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AWE Cooling Technology Study

Alliance for Water Efficiency

AWE: A Voice for Water Efficiency

- Our mission is to promote an efficient and sustainable water future
- Over 530+ member organizations in 200 watersheds delivering water to 50 million water users

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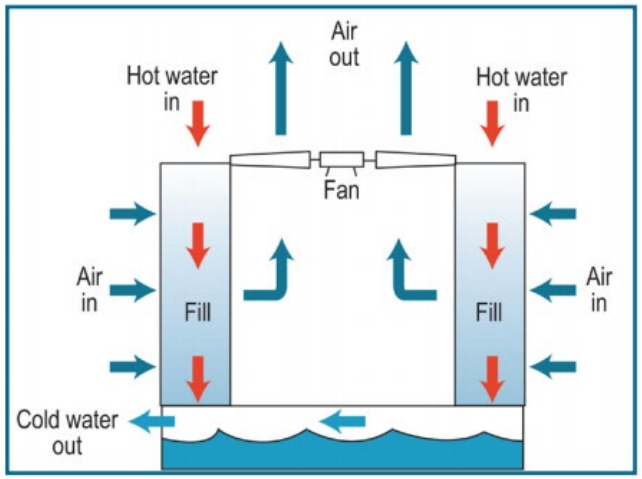
What is a Cooling Tower?

- Key component of cooling systems
- For example:
  - Cooling towers recirculate water to remove heat from air conditioning equipment in buildings
  - Heat is rejected from the building via evaporation into the atmosphere
  - Also used for cooling related to various industrial processes



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Where are Cooling Towers Used?

Examples:

- Office Buildings
- Large Multifamily Buildings
- Schools
- Hospitals
- Resorts and Large Hotels
- Data Centers
- Airports
- Industrial and Manufacturing Facilities

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Why is this Project Important?

- Cooling towers are unfamiliar to most people
- Difficult to understand the scope of cooling towers in a water provider service area
  - How many?
  - Cooling load?
  - Water use?
  - Where are they located?
- Difficult to design effective water efficiency programs
- Lack of resources and tools
- A lot of opportunity for water savings

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Project Team

Research Team

- Pacific Northwest National Laboratory

Project Managers and Advisors

- Maureen Erbeznik & Associates
- Alliance for Water Efficiency
- Project Advisory Committee
  - Funders
  - H.W. Hoffman & Associates

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1. Metropolitan Water District of Southern California, California, United States
2. Southern Nevada Water Authority, Nevada, United States
3. San Antonio Water System, Texas, United States
4. California Water Service, California, United States
5. City of Guelph, Ontario, Canada
6. Denver Water, Colorado, United States
7. Austin Water, Texas, United States
8. City of Dallas, Texas, United States
9. City of Tucson, Arizona, United States
10. City of Santa Fe, New Mexico, United States
11. Santa Clara Valley Water District, California, United States
12. City of Calgary, Alberta, Canada
13. East Bay Municipal Utility District, California, United States
14. SCV Water, California, United States
15. Western Municipal Water District, California, United States
16. Municipal Water District of Orange County, California, United States
17. Los Angeles Department of Water and Power, California
18. Commonwealth Edison, Illinois, United States

Five Main Objectives

1. Develop best practices for **identifying** water-cooled facilities in urban areas.
2. Develop best practices for **estimating consumptive and non-consumptive water demands** for cooling.
3. Determine the **conservation potential for** improvements to traditional cooling technologies such as **cooling towers**.
4. Determine the **conservation potential of alternative** cooling technologies.
5. Develop **practical guides**, incorporating study results, to increase the effectiveness of cooling water use efficiency incentive and outreach programs.

