Better Plants
U.S. DEPARTMENT OF ENERGY

Industrial Water Systems Virtual Training

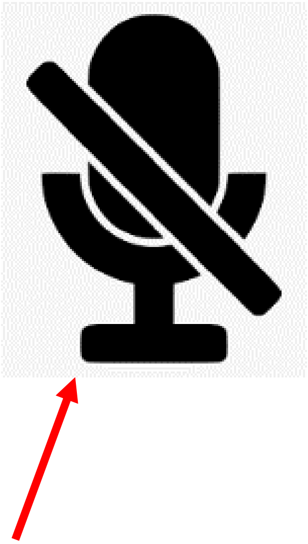
Session 1
Tuesday – June 16th, 2026
10 am – 12:30 pm

Welcome

- Welcome to the first session of the Water Virtual training series
- Eight, 2-1/2 hour webinars, focused on Industrial Water Systems, Water Assessment and Optimization
- These webinars will help you gain a significant understanding of your industrial water system, undertake a water assessment, evaluate and quantify water and cost-saving opportunities using US DOE tools and resources
- Thank you for your interest!

Safety and Housekeeping

- You are welcome to ask questions at any time during the webinar
- When you are not asking a question, please <u>MUTE</u> your mic and this will provide the best sound quality for all participants
- We will be recording all these webinars and by staying on-line and attending the meeting you are giving your consent to be recorded
  - A link to the recorded webinars will be provided, afterwards



Kiran Thirumaran, Oak Ridge National Lab

Qualification

- M.S. (2014) | Mechanical Engineering - North Carolina State University
- B.Tech. (2012) | Aeronautical Engineering
- Certified Energy Manager (2025 – present) | Association of Energy Engineers

Professional Experience

- R&D Staff, Oak Ridge National Laboratory, Nov 2015 - Present
  - Technical Account Manager for 20 companies through the Better Plants Program
  - Developed the water INPLT training and piloted it at multiple facilities
  - Lead ORNL's effort in supporting DOE National Alliance for Water Innovation
  - Developed tools to model the energy/water consumption in industrial systems
- Energy Engineer, CLEAResult Consulting, June 2014 – Oct 2015
- Graduate Research Assistant, Industrial Assessment Center (IAC-NCSU), Dec 2012 – May 2014.

It’s Great to Meet You!

Let’s get to know each other so please….

- State your name, company, position and
- What are you looking to take away from the class?

Industrial Water INPLT: Goals

- Train participants to conduct a facility level water use assessment
  - Conduct water use assessment to establish baseline water use and true cost for the host facility
- Identify measures for achieving water and cost savings
- Replicate assessment results in other facilities

Water Virtual INPLT Agenda

- Week 1 (June 16th) – Introduction to Industrial Water Assessment
- Week 2 (June 23rd) – Understanding System Level Water use
- Week 3 (June 30th) – True Cost of Water
- Week 4 (July 7th) – Water Assessment Tool Working Session
- Week 5 (July 14th) – Identifying Water Savings Opportunity
- Week 6 (July 21th) – Virtual Water Treasure Hunt
- Week 7 (July 28th) – Estimating Water Savings Opportunities
- Week 8 (Aug 4th) – Industrial Water System VINPLT Wrap-up Presentations

Agenda – Session ONE

Today's Content:

- Overview of industrial water use
- Components of an Industrial Water Assessment
- Getting Started with Water assessment
  - Plant Water Flow diagram
- Kahoot Quiz Game
- Q&A

Better Buildings is an initiative of the U.S. Department of Energy

Industrial Water Use: Overview

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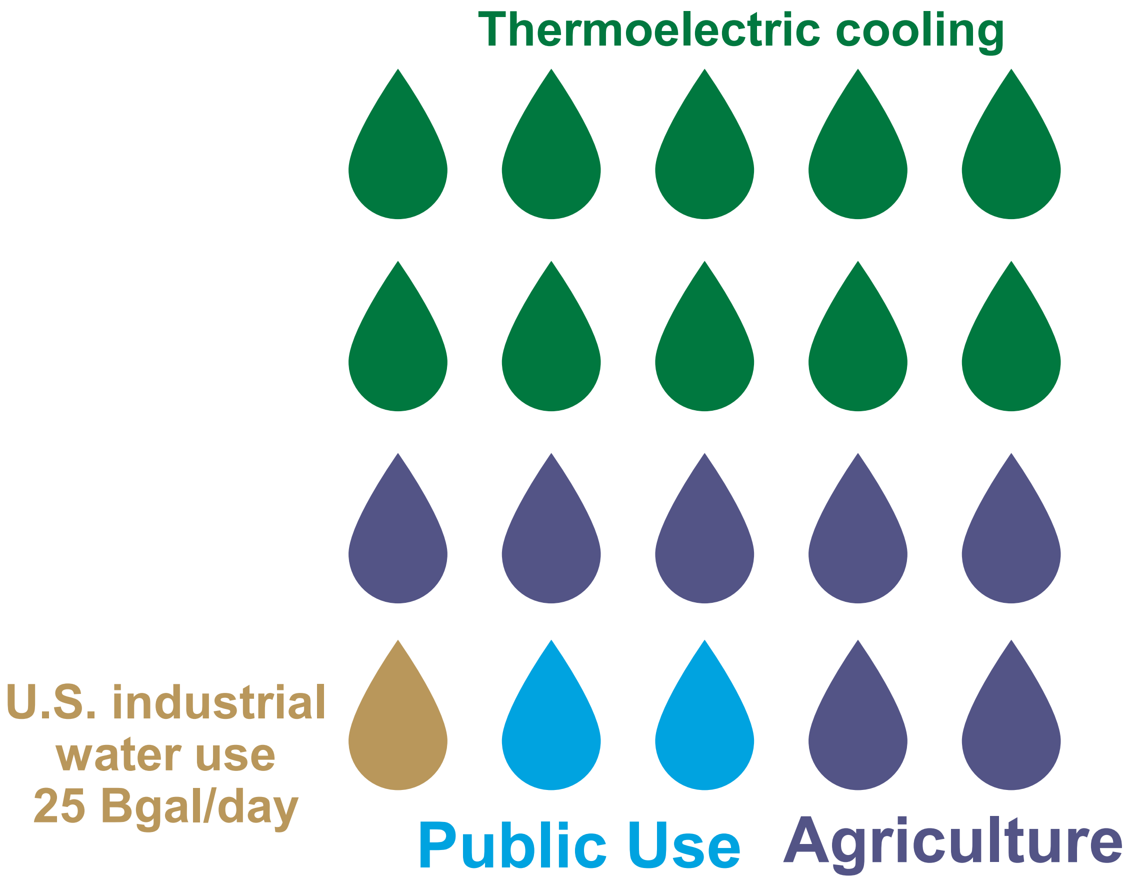
Industrial Water Use: Snapshot

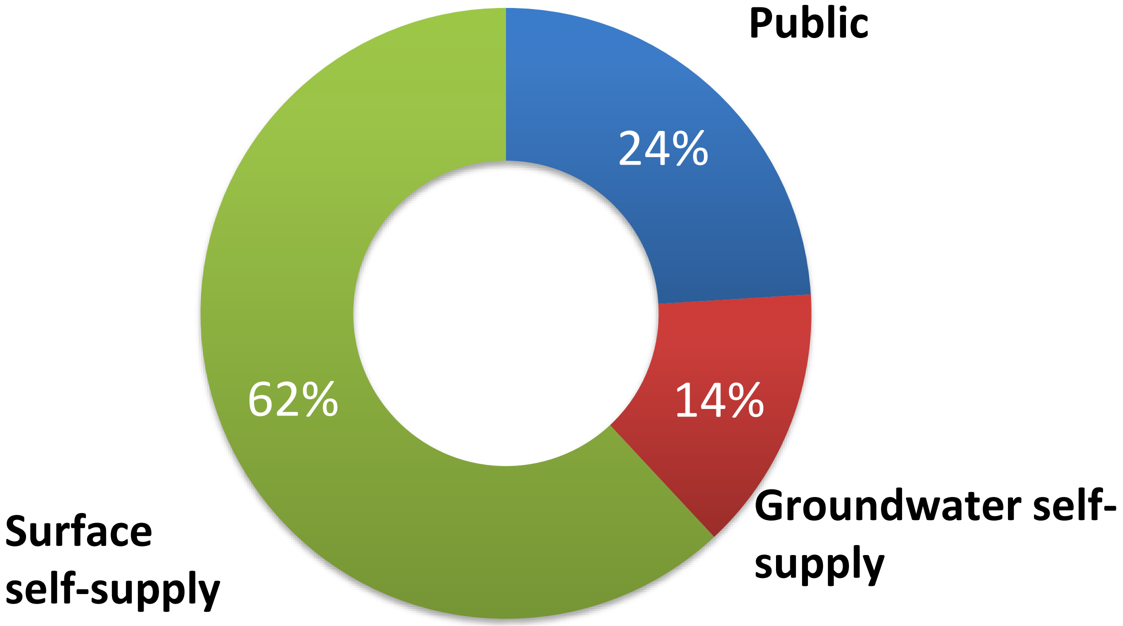
- Industrial water use
  ~ 5 – 6 % U.S. Total

- Most self-supplied

U.S. Water Use
400 billion gal/day



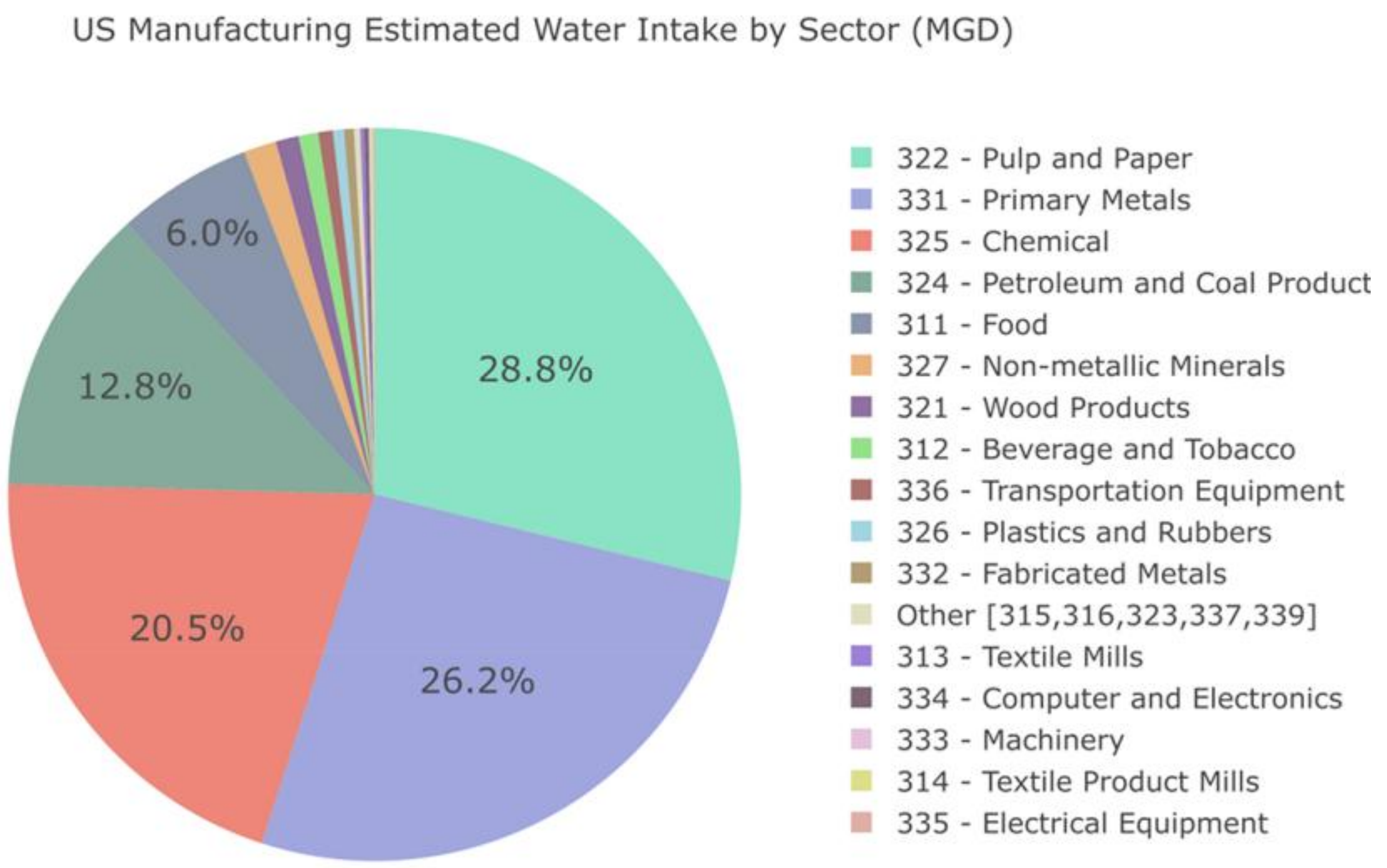
Estimated sources of manufacturing water use



