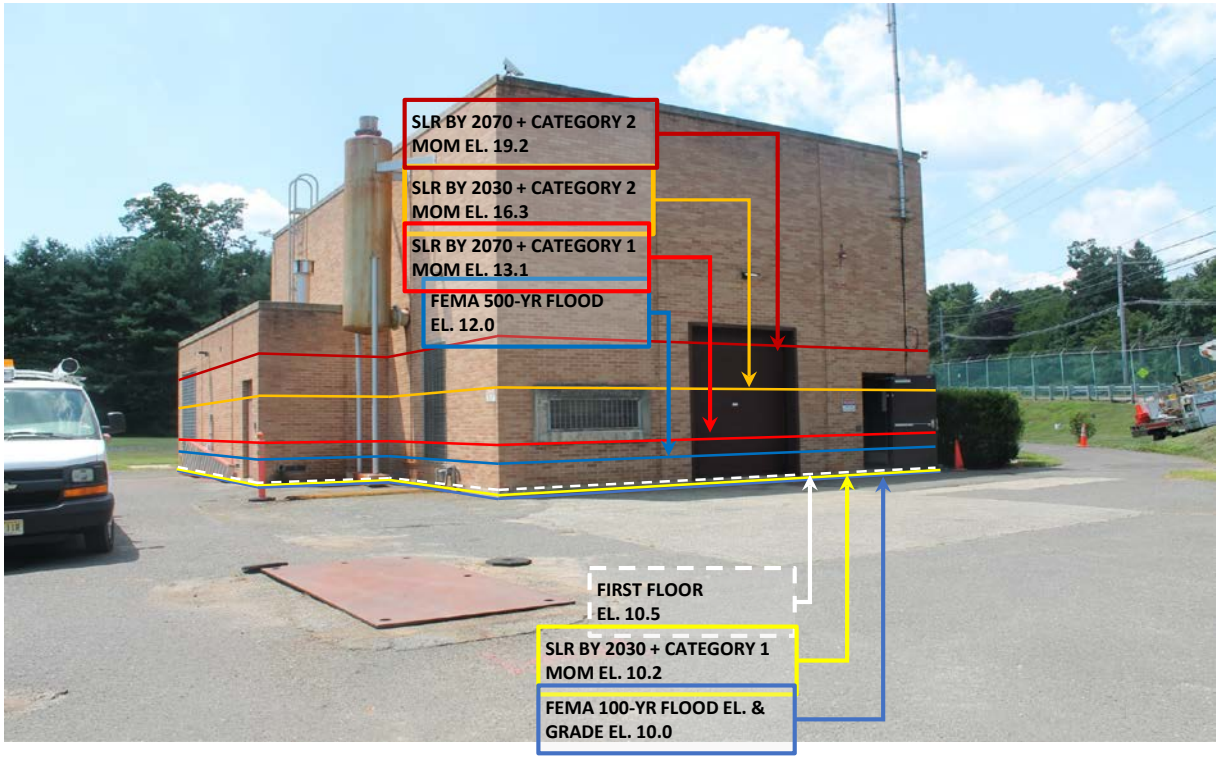
"We are operating normally and continually monitoring the water quality. The plant is operating under normal conditions and well protected by the flood wall."

Water Service Available Before, During and After Flooding
Your city will need a resilient water supply to clean up after storm events.

QCTimes.com May 2019

4th National Climate Assessment: Compound extremes can also increase the risk of cascading infrastructure failure since some infrastructure systems rely on others, and the failure of one system can lead to the failure of interconnected systems, such as water–energy infrastructure *(Ch. 4: Energy; Ch. 17: Complex System*

Plan Ahead: Sea Level Rise Threatens Coastal Areas



Pump Station adjacent to an estuary

Vulnerable to flooding

- Floor elevation 0.5 ft above historic 100-year flood elevation
- Study estimated impact of future sea level rise
- Under a future scenario of a hurricane and SLR, this building would be flooded
- Time to make plans to relocate or add flood protection

Consider Engineering Careers in Water Industry

- Project Management
- Water Supply and Facility Planning
- Engineering Design
- Construction Management
- Field Operations
- Plant Managers
- Water Quality Professionals
- Environmental Scientists, Chemists, Biologists
- Chemical, Civil, Mechanical, Electrical, Material Engineers
- Other Professionals
  - Safety, Security, Legal, Finance, Management

Questions

Check our website, youtube and social media sites for more information!

www.amwater.com

https://youtu.be/tuYB8nMFxQA

Be inspired to Create Your City of Tomorrow!

The problem you tackle in this competition could help millions of people across the planet!

THANK YOU