

Water 2050

*Forecasting Tomorrow's
Water Industry Through
Today's Research.*

Tyler Kane

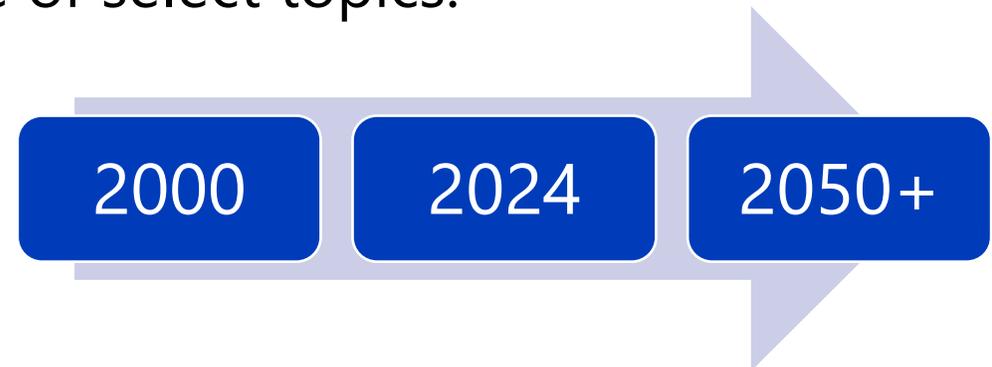
Carollo Engineers

5/3/24



Agenda

1. What are we doing this morning?
 - » Objectives for this discussion.
 - » Perspective on our water timeline.
2. Background on Water 2050.
 - » National Initiative.
 - » Regional perspectives.
3. A thought experiment on the future of select topics.
 - » Where were we?
 - » Where are we now?
 - » Where could we go?
4. Closing thoughts.



01

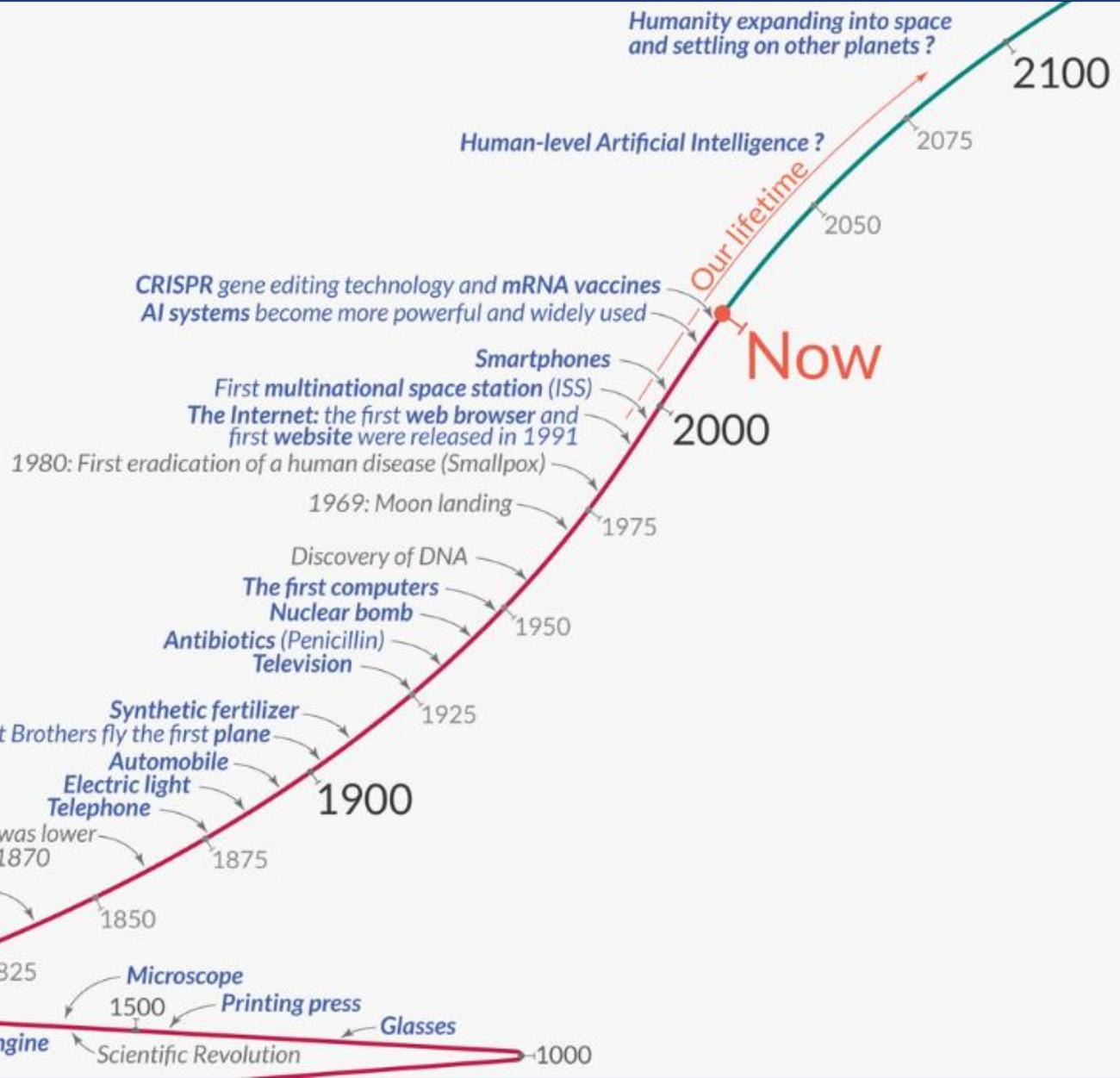
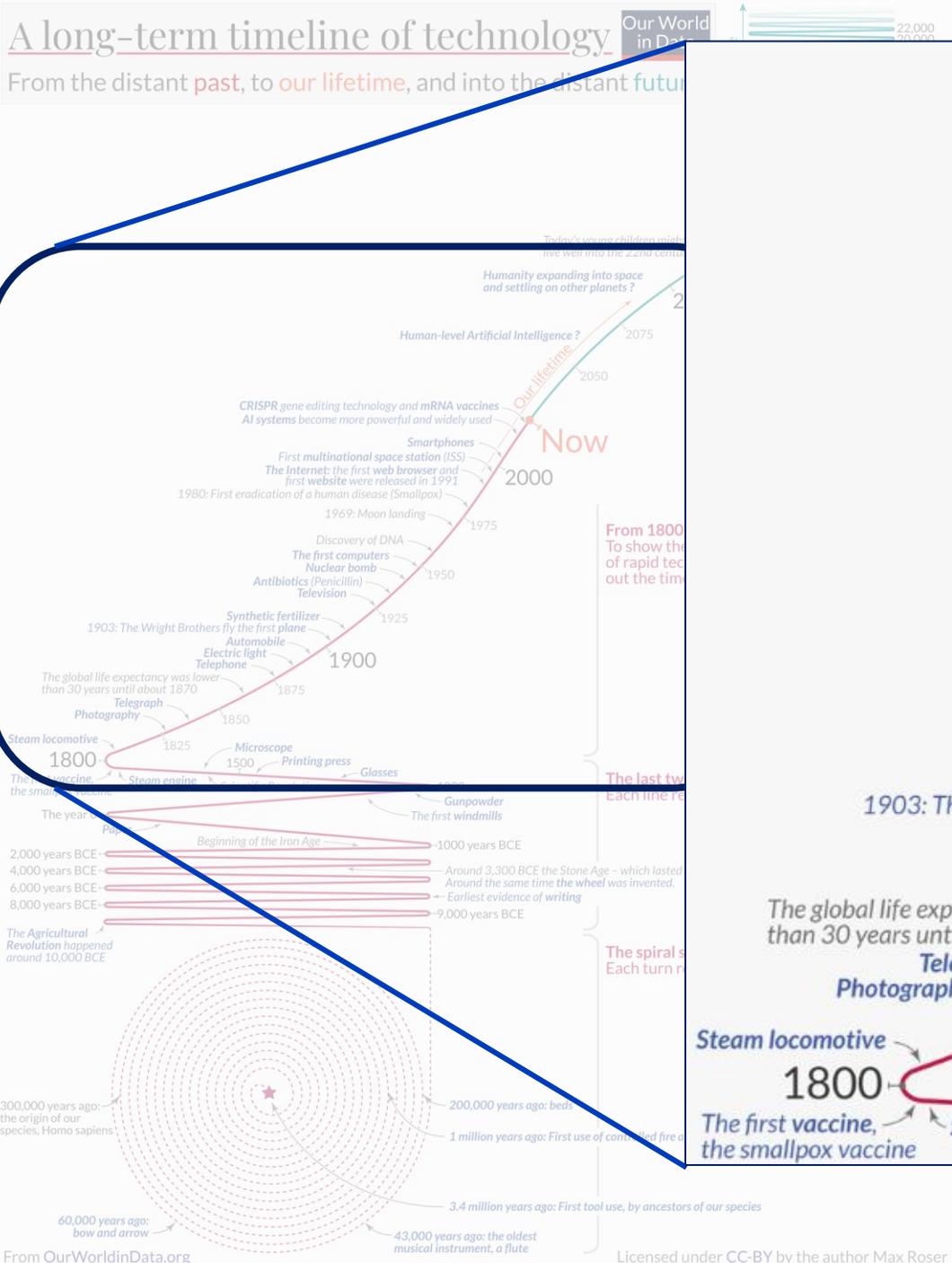
What are we doing?

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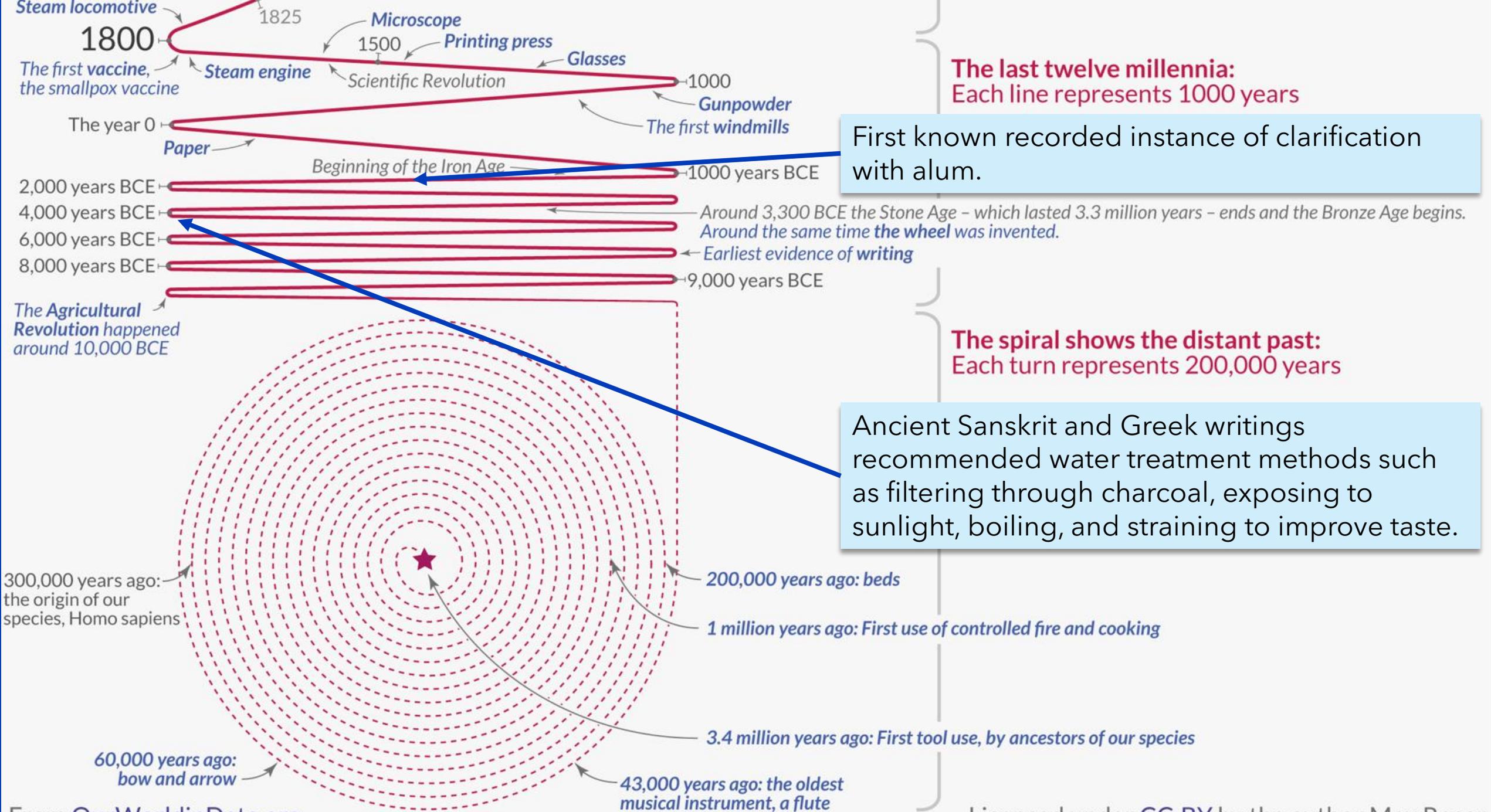
- Objective: Discuss what our industry might look like in the future based on historical trajectories and recent research.
- Inspiration from Water 2050 efforts.
 - » Regional interest in planning for the future.
- Based on our ***water timeline***, what might our industry look like in 2050? How about 2100? Or beyond...?

