Better Plants
U.S. DEPARTMENT OF ENERGY

Industrial Water Systems
Virtual INPLT Training & Assessment

Session 1

Tuesday – May 21st, 2024

10 am – 12:30 pm

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Welcome

- Welcome to the first Water Virtual INPLT 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!

Kiran Thirumaran, Oak Ridge National Lab

Education

- North Carolina State University– M.S. (Mech. Eng.)

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.

Safety and Housekeeping

- You are welcome to ask questions at any time during the webinar
- When you are not asking a question, please MUTE 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

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 INPLT 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 INPLT results in other facilities

Water Virtual INPLT Agenda

- Week 1 (May 21st) – Introduction to Industrial Water Assessment and Plant Water Profiler
- Week 2 (May 28th) – Understanding System Level Water use
- Week 3 (June 4th) – True Cost of Water
- Week 4 (June 11th) – Plant Water Profiler Working Session
- Week 5 (June 13th) – Identifying Water Savings Opportunity
- Week 6 (June 25th) – Virtual Treasure Hunt
- Week 7 (July 2nd) – Estimating Water Savings Opportunities
- Week 8 (July 9th) – Industrial Water System VINPLT Wrap-up Presentations

Agenda – Session ONE

Today's Content:

- Introduction
  - Overview of Industrial Water Use
  - Water Risks
  - Water-Energy Nexus
- 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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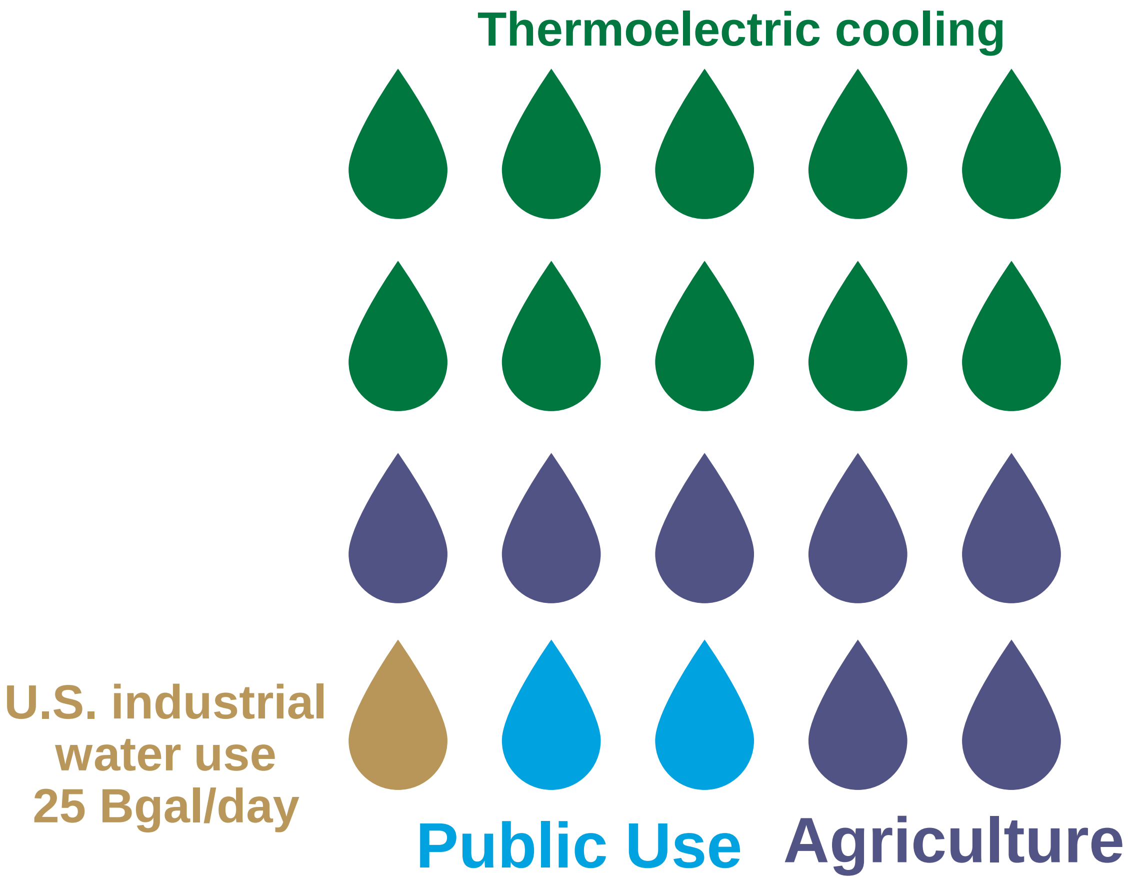
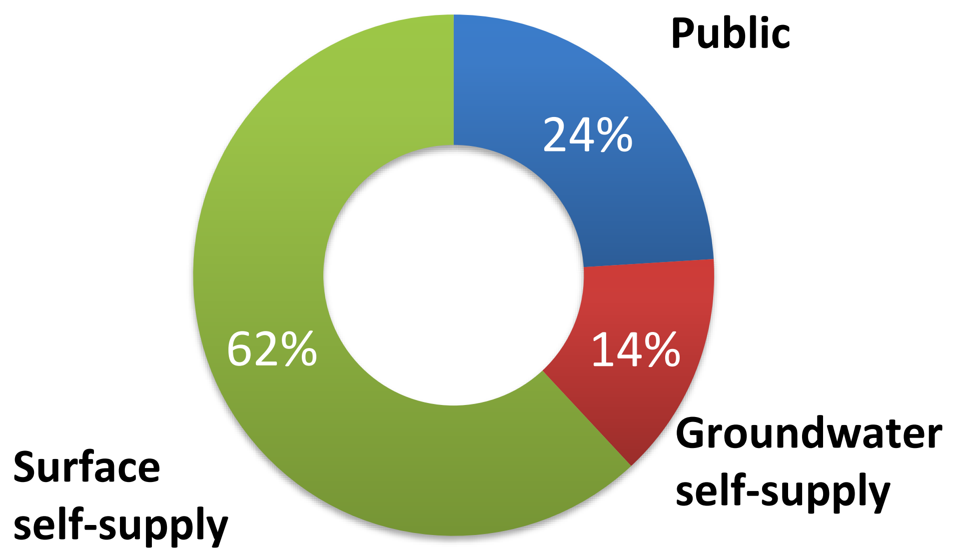
Industrial Water Use: Snapshot

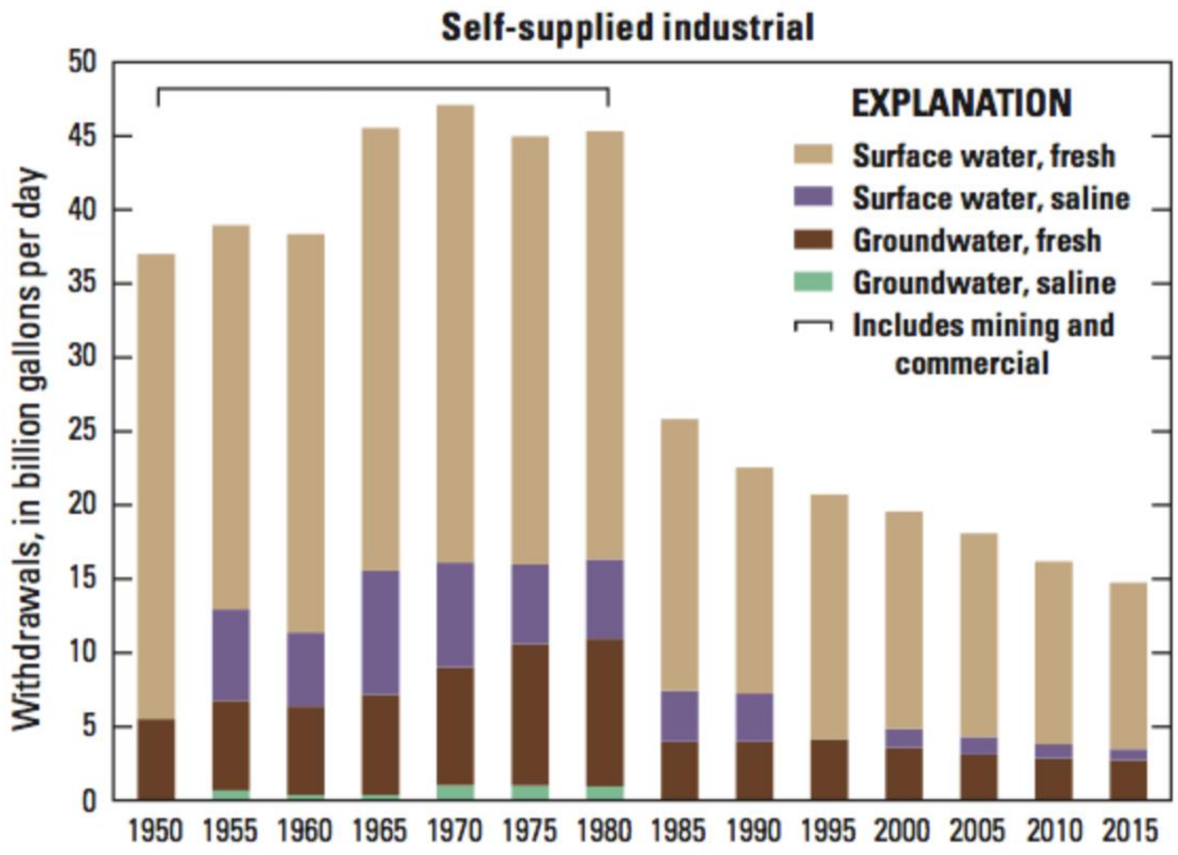
- Industrial water use
  ~ 5 – 6 % U.S. Total
- Most self-supplied
- Small fraction of total operational costs

