



# Water Systems Thinking

## Puzzling Phenomena & Local Relevance

### Sustainability Ambassadors

*Rapidly advancing a more sustainable future*

#### A - Natural Water Systems

Water Chemistry, Water Quantity, Water Cycle, Snowpack, Weather and Climate, Watershed, Groundwater, Puget Sound, Pacific Ocean

#### B - Human Water Systems

Water Supply, Wastewater Treatment, Stormwater Management, Integrated Water Resource Management

## A - Natural Water Systems

### Puzzling Phenomena & Local Relevance

---

#### Water Chemistry

1. Why is the rain not salty?
2. Where is the salt in saltwater?
3. How have salmon evolved to pull oxygen from water? How have humans evolved to pull oxygen from air? Why would salmon drown in the air and humans drown in the water?
4. What needs to happen in the cells of salmon when they transition from freshwater to saltwater?
5. Can we produce drinking water from saltwater? What is the cost/benefit ratio for our region? Where in the world is desalination working best?
6. How does water exist in the atmosphere?
7. At what point does rain fall?
8. Why does a raindrop bead up on a leaf or a window pane?
9. What makes water flow together?
10. How does snow and ice form? What happens when it melts?
11. What are the special properties of a water molecule?
12. What does this mean for biological life forms?
13. Why do we drink water?
14. How do the properties of water molecules support cell function in my own body?
15. If you put a stock of cut celery in a glass of water with food coloring, why does the coloring end up at the top of the celery? How does water defy gravity?

16. Would the same properties work in a giant tree?
17. How does evapotranspiration work? What is the role of water?
18. How is climate change a product of ancient photosynthesis?
19. What actions can I take that would have the greatest measurable impact on rebalancing the relationship between ancient and current photosynthesis?
20. What are the chemical benefits of trees in my city? What percentage of my city (my neighborhood?) is covered by tree canopy?
21. Who is behind the plan to plant 1 million trees in Seattle and King County by 2020?
22. How do we reduce and remediate toxics of concern in the Duwamish River and in Puget Sound?
23. What are the human consequences of air-borne particulate matter in our region? Who is affected the most?
24. How do you clean up toxic sediments in the Duwamish Superfund Site while respecting Indian fishing rights as guaranteed by treaties?
25. What are the heavy metals in our stormwater?
26. What are the chemicals in our pee that end up in Puget Sound?
27. Why are boy fish turning into girl fish in Puget Sound?
28. What is the relationship between PCBs and salmon avoiding predators?
29. What are the expected impacts of ocean acidification on the Puget Sound ecosystem?
30. What are the expected impacts of ocean acidification on the economy of Washington State?
31. Why do astronomers look for signs of water on other planets?
32. How would you make water in a human outpost on Mars?
33. How can we split water to make hydrogen fuel cell cars? What is the cost/benefit ratio for our region? What's the byproduct of this fuel?
34. How can we apply the principles of green chemistry to design safer products?

## Water Quantity

1. What is the ratio of water to land on our planet? What about in a tree or in an apple? What about in me?
2. How much of the world's water is saltwater? Frozen as ice? Freshwater? Groundwater? Atmospheric water? Biological water?
3. What percentage of the world's freshwater is available for human use? What percentage of this is too polluted to use?

## Water Cycle

1. How does the water cycle function in the Puget Sound basin?
2. How many inches of precipitation do we receive on an annual basis right where we live? Does this amount change for nearby communities? Why?
3. What ecosystems have evolved to take advantage of this precipitation pattern? Forest, soils, lakes and wetlands, riparian zone, stream, river, estuary, near shore, Puget Sound.
4. Will this pattern change in the future? What might be the consequences?

## Snowpack

1. How do we measure snowpack depth? Who needs to know? Why does it matter?

2. How deep is the snowpack in the Cascades this year?
3. How long does our Cascade snowpack typically last each year before it is totally melted?
4. What is the drinking water equivalent of snowpack depth? How is this calculated?
5. What are the patterns of snowpack depth over the last 50 years?
6. What is the projected trend for snowpack depth over the next 50 years?
7. What are the predicted consequences and needed solutions for our community?