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Project Resources

1. Cooling Tower Estimating Model
2. Water Quality Helper
3. Alternative Cooling Technology Report and Market Model
4. Forthcoming Program Design and Outreach Materials

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Cooling Tower Estimating Model (CTEM) Version 2.1

Overview

The **AWE Cooling Tower Estimating Model (CTEM)** provides an estimated range of the number of water-cooled facilities, number of cooling towers, total cooling capacity, water use, and water conservation potential for a utility service area based on a minimal amount of input data. Additionally, the **Auto-Populated Inventory** helps initiate a cooling tower inventory by generating an auto-populated list of select large facilities likely to have cooling towers in the given service area. With the **User-Input Inventory Module**, utilities can further develop their inventory by inputting commercial and other real property data. The model infers whether each user-entered facility is worth investigating to determine if it uses a cooling tower system.

What Input Data is Required to Use CTEM?

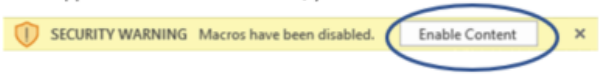
To use the model, the minimum input requirements for the base feature functionality are:

- Country (United States or Canada)
- State or Province
- County (for U.S. locations)
- Service Population
- Water Quality (measured in total dissolved solids (TDS) or conductivity)

What is a Cooling Tower?
A cooling tower is an external water cooled portion of an HVAC system often used for larger facilities with higher heat loads such as hospitals, large office buildings, and factories. It uses the ability of water to absorb and remove heat through evaporation. Cooling tower systems are designed to help reduce energy consumption in cooling at the expense of higher water-usage rates.

Required Excel Settings

CTEM requires Excel's Visual Basic for Applications to run. Therefore, you must enable Macros in Excel or the model will not work correctly.



CTEM Modules

CTEM is divided into **Base Features**, **Auto-Populated Inventory**, **User-Input Inventory**, **Results Estimates**, and **Inventory Output** sections.

The **Base Inputs** tab is used to enter the basic input data requirements to run the model. The base results estimate features and auto-populated inventory are generated after clicking the Calculate Results or Refresh Results macro buttons on the various tabs.

The **Auto-Populated Inventory** provides estimated ranges of the number of facilities with cooling towers, the total number of cooling towers, total cooling capacity, water use, and water conservation potential based on the service area location and population. This includes auto lookup functions of select large facilities likely to have cooling towers based on the service area designation. The user can then confirm or deselect each auto-populated facility entry as operating a cooling tower system in the utility service area to update the results estimate outputs and Inventory Output tab.

The **User-Input Inventory Module** provides the same results as the **Auto-Populated Inventory** , but also allows the user to upload commercial property data, if developing a robust inventory of cooling tower locations is desired. CTEM will infer whether these facilities are likely to have cooling towers and allow the user to validate the model inferences. This process can refine the model results and help a utility formulate an inventory of locations likely to have cooling towers. For additional guidance on developing commercial property data and validating model inferences, see the companion document Best Practices Guide for Identifying Cooling Towers in Urban Areas.

The **Results Estimates** tab provides the primary model outputs for the user indicated service territory and inventory input and validation inputs. The user has the ability to alter some of the estimated parameters used in estimating the results outputs, namely adjusting the cycles of concentration (CoC) and annual cooling tower usage or duty factor.

The **Inventory Output** tab is meant as a model output to aid the utility in creating a cooling tower inventory for their service territory.

MODEL USE DISCLAIMER

The AWE Cooling Tower Estimating Model is free software and comes with NO WARRANTY or GUARANTEE OF ACCURACY. Users are advised that results generated are engineering estimates and are not intended to be precise or exact. Users are advised to consult the accompanying Best Practices Guide for Identifying Cooling Towers in Urban Areas for additional information on the underlying calculations and assumptions used in this model.