- **Only 15% of total water intake in industries is consumptive**

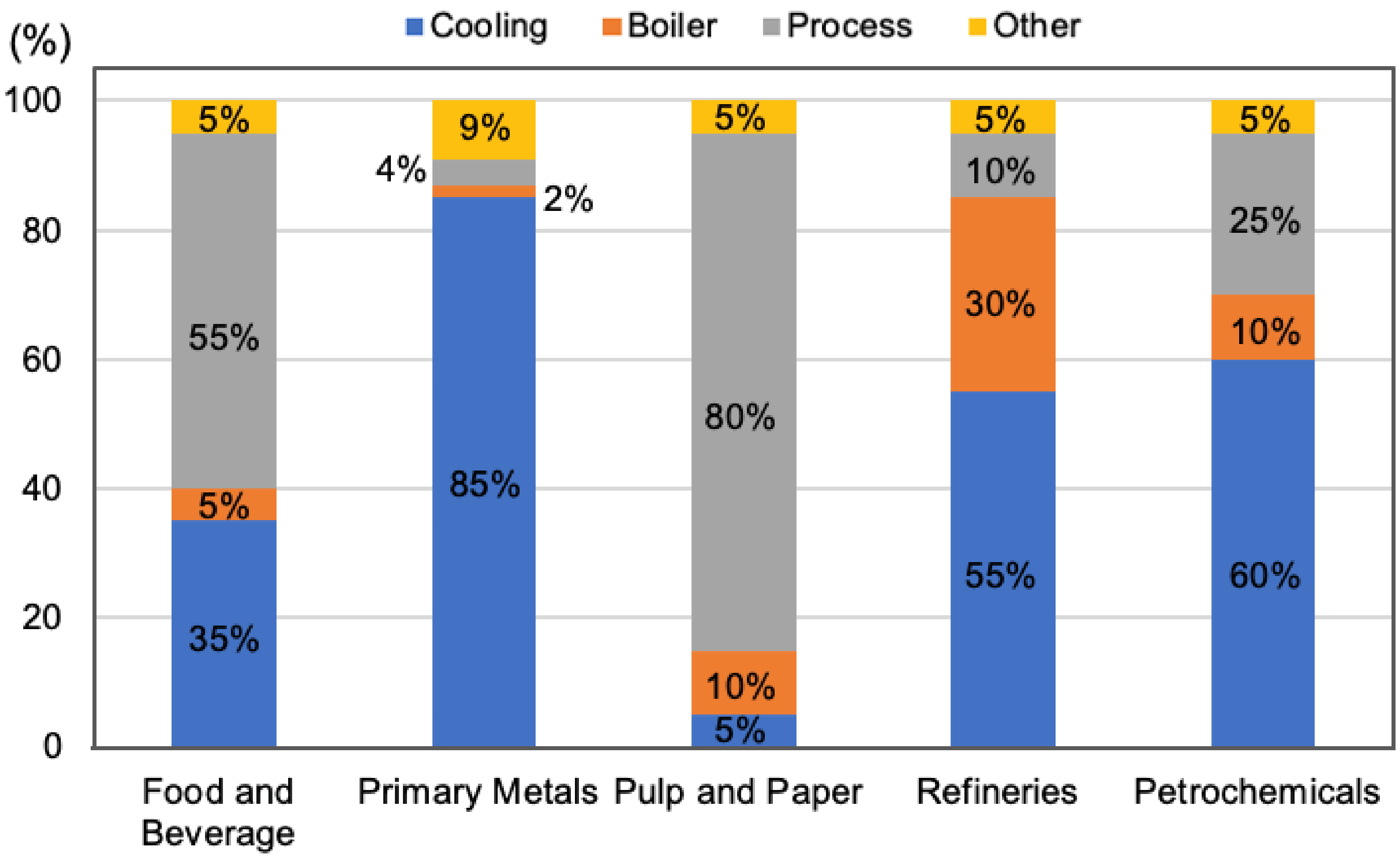
Source: Maupin, M.A. et.al, "Estimated use of water in the United States in 2015" U.S. Geological Survey Circular 1441, 65 p.

Breakdown of water use by industry



Source: P Rao et.al. "Evaluation of US Manufacturing Subsectors at Risk of Physical Water Shortages

Breakdown of water use by application



Process water includes,

- Washing/Cleaning
- Diluting (e.g., paint shop)
- Transporting a product
- Fabrication
- Bleaching
- Lubrication
- Sterilizing..

Source: Flynn, D. J., The Nalco Water Handbook. Third Edition ed.; McGraw Hill: 2009; p 1,346.

Polling Question 1

Polling Question

1) Which category best describes your facility?

A. **Heavy water user** – e.g., Petrochemicals, Refineries, Forest Products, Primary Metals, Food and Beverage, Textiles

B. **Medium water user** – e.g., Non-Metallic Minerals, Transportation equipment, Fabricated Metals, Plastics and Rubber etc.

C. **Small water user** – e.g., Electronics, Specialty manufacturing, etc.

D. **Not a water user**

Why should manufacturers consider water efficiency

Cost savings and operational improvements	• Cost of **purchasing** water for facility • Cost of **material** for water and wastewater treatment • Cost of **discharging** wastewater • Cost of energy for **heating and cooling** water • Cost of energy for **pumping** water (heating/cooling and pumping: Water Energy Nexus)
Business risks	• Scarcity – **Risk of disruption** of water supply to plant due to drought conditions, regional scarcity etc. • Regulatory – Risk of increased **regulation** on water use and pollution regulations • Disruption of water supply in supply chain
Environmental and Social Responsibility	• Sustainability strengthens public trust and helps create better relationship for business

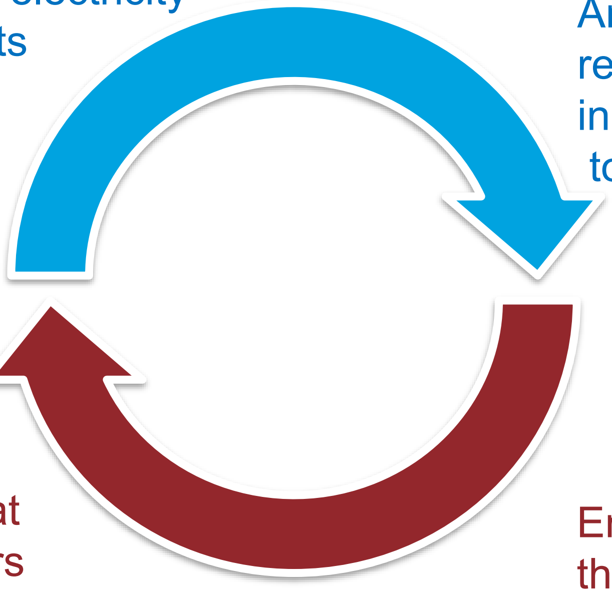
Water - Energy Nexus : Interdependence at facility level

Water for Energy

Water used in electricity generation sets

Water in fuel production

Amount of water used to remove heat in equipment is proportional to the energy consumed



Pumping energy to transport water

Energy to heat/cool the water for use

Energy in water treatment systems

Energy spent at water end users e.g. Vacuum Pumps

Energy for Water

Even if water is cheap, the correlating impact water use has on energy can make it expensive

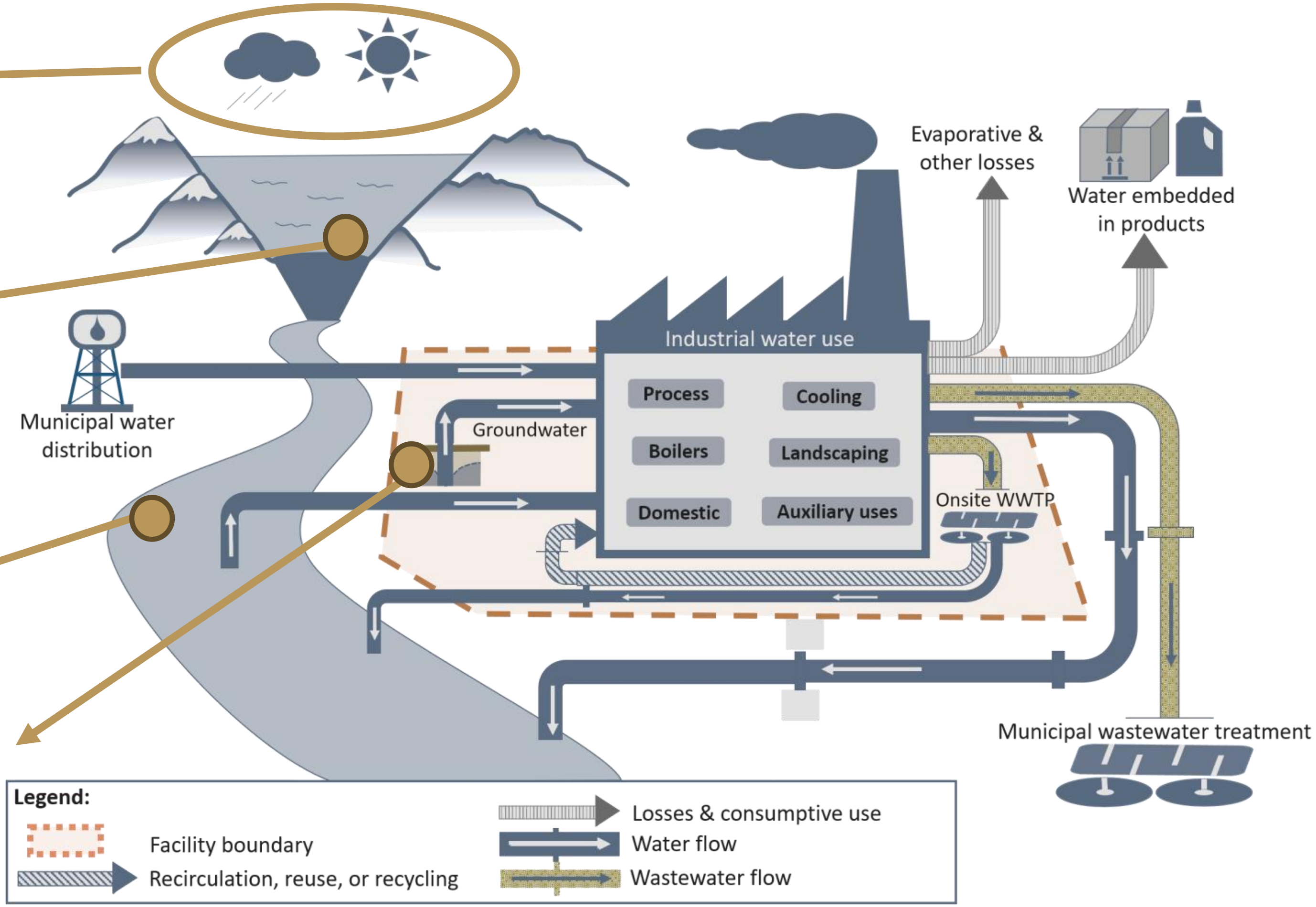
Industrial water supply is affected by external factors

Changes in rain and temperature

Changes in levels of reservoirs

Changes in surface water availability

Changes in groundwater availability



Significant changes in water availability can cause:

- Low levels in reservoirs, rivers, and wells
- Water curtailments
- Regulatory changes
- Reputational risk
- Water emergencies

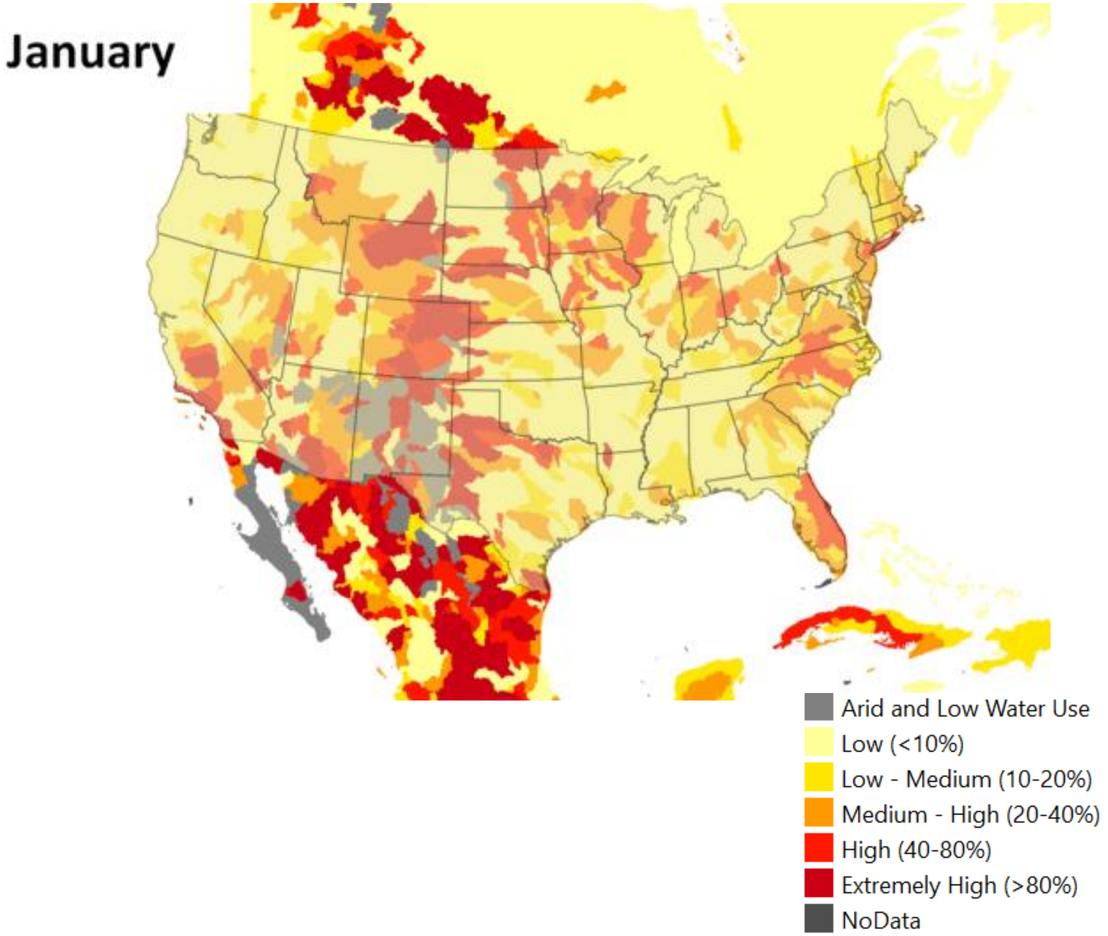
Local water availability is the predominate factor that determines the business risk related to water