## Weather and Climate

1. What is the relationship between the weather where we live and our climate?
2. What are the annual patterns of sun, wind, rain and temperature where we live?
3. How have these local patterns changed in the last 20,000 years?
4. How are these patterns expected to change in my lifetime?
5. Do climate change models predict less precipitation, more, or the same amount? How might the timing of this pattern change and what are the consequences?
6. What are the expected impacts of ocean acidification on the Puget Sound ecosystem?
7. What are the expected impacts of ocean acidification on the economy of Washington State?
8. In the future, will we continue to have summer days with smoke in the air? What are the predicted impacts to public health? To economic activity?
9. Why are forest fires worse than they were in the past?
10. How will climate change affect the forest industry in our state?
11. How will climate change affect agriculture in our state?
12. How will climate change affect the fishing industry in our state?
13. How will climate change affect the shellfish industry in our state?
14. How will climate change affect tourism and recreation in our state?
15. How will public health be affected?
16. Why is climate change a social justice issue? Based on what principles?
17. What systems will we need to adapt to accommodate changes in our local climate?
18. What are the most promising policy solutions?
19. What are the most promising engineering solutions? Green building? Clean energy? Electric vehicles? Product design? Green infrastructure?
20. What actions can I take that would have the greatest measurable impact?

## Watershed

1. I know my street address, but what is my watershed address?
2. How does my watershed move energy and matter through the ecosystem?
3. What ecosystem services were provided by our watershed when the first native peoples were the only human inhabitants?
4. How have humans adapted to and modified the ecosystem services of this watershed over time?
5. How can we assess the economic benefits of ecosystem services in our watershed?
6. Why are salmon called an indicator species in the watersheds of Puget Sound? What are they indicating in my watershed?

## Groundwater

1. When it rains in the undeveloped forests of our region, what percentage of water runs off in streams and rivers and what percentage is infiltrated into the ground?
2. When it rains in the developed suburbs and cities of our region, what percentage of water runs off in streams and rivers and what percentage is infiltrated into the ground?
3. What is the geology underneath us and how does this affect the movement of water? How can we know?
4. How much does our water table fluctuate from one season to another?
5. How have humans over time engineered systems to use groundwater for our needs?
6. What percentage of my community's water supply comes from groundwater sources? How about in other communities nearby?

## Puget Sound

1. Why would a young Orca mother in Puget Sound carry her dead baby on her nose for two weeks?
2. What happened to Puget Sound during the Ice Age?
3. How have periodic eruptions of Mt Rainier affected Puget Sound?
4. What are the systemic connections between toxic bioaccumulation in Puget Sound and Washington State's economy?
5. Why do Washington oyster growers need to send the baby oysters to Hawaii to grow before coming back to Washington?
6. What are the issues and opportunities with fish hatcheries in Puget Sound?
7. What are the issues and opportunities with wild fish harvest in Puget Sound?
8. What are the issues and opportunities related to tribal fishing rights in Puget Sound?
9. How will ocean acidification affect the Puget Sound ecosystem?
10. What are the systemic connections between eelgrass, Pacific Herring, Chinook Salmon, and Orca populations in Puget Sound?
11. What is the relationship between dams on the Snake River and Orca starvation in Puget Sound?
12. Once introduced, how long will plastic linger in the Puget Sound food web?
13. What is the ratio of microplastics to plankton in the Puget Sound food web?
14. How does my fleece sweatshirt or warm ups impact the health of the Puget Sound food web? What are the engineering solutions?
15. Why is there so much plastic in Puget Sound? What policies and programs would lead to solutions?
16. How can we use the principles of green chemistry to engineer safer products with the same functionality?

## Pacific Ocean

1. How is the climate where we live determined by currents in the Pacific Ocean?
2. What are the local impacts of El Nino and La Nina? What causes these phenomena?
3. How is the acidification of the ocean impacting the marine ecosystem of Puget Sound?
4. How is the acidification of the ocean impacting the economy of Washington State?

# B - Human Water Systems

## Puzzling Phenomena & Local Relevance

---

### Water Supply

1. Why did the first native people in our watershed build their village along a river?
2. How did the first non-native settlers in our watershed engineer water supply systems?
3. What was the sequence of engineering design improvements that led to our current water supply system?
4. Today, how does the water in my faucet get there?
5. What is the shortest possible timeframe for a water molecule in Puget Sound to end up coming out of my faucet? How is this process engineered?
6. Who cleans my water so it's safe to drink? How is this process engineered?
7. What happened in Flint, Michigan? Could it happen here?
8. Why is bottled water dumb math?
9. Why is the big water tank in my neighborhood built at the highest point?
10. What percentage of the water in my house comes from wells? How is this process engineered?
11. How is the dam that supplies my water engineered? Can the same dam generate electricity?
12. How many people can be served by the reservoir behind the dam?
13. At what point would the floating bridges on Lake Washington snap and sink, if the Chester Morse Reservoir water supply levels were not carefully monitored?
14. What role does a forest play in cleaning my drinking water?
15. What are the systemic impacts to our water supply system if a major fire were to roar through the watershed that fills the reservoir behind the dam?
16. How is the dam operated to supply water, control floods, support agriculture, ensure salmon passage, and provide recreational opportunities? Is this possible? What if it breaks?
17. What are the population pressures on our water supply system when projected out to 2030, 2040, 2050?
18. How can we ensure the highest quality drinking water for our city that never fails?
19. How can we ensure the resilience of our water system in the face of an earthquake?
20. How do I read my family's water bill?
21. If my family conserves water, will we save money? We will we save energy by conserving water? We will reduce greenhouse gas emissions by conserving water? How can we calculate all of these considerations?
22. How much water does a typical American household consume per day? For all inside uses? For all outside uses? How does the average water consumption of a typical American compare to my family's average? What is the average use of a typical European family? What about for families living in water scarce countries in Africa?
23. How can we support Goal 6 of the United Nations 17 Sustainable Development Goals?
24. What is the water footprint of an apple that I eat?
25. What is the water footprint of my hamburger?