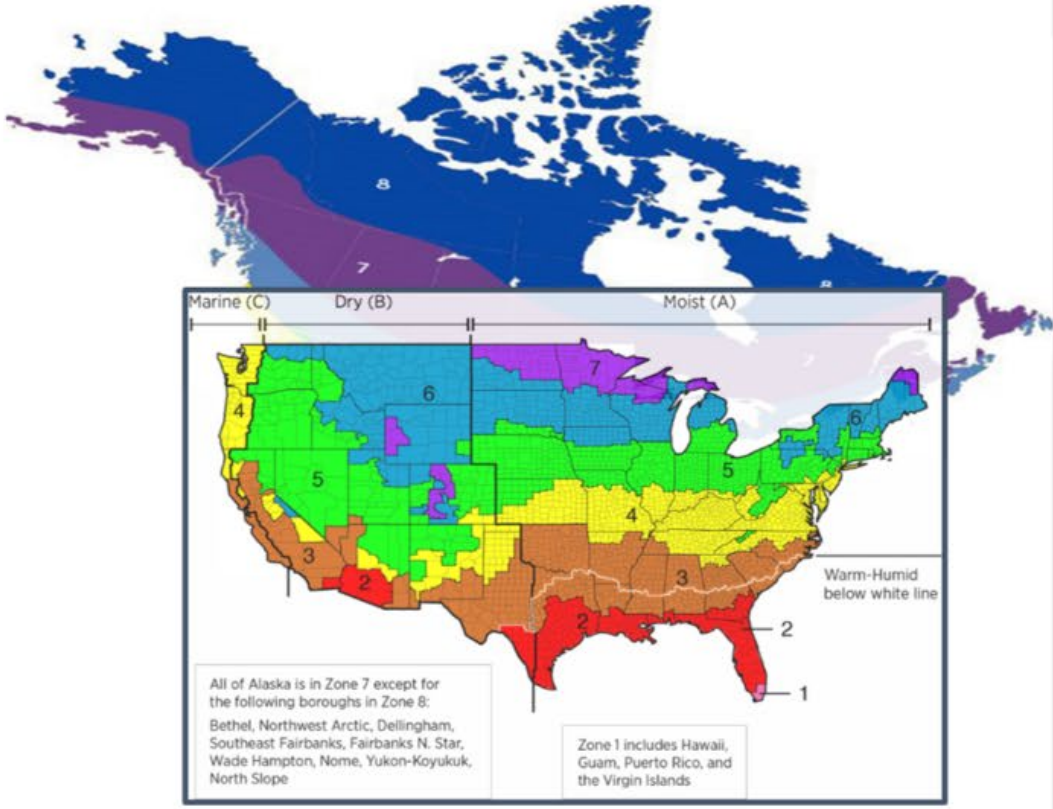
CTEM Base Inputs
V2.1

Enter Location and Water Quality Inputs

Enable macros before entering inputs

Estimate Results and Populate Inventory

Select Country:	United States
Select State:	Illinois
Select County:	Peoria
Population in County (2018):	180,621
Enter Population Served:	100,000
(This input will scale the results to the service population)	
IECC Climate Zone:	5A
Select Water Quality Measurement Type:	TDS (ppm)
(TDS or Conductivity)	
Enter Water Quality:	250



CTEM Overview | CTEM Instructions | CTEM Example & Calculations | CTEM Base Inputs | CTEM Auto-Populated Inventory | CTEM User-Input Inventory

Ready

CTEM Results Estimates
V2.1

Base Input Results Estimates

CTEM Results Estimates

All results are estimates and based on North American dataset averages and statistical correlations.

Duty Factor: (% annual utilization)	8.8%

Estimate Results

Clear Results (Cannot Undo)

	Large-Scale Facilities	Commercial Facilities	Total Service Area		
# of Facilities	8	47	**55**		
# of Cooling Towers	64	109	**173**		
Cooling Capacity, tons	20,952	35,780	**56,732**		
Annual Cooling Load, tons/year	16,142,934	27,567,110	**43,710,044**	Range	Acre-feet/year ↓
Consumptive Water Use, Mgal/year	26.0	47.5	**73.5**	71.9 - 78.7	225
Non-Consumptive Water Use, Mgal/year	8.0	15.8	**23.8**	24.0 - 26.2	73
Total Water Use, Mgal/year	34.0	63.3	**97.3**	95.8 - 104.9	299