A long-term timeline of technology

From the distant past, to our lifetime, and into the distant future



Max Roser (2023) - "Technology over the long run: zoom out to see how dramatically the world can change within a lifetime" Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/technology-long-run'



Anthropogenic pollution (incl. PFAS) began severe proliferation in our environment

Expanded applications of UV to inactivate chlorine-resistant pathogens

Improvements in membrane and ozone technologies

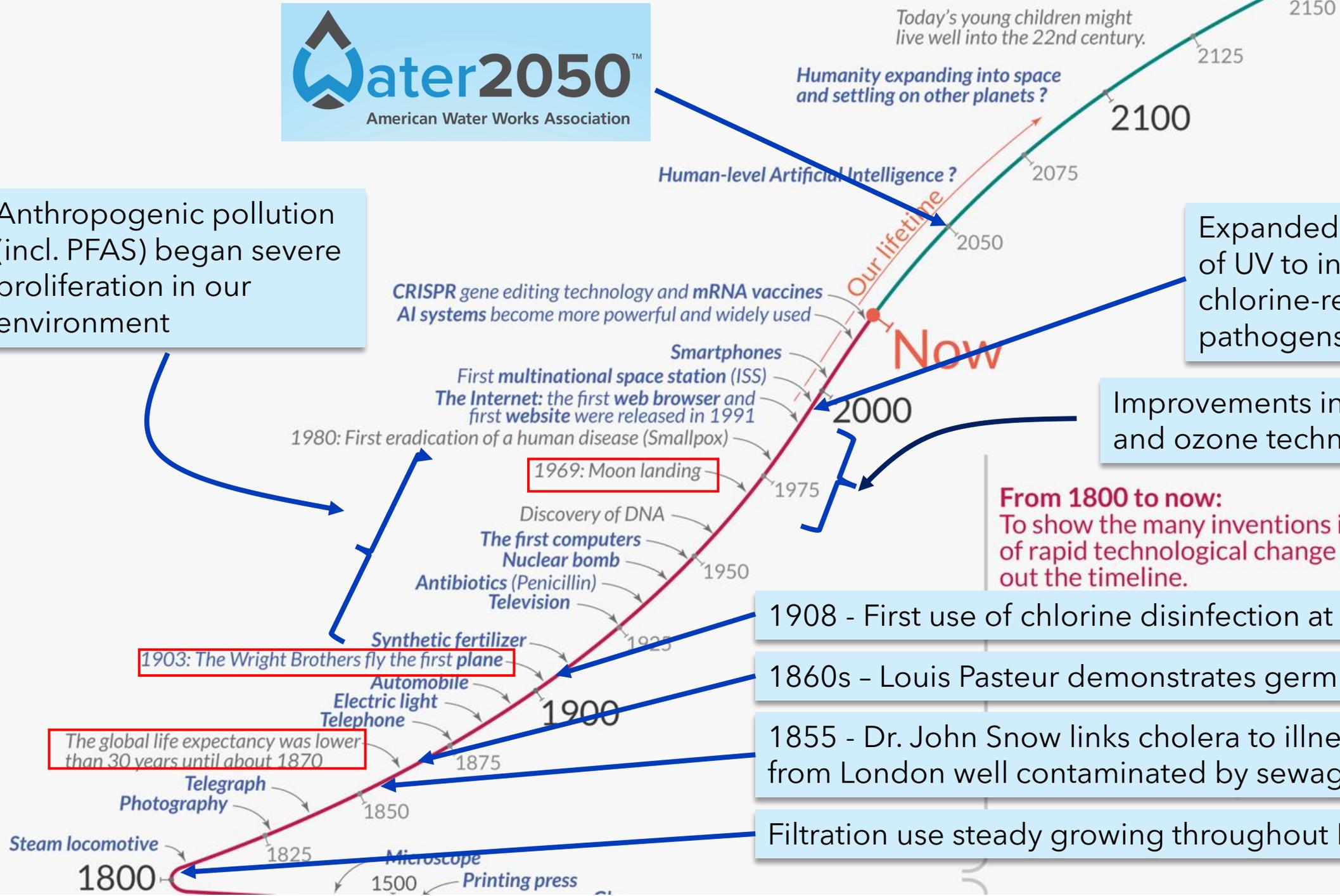
From 1800 to now:
To show the many inventions in this period of rapid technological change I stretched out the timeline.

1908 - First use of chlorine disinfection at scale in NJ

1860s - Louis Pasteur demonstrates germ theory

1855 - Dr. John Snow links cholera to illness outbreak from London well contaminated by sewage

Filtration use steady growing throughout Europe

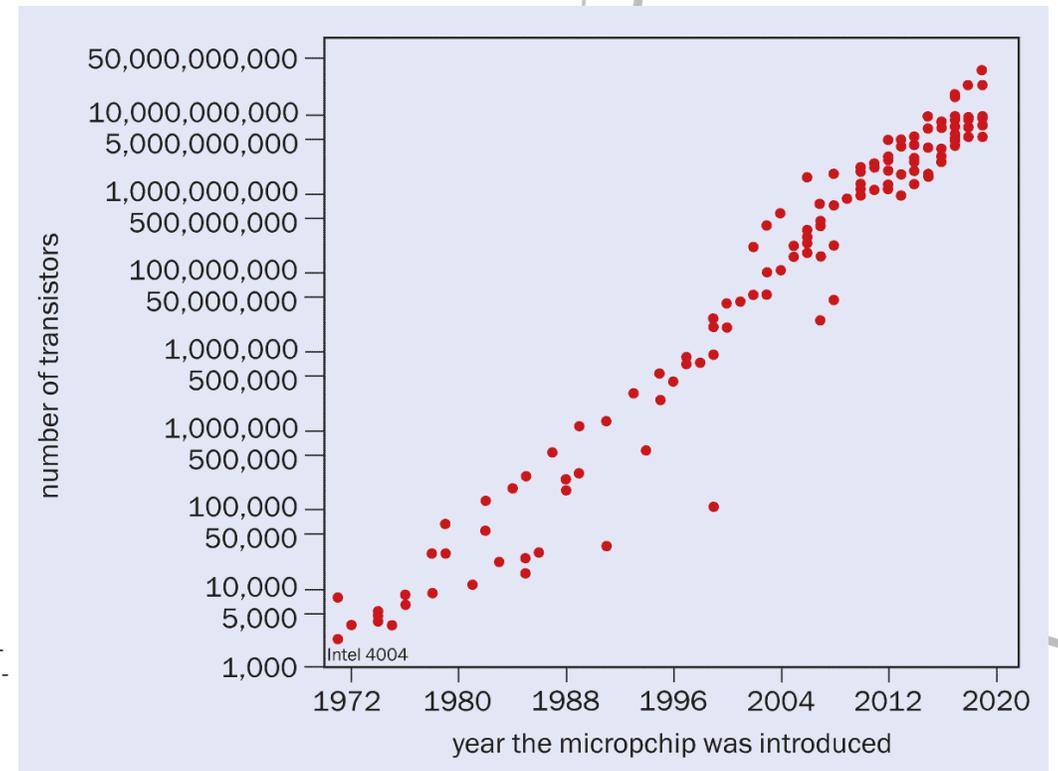


Our Water Timeline

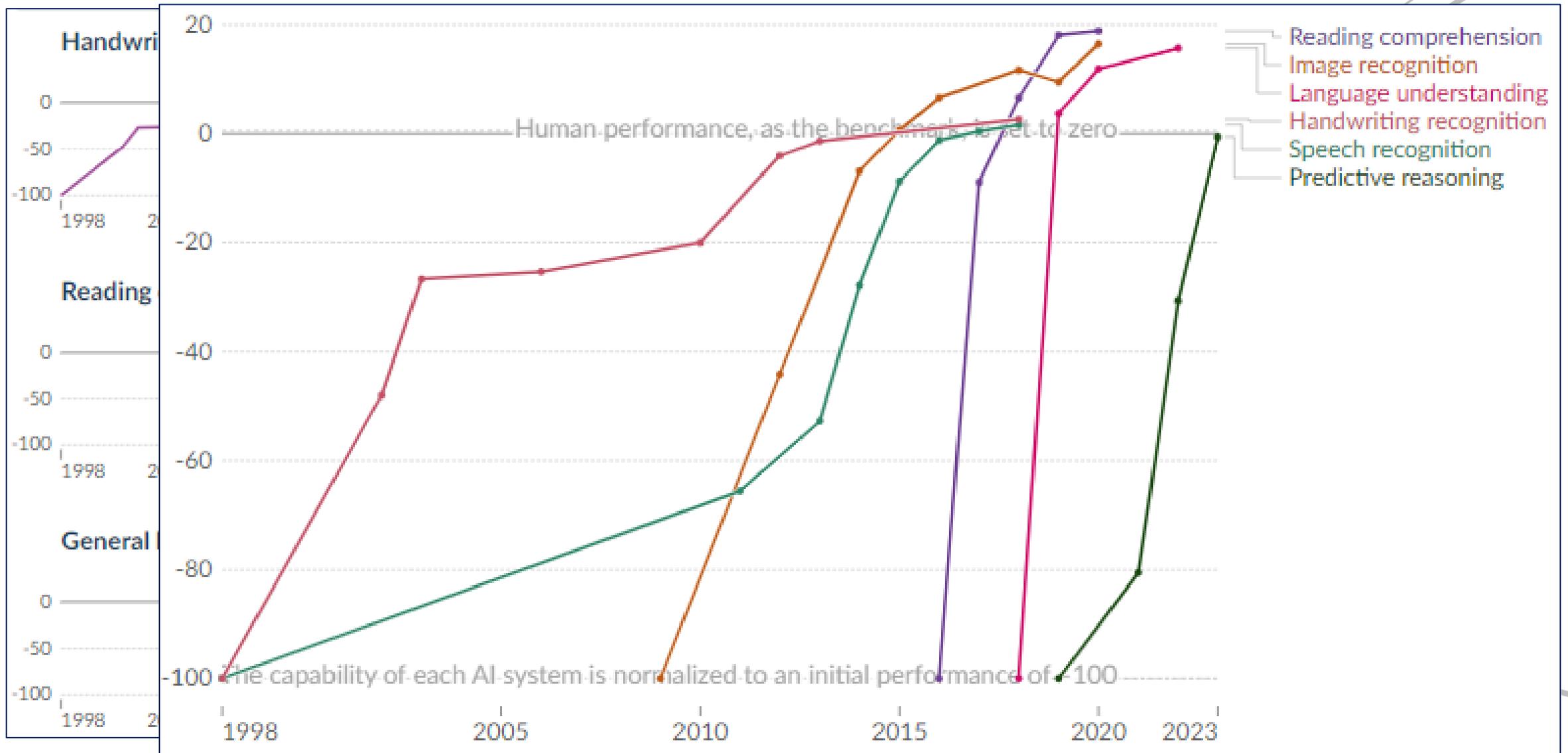
- Water treatment as we know it has expanded tremendously in 200 years.
- Even linear technological growth suggests massive changes to our world and industry within a few hundred years.