U.S. Water Use
400 billion gal/day



Estimated sources of manufacturing water use

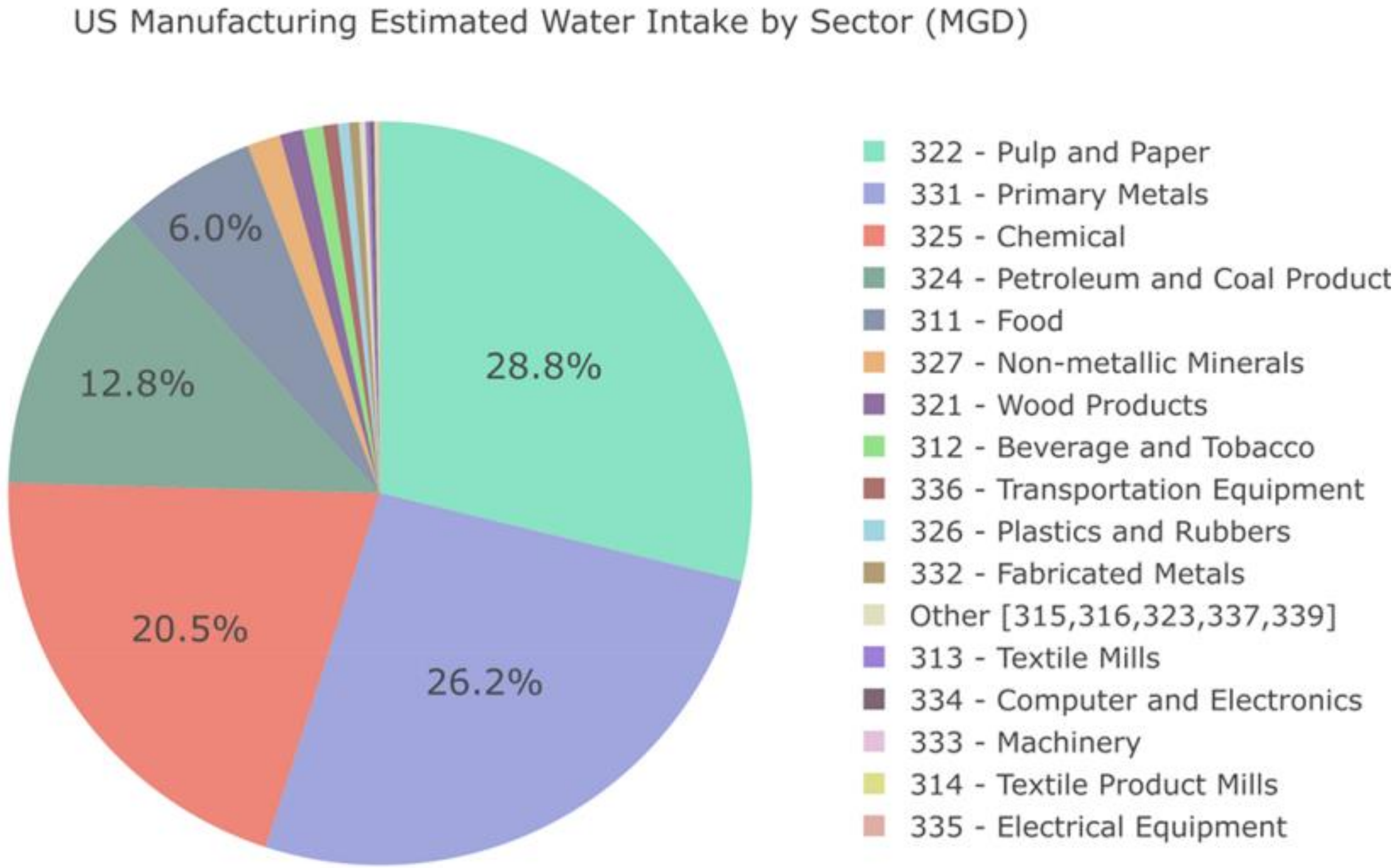




- **Only 15% of total water intake in industries is consumptive**
- **Self supplied water: 94% fresh and 6% saline**

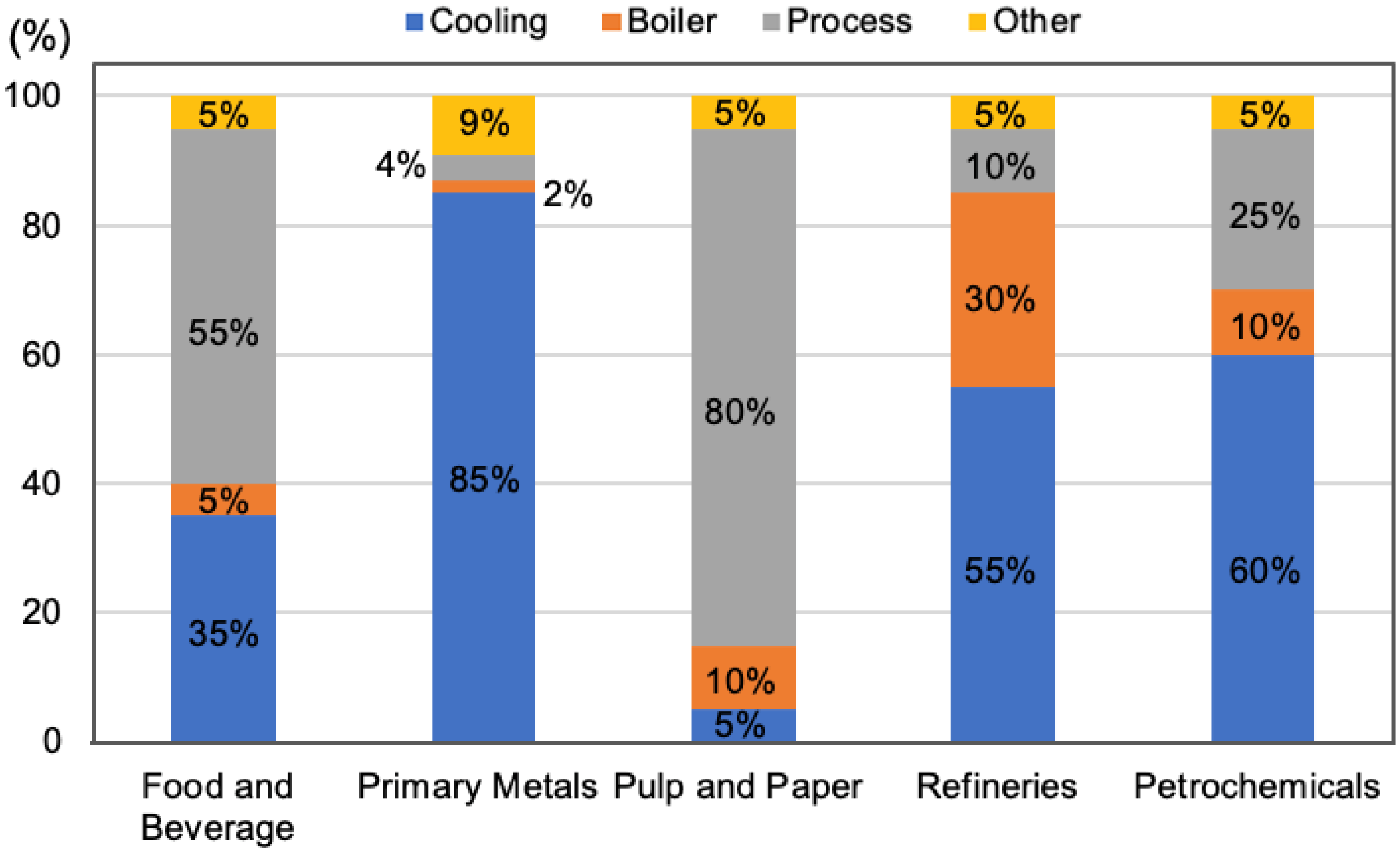
Source: Maupin, M.A. et.al, “Estimated use of water in the United States in 2015” U.S. Geological Survey Circular 1441, 65 p.

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..

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

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Polling Question 1

Polling Question

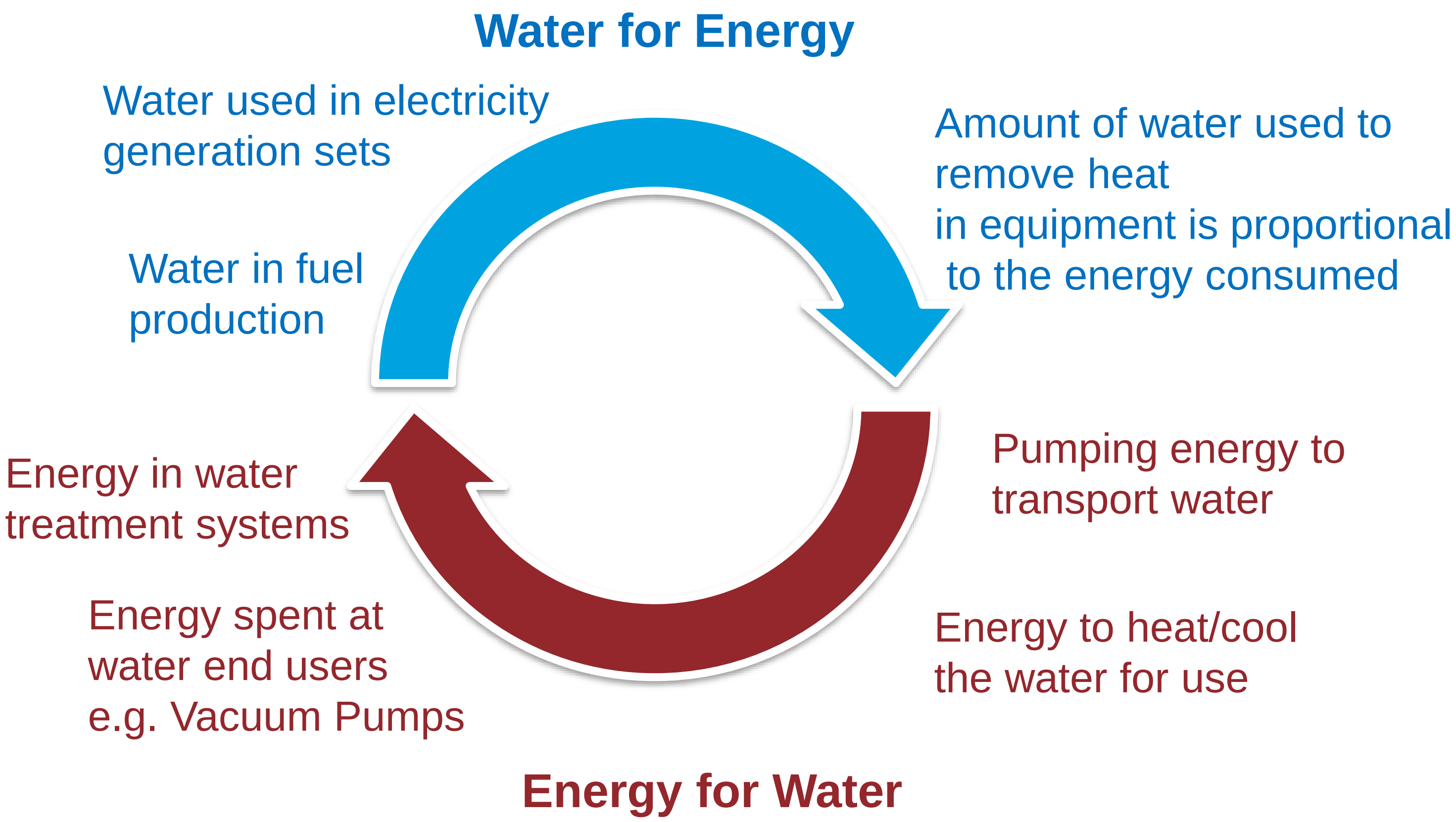
1) Which category best describes your facility?

