

Thermal Loading Regulation and Mitigation for Water Utilities

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ANNEAR WATER RESOURCES



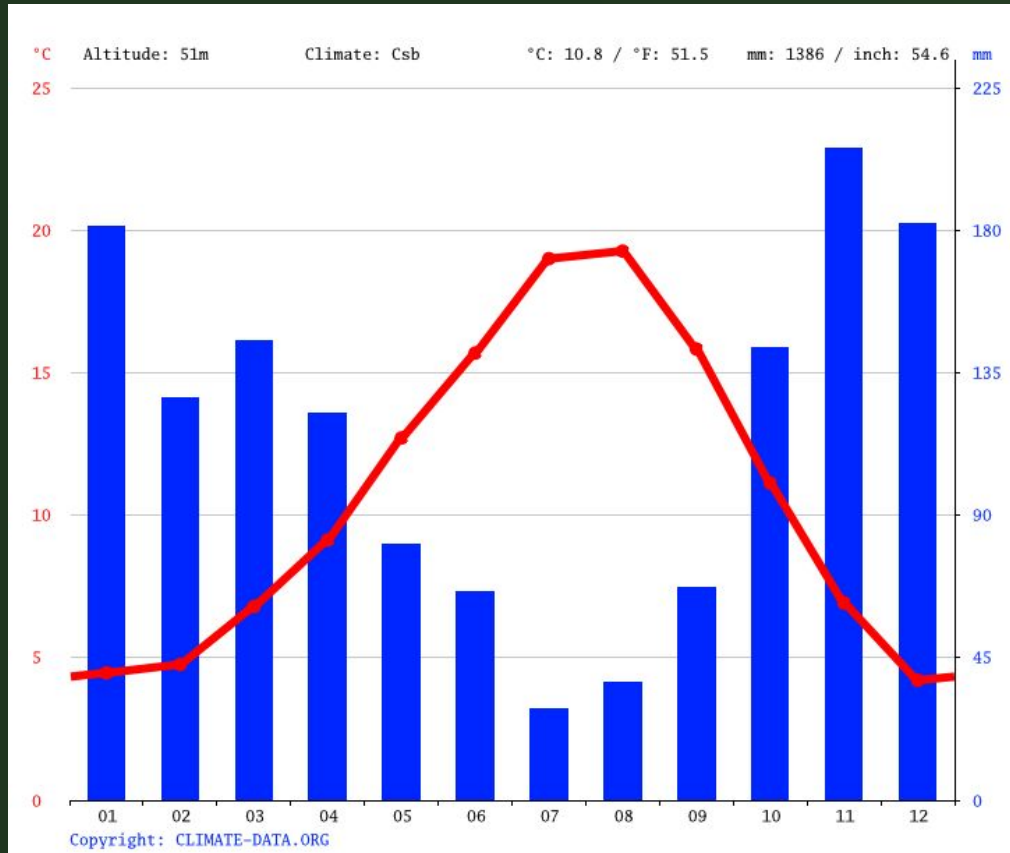
summit WATER RESOURCES

Agenda

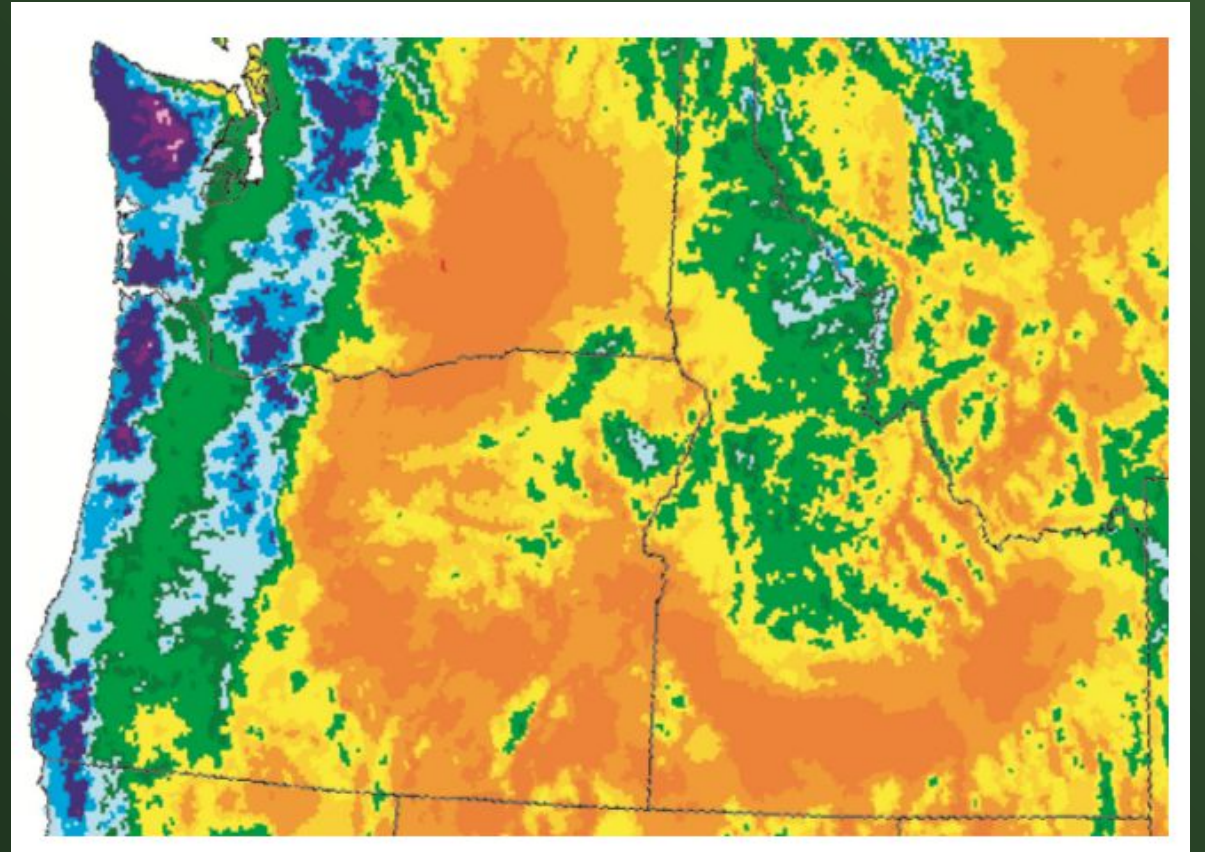
- ESA Listed fish
- Oregon Temperature Standards, 303(d) list, & TMDLs
- Water Quality Trading History
- Thermal Impacts, Wastewater
- Water Withdrawals and Temperature TMDLs
- 401 Water Quality Certification Process
- Thermal Impacts, Withdrawals
- Thermal Trading Plans
- Thermal Mitigation Strategies
- New Strategy: Aquifer Storage and Recovery
- The Future
- Q & A