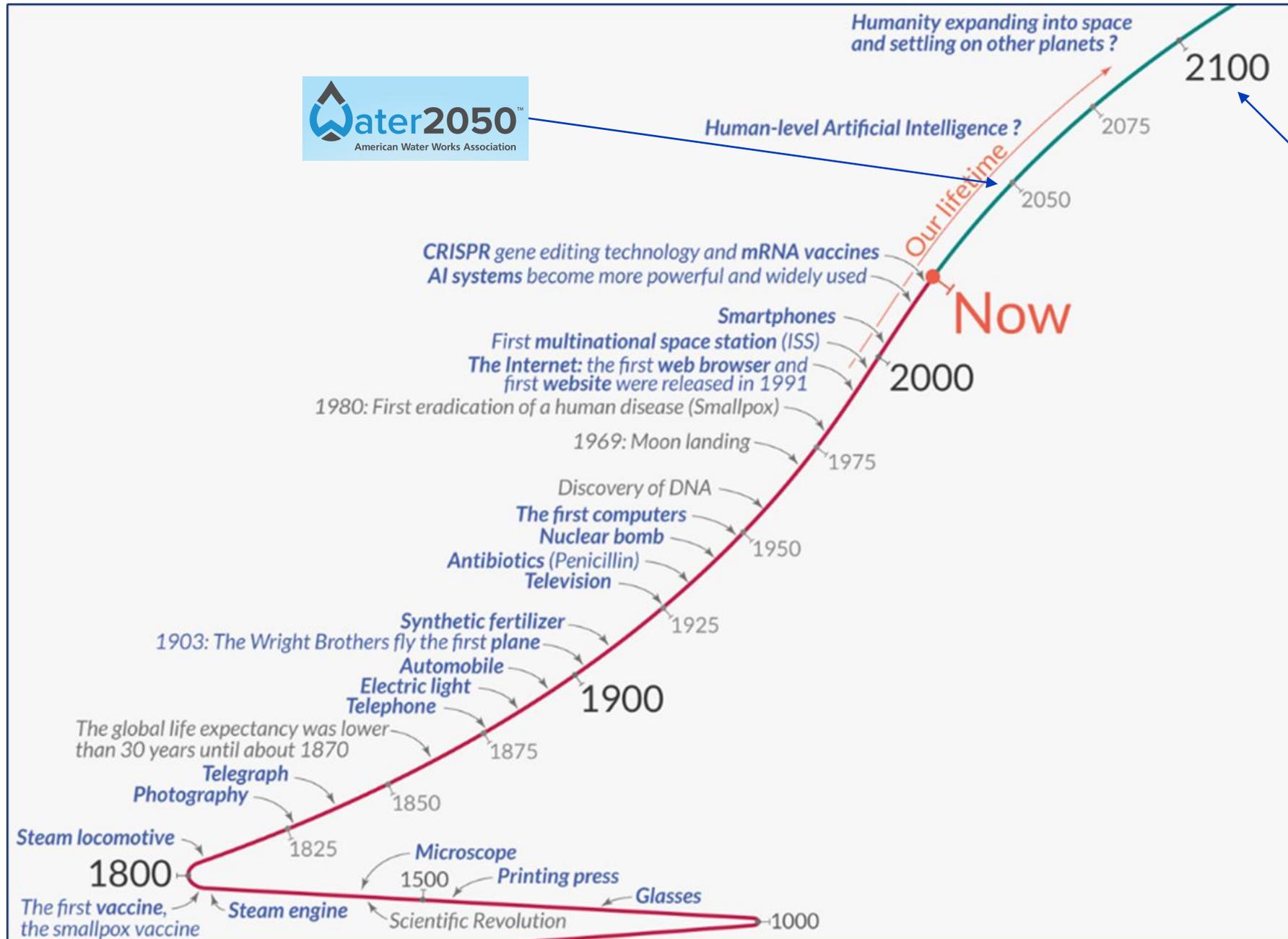
- Evidence to suggest growth may be more significant.
- Moore's Law – number of transistors on a microchip doubles every 2 years.

<https://physicsworld.com/a/moores-law-further-progress-will-push-hard-on-the-boundaries-of-physics-and-economics/>



- Artificial intelligence “knowledge” capacity expanding at rapid rates.



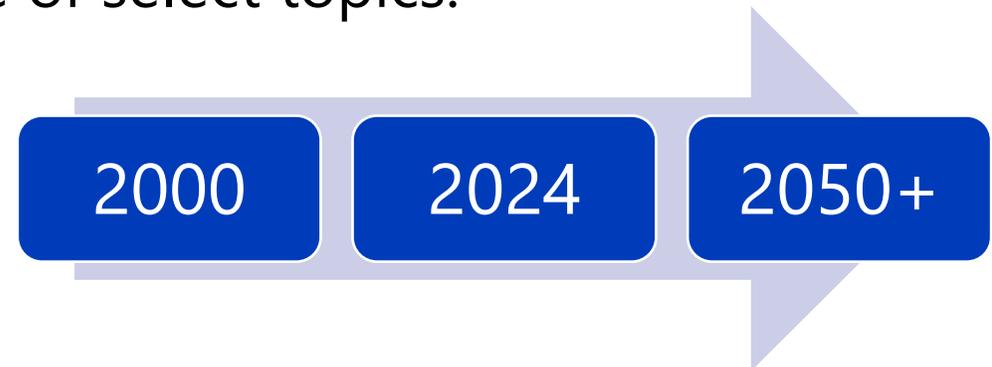


Water in 2100?

Max Roser (2023) - "Technology over the long run: zoom out to see how dramatically the world can change within a lifetime" Published online at OurWorldInData.org. Retrieved from: 'https://ourworldindata.org/technology-long-run'

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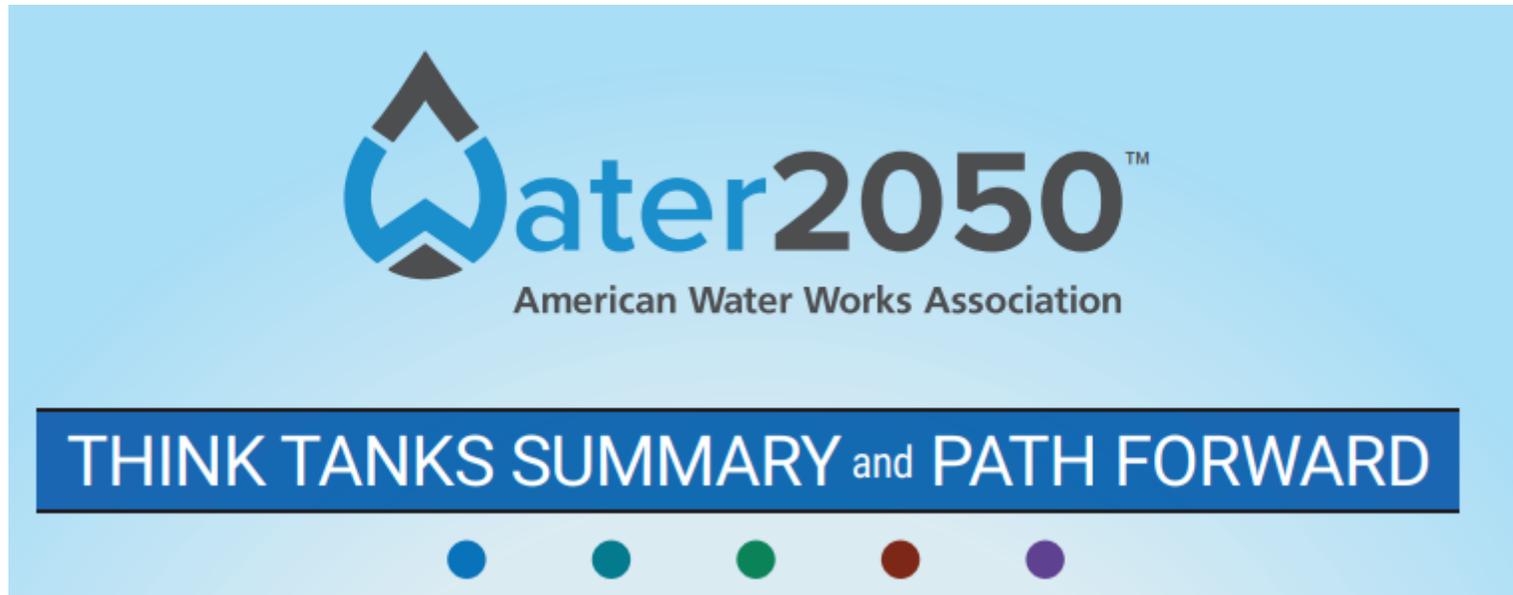


02

Background on Water 2050

AWWA's Water 2050 Efforts

- *"AWWA's Water 2050 initiative seeks to establish a long-term vision of the future of water. This collaborative exploration will chart a course for a successful and sustainable water sector. We will engage in a thoughtful, intentional, and inclusive discourse that results in bold, achievable goals."*



AWWA's Water 2050 Efforts

- Why?
 - » Water is the worlds most vital resource but faces an uncertain future.
 - » *"Most future environmental and social issues will involve water. Who has it, who doesn't, whether it is safe, whether it is affordable and accessible, how it is managed, and by whom."*
 - » *"Water issues will impact economies, shift populations, and drive innovative technologies"*

AWWA's Water 2050 Efforts

- 5 think tanks held through various events across the country.
 - » Sustainability.
 - » Technology.
 - » Economics.
 - » Governance.
 - » Social/ Demographics.



AWWA Water 2050 Consolidated Report, 2024

- Each think tank collaborated on 3-4 subcategories to focus on and up to 10 recommendations for each of the 5 main topics.

Example - Technology

CATEGORY	RECOMMENDED ACTIONS
Accelerate innovation	<ol style="list-style-type: none">① Leverage technology to break down barriers to innovation, address regulatory compliance and mitigate unintended consequences.② Incentivize investment in innovation and experimentation.③ Cultivate a technology-savvy water workforce.
Transform water services through next-generation technology	<ol style="list-style-type: none">④ Employ digital solutions such as artificial intelligence (AI) and machine learning (ML) to optimize efficiency, operations and water quality.⑤ Apply real-time monitoring, predictive analytics and material science to create “eternal infrastructure” and support resilient resources.⑥ Transform water management through expansion of in-home and fit-for-purpose treatment technologies.
Apply technology as the ‘Great Water Equalizer’	<ol style="list-style-type: none">⑦ Strive for the rapid adoption of technology that results in equitable and sustainable outcomes.⑧ Empower consumers with real-time information to make informed decisions.
Achieve a secure cyber future	<ol style="list-style-type: none">⑨ Establish a water community system and culture in which cyber risks are proactively and uniformly addressed.⑩ Strengthen public trust through steadfast data protection.

PNW Perspectives on Water 2050

- Perspectives on Water 2050 from PNWS Fall Officer Training & Spokane Truck Rodeo event.
 - » Hosted by ***Cole Benak, Jude Grounds, & Libby Barg Bakke.***
- Events discussed the themes, actions, and recommendations and ranked their top focus areas.
 - » Voted on top focus areas.
 - » Developed a 3-year action plan for top issues.

Key Themes: PNW Perspectives on Water 2050

- Technology

1. At Section Leadership Training, responses centered around embracing new technology, understanding emerging issues, and regional collaboration.
2. Truck Rodeo responses focused on need to communicate and educate employees and consumers on technology.

Technology: What focus area is most important to you?

Response options	Count	Percentage
Communication & education: employee & consumer	18	53%
Innovations to support a sustainable water future in 2050 and beyond	6	18%
Data security & comprehension	10	29%

Key Themes: PNW Perspectives on Water 2050

3. Leadership training & Truck Rodeo – Sustainability concerns center around workforce, training, and knowledge transfer.