   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 (last two items: 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 **government 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



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

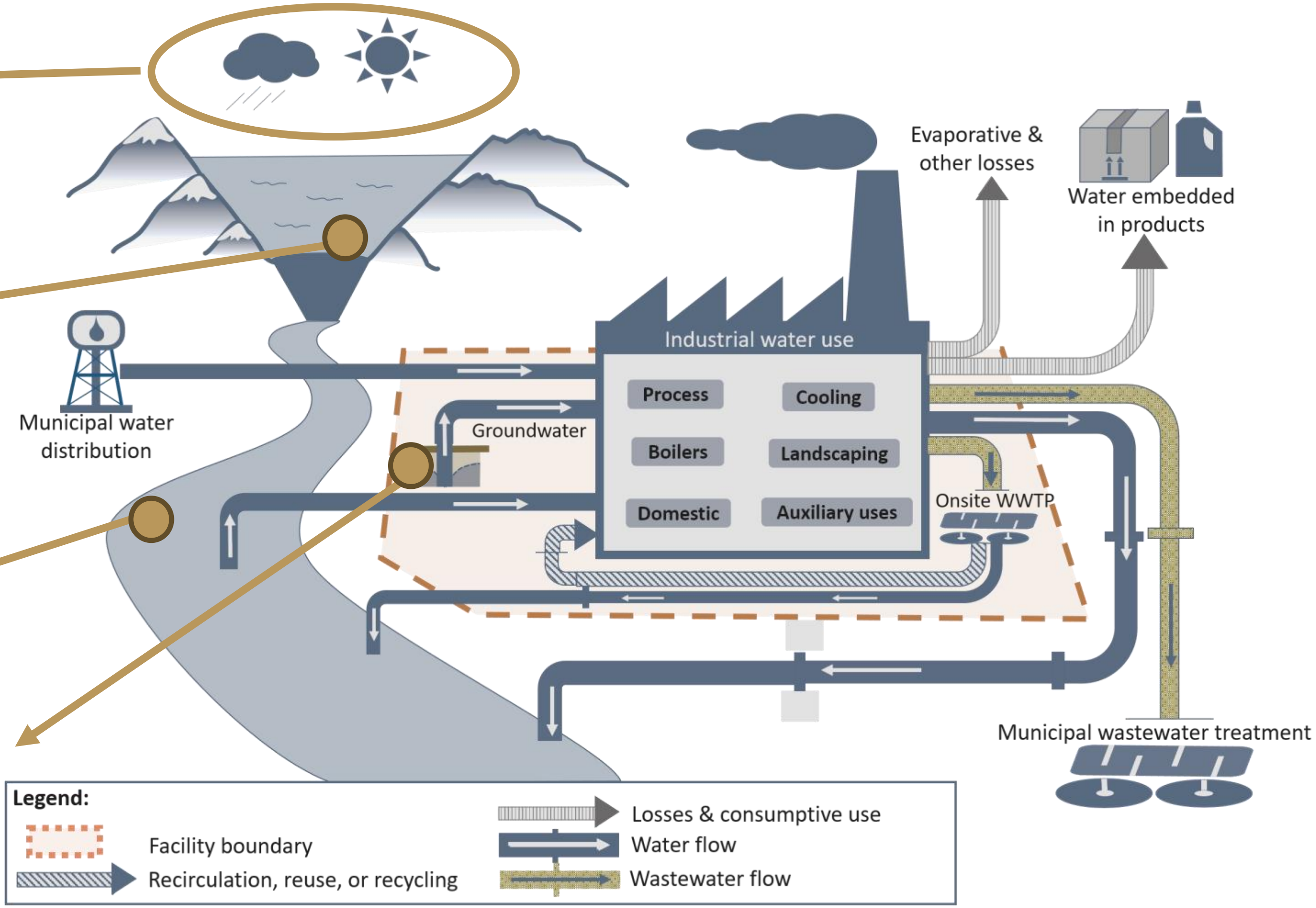
Industrial water supply is affected by external factors

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

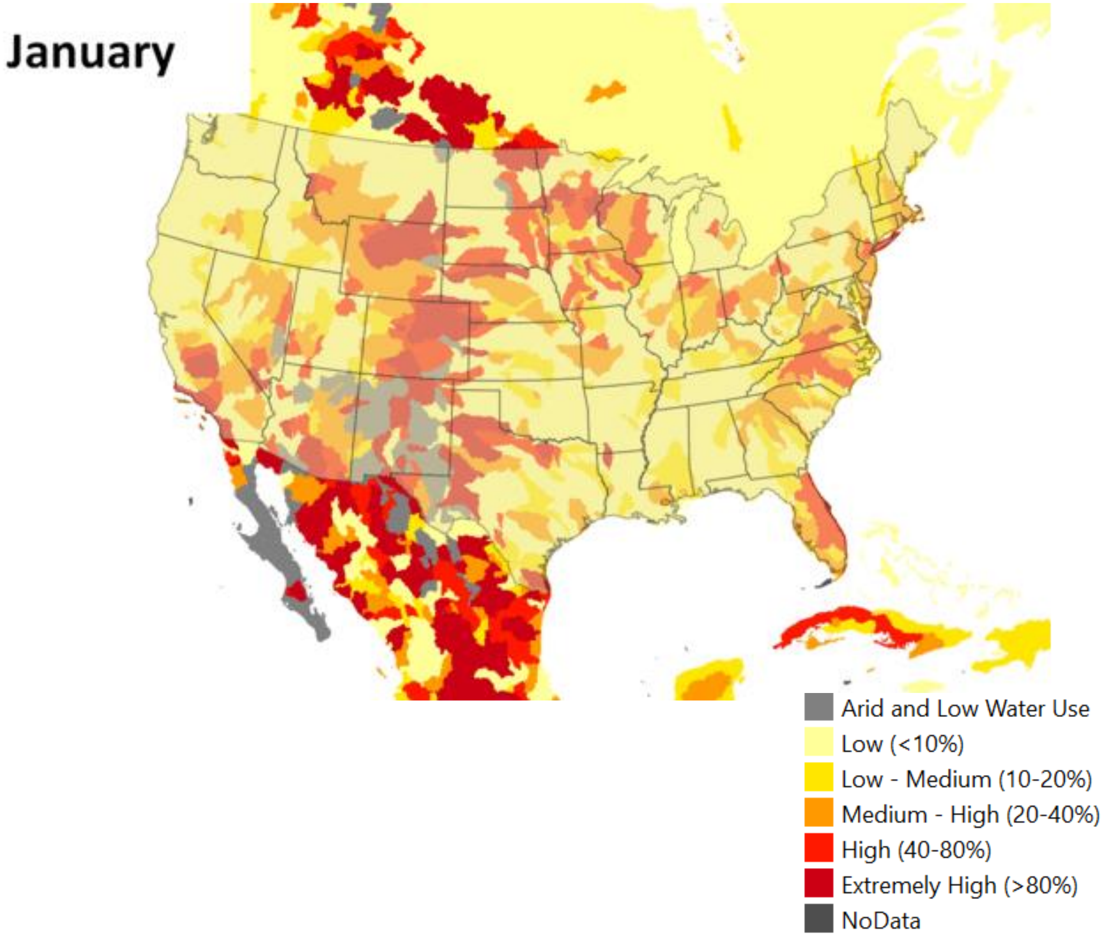
Local water availability is the predominate factor that determines the business risk related to water

Water risks in your region

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

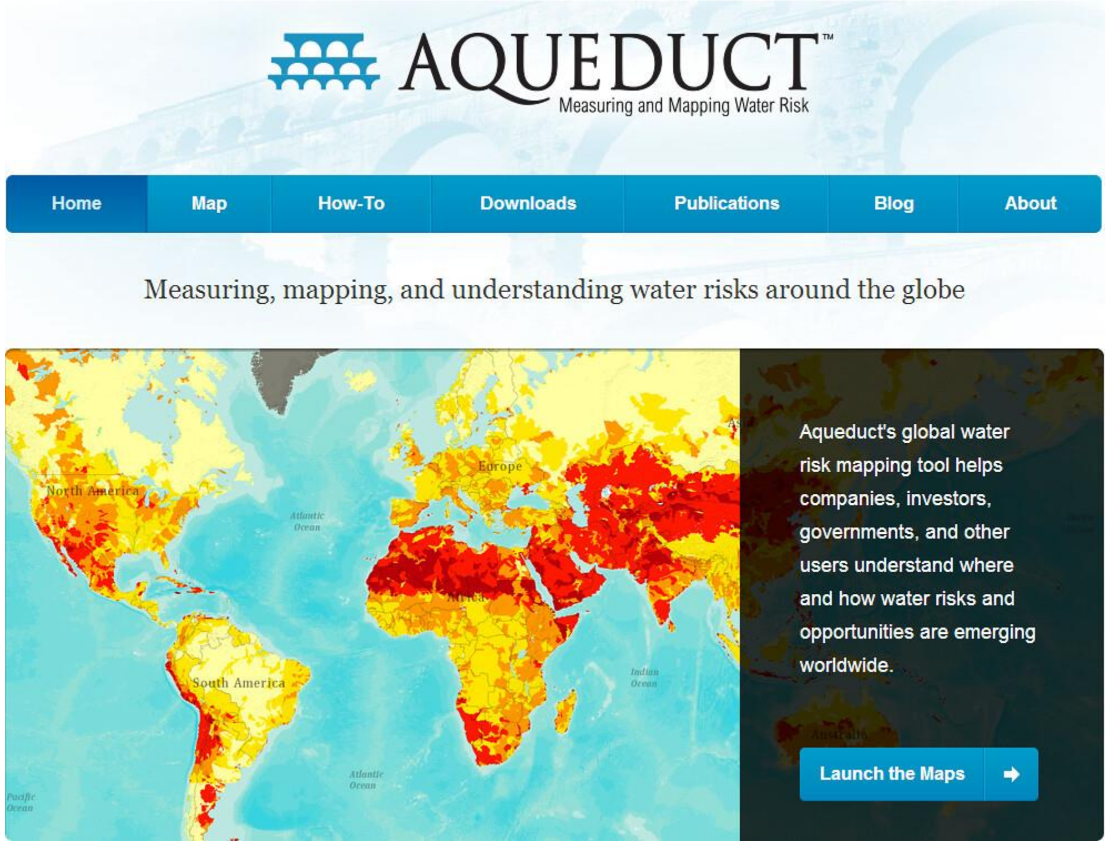
Physical Risk – Quality
Measure's risk related to water that is unfit for use. Eg. Untreated Connected Wastewater

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



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

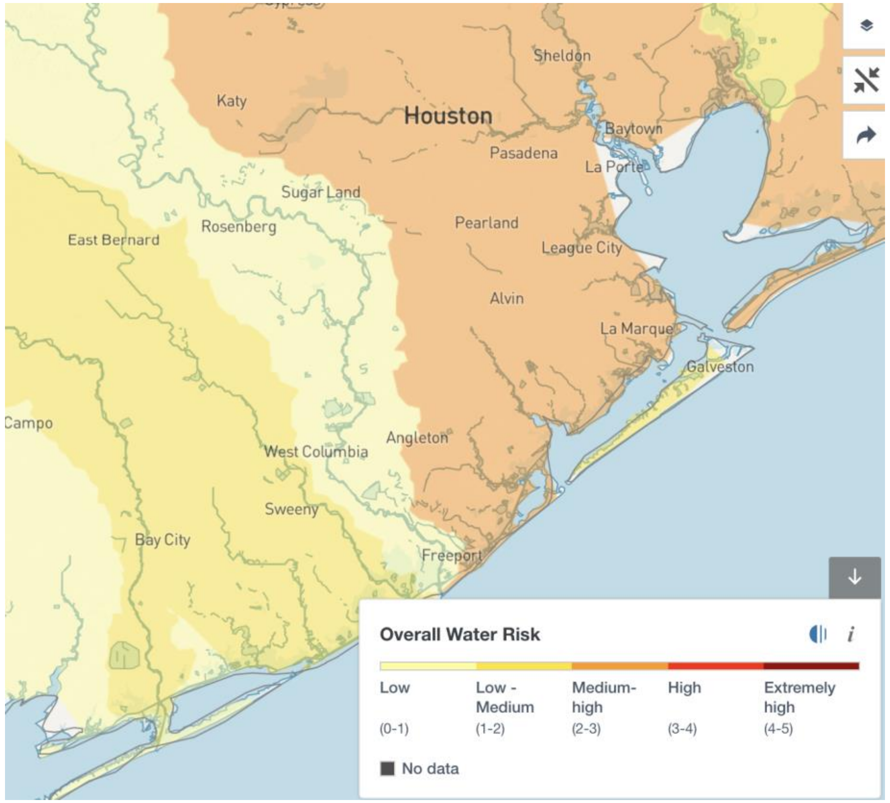
Regulatory and Reputation Risks

- Unimproved/No Drinking Water
- Unimproved/No Sanitation
- Country ESG Risk Index