26. What is the water footprint of my jeans? T-Shirt? Laptop?
27. What is my total water footprint? How can it be calculated? And how does it differ from my daily water consumption?
28. How is a flower naturally engineered to survive on its rain budget?
29. How is a tall cedar tree naturally engineered to survive on its rain budget?
30. Can a house be engineered to survive on its rain budget or net zero water over the course of a year? How about a school? An entire city?
31. How can we calculate the size of a cistern to meet 100% of the water needs for my house, apartment, or school for one year?
32. How is Singapore, an island nation smaller than the city of Los Angeles, integrating its water systems to survive on its rain budget? How is this engineered?
33. Can we turn Puget Sound saltwater into regular drinking water? How is this engineered?

## Wastewater Treatment

1. What is the engineering history of wastewater treatment in King County? What were the prototypes and tipping points?
2. How can we flush a toilet at home or at school and have perfectly clean water back in Puget Sound within about 12 hours? How is this engineered?
3. Why do we use drinking water to flush toilets, put out fires, and irrigate soccer fields? Can we engineer a more efficient solution?
4. How can we use mechanical systems to clean wastewater?
5. How can we use biological systems to clean wastewater?
6. Can we grow better crops using our own poop?
7. Can we generate energy from processing our own poop?
8. How is Singapore, an island nation smaller than the city of Los Angeles, turning wastewater into drinking water for its people? Where else in the world is this happening? What progress are we making in King County on recycling wastewater? How is this engineered?

## Stormwater Management

1. Is stormwater good or bad?
2. How is a forest naturally engineered to capture, filter and infiltrate stormwater?
3. How is a rain garden engineered to capture, filter and infiltrate stormwater?
4. How does the micro-ecosystem in the soil of a rain garden capture, filter and infiltrate polluted stormwater runoff?
5. What's the problem with brake pads in polluted stormwater runoff?
6. What's the problem with rubber tire dust in polluted stormwater runoff?
7. What's the problem with lawn fertilizer in polluted stormwater runoff?
8. What's the problem with dog poop in polluted stormwater runoff?
9. What's the problem with carwash soap in polluted stormwater runoff?
10. Where do PCBs come from and how long will they be in our ecosystem?
11. Why is there a fish consumption advisory in the Duwamish River?
12. If the gray infrastructure of streets, curbs, gutters and drains was engineered to quickly redirect stormwater to the nearest waterbody, how can green infrastructure solve it?
13. What's the engineering of a green roof?

14. Can a home or a school be engineered to capture, filter and infiltrate 100% of the stormwater that falls on the site?
15. How is Singapore, an island nation smaller than the city of Los Angeles, planning to capture up to 90% of the rain water that falls on its territory?
16. If we can capture stormwater on site can we engineer beneficial uses for it?
17. What's better, a clump of trees or a rain garden? Prove it.
18. How do you make pervious concrete strong enough for a car but porous enough for rain to pass through?
19. Why do adult salmon returning to urban streams die before they can spawn?
20. Why are boy fish turning into girl fish in Puget Sound?
21. Why are salmon on drugs that we pee?

## **Integrated Water Resources Management**

1. How is Singapore, an island nation smaller than the city of Los Angeles, integrating four distinct water systems to become water independent by the year 2060? How is this engineered?
2. What efforts are we making in our city or region to integrate our water systems?
3. How would you achieve net zero water in a home or school by integrating water systems?
4. How does the Bullitt Center on Capitol Hill in Seattle achieve net zero water?
5. How can a building behave like a flower? (Living Building Challenge)
6. How do astronauts on the International Space Station integrate water systems?
7. What are the systemic impacts to our water systems in the event of an earthquake?
8. What are the systemic impacts to our water systems in the event of a Lahar?
9. What are the systemic impacts from climate change?
10. How do we plan for resilience in our region in the face of climate change?