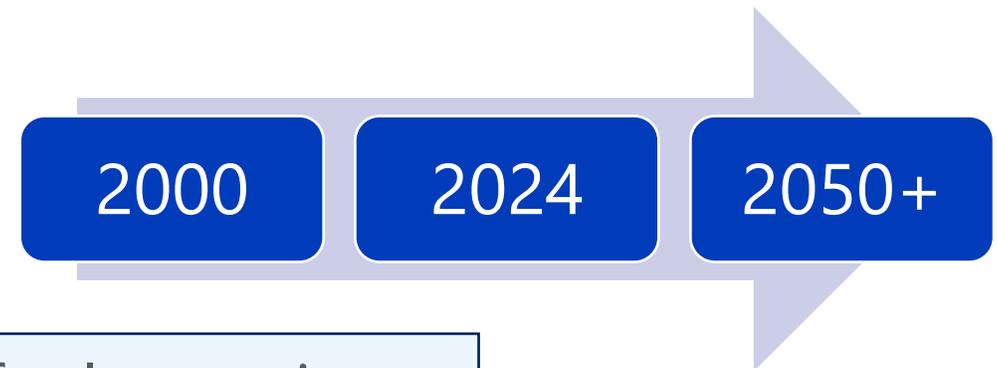
Sustainability: What focus area is most important to you?		
Response options	Count	Percentage
Aging Infrastructure and maintenance	16	46%
Establish a climate resilient water future	1	3%
Define the value of water for a new reality	1	3%
Workforce: retiring, retaining and incentivizing	17	49%

Key Themes: PNW Perspectives on Water 2050

1. Desire to share & learn about new technology.
2. Need to collaborate on ways to protect our water and empower operations.
3. Continue to leverage methods to communicate the value of water and share knowledge, both within our industry and to the public.

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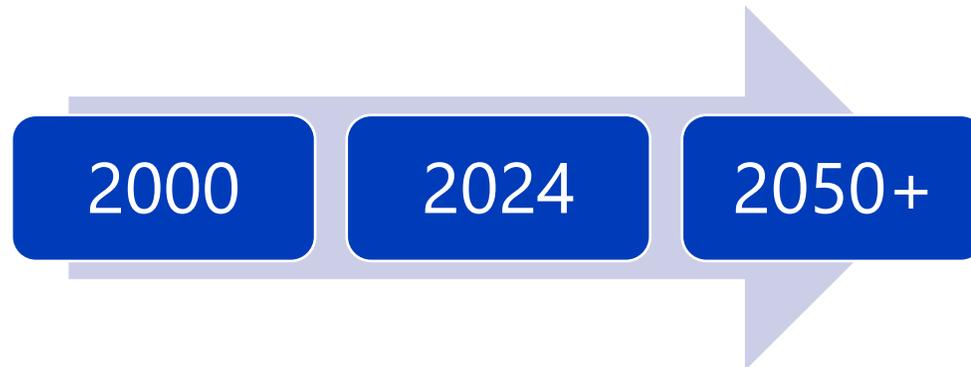


03

A thought experiment on
the future of our industry

Key Themes

1. Share & learn new technology.
2. Protect our water & empower operations.
3. Communicate the value of water and share knowledge, internally & externally.



A brief thought experiment....

2000

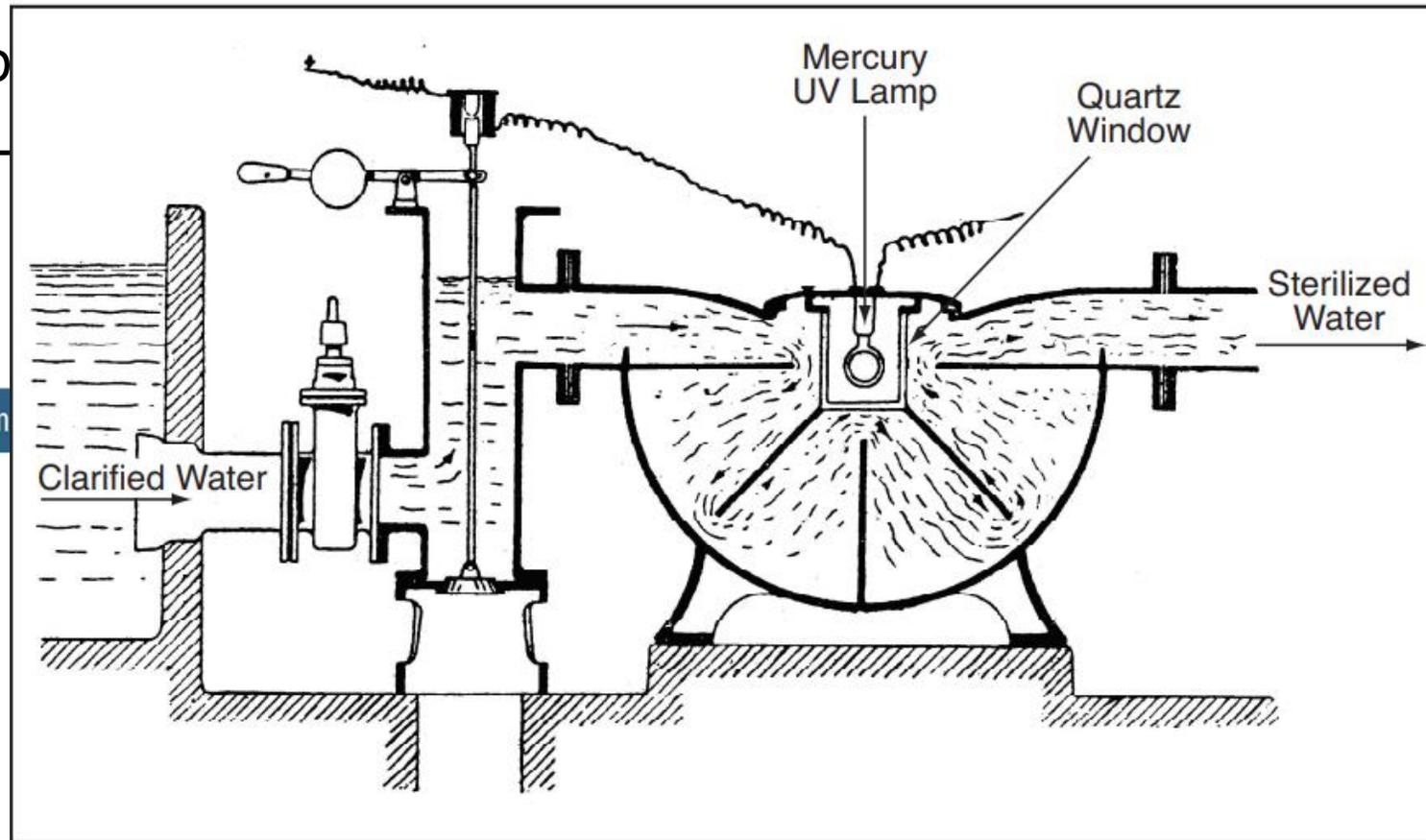
2024

2050+

1. *Share & learn new technology.*
 - *UV Disinfection/ UV AOP.*

- Even b
- 1801 -
- 1870's
- 1910's

Gamm



[nei.nih.gov/about/news-ews/protecting-your-light](https://www.nei.nih.gov/about/news-ews/protecting-your-light)

[awwa.org/portals/0/files/publications/documents/ultravioletdisinfectionhandbook.pdf](https://www.awwa.org/portals/0/files/publications/documents/ultravioletdisinfectionhandbook.pdf)

A brief thought experiment....

2000

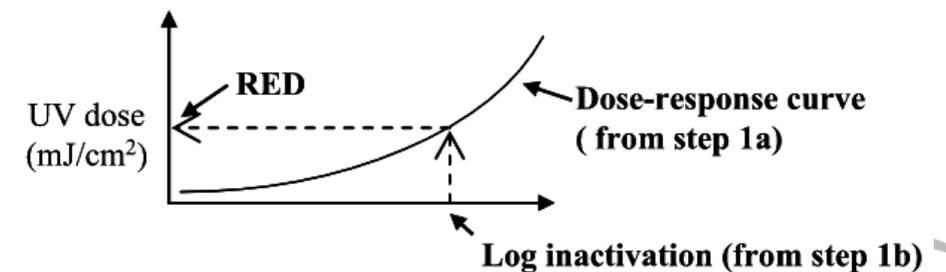
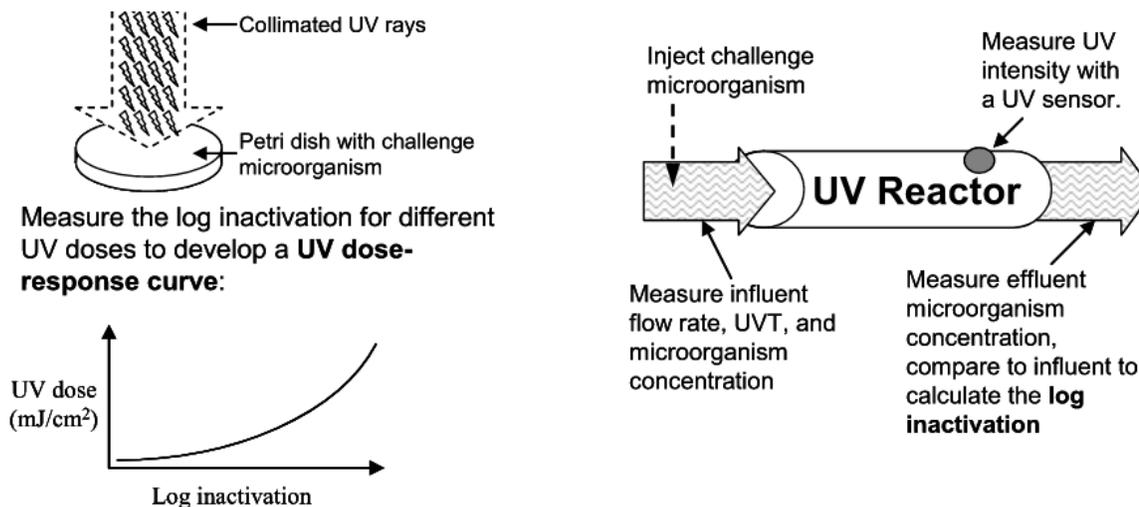
2024

2050+

1. Share & learn new technology.

– UV Disinfection/ UV AOP.

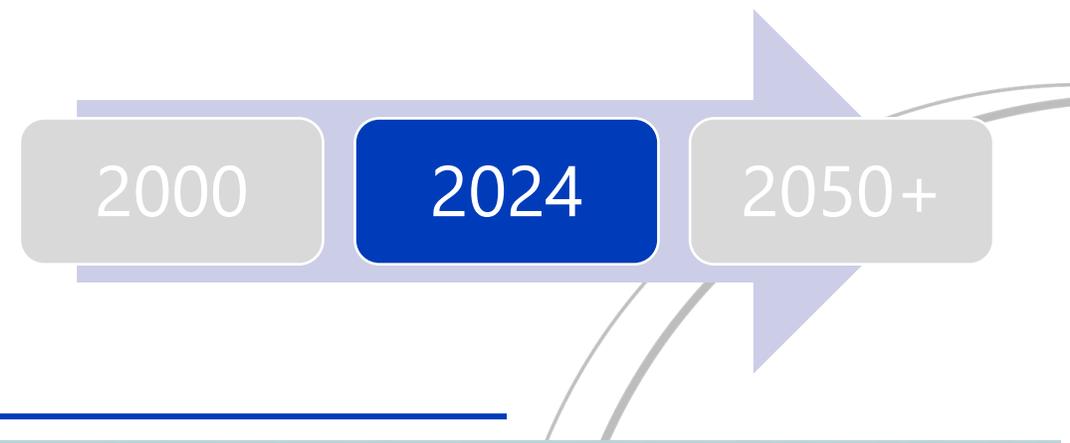
- 1998 – discovery that UV was very effective against *Cryptosporidium*.
- 2003/ 2006 – Draft and Final UVDGMs.
 - » LT2ESWR ('06) required *Crypto* treatment based on log removal.
 - » UV Validation allowed for systems to demonstrate certain log removals.
 - » Algorithm development allowed for a calculated dose approach.