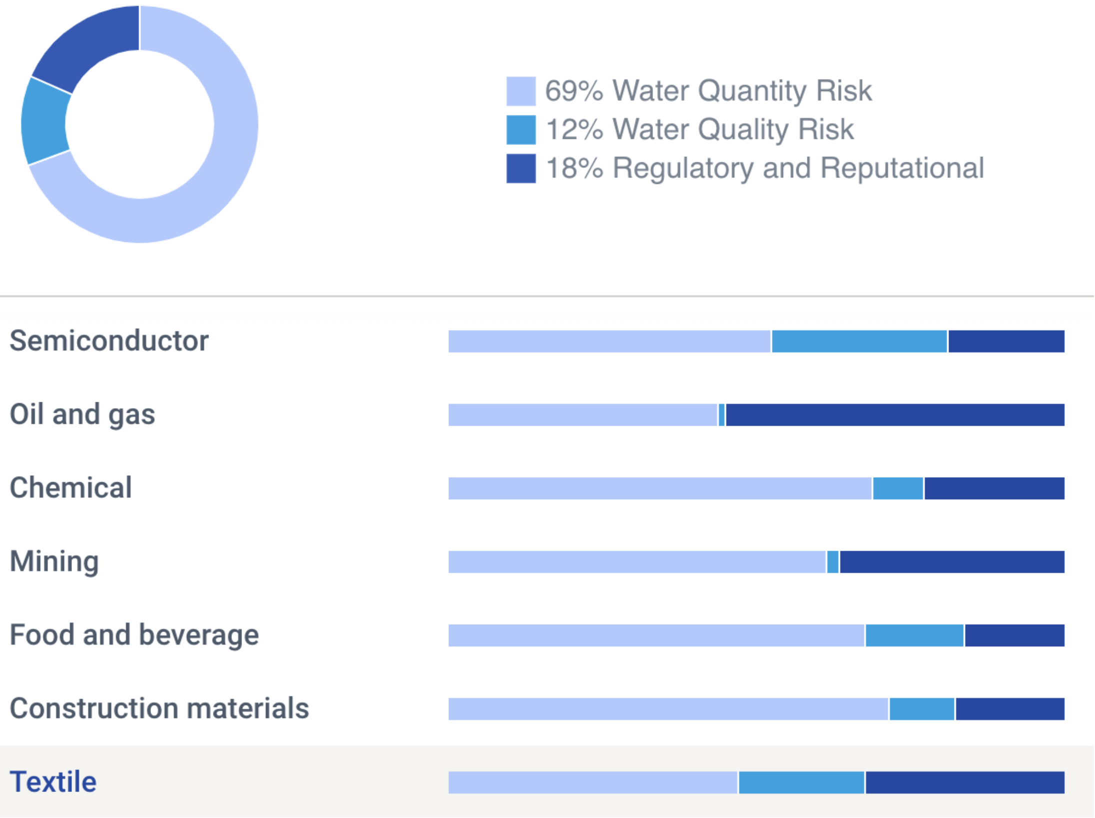
Risk Indicators Measured

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.



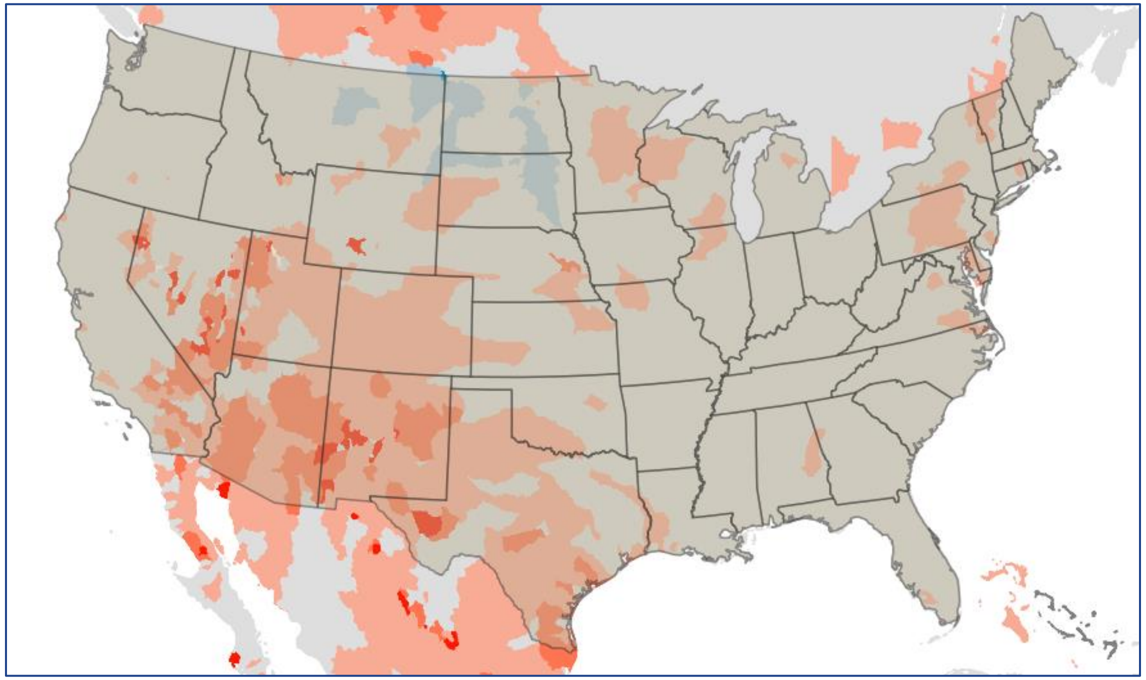
Overall Risk Index for a Food and Beverage manufacturer in the Houston, TX area.



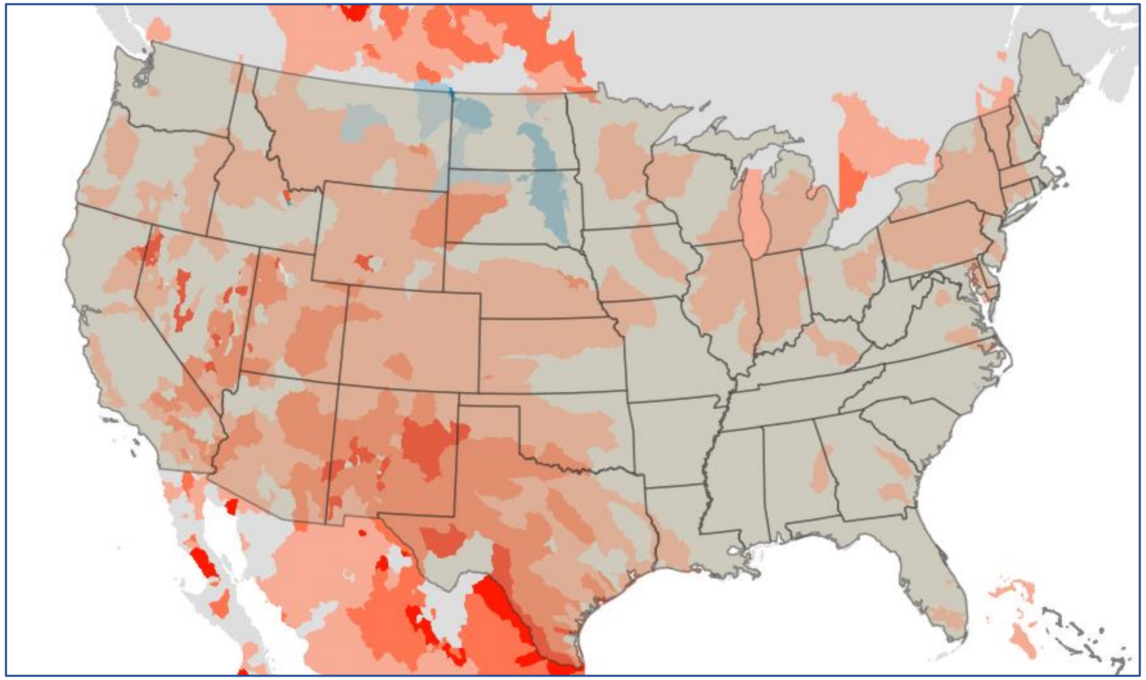
Water Risk weightages considered to calculate the overall risk metric