Pacific Northwest Climate

Typical Pacific Northwest Climate



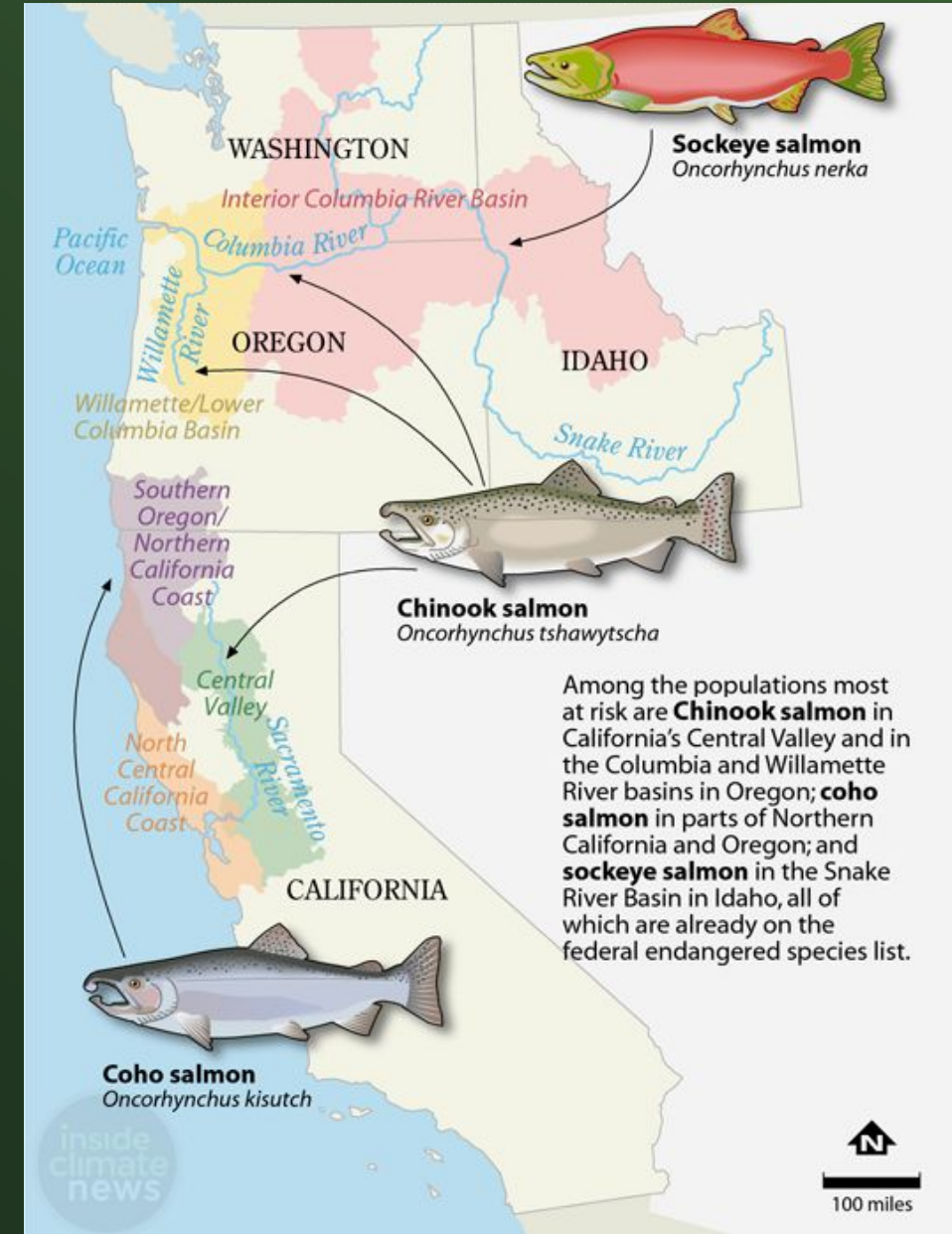
Precipitation Distribution



Pacific Northwest Salmon Habitat and Value

- Economic value of commercial salmon fishing (\$1.1B per year, >40,000 jobs)
- Cultural value
- Essential role in ecosystem function and diversity
- Several salmon species are Endangered Species Act (ESA) listed

Pacific Northwest Salmon Habitat Distribution



SOURCE: Crozier, et al. 2019

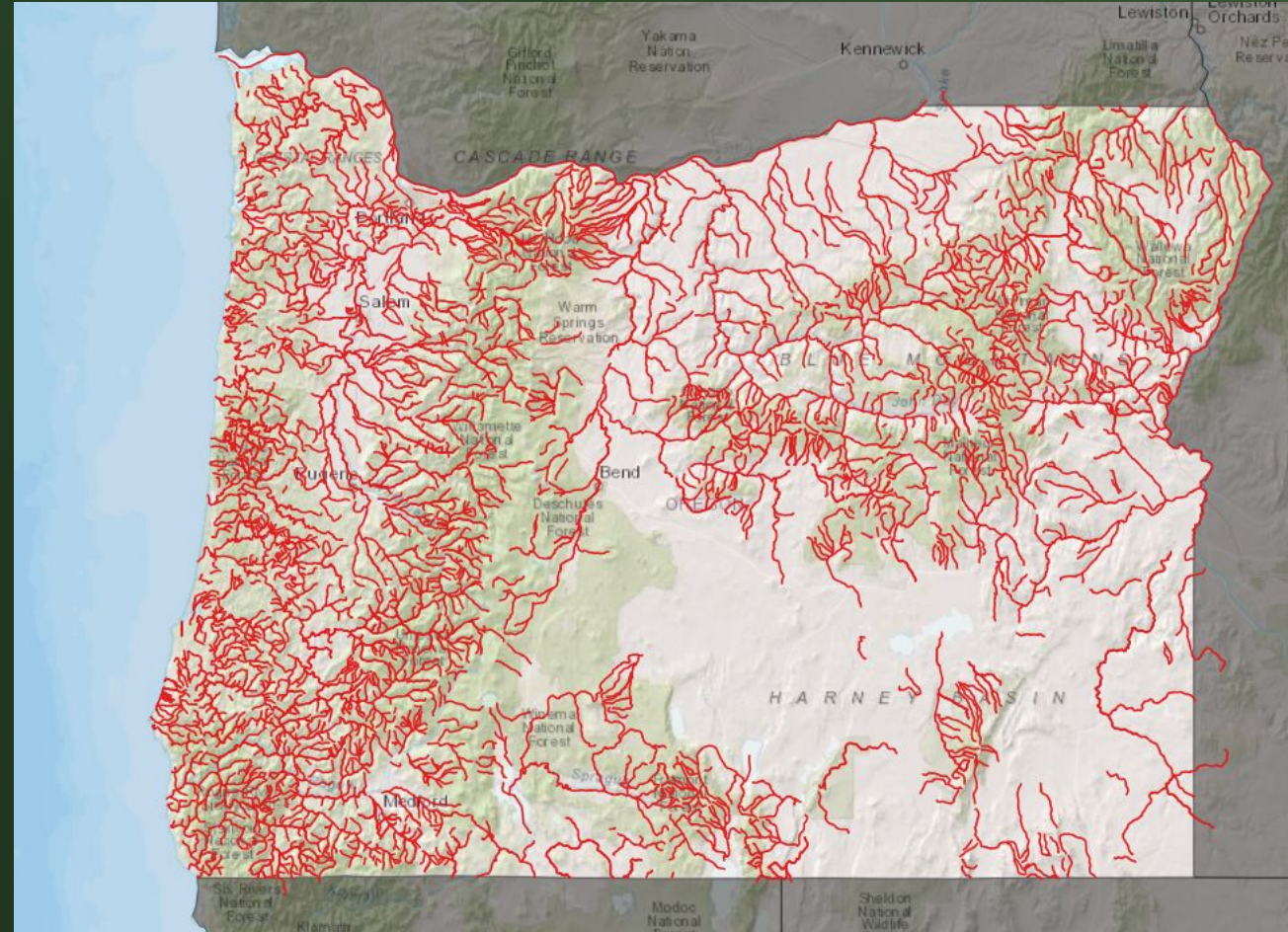
PAUL HORN / InsideClimate News

Rising Stream Temperatures



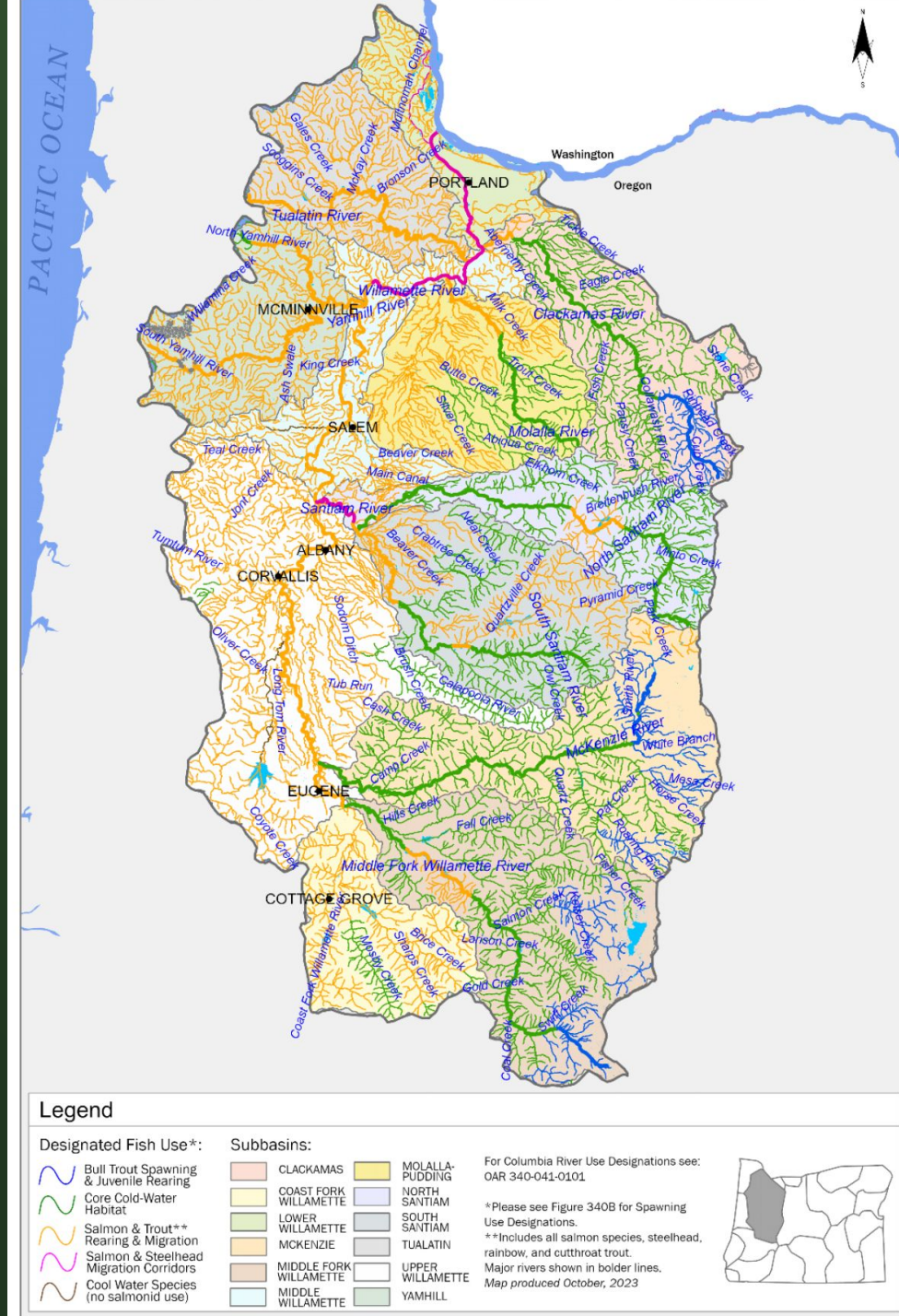
- Chronic exposure to elevated stream temperatures ($>17.8^{\circ}\text{C}$) can impair the ability of salmon to migrate, reproduce, grow, and survive.
- Acute exposure to higher temperatures ($>21^{\circ}\text{C}$) can be lethal
- Approximately 81% of Oregon's rivers do meet water quality standards for temperature (DEQ, 2022)