*This data is for Peoria, IL with service population 100000 compiled 4/16/2021 3:56:03 PM

Water Conservation Opportunity Estimates From Base Inputs

Conservation Opportunity Estimates:

From Potential Increased Cycles of Concentration (CoC)

CTEM Results Estimates

		↓ Adjustable ↓	
Cycles of Concentration (CoC)	Average CTEM Baseline	6.0	*250 TDS, 400 EC*
	Potential	7.0	
Non-Consumptive Water Use	Mgal/year (baseline)	25.1	Any difference from value in G14 results from large-scale facility calculation rounding errors
	Mgal/year (potential)	20.9	
Savings Potential	Mgal/year	4	
	% Savings	17%	

CTEM Auto-Populated Inventory | CTEM User-Input Inventory | CTEM Results Estimates | CTEM Inventory Output | Building and Facility Types

CTEM Auto-Populated Inventory
V2.1

↓ Confirm for each facility ↓
(if no boxes are checked, all facilities will be exported to the final inventory)

Update Export to Final Inventory and Estimate Results

The location inputs the user entered in the 'CTEM Base Inputs' tab were used to compile an inventory of large buildings likely to have cooling towers. This tab allows the user to verify each of these buildings is located in the service territory and has a cooling tower before exporting to the Final Inventory tab. Using the user inputs, cells will change to green when a "Yes" has been entered for both categories, indicating the tool will pull the building into the final inventory. Cells will change to red when a "No" is checked for either category, indicating the tool will not pull the building into the final inventory. If no user confirmation is entered, the building is also pulled into the final inventory. After completing the verification process for all buildings, click the 'Export Inventory' button.

To aid in estimateing cooling tower capacity from visual identification, enter the number of small medium and large cooling towers at the faculity (see Google Maps images below for rough size refernce) and record the estimated capacity from cell Q4