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

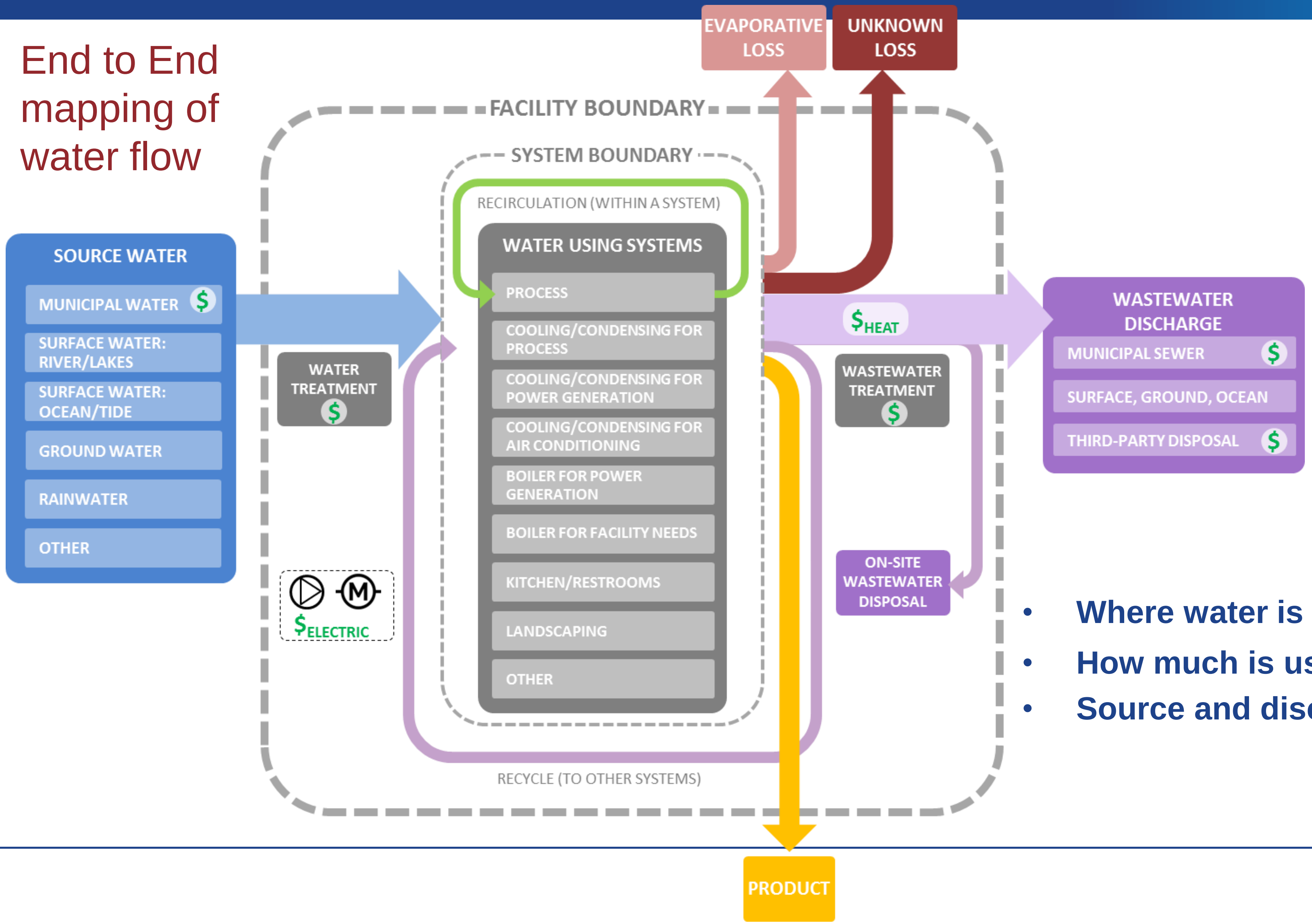
Step 1. Baselining water use

Step 2. Quantify true cost of water

Step 3. Identifying water savings opportunity

Step 1. Baselining water use

End to End mapping of water flow

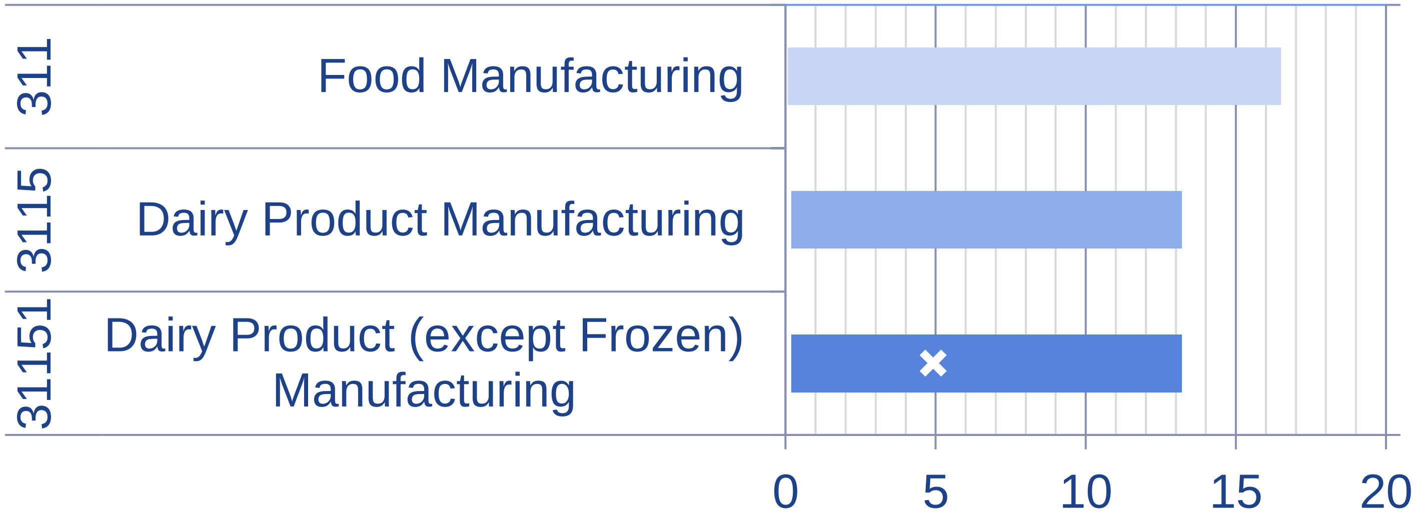


- Where water is used
- How much is used
- Source and discharge

Step 1. Baselining water use

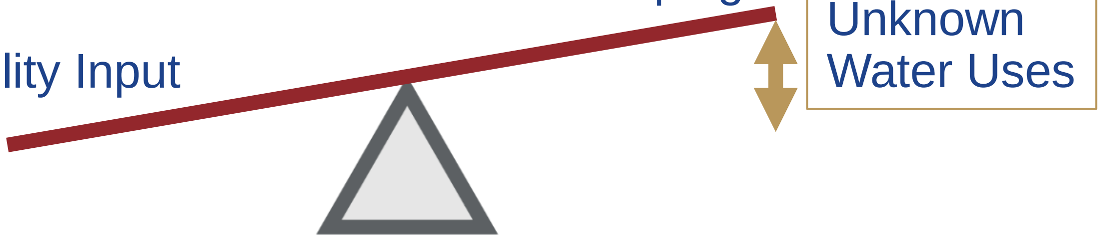
Significance to the facility

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

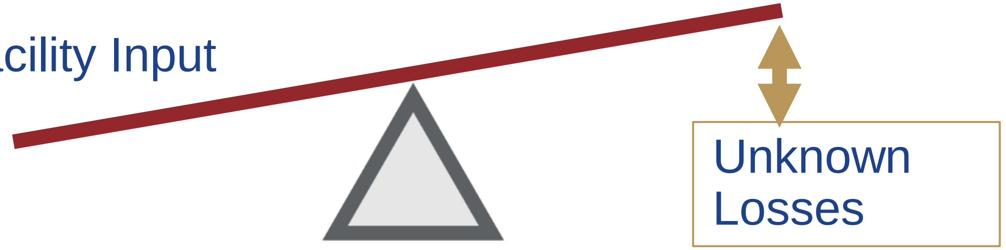


Water Balance

- Total of all water used by individual **Systems** should equal **Plant Water Intake**



- **Plant Water Intake** should equal **Plant Water outflows**



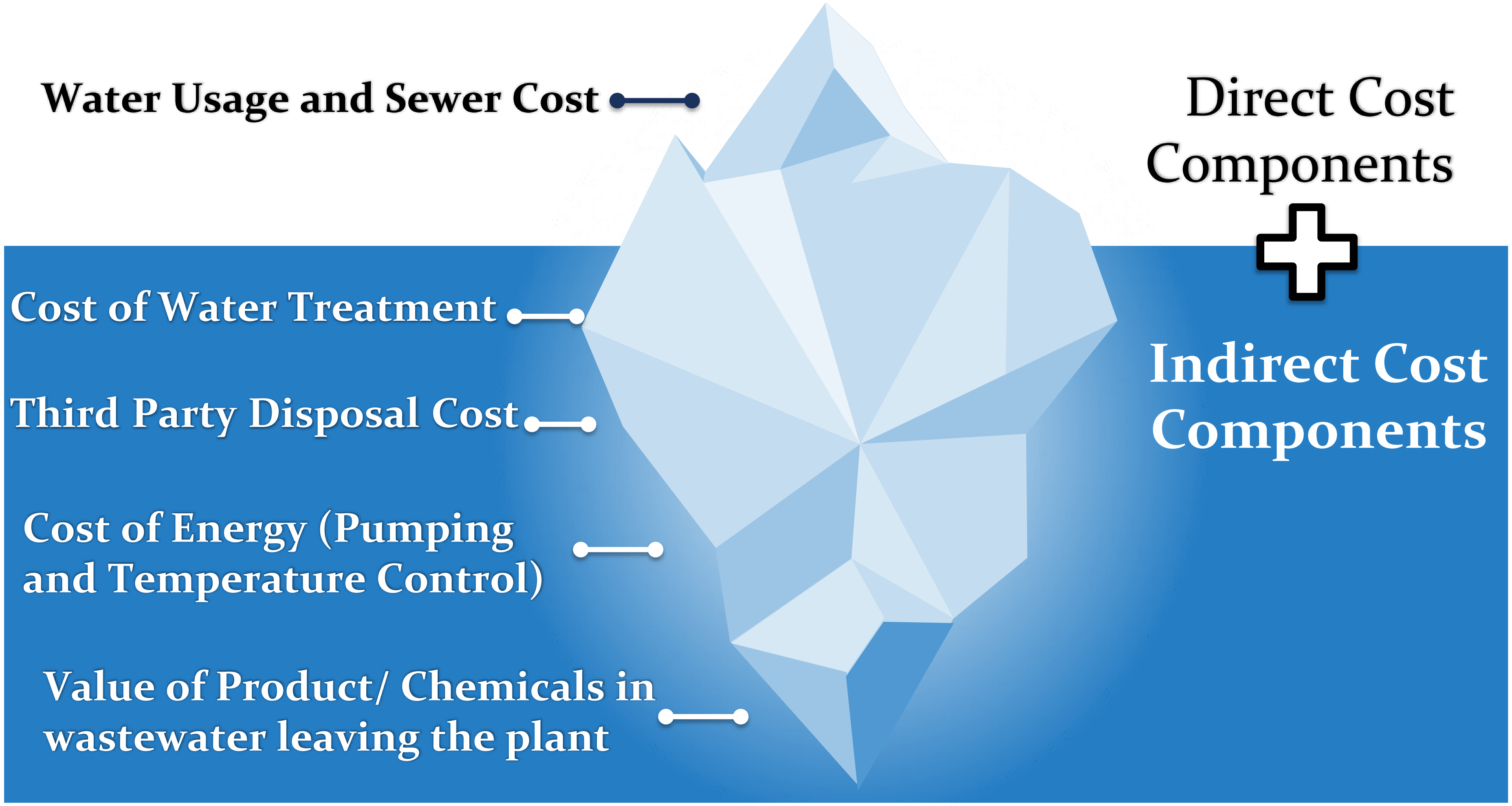
A “Water Balance” helps baseline water consumption

Why to Conduct a Water Balance?