Water risks in your region

Physical Risks – Quantity
Measure's risk related to too little or too much water Eg. Water Stress

Physical Risk – Quality
Measure's risk related to water that is unfit for use. Eg. Untreated Connected Wastewater

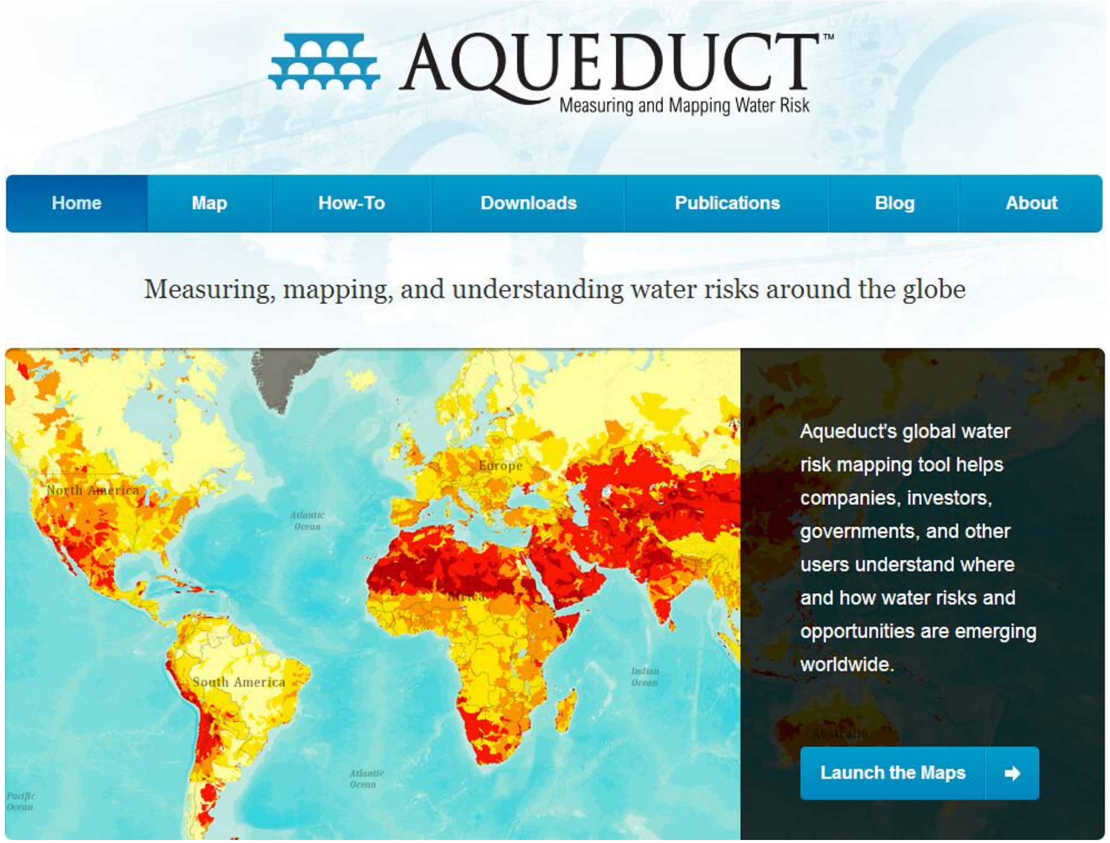
Regulatory and Reputation Risks
Measures risk related to uncertainty in regulatory change and perception with the public. Eg. Environmental, social, and governance risk



Source: The Water-Energy Nexus, Challenges and Opportunities," US Department of Energy, June 2014.

Aquaduct Water Risk Atlas – World Resource Institute (WRI)

WRI's tool for measuring and mapping water risks worldwide.



https://www.wri.org/data/aqueduct-water-risk-atlas

Physical Risks – Quantity
- Water Stress
- Water Depletion
- Interannual Variability
- Seasonal Variability
- Groundwater Table Decline
- Riverine flood risk
- Coastal flood risk
- Drought Risk

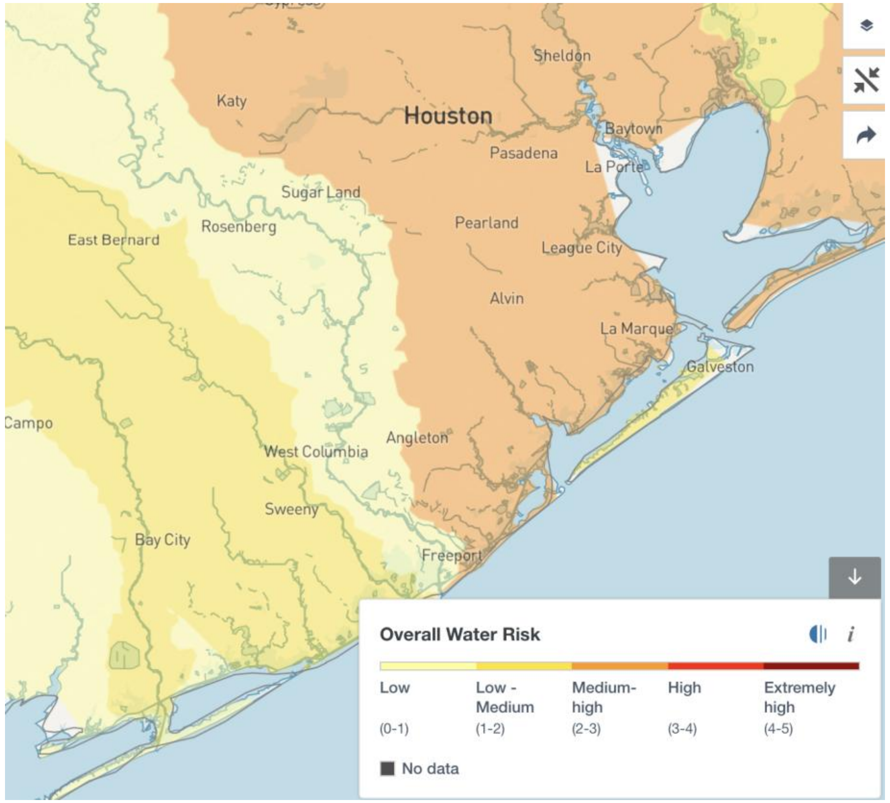
Physical Risk – Quality
- Untreated Connected Wastewater
- Coastal Eutrophication Potential

Regulatory and Reputation Risks
- Unimproved/No Drinking Water
- Unimproved/No Sanitation
- Country ESG Risk Index

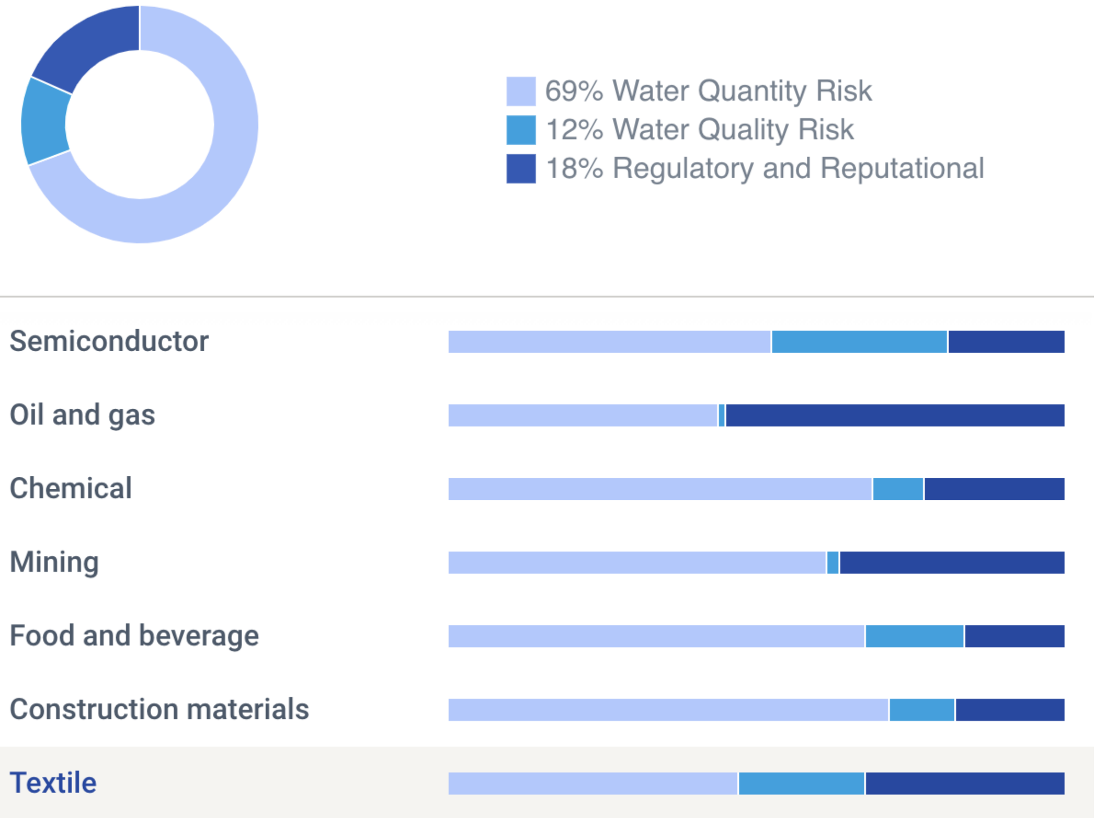
Risk Indicators Measured

Aquaduct Water Risk Atlas – Overall Water Risk Index

Overall Water Risk Index: Measures all water-related risks, by aggregating all selected indicators from the Physical Quantity, Quality and Regulatory & Reputational Risk categories.



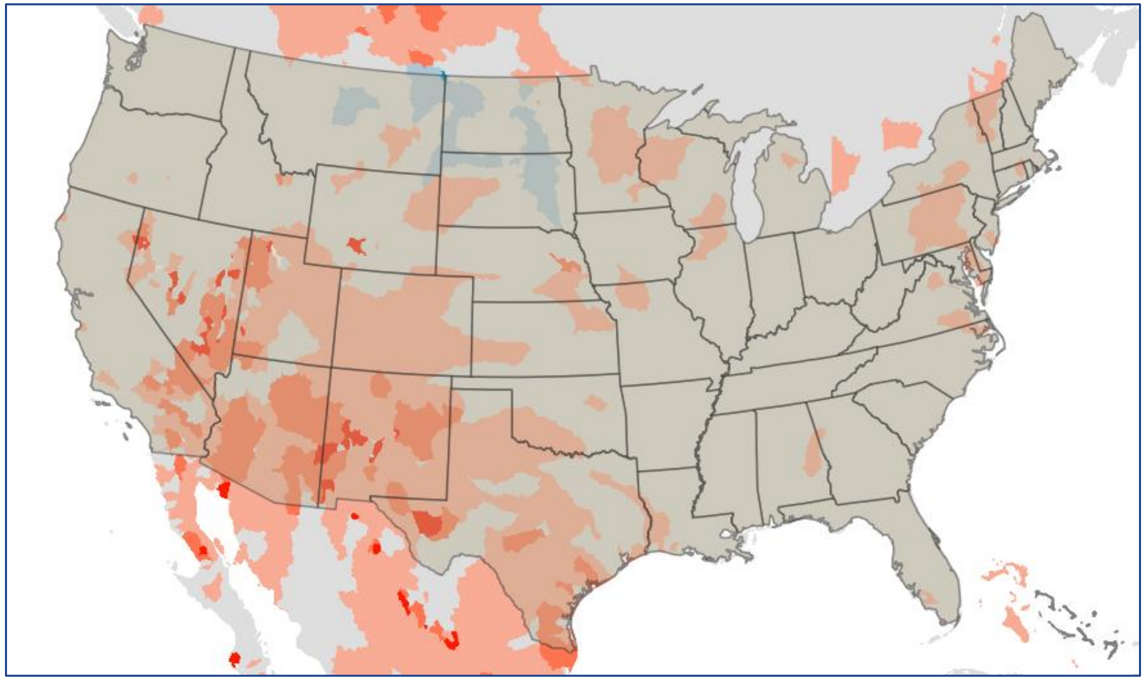
Overall Risk Index for a Food and Beverage manufacturer in the Houston, TX area.