# Small Cooling Towers	# Medium Cooling Towers	# Large Cooling Towers	Estimated Cooling Tower System Capacity
		3	3750

Located in Service Territory? Yes	Located in Service Territory? No	Has a cooling tower? Yes	Has a cooling tower? No	Facility Type	Facility Name	Address	City	State	Zip Code	County	User Entered Cooling Tower Capacity (tons)
				Airport	General Wayne A. Downing Peoria International Airport	6100 W Everett McKinley Dirksen Pkwy	Peoria	IL	61607	Peoria	*(click to enter values if known)*
				College/University	Bradley University		Peoria	IL		Peoria	*(click to enter values if known)*
				Data Center	A5.com	606 NE Jefferson Street	Peoria	IL	61603	Peoria	*(click to enter values if known)*
				Hospital	Kindred Hospital Peoria	500 West Romeo B Garrett Ave.	Peoria	IL	61605	Peoria	*(click to enter values if known)*
				Hospital	Kindred Hospital Peoria	500 West Romeo B Garrett Ave.	Peoria	IL	61605	Peoria	*(click to enter values if known)*
				Hospital	Methodist Medical Ctr Of Illinois	221 N E Glen Oak	Peoria	IL	61636	Peoria	*(click to enter values if known)*
✓		✓		Hospital	Proctor Hospital	5409 N. Knoxville	Peoria	IL	61614	Peoria	6,500
✓		✓		Hospital	Saint Francis Medical Center	S	Peoria	IL	61637	Peoria	4,000
				< click to add additional facilities >							
				< click to add additional facilities >							
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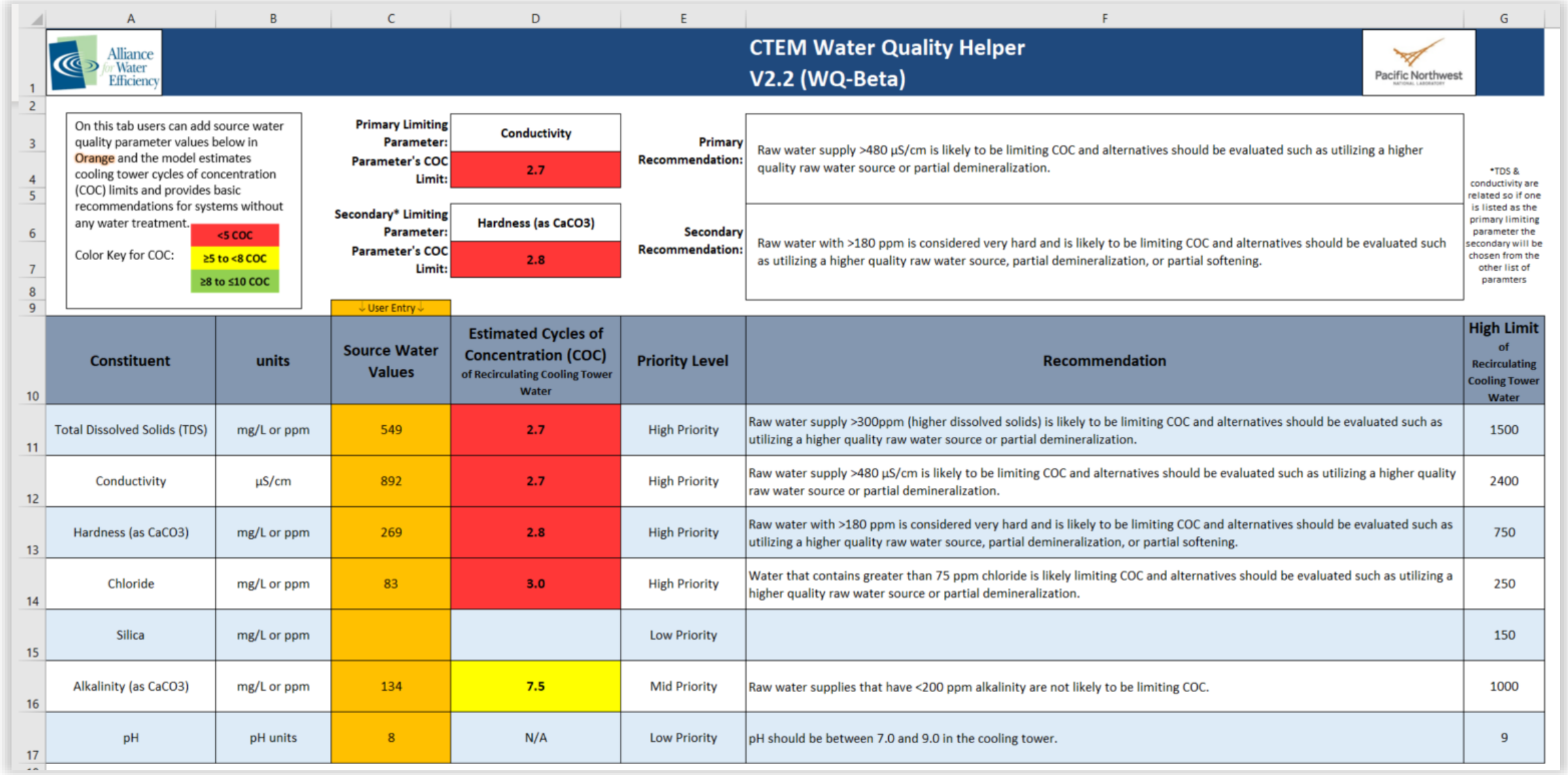
Water Quality Helper



CTEM Water Quality Helper V2.2 (WQ-Beta)

On this tab users can add source water quality parameter values below in Orange and the model estimates cooling tower cycles of concentration (COC) limits and provides basic recommendations for systems without any water treatment.

Color Key for COC:

- <5 COC
- ≥5 to <8 COC
- ≥8 to ≤10 COC

Primary Limiting Parameter:	Conductivity
Parameter's COC Limit:	2.7
Secondary* Limiting Parameter:	Hardness (as CaCO3)
Parameter's COC Limit:	2.8

Primary Recommendation: Raw water supply >480 µS/cm is likely to be limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source or partial demineralization.