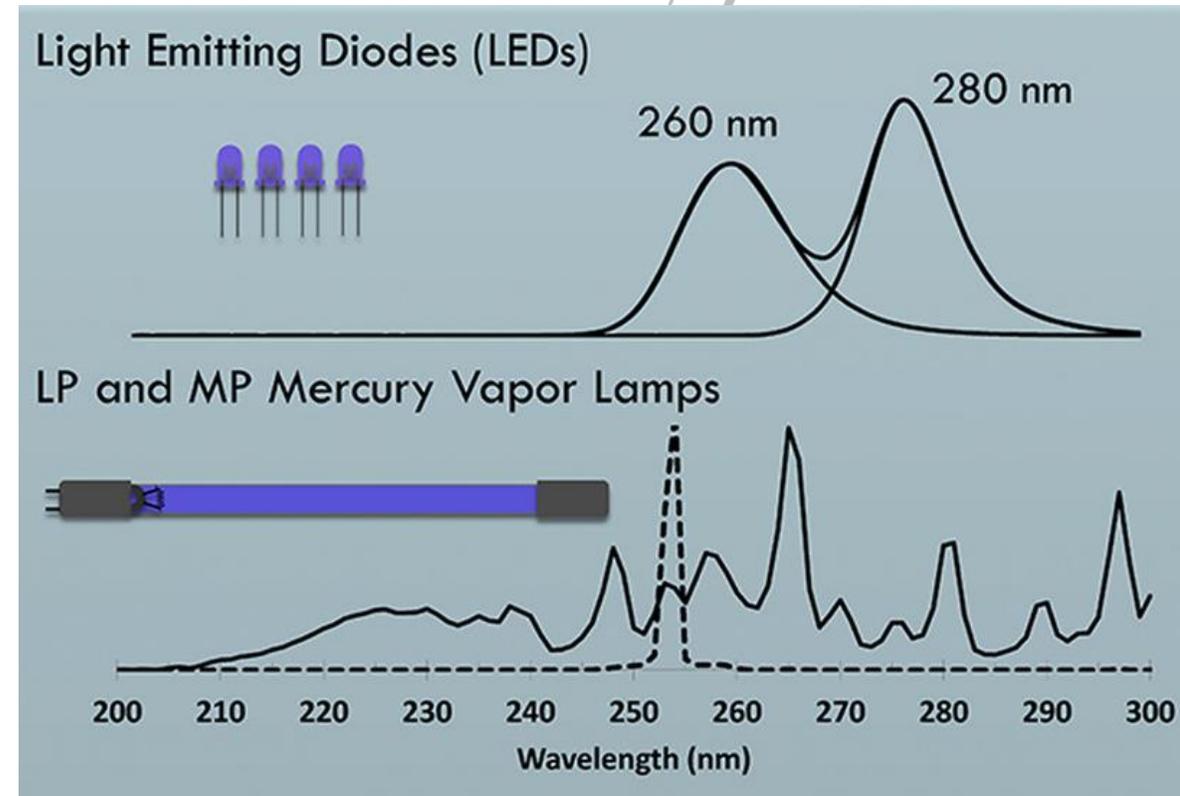
A brief thought experiment....

1. *Share & learn new technology.*
 - *UV Disinfection/ UV AOP.*

- UV LEDs gaining interest in market.
- Semiconductors with materials to allow for controlled excitation of electrons, resulting in the emission of photons.



	LEDs	LP/MP
Life expectancy (hrs)	20 – 30,000	6,000 – 15,000
Warm up time	Instantaneous	15-30 minutes
Notes	Compact, flow through system	Large, lamps obstruct flow



<https://uvlampconsulting.com/news-posts/evaluating-uv-c-led-disinfection-performance/>

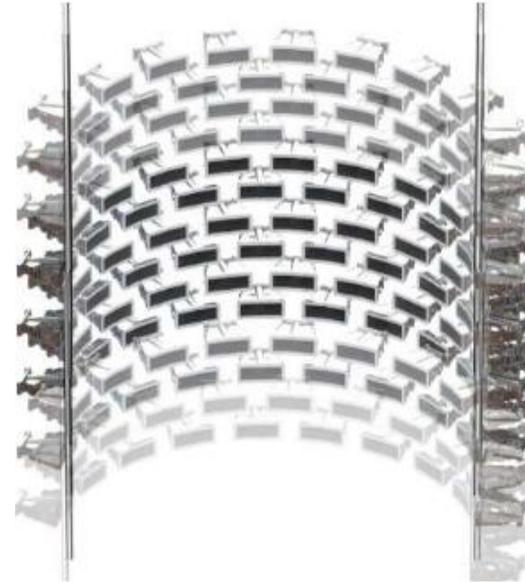
A brief thought experiment....

1. *Share & learn new technology.*
 - *UV Disinfection/ UV AOP.*

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2024

2050+



<https://waterprojectsonline.com/case-studies/led-uv-treatment-2020/>

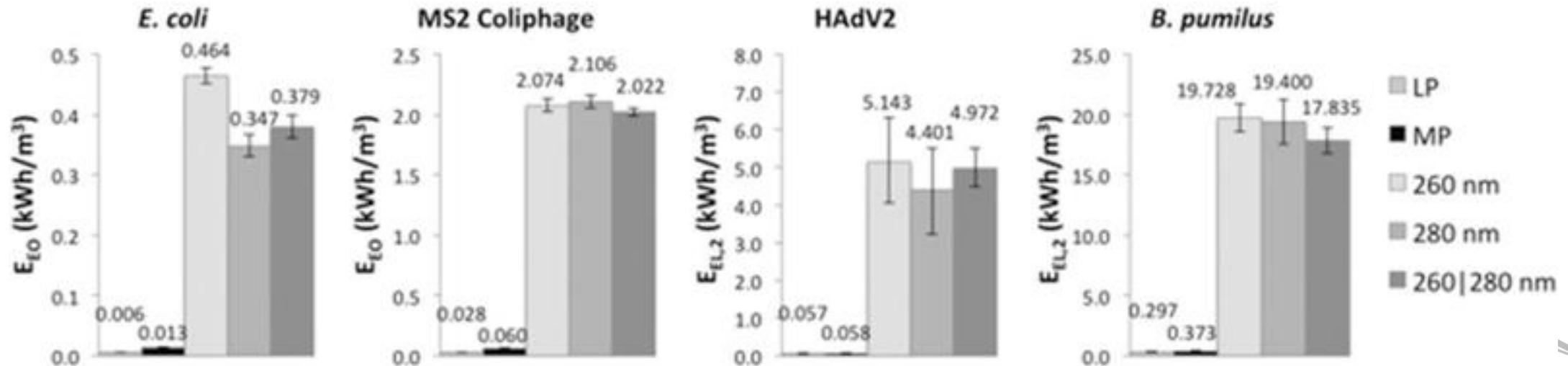
https://waterprojectsonline.com/wp-content/uploads/case_studies/2020/UU-Cumwhinton-LED-UV-2020.pdf

A brief thought experiment....

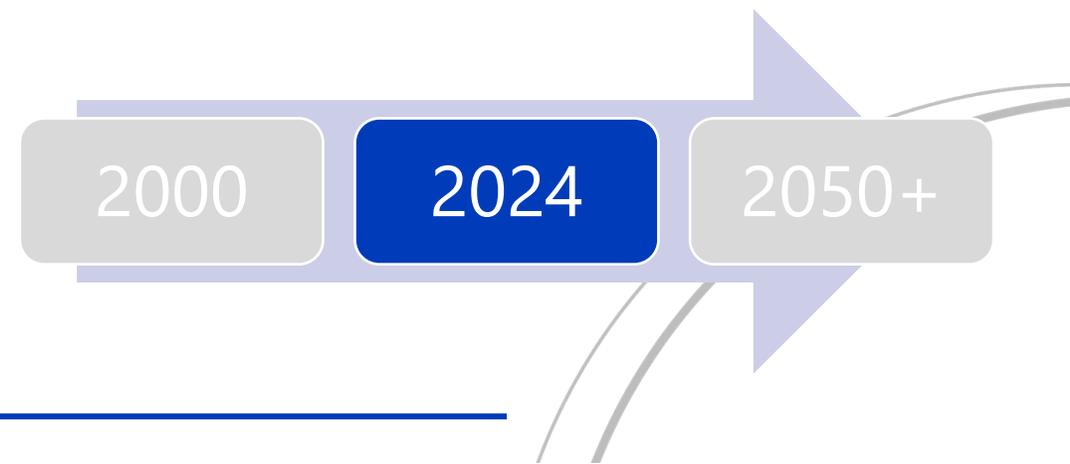


1. *Share & learn new technology.*
 - *UV Disinfection/ UV AOP.*

- Beck, et al. 2016 – compared E_{E0} , which defines the amount of energy (kWh/m³) required to decrease the concentration of a contaminant or a microorganism by 1 order of magnitude.

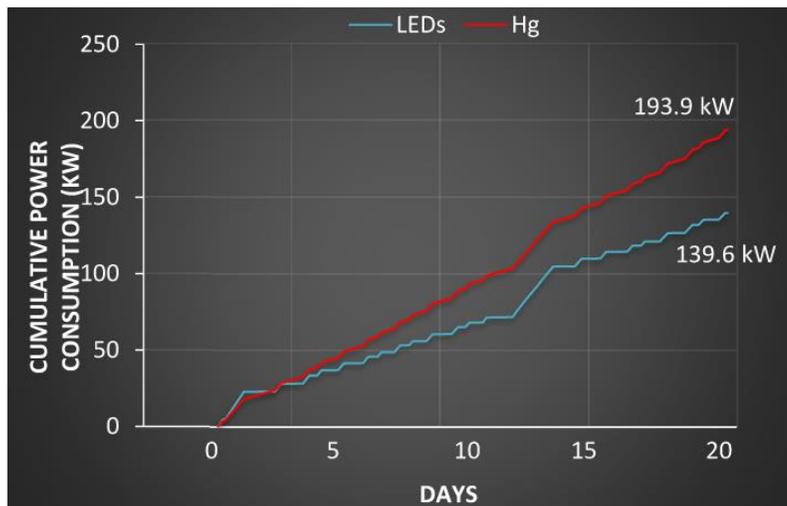


A brief thought experiment....



1. *Share & learn new technology.*
 - *UV Disinfection/ UV AOP.*

- LP Wall plug efficiency is 25 – 40%.
- LEDs not as efficient in comparison, but studies predicted better efficiency over time (Harris et al., 2013).
- Typhon Case study shows with varying conditions, LEDs used less energy than LP systems.
- Capital cost is becoming competitive for large systems, but O&M is lagging (EPRI 2021).



Year	LED Wall Plug Efficiency	Source
2016	1 – 3% (measured)	Beck, et al. (2016)
2023	10% (predicted)	Harris, et al. (2013)
2022	~8%-10% (measured)	IUVA conference presentations (2022)

A brief thought experiment....

1. Share & learn new technology.

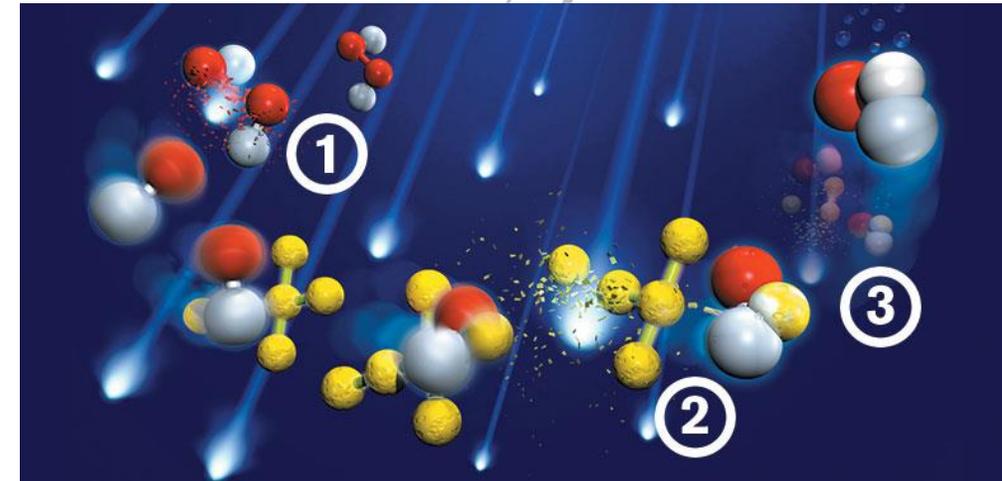
- UV Disinfection/ UV AOP.

- Implications for more efficient UV AOP.
 - » Photolysis via LED can target specific wavelengths.
- Implications for new processes altogether.
 - » Guangxin Lv, et al. (2024).

How light can vaporize water without the need for heat

Surprising “photomolecular effect” discovered by MIT researchers could affect calculations of climate change and may lead to improved desalination and drying processes.

David L. Chandler | MIT News
April 23, 2024



https://www.trojantechnologies.com/en/technologies/uv-advanced-oxidation-process?_bk=uv%20aop&_bm=p&_bt=635114691518&_bn=g&_bg=147188524247&_bt=635114691518&_bk=uv%20aop&_bm=p&_bn=g&utm_id=go_cmp-18929717036_adg-147188524247_ad-635114691518_kwd-420234970766_dev-c_ext-_prd-&utm

A brief thought experiment....