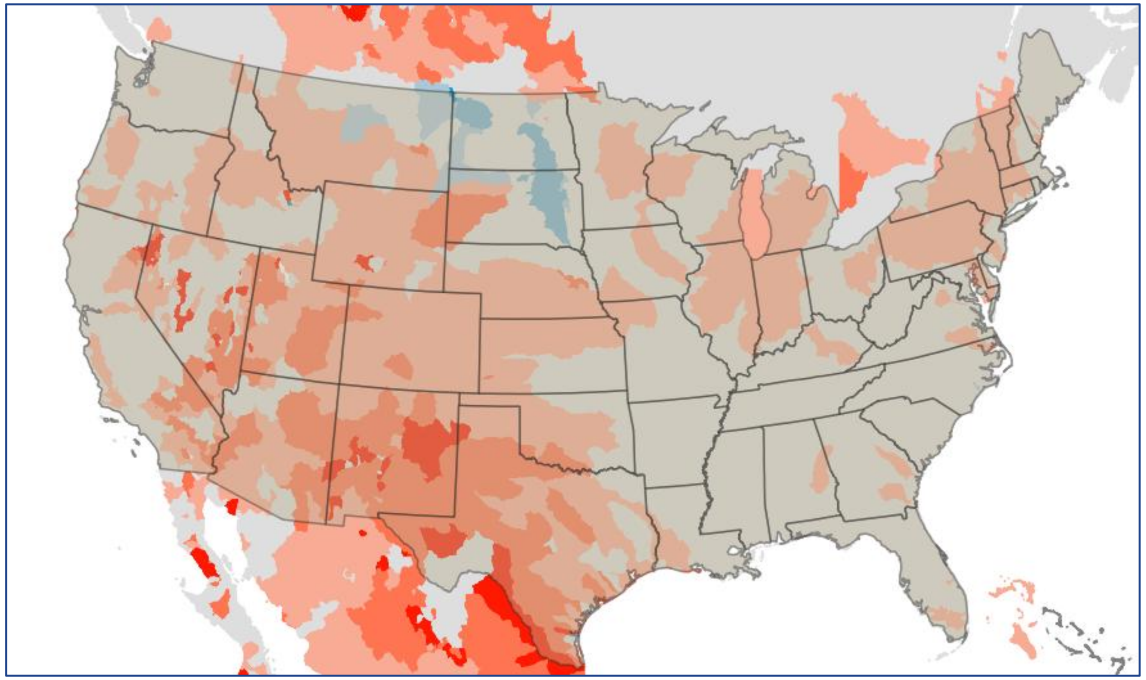
Water Risk weightages considered to calculate the overall risk metric

Water Stress - Business as usual

Water stress is an indicator of competition for water resources and is defined informally as the ratio of demand for water by human society divided by available water.



2030



2040

- 2.8x or greater decrease
- 2x decrease
- 1.4x decrease
- Near normal
- 1.4x increase
- 2x increase
- 2.8x or greater increase
- No data

Water Stress = water withdrawals/available water

Source: WRI Aqueduct – Water Risk Atlas

Polling Question 2

Polling Question

1) Why is water efficiency important to you?
   A. Cost Savings
   B. Reducing risk and improve resilience
   C. Sustainability Targets
   D. Product Quality improvement
   E. Others

Barriers to Industrial Water Use Reduction

- Lack of reliable data of industrial water use -- the extent of water-use related risks is unknown
- Lack of understanding of hidden costs of water use
- Lack of incentives from utility & state government

Economic justification for potentially expensive water use reduction projects

This is changing …

Introduction to Industrial Water Assessment

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Conducting a Water Use Assessment

Step 1. Baselining water use

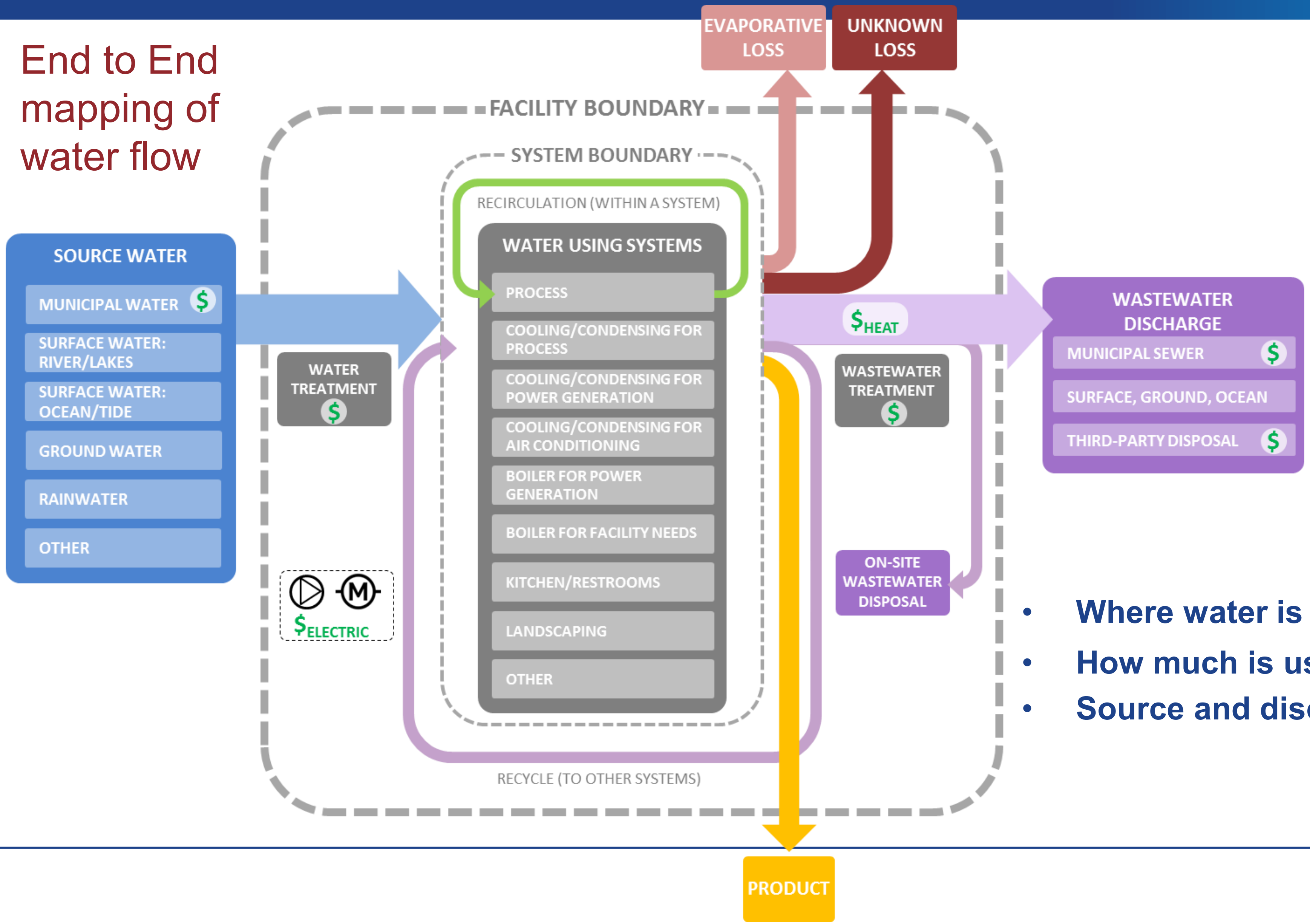
Step 2. Quantify true cost of water

Step 3. Water Quality Characterization

Step 4. Identifying water savings opportunity

Step 1. Baselining water use

End to End mapping of water flow

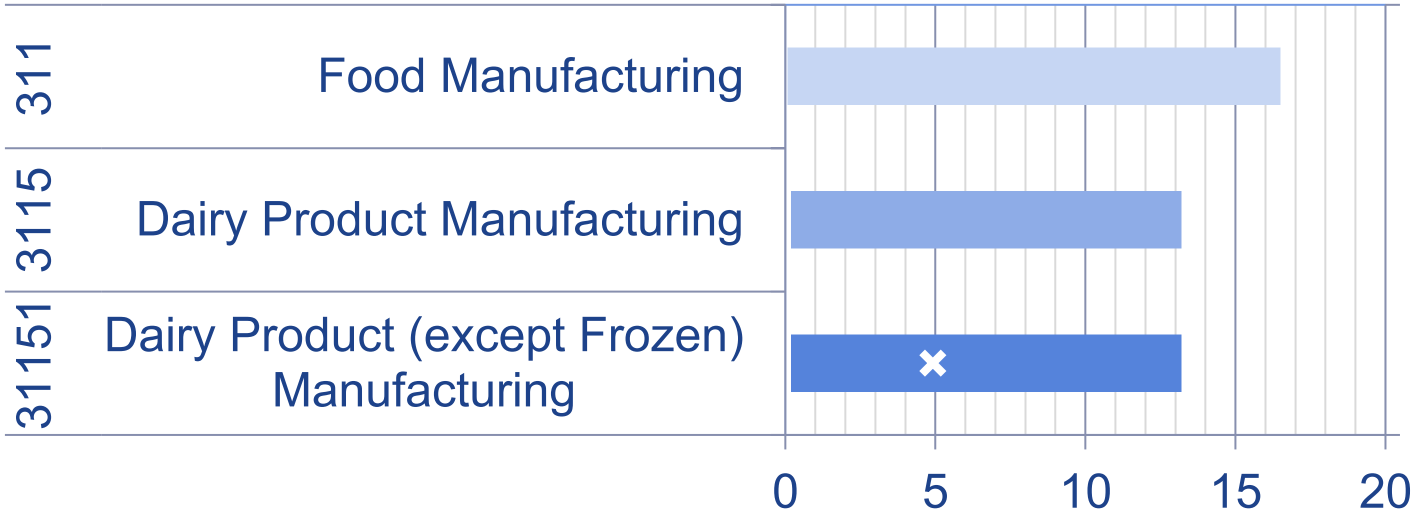


- Where water is used
- How much is used
- Source and discharge

Step 1. Baselining water use

Significance to the facility

- Establishes baseline to track water use over time
- Allows comparison with other industries (motivation)



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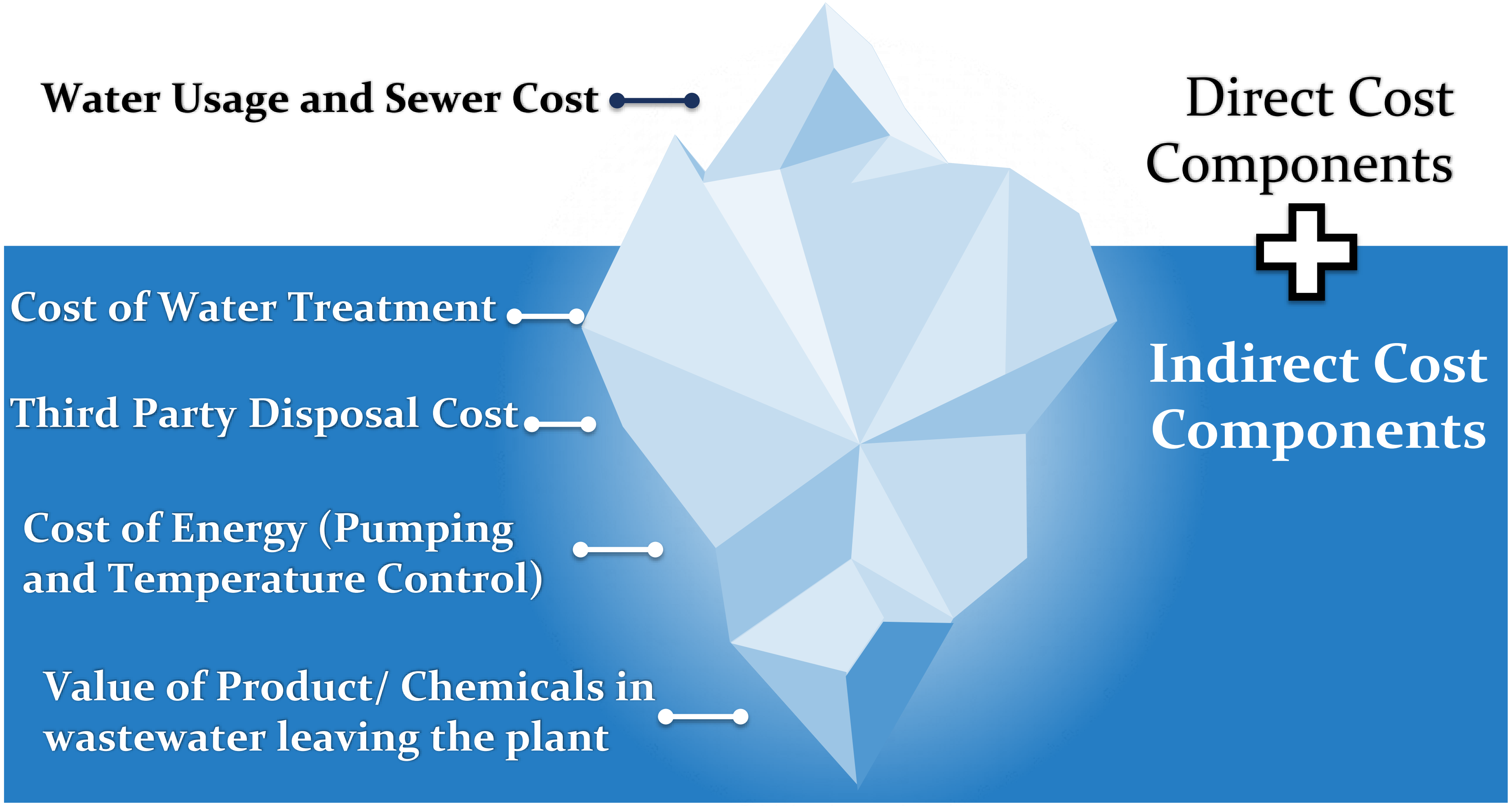
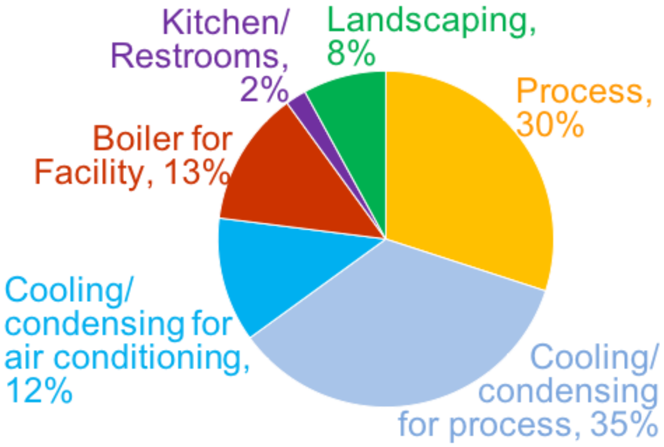
Step 2. True Cost of Water