Surface Waters on 303(d) List for Thermal Impairment, Oregon



Oregon Temperature Standards

- Driven by ESA listed fish species
- Standard is based on the 7-day moving average of the daily maximum water temperature (7DMADM)
- Spatially and temporally explicit by fish species, time of year (spawning, rearing etc.)
- Example: Willamette River basin
 - Salmon and steelhead spawning: 13.0 °C.
 - Core cold water habitat: 16.0 °C.



Total Maximum Daily Loads (TMDLs)

- Oregon, Washington and Idaho have been developing water temperature total maximum daily loads (TMDLs)
- TMDLs have put thermal loading limitations on dischargers such as WWTPs and POTWs.
- Oregon is in the process of updating many of the water temperature TMDLs from 2004 to 2008 to respond to lawsuits related to the old temperature standard.

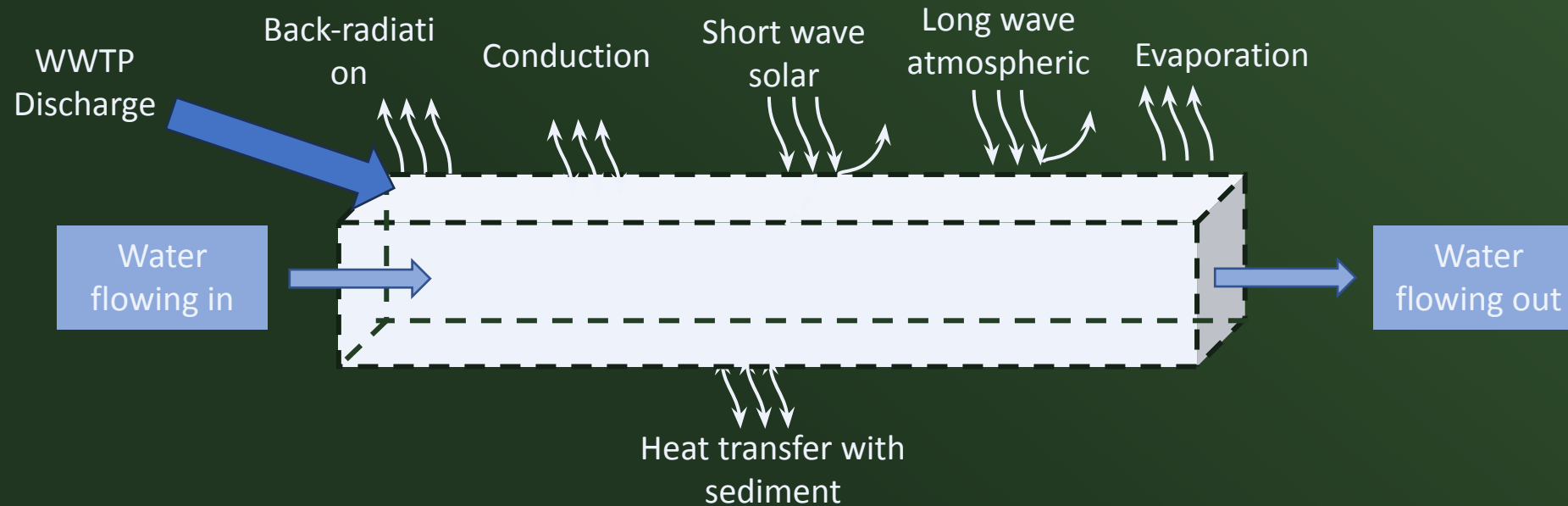
Water Quality Trading History

- 2003 EPA Trading Policy, U.S. EPA, Water Quality Trading Policy, 68 Fed. Reg. 1608, 1610 (Jan. 13, 2003):
 - <https://www.gpo.gov/fdsys/pkg/FR-2003-01-13/html/03-620.htm>
 - <https://www.govinfo.gov/app/details/FR-2003-01-13/03-620>
- 2004+ Oregon DEQ has been issuing permits that include thermal credit trading – primarily focused on wastewater
 - Started with Clean Water Services – Thank you for being at the forefront
- 2015 - Oregon Environmental Quality Commission approved rules establishing a voluntary water quality trading program
 - OAR 340 Division 039 - A set of rules outlining the basic requirements for a viable water quality trading program

Water Quality Trading History

- 2016 - DEQ issued an Internal Management Directive
 - Provides direction on evaluating and approving water quality trades
- 2017 - DEQ started regulating drinking water withdrawals for thermal impacts
 - Drinking Water (March 2017): Willamette Water Supply System submitted a Joint Permit Application to the U.S. Army Corps of Engineers seeking to withdraw from the Willamette River.
 - Triggered 401 Water Quality Certification process
 - Wastewater: Clean Water Services, Medford Regional Water Reclamation Facility, City of Ashland, Metropolitan Wastewater Management Commission (Springfield/Eugene)

Thermal Impacts, Wastewater



- Discharge adds water and heat to the river
- Changes the velocity of the river (more flow => higher velocity)
- Thermal impacts ameliorated over time and distance as combined effluent and river are attenuated by diurnal cycle of atmospheric warming and solar radiation

Wastewater Discharge Heat Load

- Thermal Exceedance = Facility Excess Thermal Load – Excess Thermal Load Limit.
 - $TE = ETL - ETLL$
- where:
 - $ETL = Q_{\text{effluent}} \text{ cfs} \times (\text{Temp}_{\text{effluent}} - \text{Temp Criteria } ^\circ\text{C}) \times CF$
 - $ETLL = (Q_{\text{river}} + Q_{\text{effluent}} \text{ cfs}) \times (\text{Temp Human Use Allowance } ^\circ\text{C}) \times CF$
- CF: Unit conversion factor = $1,000 \text{ kg/m}^3 \times 86,400 \text{ s/day} \times (1 \text{ kcal})/(\text{kg} \times ^\circ\text{C})$
- Thermal Exceedance (Heat Load) has units of kcal/day.
- TMDL looks at two surface model scenarios – with and without individual discharges

Regulation of Wastewater Discharges

- Utilize TMDL process to develop load allocations for WWTPs, POTWs and industrial discharges.
- TMDL addresses non-point sources such as lack of riparian shade
- TMDL does not address water withdrawals
- NPDES permit is updated with new load allocations at the next permit renewal.
- Dischargers with Thermal Trading Plans – Annual reporting to DEQ to demonstrate developing mitigation projects AND document thermal credits generated.

Water Withdrawals and Temperature TMDLs

- If water utility plans a new withdrawal or upgrade a withdrawal
- The waterbody has a water temperature TMDL or 303(d) listing
- DEQ considers the water withdrawal as a nonpoint source polluter for water temperature
 - The waterbody is limited for temperature (too warm).
 - Withdrawal removes water while the waterbody still experiences the same seasonal warming.
 - In general, this results in a warmer waterbody
- The permitting nexus is 401 Water Quality Certification process, which involves DEQ.
- Requires water withdrawal permittee to:
 - Calculate the thermal impacts to the waterbody
 - Develop a Thermal Trading Plan to mitigate thermal impacts
 - Implement mitigation strategies and report annually to DEQ on progress.