- **Accurate water accounting is the key to true cost determination**

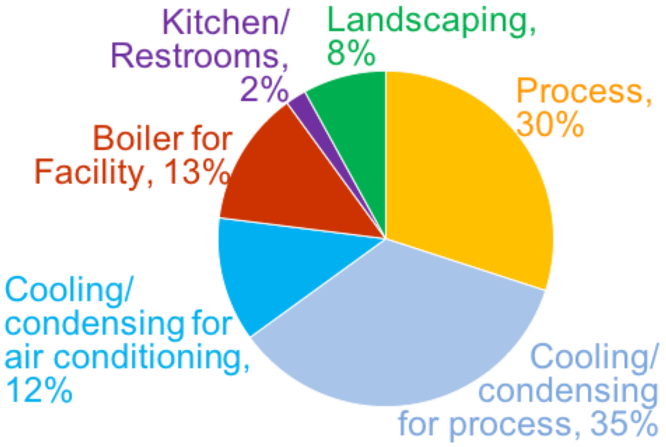
- **Water balance** gives the opportunity to
  - Perform sanity check on water estimates
  - Reduce uncertainty in baseline water use and associated true cost components
  - Quantify unaccounted water use or unknown water loss
  - Better accuracy in estimating water and true cost savings from water-efficiency measures

Step 2. True Cost of Water

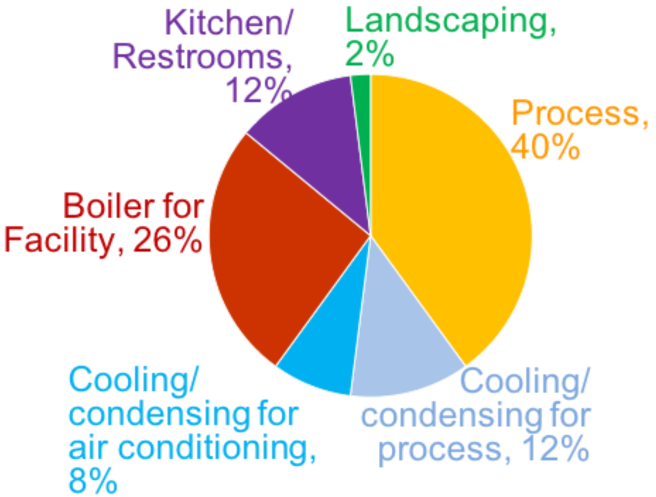


Significance to finding True Cost of Water

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



Source water intake

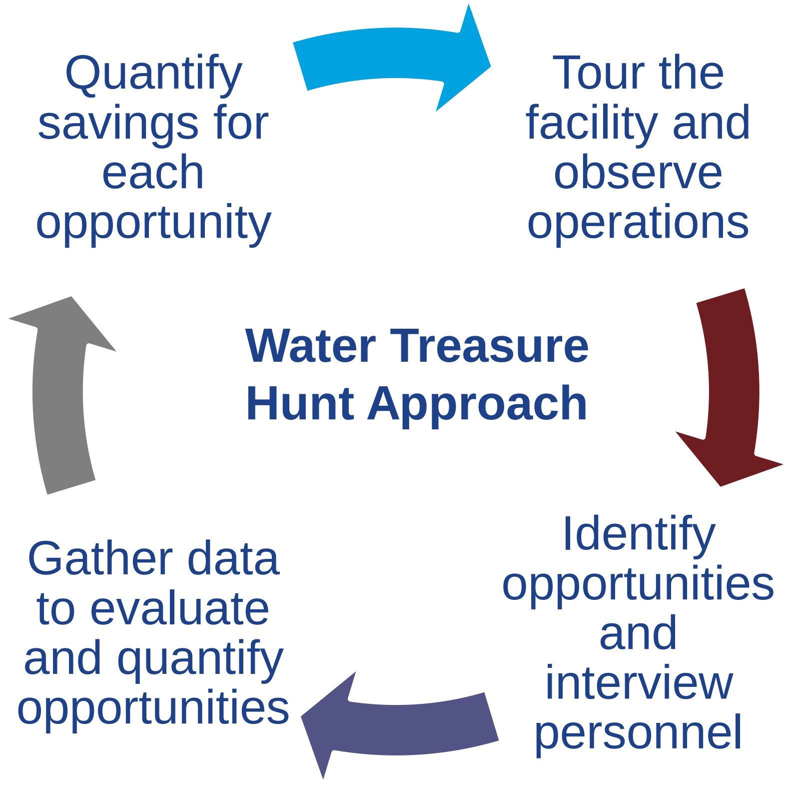


True cost of water

Step 3: 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.

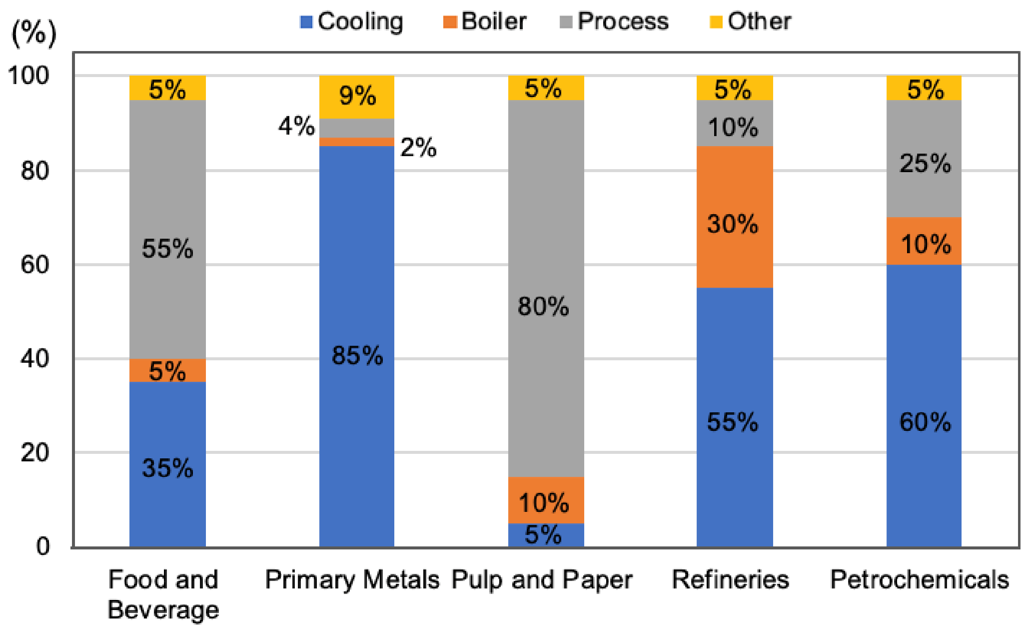
Source: DOE Better Plants Solution Center

Plant Water Flow Diagram

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 (direct or indirect), 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.

Direct and Indirect Water Users

Indirect or non-contact water does not touch any raw material, intermediate product, waste product, or finished product. They are typically part of a closed loop system.

Most relevant and typically seen in cooling applications

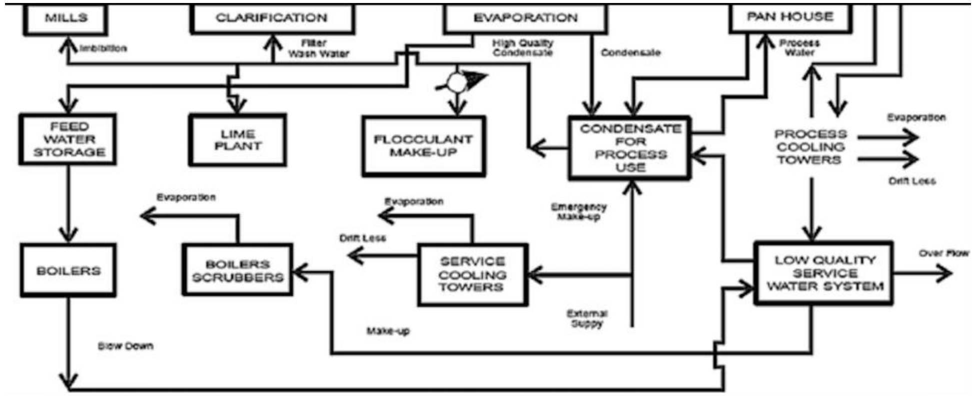
Direct Cooling

- Product cooling by contact (plastic extrusion, metal surface cooling)
- Effluent picks up contaminates from the product/raw material and needs to be treated

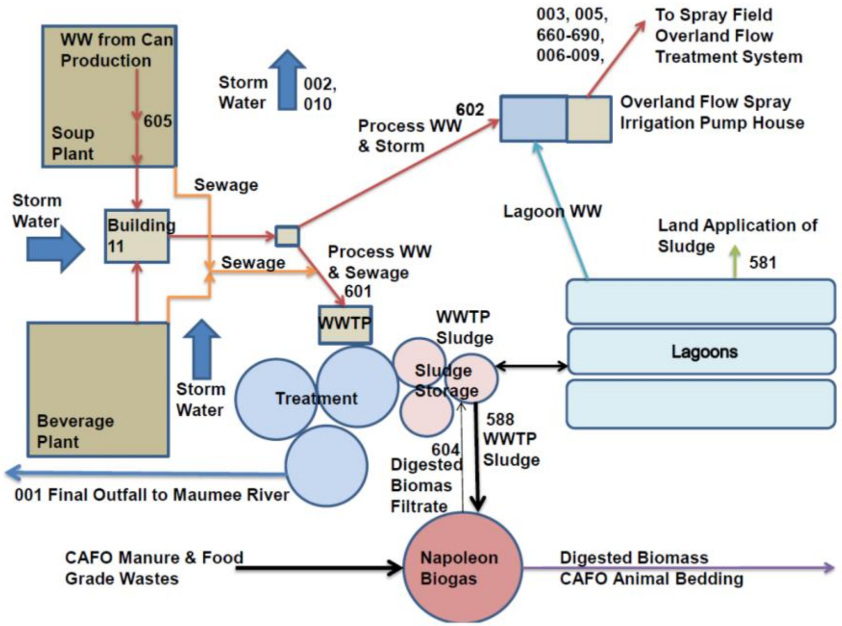
Indirect Cooling

- Cooling done via a heat exchangers and cooling tower or once through indirect cooling system (furnace cooling)
- Effluent stream is typically contaminant free and requires no/minimum treatment before being reused

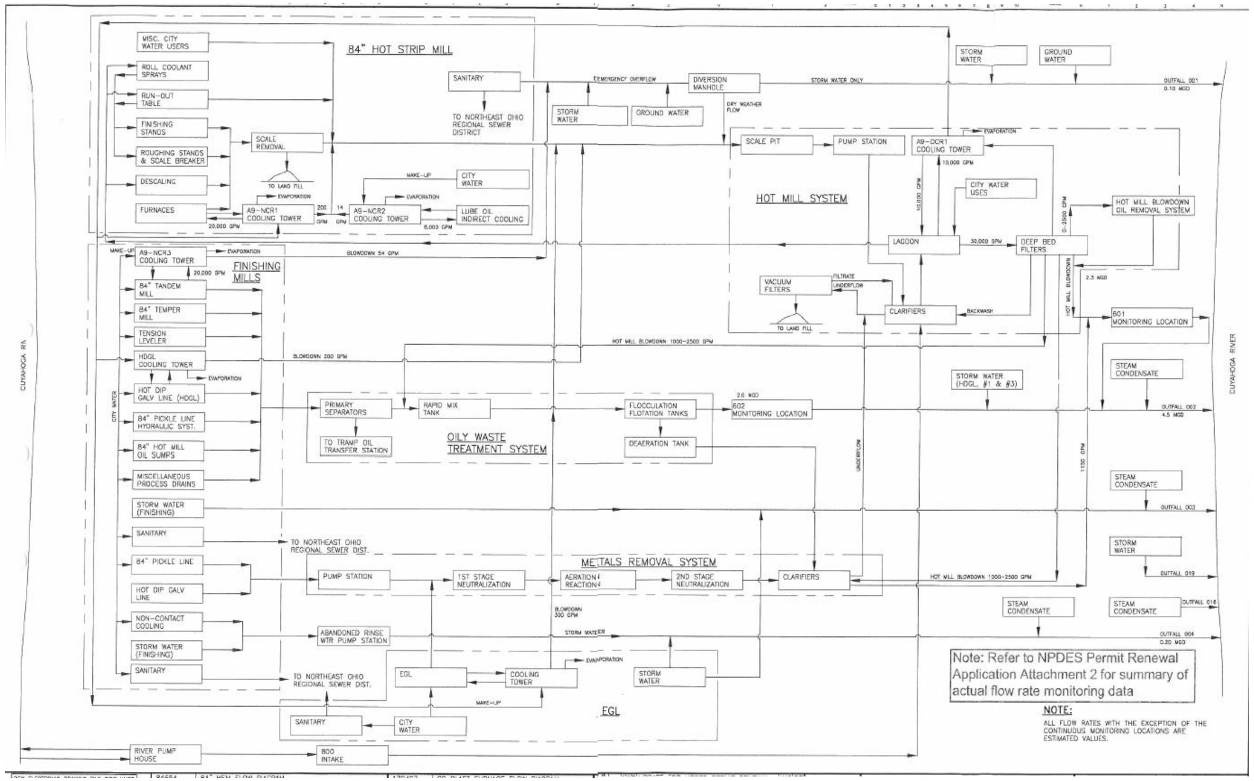
Water Flow Diagrams can be complex



Water Flow in Sugar Industry [1]