Secondary Recommendation: Raw water with >180 ppm is considered very hard and is likely to be limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source, partial demineralization, or partial softening.

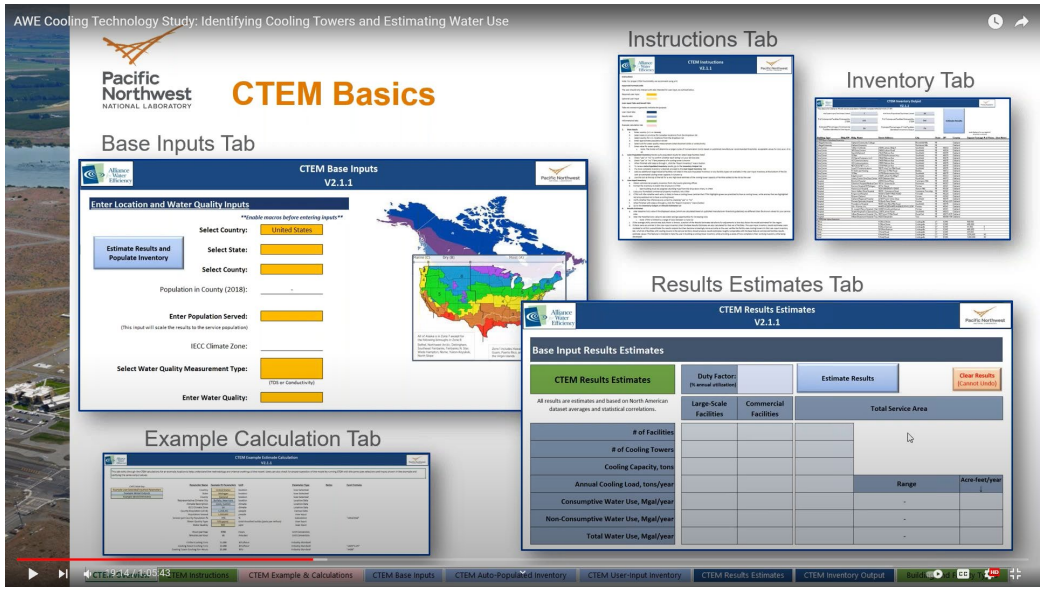
*TDS & conductivity are related so if one is listed as the primary limiting parameter the secondary will be chosen from the other list of paramters