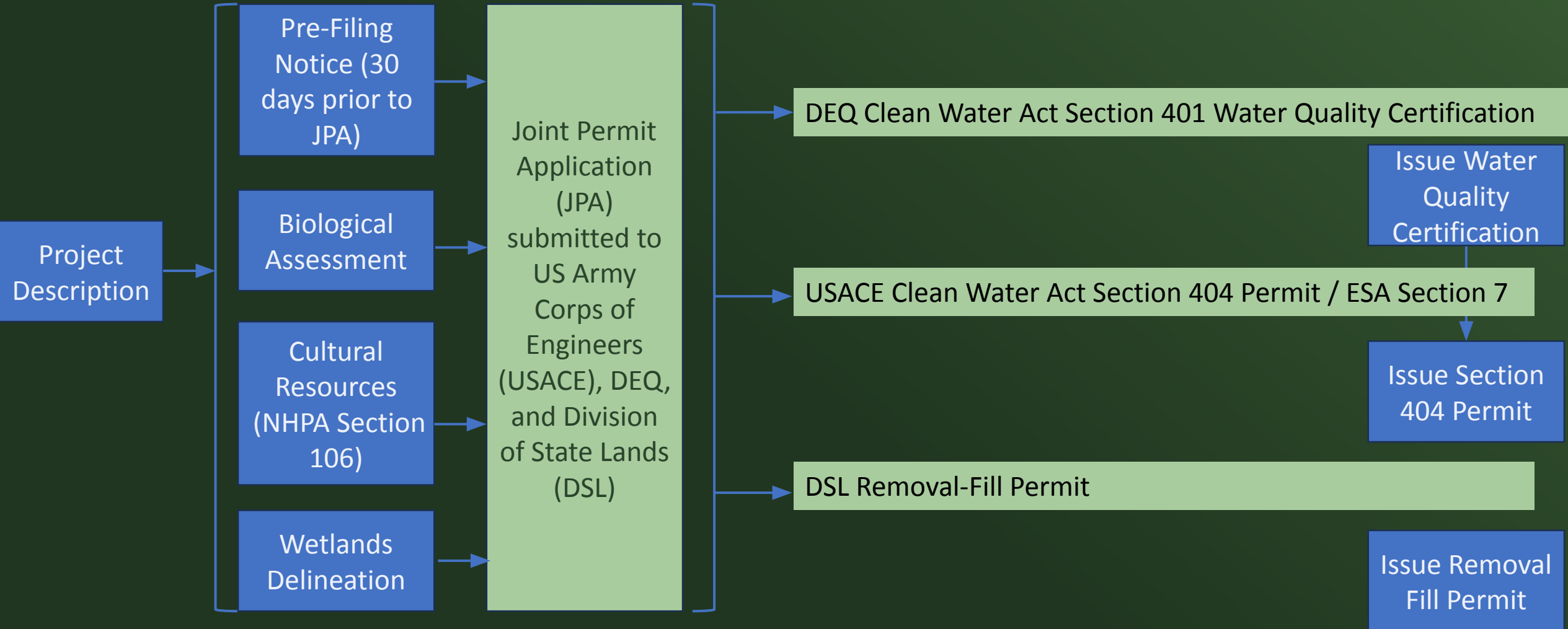
Nexus with Drinking Water Utilities

nexus to surface water (ESA fish & water quality limited streams)

- Permitting requirements are defined by the Project
- What is the Project?
 - Seismic upgrades to the intake structure
 - New intake structure
 - Water Treatment Plant, pipelines and more
- What is nexus with surface water?
 - Construction at the intake structure, in-water work
 - Water withdrawal
- What is the nexus with Endangered Species Act (ESA) listed fish?

Permitting Process

nexus to surface water (ESA fish & water quality limited streams)



Permitting Process

nexus to surface water (ESA fish & water quality limited streams)

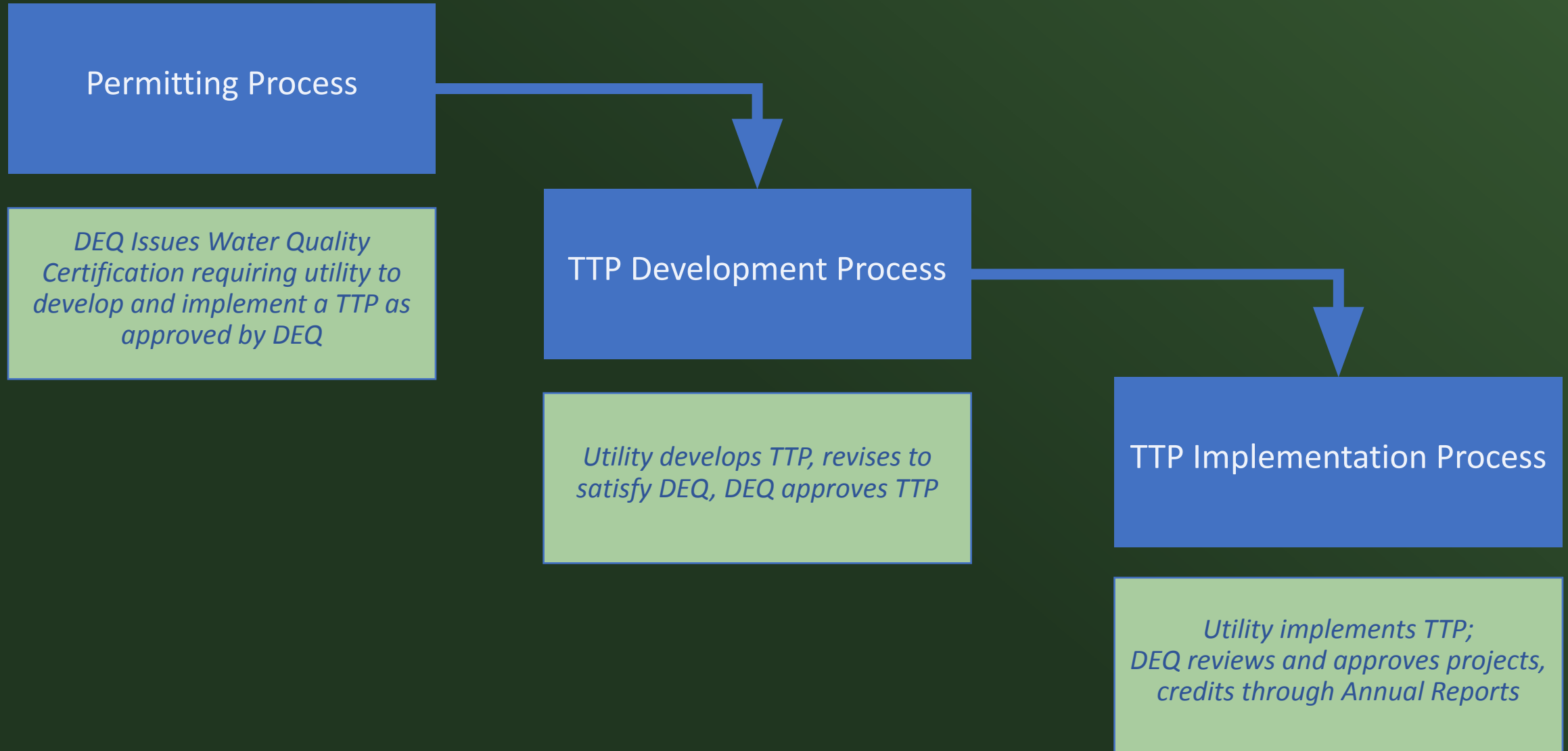
DEQ Clean Water Act Section 401 Water Quality Certification