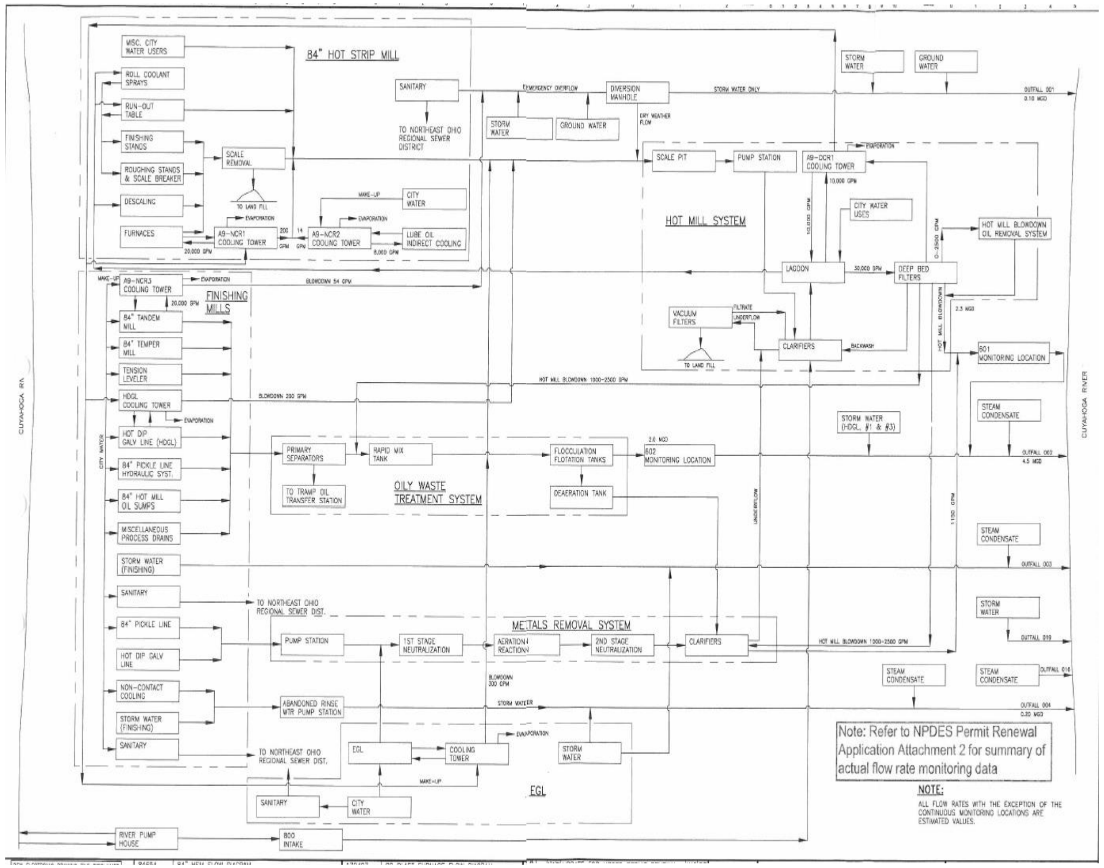
Water and Wastewater Flow in a Food plant [2]

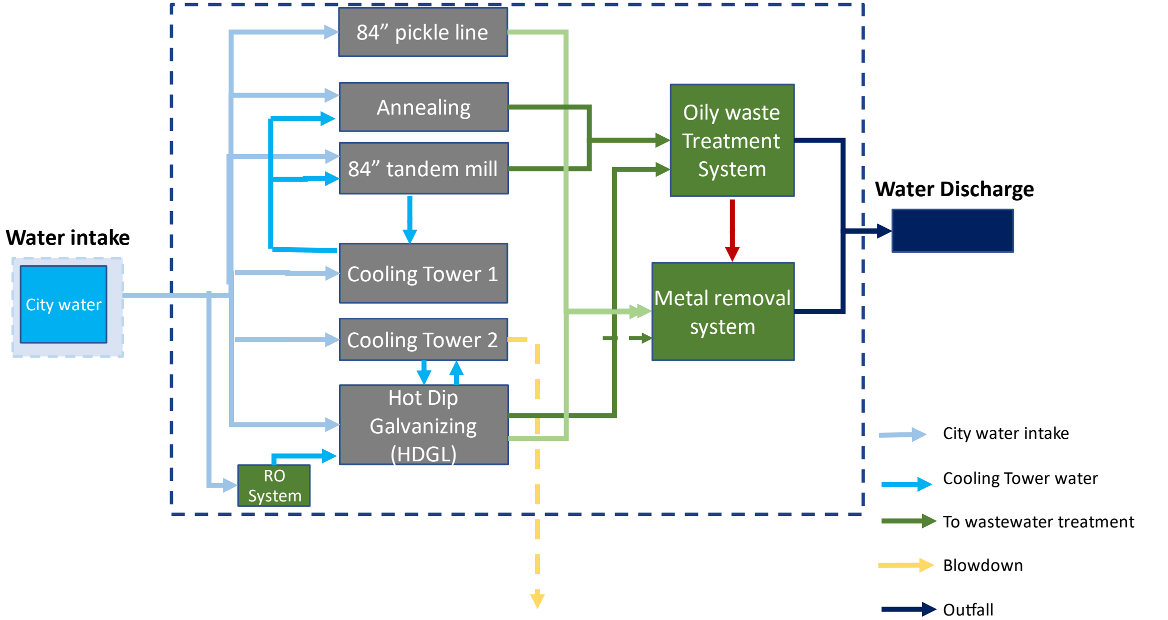


Water flow in a integrated steel plant [2]

[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

An ideal water flow diagram makes baselining simpler





For a baseline assessment and water balance, water flow across each system or group need to be known

Creating a diagram optimized for water assessment

- Define appropriate plant and system boundaries:
  - Depending on the size of the plant, plant boundary may be the entire facility or only include specific parts of a plant
  - System Boundaries are defined by segregating or combining processes/systems into manageable groups such that you can quantify water flows across each group
- 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

Some Guidelines for defining system boundary

- Step 1: Identify all water using systems
  - Define the cooling towers and boilers separately from the process water users
  - Separate direct and indirect cooling water users
  - Indirect cooling applications need to be considered separately only if water is consumed or gained in the process e.g., partially open loop that requires water makeup, fully open single pass cooling systems.

- Step 2: For each system that uses water directly, 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 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.

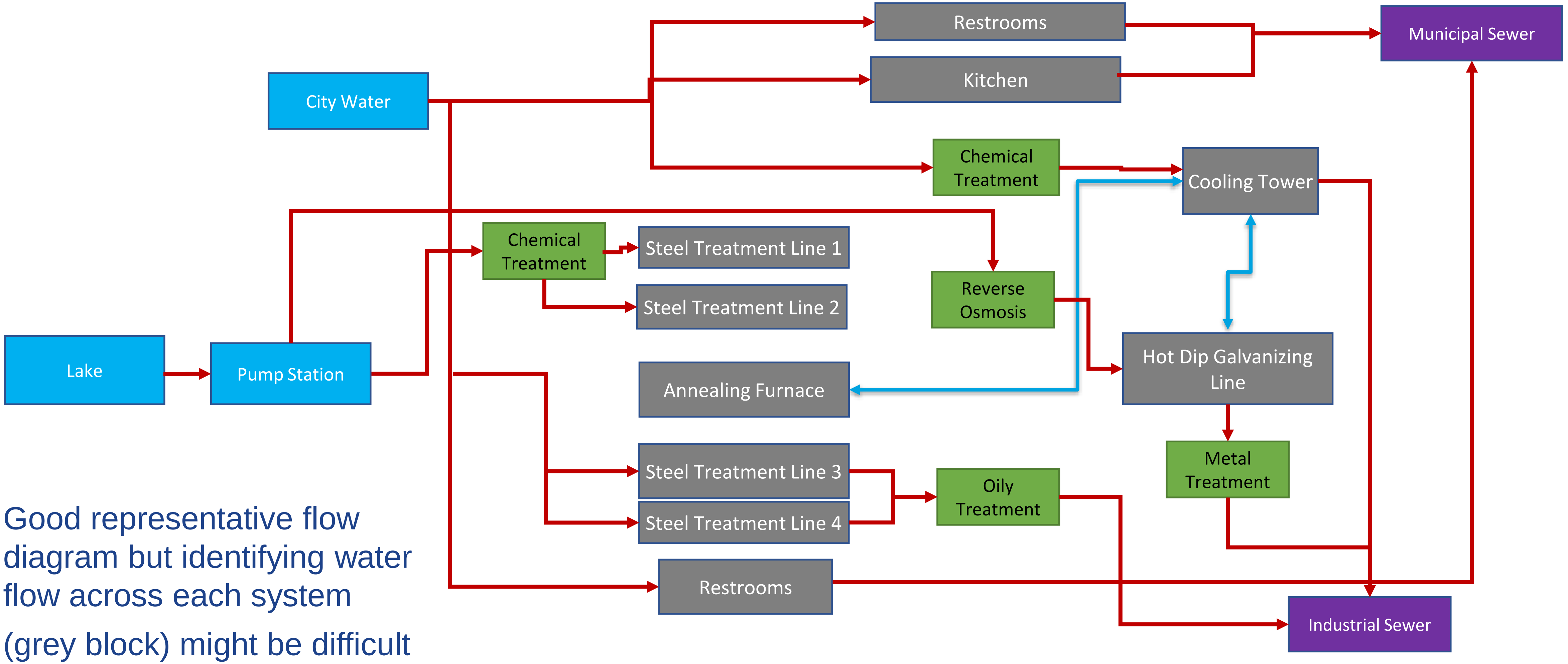
- An annealing furnace that uses cooling tower water for furnace cooling (closed loop system via a heat exchanger)

- 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 Tower Makeup

cooling loads

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

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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.