1. Share & learn new technology.

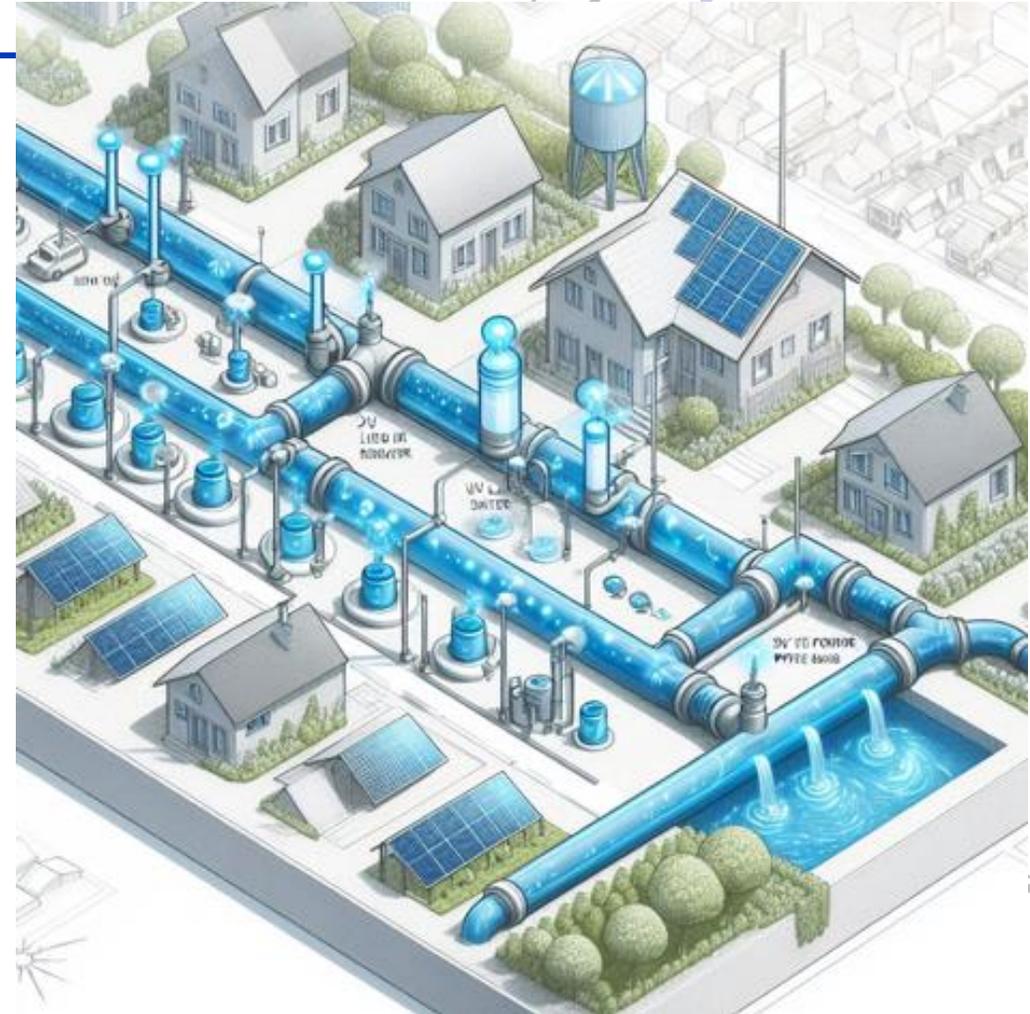
— UV Disinfection/ UV AOP

- By 2050: LEDs may be in their primetime.
- Beyond: we may look for more unique applications of UV disinfection.
 - » In-line distribution system disinfection?
 - » Regional dosing areas?
 - » Reduced need for residual disinfection?
- Targeted contaminant destruction with LEDs.
- More efficient desalination with LED photomolecular vaporization.

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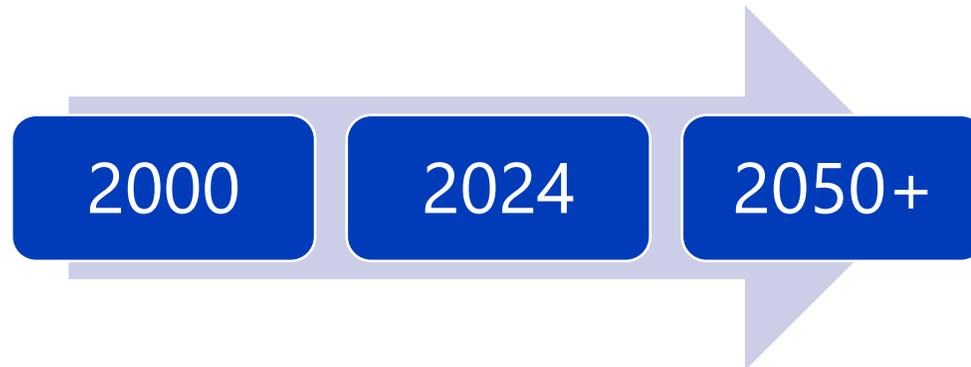
2024

2050+



Key Themes

1. Share & learn new technology.
2. Protect our water & empower operations.
3. Communicate the value of water and share knowledge, internally & externally.



A brief thought experiment....

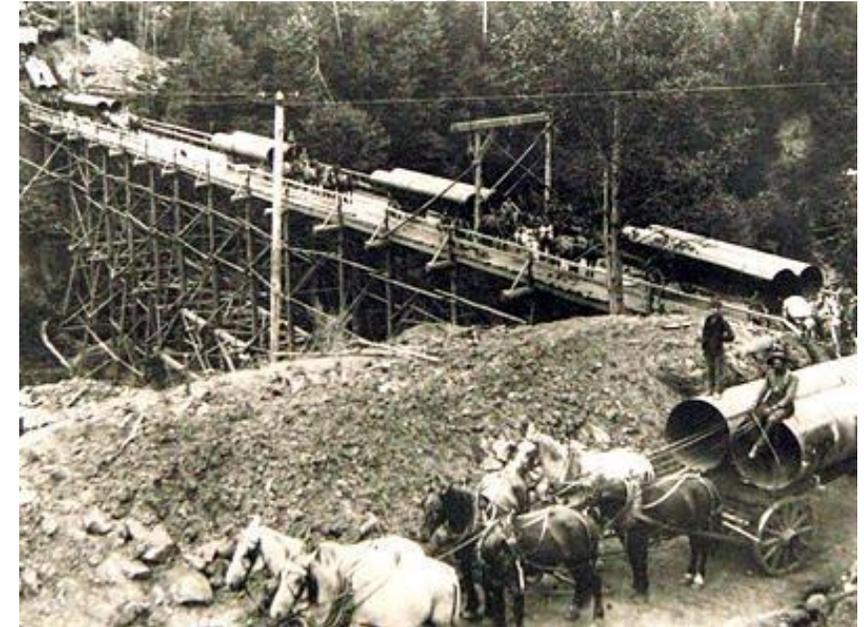
2. *Protect our water & empower operations.*

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2024

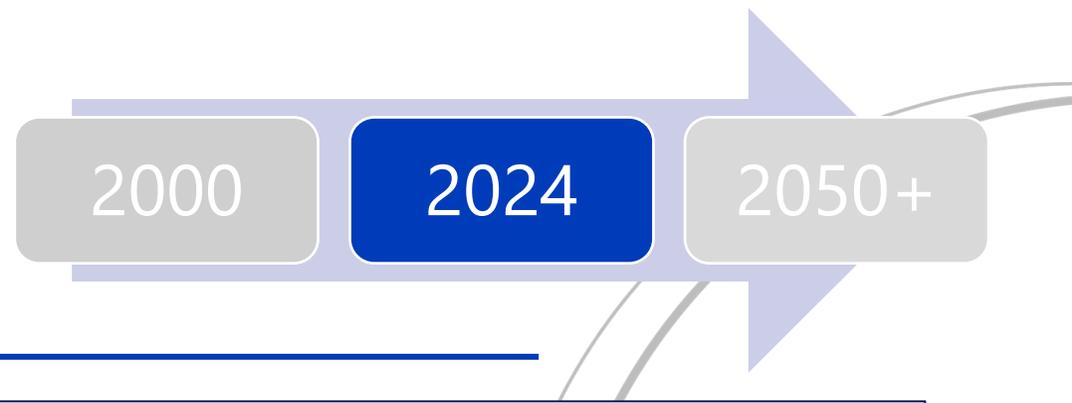
2050+

- Source protection is nothing new.
- Operations staff historically had varying degrees of influence on the ability of their system to maintain safe drinking water.
 - » Limited ability to proactively respond to events.



<https://www.opb.org/television/programs/oregonexperience/article/oex-bull-run/>

A brief thought experiment....



2. *Protect our water & empower operations.*

- Advancements in source protection, automation, and controls to meet more stringent requirements.
 - » Still, operations may lack tools needed to secure/ maintain safe water.

NEWS

Salem reissues do-not-drink alert after toxins found again in drinking water

Jonathan Bach and Zach Urness Statesman Journal
Published 10:50 a.m. PT June 6, 2018 | Updated 7:05 p.m. PT June 6, 2018

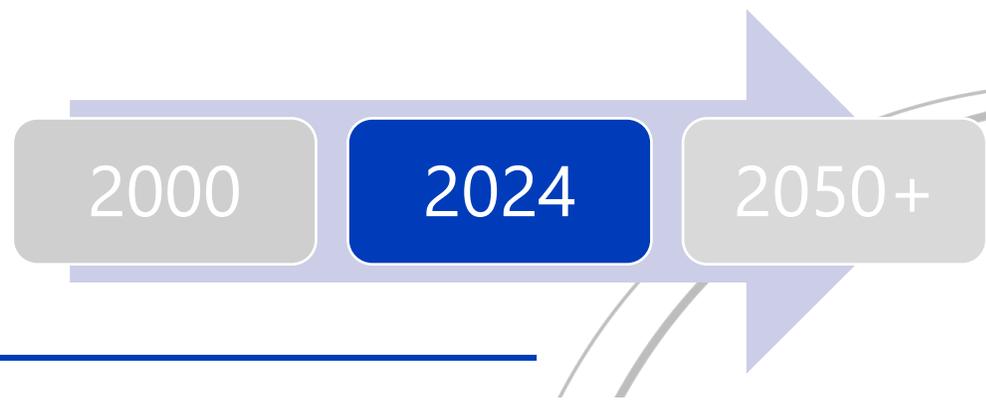
   



The levels are a result of **algae** blooms from Detroit Lake.

<https://www.statesmanjournal.com/story/news/2018/06/06/salem-emergency-advisory-toxins-found-water/677619002/>

A brief thought experiment....



2. Protect our water & empower operations.

- Machine learning as a prediction tool & support tool.

If HABs are a naturally occurring phenomena, what can we do? Well, just like the weather, having advanced warning is key to minimizing their costs...



Just like the weather, value is in knowing **IN ADVANCE** that a bloom is coming

So we collect data



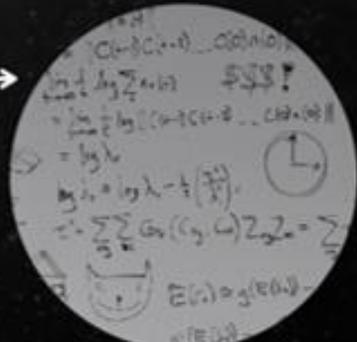
NATIONAL WEATHER SERVICE
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION

HOME FORECAST FAST WEATHER SAFETY INFORMATION EDUCATION

Local Forecast by ZIP, BC, or ZIP code
Enter location: Go
[Location Help](#)

Severe Storms Possible in the South; Southwest Critical Fire Weather
Severe storms with large to very large hail, damaging winds, a couple of tornadoes, may develop across the eastern South Plains to the Deep South. Dry, gusty winds critical. Elevated fire weather threats also in portions of the East. Cool and snowy in

Water samples, satellite imagery, qPCR (DNA), USGS, NOAA weather...etc

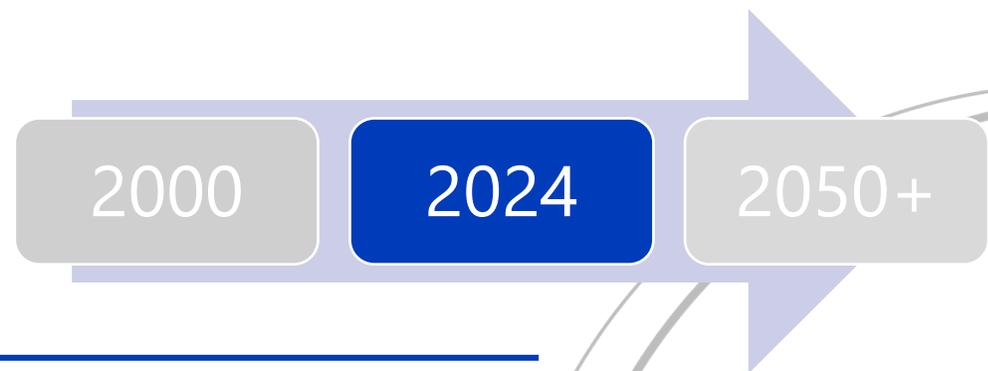


Then we use math and machine learning algorithms to make predictions.