Single “bite of the apple” approach

The final Thermal Trading Plan becomes a
Condition of the 401 WQ Certification

Thermal Trading: Permitting through Implementation

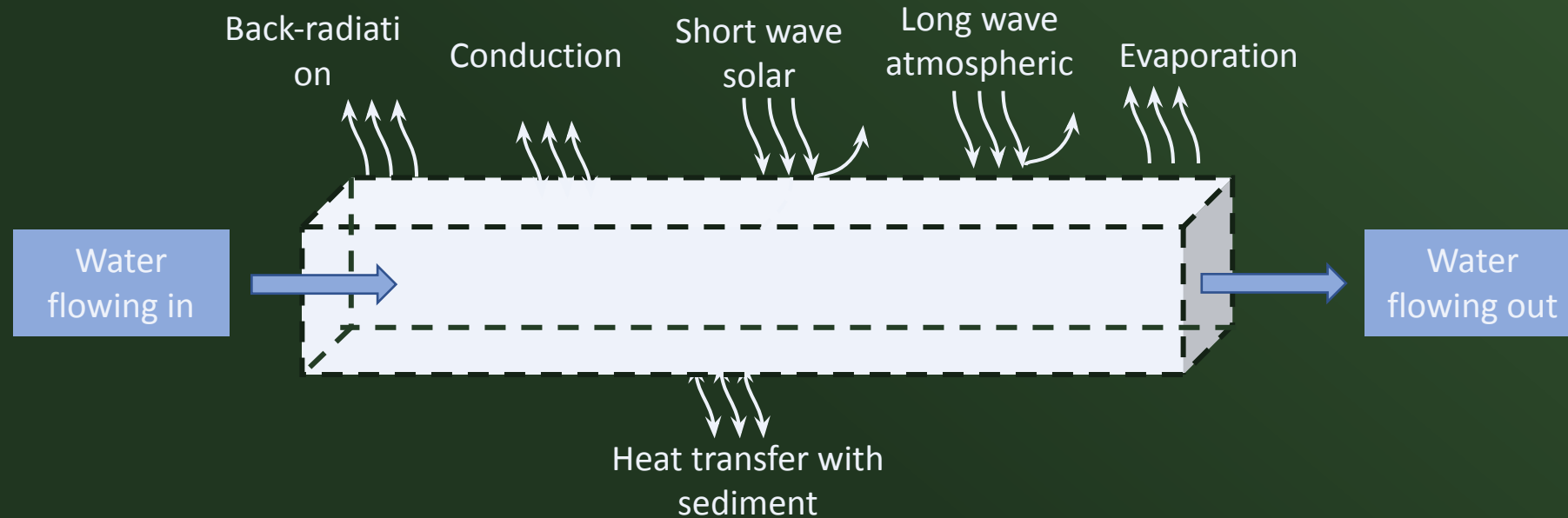


401 Water Quality Certification Process

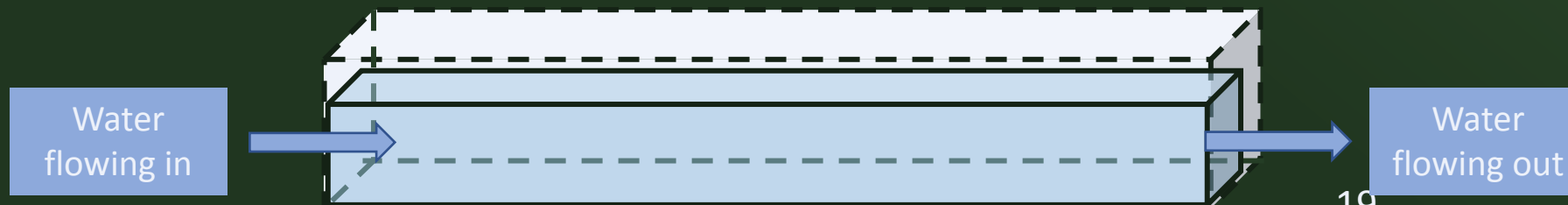
- The Project defines what permits are needed.
- The Permits and requirements are specific to the Project.
- The thermal impacts analysis is specific to the Project.
- The 401 Water Quality Certification is specific to the Project and it's impacts on the receiving water.
- A condition of the 401 Water Quality Certification is the Thermal Trading Plan (TTP).
 - The TTP is specific to the Project thermal impacts and outlines the mitigation concepts to be implemented.

Thermal Impact, Water Withdrawals

- Changes the velocity of the river (less flow => lower velocity)
- Thermal impacts continue downstream, but does decrease over distance



Less volume, same environmental forcings = results in warmer water after same time
= results in less time to warm up to same temperature



Water Withdrawal Thermal Impact

- Thermal Impact = $Q_{\text{river}} \times \Delta T \times \text{CF}$
 - ΔT is the difference in the 7-day average of the daily maximum water temperature ($T_{\text{future}} - T_{\text{baseline}}$), in $^{\circ}\text{C}$
 - Q_{river} is the daily average river flow (Q_{future}), in m^3/s or the 7Q10 flow
- CF: Unit conversion factor = $1,000 \text{ kg}/\text{m}^3 \times 86,400 \text{ s}/\text{day} \times (1 \text{ kcal})/(\text{kg} \times ^{\circ}\text{C})$
- Units of kcal/day.
- Utilize two surface model scenarios – with and without the withdrawal
- Identify the maximum point of thermal impact.
 - Can be miles downstream of withdrawal intake

What is in a Thermal Trading Plan?

(OAR 340-039)

- Eligibility
- Water Quality trading to undertake (water temperature)
- Baseline conditions and requirements
- Trading Area (upstream of the Maximum Point of Impact)
- Best Management Practices considered – high level – NOT project specific
- Trading Ratio (stream side shading is 2:1)
- Trading Credits – thermal impacts and therefore credits needed to offset
- Credit Duration
- Monitoring Requirements
- Plan Performance Verification
- Tracking and Reporting – Annual Reports to DEQ on progress with meeting thermal mitigation targets
- Trading Plan Revisions

Thermal Trading Plans, Annual Reporting

- Annual activities
 - Projects in the works, current status of each project - plantings etc.
 - Site visits by DEQ
 - Site maintenance
 - Monitoring
- Credit generation
 - Ledger of credits created towards the amount needed
- Projected future work

Thermal Trading Strategies Approved by Oregon DEQ

- **Flow Augmentation**

- Buying or leasing other water rights
- Stored water
- New water rights
- Utilize surface water models like Heat Source, CE-QUAL-W2 or other methods, approved by DEQ

- **Limitations**

- No new water rights may be available
- No water rights available to buy or lease
- Insufficient water rights to buy, lease and apply for
- Can be costly to acquire stored water
- Timing of available water may not line up with largest impacts

Thermal Trading Strategies Approved by Oregon DEQ

- **Stream riparian shading**

- Required a 2:1 ratio to mitigate impacts
- Cost: roughly \$150k/mile
- Mitigates: 10.5 Mkcal/day per mile
- Utilize tool “Shade-a-lator”, approved by DEQ

- **Limitations**

- Need sufficient miles upstream of the maximum point of temperature and thermal impact
- May be competing against other regulated parties

Thermal Trading Strategies Approved by Oregon DEQ

- **Narrowing the stream channel**

- Approved but not implemented yet.
- Could be done in conjunction with stream riparian shading
- Utilize tool “Shade-a-lator”, approved by DEQ

- **Limitations**

- Can be costly
- Thermal benefits are unknown at this time.

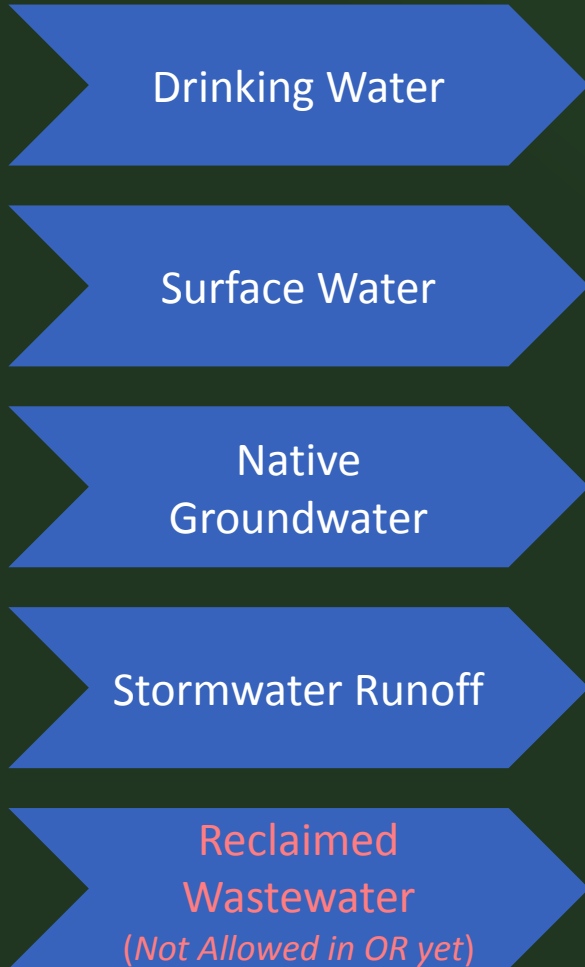
There is a critical need for more cost-effective strategies for thermal mitigation

Thermal Mitigation Strategies

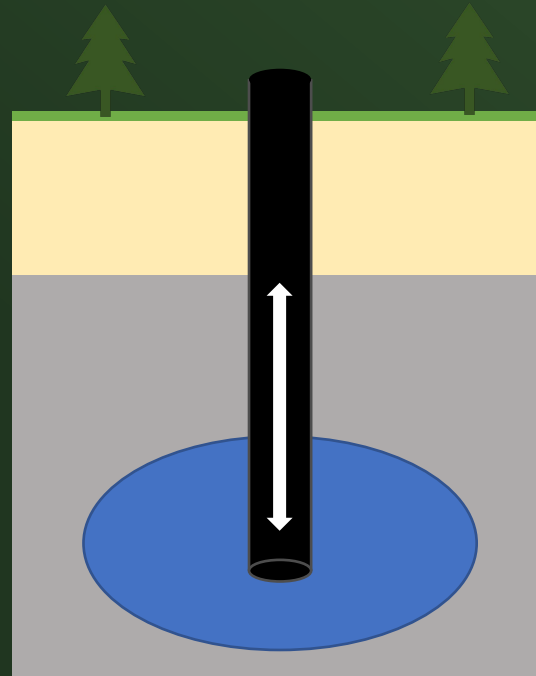
- Limited number of strategies
- Methodology for using new mitigation strategies must be in the Thermal Trading Plan
 - How to quantify cold water refugia benefits?
 - How to quantify floodplain restoration?
 - What happens if you have nutrient load reductions and dissolved oxygen benefits?
 - How are these considered when thermal mitigation is what's needed??
- DEQ must approve the methodology
- Burden of developing new methodologies and proving “worthy” falls on the permittee.