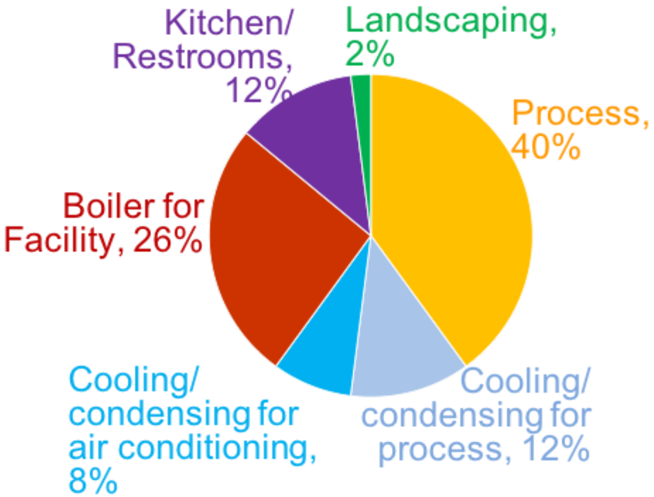


Significance to finding True Cost of Water

- Reveals hidden costs of using water
- Identifies water use-intensive versus cost-intensive systems to help prioritize measures



Source water intake



True cost of water

Step 3: Water Quality Characterization

Process Requirements: Certain industrial processes require water at a specific quality

Regulatory Compliance: Facilities might need to treat wastewater to meet local environmental regulations before discharging it into public sewers or natural bodies of water.

Treating water efficiently allows for **recycling and reuse** within the plant, which reduces the total intake of fresh water and lowers operational costs.

Step 4: Identifying Water Savings Opportunity

Water efficiency can reduce cost, improve resilience and reduce environmental impacts.

- Recycle and Reuse Water
- Efficient Design
- Implementing new technologies
- Optimized Operations
- Behavioral Improvements
- Proper Maintenance

Examples

New Technology

PepsiCo switched to purified air for cleaning Gatorade® bottles, achieving a **20 percent reduction** in water consumption throughout the process

New technology

Canola Processor uses RO system to treat incoming water **saving 965,000 gallons of water** used for softener regeneration

Recycle and Reuse Water

Nissan installed an automated water filtration system to eliminate the once-through rinse water, saving **48.6 million gallons** of water annually.

Source: DOE Better Plants Solution Center https://betterbuildingssolutioncenter.energy.gov/

Plant Water Flow Diagram

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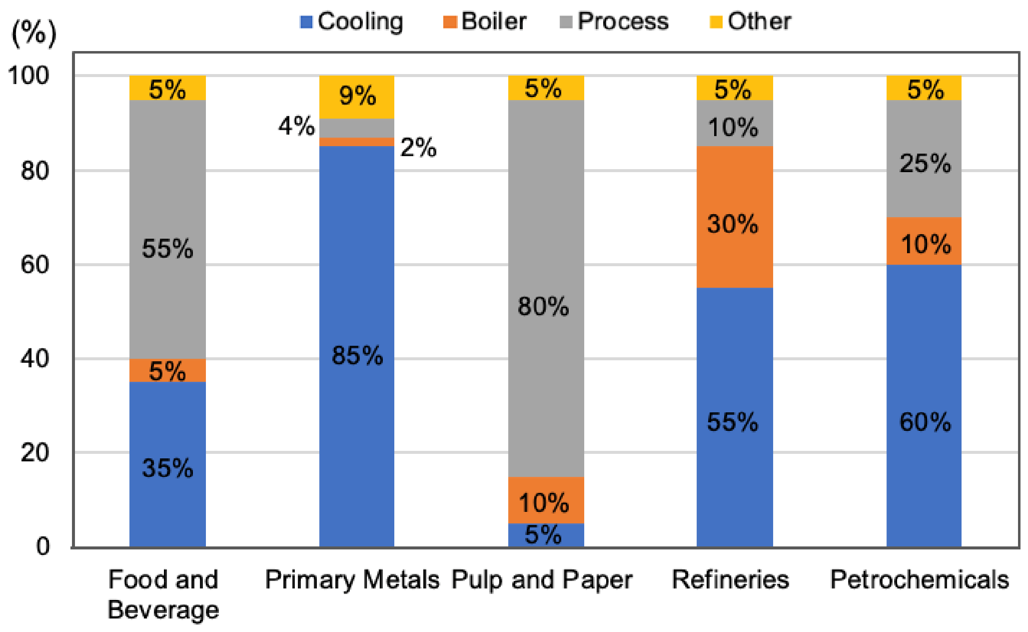
Plant water flow diagram connects all water users in a plant

A water flow diagram helps understand the water users in a facility and its components intuitively and makes performing a water balance easier.

Typical water using systems in industries:

Cooling (contact/non-contact, closed/open loop), Boilers and Process water uses



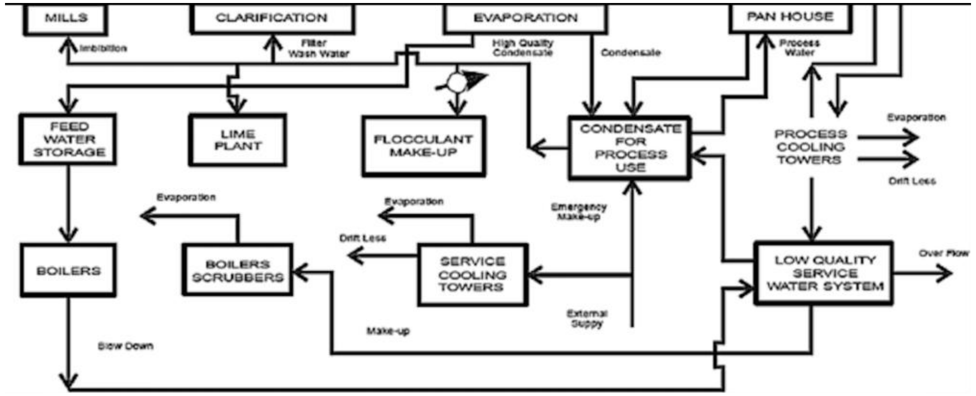
Process water includes,

- Washing/Cleaning
- Diluting (e.g., paint shop)
- Transporting a product
- Fabrication
- Bleaching
- Lubrication
- Sterilizing..

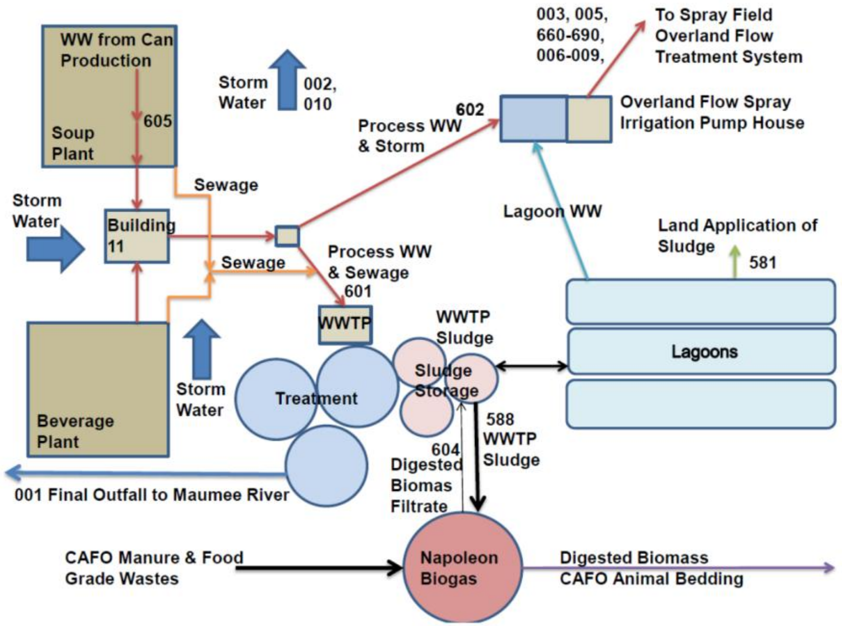
Source: Flynn, D. J., The Nalco Water Handbook. Third Edition ed.; McGraw Hill: 2009; p 1,346.

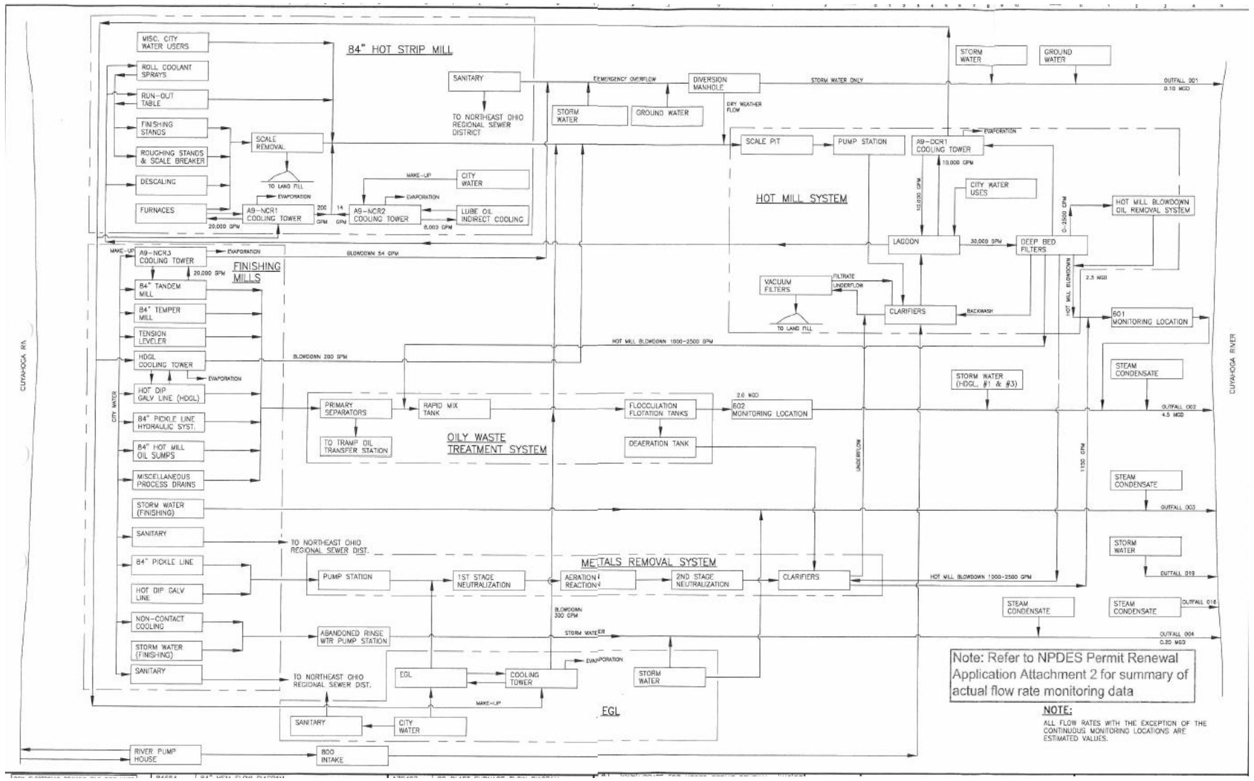
Water Flow Diagrams can be complex

Water Flow in Sugar Industry [1]



Water and Wastewater Flow in a Food plant [2]