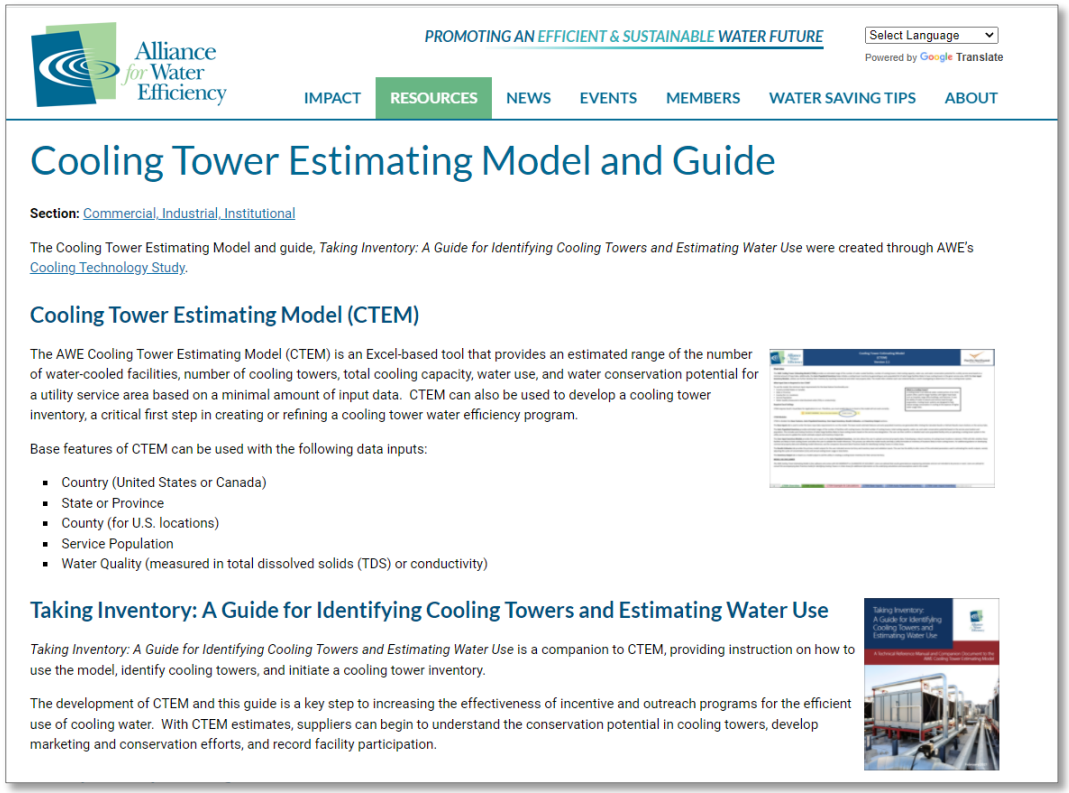
↓User Entry↓

Constituent	units	Source Water Values	Estimated Cycles of Concentration (COC) of Recirculating Cooling Tower Water	Priority Level	Recommendation	High Limit of Recirculating Cooling Tower Water
Total Dissolved Solids (TDS)	mg/L or ppm	549	2.7	High Priority	Raw water supply >300ppm (higher dissolved solids) is likely to be limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source or partial demineralization.	1500
Conductivity	µS/cm	892	2.7	High Priority	Raw water supply >480 µS/cm is likely to be limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source or partial demineralization.	2400
Hardness (as CaCO3)	mg/L or ppm	269	2.8	High Priority	Raw water with >180 ppm is considered very hard and is likely to be limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source, partial demineralization, or partial softening.	750
Chloride	mg/L or ppm	83	3.0	High Priority	Water that contains greater than 75 ppm chloride is likely limiting COC and alternatives should be evaluated such as utilizing a higher quality raw water source or partial demineralization.	250
Silica	mg/L or ppm			Low Priority		150
Alkalinity (as CaCO3)	mg/L or ppm	134	7.5	Mid Priority	Raw water supplies that have <200 ppm alkalinity are not likely to be limiting COC.	1000
pH	pH units	8	N/A	Low Priority	pH should be between 7.0 and 9.0 in the cooling tower.	9

How Do I Get a Copy of CTEM???

1. Available free for AWE Members
2. Visit: https://www.allianceforwaterefficiency.org/resources/topic/ctem
3. Webinar held April 14, 2021
   https://www.youtube.com/watch?v=8LtXZ3-NdSc





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Alternative Cooling Technology