New Strategy, Aquifer Storage and Recovery (ASR)

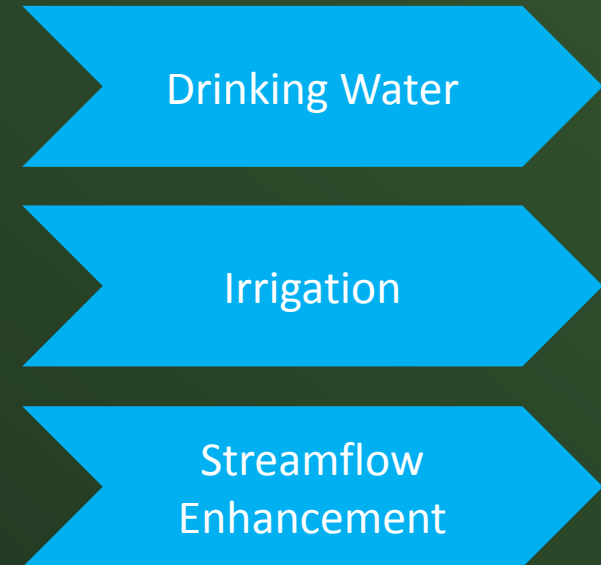
Recharge Source Water



Storage



Recovery Use



Feasibility of ASR

- Source Water

- Sufficient quantities/durations available? (OWRD WARS)
- Sufficient thermal characteristics? ($<10^{\circ}\text{C}$)

- Treatment

- Drinking water standards (ASR rules) or antidegradation (AR rules)
- Surface water treatment is typically for turbidity and microbiological constituents

- Storage Aquifer

- Confined (to minimize water loss)
- Highly transmissive hydraulic properties (to accept large quantities of water)
- Inert chemical composition (to maintain original WQ characteristics [temp])

- Geochemical Compatibility

- Unwanted reactions (mineral precipitation and clogging)

ASR Permitting Overview

Artificial Recharge (AR)

OAR 690-350-0110

- Rules developed in 1961
- Surface infiltration or well recharge
- Anti-degradation WQ standards
- Separate authorizations for recharge and recovery

Aquifer Storage and Recovery (ASR)

OAR 690-350-0010

- Rules developed in 1995
- Well recharge only
- Drinking water quality standards
- Use existing water rights



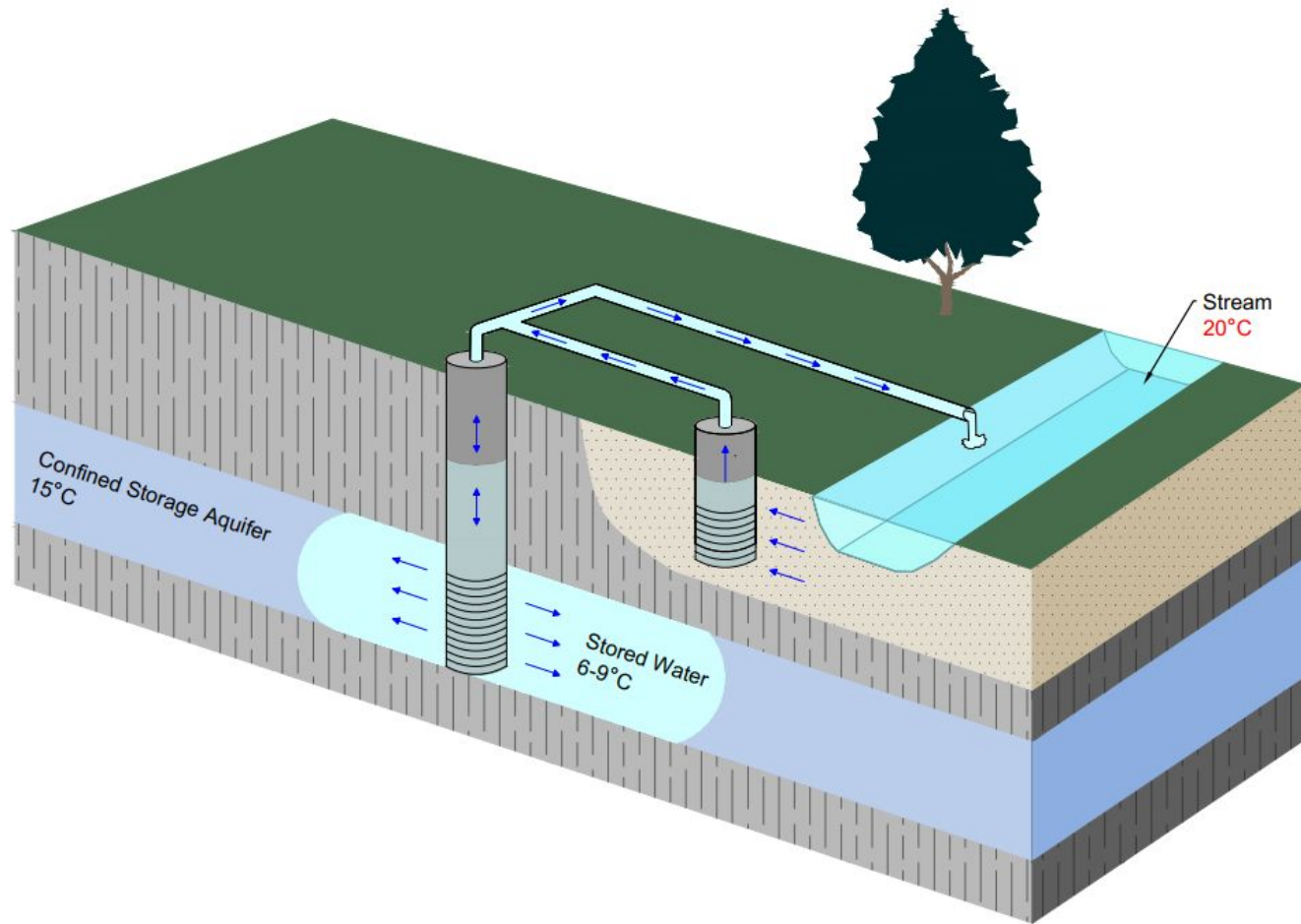
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graph TD; AR[Artificial Recharge (AR)] --> UIC[UIC Registration]; ASR[Aquifer Storage and Recovery (ASR)] --> UIC;
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UIC Registration

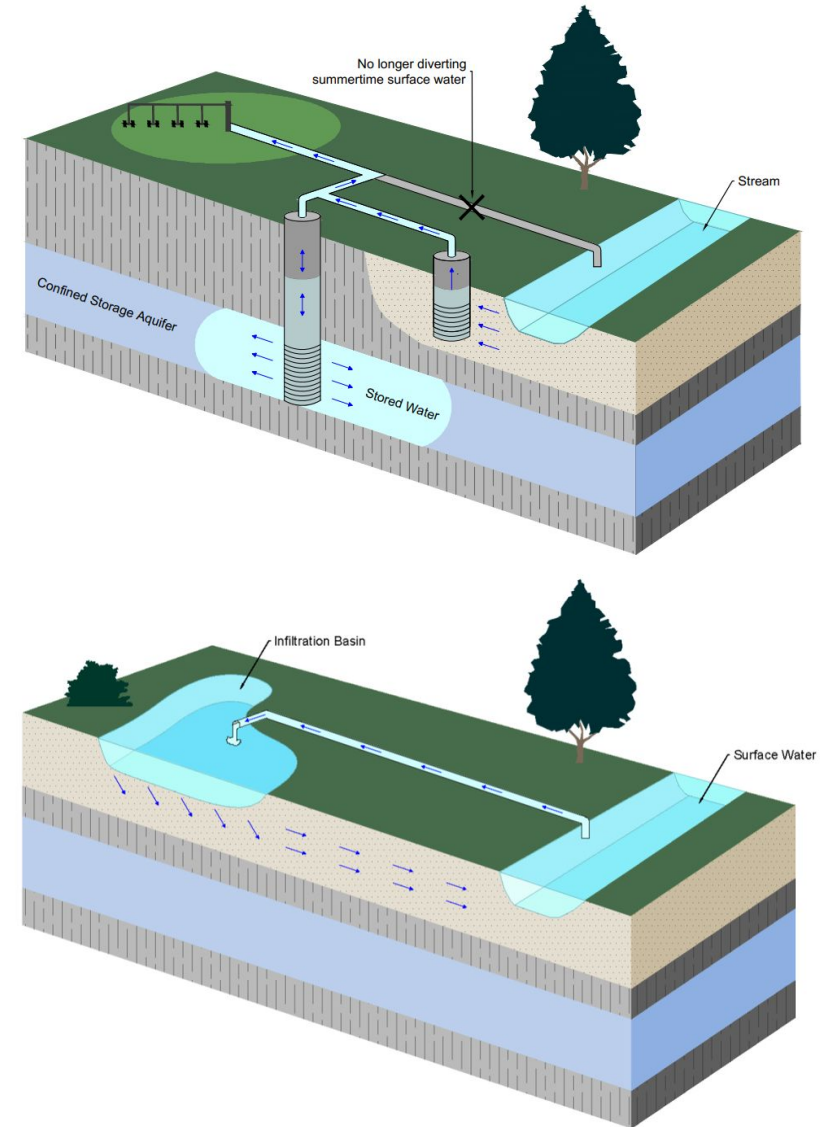
- Classified as Class V UIC System
- Registered and permitted either by rule or state permit (1200U, 1900B)