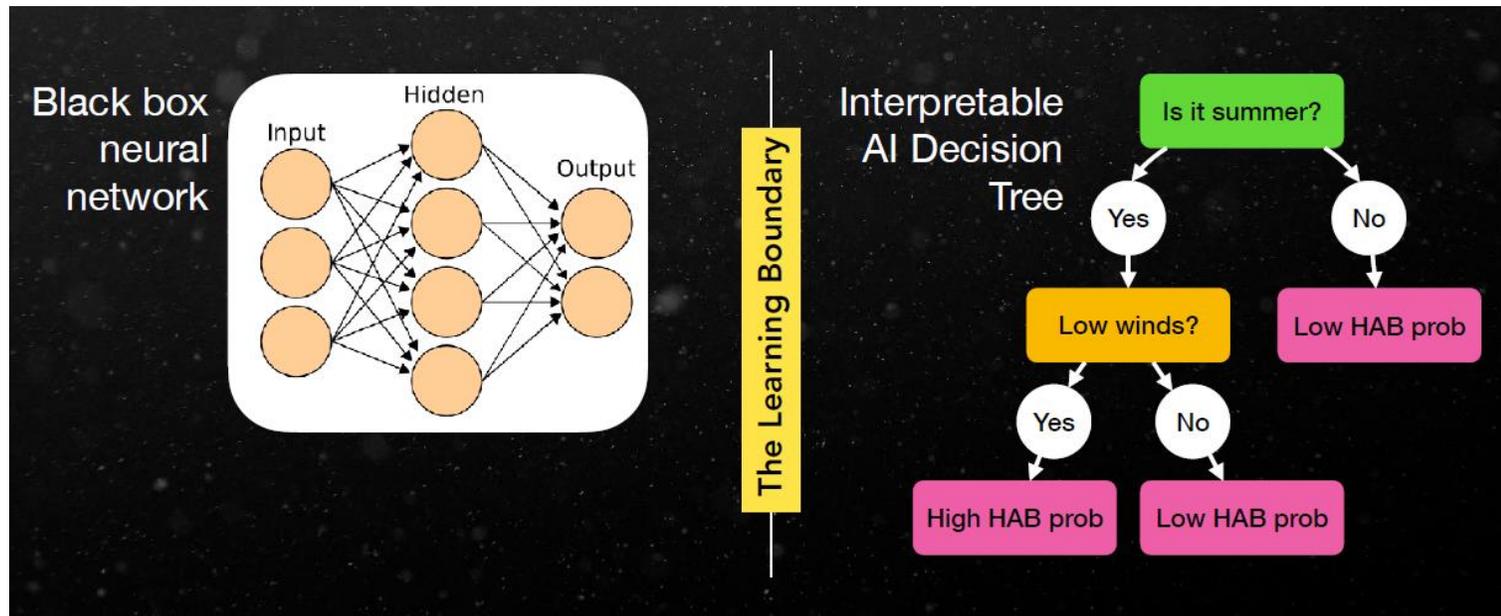
Assessing the Vulnerability of Source Waters to Harmful Algal Blooms Using Machine Learning
Caroline Russell, Carollo Engineers, Inc.
Mat Titus, ClearWater Analytica

A brief thought experiment....



2. *Protect our water & empower operations.*

- Collect data.
- Feed the model data with a known outcome.
- Those data are used to train the model.
- Then use the model to predict the outcome.



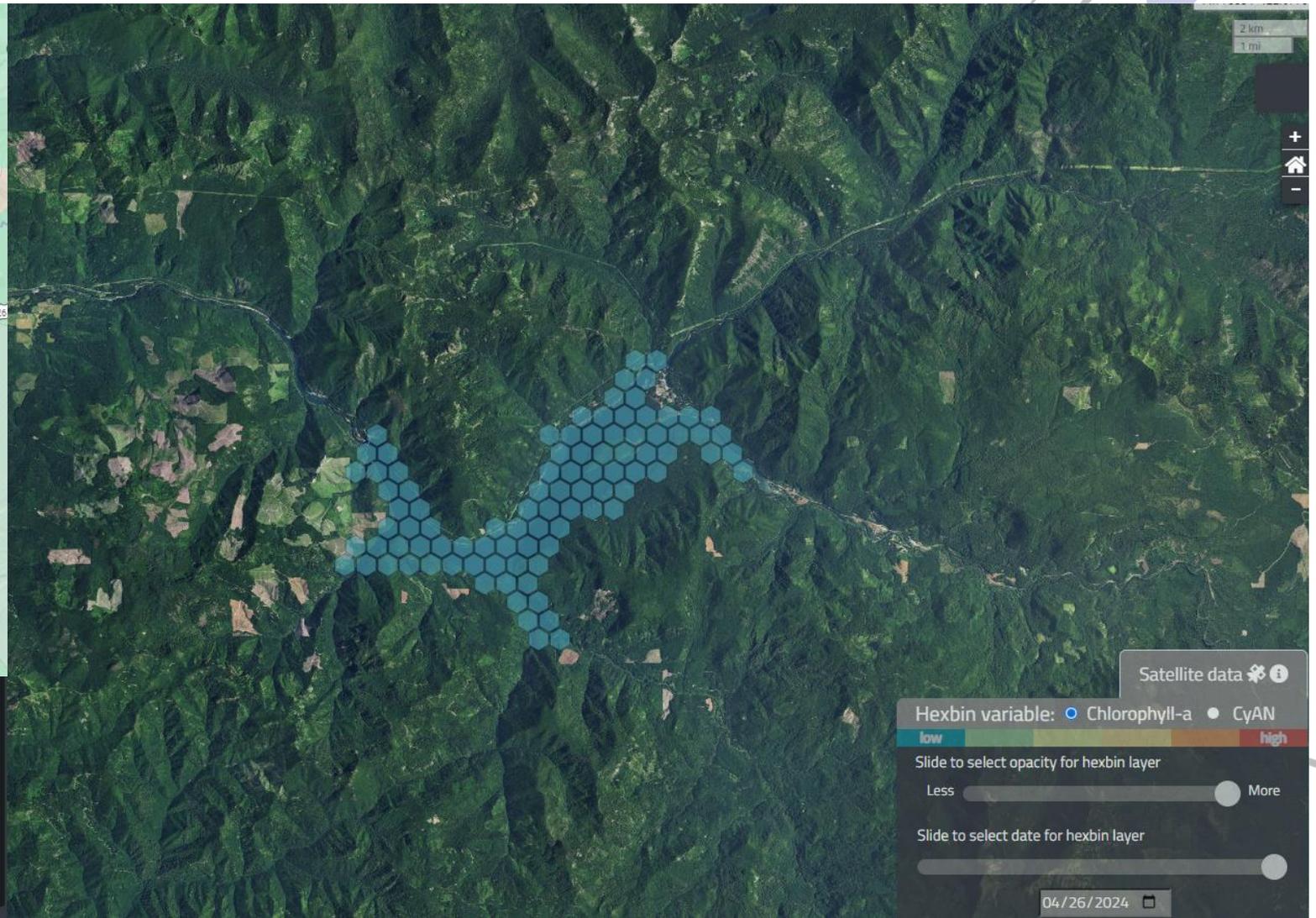
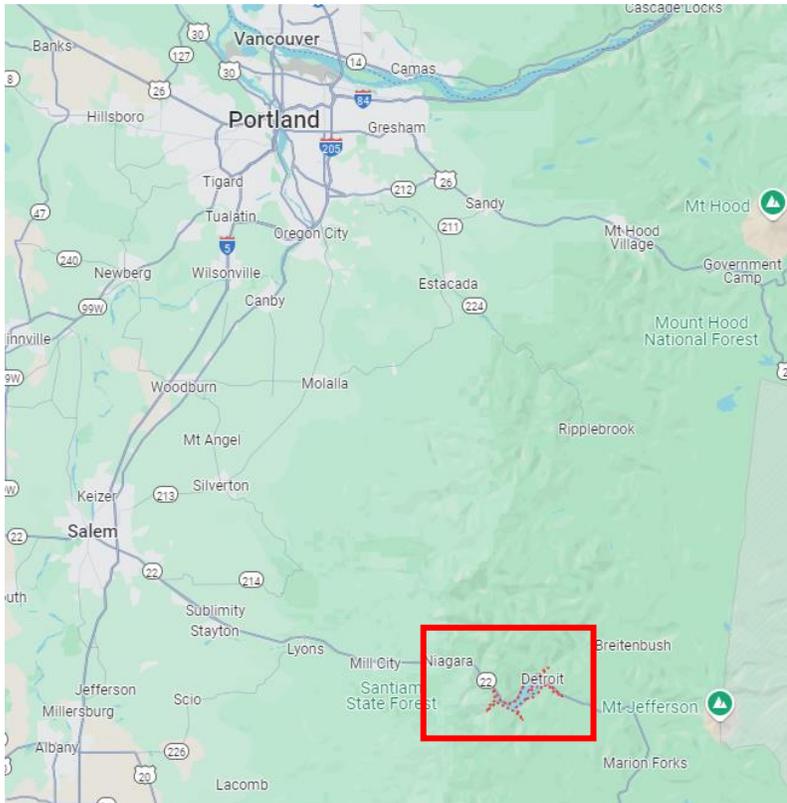
A brief thought experiment....

2. *Protect our water & empower operations.*

2000

2024

2050+



HAB Season

These charts show the relative risk levels of a cyanobacterial bloom. The forecast for the coming week is highlighted on the right while previous algae levels (Low/Med/High) are displayed on the left chart. Click the time series below to change the date displayed.