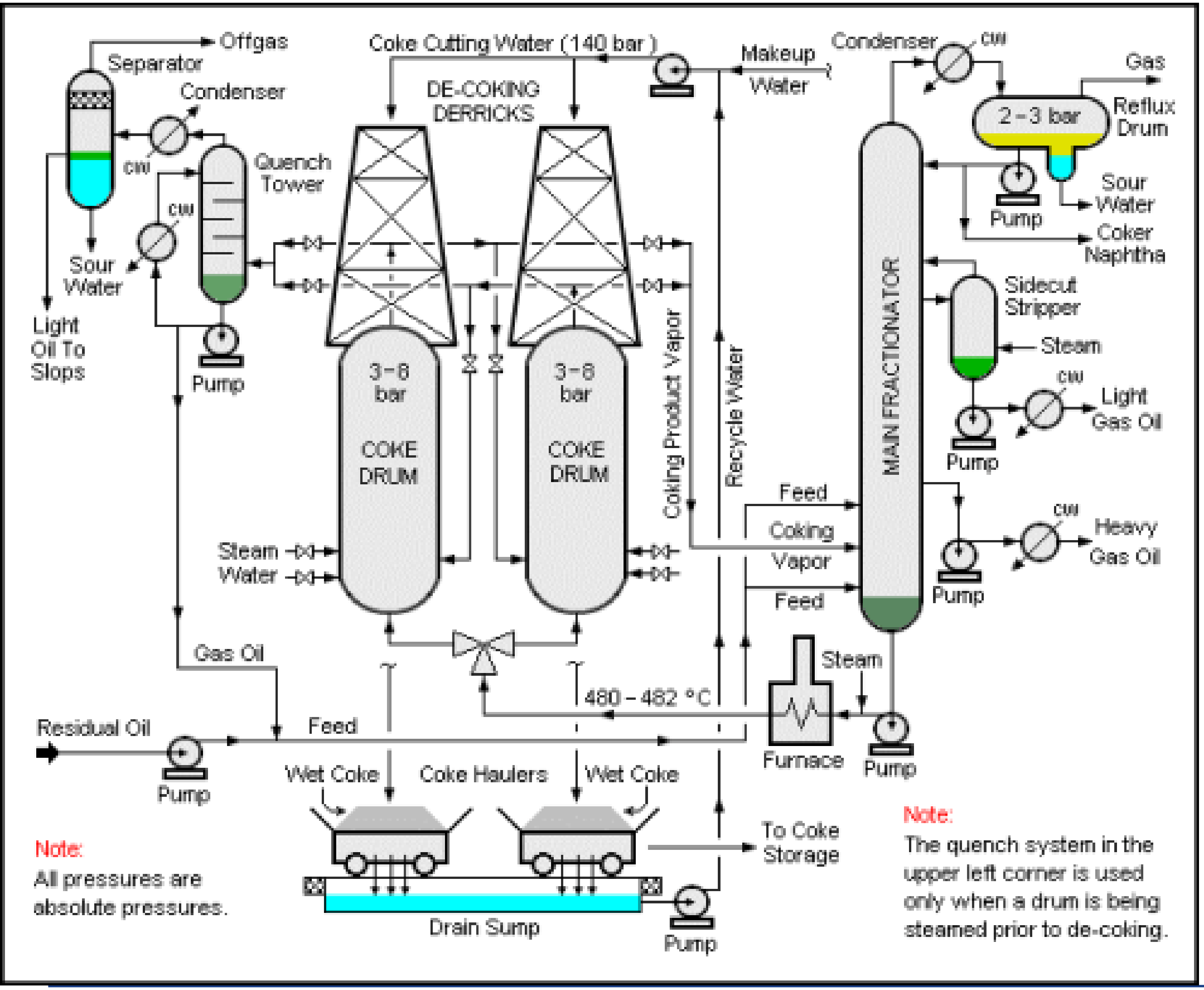


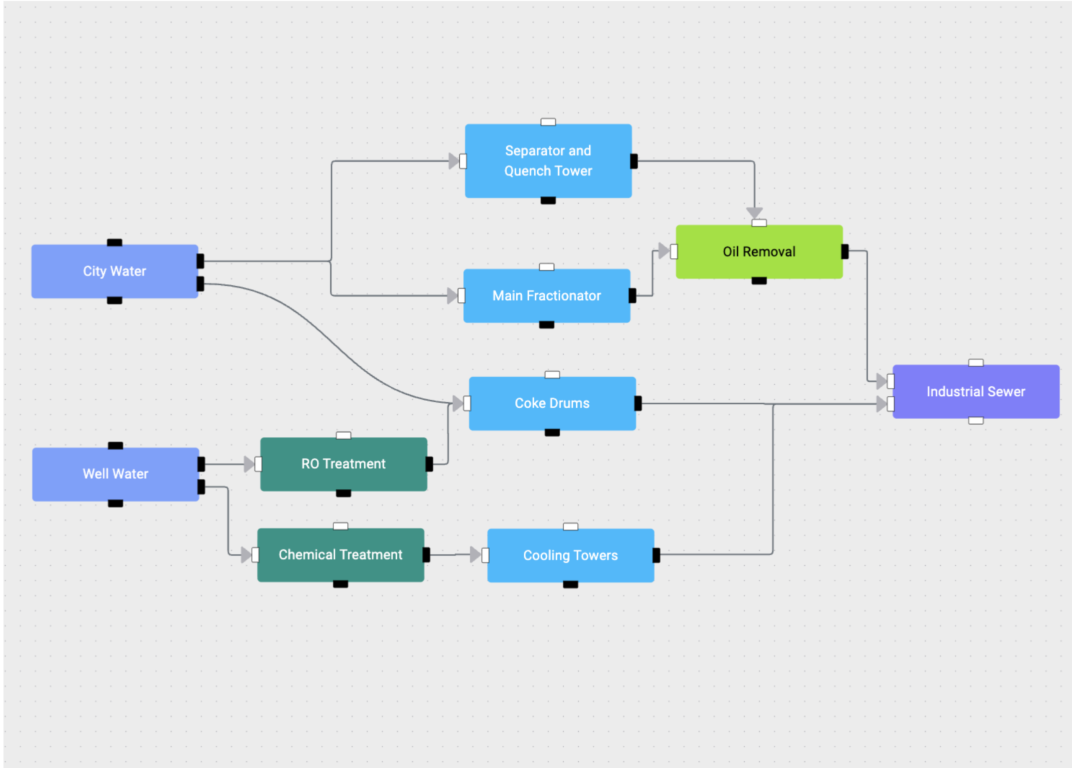


PID water flow diagram in an integrated steel plant [2]

[1] Poddar, Pradeep & Sahu, Omprakash. (2015). Quality and management of wastewater in sugar industry. Applied Water Science.
[2] EPA fact Sheet - National Pollutant Discharge Elimination System (NPDES) Permit Program

A water flow diagram optimized for water assessment is highly recommended

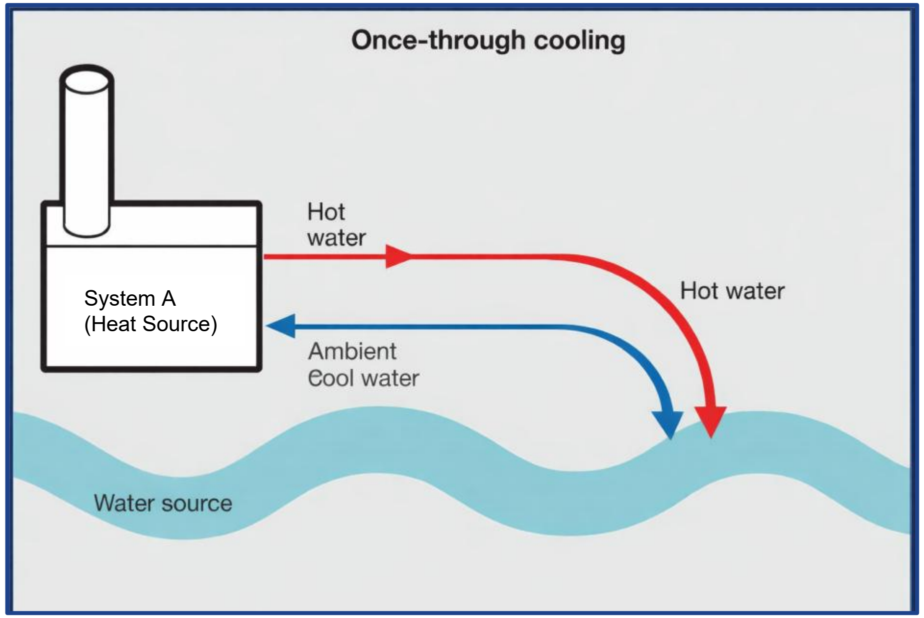




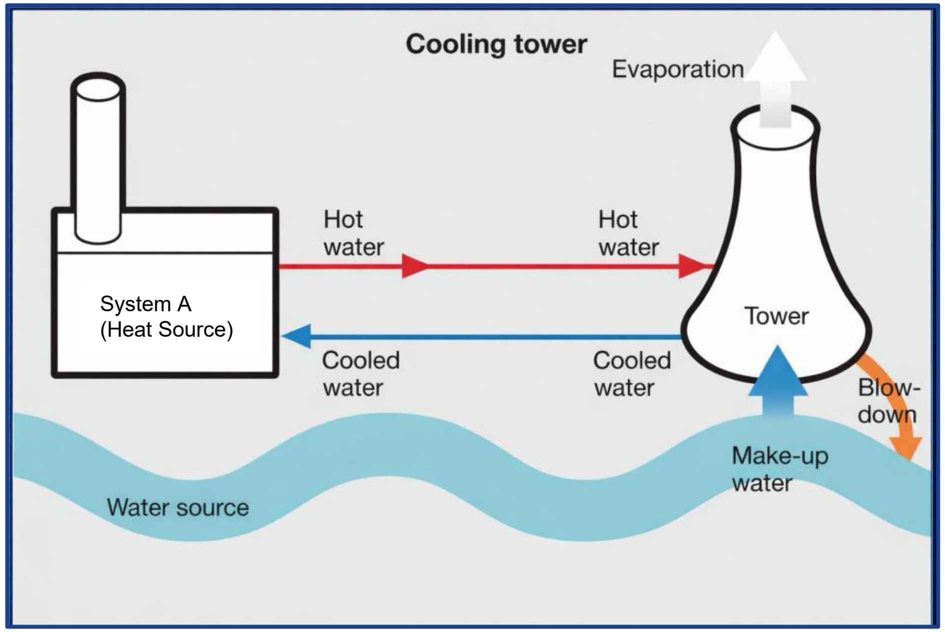
For a baseline assessment and water balance, water flow across each system (block) need to be known

Some Guidelines for defining system boundary

- Step 1: Identify assessment boundary
- Step 2: Identify all water using systems within plant boundary
  - Closed loop non-contact cooling applications (systems without makeup water) need not to be considered separately e.g. closed loop chilled water systems.



Open Loop Cooling system – Once through cooling



Closed Loop Cooling System with Cooling Tower

Source: Wartsila, Efficient use and consumption of water in power generation

Some Guidelines for defining system boundary

- Step 2: For each system that uses water, understand the water intake sources, wastewater discharge outlets, water treatment processes, and wastewater treatment processes

- Step 3: Group systems based on if water consumption and discharge is easier to estimate as a group
  - Each group should draw water from the same intake source, have similar water treatment steps and discharge to the same outlet.
  - Multiple cooling towers/boilers can be combined if needed
  - Combine all sanitary water use (kitchen, restrooms, laundry, etc.) into a single group

Creating a diagram optimized for water assessment

- Trade-off between System Resolution and Data Availability
  - While consider each water users separately (e.g. every quench tank in each production line) will give more insight and resolution into water consumption, it would need more effort to collect the data
  - Start of with a basic water flow diagram that consolidates as many water users as possible, complexities can be added after

Creating Master Table and Water Flow Diagram

Plant Boundary:	**Water Intake Source**	**Wastewater Discharge Outlets**	**Water Treatment Process**	**Wastewater Treatment Process**	Water Recirculation within a System	Water recycled for use in other systems	Water used in product	Evaporative loss	Other loss
Water-Using System									

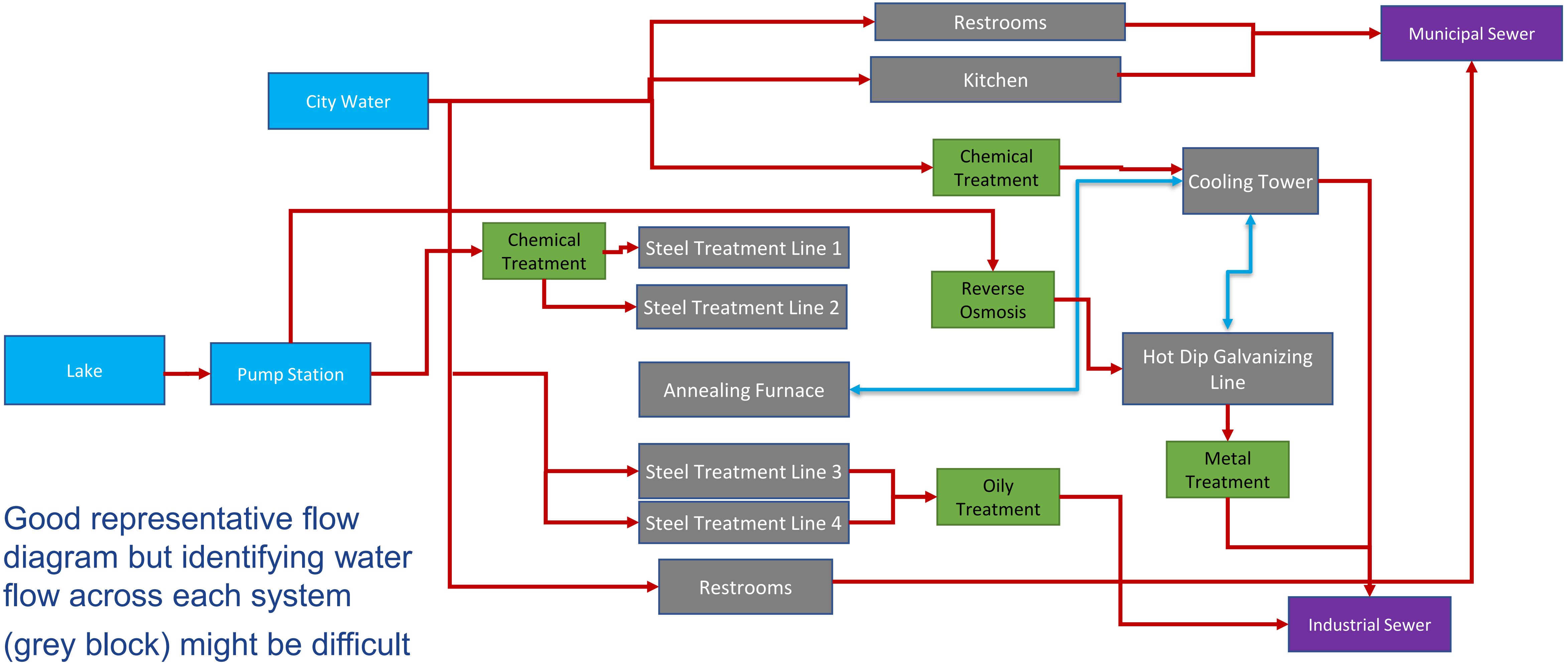
Master Table helps compile all information needed to draw a water flow diagram optimized for water assessment

Example Facility – Water Users

A metal finishing facility has following operations that use water

- There are 4 steel surface treatment lines
  - Lines 1 and 2 served by the lake water after being chemically treated
  - Lines 3 and 4 are served by untreated city water.
  - All the discharge needs to be treated for oil contaminates before being discharged to industrial sewer.
- An annealing furnace that uses cooling tower water for furnace cooling (closed loop system via a heat exchanger)
- A hot dip galvanization line (HDGL)
  - Uses reverse osmosis (RO) treated lake water as make up for diluting its chemical bath
  - Cooling tower water to remove heat from the gears and other mechanical equipment via a heat exchanger
  - The discharge needs to be treated for metal contaminates before being discharged to industrial sewer
- The cooling tower that serves annealing furnace and the HDGL line gets its water from the nearby lake which must be chemically treated before being used as makeup. Blowdown is sent to industrial sewer.
- The restrooms in the location use city water and drains to domestic sewer.