ASR Thermal Mitigation Concept

Subsurface Storage Release

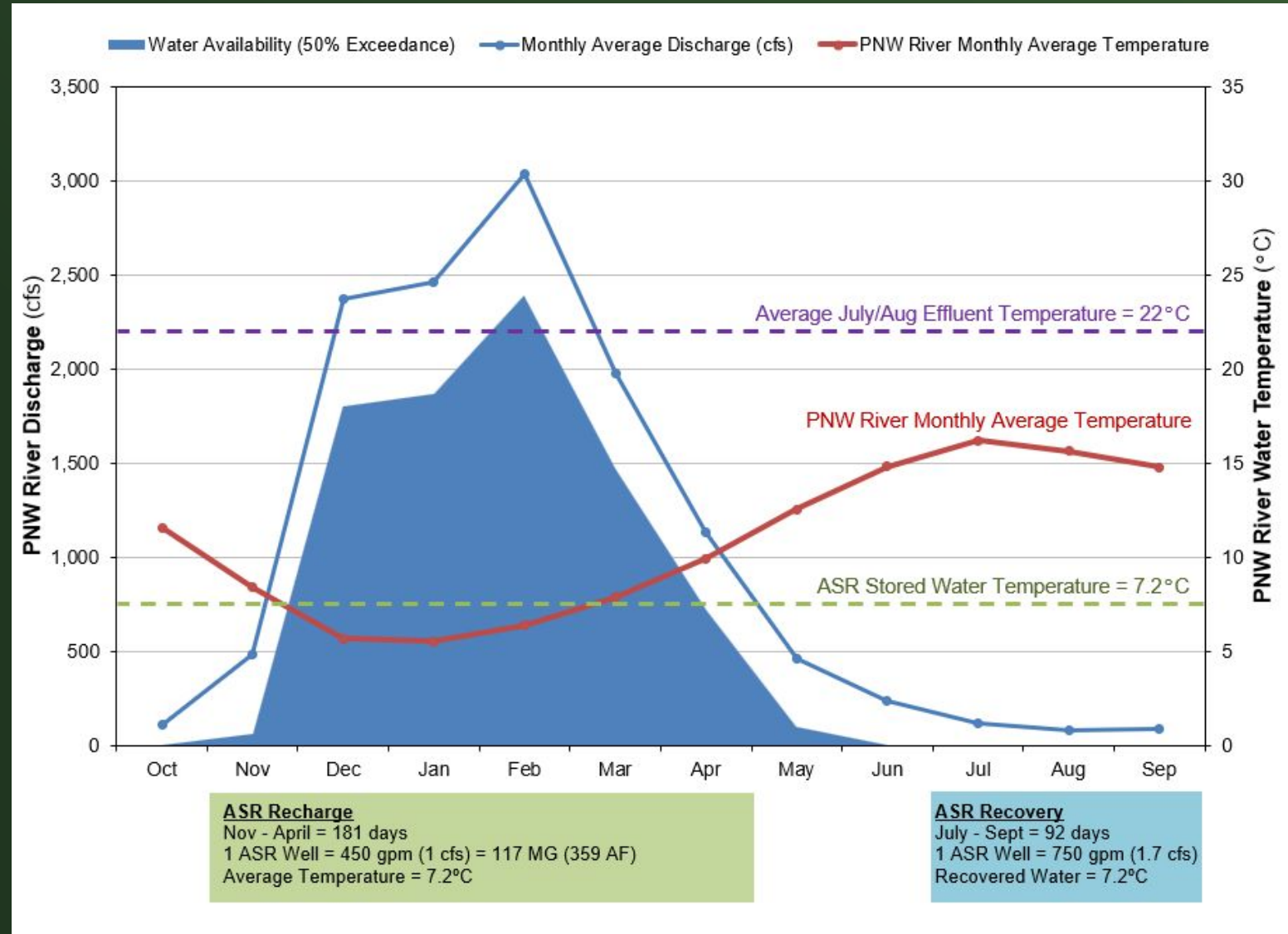


Subsurface Storage Exchange



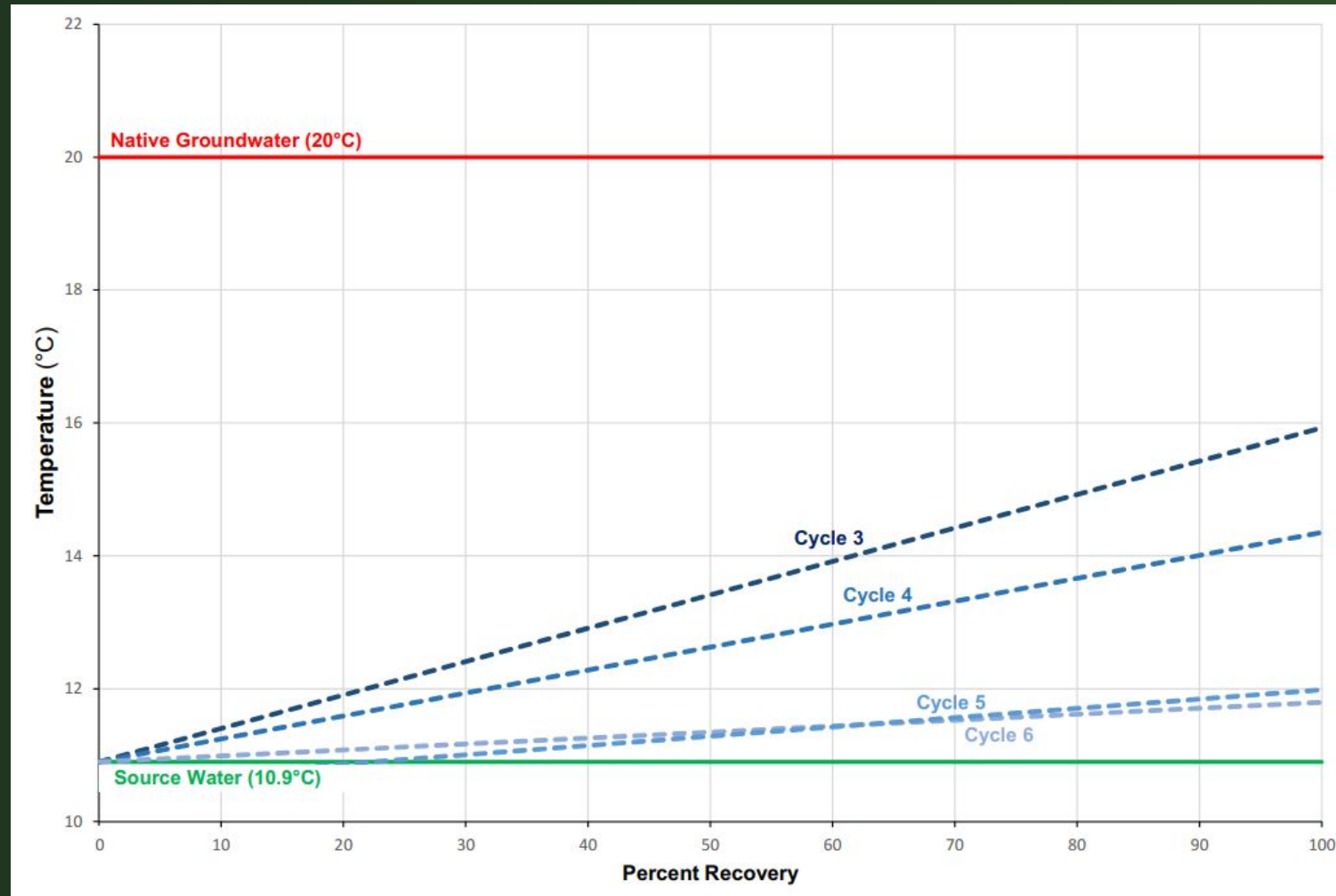
ASR Thermal Mitigation Concept

- Store cold water ($<10^{\circ}\text{C}$) surface water during periods of excess (winter/spring) and then recover during the summer for flow enhancement
- Benefits may include:
 - Reduction of instream temperatures
 - Generation of thermal credits for WQ credit trading programs
 - Provide cold water refugia for aquatic species



ASR for Thermal Mitigation

Temperature of Recovered ASR Water



How can ASR be used for Drinking Water Withdrawal?