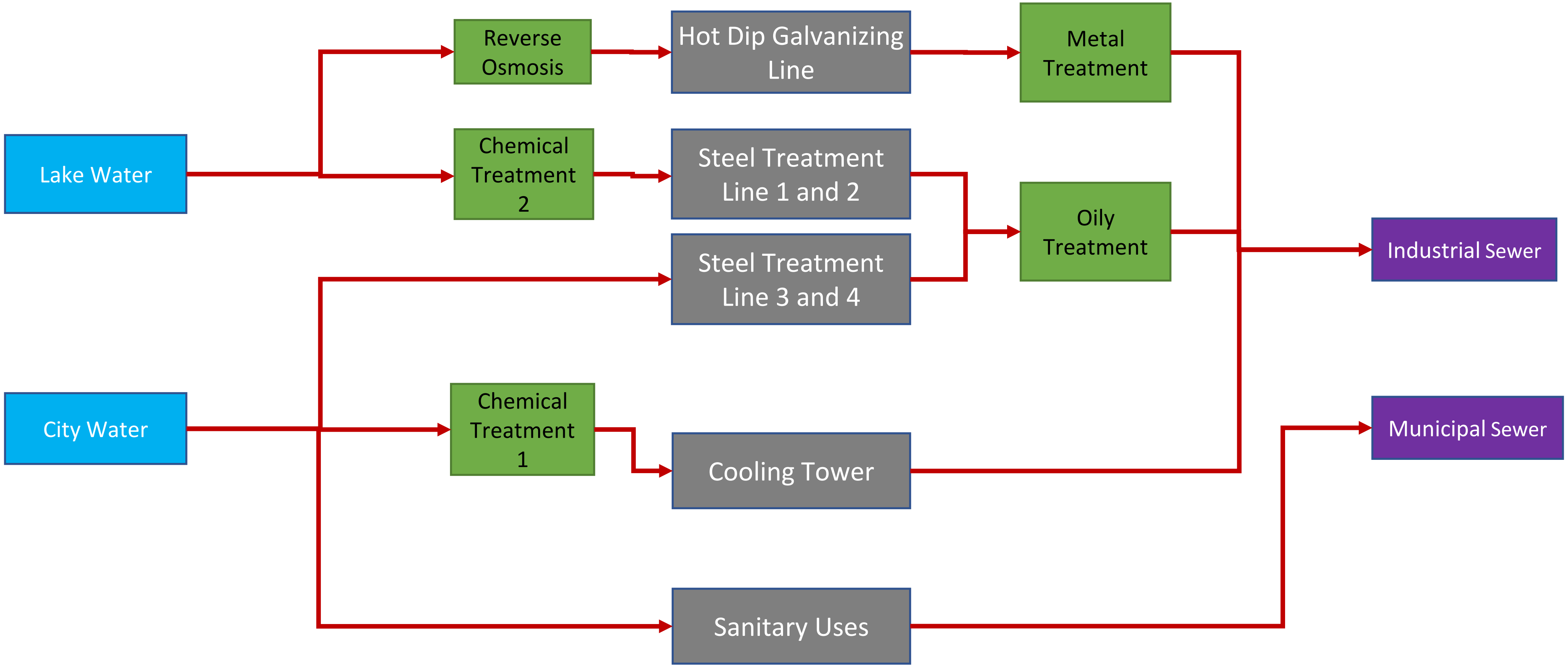
- **List all wastewater discharge outlets (on the right)**
  - Example : Municipal Sewer, Third-party Disposal, River or Lake, Ocean or Tide, Groundwater, Onsite Disposal, Stormwater

- 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

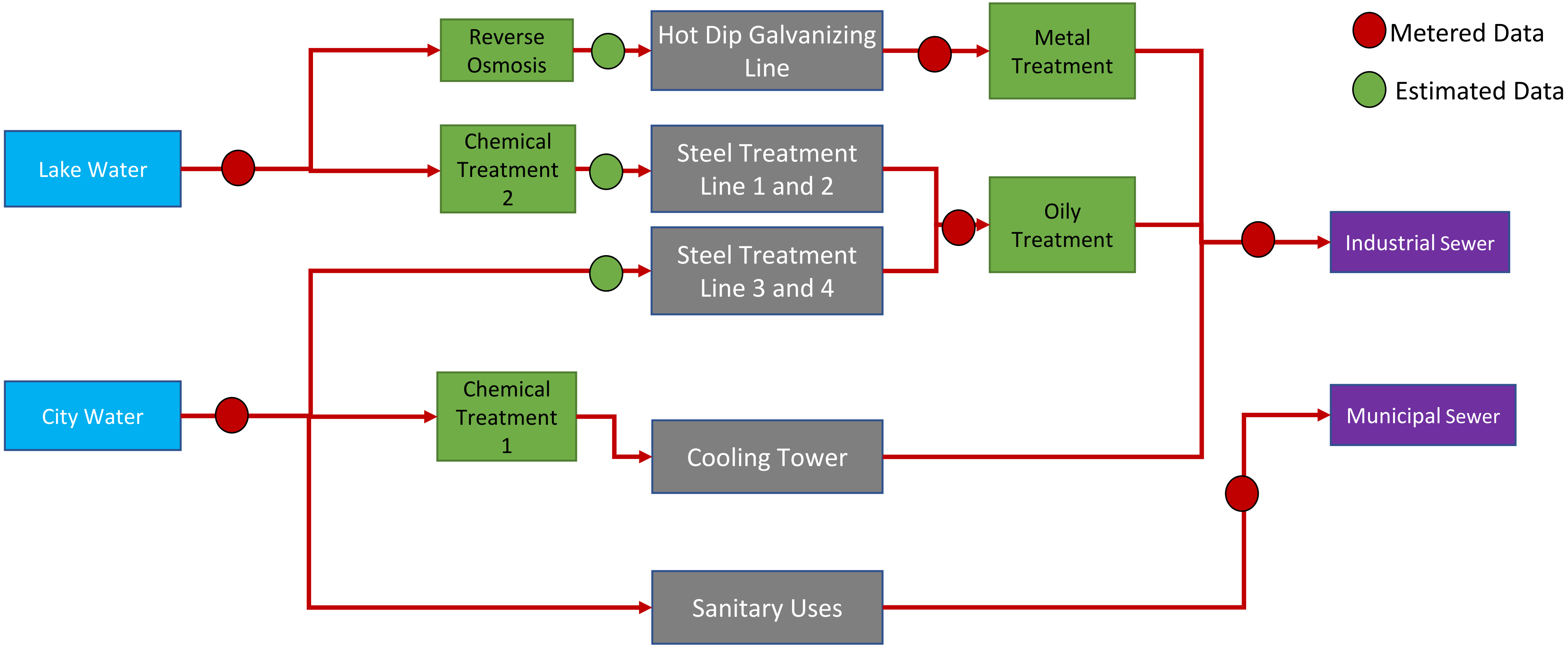
Steps to Water Flow Diagram

- 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 – you can make use of the master table template provided as needed

2. Mark the points where metered data is available.

Optional Exercises

1. Use the WRI Aqueduct tool to identify the overall water risk for your location. Change the weighting of the risk indicators according to your industry, you can create a custom weightage as your see appropriate if your sector does not have default indicator weights.

2. What will be the water stress in your area under a Business-as-Usual Scenario in 2030 and 2040?

Plant Water Profiler Tool - Overview

Plant Water Profiler (PWP) Tool

The Plant Water Profiler (PWP) tool is a comprehensive excel-based tool designed for use by manufacturing plants to help perform a facility level water assessment

https://www.energy.gov/eere/amo/plant-water-profiler-tool-excel-beta-version-pwpex-v01

Plant Water Profiler Tool

Language:	English
Water Measurement Unit:	Million Gallons
Currency:	USD

Note: The Plant Water Profiler Tool is currently available in the English language only. It uses only Million Gallons for water use calculations and USD for cost calculations.

Disclaimer

This tool was prepared as an account of work sponsored by an agency of the United States Government. Neither the United States Government nor any agency thereof, nor any of their employees, makes any warranty, express or implied, or assumes any legal liability or responsibility for the accuracy, completeness, or usefulness of any information, apparatus, product, or process disclosed, or represents that its use would not infringe privately owned rights. Reference herein to any specific commercial product, process, or service by trade name, trademark, manufacturer, or otherwise, does not necessarily constitute or imply its endorsement, recommendation, or favoring by the United States Government or any agency thereof. The views and opinions of authors expressed herein do not necessarily state or reflect those of the United States Government or any agency thereof.

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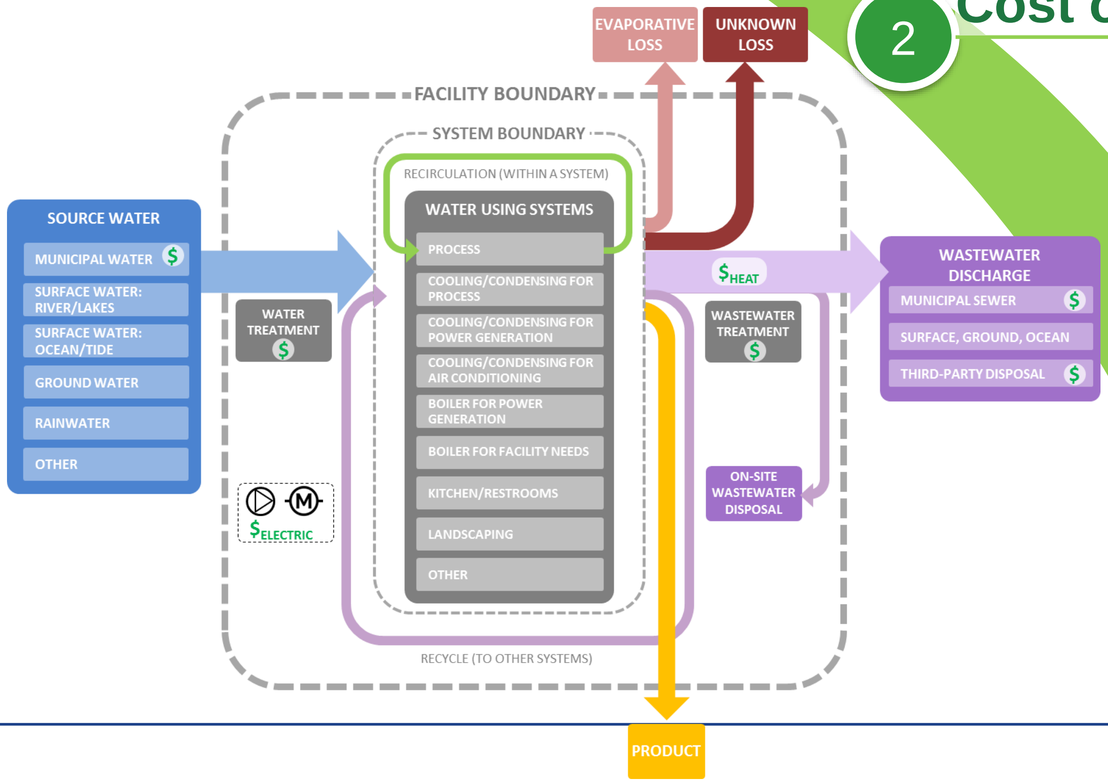
PWP Tool Concept

1 Baseline Water Use and Water Balance

2 Determine True Cost of Water

3 Identify Water Efficiency Opportunities



Thank You all for attending today's webinar.

See you all on next Tuesday – May 28, 2024 – 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

U.S. DEPARTMENT OF ENERGY