Example Facility – Draft Flow Diagram



Good representative flow diagram but identifying water flow across each system (grey block) might be difficult

Identify all water using systems

Plant Boundary – Entire Facility

System Boundary

List of Direct Water Use System

- Hot Dip Galvanization Line
- Steel Treatment Line 1
- Steel Treatment Line 2
- Steel Treatment Line 3
- Steel Treatment Line 4

Non-Contact (indirect) Water Using System

- ~~Furnace Cooling (Annealing)~~
- ~~Equipment Cooling (HDGL)~~

cooling loads

- Cooling Tower Makeup

Water Treatment System

- Chemical Treatment
- RO System

Wastewater Treatment System

- Metal Treatment
- Oil Treatment

Understand the water flows and group systems

- Cooling Tower
  - Make up from chemically treated city water
  - Blowdown to industrial sewer
- Steel treatment Line 1 and 2
  - Make up from lake water after chemical treatment
  - Discharge to industrial sewer after oil removal
- Steel treatment Line 3 and 4
  - Make up from City water
  - Discharge to industrial sewer after oil removal
- Hot Dip Galvanization Line
  - Make up from RO treated lake water
  - Discharge to industrial sewer after metal removal
- Sanitary
  - Make up from city water
  - Discharge to domestic sewer

Master Table to compile information

Plant Boundary:	Water Intake Source	Wastewater Discharge Outlets	Water Treatment Process	Wastewater Treatment Process	Water Recirculation within a System	Water recycled for use in other systems	Water used in product	Evaporative loss	Other loss
Water-Using System									

Master Table for example facility

Plant Boundary:	Water Intake Source	Wastewater Discharge Outlets	Water Treatment Process	Wastewater Treatment Process	Water Recirculation within a System	Water recycled for use in other systems	Water used in product	Evaporative loss	Other loss
Whole Facility	1 Lake Water 2. City Water	1 Industrial Sewer 2. Municipal Sewer	1. Chemicals for Cooling Tower 2. Chemicals for Steel Lines 3. Reverse Osmosis	1. Oily Removal 2. Metals Removal					
Water-Using System									

Master Table for example facility

Plant Boundary:	Water Intake Source	Wastewater Discharge Outlets	Water Treatment Process	Wastewater Treatment Process	Water Recirculation within a System	Water recycled for use in other systems	Water used in product	Evaporative loss	Other loss
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Water-Using System									
Cooling Tower									
Steel treatment 1 & 2									
Steel treatment 3 & 4									
Hot Dip Galvanization Line									
Sanitary									

Master Table for example facility

Plant Boundary:	Water Intake Source	Wastewater Discharge Outlets	Water Treatment Process	Wastewater Treatment Process	Water Recirculation within a System	Water recycled for use in other systems	Water used in product	Evaporative loss	Other loss
Whole Facility / **Water-Using System**	1 Lake Water 2. City Water	1 Industrial Sewer 2. Municipal Sewer	1. Chemicals for Cooling Tower 2. Chemicals for Steel Lines 3. Reverse Osmosis	1. Oily Removal 2. Metals Removal					
Cooling Tower	**2**	**1**	**1**	**-**	**x**	**-**	**-**	**x**	**-**
Steel treatment 1 & 2	**1**	**1**	**2**	**1**	**-**	**-**	**-**	**x**	**-**
Steel treatment 3 & 4	**2**	**1**	**-**	**1**	**-**	**-**	**-**	**x**	**-**
Hot Dip Galvanization Line	**1**	**1**	**3**	**2**	**-**	**-**	**-**	**x**	**-**
Sanitary	**2**	**2**	**-**	**-**	**-**	**-**	**-**	**x**	**x**

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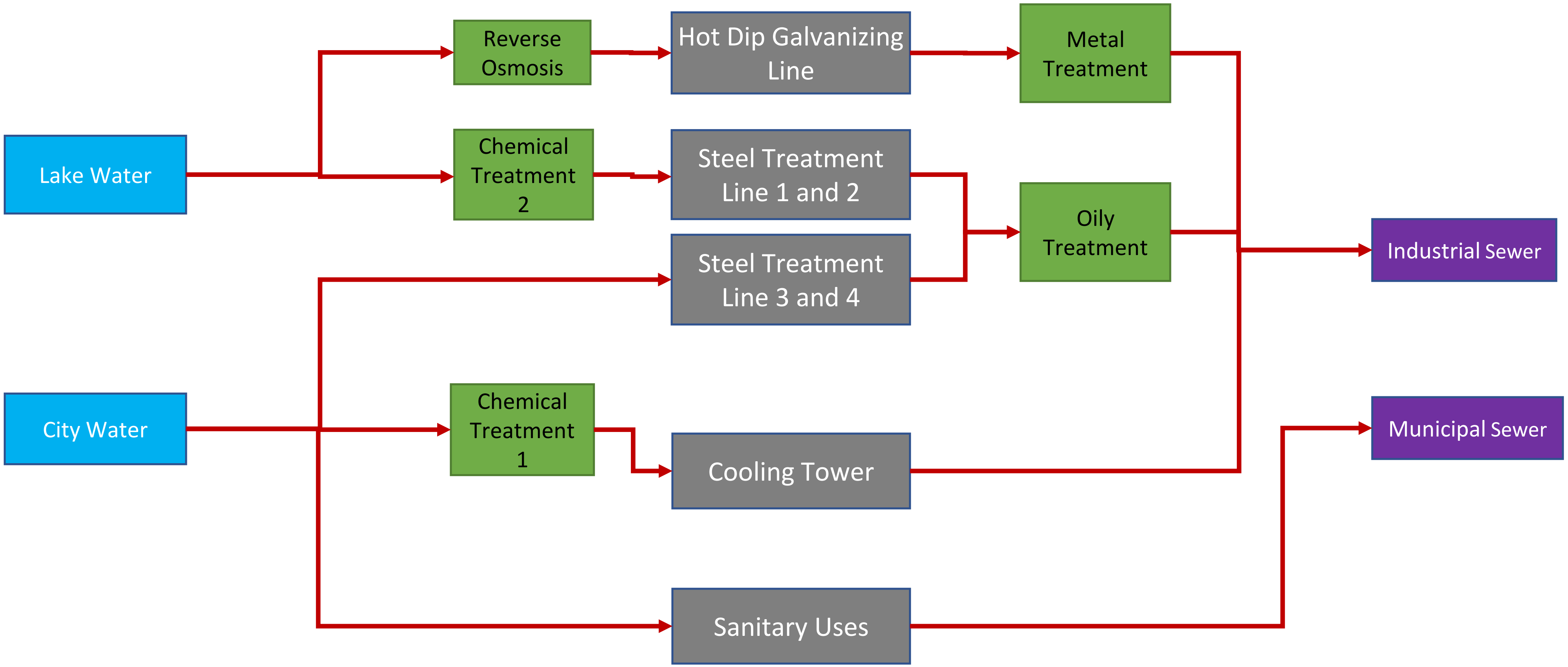
Creating Plant Water Flow Diagram

- **List all water discharge outlets (on the left)**
  - Example : Municipal Water, River or Lake, Ocean or Tide, Groundwater, Rainwater, Other.
- **List all wastewater discharge outlets (on the right)**
  - Example : Municipal Sewer, Third-party Disposal, River or Lake, Ocean or Tide, Groundwater, Onsite Disposal, Stormwater
- List all system boundaries identified for water balance in the middle
  - Example : Direct water users , Cooling towers , boilers etc.
- List all water treatment processes and wastewater treatment processes between the systems are the inlet/discharge
- Mark the appropriate water flows including water recycle, recirculation, losses etc.

Example Facility –Flow Diagram Optimized for Water Balance



Exercise

List out the water users in your facility, think through their water flows and based on the guidelines discussed identify how they can be grouped together for water baselining/water balance.

Let's review what we've learned

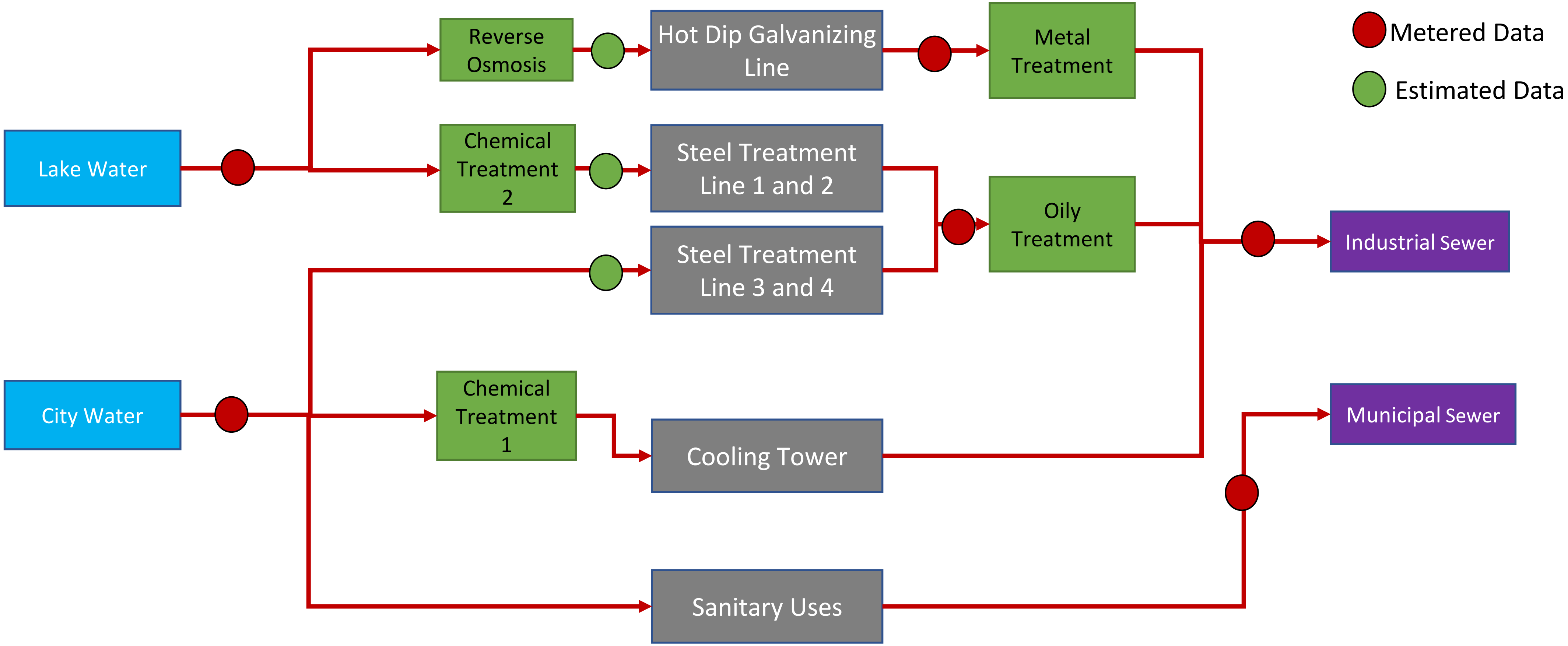
Steps to Water Flow Diagram

- Understand where water is used the facility and list them
- Group water end users to make water assessment easier
- Determine the water flows including recirculation and create a master table
- Draw a schematic easy to follow water flow diagram

Next Step

- Put together a data collection strategy

Example Facility – Water Flow Diagram



Homework #1

1. Draw a water flow diagram for your facility based on the guidelines discussed using the MEASUR tool – you can make use of the master table template provided as needed