- Strategy 1

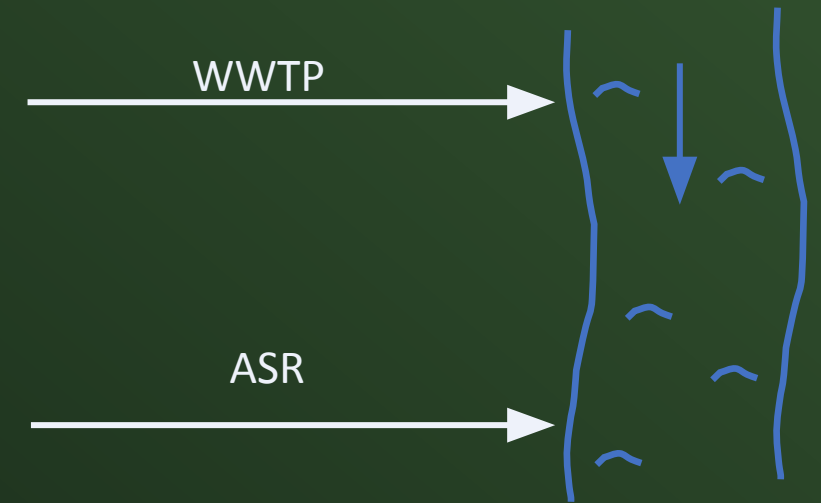
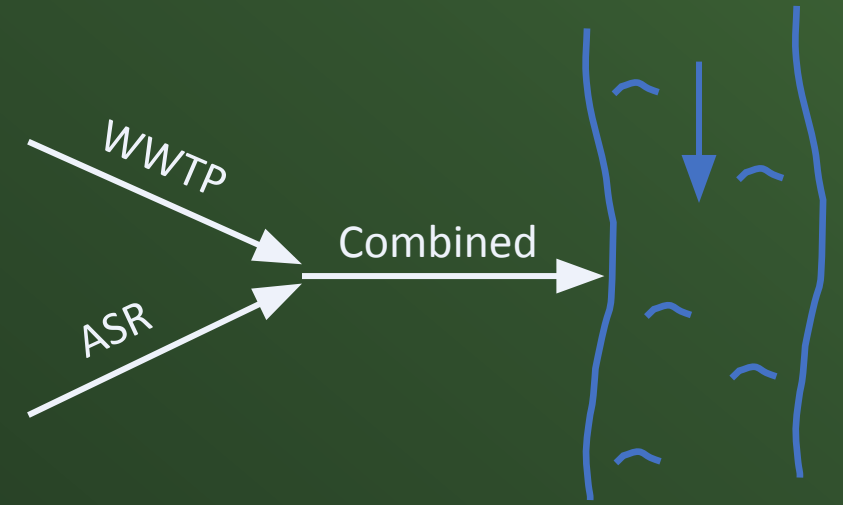
- Utilize ASR discharge flows upstream of water withdrawal to restore volume of water
- Trying to replace every drop withdrawal – likely no feasible.
- Provides additional flow and cooling (GW temperature)

- Strategy 2

- Utilize ASR discharge flows just upstream of the maximum point of thermal impact
- Provides additional flow and cooling (GW temperature)
- Need less water than Strategy 1

How can ASR be used for Wastewater?

- Could be combined with a WWTP discharge
 - Seasonal variation
 - Modifies WWTP discharge
- Stand alone
 - Could be discharged near discharge, withdrawal, or maximum point of impact.
 - Support NPDES Permit mitigation
 - Support water withdrawal mitigation



NPDES Permitting

- Combined with WWTP discharge
 - Discharge characteristics may change over the season
 - Would the combined water quality characteristics need to be redefined?
 - Would a new permit be needed?
 - Would a mixing zone be needed?
- Stand alone, while providing a thermal benefit:
 - Would the water quality characteristics need to be defined?
 - Would a NPDES permit be needed?
 - Would a mixing zone be needed?

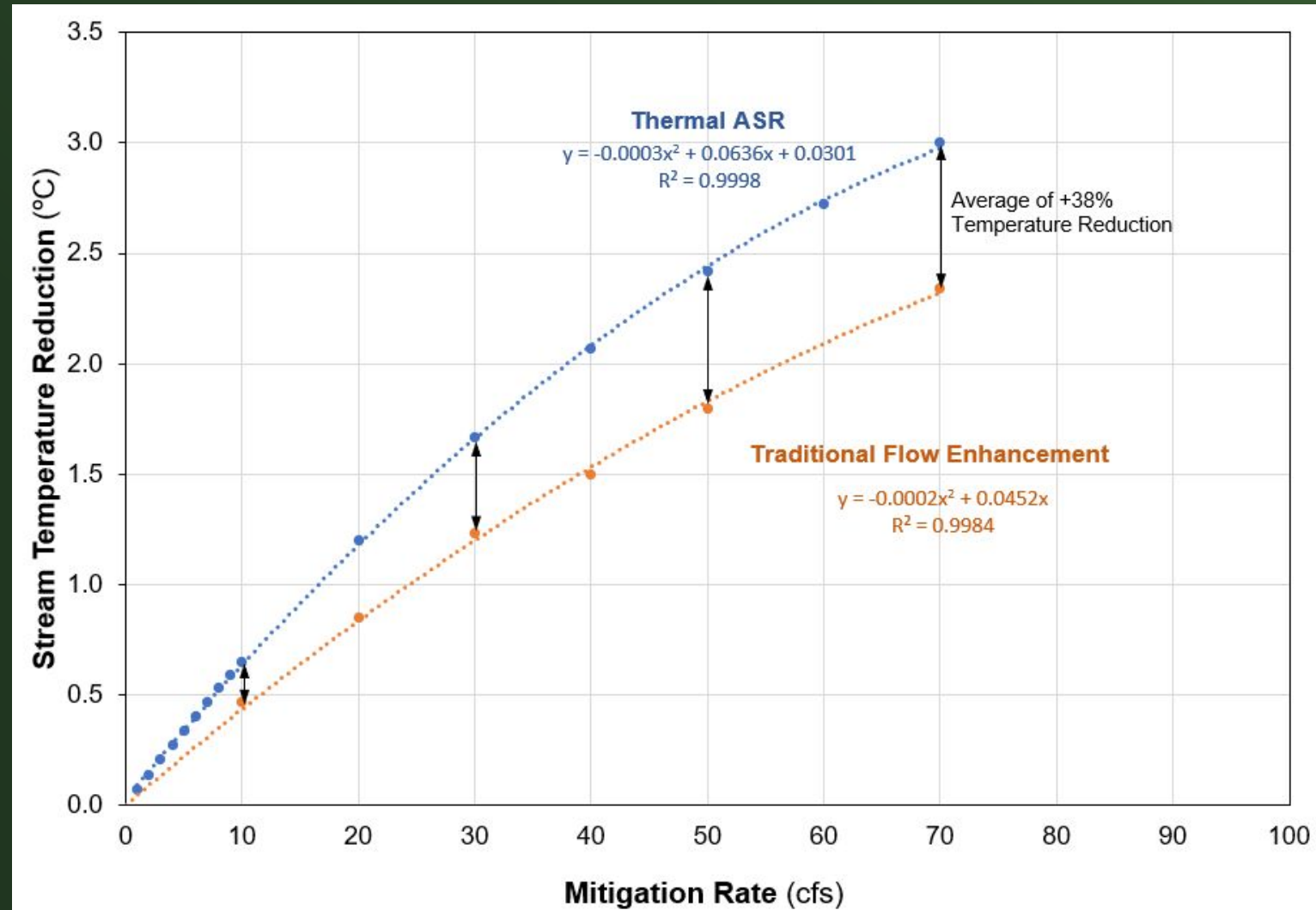
Quantifying Thermal Mitigation Benefits

- A key aspect of an ASR discharge is potential thermal benefits
- Options for demonstrating thermal benefits:
 - Mass balance approach
 - Numerical modeling , e.g. CE-QUAL-W2 or Heat Source
 - Data collection
- Scenarios that could be explored with options above
 - Current conditions, without ASR flow
 - With ASR flow using different operational scenarios
 - Compare thermal regimes, consisted with Thermal Trading Plan approach

Theoretical Comparison of Mitigation

On a per unit basis, thermal ASR may reduce stream temperatures 38% more than traditional methods (flow augmentation from reservoirs)

Comparison of Mitigation Methods



The Future

- DEQ will regulate WWTPs and water withdrawals for thermal impacts.
- At least four other withdrawals are in this process and will need to comply.
- Washington and Idaho – similar routes to Oregon?
 - Washington – Draft Water Quality Trading/Offset Framework (2018)
 - Similar to Oregon's Thermal Trading Program
 - Buying and selling credits – utilizes a marketplace
 - No discussion of water withdrawals/401 Water Quality Certifications
 - Idaho - Water Quality Trading Guidance (2016)
 - Similar to Oregon's Thermal Trading Program
 - No discussion of water withdrawals/401 Water Quality Certifications

The Future (continued)

- More approved BMPs are needed.
- States need to work with permittees to achieve this outside of trading plans.
- Environmental groups are suing DEQ over their Thermal Trading Plan and its implementation

Summary

- Oregon is using the JPA/404/401 permitting process to regulate water withdrawals for thermal impacts.
- The Thermal Trading Plan is a condition of the 401 WQ Certification.
- It's not clear how much this approach is being used in Washington and Idaho
- The cost impacts can be huge
- May raise conflicts between water withdrawals and WWTPs competing for mitigation opportunities.
- There is a need for more thermal mitigation strategies
- Aquifer Storage and Recovery can be an excellent new strategy providing both flow and temperature benefits.



Questions?

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