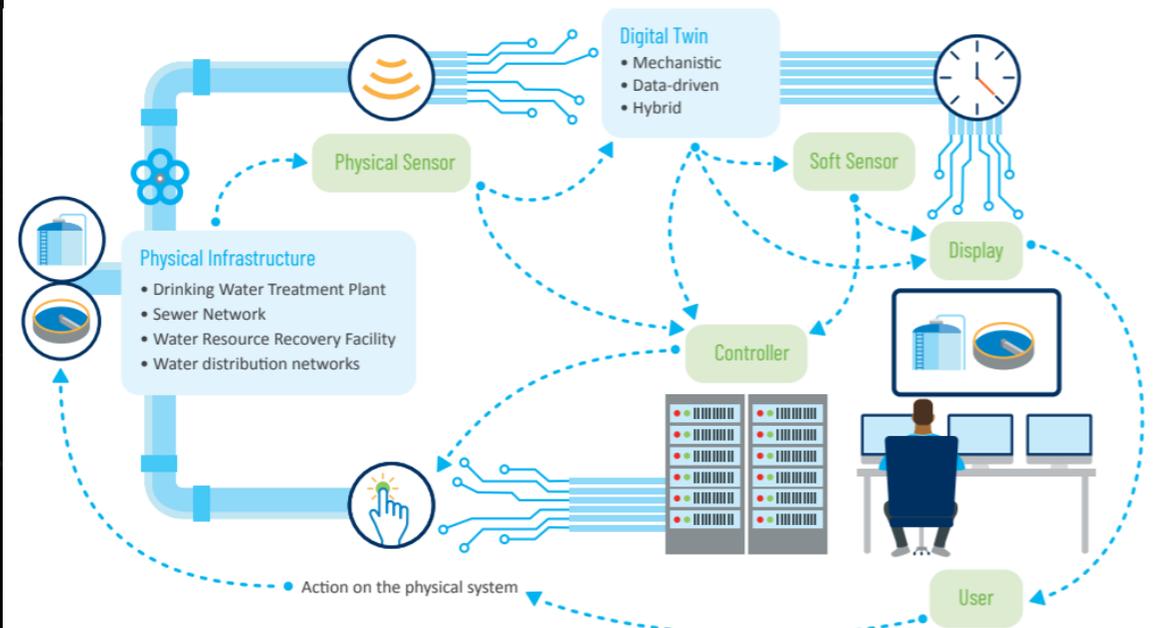
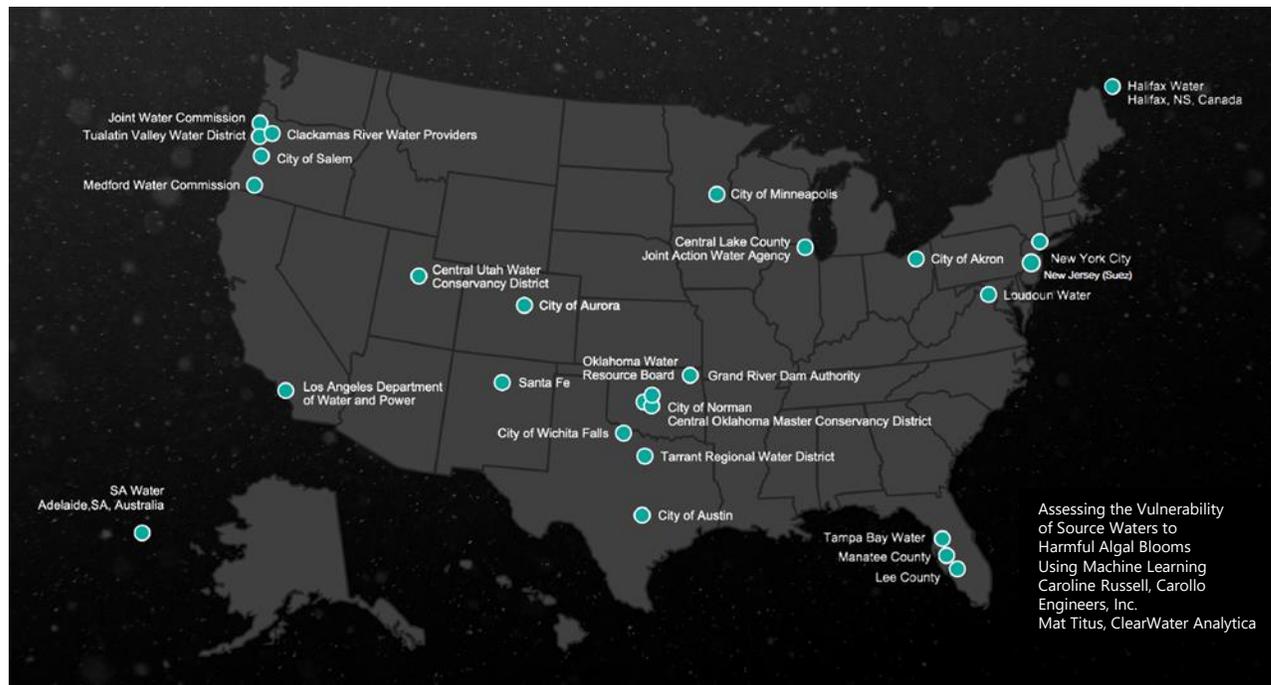
<https://detroitlake.clrwater.io/>

A brief thought experiment....



2. Protect our water & empower operations.

- Implications for the process to be replicated at other watersheds.
 - » Provides operations tools to prepare and respond.
- Digital twin machine learning can support process challenges.



A brief thought experiment....

2. *Protect our water & empower operations.*

2000

2024

2050+

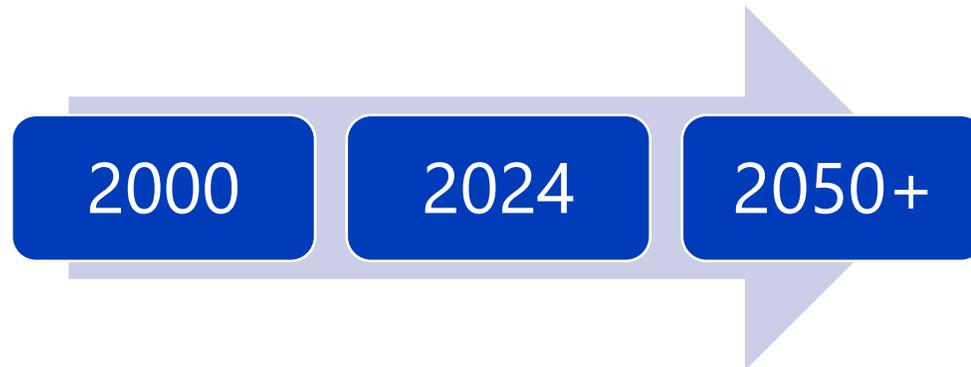
- Machine learning tools will be commonplace.
 - » Source protection tools allow for ample preparedness and can automatically respond.
 - » Digital twin tools will automatically adjust to mitigate upsets or identify problems.
- *“In the future, medical doctors will be required to consult a medical AI database before providing a diagnosis”* – Gigi Karmous-Edwards

CEO of Karmous-Edwards Consulting, leader in digital technologies within the water sector.



Key Themes

1. Share & learn new technology.
2. Protect our water & empower operations.
3. Communicate the value of water and share knowledge, internally & externally.



A brief thought experiment....

3. *Communicate the value of water & share knowledge*

2000

2024

2050+

- As is the case today, knowledge transfer within water systems varies.
- Communicating to the public was limited until 1998.
 - » Consumer Confidence Reports became federal requirements

§ 141.153 Content of the reports.

(a) Each community water system must provide to its customers an annual report that contains the information specified in this section and § 141.154.

(b) Information on the source of the water delivered:

(1) Each report must identify the source(s) of the water delivered by the community water system by providing information on:

- (i) The type of the water: e.g., surface water, ground water; and
- (ii) The commonly used name (if any) and location of the body (or bodies) of water.

§ 141.154 Required additional health information.

(b) A system which detects arsenic at levels above 25 $\mu\text{g/l}$, but below the MCL:

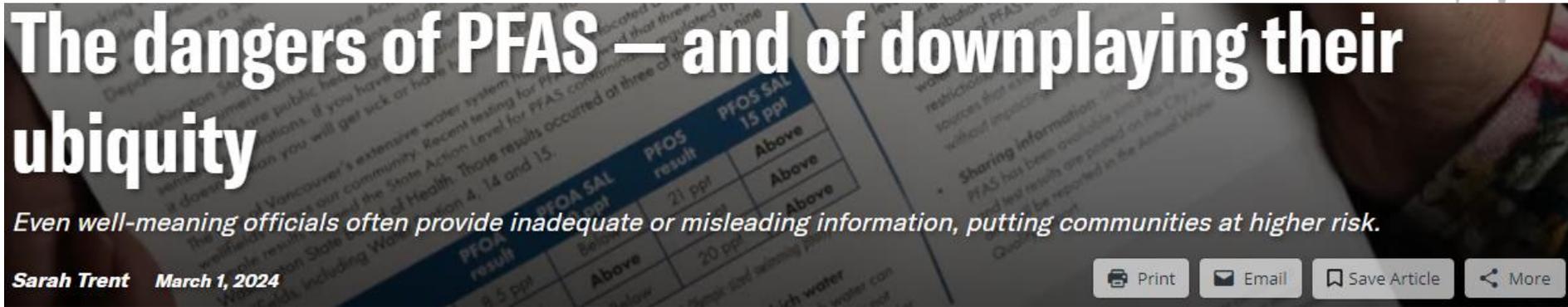
(1) Must include in its report a short informational statement about arsenic, using language such as: EPA is reviewing the drinking water standard for arsenic because of special concerns that it may not be stringent enough. Arsenic is a naturally-occurring mineral known to cause cancer in humans at high concentrations

A brief thought experiment....

3. Communicate the value of water & share knowledge



- Information (and misinformation) spreads at its fastest rate in human history.
- Pollution of drinking water among top fear in America.



Official health communications are failing PFAS-contaminated communities

Alan Ducatman¹, Jonas LaPier², Rebecca Fuoco², Jamie C DeWitt³

Affiliations + expand

PMID: 35538533 PMCID: PMC9092686 DOI: 10.1186/s12940-022-00857-9

A brief thought experiment....



3. *Communicate the value of water & share knowledge*

- Our industry (operations especially) is in the best position to communicate the value of water.
- Tools may change in the future, but basic guidelines (as seen in WRF's recommendations for further engagement research) may still hold:
 - Social science research – understand what will work.
 - **Workforce – identify strategies to build workforce.**
 - Social media channels – to strengthen workforce & build public trust.
 - Media messaging and communication – resources during good times and bad.
 - **Community engagement – education, involvement, and interaction with customers.**
 - Could include virtual trainings, internships, community challenges, virtual reality platforms, video games (WRF, 2022)

A brief thought experiment....

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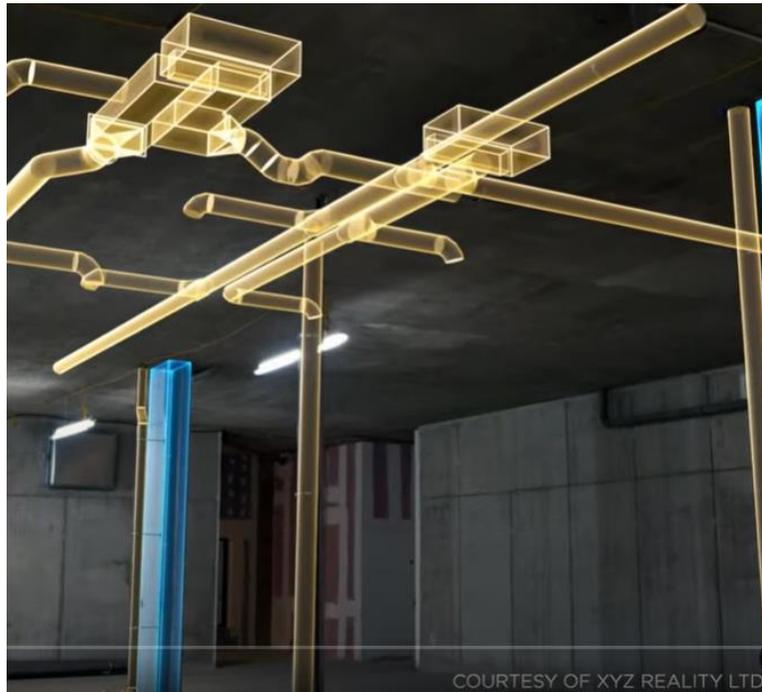
2024

2050+

3. *Communicate the value of water & share knowledge*

- Visualization may be able to help with knowledge transfer.

AR facility guides/ O&Ms / SOPs



Public interpretive displays



A brief thought experiment....

2000

2024

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3. *Communicate the value of water & share knowledge*

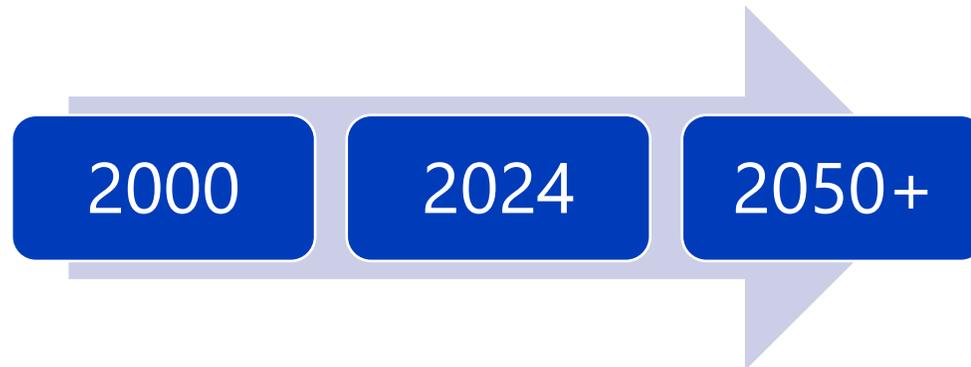
- Visualization may be able to help with knowledge transfer.

Visualization support during and after projects.



Key Themes

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2. Protect our water & empower operations.
3. Communicate the value of water and share knowledge, internally & externally.



04

Closing thoughts

We can shape the direction on the future of water.

Tyler Kane

Lead Engineer
Portland, OR

Tkane@Carollo.com



Bloopers