Optional Exercises

1. Mark the points where metered data is available.

2. Use the WRI Aqueduct tool to identify the water stress for your location.

MEASUR – Water Diagram Module

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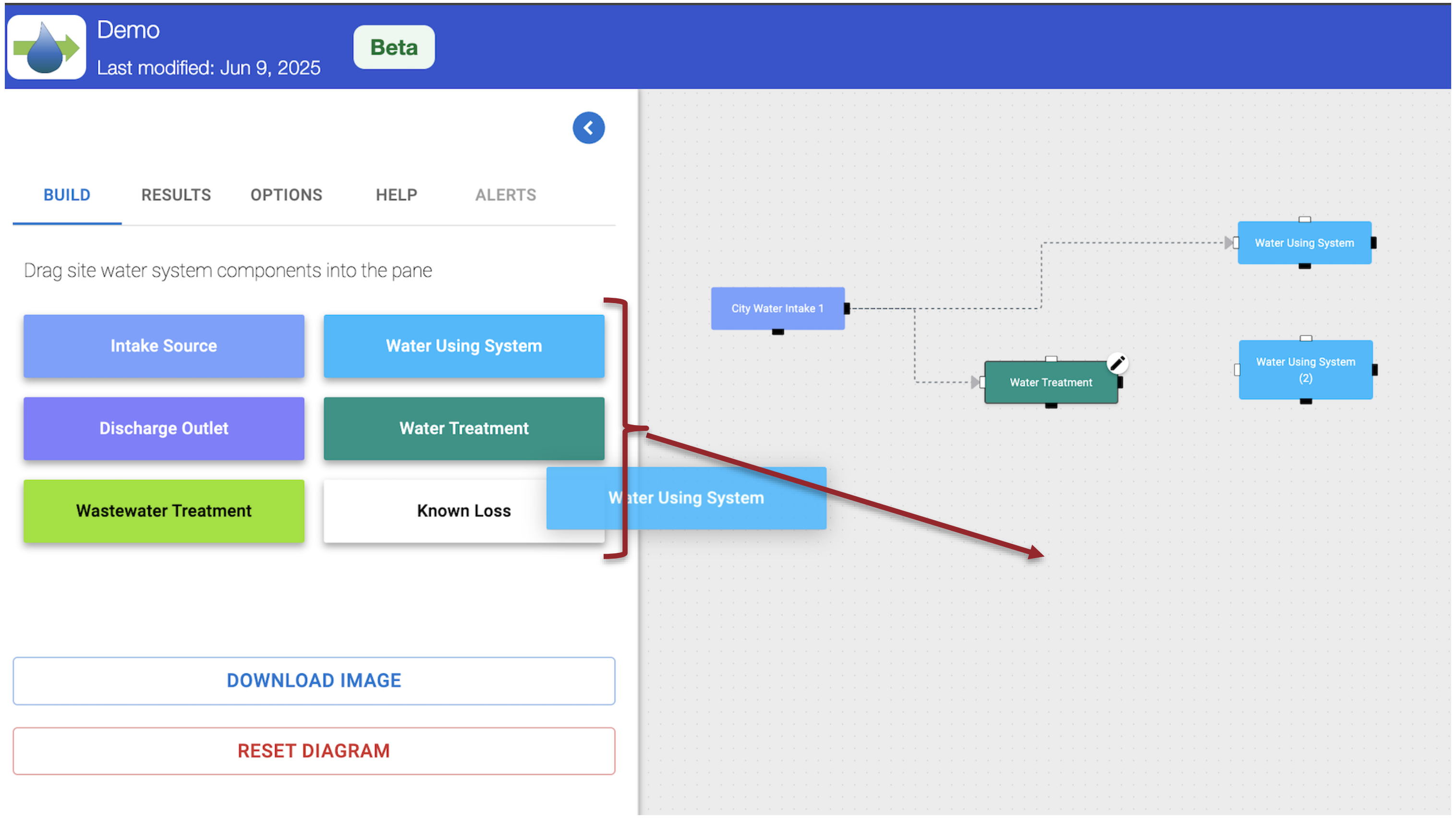
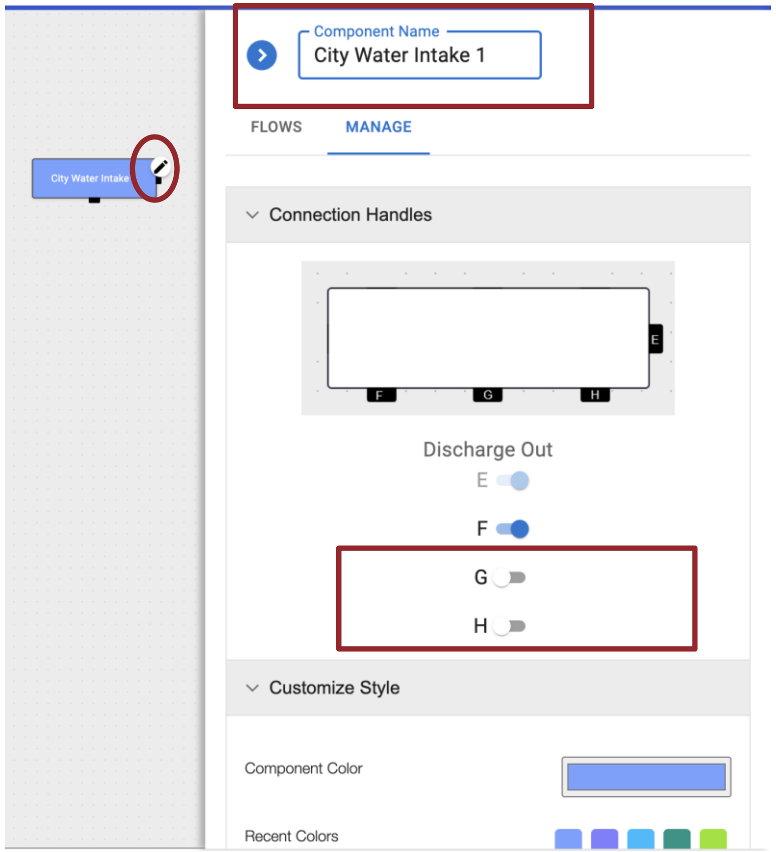
Water Baseline – Flow Diagram

- Drag, Drop and Connect Components as per water flows

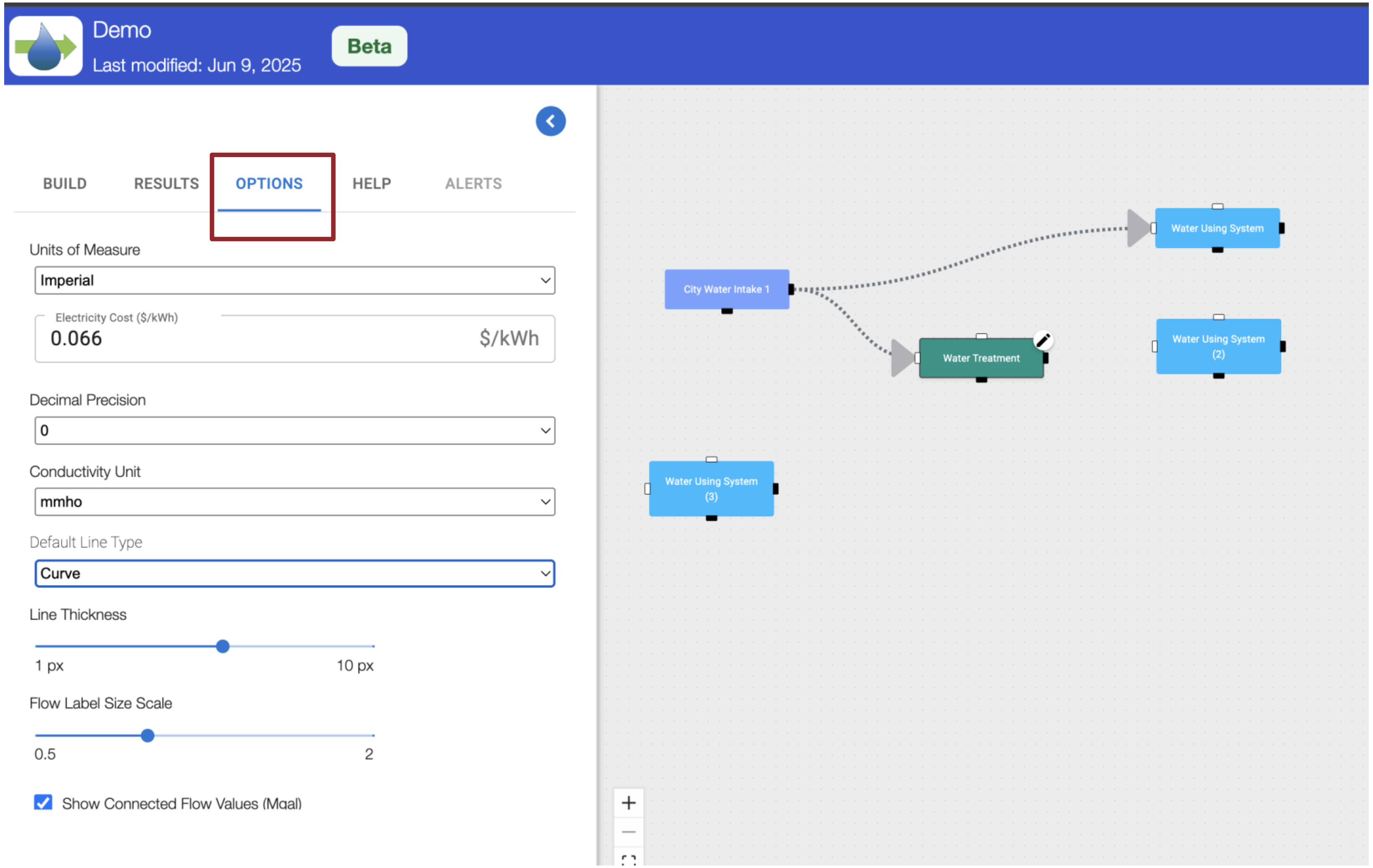


- Edit individual components using pencil icon

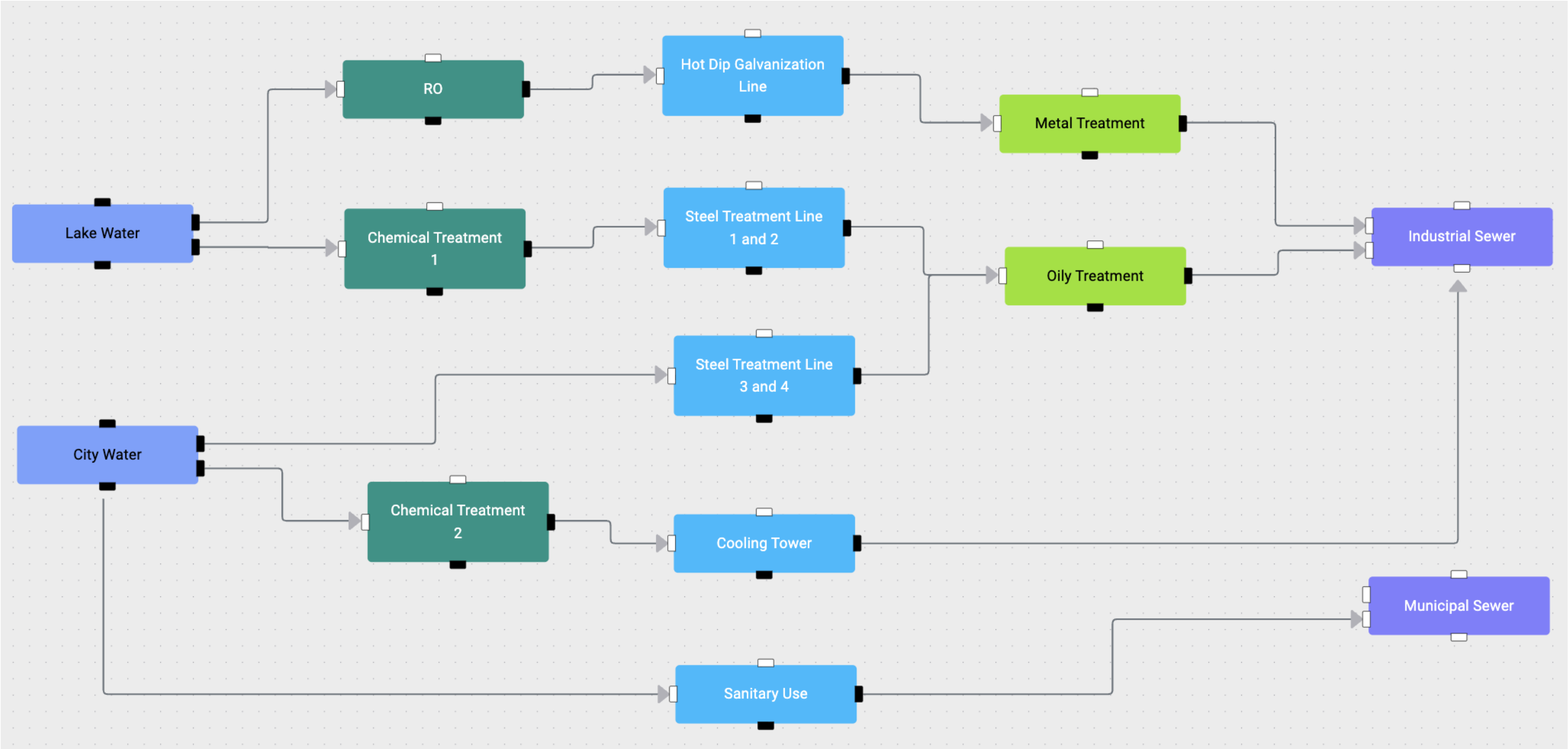


Water Baseline – Flow Diagram

Use “Options” tab to customize flow diagram



Water Map



RO
Hot Dip Galvanization Line
Metal Treatment
Lake Water
Chemical Treatment 1
Steel Treatment Line 1 and 2
Industrial Sewer
Oily Treatment
Steel Treatment Line 3 and 4
City Water
Chemical Treatment 2
Cooling Tower
Municipal Sewer
Sanitary Use

Thank You all for attending today’s webinar.

See you all on next Tuesday – June 23, 2026 – 10 am ET

If you have specific questions, please stay online and we will try and answer them.

Alternately, you can email questions to me at thirumarank@ornl.gov

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