1. Thermosyphon Cooling
2. Hygroscopic Cooling
3. Adiabatic Cooling
4. Thermal Membrane Distillation
5. Plume Abatement

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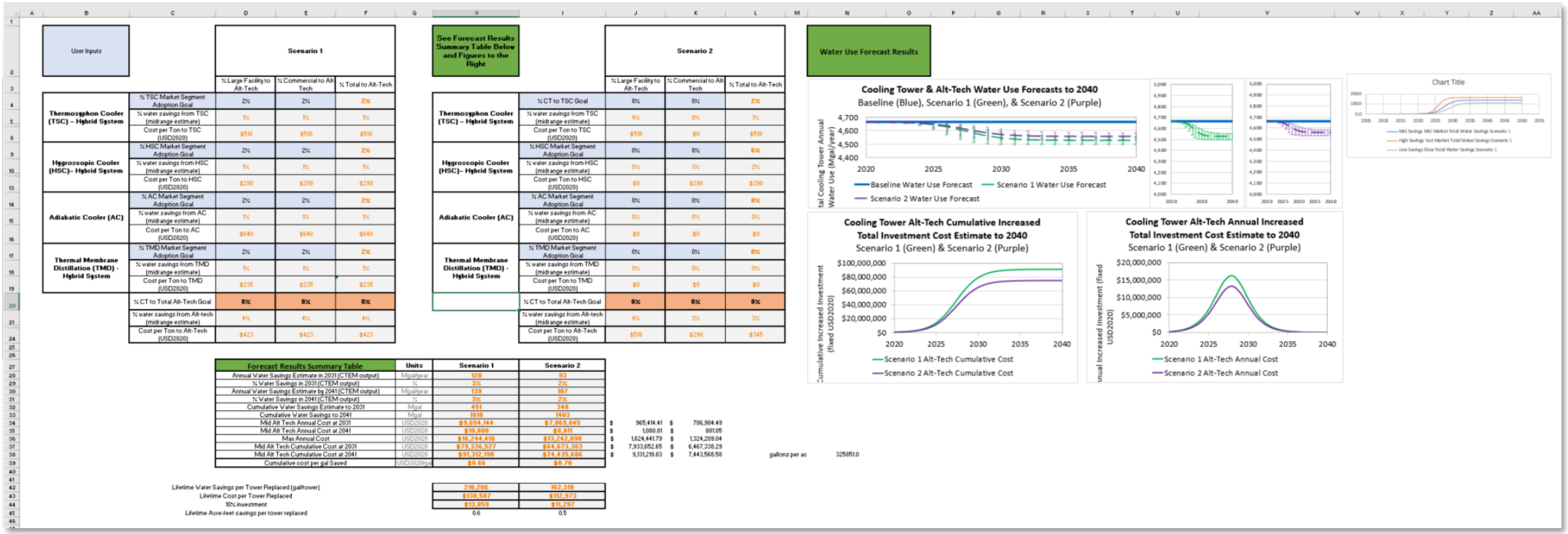
Alternative Cooling Technology - Resources

1. Report
2. Market Penetration Model - to assess the uptake of alternative cooling technologies



Next Steps

1. Developing additional tools, guides, and outreach materials
   a) "How To" guide on setting up a cooling tower water efficiency program
   b) Summary of efficiency strategies and how to select what is optimal based on water quality and climate
   c) Cooling tower assessment form

What would help you get started or improve an existing cooling tower water efficiency program???

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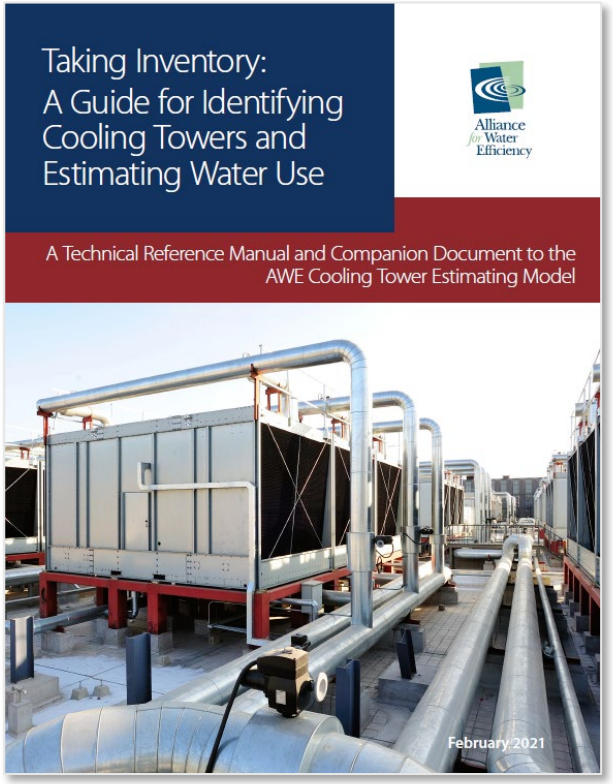

Questions?

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